

**3GPP TSG-RAN Meeting #15
Jeju, Korea, 5 – 8, March, 2002**

RP-020058

Title: Agreed CRs (Rel-5) for the WI of "High Speed Downlink Packet Access -- Physical Layer"

Source: TSG-RAN WG1

Agenda item: 9.7.1

No.	Spec	CR	Rev	R1 T-doc	Subject	Release	Cat	Workitem	V_old	V_new
1	25.201	013	-	R1-02-0437	Specification of HS-DSCH for Release 5 in 25.201	Rel-5	B	HSDPA-Phys	4.1.0	5.0.0
2	25.211	146	-	R1-02-0470	Specification of HS-DSCH for Release 5 in 25.211	Rel-5	B	HSDPA-Phys	4.3.0	5.0.0
3	25.212	126	1	R1-02-0492	Changes to 25.212 for HSDPA work item	Rel-5	B	HSDPA-Phys	4.3.0	5.0.0
4	25.213	049	-	R1-02-0515	The inclusion of HSDPA into 25.213	Rel-5	B	HSDPA-Phys	4.2.0	5.0.0
5	25.214	237	2	R1-02-0480	Introduction of HSDPA feature to TS25.214	Rel-5	B	HSDPA-Phys	4.3.0	5.0.0
6	25.214	251	-	R1-020404	Introduction of power control aspects for HSDPA feature in TS25.214	Rel-5	B	HSDPA-Phys	4.3.0	5.0.0
7	25.221	076	1	R1-02-0507	CR to include HSDPA in TS25.221	Rel-5	B	HSDPA-Phys	4.3.0	5.0.0
8	25.222	066	2	R1-02-0508	Inclusion of HSDPA in 25.222	Rel-5	B	HSDPA-Phys	4.2.0	5.0.0
9	25.223	026	1	R1-02-0509	CR to include HSDPA in TS25.223	Rel-5	B	HSDPA-Phys	4.3.0	5.0.0
10	25.224	081	1	R1-02-0502	Power control and procedures for HSDPA	Rel-5	B	HSDPA-Phys	4.3.0	5.0.0

CHANGE REQUEST

⌘ **25.201 CR 013** ⌘ rev **-** ⌘ Current version: **4.1.0** ⌘

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Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ Specification of HS-DSCH for Release 5 in 25.201		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ DD-Feb-2002
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories: F (correction) A (corresponds to a correction in an earlier release) B (addition of feature), C (functional modification of feature) D (editorial modification) Detailed explanations of the above categories can be found in 3GPP TR 21.900 .		Use <u>one</u> of the following releases: 2 (GSM Phase 2) R96 (Release 1996) R97 (Release 1997) R98 (Release 1998) R99 (Release 1999) REL-4 (Release 4) REL-5 (Release 5)

Reason for change:	⌘ The recommended changes implement HDSPA functionality and performance in the specification.
Summary of change:	⌘ Acronym list is updated. 16 QAM, link adaptation and H-ARQ functions are introduced.
Consequences if not approved:	⌘ Work item for HSDPA-Phys will not be part of REL-5.

Clauses affected:	⌘ 3 and 4		
Other specs affected:	<input type="checkbox"/> Other core specifications	⌘	REL-4 25.211,25.212, 25.213, 25.214
	<input type="checkbox"/> Test specifications		
	<input type="checkbox"/> O&M Specifications		
Other comments:	⌘		

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- 3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

16QAM	16 Quadrature Amplitude Modulation
ARQ	Automatic Repeat Request
BER	Bit Error Rate
CCTrCH	Coded Composite Transport Channel
CPCH	Common Packet Channel
DCA	Dynamic channel allocation
DCH	Dedicated Channel
DS-CDMA	Direct-Sequence Code Division Multiple Access
DSCH	Downlink Shared Channel
DwPCH	Downlink Pilot Channel
DwPTS	Downlink Pilot Time Slot
FAUSCH	Fast Uplink Signalling Channel
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FER	Frame Error Rate
GSM	Global System for Mobile Communication
HS-DSCH	High Speed Downlink Shared channel
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
LAC	Link Access Control
MAC	Medium Access Control
Mcps	Mega Chip Per Second
ODMA	Opportunity Driven Multiple Access
QPSK	Quaternary Phase Shift Keying
RACH	Random Access Channel
RF	Radio Frequency
RLC	Radio Link Control
RRC	Radio Resource Control
SAP	Service Access Point
SCCC	Serial Concatenated Convolutional Code
SCH	Synchronisation Channel
SIR	Signal-to-Interference Ratio
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TFCI	Transport-Format Combination Indicator
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
UpPTS	Uplink Pilot Time Slot
UpPCH	Uplink Pilot Channel
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
WCDMA	Wide-band Code Division Multiple Access

4 General description of Layer 1

4.1 Relation to other layers

4.1.1 General Protocol Architecture

Radio interface which is prescribed by this specification means the Uu point between User Equipment (UE) and network. The radio interface is composed of Layers 1, 2 and 3. Layer 1 is based on WCDMA/TD-SCDMA technology and the TS 25.200 series describes the Layer-1 specification. Layers 2 and 3 of the radio interface are described in the TS 25.300 and 25.400 series, respectively.

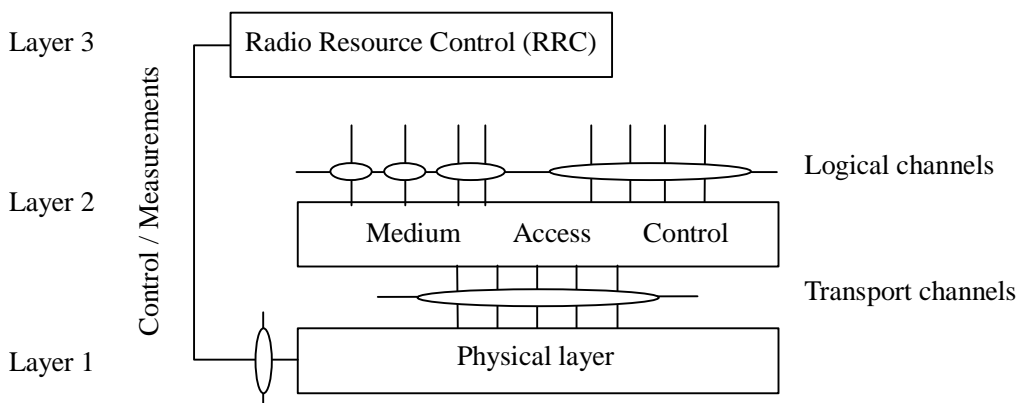


Figure 1: Radio interface protocol architecture around the physical layer

Figure 1 shows the UTRA radio interface protocol architecture around the physical layer (Layer 1). The physical layer interfaces the Medium Access Control (MAC) sub-layer of Layer 2 and the Radio Resource Control (RRC) Layer of Layer 3. The circles between different layer/sub-layers indicate Service Access Points (SAPs). The physical layer offers different Transport channels to MAC. A transport channel is characterized by how the information is transferred over the radio interface. MAC offers different Logical channels to the Radio Link Control (RLC) sub-layer of Layer 2. A logical channel is characterized by the type of information transferred. Physical channels are defined in the physical layer. There are two duplex modes: Frequency Division Duplex (FDD) and Time Division Duplex (TDD). In the FDD mode a physical channel is characterized by the code, frequency and in the uplink the relative phase (I/Q). In the TDD mode the physical channels is also characterized by the timeslot. The physical layer is controlled by RRC.

4.1.2 Service provided to higher layers

The physical layer offers data transport services to higher layers. The access to these services is through the use of transport channels via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service. See also TS 25.302:

- Macrodiversity distribution/combining and soft handover execution.
- Error detection on transport channels and indication to higher layers.
- FEC encoding/decoding of transport channels.
- Multiplexing of transport channels and demultiplexing of coded composite transport channels (CCTrCHs).
- Rate matching of coded transport channels to physical channels.
- Mapping of coded composite transport channels on physical channels.
- Power weighting and combining of physical channels.
- Modulation and spreading/demodulation and despreading of physical channels.
- Frequency and time (chip, bit, slot, frame) synchronisation.

- Radio characteristics measurements including FER, SIR, Interference Power, etc., and indication to higher layers.
- Inner - loop power control.
- RF processing. (Note: RF processing is defined in TS 25.100 series).
- synchronization shift control
- beamforming
- Hybrid ARQ soft-combining for HS-DSCH

When network elements (UEs and network) provide compatible service bearers (for example support a speech bearer) they should be assured of successful interworking. Moreover, different implementation options of the same (optional) feature would lead to incompatibility between UE and network. Therefore, this shall be avoided.

4.2 General description of Layer 1

4.2.1 Multiple Access

The access scheme is Direct-Sequence Code Division Multiple Access (DS-CDMA) with information either spread over approximately 5 MHz (FDD and 3.84 Mcps TDD) bandwidth, thus also often denoted as Wideband CDMA (WCDMA) due that nature. or 1.6MHz (1.28Mcps TDD), thus also often denoted as Narrowband CDMA. UTRA has two modes, FDD (Frequency Division Duplex) & TDD (Time Division Duplex), for operating with paired and unpaired bands respectively. The possibility to operate in either FDD or TDD mode allows for efficient utilisation of the available spectrum according to the frequency allocation in different regions. FDD and TDD modes are defined as follows:

FDD: A duplex method whereby uplink and downlink transmissions use two separated radio frequencies. In the FDD, each uplink and downlink uses the different frequency band. A pair of frequency bands which have specified separation shall be assigned for the system.

TDD: A duplex method whereby uplink and downlink transmissions are carried over same radio frequency by using synchronised time intervals. In the TDD, time slots in a physical channel are divided into transmission and reception part. Information on uplink and downlink are transmitted reciprocally.

UTRA TDD has two options, the 3.84Mcps option and the 1.28Mcps option. In UTRA TDD there is TDMA component in the multiple access in addition to DS-CDMA. Thus the multiple access has been also often denoted as TDMA/CDMA due added TDMA nature.

A 10 ms radio frame is divided into 15 slots (2560 chip/slot at the chip rate 3.84 Mcps). A physical channel is therefore defined as a code (or number of codes) and additionally in TDD mode the sequence of time slots completes the definition of a physical channel.

The information rate of the channel varies with the symbol rate being derived from the 3.84 Mcps chip rate and the spreading factor. Spreading factors are from 256 to 4 with FDD uplink, from 512 to 4 with FDD downlink, and from 16 to 1 for TDD uplink and downlink. Thus the respective modulation symbol rates vary from 960 k symbols/s to 15 k symbols/s (7.5 k symbols/s) for FDD uplink (downlink), and for TDD the momentary modulation symbol rates shall vary from 3.84 M symbols/s to 240 k symbols/s.

For 1.28Mcps TDD option, a 10 ms radio frame is divided into two 5ms sub-frames. In each sub-frame, there are 7 normal time slots and 3 special time slots. A basic physical channel is therefore characterised by the frequency, code and time slot.

The information rate of the channel varies with the symbol rate being derived from the 1.28 Mcps chiprate and the spreading factor. Spreading factors is from 16 to 1 for both uplink and downlink. Thus the respective modulation symbol rates shall vary from 80.0K symbols/s to 1.28M symbols/s.

4.2.2 Channel coding and interleaving

For the channel coding in UTRA three options are supported:

- Convolutional coding.

- Turbo coding.
- No coding.

Channel coding selection is indicated by higher layers. In order to randomise transmission errors, bit interleaving is performed further.

4.2.3 Modulation and spreading

The UTRA modulation scheme is QPSK (8PSK is also used for 1.28Mcps TDD option). [For HS-DSCH transmission, 16QAM can also be used.](#) Pulse shaping is specified in the TS 25.100 series.

With CDMA nature the spreading (& scrambling) process is closely associated with modulation. In UTRA different families of spreading codes are used to spread the signal:

- For separating channels from same source, channelisation codes derived with the code tree structure as given in TS 25.213 and 25.223 are used.
- For separating different cells the following solutions are supported.
- FDD mode: Gold codes with 10 ms period (38400 chips at 3.84 Mcps) used, with the actual code itself length $2^{18}-1$ chips, as defined in TS 25.213.
- TDD mode: Scrambling codes with the length 16 used as defined in TS 25.223.
- For separating different UEs the following code families are defined.
- FDD mode: Gold codes with 10 ms period, or alternatively S(2) codes 256 chip period.
- TDD mode: codes with period of 16 chips and midamble sequences of different length depending on the environment.

4.2.4 Physical layer procedures

There are several physical layer procedures involved with UTRA operation. Such procedures covered by physical layer description are:

- 1) The power control, with both inner loop and slow quality loop for FDD mode, and for 3.84Mcps TDD option open loop in uplink and inner loop in downlink, for 1.28Mcps TDD option, open loop in uplink and inner loop in both uplink and downlink.
- 2) Cell search operation.
- 3) Uplink synchronization control with open and closed loop.
- 4) Random access
- 5) [Procedures related to HS-DSCH transmission.](#)

4.2.5 Physical layer measurements

Radio characteristics including FER, SIR, Interference power, etc., are measured and reported to higher layers and network. Such measurements are:

- 1) Handover measurements for handover within UTRA. Specific features being determined in addition to the relative strength of the cell, for the FDD mode the timing relation between for cells for support of asynchronous soft handover.
- 2) The measurement procedures for preparation for handover to GSM900/GSM1800.
- 3) The measurement procedures for UE before random access process.
- 4) The measurement procedures for Dynamic Channel Allocation (DCA) of TDD mode.

4.2.6 Relationship of the physical layer functions

The functionality of the layer 1 is split over several specifications each for FDD and TDD. The following figures, although not categorical, show as an introduction the relationship of layer 1 functions by specification in terms of users plane information flow.

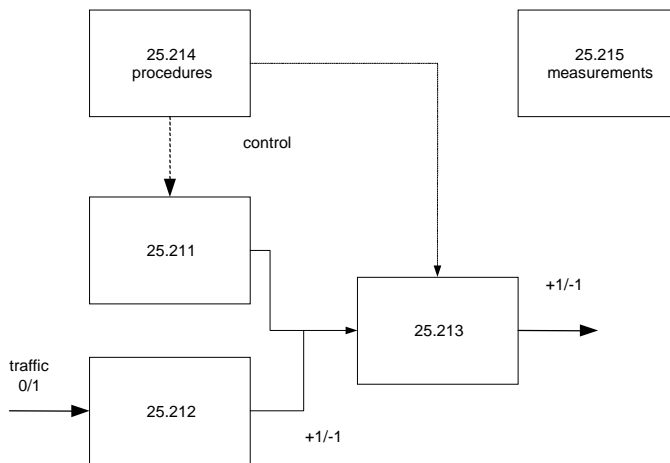


Figure 2 - FDD layer 1 functions relationships by specification

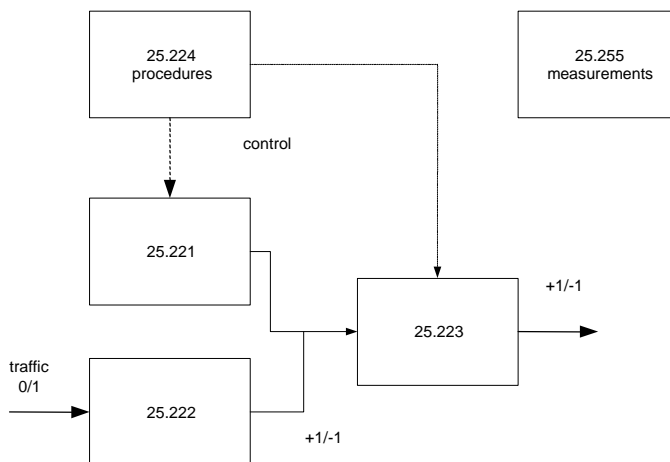


Figure 3 - TDD layer 1 functions relationships by specification

CHANGE REQUEST

⌘ **25.211 CR 146** ⌘ rev **-** ⌘ Current version: **4.3.0** ⌘

For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.

Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ Specification of HS-DSCH for Release 5 in 25.211		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ 21 Feb, 2002
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories:		Use <u>one</u> of the following releases:
	F (correction)	2	(GSM Phase 2)
	A (corresponds to a correction in an earlier release)	R96	(Release 1996)
	B (addition of feature),	R97	(Release 1997)
	C (functional modification of feature)	R98	(Release 1998)
	D (editorial modification)	R99	(Release 1999)
	Detailed explanations of the above categories can be found in 3GPP TR 21.900.		REL-4 (Release 4)
			REL-5 (Release 5)

Reason for change:	⌘ The recommended changes implement HDSPA functionality and performance in the specification.
Summary of change:	⌘ Acronym list is updated. New sections are added to define HS-DSCH transport, HS-PDSCH, HS-DSCH, HS-DPCCH and the new slot formats and subframe structures. Also uplink and downlink characteristics are specified including downlink control subframe structure, slot formats and timing.
Consequences if not approved:	⌘ Work item for HSDPA-Phys will not be part of REL-5.

Clauses affected:	⌘ 3,4,5,6,7		
Other specs affected:	<input type="checkbox"/> Other core specifications	⌘	REL-4 25.201,25.212, 25.213, 25.214
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	<input type="checkbox"/> O&M Specifications		
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**3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Physical channels and mapping of transport channels
onto physical channels (FDD)
(Release 4)**



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Keywords

UMTS, radio, layer 1

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Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
 - 2 presented to TSG for approval;
 - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document describes the characteristics of the Layer 1 transport channels and physical channels in the FDD mode of UTRA. The main objectives of the document are to be a part of the full description of the UTRA Layer 1, and to serve as a basis for the drafting of the actual technical specification (TS).

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TS 25.201: "Physical layer - general description".
- [2] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".
- [3] 3GPP TS 25.212: "Multiplexing and channel coding (FDD)".
- [4] 3GPP TS 25.213: "Spreading and modulation (FDD)".
- [5] 3GPP TS 25.214: "Physical layer procedures (FDD)".
- [6] 3GPP TS 25.221: "Transport channels and physical channels (TDD)".
- [7] 3GPP TS 25.222: "Multiplexing and channel coding (TDD)".
- [8] 3GPP TS 25.223: "Spreading and modulation (TDD)".
- [9] 3GPP TS 25.224: "Physical layer procedures (TDD)".
- [10] 3GPP TS 25.215: "Physical layer - Measurements (FDD)".
- [11] 3GPP TS 25.301: "Radio Interface Protocol Architecture".
- [12] 3GPP TS 25.302: "Services Provided by the Physical Layer".
- [13] 3GPP TS 25.401: "UTRAN Overall Description".
- [14] 3GPP TS 25.133: "Requirements for Support of Radio Resource Management (FDD)".
- [15] 3G TS 25.427: "UTRAN Overall Description :UTRA Iub/Iur Interface User Plane Protocol for DCH data streams".
- [16] 3GPP TS 25.435: "UTRAN Iub Interface User Plane Protocols for Common Transport Channel Data Streams".

3 Symbols and abbreviations

3.1 Symbols

N_{data1} The number of data bits per downlink slot in Data1 field.

N_{data2} The number of data bits per downlink slot in Data2 field. If the slot format does not contain a Data2 field, $N_{data2} = 0$.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

16QAM	16 Quadrature Amplitude Modulation
AI	Acquisition Indicator
AICH	Acquisition Indicator Channel
AP	Access Preamble
AP-AICH	Access Preamble Acquisition Indicator Channel
API	Access Preamble Indicator
BCH	Broadcast Channel
CA	Channel Assignment
CAI	Channel Assignment Indicator
CCC	CPCH Control Command
CCPCH	Common Control Physical Channel
CCTrCH	Coded Composite Transport Channel
CD	Collision Detection
CD/CA-ICH	Collision Detection/Channel Assignment Indicator Channel
CDI	Collision Detection Indicator
CPCH	Common Packet Channel
CPICH	Common Pilot Channel
CQI	Channel Quality Indicator
CSICH	CPCH Status Indicator Channel
DCH	Dedicated Channel
DPCCH	Dedicated Physical Control Channel
DPCH	Dedicated Physical Channel
DPDCH	Dedicated Physical Data Channel
DSCH	Downlink Shared Channel
DSMA-CD	Digital Sense Multiple Access - Collision Detection
DTX	Discontinuous Transmission
FACH	Forward Access Channel
FBI	Feedback Information
FSW	Frame Synchronization Word
HS-DPCCH	Dedicated Physical Control Channel (uplink) for HS-DSCH
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	Shared Control Channel for HS-DSCH
ICH	Indicator Channel
MUI	Mobile User Identifier
PCH	Paging Channel
P-CCPCH	Primary Common Control Physical Channel
PCPCH	Physical Common Packet Channel
PDSCH	Physical Downlink Shared Channel
PICH	Page Indicator Channel
PRACH	Physical Random Access Channel
PSC	Primary Synchronisation Code
RACH	Random Access Channel
RNC	Radio Network Controller
S-CCPCH	Secondary Common Control Physical Channel
SCH	Synchronisation Channel
SF	Spreading Factor
SFN	System Frame Number
SI	Status Indicator
SSC	Secondary Synchronisation Code
STTD	Space Time Transmit Diversity
TFCI	Transport Format Combination Indicator
TSTD	Time Switched Transmit Diversity
TPC	Transmit Power Control
UE	User Equipment

4 Services offered to higher layers

4.1 Transport channels

Transport channels are services offered by Layer 1 to the higher layers. General concepts about transport channels are described in [12].

A transport channel is defined by how and with what characteristics data is transferred over the air interface. A general classification of transport channels is into two groups:

- Dedicated channels, using inherent addressing of UE;
- Common channels, using explicit addressing of UE if addressing is needed.

4.1.1 Dedicated transport channels

There exists only one type of dedicated transport channel, the Dedicated Channel (DCH).

4.1.1.1 DCH - Dedicated Channel

The Dedicated Channel (DCH) is a downlink or uplink transport channel. The DCH is transmitted over the entire cell or over only a part of the cell using e.g. beam-forming antennas.

4.1.2 Common transport channels

There are six types of common transport channels: BCH, FACH, PCH, RACH, CPCH and DSCH.

4.1.2.1 BCH - Broadcast Channel

The Broadcast Channel (BCH) is a downlink transport channel that is used to broadcast system- and cell-specific information. The BCH is always transmitted over the entire cell and has a single transport format.

4.1.2.2 FACH - Forward Access Channel

The Forward Access Channel (FACH) is a downlink transport channel. The FACH is transmitted over the entire cell. The FACH can be transmitted using power setting described in [16].

4.1.2.3 PCH - Paging Channel

The Paging Channel (PCH) is a downlink transport channel. The PCH is always transmitted over the entire cell. The transmission of the PCH is associated with the transmission of physical-layer generated Paging Indicators, to support efficient sleep-mode procedures.

4.1.2.4 RACH - Random Access Channel

The Random Access Channel (RACH) is an uplink transport channel. The RACH is always received from the entire cell. The RACH is characterized by a collision risk and by being transmitted using open loop power control.

4.1.2.5 CPCH - Common Packet Channel

The Common Packet Channel (CPCH) is an uplink transport channel. CPCH is associated with a dedicated channel on the downlink which provides power control and CPCH Control Commands (e.g. Emergency Stop) for the uplink CPCH. The CPCH is characterised by initial collision risk and by being transmitted using inner loop power control.

4.1.2.6 DSCH - Downlink Shared Channel

The Downlink Shared Channel (DSCH) is a downlink transport channel shared by several UEs. The DSCH is associated with one or several downlink DCH. The DSCH is transmitted over the entire cell or over only a part of the cell using e.g. beam-forming antennas.

4.1.2.7 HS-DSCH – High Speed Downlink Shared Channel

The High Speed Downlink Shared Channel is a downlink transport channel shared by several UE. The HS-DSCH is associated with one downlink DPCH, and one or several Shared Control Channels (HS-SCCH). The HS-DSCH is transmitted over the entire cell or over only part of the cell using e.g. beam-forming antennas.

4.2 Indicators

Indicators are means of fast low-level signalling entities which are transmitted without using information blocks sent over transport channels. The meaning of indicators is specific to the type of indicator.

The indicators defined in the current version of the specifications are: Acquisition Indicator (AI), Access Preamble Indicator (API), Channel Assignment Indicator (CAI), Collision Detection Indicator (CDI), Page Indicator (PI) and Status Indicator (SI).

Indicators may be either boolean (two-valued) or three-valued. Their mapping to indicator channels is channel specific.

Indicators are transmitted on those physical channels that are indicator channels (ICH).

5 Physical channels and physical signals

Physical channels are defined by a specific carrier frequency, scrambling code, channelization code (optional), time start & stop (giving a duration) and, on the uplink, relative phase (0 or $\pi/2$). Scrambling and channelization codes are specified in [4]. Time durations are defined by start and stop instants, measured in integer multiples of chips. Suitable multiples of chips also used in specification are:

Radio frame: A radio frame is a processing duration which consists of 15 slots. The length of a radio frame corresponds to 38400 chips.

Slot: A slot is a duration which consists of fields containing bits. The length of a slot corresponds to 2560 chips.

HS-DSCH sub-frame: The HS-DSCH sub-frame is the basic time interval for HS-DSCH transmission and HS-DSCH-related signalling at the physical layer. The length of the HS-DSCH sub-frame corresponds to 3 slots (7680 chips).

The default time duration for a physical channel is continuous from the instant when it is started to the instant when it is stopped. Physical channels that are not continuous will be explicitly described.

Transport channels are described (in more abstract higher layer models of the physical layer) as being capable of being mapped to physical channels. Within the physical layer itself the exact mapping is from a composite coded transport channel (CCTrCH) to the data part of a physical channel. In addition to data parts there also exist channel control parts and physical signals.

5.1 Physical signals

Physical signals are entities with the same basic on-air attributes as physical channels but do not have transport channels or indicators mapped to them. Physical signals may be associated with physical channels in order to support the function of physical channels.

5.2 Uplink physical channels

5.2.1 Dedicated uplink physical channels

There are two types of uplink dedicated physical channels, the uplink Dedicated Physical Data Channel (uplink DPDCH), and the uplink Dedicated Physical Control Channel (uplink DPCCH), and the uplink Dedicated Control Channel associated with HS-DSCH transmission (uplink HS-DPCCH).

The DPDCH, and the DPCCH and the HS-DPCCH are I/Q code multiplexed within each radio frame (see [4]).

The uplink DPDCH is used to carry the DCH transport channel. There may be zero, one, or several uplink DPDCHs on each radio link.

The uplink DPCCH is used to carry control information generated at Layer 1. The Layer 1 control information consists of known pilot bits to support channel estimation for coherent detection, transmit power-control (TPC) commands, feedback information (FBI), and an optional transport-format combination indicator (TFCI). The transport-format combination indicator informs the receiver about the instantaneous transport format combination of the transport channels mapped to the simultaneously transmitted uplink DPDCH radio frame. There is one and only one uplink DPCCH on each radio link.

Figure 1 shows the frame structure of the uplink dedicated physical channels DPDCH and the uplink DPCCH. Each radio frame of length 10 ms is split into 15 slots, each of length $T_{\text{slot}} = 2560$ chips, corresponding to one power-control period. The DPDCH and DPCCH are always frame aligned with each other.

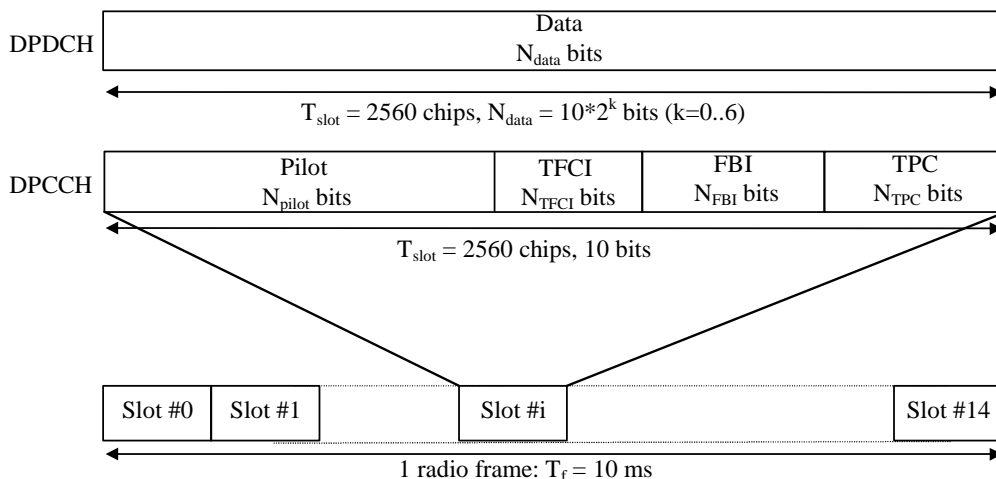


Figure 1: Frame structure for uplink DPDCH/DPCCH

The parameter k in figure 1 determines the number of bits per uplink DPDCH slot. It is related to the spreading factor SF of the DPDCH as $SF = 256/2^k$. The DPDCH spreading factor may range from 256 down to 4. The spreading factor of the uplink DPCCH is always equal to 256, i.e. there are 10 bits per uplink DPCCH slot.

The exact number of bits of the uplink DPDCH and the different uplink DPCCH fields (N_{pilot} , N_{TFCI} , N_{FBI} , and N_{TPC}) is given by table 1 and table 2. What slot format to use is configured by higher layers and can also be reconfigured by higher layers.

The channel bit and symbol rates given in table 1 and table 2 are the rates immediately before spreading. The pilot patterns are given in table 3 and table 4, the TPC bit pattern is given in table 5.

The FBI bits are used to support techniques requiring feedback from the UE to the UTRAN Access Point, including closed loop mode transmit diversity and site selection diversity transmission (SSDT). The structure of the FBI field is shown in figure 2 and described below.

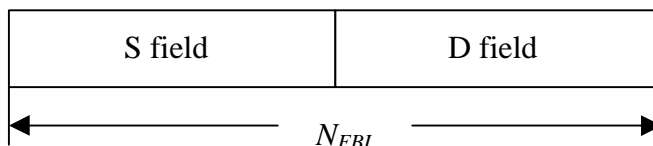


Figure 2: Details of FBI field

The S field is used for SSST signalling, while the D field is used for closed loop mode transmit diversity signalling. The S field consists of 0, 1 or 2 bits. The D field consists of 0 or 1 bit. The total FBI field size N_{FBI} is given by table 2. If total FBI field is not filled with S field or D field, FBI field shall be filled with "1". When N_{FBI} is 2bits, S field is 0bit and D field is 1bit, left side field shall be filled with "1" and right side field shall be D field. The use of the FBI fields is described in detail in [5].

Table 1: DPDCH fields

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/Frame	Bits/Slot	N_{data}
0	15	15	256	150	10	10
1	30	30	128	300	20	20
2	60	60	64	600	40	40
3	120	120	32	1200	80	80
4	240	240	16	2400	160	160
5	480	480	8	4800	320	320
6	960	960	4	9600	640	640

There are two types of uplink dedicated physical channels; those that include TFCI (e.g. for several simultaneous services) and those that do not include TFCI (e.g. for fixed-rate services). These types are reflected by the duplicated rows of table 2. It is the UTRAN that determines if a TFCI should be transmitted and it is mandatory for all UEs to support the use of TFCI in the uplink. The mapping of TFCI bits onto slots is described in [3].

In compressed mode, DPCCH slot formats with TFCI fields are changed. There are two possible compressed slot formats for each normal slot format. They are labelled A and B and the selection between them is dependent on the number of slots that are transmitted in each frame in compressed mode.

Table 2: DPCCH fields

Slot Form at #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/Frame	Bits/Slot	N_{pilot}	N_{TPC}	N_{TFCI}	N_{FBI}	Transmitted slots per radio frame
0	15	15	256	150	10	6	2	2	0	15
0A	15	15	256	150	10	5	2	3	0	10-14
0B	15	15	256	150	10	4	2	4	0	8-9
1	15	15	256	150	10	8	2	0	0	8-15
2	15	15	256	150	10	5	2	2	1	15
2A	15	15	256	150	10	4	2	3	1	10-14
2B	15	15	256	150	10	3	2	4	1	8-9
3	15	15	256	150	10	7	2	0	1	8-15
4	15	15	256	150	10	6	2	0	2	8-15
5	15	15	256	150	10	5	1	2	2	15
5A	15	15	256	150	10	4	1	3	2	10-14
5B	15	15	256	150	10	3	1	4	2	8-9

The pilot bit patterns are described in table 3 and table 4. The shadowed column part of pilot bit pattern is defined as FSW and FSWs can be used to confirm frame synchronization. (The value of the pilot bit pattern other than FSWs shall be "1".)

Table 3: Pilot bit patterns for uplink DPCCH with $N_{\text{pilot}} = 3, 4, 5$ and 6

Bit #	$N_{\text{pilot}} = 3$			$N_{\text{pilot}} = 4$				$N_{\text{pilot}} = 5$					$N_{\text{pilot}} = 6$					
	0	1	2	0	1	2	3	0	1	2	3	4	0	1	2	3	4	5
Slot #0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0
1	0	0	1	1	0	0	1	0	0	1	1	0	1	0	0	1	1	0
2	0	1	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1
3	0	0	1	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
4	1	0	1	1	1	0	1	1	0	1	0	1	1	1	0	1	0	1
5	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0
6	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0
7	1	0	1	1	1	0	1	1	0	1	0	0	1	1	0	1	0	0
8	0	1	1	1	0	1	1	0	1	1	1	0	1	0	1	1	1	0
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	0	1	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1
11	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0	1	1	1
12	1	0	1	1	1	0	1	1	0	1	0	0	1	1	0	1	0	0
13	0	0	1	1	0	0	1	0	0	1	1	1	1	0	0	1	1	1
14	0	0	1	1	0	0	1	0	0	1	1	1	1	0	0	1	1	1

Table 4: Pilot bit patterns for uplink DPCCH with $N_{\text{pilot}} = 7$ and 8

Bit #	$N_{\text{pilot}} = 7$							$N_{\text{pilot}} = 8$							
	0	1	2	3	4	5	6	0	1	2	3	4	5	6	7
Slot #0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0
1	1	0	0	1	1	0	1	1	0	1	0	1	1	1	0
2	1	0	1	1	0	1	1	1	0	1	1	1	0	1	1
3	1	0	0	1	0	0	1	1	0	1	0	1	0	1	0
4	1	1	0	1	0	1	1	1	1	1	0	1	0	1	1
5	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0
6	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0
7	1	1	0	1	0	0	1	1	1	1	0	1	0	1	0
8	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	0	1	1	0	1	1	1	0	1	1	1	0	1	1
11	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1
12	1	1	0	1	0	0	1	1	1	1	0	1	0	1	0
13	1	0	0	1	1	1	1	1	0	1	0	1	1	1	1
14	1	0	0	1	1	1	1	1	0	1	0	1	1	1	1

The relationship between the TPC bit pattern and transmitter power control command is presented in table 5.

Table 5: TPC Bit Pattern

TPC Bit Pattern		Transmitter power control command
$N_{\text{TPC}} = 1$	$N_{\text{TPC}} = 2$	
1	11	1
0	00	0

Multi-code operation is possible for the uplink dedicated physical channels. When multi-code transmission is used, several parallel DPDCH are transmitted using different channelization codes, see [4]. However, there is only one DPCCH per radio link.

A period of uplink DPCCH transmission prior to the start of the uplink DPDCH transmission (uplink DPCCH power control preamble) shall be used for initialisation of a DCH. The length of the power control preamble is a higher layer parameter, N_{pcp} , signalled by the network [5]. The UL DPCCH shall take the same slot format in the power control preamble as afterwards, as given in table 2. When $N_{\text{pcp}} > 0$ the pilot patterns of table 3 and table 4 shall be used. The timing of the power control preamble is described in [5], subclause 4.3.2.3. The TFCI field is filled with "0" bits.

Figure 3 illustrates the frame structure of the HS-DPCCH. The HS-DPCCH carries uplink feedback signalling related to downlink HS-DSCH transmission. The HS-DSCH-related feedback signalling consists of Hybrid-ARQ Acknowledgement (HARQ-ACK) and Channel-Quality Indication (CQI) [3]. Each sub frame of length 2 ms (3×2560 chips) consists of 3 slots, each of length 2560 chips. The HARQ-ACK is carried in the first slot of the HS-DPCCH sub-

frame. The CQI is carried in the second and third slot of a HS-DSCH sub-frame. There is atmost one HS-DPCCH on each radio link. The HS-DPCCH can only exist together with an uplink DPCCH. The timing of the HS-DPCCH relative to the uplink DPCCH is shown in section 7.7.

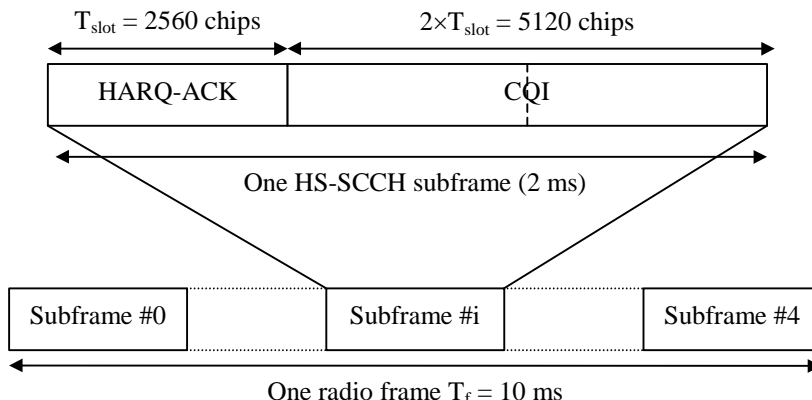


Figure 3: Frame structure for uplink HS-DPCCH

The spreading factor of the HS-DPCCH is 256 i.e. there are 10 bits per uplink HS-DPCCH slot. The slot format for uplink HS-DPCCH is defined in Table 6.

Table 6: HS-DPCCH fields

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ Subframe	Bits/ Slot	Transmitted slots per Subframe
0	15	15	256	30	10	3

5.2.2 Common uplink physical channels

5.2.2.1 Physical Random Access Channel (PRACH)

The Physical Random Access Channel (PRACH) is used to carry the RACH.

5.2.2.1.1 Overall structure of random-access transmission

The random-access transmission is based on a Slotted ALOHA approach with fast acquisition indication. The UE can start the random-access transmission at the beginning of a number of well-defined time intervals, denoted *access slots*. There are 15 access slots per two frames and they are spaced 5120 chips apart, see figure 43. The timing of the access slots and the acquisition indication is described in subclause 7.3. Information on what access slots are available for random-access transmission is given by higher layers.

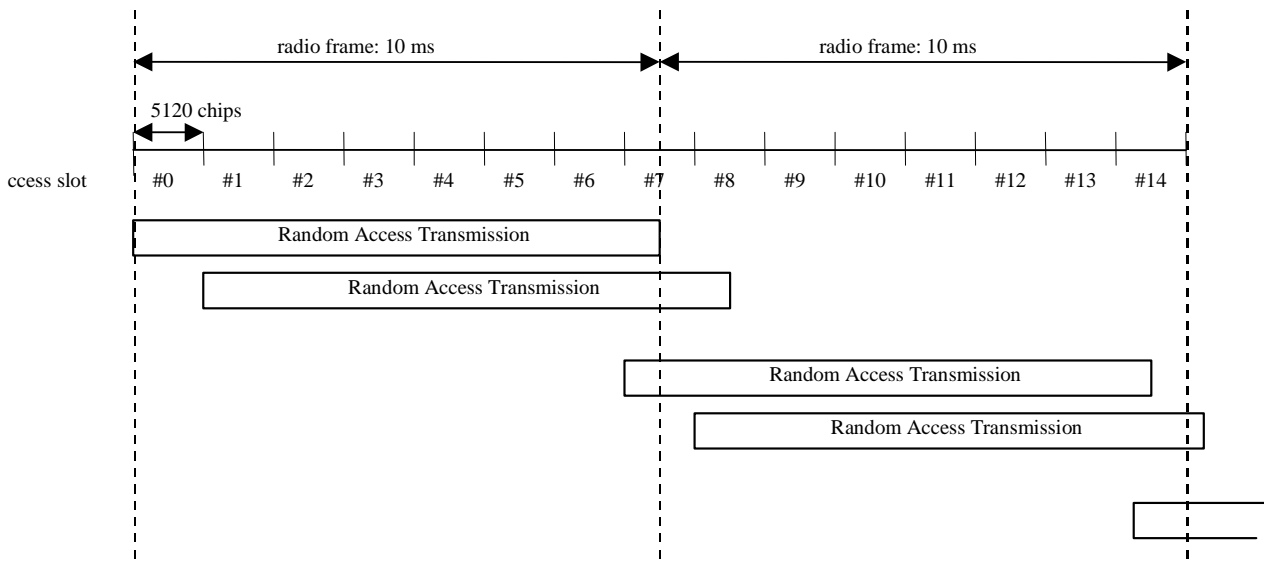


Figure 43: RACH access slot numbers and their spacing

The structure of the random-access transmission is shown in figure 54. The random-access transmission consists of one or several *preambles* of length 4096 chips and a *message* of length 10 ms or 20 ms.

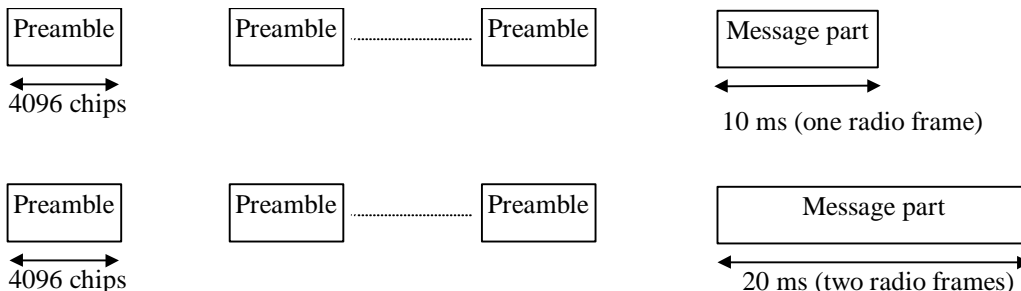


Figure 54: Structure of the random-access transmission

5.2.2.1.2 RACH preamble part

Each preamble is of length 4096 chips and consists of 256 repetitions of a signature of length 16 chips. There are a maximum of 16 available signatures, see [4] for more details.

5.2.2.1.3 RACH message part

Figure 65 shows the structure of the random-access message part radio frame. The 10 ms message part radio frame is split into 15 slots, each of length $T_{slot} = 2560$ chips. Each slot consists of two parts, a data part to which the RACH transport channel is mapped and a control part that carries Layer 1 control information. The data and control parts are transmitted in parallel. A 10 ms message part consists of one message part radio frame, while a 20 ms message part consists of two consecutive 10 ms message part radio frames. The message part length is equal to the Transmission Time Interval of the RACH Transport channel in use. This TTI length is configured by higher layers.

The data part consists of $10 \cdot 2^k$ bits, where $k=0,1,2,3$. This corresponds to a spreading factor of 256, 128, 64, and 32 respectively for the message data part.

The control part consists of 8 known pilot bits to support channel estimation for coherent detection and 2 TFCI bits. This corresponds to a spreading factor of 256 for the message control part. The pilot bit pattern is described in table 98. The total number of TFCI bits in the random-access message is $15 \cdot 2 = 30$. The TFCI of a radio frame indicates the transport format of the RACH transport channel mapped to the simultaneously transmitted message part radio frame. In case of a 20 ms PRACH message part, the TFCI is repeated in the second radio frame.

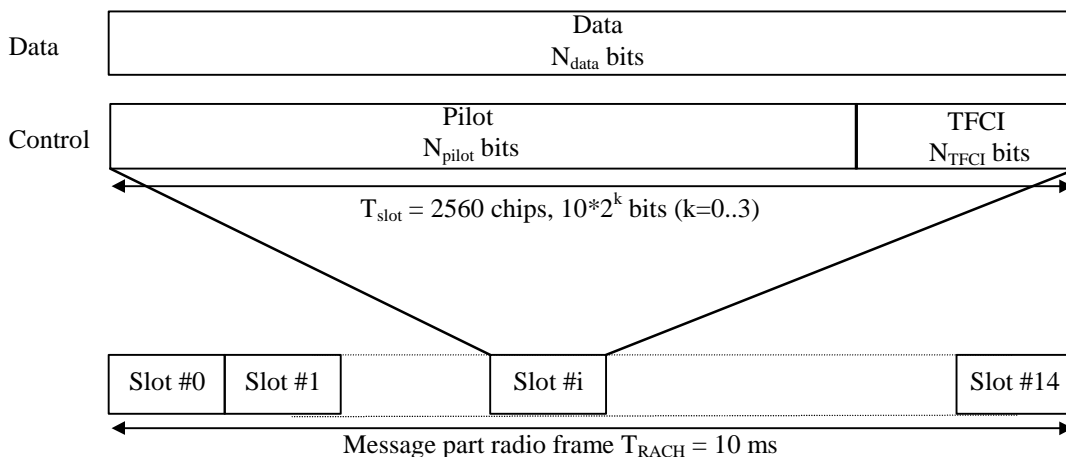


Figure 65: Structure of the random-access message part radio frame

Table 76: Random-access message data fields

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ Frame	Bits/ Slot	N _{data}
0	15	15	256	150	10	10
1	30	30	128	300	20	20
2	60	60	64	600	40	40
3	120	120	32	1200	80	80

Table 87: Random-access message control fields

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ Frame	Bits/ Slot	N _{pilot}	N _{TFCI}
0	15	15	256	150	10	8	2

Table 98: Pilot bit patterns for RACH message part with N_{pilot} = 8

Bit #	N _{pilot} = 8							
	0	1	2	3	4	5	6	7
Slot #0	1	1	1	1	1	1	1	0
1	1	0	1	0	1	1	1	0
2	1	0	1	1	1	0	1	1
3	1	0	1	0	1	0	1	0
4	1	1	1	0	1	0	1	1
5	1	1	1	1	1	1	1	0
6	1	1	1	1	1	0	1	0
7	1	1	1	0	1	0	1	0
8	1	0	1	1	1	1	1	0
9	1	1	1	1	1	1	1	1
10	1	0	1	1	1	0	1	1
11	1	1	1	0	1	1	1	1
12	1	1	1	0	1	0	1	0
13	1	0	1	0	1	1	1	1
14	1	0	1	0	1	1	1	1

5.2.2.2 Physical Common Packet Channel (PCPCH)

The Physical Common Packet Channel (PCPCH) is used to carry the CPCH.

5.2.2.2.1 CPCH transmission

The CPCH transmission is based on DSMA-CD approach with fast acquisition indication. The UE can start transmission at the beginning of a number of well-defined time-intervals, relative to the frame boundary of the received BCH of the current cell. The access slot timing and structure is identical to RACH in subclause 5.2.2.1.1. The structure of the CPCH access transmission is shown in figure 76. The CPCH access transmission consists of one or several Access Preambles [A-P] of length 4096 chips, one Collision Detection Preamble (CD-P) of length 4096 chips, a CPCH Power Control Preamble (PC-P) which is either 0 slots or 8 slots in length, and a message of variable length $N \times 10$ ms.

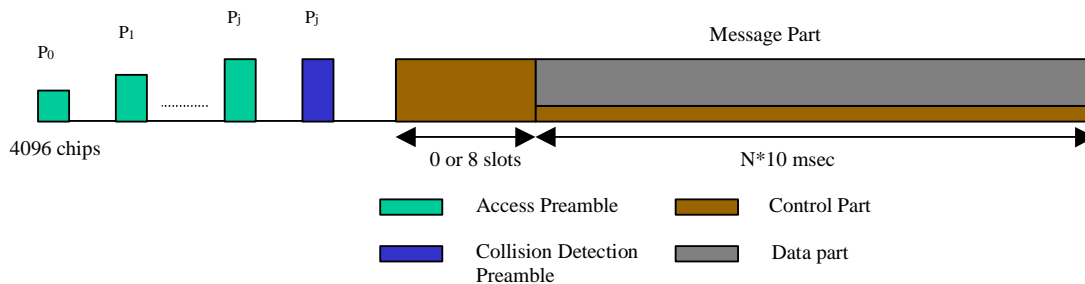


Figure 76: Structure of the CPCH access transmission

5.2.2.2.2 CPCH access preamble part

Similar to 5.2.2.1.2 (RACH preamble part). The RACH preamble signature sequences are used. The number of sequences used could be less than the ones used in the RACH preamble. The scrambling code could either be chosen to be a different code segment of the Gold code used to form the scrambling code of the RACH preambles (see [4] for more details) or could be the same scrambling code in case the signature set is shared.

5.2.2.2.3 CPCH collision detection preamble part

Similar to 5.2.2.1.2 (RACH preamble part). The RACH preamble signature sequences are used. The scrambling code is chosen to be a different code segment of the Gold code used to form the scrambling code for the RACH and CPCH preambles (see [4] for more details).

5.2.2.2.4 CPCH power control preamble part

The power control preamble segment is called the CPCH Power Control Preamble (PC-P) part. The slot format for CPCH PC-P part shall be the same as for the following message part in Table 109 in subclause 5.2.2.2.5. The Power Control Preamble length is a higher layer parameter, $L_{pc-preamble}$ (see [5], section 6.2), which shall take the value 0 or 8 slots. When $L_{pc-preamble} > 0$, the pilot bit patterns from slot $\#(15 - L_{pc-preamble})$ to slot $\#14$ of table 3 and 4 in subclause 5.2.1 shall be used for CPCH PC-P pilot bit patterns. The TFCI field is filled with "1" bits.

5.2.2.2.5 CPCH message part

Figure 1 in subclause 5.2.1 shows the structure of the CPCH message part. Each message consists of up to N_Max_frames 10 ms frames. N_Max_frames is a higher layer parameter. Each 10 ms frame is split into 15 slots, each of length $T_{slot} = 2560$ chips. Each slot consists of two parts, a data part that carries higher layer information and a control part that carries Layer 1 control information. The data and control parts are transmitted in parallel.

The entries of table 1 in subclause 5.2.1 apply to the data part of the CPCH message part. The spreading factor for the control part of the CPCH message part shall be 256. Table 109 defines the slot format of the control part of CPCH message part. The pilot bit patterns of table 3 in subclause 5.2.1 shall be used for pilot bit patterns of the CPCH message part.

Table 109: Slot format of the control part of CPCH message part

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ Frame	Bits/ Slot	N _{pilot}	N _{TPC}	N _{TFCI}	N _{FBI}
0	15	15	256	150	10	6	2	2	0
1	15	15	256	150	10	5	2	2	1

Figure 87 shows the frame structure of the uplink common packet physical channel. Each frame of length 10 ms is split into 15 slots, each of length $T_{slot} = 2560$ chips, corresponding to one power-control period.

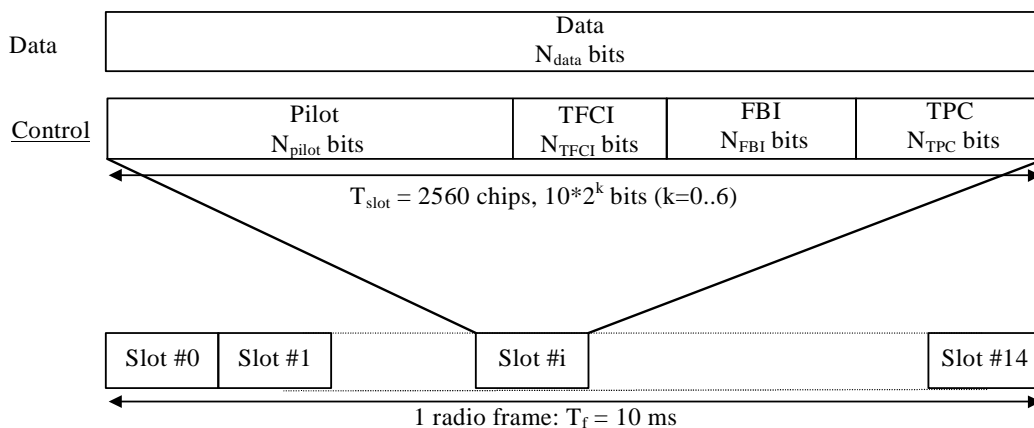


Figure 87: Frame structure for uplink Data and Control Parts Associated with PCPCH

The data part consists of $10 * 2^k$ bits, where $k = 0, 1, 2, 3, 4, 5, 6$, corresponding to spreading factors of 256, 128, 64, 32, 16, 8, 4 respectively.

5.3 Downlink physical channels

5.3.1 Downlink transmit diversity

Table 110 summarizes the possible application of open and closed loop transmit diversity modes on different downlink physical channel types. Simultaneous use of STTD and closed loop modes on the same physical channel is not allowed. In addition, if Tx diversity is applied on any of the downlink physical channels it shall also be applied on P-CCPCH and SCH. Regarding CPICH transmission in case of transmit diversity, see subclause 5.3.3.1.

With respect to the usage of Tx diversity on different radio links within an active set, the following rules apply:

- Different Tx diversity modes (STTD and closed loop) shall not be used on the radio links within one active set.
- No Tx diversity on one or more radio links shall not prevent UTRAN to use Tx diversity on other radio links within the same active set. However, the UE shall operate this Tx diversity mode on all radio links.

Furthermore, the transmit diversity mode used for a PDSCH frame shall be the same as the transmit diversity mode used for the DPCH associated with this PDSCH frame. The transmit diversity mode on the associated DPCH may not change during a PDSCH frame and within the slot prior to the PDSCH frame. This includes any change between no Tx diversity, open loop, closed loop mode 1 or closed loop mode 2.

Table 110: Application of Tx diversity modes on downlink physical channel types
 "X" – can be applied, "-" – not applied

Physical channel type	Open loop mode		Closed loop Mode
	TSTD	STTD	
P-CCPCH	-	X	-
SCH	X	-	-
S-CCPCH	-	X	-
DPCH	-	X	X
PICH	-	X	-
PDSCH	-	X	X
AICH	-	X	-
CSICH	-	X	-
AP-AICH	-	X	-
CD/CA-ICH	-	X	-
DL-DPCCH for CPCH	-	X	X

5.3.1.1 Open loop transmit diversity

5.3.1.1.1 Space time block coding based transmit antenna diversity (STTD)

The open loop downlink transmit diversity employs a space time block coding based transmit diversity (STTD).

The STTD encoding is optional in UTRAN. STTD support is mandatory at the UE.

If higher layers signal that neither P-CPICH nor S-CPICH can be used as phase reference for the downlink DPCH for a radio link in a cell, the UE shall assume that STTD is not used for the downlink DPCH (and the associated PDSCH if applicable) in that cell.

STTD encoding is applied on blocks of 4 consecutive channel bits. A block diagram of a generic STTD encoder for channel bits b_0, b_1, b_2, b_3 is shown in the figure 98 below. Channel coding, rate matching and interleaving is done as in the non-diversity mode. The bit b_i is real valued $\{0\}$ for DTX bits and $\{1, -1\}$ for all other channel bits.

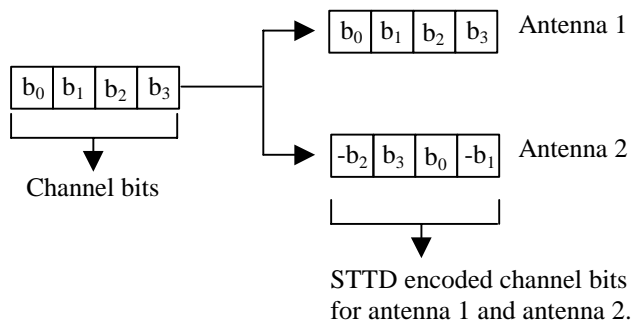


Figure 98: Generic block diagram of the STTD encoder

5.3.1.1.2 Time Switched Transmit Diversity for SCH (TSTD)

Transmit diversity, in the form of Time Switched Transmit Diversity (TSTD), can be applied to the SCH. TSTD for the SCH is optional in UTRAN, while TSTD support is mandatory in the UE. TSTD for the SCH is described in subclause 5.3.3.5.1.

5.3.1.2 Closed loop transmit diversity

Closed loop transmit diversity is described in [5]. Both closed loop transmit diversity modes shall be supported at the UE and may be supported in the UTRAN.

5.3.2 Dedicated downlink physical channels

There is only one type of downlink dedicated physical channel, the Downlink Dedicated Physical Channel (downlink DPCH).

Within one downlink DPCH, dedicated data generated at Layer 2 and above, i.e. the dedicated transport channel (DCH), is transmitted in time-multiplex with control information generated at Layer 1 (known pilot bits, TPC commands, and an optional TFCI). The downlink DPCH can thus be seen as a time multiplex of a downlink DPDCH and a downlink DPCCH, compare subclause 5.2.1.

Figure 109 shows the frame structure of the downlink DPCH. Each frame of length 10 ms is split into 15 slots, each of length $T_{slot} = 2560$ chips, corresponding to one power-control period.

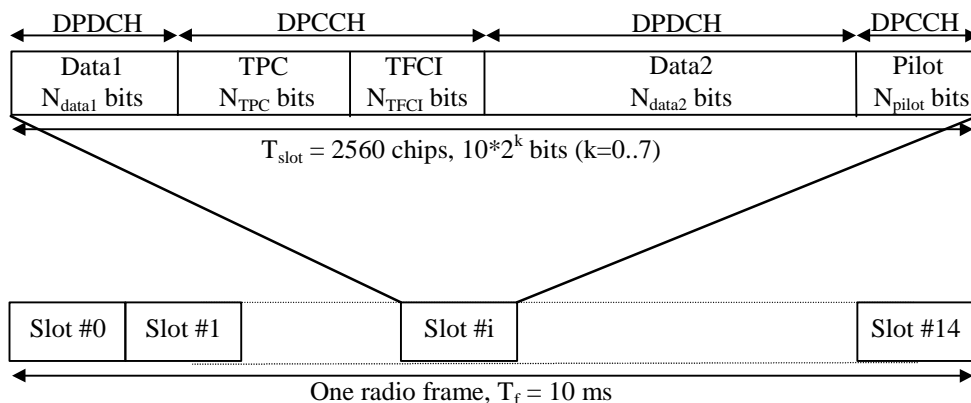


Figure 109: Frame structure for downlink DPCH

The parameter k in figure 109 determines the total number of bits per downlink DPCH slot. It is related to the spreading factor SF of the physical channel as $SF = 512/2^k$. The spreading factor may thus range from 512 down to 4.

The exact number of bits of the different downlink DPCH fields (N_{pilot} , N_{TPC} , N_{TFCI} , N_{data1} and N_{data2}) is given in table 124. What slot format to use is configured by higher layers and can also be reconfigured by higher layers.

There are basically two types of downlink Dedicated Physical Channels; those that include TFCI (e.g. for several simultaneous services) and those that do not include TFCI (e.g. for fixed-rate services). These types are reflected by the duplicated rows of table 124. It is the UTRAN that determines if a TFCI should be transmitted and it is mandatory for all UEs to support the use of TFCI in the downlink. The mapping of TFCI bits onto slots is described in [3].

In compressed frames, a different slot format is used compared to normal mode. There are two possible compressed slot formats that are labelled A and B. Slot format B shall be used in frames compressed by spreading factor reduction and slot format A shall be used in frames compressed by puncturing or higher layer scheduling. The channel bit and symbol rates given in table 124 are the rates immediately before spreading.

Table 121: DPDCH and DPCCH fields

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/Slot	DPDCH Bits/Slot		DPCCH Bits/Slot			Transmitted slots per radio frame N _{Tr}
					N _{Data1}	N _{Data2}	N _{TPC}	N _{TFCI}	N _{Pilot}	
0	15	7.5	512	10	0	4	2	0	4	15
0A	15	7.5	512	10	0	4	2	0	4	8-14
0B	30	15	256	20	0	8	4	0	8	8-14
1	15	7.5	512	10	0	2	2	2	4	15
1B	30	15	256	20	0	4	4	4	8	8-14
2	30	15	256	20	2	14	2	0	2	15
2A	30	15	256	20	2	14	2	0	2	8-14
2B	60	30	128	40	4	28	4	0	4	8-14
3	30	15	256	20	2	12	2	2	2	15
3A	30	15	256	20	2	10	2	4	2	8-14
3B	60	30	128	40	4	24	4	4	4	8-14
4	30	15	256	20	2	12	2	0	4	15
4A	30	15	256	20	2	12	2	0	4	8-14
4B	60	30	128	40	4	24	4	0	8	8-14
5	30	15	256	20	2	10	2	2	4	15
5A	30	15	256	20	2	8	2	4	4	8-14
5B	60	30	128	40	4	20	4	4	8	8-14
6	30	15	256	20	2	8	2	0	8	15
6A	30	15	256	20	2	8	2	0	8	8-14
6B	60	30	128	40	4	16	4	0	16	8-14
7	30	15	256	20	2	6	2	2	8	15
7A	30	15	256	20	2	4	2	4	8	8-14
7B	60	30	128	40	4	12	4	4	16	8-14
8	60	30	128	40	6	28	2	0	4	15
8A	60	30	128	40	6	28	2	0	4	8-14
8B	120	60	64	80	12	56	4	0	8	8-14
9	60	30	128	40	6	26	2	2	4	15
9A	60	30	128	40	6	24	2	4	4	8-14
9B	120	60	64	80	12	52	4	4	8	8-14
10	60	30	128	40	6	24	2	0	8	15
10A	60	30	128	40	6	24	2	0	8	8-14
10B	120	60	64	80	12	48	4	0	16	8-14
11	60	30	128	40	6	22	2	2	8	15
11A	60	30	128	40	6	20	2	4	8	8-14
11B	120	60	64	80	12	44	4	4	16	8-14
12	120	60	64	80	12	48	4	8*	8	15
12A	120	60	64	80	12	40	4	16*	8	8-14
12B	240	120	32	160	24	96	8	16*	16	8-14
13	240	120	32	160	28	112	4	8*	8	15
13A	240	120	32	160	28	104	4	16*	8	8-14
13B	480	240	16	320	56	224	8	16*	16	8-14
14	480	240	16	320	56	232	8	8*	16	15
14A	480	240	16	320	56	224	8	16*	16	8-14
14B	960	480	8	640	112	464	16	16*	32	8-14
15	960	480	8	640	120	488	8	8*	16	15
15A	960	480	8	640	120	480	8	16*	16	8-14
15B	1920	960	4	1280	240	976	16	16*	32	8-14
16	1920	960	4	1280	248	1000	8	8*	16	15
16A	1920	960	4	1280	248	992	8	16*	16	8-14

* If TFCI bits are not used, then DTX shall be used in TFCI field.

NOTE 1: Compressed mode is only supported through spreading factor reduction for SF=512 with TFCI.

NOTE 2: Compressed mode by spreading factor reduction is not supported for SF=4.

NOTE 3: If the Node B receives an invalid combination of data frames for downlink transmission, the procedure specified in [15], sub-clause 5.1.2, may require the use of DTX in both the DPDCH and the TFCI field of the DPCCH.

The pilot bit patterns are described in table 132. The shadowed column part of pilot bit pattern is defined as FSW and FSWs can be used to confirm frame synchronization. (The value of the pilot bit pattern other than FSWs shall be "11".) In table 132, the transmission order is from left to right.

In downlink compressed mode through spreading factor reduction, the number of bits in the TPC and Pilot fields are doubled. Symbol repetition is used to fill up the fields. Denote the bits in one of these fields in normal mode by $x_1, x_2, x_3, \dots, x_X$. In compressed mode the following bit sequence is sent in corresponding field: $x_1, x_2, x_1, x_2, x_3, x_4, x_3, x_4, \dots, x_X$.

Table 132: Pilot bit patterns for downlink DPCCH with $N_{pilot} = 2, 4, 8$ and 16

Symbol #	$N_{pilot} = 2$	$N_{pilot} = 4$ (*1)		$N_{pilot} = 8$ (*2)				$N_{pilot} = 16$ (*3)							
	0	0	1	0	1	2	3	0	1	2	3	4	5	6	7
Slot #0	11	11	11	11	11	11	10	11	11	11	10	11	11	11	10
1	00	11	00	11	00	11	10	11	00	11	10	11	11	11	00
2	01	11	01	11	01	11	01	11	01	11	01	11	10	11	00
3	00	11	00	11	00	11	00	11	00	11	00	11	01	11	10
4	10	11	10	11	10	11	01	11	10	11	01	11	11	11	11
5	11	11	11	11	11	11	10	11	11	11	10	11	01	11	01
6	11	11	11	11	11	11	00	11	11	11	00	11	10	11	11
7	10	11	10	11	10	11	00	11	10	11	00	11	10	11	00
8	01	11	01	11	01	11	10	11	01	11	10	11	00	11	11
9	11	11	11	11	11	11	11	11	11	11	11	11	00	11	11
10	01	11	01	11	01	11	01	11	01	11	01	11	11	11	10
11	10	11	10	11	10	11	11	11	10	11	11	11	00	11	10
12	10	11	10	11	10	11	00	11	10	11	00	11	01	11	01
13	00	11	00	11	00	11	11	11	00	11	11	11	00	11	00
14	00	11	00	11	00	11	11	11	00	11	11	11	10	11	01

- NOTE *1: This pattern is used except slot formats 2B and 3B.
- NOTE *2: This pattern is used except slot formats 0B, 1B, 4B, 5B, 8B, and 9B.
- NOTE *3: This pattern is used except slot formats 6B, 7B, 10B, 11B, 12B, and 13B.
- NOTE: For slot format nB where $n = 0, \dots, 15$, the pilot bit pattern corresponding to $N_{pilot}/2$ is to be used and symbol repetition shall be applied.

The relationship between the TPC symbol and the transmitter power control command is presented in table 143.

Table 143: TPC Bit Pattern

TPC Bit Pattern			Transmitter power control command
$N_{TPC} = 2$	$N_{TPC} = 4$	$N_{TPC} = 8$	
11	1111	11111111	1
00	0000	00000000	0

Multicode transmission may be employed in the downlink, i.e. the CCTrCH (see [3]) is mapped onto several parallel downlink DPCHs using the same spreading factor. In this case, the Layer 1 control information is transmitted only on the first downlink DPCH. DTX bits are transmitted during the corresponding time period for the additional downlink DPCHs, see figure 110.

In case there are several CCTrCHs mapped to different DPCHs transmitted to the same UE different spreading factors can be used on DPCHs to which different CCTrCHs are mapped. Also in this case, Layer 1 control information is only transmitted on the first DPCH while DTX bits are transmitted during the corresponding time period for the additional DPCHs.

Note : support of multiple CCTrCHs of dedicated type is not part of the current release.

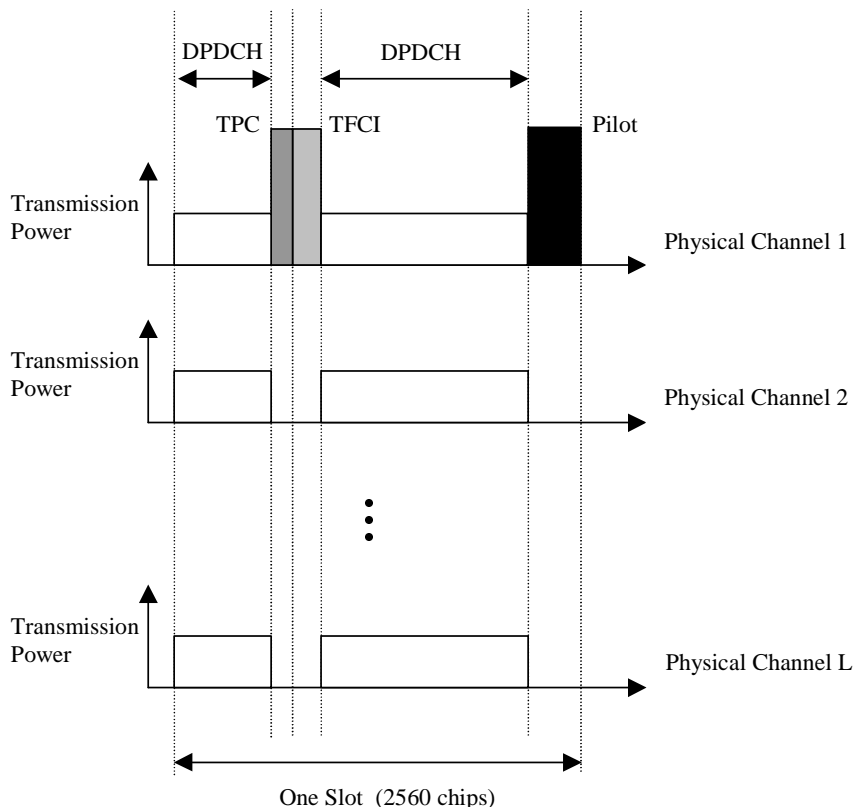


Figure 110: Downlink slot format in case of multi-code transmission

5.3.2.1 STTD for DPCH

The pilot bit pattern for the DPCH channel transmitted on antenna 2 is given in table 154.

- For $N_{\text{pilot}} = 8, 16$ the shadowed part indicates pilot bits that are obtained by STTD encoding the corresponding (shadowed) bits in Table 132. The non-shadowed pilot bit pattern is orthogonal to the corresponding (non-shadowed) pilot bit pattern in table 132.
- For $N_{\text{pilot}} = 4$, the diversity antenna pilot bit pattern is obtained by STTD encoding both the shadowed and non-shadowed pilot bits in table 132.
- For $N_{\text{pilot}} = 2$, the diversity antenna pilot pattern is obtained by STTD encoding the two pilot bits in table 132 with the last two bits (data or DTX) of the second data field (data2) of the slot. Thus for $N_{\text{pilot}} = 2$ case, the last two bits of the second data field (data 2) after STTD encoding, follow the diversity antenna pilot bits in Table 154.

STTD encoding for the DPDCH, TPC, and TFCI fields is done as described in subclause 5.3.1.1.1. For the SF=512 DPCH, the first two bits in each slot, i.e. TPC bits, are not STTD encoded and the same bits are transmitted with equal power from the two antennas. The remaining four bits are STTD encoded.

For compressed mode through spreading factor reduction and for $N_{\text{pilot}} > 4$, symbol repetition shall be applied to the pilot bit patterns of table 154, in the same manner as described in 5.3.2. For slot formats 2B and 3B, i.e. compressed mode through spreading factor reduction and $N_{\text{pilot}} = 4$, the pilot bits transmitted on antenna 2 are STTD encoded, and thus the pilot bit pattern is as shown in the most right set of table 154.

Table 154: Pilot bit patterns of downlink DPCCH for antenna 2 using STTD

Symbol #	$N_{pilot} = 2$ (*1)		$N_{pilot} = 4$ (*2)		$N_{pilot} = 8$ (*3)			$N_{pilot} = 16$ (*4)							$N_{pilot} = 4$ (*5)		
	0	0	1	0	1	2	3	0	1	2	3	4	5	6	7	0	1
Slot #0	01	01	10	11	00	00	10	11	00	00	10	11	00	00	10	01	10
1	10	10	10	11	00	00	01	11	00	00	01	11	10	00	10	10	01
2	11	11	10	11	11	00	00	11	11	00	00	11	10	00	11	11	00
3	10	10	10	11	10	00	01	11	10	00	01	11	00	00	00	10	01
4	00	00	10	11	11	00	11	11	11	00	11	11	01	00	10	00	11
5	01	01	10	11	00	00	10	11	00	00	10	11	11	00	00	01	10
6	01	01	10	11	10	00	10	11	10	00	10	11	01	00	11	01	10
7	00	00	10	11	10	00	11	11	10	00	11	11	10	00	11	00	11
8	11	11	10	11	00	00	00	11	00	00	00	11	01	00	01	11	00
9	01	01	10	11	01	00	10	11	01	00	10	11	01	00	01	01	10
10	11	11	10	11	11	00	00	11	11	00	00	11	00	00	10	11	00
11	00	00	10	11	01	00	11	11	01	00	11	11	00	00	01	00	11
12	00	00	10	11	10	00	11	11	10	00	11	11	11	00	00	00	11
13	10	10	10	11	01	00	01	11	01	00	01	11	10	00	01	10	01
14	10	10	10	11	01	00	01	11	01	00	01	11	11	00	11	10	01

- NOTE *1: The pilot bits precede the last two bits of the data2 field.
- NOTE *2: This pattern is used except slot formats 2B and 3B.
- NOTE *3: This pattern is used except slot formats 0B, 1B, 4B, 5B, 8B, and 9B.
- NOTE *4: This pattern is used except slot formats 6B, 7B, 10B, 11B, 12B, and 13B.
- NOTE *5: This pattern is used for slot formats 2B and 3B.
- NOTE: For slot format nB where $n = 0, 1, 4, 5, 6, \dots, 15$, the pilot bit pattern corresponding to $N_{pilot}/2$ is to be used and symbol repetition shall be applied.

5.3.2.2 Dedicated channel pilots with closed loop mode transmit diversity

In closed loop mode 1 different pilot patterns (orthogonal when $N_{pilot} > 2$) are used between the transmit antennas. Pilot patterns defined in the table 132 will be used on antenna 1 and pilot patterns defined in the table 165 on antenna 2. This is illustrated in the figure 124 a which indicates the difference in the pilot patterns with different shading.

Table 165: Pilot bit patterns of downlink DPCCH for antenna 2 using closed loop mode 1

Symbol #	$N_{pilot} = 2$ (*1)		$N_{pilot} = 4$ (*2)				$N_{pilot} = 8$ (*3)							$N_{pilot} = 16$ (*4)			
	0	0	1	0	1	2	3	0	1	2	3	4	5	6	7	0	1
Slot #0	01	01	10	11	00	00	10	11	00	00	10	11	00	00	10	01	10
1	10	10	10	11	00	00	01	11	00	00	01	11	10	00	10	10	01
2	11	11	10	11	11	00	00	11	11	00	00	11	10	00	11	11	00
3	10	10	10	11	10	00	01	11	10	00	01	11	00	00	00	10	01
4	00	00	10	11	11	00	11	11	11	00	11	11	01	00	10	00	11
5	01	01	10	11	00	00	10	11	00	00	10	11	11	00	00	01	10
6	01	01	10	11	10	00	10	11	10	00	10	11	01	00	11	01	10
7	00	00	10	11	10	00	11	11	10	00	11	11	10	00	11	00	11
8	11	11	10	11	00	00	00	11	00	00	00	11	01	00	01	11	00
9	01	01	10	11	01	00	10	11	01	00	10	11	01	00	01	01	10
10	11	11	10	11	11	00	00	11	11	00	00	11	00	00	10	11	00
11	00	00	10	11	01	00	11	11	01	00	11	11	00	00	01	00	11
12	00	00	10	11	10	00	11	11	10	00	11	11	11	00	00	00	11
13	10	10	10	11	01	00	01	11	01	00	01	11	10	00	01	10	01
14	10	10	10	11	01	00	01	11	01	00	01	11	11	00	11	10	01

- NOTE *1: This pattern is used except slot formats 2B and 3B.
- NOTE *2: This pattern is used except slot formats 0B, 1B, 4B, 5B, 8B, and 9B.
- NOTE *3: This pattern is used except slot formats 6B, 7B, 10B, 11B, 12B, and 13B.
- NOTE *4: This pattern is used for slot formats 2B and 3B.
- NOTE: For slot format nB where $n = 0, 1, 4, 5, 6, \dots, 15$, the pilot bit pattern corresponding to $N_{pilot}/2$ is to be used and symbol repetition shall be applied.

In closed loop mode 2 same pilot pattern is used on both of the antennas (see figure 124 b). The pattern to be used is according to the table 132.

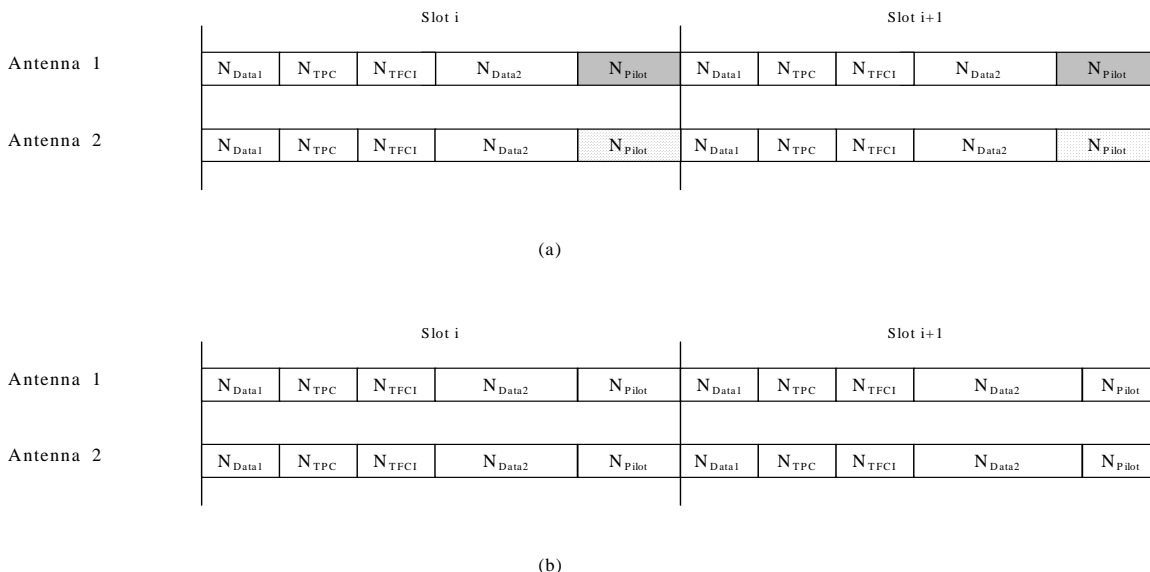


Figure 124: Slot structures for downlink dedicated physical channel diversity transmission.
Structure (a) is used in closed loop mode 1.
Structure (b) is used in closed loop mode 2.
Different shading of the pilots indicate orthogonality of the patterns

5.3.2.3 DL-DPCCH for CPCH

The downlink DPCCH for CPCH is a special case of downlink dedicated physical channel of the slot format #0 in table 124. The spreading factor for the DL-DPCCH is 512. Figure 132 shows the frame structure of DL-DPCCH for CPCH.

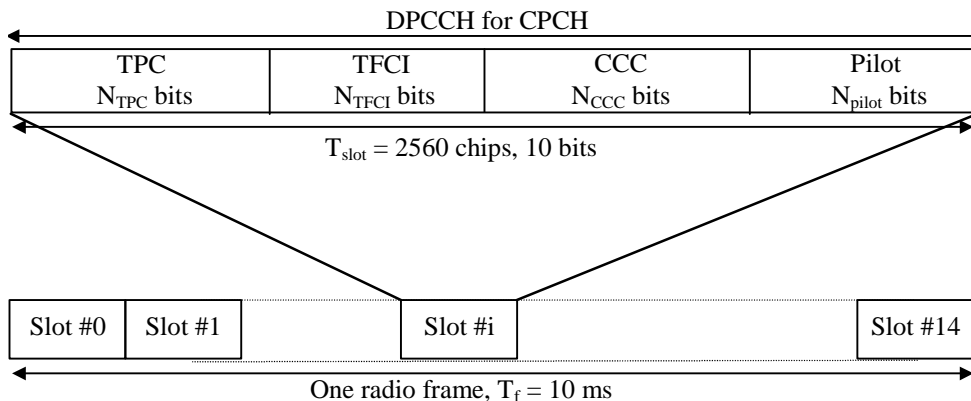


Figure 132: Frame structure for downlink DPCCH for CPCH

DL-DPCCH for CPCH consists of known pilot bits, TFCI, TPC commands and CPCH Control Commands (CCC). CPCH control commands are used to support CPCH signalling. There are two types of CPCH control commands: Layer 1 control command such as Start of Message Indicator, and higher layer control command such as Emergency Stop command. The exact number of bits of DL DPCCH fields (N_{pilot} , N_{TFC1} , N_{CCC} and N_{TPC}) is determined in Table 176. The pilot bit pattern for $N_{pilot}=4$ of table 132 is used for DPCCH for CPCH.

Table 176: DPCCH fields for CPCH message transmission

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/Slot	DPCCH Bits/Slot				Transmitted slots per radio frame N_{Tr}
					N_{TPC}	N_{TFC1}	N_{CCC}	N_{Pilot}	
0	15	7.5	512	10	2	0	4	4	15

The DL DPCCCH power control preamble for CPCH shall take the same slot format as afterwards, as given in Table 176. The length of the power control preamble is a higher-layer parameter, $L_{pc-preamble}$ (see [5], section 6.2), signalled by the network. When $L_{pc-preamble} > 0$, the pilot patterns from slot #(15 - N_{pcp}) to slot #14 of table 132 shall be used for the power control preamble pilot patterns. The TFCI field is filled with "1" bits.

CCC field in figure 132 is used for the transmission of CPCH control command. On CPCH control command transmission request from higher layer, a certain pattern is mapped onto CCC field, otherwise nothing is transmitted in CCC field. There is one to one mapping between the CPCH control command and the pattern. In case of Emergency Stop of CPCH transmission, [1111] pattern is mapped onto CCC field. The Emergency Stop command shall not be transmitted during the first $N_{Start_Message}$ frames of DL DPCCCH after Power Control preamble.

Start of Message Indicator shall be transmitted during the first $N_{Start_Message}$ frames of DL DPCCCH after Power Control preamble. [1010] pattern is mapped onto CCC field for Start of Message Indicator. The value of $N_{Start_Message}$ shall be provided by higher layers.

5.3.3 Common downlink physical channels

5.3.3.1 Common Pilot Channel (CPICH)

The CPICH is a fixed rate (30 kbps, SF=256) downlink physical channel that carries a pre-defined bit/symbol sequence. Figure 143 shows the frame structure of the CPICH.

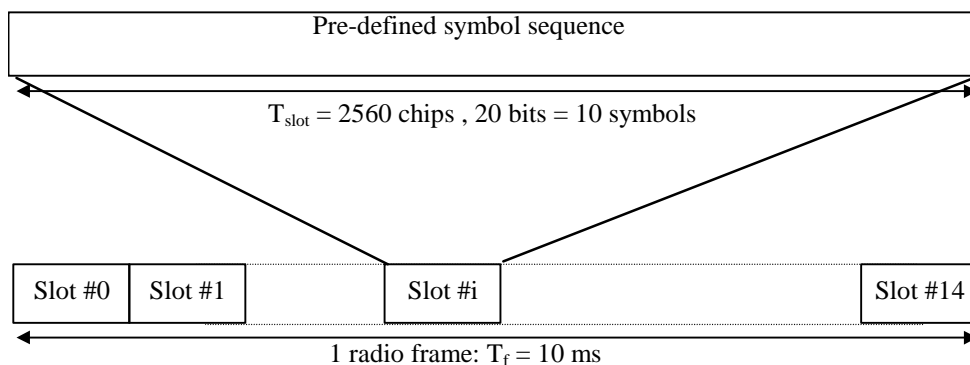


Figure 143: Frame structure for Common Pilot Channel

In case transmit diversity (open or closed loop) is used on any downlink channel in the cell, the CPICH shall be transmitted from both antennas using the same channelization and scrambling code. In this case, the pre-defined symbol sequence of the CPICH is different for Antenna 1 and Antenna 2, see figure 154. In case of no transmit diversity, the symbol sequence of Antenna 1 in figure 154 is used.

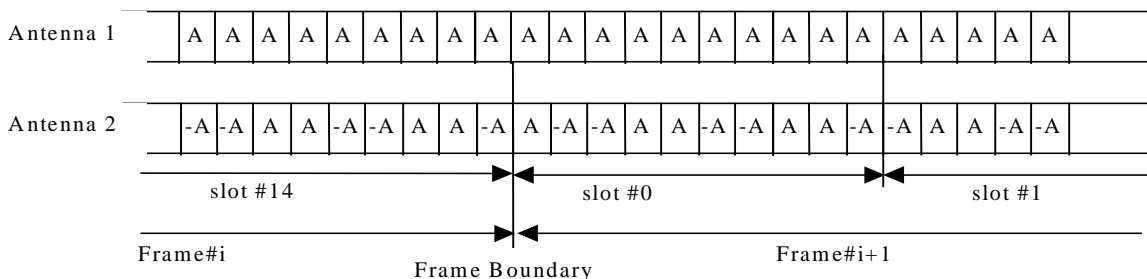


Figure 154: Modulation pattern for Common Pilot Channel (with A = 1+j)

There are two types of Common pilot channels, the Primary and Secondary CPICH. They differ in their use and the limitations placed on their physical features.

5.3.3.1.1 Primary Common Pilot Channel (P-CPICH)

The Primary Common Pilot Channel (P-CPICH) has the following characteristics:

- The same channelization code is always used for the P-CPICH, see [4];
- The P-CPICH is scrambled by the primary scrambling code, see [4];
- There is one and only one P-CPICH per cell;
- The P-CPICH is broadcast over the entire cell.

The Primary CPICH is a phase reference for the following downlink channels: SCH, Primary CCPCH, AICH, PICH AP-AICH, CD/CA-ICH, CSICH, DL-DPCCH for CPCH and the S-CCPCH. By default, the Primary CPICH is also a phase reference for downlink DPCH and any associated PDSCH. The UE is informed by higher layer signalling if the P-CPICH is not a phase reference for a downlink DPCH and any associated PDSCH.

The Primary CPICH is always a phase reference for a downlink physical channel using closed loop TX diversity.

5.3.3.1.2 Secondary Common Pilot Channel (S-CPICH)

A Secondary Common Pilot Channel (S-CPICH) has the following characteristics:

- An arbitrary channelization code of SF=256 is used for the S-CPICH, see [4];
- A S-CPICH is scrambled by either the primary or a secondary scrambling code, see [4];
- There may be zero, one, or several S-CPICH per cell;
- A S-CPICH may be transmitted over the entire cell or only over a part of the cell;

A Secondary CPICH may be a phase reference for a downlink DPCH. If this is the case, the UE is informed about this by higher-layer signalling.

The Secondary CPICH can be a phase reference for a downlink physical channel using open loop TX diversity, instead of the Primary CPICH being a phase reference.

Note that it is possible that neither the P-CPICH nor any S-CPICH is a phase reference for a downlink DPCH.

5.3.3.2 Downlink phase reference

Table 187 summarizes the possible phase references usable on different downlink physical channel types.

Table 187: Application of phase references on downlink physical channel types
"X" – can be applied, "–" – not applied

Physical channel type	Primary-CPICH	Secondary-CPICH	Dedicated pilot
P-CCPCH	X	–	–
SCH	X	–	–
S-CCPCH	X	–	–
DPCH	X	X	X
PICH	X	–	–
PDSCH*	X	X	X
AICH	X	–	–
CSICH	X	–	–
DL-DPCCH for CPCH	X	–	–

Note *: the same phase reference as with the associated DPCH shall be used.

Furthermore, during a PDSCH frame, and within the slot prior to that PDSCH frame, the phase reference on the associated DPCH shall not change.

5.3.3.3 Primary Common Control Physical Channel (P-CCPCH)

The Primary CCPCH is a fixed rate (30 kbps, SF=256) downlink physical channels used to carry the BCH transport channel.

Figure 165 shows the frame structure of the Primary CCPCH. The frame structure differs from the downlink DPCH in that no TPC commands, no TFCI and no pilot bits are transmitted. The Primary CCPCH is not transmitted during the first 256 chips of each slot. Instead, Primary SCH and Secondary SCH are transmitted during this period (see subclause 5.3.3.5).

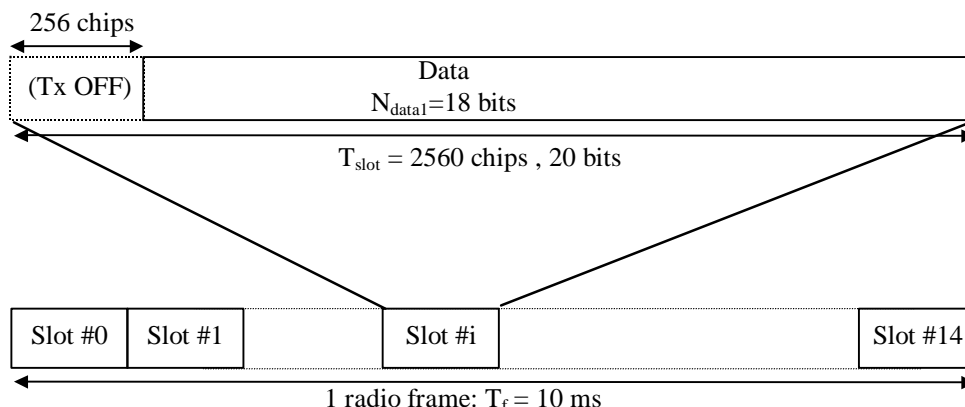


Figure 165: Frame structure for Primary Common Control Physical Channel

5.3.3.3.1 Primary CCPCH structure with STTD encoding

In case the diversity antenna is present in UTRAN and the P-CCPCH is to be transmitted using open loop transmit diversity, the data bits of the P-CCPCH are STTD encoded as given in subclause 5.3.1.1.1. The last two data bits in even numbered slots are STTD encoded together with the first two data bits in the following slot, except for slot #14 where the two last data bits are not STTD encoded and instead transmitted with equal power from both the antennas, see figure 176. Higher layers signal whether STTD encoding is used for the P-CCPCH or not. In addition the presence/absence of STTD encoding on P-CCPCH is indicated by modulating the SCH, see 5.3.3.4. During power on and hand over between cells the UE can determine the presence of STTD encoding on the P-CCPCH, by either receiving the higher layer message, by demodulating the SCH channel, or by a combination of the above two schemes.

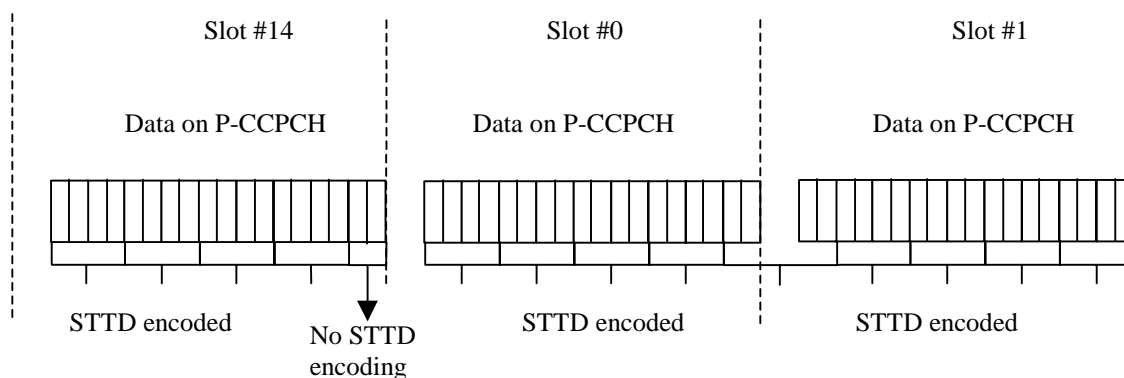


Figure 176: STTD encoding for the data bits of the P-CCPCH

5.3.3.4 Secondary Common Control Physical Channel (S-CCPCH)

The Secondary CCPCH is used to carry the FACH and PCH. There are two types of Secondary CCPCH: those that include TFCI and those that do not include TFCI. It is the UTRAN that determines if a TFCI should be transmitted, hence making it mandatory for all UEs to support the use of TFCI. The set of possible rates for the Secondary CCPCH is the same as for the downlink DPCH, see subclause 5.3.2. The frame structure of the Secondary CCPCH is shown in figure 187.

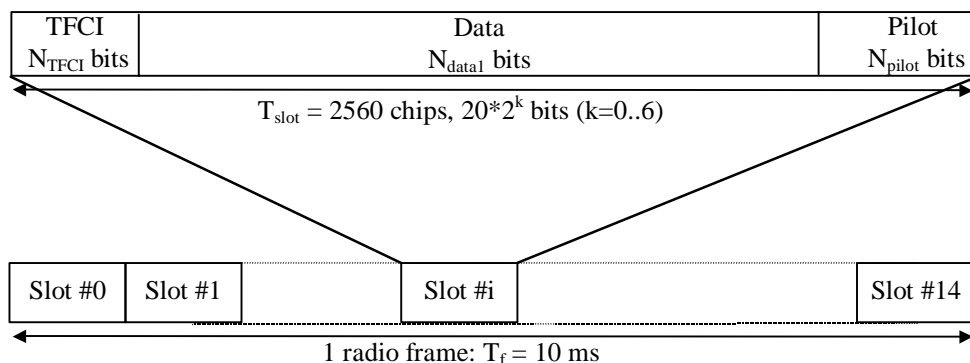


Figure 187: Frame structure for Secondary Common Control Physical Channel

The parameter k in figure 187 determines the total number of bits per downlink Secondary CCPCH slot. It is related to the spreading factor SF of the physical channel as $SF = 256/2^k$. The spreading factor range is from 256 down to 4.

The values for the number of bits per field are given in Table 198. The channel bit and symbol rates given in Table 198 are the rates immediately before spreading. The slot formats with pilot bits are not supported in this release. The pilot patterns are given in Table 2019.

The FACH and PCH can be mapped to the same or to separate Secondary CCPCHs. If FACH and PCH are mapped to the same Secondary CCPCH, they can be mapped to the same frame. The main difference between a CCPCH and a downlink dedicated physical channel is that a CCPCH is not inner-loop power controlled. The main difference between the Primary and Secondary CCPCH is that the transport channel mapped to the Primary CCPCH (BCH) can only have a fixed predefined transport format combination, while the Secondary CCPCH support multiple transport format combinations using TFCI.

Table 198: Secondary CCPCH fields

Slot Format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ Frame	Bits/ Slot	N _{data1}	N _{pilot}	N _{TFCI}
0	30	15	256	300	20	20	0	0
1	30	15	256	300	20	12	8	0
2	30	15	256	300	20	18	0	2
3	30	15	256	300	20	10	8	2
4	60	30	128	600	40	40	0	0
5	60	30	128	600	40	32	8	0
6	60	30	128	600	40	38	0	2
7	60	30	128	600	40	30	8	2
8	120	60	64	1200	80	72	0	8*
9	120	60	64	1200	80	64	8	8*
10	240	120	32	2400	160	152	0	8*
11	240	120	32	2400	160	144	8	8*
12	480	240	16	4800	320	312	0	8*
13	480	240	16	4800	320	296	16	8*
14	960	480	8	9600	640	632	0	8*
15	960	480	8	9600	640	616	16	8*
16	1920	960	4	19200	1280	1272	0	8*
17	1920	960	4	19200	1280	1256	16	8*

* If TFCI bits are not used, then DTX shall be used in TFCI field.

The pilot symbol pattern described in Table 2019 is not supported in this release. The shadowed part can be used as frame synchronization words. (The symbol pattern of pilot symbols other than the frame synchronization word shall be "11"). In Table 2019, the transmission order is from left to right. (Each two-bit pair represents an I/Q pair of QPSK modulation.)

Table 2019: Pilot Symbol Pattern

Symbol #	N _{pilot} = 8				N _{pilot} = 16							
	0	1	2	3	0	1	2	3	4	5	6	7
Slot #0	11	11	11	10	11	11	11	10	11	11	11	10
1	11	00	11	10	11	00	11	10	11	11	11	00
2	11	01	11	01	11	01	11	01	11	10	11	00
3	11	00	11	00	11	00	11	00	11	01	11	10
4	11	10	11	01	11	10	11	01	11	11	11	11
5	11	11	11	10	11	11	11	10	11	01	11	01
6	11	11	11	00	11	11	11	00	11	10	11	11
7	11	10	11	00	11	10	11	00	11	10	11	00
8	11	01	11	10	11	01	11	10	11	00	11	11
9	11	11	11	11	11	11	11	11	11	00	11	11
10	11	01	11	01	11	01	11	01	11	11	11	10
11	11	10	11	11	11	10	11	11	11	00	11	10
12	11	10	11	00	11	10	11	00	11	01	11	01
13	11	00	11	11	11	00	11	11	11	00	11	00
14	11	00	11	11	11	00	11	11	11	10	11	01

For slot formats using TFCI, the TFCI value in each radio frame corresponds to a certain transport format combination of the FACHs and/or PCHs currently in use. This correspondence is (re-)negotiated at each FACH/PCH addition/removal. The mapping of the TFCI bits onto slots is described in [3].

5.3.3.4.1 Secondary CCPCH structure with STTD encoding

In case the diversity antenna is present in UTRAN and the S-CCPCH is to be transmitted using open loop transmit diversity, the data symbols of the S-CCPCH are STTD encoded as given in subclause 5.3.1.1.1. The pilot symbol pattern for antenna 2 for the S-CCPCH given in Table 210 is not supported in this release.

Table 210: Pilot symbol pattern for antenna 2 when STTD encoding is used on the S-CCPCH

Symbol #	N _{pilot} = 8				N _{pilot} = 16							
	0	1	2	3	0	1	2	3	4	5	6	7
Slot #0	11	00	00	10	11	00	00	10	11	00	00	10
1	11	00	00	01	11	00	00	01	11	10	00	10
2	11	11	00	00	11	11	00	00	11	10	00	11
3	11	10	00	01	11	10	00	01	11	00	00	00
4	11	11	00	11	11	11	00	11	11	01	00	10
5	11	00	00	10	11	00	00	10	11	11	00	00
6	11	10	00	10	11	10	00	10	11	01	00	11
7	11	10	00	11	11	10	00	11	11	10	00	11
8	11	00	00	00	11	00	00	00	11	01	00	01
9	11	01	00	10	11	01	00	10	11	01	00	01
10	11	11	00	00	11	11	00	00	11	00	00	10
11	11	01	00	11	11	01	00	11	11	00	00	01
12	11	10	00	11	11	10	00	11	11	11	00	00
13	11	01	00	01	11	01	00	01	11	10	00	01
14	11	01	00	01	11	01	00	01	11	11	00	11

5.3.3.5 Synchronisation Channel (SCH)

The Synchronisation Channel (SCH) is a downlink signal used for cell search. The SCH consists of two sub channels, the Primary and Secondary SCH. The 10 ms radio frames of the Primary and Secondary SCH are divided into 15 slots, each of length 2560 chips. Figure 198 illustrates the structure of the SCH radio frame.

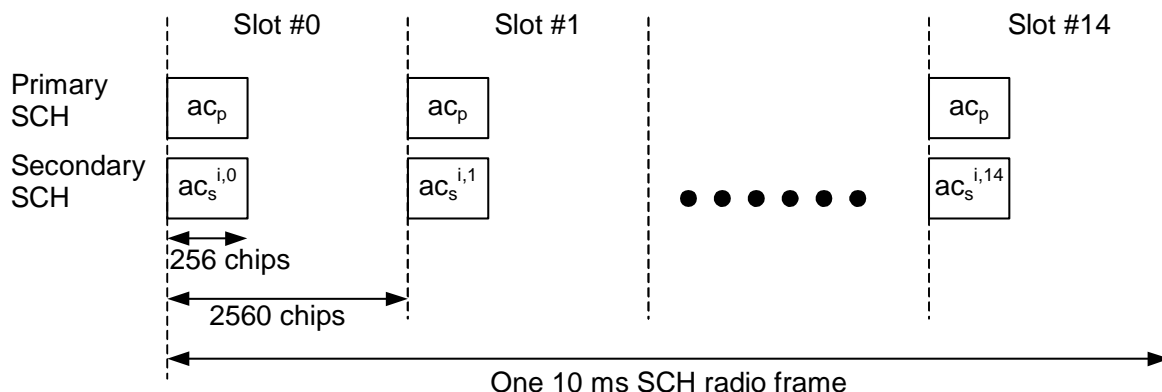


Figure 198: Structure of Synchronisation Channel (SCH)

The Primary SCH consists of a modulated code of length 256 chips, the Primary Synchronisation Code (PSC) denoted c_p in figure 198, transmitted once every slot. The PSC is the same for every cell in the system.

The Secondary SCH consists of repeatedly transmitting a length 15 sequence of modulated codes of length 256 chips, the Secondary Synchronisation Codes (SSC), transmitted in parallel with the Primary SCH. The SSC is denoted $c_s^{i,k}$ in figure 198, where $i = 0, 1, \dots, 63$ is the number of the scrambling code group, and $k = 0, 1, \dots, 14$ is the slot number. Each SSC is chosen from a set of 16 different codes of length 256. This sequence on the Secondary SCH indicates which of the code groups the cell's downlink scrambling code belongs to.

The primary and secondary synchronization codes are modulated by the symbol a shown in figure 198, which indicates the presence/ absence of STTD encoding on the P-CCPCH and is given by the following table:

P-CCPCH STTD encoded	$a = +1$
P-CCPCH not STTD encoded	$a = -1$

5.3.3.5.1 SCH transmitted by TSTD

Figure 2049 illustrates the structure of the SCH transmitted by the TSTD scheme. In even numbered slots both PSC and SSC are transmitted on antenna 1, and in odd numbered slots both PSC and SSC are transmitted on antenna 2.

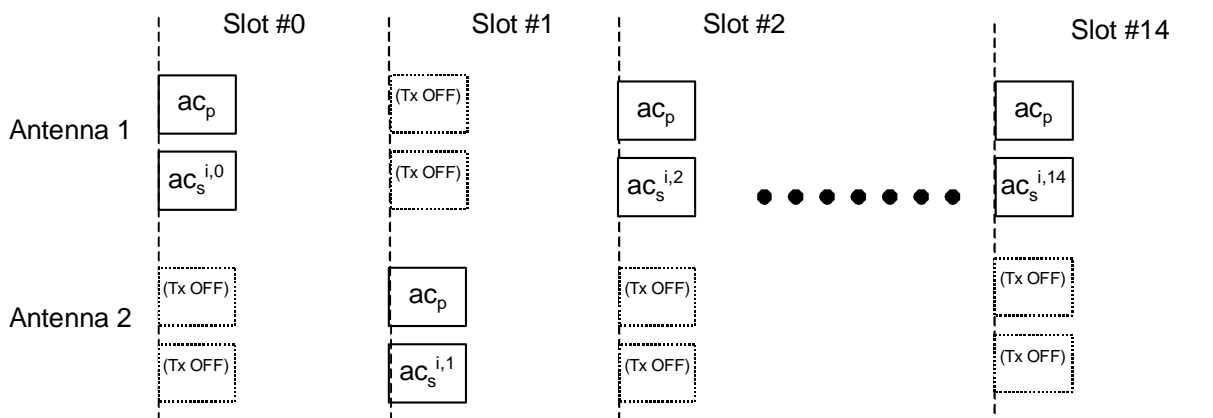


Figure 2049: Structure of SCH transmitted by TSTD scheme

5.3.3.6 Physical Downlink Shared Channel (PDSCH)

The Physical Downlink Shared Channel (PDSCH) is used to carry the Downlink Shared Channel (DSCH).

A PDSCH corresponds to a channelisation code below or at a PDSCH root channelisation code. A PDSCH is allocated on a radio frame basis to a single UE. Within one radio frame, UTRAN may allocate different PDSCHs under the same PDSCH root channelisation code to different UEs based on code multiplexing. Within the same radio frame, multiple

parallel PDSCHs, with the same spreading factor, may be allocated to a single UE. This is a special case of multicode transmission. All the PDSCHs are operated with radio frame synchronisation.

The notion of PDSCH root channelisation code is defined in [4].

PDSCHs allocated to the same UE on different radio frames may have different spreading factors.

The frame and slot structure of the PDSCH are shown on figure 210.

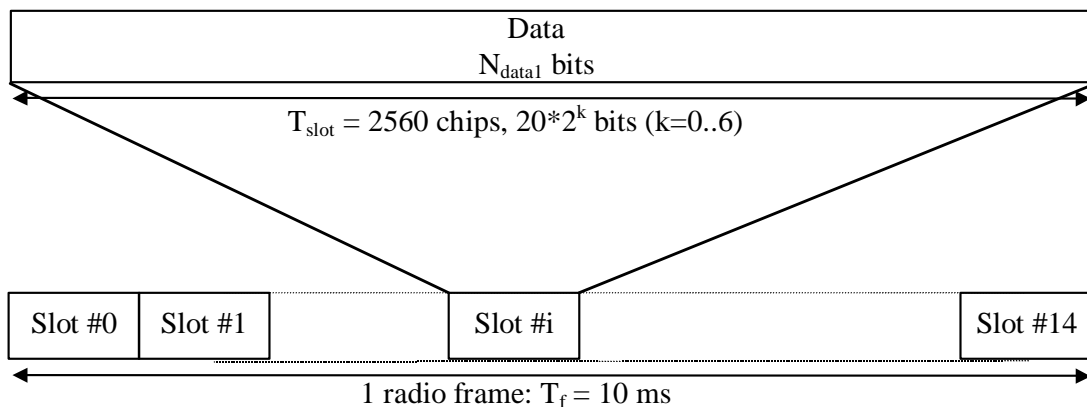


Figure 210: Frame structure for the PDSCH

For each radio frame, each PDSCH is associated with one downlink DPCH. The PDSCH and associated DPCH do not necessarily have the same spreading factors and are not necessarily frame aligned.

All relevant Layer 1 control information is transmitted on the DPCH part of the associated DPCH, i.e. the PDSCH does not carry Layer 1 information. To indicate for UE that there is data to decode on the DSCH, the TFCI field of the associated DPCH shall be used.

The TFCI informs the UE of the instantaneous transport format parameters related to the PDSCH as well as the channelisation code of the PDSCH.

The channel bit rates and symbol rates for PDSCH are given in Table 221.

For PDSCH the allowed spreading factors may vary from 256 to 4.

Table 221: PDSCH fields

Slot format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ Frame	Bits/ Slot	N _{data1}
0	30	15	256	300	20	20
1	60	30	128	600	40	40
2	120	60	64	1200	80	80
3	240	120	32	2400	160	160
4	480	240	16	4800	320	320
5	960	480	8	9600	640	640
6	1920	960	4	19200	1280	1280

When open loop transmit diversity is employed for the PDSCH, STTD encoding is used on the data bits as described in subclause 5.3.1.1.1.

When closed loop transmit diversity is employed on the associated DPCH, it shall be used also on the PDSCH as described in [5].

5.3.3.7 Acquisition Indicator Channel (AICH)

The Acquisition Indicator channel (AICH) is a fixed rate (SF=256) physical channel used to carry Acquisition Indicators (AI). Acquisition Indicator AI_s corresponds to signature s on the PRACH.

Figure 224 illustrates the structure of the AICH. The AICH consists of a repeated sequence of 15 consecutive *access slots* (AS), each of length 5120 chips. Each access slot consists of two parts, an *Acquisition-Indicator* (AI) part consisting of 32 real-valued symbols a_0, \dots, a_{31} and a part of duration 1024 chips with no transmission that is not formally part of the AICH. The part of the slot with no transmission is reserved for possible use by CSICH or possible future use by other physical channels.

The spreading factor (SF) used for channelisation of the AICH is 256.

The phase reference for the AICH is the Primary CPICH.

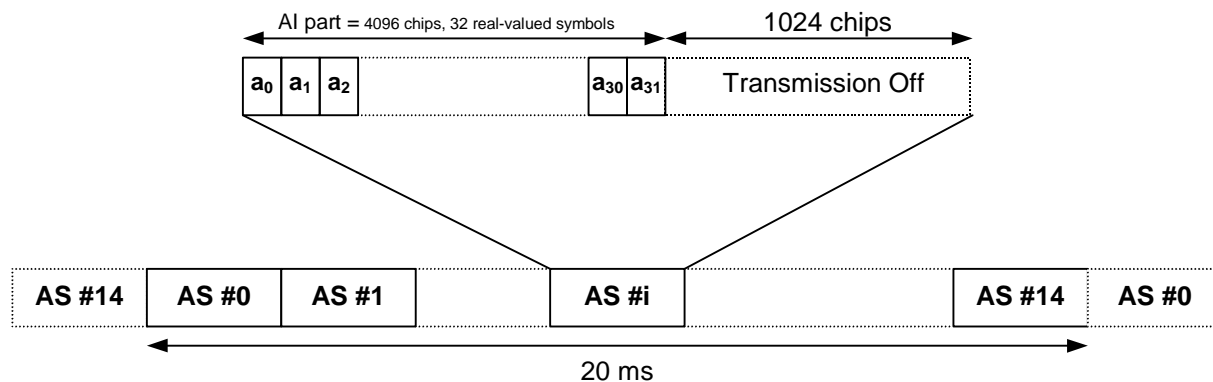


Figure 224: Structure of Acquisition Indicator Channel (AICH)

The real-valued symbols a_0, a_1, \dots, a_{31} in figure 224 are given by

$$a_j = \sum_{s=0}^{15} AI_s b_{s,j}$$

where AI_s , taking the values +1, -1, and 0, is the acquisition indicator corresponding to signature s and the sequence $b_{s,0}, \dots, b_{s,31}$ is given by Table 232. If the signature s is not a member of the set of available signatures for all the Access Service Class (ASC) for the corresponding PRACH (cf [5]), then AI_s shall be set to 0.

The use of acquisition indicators is described in [5]. If an Acquisition Indicator is set to +1, it represents a positive acknowledgement. If an Acquisition Indicator is set to -1, it represents a negative acknowledgement.

The real-valued symbols, a_j , are spread and modulated in the same fashion as bits when represented in $\{ +1, -1 \}$ form.

In case STTD-based open-loop transmit diversity is applied to AICH, STTD encoding according to subclause 5.3.1.1.1 is applied to each sequence $b_{s,0}, b_{s,1}, \dots, b_{s,31}$ separately before the sequences are combined into AICH symbols a_0, \dots, a_{31} .

The real-valued symbols, a_j , are spread and modulated in the same fashion as bits when represented in $\{ +1, -1 \}$ form.

In case STTD-based open-loop transmit diversity is applied to AP-AICH, STTD encoding according to subclause 5.3.1.1.1 is applied to each sequence $b_{s,0}, b_{s,1}, \dots, b_{s,31}$ separately before the sequences are combined into AP-AICH symbols a_0, \dots, a_{31} .

5.3.3.9 CPCH Collision Detection/Channel Assignment Indicator Channel (CD/CA-ICH)

The Collision Detection Channel Assignment Indicator channel (CD/CA-ICH) is a fixed rate (SF=256) physical channel used to carry CD Indicator (CDI) only if the CA is not active, or CD Indicator/CA Indicator (CDI/CAI) at the same time if the CA is active. The structure of CD/CA-ICH is shown in figure 243. CD/CA-ICH and AP-AICH may use the same or different channelisation codes.

The CD/CA-ICH has a part of duration of 4096chips where the CDI/CAI is transmitted, followed by a part of duration 1024chips with no transmission that is not formally part of the CD/CA-ICH. The part of the slot with no transmission is reserved for possible use by CSICH or possible future use by other physical channels.

The spreading factor (SF) used for channelisation of the CD/CA-ICH is 256.

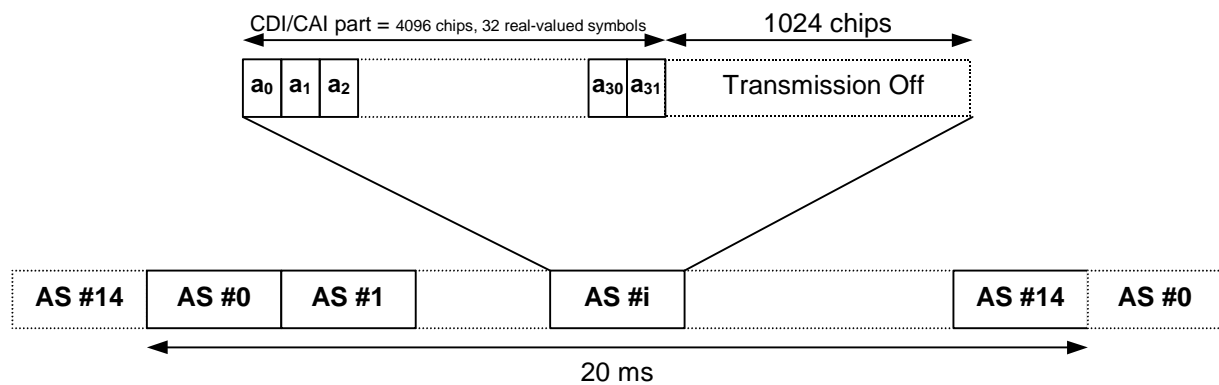


Figure 243: Structure of CD/CA Indicator Channel (CD/CA-ICH)

In case STTD-based open-loop transmit diversity is applied to CD/CA-ICH, STTD encoding according to subclause 5.3.1.1.1 is applied to each sequence $b_{s,0}, b_{s,1}, \dots, b_{s,31}$ separately before the sequences are combined into CD/CA-ICH symbols a_0, \dots, a_{31} .

In case CA is not active, the real-valued symbols a_0, a_1, \dots, a_{31} in figure 243 are given by

$$a_j = \sum_{s=0}^{15} \text{CDI}_s \times b_{s,j}$$

where CDI_s , taking the values +1, and 0, is the CD indicator corresponding to CD preamble signature s transmitted by UE and the sequence $b_{s,0}, \dots, b_{s,31}$ is given in Table 232. If the signature s is not a member of the set of CD Preamble signatures for the corresponding PCPCH (cf [5]), then CDI_s shall be set to 0.

The real-valued symbols, a_j , are spread and modulated in the same fashion as bits when represented in $\{ +1, -1 \}$ form.

In case CA is active, the real-valued symbols a_0, a_1, \dots, a_{31} in figure 243 are given by

$$a_j = \sum_{i=0}^{15} \text{CDI}_i \times b_{s_i,j} + \sum_{k=0}^{15} \text{CAI}_k \times b_{s_k,j}$$

where the subscript s_i, s_k depend on the indexes i, k according to Table 243, respectively, and indicate the signature number s in Table 232. The sequence $b_{s,0}, \dots, b_{s,31}$ is given in Table 232. CDI_i , taking the values +1/0 or -1/0, is the CD indicator corresponding to the CD preamble i transmitted by the UE, and CAI_k , taking the values +1/0 or -1/0, is the CA indicator corresponding to the assigned channel index k as given in Table 243. If the signature s_j is not a member of the

set of CD Preamble signatures for the corresponding PCPCH (cf [5]), then CDI_s shall be set to 0. Similarly, if the signature s_k is not a member of the set of CD Preamble signatures for the corresponding PCPCH (cf [5]), then CDI_s shall be set to 0.

Table 243. Generation of CDI_i/CAI_k

UE transmitted CD Preamble i	CDI_i	signature s_i	Channel Assignment Index k	CAI_k	signature s_k
0	+1/0	1	0	+1/0	0
1	-1/0		1	-1/0	
2	+1/0	3	2	+1/0	8
3	-1/0		3	-1/0	
4	+1/0	5	4	+1/0	4
5	-1/0		5	-1/0	
6	+1/0	7	6	+1/0	12
7	-1/0		7	-1/0	
8	+1/0	9	8	+1/0	2
9	-1/0		9	-1/0	
10	+1/0	11	10	+1/0	10
11	-1/0		11	-1/0	
12	+1/0	13	12	+1/0	6
13	-1/0		13	-1/0	
14	+1/0	15	14	+1/0	14
15	-1/0		15	-1/0	

5.3.3.10 Paging Indicator Channel (PICH)

The Paging Indicator Channel (PICH) is a fixed rate (SF=256) physical channel used to carry the paging indicators. The PICH is always associated with an S-CCPCH to which a PCH transport channel is mapped.

Figure 254 illustrates the frame structure of the PICH. One PICH radio frame of length 10 ms consists of 300 bits (b_0, b_1, \dots, b_{299}). Of these, 288 bits (b_0, b_1, \dots, b_{287}) are used to carry paging indicators. The remaining 12 bits are not formally part of the PICH and shall not be transmitted. The part of the frame with no transmission is reserved for possible future use.

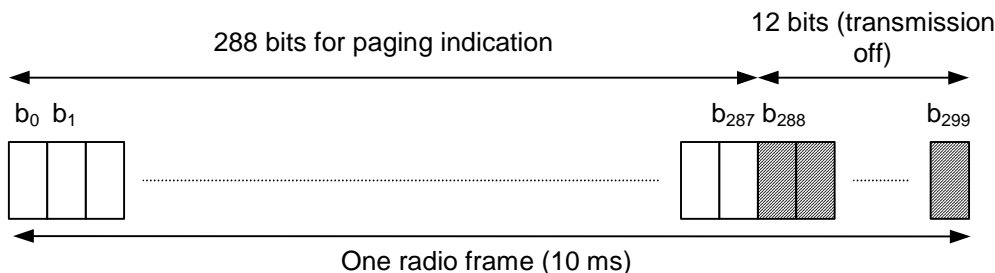


Figure 254: Structure of Paging Indicator Channel (PICH)

In each PICH frame, N_p paging indicators $\{P_0, \dots, P_{N_p-1}\}$ are transmitted, where $N_p=18, 36, 72, \text{ or } 144$.

The PI calculated by higher layers for use for a certain UE, is associated to the paging indicator P_q , where q is computed as a function of the PI computed by higher layers, the SFN of the P-CCPCH radio frame during which the start of the PICH radio frame occurs, and the number of paging indicators per frame (N_p):

$$q = \left(PI + \left[\left((18 \times (SFN + \lfloor SFN/8 \rfloor) + \lfloor SFN/64 \rfloor + \lfloor SFN/512 \rfloor) \right) \bmod 144 \right] \times \frac{N_p}{144} \right) \bmod N_p$$

Further, the PI calculated by higher layers is associated with the value of the paging indicator P_q . If a paging indicator in a certain frame is set to "1" it is an indication that UEs associated with this paging indicator and PI should read the corresponding frame of the associated S-CCPCH.

The PI bitmap in the PCH data frames over Iub contains indication values for all higher layer PI values possible. Each bit in the bitmap indicates if the paging indicator associated with that particular PI shall be set to 0 or 1. Hence, the calculation in the formula above is to be performed in Node B to make the association between PI and P_q .

The mapping from $\{P_0, \dots, P_{N_p-1}\}$ to the PICH bits $\{b_0, \dots, b_{287}\}$ are according to Table 254.

Table 254: Mapping of paging indicators P_q to PICH bits

Number of paging indicators per frame (N_p)	$P_q = 1$	$P_q = 0$
$N_p=18$	$\{b_{16q}, \dots, b_{16q+15}\} = \{-1, -1, \dots, -1\}$	$\{b_{16q}, \dots, b_{16q+15}\} = \{+1, +1, \dots, +1\}$
$N_p=36$	$\{b_{8q}, \dots, b_{8q+7}\} = \{-1, -1, \dots, -1\}$	$\{b_{8q}, \dots, b_{8q+7}\} = \{+1, +1, \dots, +1\}$
$N_p=72$	$\{b_{4q}, \dots, b_{4q+3}\} = \{-1, -1, \dots, -1\}$	$\{b_{4q}, \dots, b_{4q+3}\} = \{+1, +1, \dots, +1\}$
$N_p=144$	$\{b_{2q}, b_{2q+1}\} = \{-1, -1\}$	$\{b_{2q}, b_{2q+1}\} = \{+1, +1\}$

When transmit diversity is employed for the PICH, STTD encoding is used on the PICH bits as described in subclause 5.3.1.1.1.

5.3.3.11 CPCH Status Indicator Channel (CSICH)

The CPCH Status Indicator Channel (CSICH) is a fixed rate (SF=256) physical channel used to carry CPCH status information.

A CSICH is always associated with a physical channel used for transmission of CPCH AP-AICH and uses the same channelization and scrambling codes. Figure 265 illustrates the frame structure of the CSICH. The CSICH frame consists of 15 consecutive access slots (AS) each of length 40 bits. Each access slot consists of two parts, a part of duration 4096 chips with no transmission that is not formally part of the CSICH, and a Status Indicator (SI) part consisting of 8 bits b_{8i}, \dots, b_{8i+7} , where i is the access slot number. The part of the slot with no transmission is reserved for use by AICH, AP-AICH or CD/CA-ICH. The modulation used by the CSICH is the same as for the PICH. The phase reference for the CSICH is the Primary CPICH.

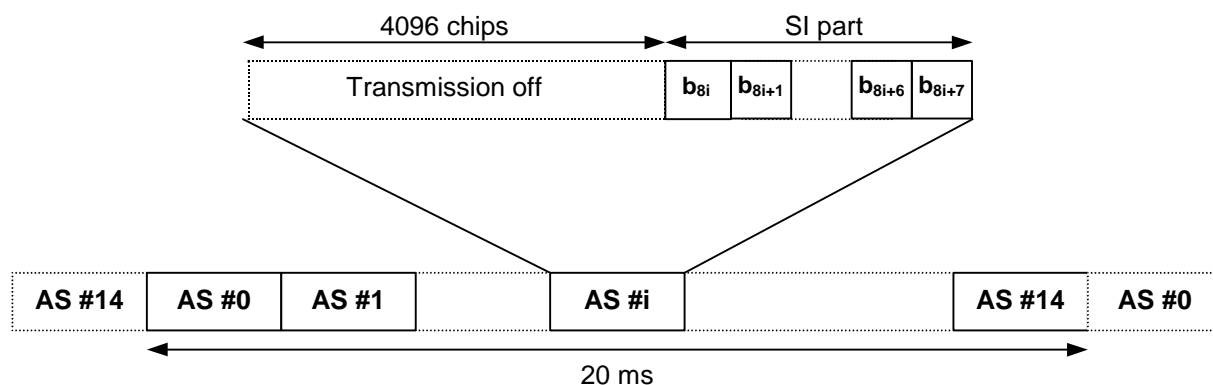


Figure 265: Structure of CPCH Status Indicator Channel (CSICH)

N Status Indicators $\{SI_0, \dots, SI_{N-1}\}$ shall be transmitted in each CSICH frame. The mapping from $\{SI_0, \dots, SI_{N-1}\}$ to the CSICH bits $\{b_0, \dots, b_{119}\}$ is according to Table 265. The Status Indicators shall be transmitted in all the access slots of the CSICH frame, even if some signatures and/or access slots are shared between CPCH and RACH.

Table 265: Mapping of Status Indicators (SI) to CSICH bits

Number of SI per frame (N)	SI _n = 1	SI _n = 0
N=1	{b ₀ , ..., b ₁₁₉ } = {-1,-1,...,-1}	{b ₀ , ..., b ₁₁₉ } = {+1,+1,...,+1}
N=3	{b _{40n} , ..., b _{40n+39} } = {-1,-1,...,-1}	{b _{40n} , ..., b _{40n+39} } = {+1,+1,...,+1}
N=5	{b _{24n} , ..., b _{24n+23} } = {-1,-1,...,-1}	{b _{24n} , ..., b _{24n+23} } = {+1,+1,...,+1}
N=15	{b _{8n} , ..., b _{8n+7} } = {-1,-1,...,-1}	{b _{8n} , ..., b _{8n+7} } = {+1,+1,...,+1}
N=30	{b _{4n} , ..., b _{4n+3} } = {-1, -1, -1, -1}	{b _{4n} , ..., b _{4n+3} } = {+1, +1, +1, +1}
N=60	{b _{2n} , b _{2n+1} } = {-1,-1}	{b _{2n} , b _{2n+1} } = {+1,+1}

When transmit diversity is employed for the CSICH, STTD encoding is used on the CSICH bits as described in subclause 5.3.1.1.1.

The CPCH Status Indicator mode (CSICH mode) defines the structure of the information carried on the CSICH. At the UTRAN the value of the CPCH Status Indicator mode is set by higher layers. There are two CSICH modes depending on whether Channel Assignment is active or not. The CSICH mode defines the number of status indicators per frame and the content of each status indicator. Layer 1 transmits the CSICH information according to the CSICH mode and the structures defined in the following paragraphs.

5.3.3.11.1 CSICH Information Structure when Channel Assignment is not active

In this mode, CPCH Status Indication conveys the PCPCH Channel Availability value which is a 1 to 16 bit value which indicates the availability of each of the 1 to 16 defined PCPCHs in the CPCH set. PCPCHs are numbered from PCPCH0 through PCPCH15. There is one bit of the PCPCH Resource Availability (PRA) value for each defined PCPCH channel. If there are 2 PCPCHs defined in the CPCH set, then there are 2 bits in the PRA value. And likewise for other numbers of defined PCPCH channels up to 16 maximum CPCH channels per set when Channel Assignment is not active.

The number of SIs (Status Indicators) per frame is a function of the number of defined PCPCH channels.

Number of defined PCPCHs(=K)	Number of SIs per frame(=N)
1, 2, 3	3
4,5	5
6,7,8,9,10,11,12,13,14,15	15
16	30

The value of the SI shall indicate the PRA value for one of the defined PCPCHs, where PRA(n)=1 indicates that the PCPCH is available, and PRA(n)=0 indicates that the PCPCH_n is not available. SI(0) shall indicate PRA(0) for PCPCH0, SI(1) shall indicate PRA(1) for PCPCH1, etc., for each defined PCPCH. When the number of SIs per frame exceeds the number of defined PCPCHs (K), the SIs which exceed K shall be set to repeat the PRA values for the defined PCPCHs. In general ,

$$SI(n) = PRA(n \bmod (K)),$$

where PRA(i) is availability of PCPCH_i,

and n ranges from 0 to N-1.

5.3.3.11.2 PCPCH Availability when Channel Assignment is active

In this mode, CPCH Status Indication conveys two pieces of information. One is the Minimum Available Spreading Factor (MASF) value and the other is the PCPCH Resource Availability (PRA) value.

- MASF is a 3 bit number with bits MASF(0) through MASF(2) where MASF(0) is the MSB of the MASF value and MASF(2) is the LSB of the MASF value.

The following table defines MASF(0), MASF(1) and MASF(2) values to convey the MASF. All spreading factors greater than MASF are available

Minimum Available Spreading Factor (MASF)	MASF(0)	MASF(1)	MASF(2)
N/A (No available CPCH resources)	0	0	0
256	0	0	1
128	0	1	0
64	0	1	1
32	1	0	0
16	1	0	1
08	1	1	0
04	1	1	1

The number of SIs (Status Indicators) per frame, N is a function of the number of defined PCPCH channels, K.

Number of defined PCPCHs(K)	Number of SIs per frame(N)
1, 2,	5
3,4,5,6,7,8,9,10,11,12	15
13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	30
28....57	60

PRA(n)=1 indicates that the PCPCHn is available, and PRA(n)=0 indicates that the PCPCHn is not available. PRA value for each PCPCH channel defined in a CPCH set shall be assigned to one SI (Status Indicator), and 3-bit MASF value shall be assigned to SIs as shown in Figure 276.

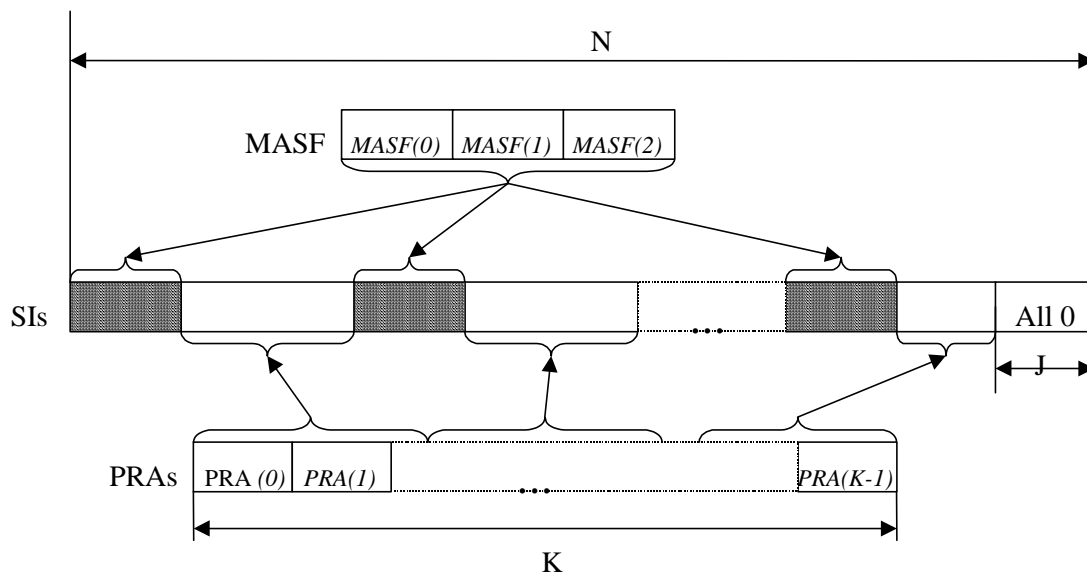


Figure 276: Mapping of MASF and PRAs to SIs in CSICH

The number of repetition that 3-bit MASF values shall be repeated is

$$T = \lfloor (N - K) / 3 \rfloor$$

where $\lfloor x \rfloor$ is largest integer less than or equal to x. Each MASF value it, MASF(n), shall be mapped to SI as follows.

$$SI_{l(t+4)+i} = MASF(i), \quad 0 \leq i \leq 2 \quad l = 0, 1, \dots, s-1$$

$$SI_{s+l(t+3)+i} = MASF(i), \quad 0 \leq i \leq 2 \quad l = s, s+1, \dots, T-1$$

where

$$t = \lfloor K / T \rfloor$$

and

$$s = K - t \cdot T$$

Each PRA value bit, PRA(n), shall be mapped to SI as follows.

$$SI_{l(t+4)+j+3} = PRA(l+l \cdot t + j), \quad 0 \leq j \leq t \quad l = 0, 1, \dots, s-1$$

$$SI_{s+l(t+3)+j+3} = PRA(s+l \cdot t + j), \quad 0 \leq j \leq t-1 \quad l = s, s+1, \dots, T-1$$

The remaining

$$J = N - (3T + K)$$

SIs shall be set to 0.

5.3.3.12 Shared Control Channel (HS-SCCH)

The HS-SCCH is a fixed rate (60 kbps, SF=128) downlink physical channel used to carry downlink signalling related to HS-DSCH transmission. Figure 28 illustrates the sub-frame structure of the HS-SCCH.

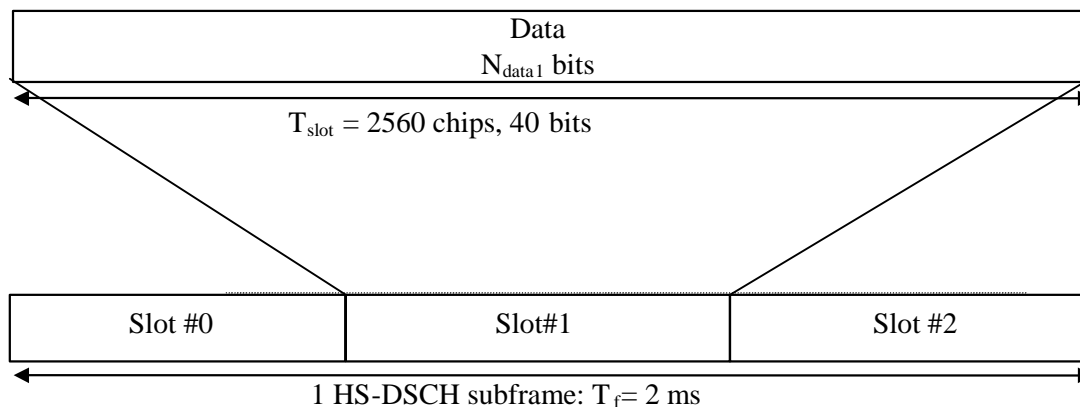


Figure 28: Subframe structure for the HS-SCCH

5.3.3.13 High Speed Physical Downlink Shared Channel (HS-PDSCH)

The High Speed Physical Downlink Shared Channel (HS- PDSCH) is used to carry the High Speed Downlink Shared Channel (HS-DSCH).

A HS-PDSCH corresponds to one channelization code of fixed spreading factor SF=16 from the set of channelization codes reserved for HS-DSCH transmission. Multi-code transmission is allowed, which translates to UE being assigned multiple channelisation codes in the same HS-PDSCH subframe, depending on its UE capability.

The subframe and slot structure of HS-PDSCH are shown in figure 29.

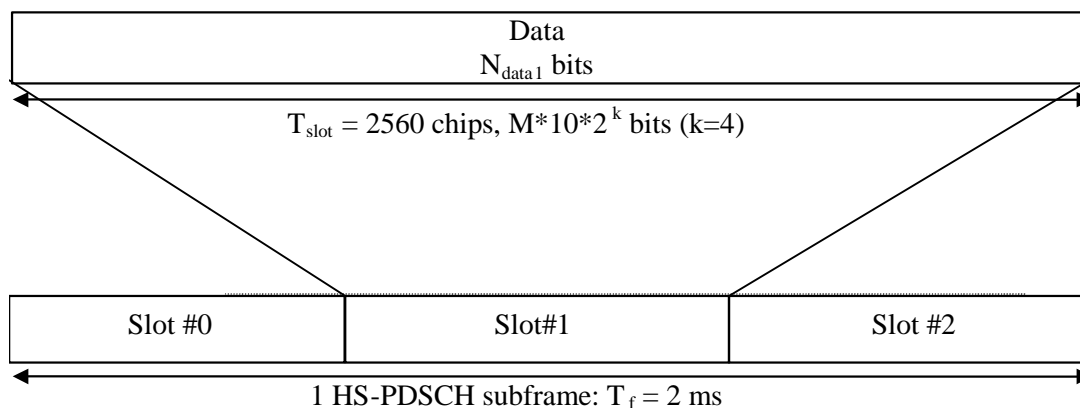


Figure 29: Subframe structure for the HS-PDSCH

An HS-PDSCH may use QPSK or 16QAM modulation symbols. In figure 29, M is the number of bits per modulation symbols i.e. M=2 for QPSK and M=4 for 16QAM. The slot formats are shown in table 27.

Table 27: HS-DSCH fields

Slot format #i	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ HS-DSCH subframe	Bits/ Slot	Ndata
0(QPSK)	480	240	16	960	320	320
1(16QAM)	960	240	16	1920	640	640

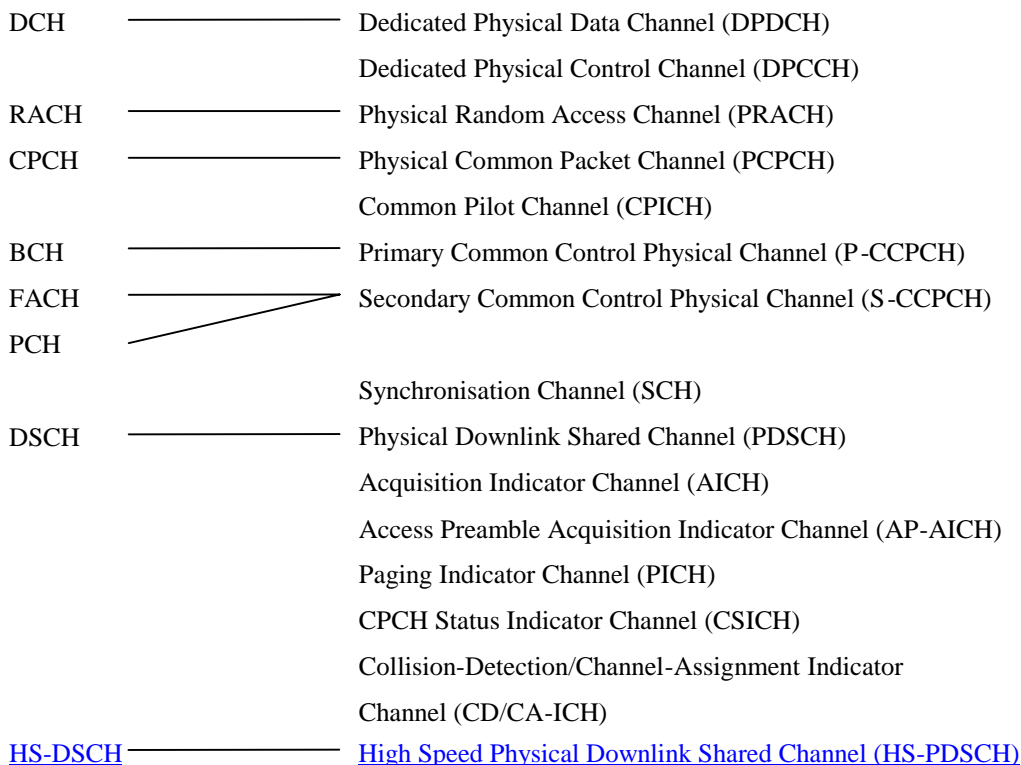
All relevant Layer 1 information is transmitted in the associated HS-PSCCH i.e. the HS-PDSCH does not carry any Layer 1 information.

6 Mapping and association of physical channels

6.1 Mapping of transport channels onto physical channels

Figure 3027 summarises the mapping of transport channels onto physical channels.

Physical Channels



Transport Channels

Physical Channels

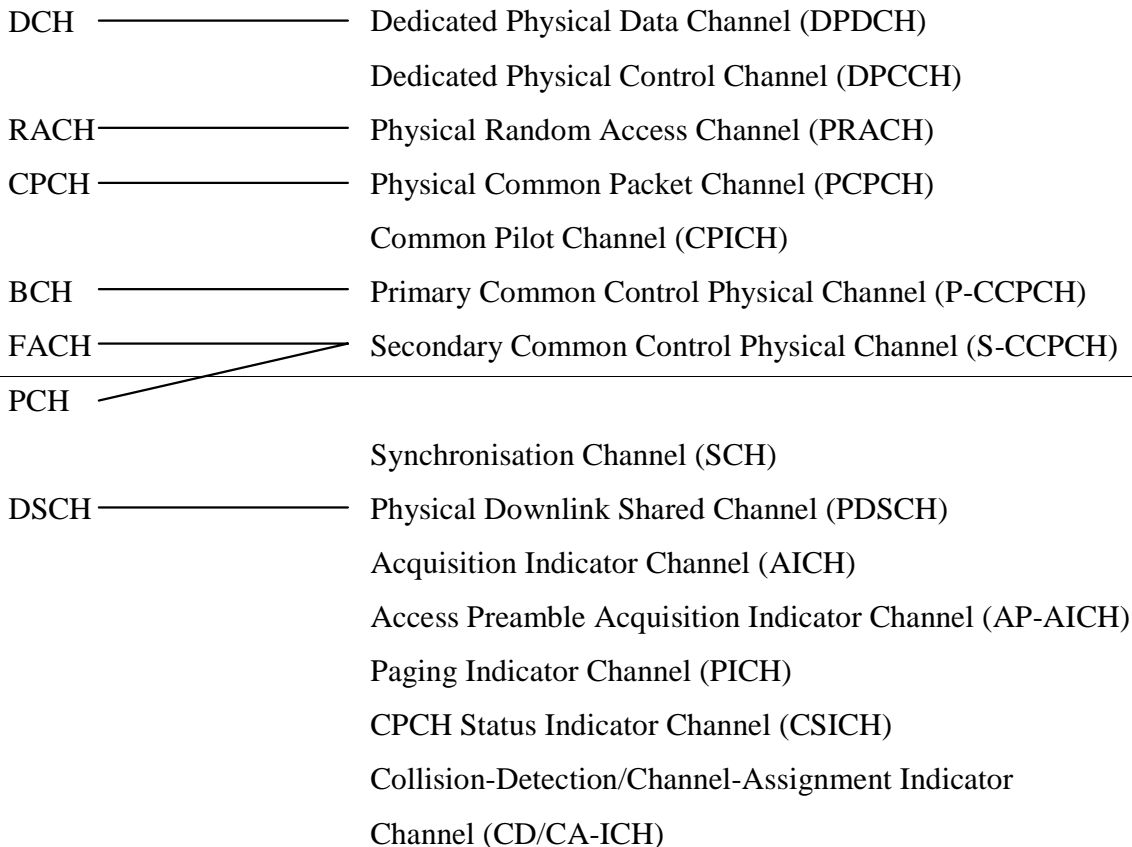


Figure 3027: Transport-channel to physical-channel mapping

The DCHs are coded and multiplexed as described in [3], and the resulting data stream is mapped sequentially (first-in-first-mapped) directly to the physical channel(s). The mapping of BCH and FACH/PCH is equally straightforward, where the data stream after coding and interleaving is mapped sequentially to the Primary and Secondary CCPCH respectively. Also for the RACH, the coded and interleaved bits are sequentially mapped to the physical channel, in this case the message part of the PRACH.

6.2 Association of physical channels and physical signals

Figure 3128 illustrates the association between physical channels and physical signals.

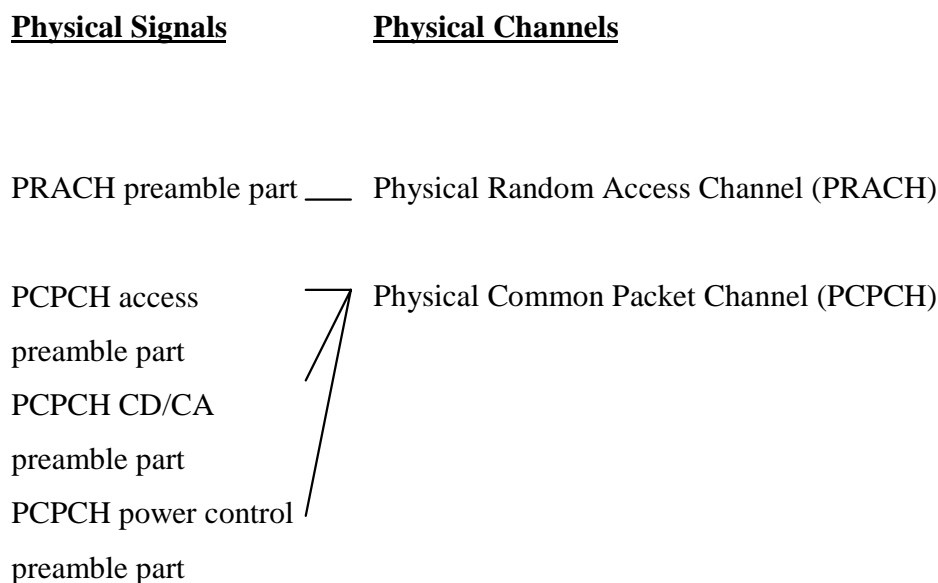


Figure 3128: Physical channel and physical signal association

7 Timing relationship between physical channels

7.1 General

The P-CCPCH, on which the cell SFN is transmitted, is used as timing reference for all the physical channels, directly for downlink and indirectly for uplink.

Figure 3229 below describes the frame timing of the downlink physical channels. For the AICH the access slot timing is included. Transmission timing for uplink physical channels is given by the received timing of downlink physical channels, as described in the following subclauses.

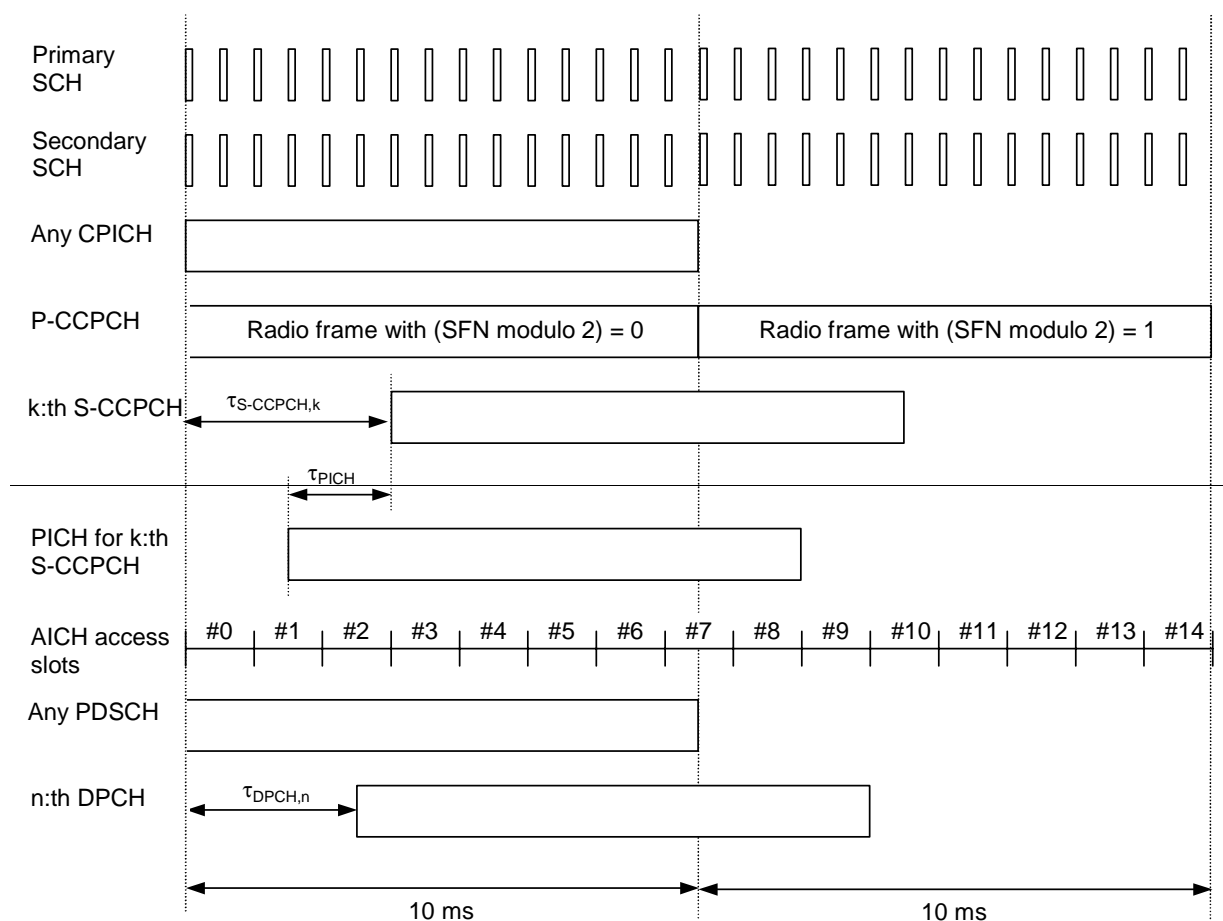
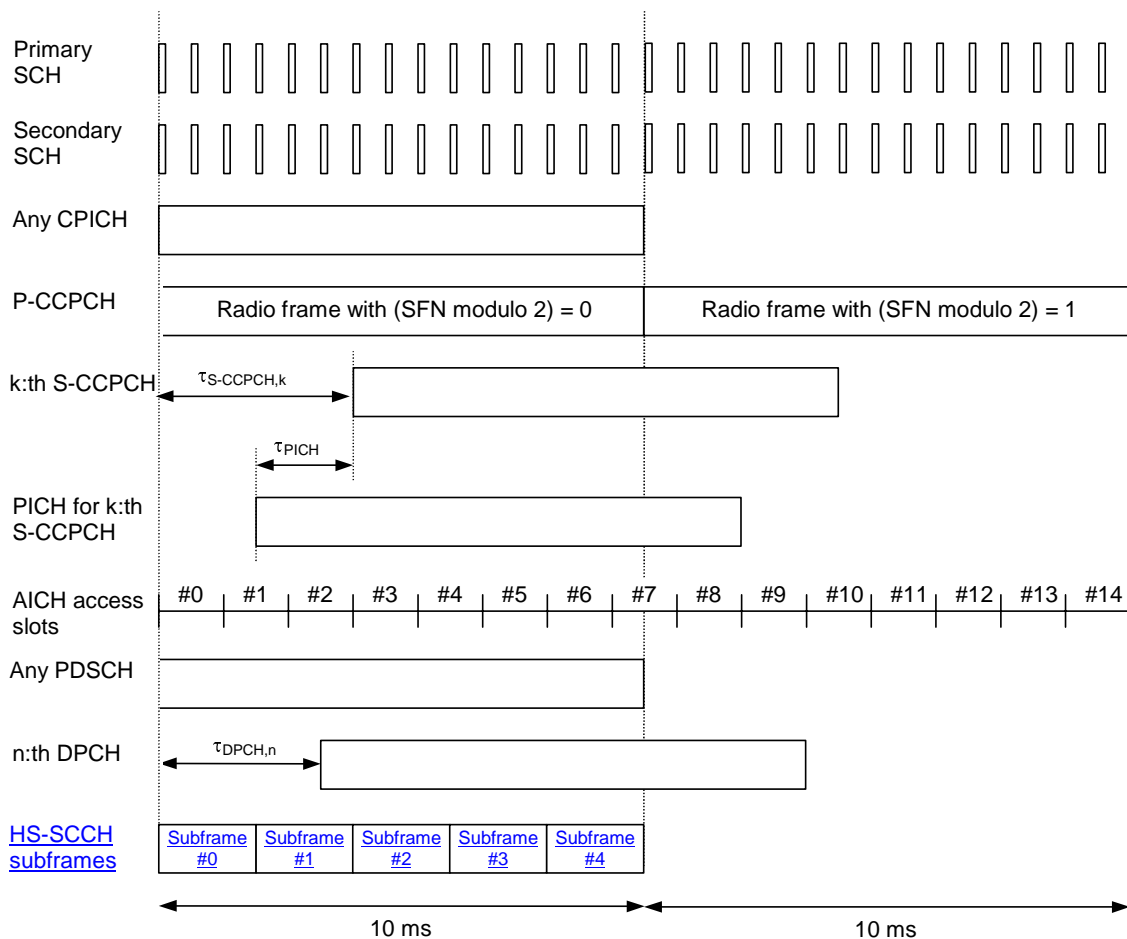


Figure 3229: Radio frame timing and access slot timing of downlink physical channels

The following applies:

- SCH (primary and secondary), CPICH (primary and secondary), P-CCPCH, and PDSCH have identical frame timings.
- The S-CCPCH timing may be different for different S-CCPCHs, but the offset from the P-CCPCH frame timing is a multiple of 256 chips, i.e. $\tau_{S-CCPCH,k} = T_k \times 256$ chip, $T_k \in \{0, 1, \dots, 149\}$.
- The PICH timing is $\tau_{PICH} = 7680$ chips prior to its corresponding S-CCPCH frame timing, i.e. the timing of the S-CCPCH carrying the PCH transport channel with the corresponding paging information, see also subclause 7.2.
- AICH access slots #0 starts the same time as P-CCPCH frames with $(SFN \text{ modulo } 2) = 0$. The AICH/PRACH and AICH/PCPCH timing is described in subclauses 7.3 and 7.4 respectively.
- The relative timing of associated PDSCH and DPCH is described in subclause 7.5.
- The DPCH timing may be different for different DPCHs, but the offset from the P-CCPCH frame timing is a multiple of 256 chips, i.e. $\tau_{DPCH,n} = T_n \times 256$ chip, $T_n \in \{0, 1, \dots, 149\}$. The DPCH (DPCCH/DPDCH) timing relation with uplink DPCCH/DPDCHs is described in subclause 7.6.
- The start of HS-SSCH subframe #0 is aligned with the start of the P-CCPCH frames. The relative timing between a HS-PDSCH and the corresponding HS-SSCH is described in subclause 7.7.

7.2 PICH/S-CCPCH timing relation

Figure 330 illustrates the timing between a PICH frame and its associated single S-CCPCH frame, i.e. the S-CCPCH frame that carries the paging information related to the paging indicators in the PICH frame. A paging indicator set in a PICH frame means that the paging message is transmitted on the PCH in the S-CCPCH frame starting τ_{PICH} chips after the transmitted PICH frame. τ_{PICH} is defined in subclause 7.1.

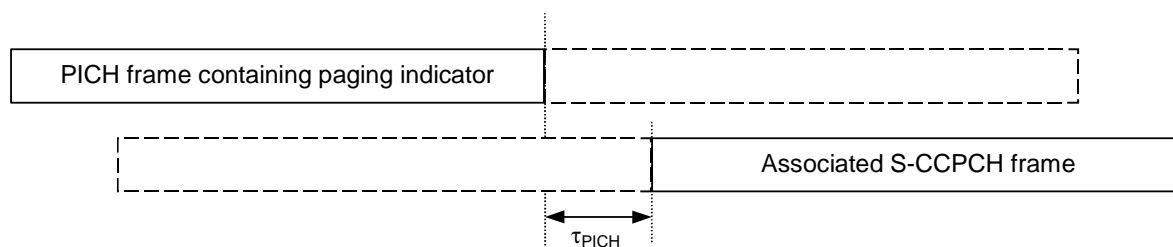


Figure 330: Timing relation between PICH frame and associated S-CCPCH frame

7.3 PRACH/AICH timing relation

The downlink AICH is divided into downlink access slots, each access slot is of length 5120 chips. The downlink access slots are time aligned with the P-CCPCH as described in subclause 7.1.

The uplink PRACH is divided into uplink access slots, each access slot is of length 5120 chips. Uplink access slot number n is transmitted from the UE τ_{p-a} chips prior to the reception of downlink access slot number n , $n = 0, 1, \dots, 14$.

Transmission of downlink acquisition indicators may only start at the beginning of a downlink access slot. Similarly, transmission of uplink RACH preambles and RACH message parts may only start at the beginning of an uplink access slot.

The PRACH/AICH timing relation is shown in figure 344.

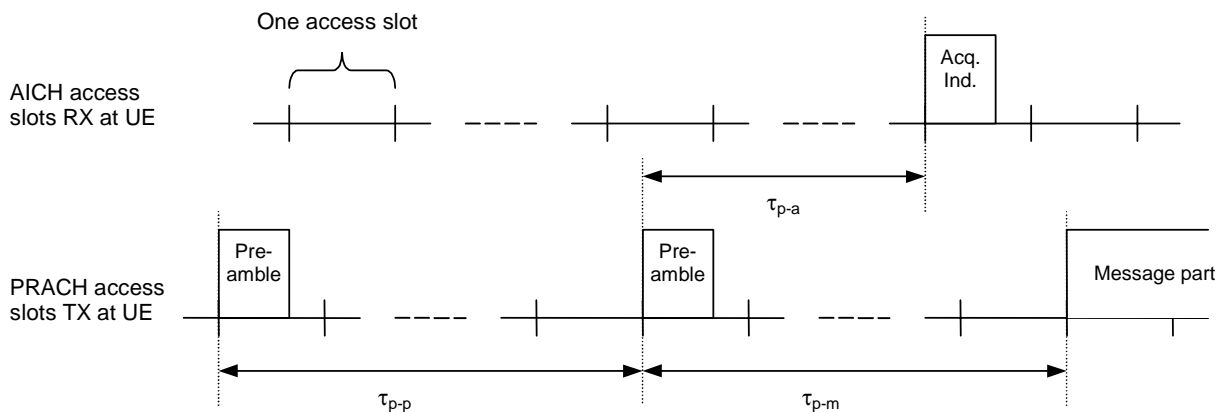


Figure 344: Timing relation between PRACH and AICH as seen at the UE

The preamble-to-preamble distance τ_{p-p} shall be larger than or equal to the minimum preamble-to-preamble distance $\tau_{p-p,min}$, i.e. $\tau_{p-p} \geq \tau_{p-p,min}$.

In addition to $\tau_{p-p,min}$, the preamble-to-AI distance τ_{p-a} and preamble-to-message distance τ_{p-m} are defined as follows:

- when AICH_Transmission_Timing is set to 0, then

$$\tau_{p-p,min} = 15360 \text{ chips (3 access slots)}$$

$$\tau_{p-a} = 7680 \text{ chips}$$

$$\tau_{p-m} = 15360 \text{ chips (3 access slots)}$$

- when AICH_Transmission_Timing is set to 1, then

$$\tau_{p-p,min} = 20480 \text{ chips (4 access slots)}$$

$$\tau_{p-a} = 12800 \text{ chips}$$

$$\tau_{p-m} = 20480 \text{ chips (4 access slots)}$$

The parameter AICH_Transmission_Timing is signalled by higher layers.

7.4 PCPCH/AICH timing relation

The uplink PCPCH is divided into uplink access slots, each access slot is of length 5120 chips. Uplink access slot number n is transmitted from the UE τ_{p-a1} chips prior to the reception of downlink access slot number n , $n=0, 1, \dots, 14$.

The timing relationship between preambles, AICH, and the message is the same as PRACH/AICH. Note that the collision resolution preambles follow the access preambles in PCPCH/AICH. However, the timing relationships between CD-Preamble and CD/CA-ICH is identical to RACH Preamble and AICH. The timing relationship between CD/CA-ICH and the Power Control Preamble in CPCH is identical to AICH to message in RACH. The T_{cpch} timing parameter is identical to the PRACH/AICH transmission timing parameter. When T_{cpch} is set to zero or one, the following PCPCH/AICH timing values apply.

Note that a1 corresponds to AP-AICH and a2 corresponds to CD/CA-ICH.

$$\tau_{p-p} = \text{Time to next available access slot, between Access Preambles.}$$

$$\text{Minimum time} = 15360 \text{ chips} + 5120 \text{ chips} \times T_{cpch}$$

$$\text{Maximum time} = 5120 \text{ chips} \times 12 = 61440 \text{ chips}$$

Actual time is time to next slot (which meets minimum time criterion) in allocated access slot subchannel group.

- τ_{p-a1} = Time between Access Preamble and AP-AICH has two alternative values: 7680 chips or 12800 chips, depending on T_{cpch}
- τ_{a1-cdp} = Time between receipt of AP-AICH and transmission of the CD Preamble τ_{a1-cdp} has a minimum value of $\tau_{a1-cdp, min} = 7680$ chips.
- τ_{p-cdp} = Time between the last AP and CD Preamble. τ_{p-cdp} has a minimum value of $\tau_{p-cdp-min}$ which is either 3 or 4 access slots, depending on T_{cpch}
- τ_{cdp-a2} = Time between the CD Preamble and the CD/CA-ICH has two alternative values: 7680 chips or 12800 chips, depending on T_{cpch}
- $\tau_{cdp-pcp}$ = Time between CD Preamble and the start of the Power Control Preamble is either 3 or 4 access slots, depending on T_{cpch} .

The time between the start of the reception of DL-DPCCH slot at UE and the Power Control Preamble is T_0 chips, where T_0 is as in subclause 7.6.3.

The message transmission shall start 0 or 8 slots after the start of the power control preamble depending on the length of the power control preamble.

Figure 352 illustrates the PCPCH/AICH timing relationship when T_{cpch} is set to 0 and all access slot subchannels are available for PCPCH.

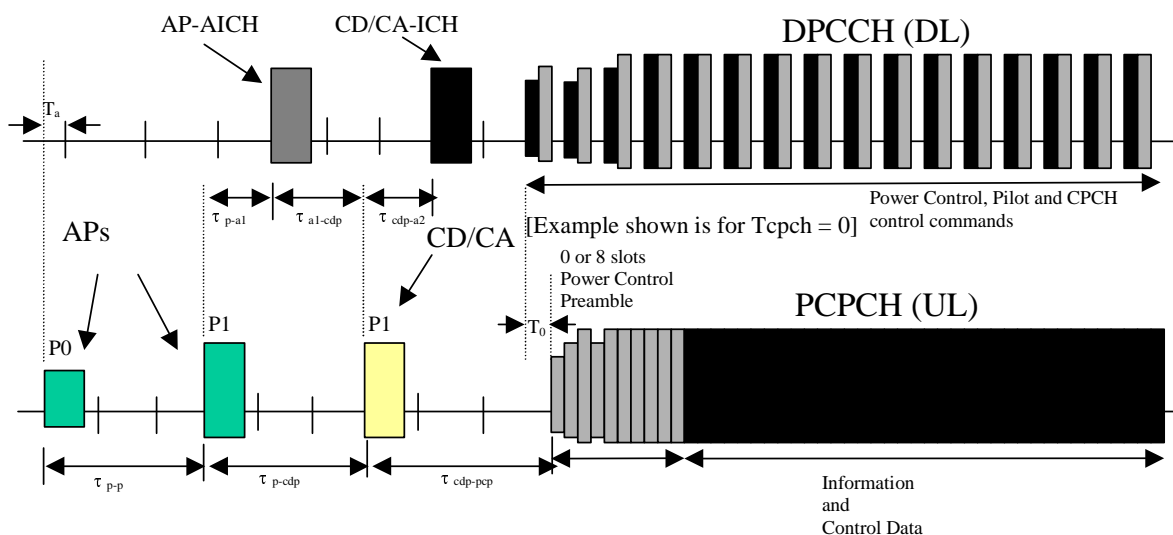


Figure 352: Timing of PCPCH and AICH transmission as seen by the UE, with $T_{cpch} = 0$

7.5 DPCH/PDSCH timing

The relative timing between a DPCH frame and the associated PDSCH frame is shown in figure 363.

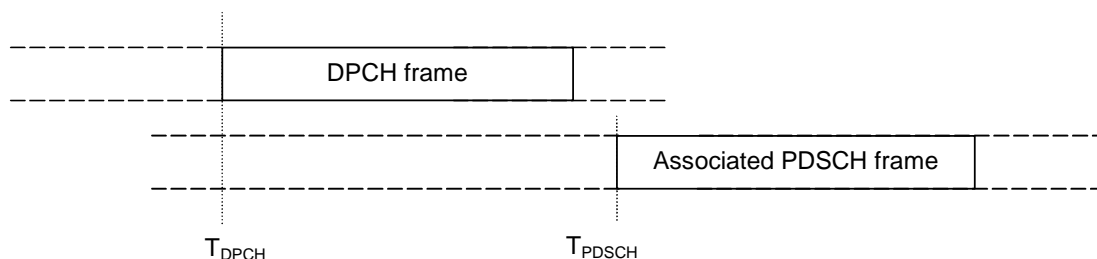


Figure 363: Timing relation between DPCH frame and associated PDSCH frame

The start of a DPCH frame is denoted T_{DPCH} and the start of the associated PDSCH frame is denoted T_{PDSCH} . Any DPCH frame is associated to one PDSCH frame through the relation $46080 \text{ chips} \leq T_{PDSCH} - T_{DPCH} < 84480 \text{ chips}$, i.e., the associated PDSCH frame starts between three slots after the end of the DPCH frame and 18 slots after the end of the DPCH frame, as described in subclause 7.1.

7.6 DPCCH/DPDCH timing relations

7.6.1 Uplink

In uplink the DPCCH and all the DPDCHs transmitted from one UE have the same frame timing.

7.6.2 Downlink

In downlink, the DPCCH and all the DPDCHs carrying CCTrCHs of dedicated type to one UE have the same frame timing.

Note: support of multiple CCTrCHs of dedicated type is not part of the current release.

7.6.3 Uplink/downlink timing at UE

At the UE, the uplink DPCCH/DPDCH frame transmission takes place approximately T_0 chips after the reception of the first detected path (in time) of the corresponding downlink DPCCH/DPDCH frame. T_0 is a constant defined to be 1024 chips. The first detected path (in time) is defined implicitly by the relevant tests in [14]. More information about the uplink/downlink timing relation and meaning of T_0 can be found in [5].

7.7 Uplink HS-DPCCH/HS-PDSCH timing

Figure 37 shows the timing offset between the downlink associated DPCH and the uplink HS-DPCCH. The code-multiplexed uplink HS-DPCCH starts $m \cdot 256$ chips after the start of the uplink DPCCH with m selected by the UE such that the ACK/NACK transmission starts within the first 0-255 chips after 7.5 slots following the end of the received HS-PDSCH.

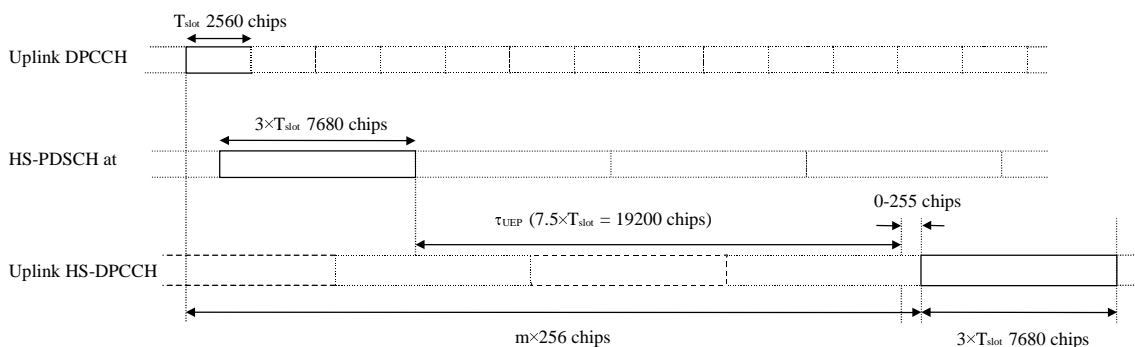


Figure 37: Timing structure at UE for UL HS-DPCCH control signalling

Annex A (informative):
Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
	RAN_05	RP-99587	-		Approved at TSG RAN #5 and placed under Change Control	-	3.0.0
14/01/00	RAN_06	RP-99676	001	1	Removal of superframe notation	3.0.0	3.1.0
14/01/00	RAN_06	RP-99677	002	-	Use of CPICH in case of open loop Tx	3.0.0	3.1.0
14/01/00	RAN_06	RP-99677	003	2	CPCH power control preamble length	3.0.0	3.1.0
14/01/00	RAN_06	RP-99684	005	1	Editorial corrections	3.0.0	3.1.0
14/01/00	RAN_06	RP-99676	006	-	Change to the description of TSTD for SCH	3.0.0	3.1.0
14/01/00	RAN_06	RP-99678	007	1	Introduction of compressed mode by higher layer scheduling	3.0.0	3.1.0
14/01/00	RAN_06	RP-99676	008	1	Modifications to STTD text	3.0.0	3.1.0
14/01/00	RAN_06	RP-99684	009	1	20 ms RACH message length	3.0.0	3.1.0
14/01/00	RAN_06	RP-99676	010	-	Update to AICH description	3.0.0	3.1.0
14/01/00	RAN_06	RP-99678	011	1	Sliding paging indicators	3.0.0	3.1.0
14/01/00	RAN_06	RP-99677	016	-	TAB structure and timing relation for USTS	3.0.0	3.1.0
14/01/00	RAN_06	RP-99677	017	-	Timing for initialisation procedures	3.0.0	3.1.0
14/01/00	RAN_06	RP-99677	022	-	Modification of the STTD encoding scheme on DL DPCH with SF 512	3.0.0	3.1.0
14/01/00	-	-	-	-	Change history was added by the editor	3.1.0	3.1.1
31/03/00	RAN_07	RP-000060	013	6	Addition of a downlink channel indicating CPCH status	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	023	6	CPCH-related editorial changes, technical changes and additions to 25.211 and some clarifications to 7.4 PCPCH/AICH timing relation.	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	024	1	Additional description of TX diversity for PDSCH	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	025	1	Consistent numbering of scrambling code groups	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	026	-	Minor corrections to timing section	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	028	1	Timing of PDSCH	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	029	1	Modifications to STTD text	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	031	4	CD/CA-ICH for dual mode CPCH	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	033	-	Clarification of frame synchronization word and its usage	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	034	1	Editorial updates to 25.211	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	036	-	PDSCH multi-code transmission	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	037	-	Clarification of pilot bit patterns for CPCH and slot formats for CPCH PC-P and message part	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	039	-	Further restrictions on the application of the Tx diversity modes in DL	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	040	-	Clarification of downlink pilot bit patterns	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	041	-	Clarification of DCH initialisation	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	044	2	Emergency Stop of CPCH transmission and Start of Message Indicator	3.1.1	3.2.0
31/03/00	RAN_07	RP-000060	046	-	Clean up of USTS related specifications	3.1.1	3.2.0
26/06/00	RAN_08	RP-000265	047	4	Clarifications to power control preamble sections	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	048	-	Propagation delay for PCPCH	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	049	1	PICH undefined bits and AICH, AP-ICH, CD/CA-ICH non-transmitted chips	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	051	1	Bit value notation change for PICH and CSICH	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	053	1	Revision of notes in sections 5.3.2 and 5.3.2.1	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	054	5	Slot format clarification for CPCH	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	055	3	Physical channel nomenclature in FDD	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	056	3	Clarification for the PDSCH channelisation code association with DPCH in 25.211	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	057	2	Clarification for the PDSCH channelisation code association with DPCH in 25.211	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	058	-	Clarification of spreading factor for AICH	3.2.0	3.3.0
26/06/00	RAN_08	RP-000265	060	-	Explicit mention of slot format reconfiguration also for uplink	3.2.0	3.3.0
23/09/00	RAN_09	RP-000340	065	-	Correction of reference	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	066	4	Clarification of paging indicator mapping	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	068	-	Editorial modification of the 25.211 about the CD/CA-ICH	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	070	1	Support of closed loop transmit diversity modes	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	071	-	DPCH initialisation procedure	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	072	3	Correction on indicators	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	074	-	Correction of STTD for DPCH	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	075	-	Clarification of first significant path	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	076	-	Clarification of SCH transmitted by TSTD	3.3.0	3.4.0
23/09/00	RAN_09	RP-000340	077	1	Clarification of FBI field	3.3.0	3.4.0
15/12/00	RAN_10	RP-000537	079	2	Clarification of downlink phase reference	3.4.0	3.5.0
15/12/00	RAN_10	RP-000537	083	1	DL Transmission in the case of invalid data frames	3.4.0	3.5.0
15/12/00	RAN_10	RP-000537	084	-	Clarification of figure 28	3.4.0	3.5.0
15/12/00	RAN_10	RP-000537	087	-	RACH message part length	3.4.0	3.5.0
15/12/00	RAN_10	RP-000537	088	-	Clarifications on power control preambles	3.4.0	3.5.0

CHANGE REQUEST

⌘ **25.212 CR 126** ⌘ rev **1** ⌘ Current version: **4.3.0** ⌘

For [HELP](#) on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.

Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ Changes to 25.212 for HSDPA work item		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ 22-Feb-02
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories:		Use <u>one</u> of the following releases:
	F (correction)	2 (GSM Phase 2)	
	A (corresponds to a correction in an earlier release)	R96 (Release 1996)	
	B (addition of feature),	R97 (Release 1997)	
	C (functional modification of feature)	R98 (Release 1998)	
	D (editorial modification)	R99 (Release 1999)	
	Detailed explanations of the above categories can be found in 3GPP TR 21.900 .		REL-4 (Release 4)
			REL-5 (Release 5)

Reason for change:	⌘ Embodies necessary changes for work item on HSDPA		
Summary of change:	⌘ Adds channel coding and multiplexing chain for HS-DSCH		
Consequences if not approved:	⌘ Work item HSDPA-Phys will not be implemented in TS 25.212 for REL-5.		

Clauses affected:	⌘ 3.3, 4.2, 4.5, 4.6, 4.7		
Other specs affected:	⌘ <input type="checkbox"/> Other core specifications	⌘	
	<input type="checkbox"/> Test specifications		
	<input type="checkbox"/> O&M Specifications		
Other comments:	⌘ Based on TR25.858 v1.0.4. Also uses tdocs 427, 234, 345, 260, 182, 463, 444, 482 and noting 273 from meeting RAN wg1#24.		

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- 3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

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Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document describes the characteristics of the Layer 1 multiplexing and channel coding in the FDD mode of UTRA.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

- [1] 3GPP TS 25.201: "Physical layer – General Description".
 - [2] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".
 - [3] 3GPP TS 25.213: "Spreading and modulation (FDD)".
 - [4] 3GPP TS 25.214: "Physical layer procedures (FDD)".
 - [5] 3GPP TS 25.215: "Physical layer – Measurements (FDD)".
 - [6] 3GPP TS 25.221: "Physical channels and mapping of transport channels onto physical channels (TDD)".
 - [7] 3GPP TS 25.222: "Multiplexing and channel coding (TDD)".
 - [8] 3GPP TS 25.223: "Spreading and modulation (TDD)".
 - [9] 3GPP TS 25.224: "Physical layer procedures (TDD)".
 - [10] 3GPP TS 25.225: "Physical layer – Measurements (TDD)".
 - [11] 3GPP TS 25.302: "Services Provided by the Physical Layer".
 - [12] 3GPP TS 25.402: "Synchronisation in UTRAN, Stage 2".
-

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

TG: Transmission Gap is consecutive empty slots that have been obtained with a transmission time reduction method. The transmission gap can be contained in one or two consecutive radio frames.

TGL: Transmission Gap Length is the number of consecutive empty slots that have been obtained with a transmission time reduction method. $0 \leq TGL \leq 14$. The CFNs of the radio frames containing the first empty slot of the transmission gaps, the CFNs of the radio frames containing the last empty slot, the respective positions N_{first} and N_{last} within these frames of the first and last empty slots of the transmission gaps, and the transmission gap lengths can be calculated with the compressed mode parameters described in [5].

TrCH number: Transport channel number represents a TrCH ID assigned to L1 by L2. Transport channels are multiplexed to the CCTrCH in the ascending order of these IDs.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

$\lceil x \rceil$	round towards ∞ , i.e. integer such that $x \leq \lceil x \rceil < x+1$
$\lfloor x \rfloor$	round towards $-\infty$, i.e. integer such that $x-1 < \lfloor x \rfloor \leq x$
$ x $	absolute value of x
$\text{sgn}(x)$	signum function, i.e. $\text{sgn}(x) = \begin{cases} 1; & x \geq 0 \\ -1; & x < 0 \end{cases}$
N_{first}	The first slot in the TG , located in the first compressed radio frame if the TG spans two frames.
N_{last}	The last slot in the TG , located in the second compressed radio frame if the TG spans two frames.
N_{tr}	Number of transmitted slots in a radio frame.

Unless otherwise is explicitly stated when the symbol is used, the meaning of the following symbols is:

i	TrCH number
j	TFC number
k	Bit number
l	TF number
m	Transport block number
n_i	Radio frame number of TrCH i .
p	PhCH number
r	Code block number
I	Number of TrCHs in a CCTrCH.
C_i	Number of code blocks in one TTI of TrCH i .
F_i	Number of radio frames in one TTI of TrCH i .
M_i	Number of transport blocks in one TTI of TrCH i .
$N_{data,j}$	Number of data bits that are available for the CCTrCH in a radio frame with TFC j .
$N_{data,j}^{cm}$	Number of data bits that are available for the CCTrCH in a compressed radio frame with TFC j .
P	Number of PhCHs used for one CCTrCH.
PL	Puncturing Limit for the uplink. Signalled from higher layers
RM_i	Rate Matching attribute for TrCH i . Signalled from higher layers.

Temporary variables, i.e. variables used in several (sub)clauses with different meaning.

x, X
 y, Y
 z, Z

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ARQ	Automatic Repeat Request
BCH	Broadcast Channel
BER	Bit Error Rate
BLER	Block Error Rate
BS	Base Station
CCPCH	Common Control Physical Channel
CCTrCH	Coded Composite Transport Channel
CFN	Connection Frame Number
CRC	Cyclic Redundancy Check
DCH	Dedicated Channel
DL	Downlink (Forward link)
DPCCH	Dedicated Physical Control Channel
DPCH	Dedicated Physical Channel

DPDCH	Dedicated Physical Data Channel
DS-CDMA	Direct-Sequence Code Division Multiple Access
DSCH	Downlink Shared Channel
DTX	Discontinuous Transmission
FACH	Forward Access Channel
FDD	Frequency Division Duplex
FER	Frame Error Rate
GF	Galois Field
HARQ	Hybrid Automatic Repeat reQuest
HS-DPCCH	Dedicated Physical Control Channel (uplink) for HS-DSCH
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	Shared Control Channel for HS-DSCH
MAC	Medium Access Control
Mcps	Mega Chip Per Second
MS	Mobile Station
OVSF	Orthogonal Variable Spreading Factor (codes)
PCCC	Parallel Concatenated Convolutional Code
PCH	Paging Channel
PhCH	Physical Channel
PRACH	Physical Random Access Channel
RACH	Random Access Channel
RSC	Recursive Systematic Convolutional Coder
RV	Redundancy Version
RX	Receive
SCH	Synchronisation Channel
SF	Spreading Factor
SFN	System Frame Number
SIR	Signal-to-Interference Ratio
SNR	Signal to Noise Ratio
TF	Transport Format
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TPC	Transmit Power Control
TrCH	Transport Channel
TTI	Transmission Time Interval
TX	Transmit
UL	Uplink (Reverse link)

4 Multiplexing, channel coding and interleaving

4.1 General

Data stream from/to MAC and higher layers (Transport block / Transport block set) is encoded/decoded to offer transport services over the radio transmission link. Channel coding scheme is a combination of error detection, error correcting, rate matching, interleaving and transport channels mapping onto/splitting from physical channels.

4.2 ~~Transport-channel~~General coding/multiplexing of TrCHs

This section only applies to the transport channels: DCH, RACH, CPCH, DSCH, BCH, FACH and PCH. Other transport channels which do not use the general method are described separately below.

Data arrives to the coding/multiplexing unit in form of transport block sets once every transmission time interval. The transmission time interval is transport-channel specific from the set {10 ms, 20 ms, 40 ms, 80 ms}.

The following coding/multiplexing steps can be identified:

- add CRC to each transport block (see subclause 4.2.1);

- transport block concatenation and code block segmentation (see subclause 4.2.2);
- channel coding (see subclause 4.2.3);
- radio frame equalisation (see subclause 4.2.4);
- rate matching (see subclause 4.2.7);
- insertion of discontinuous transmission (DTX) indication bits (see subclause 4.2.9);
- interleaving (two steps, see subclauses 4.2.5 and 4.2.11);
- radio frame segmentation (see subclause 4.2.6);
- multiplexing of transport channels (see subclause 4.2.8);
- physical channel segmentation (see subclause 4.2.10);
- mapping to physical channels (see subclause 4.2.12).

The coding/multiplexing steps for uplink and downlink are shown in figure 1 and figure 2 respectively.

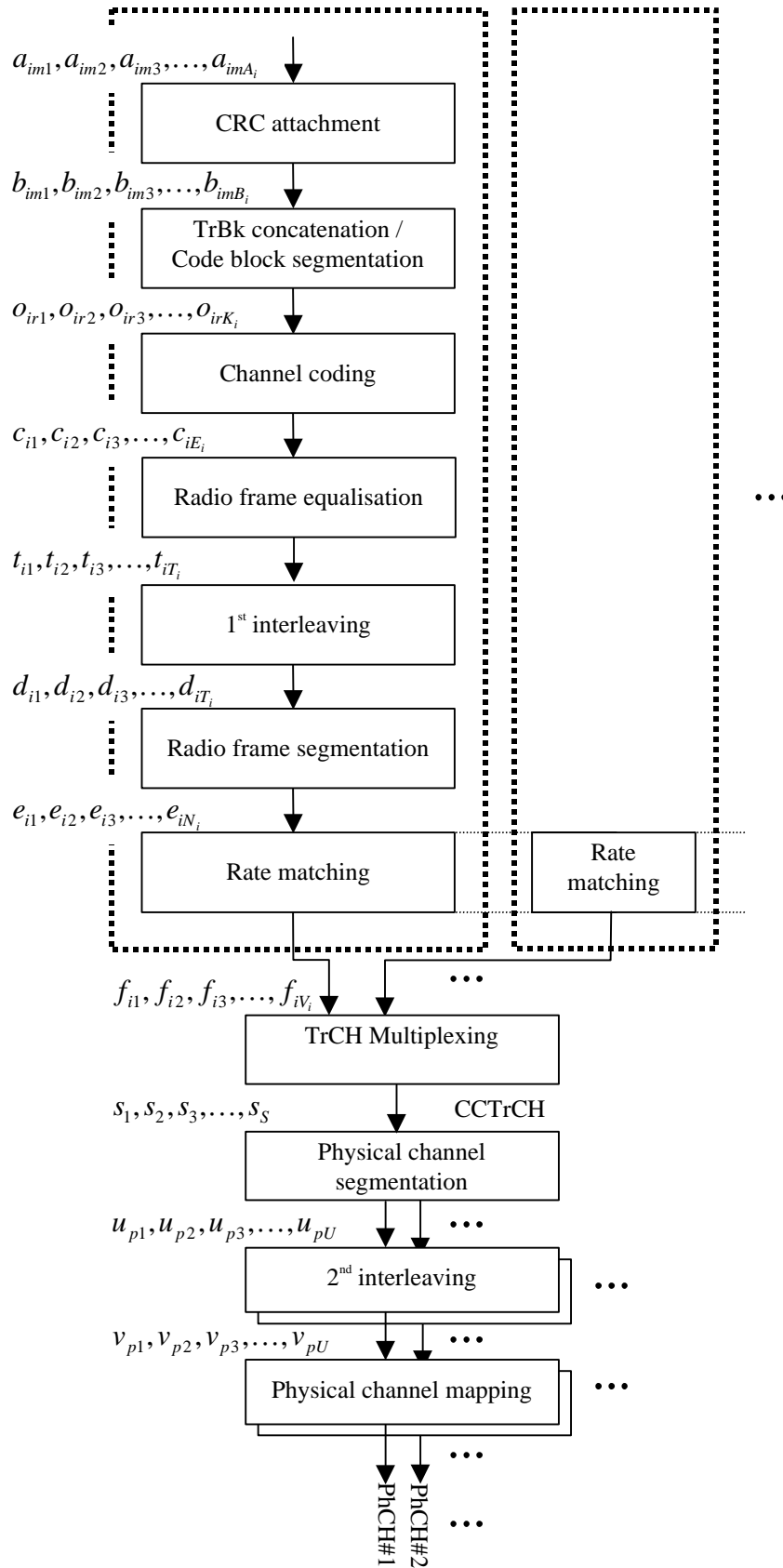


Figure 1: Transport channel multiplexing structure for uplink

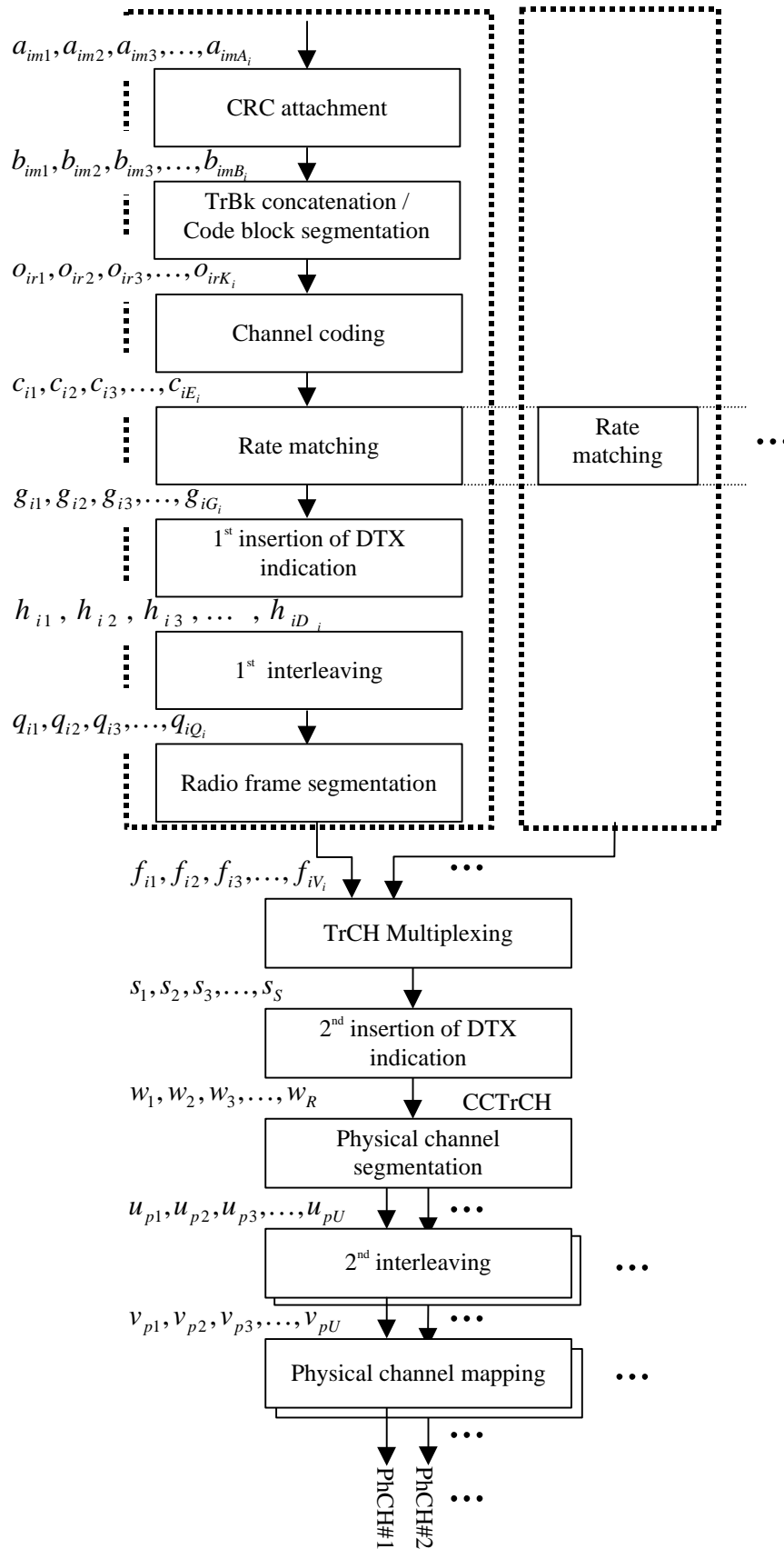


Figure 2: Transport channel multiplexing structure for downlink

The single output data stream from the TrCH multiplexing, including DTX indication bits in downlink, is denoted *Coded Composite Transport Channel (CCTrCH)*. A CCTrCH can be mapped to one or several physical channels.

4.2.1 CRC attachment

Error detection is provided on transport blocks through a Cyclic Redundancy Check (CRC). The size of the CRC is 24, 16, 12, 8 or 0 bits and it is signalled from higher layers what CRC size that should be used for each TrCH.

4.2.1.1 CRC Calculation

The entire transport block is used to calculate the CRC parity bits for each transport block. The parity bits are generated by one of the following cyclic generator polynomials:

- $g_{\text{CRC24}}(D) = D^{24} + D^{23} + D^6 + D^5 + D + 1$;
- $g_{\text{CRC16}}(D) = D^{16} + D^{12} + D^5 + 1$;
- $g_{\text{CRC12}}(D) = D^{12} + D^{11} + D^3 + D^2 + D + 1$;
- $g_{\text{CRC8}}(D) = D^8 + D^7 + D^4 + D^3 + D + 1$.

Denote the bits in a transport block delivered to layer 1 by $a_{im1}, a_{im2}, a_{im3}, \dots, a_{imA_i}$, and the parity bits by $p_{im1}, p_{im2}, p_{im3}, \dots, p_{imL_i}$. A_i is the size of a transport block of TrCH i , m is the transport block number, and L_i is the number of parity bits. L_i can take the values 24, 16, 12, 8, or 0 depending on what is signalled from higher layers.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial:

$$a_{im1}D^{A_i+23} + a_{im2}D^{A_i+22} + \dots + a_{imA_i}D^{24} + p_{im1}D^{23} + p_{im2}D^{22} + \dots + p_{im23}D^1 + p_{im24}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC24}}(D)$, polynomial:

$$a_{im1}D^{A_i+15} + a_{im2}D^{A_i+14} + \dots + a_{imA_i}D^{16} + p_{im1}D^{15} + p_{im2}D^{14} + \dots + p_{im15}D^1 + p_{im16}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC16}}(D)$, polynomial:

$$a_{im1}D^{A_i+11} + a_{im2}D^{A_i+10} + \dots + a_{imA_i}D^{12} + p_{im1}D^{11} + p_{im2}D^{10} + \dots + p_{im11}D^1 + p_{im12}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC12}}(D)$ and polynomial:

$$a_{im1}D^{A_i+7} + a_{im2}D^{A_i+6} + \dots + a_{imA_i}D^8 + p_{im1}D^7 + p_{im2}D^6 + \dots + p_{im7}D^1 + p_{im8}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC8}}(D)$.

If no transport blocks are input to the CRC calculation ($M_i = 0$), no CRC attachment shall be done. If transport blocks are input to the CRC calculation ($M_i \neq 0$) and the size of a transport block is zero ($A_i = 0$), CRC shall be attached, i.e. all parity bits equal to zero.

4.2.1.2 Relation between input and output of the CRC attachment block

The bits after CRC attachment are denoted by $b_{im1}, b_{im2}, b_{im3}, \dots, b_{imB_i}$, where $B_i = A_i + L_i$. The relation between a_{imk} and b_{imk} is:

$$b_{imk} = a_{imk} \quad k = 1, 2, 3, \dots, A_i$$

$$b_{imk} = p_{im(L_i+1-(k-A_i))} \quad k = A_i + 1, A_i + 2, A_i + 3, \dots, A_i + L_i$$

4.2.2 Transport block concatenation and code block segmentation

All transport blocks in a TTI are serially concatenated. If the number of bits in a TTI is larger than Z , the maximum size of a code block in question, then code block segmentation is performed after the concatenation of the transport blocks. The maximum size of the code blocks depends on whether convolutional coding, turbo coding or no coding is used for the TrCH.

4.2.2.1 Concatenation of transport blocks

The bits input to the transport block concatenation are denoted by $b_{im1}, b_{im2}, b_{im3}, \dots, b_{imB_i}$ where i is the TrCH number, m is the transport block number, and B_i is the number of bits in each block (including CRC). The number of transport blocks on TrCH i is denoted by M_i . The bits after concatenation are denoted by $x_{i1}, x_{i2}, x_{i3}, \dots, x_{iX_i}$, where i is the TrCH number and $X_i = M_i B_i$. They are defined by the following relations:

$$x_{ik} = b_{i1k} \quad k = 1, 2, \dots, B_i$$

$$x_{ik} = b_{i,2,(k-B_i)} \quad k = B_i + 1, B_i + 2, \dots, 2B_i$$

$$x_{ik} = b_{i,3,(k-2B_i)} \quad k = 2B_i + 1, 2B_i + 2, \dots, 3B_i$$

...

$$x_{ik} = b_{i,M_i,(k-(M_i-1)B_i)} \quad k = (M_i - 1)B_i + 1, (M_i - 1)B_i + 2, \dots, M_i B_i$$

4.2.2.2 Code block segmentation

Segmentation of the bit sequence from transport block concatenation is performed if $X_i > Z$. The code blocks after segmentation are of the same size. The number of code blocks on TrCH i is denoted by C_i . If the number of bits input to the segmentation, X_i , is not a multiple of C_i , filler bits are added to the beginning of the first block. If turbo coding is selected and $X_i < 40$, filler bits are added to the beginning of the code block. The filler bits are transmitted and they are always set to 0. The maximum code block sizes are:

- convolutional coding: $Z = 504$;
- turbo coding: $Z = 5114$;
- no channel coding: $Z = \text{unlimited}$.

The bits output from code block segmentation, for $C_i \neq 0$, are denoted by $o_{ir1}, o_{ir2}, o_{ir3}, \dots, o_{irK_i}$, where i is the TrCH number, r is the code block number, and K_i is the number of bits per code block.

Number of code blocks:

$$C_i = \begin{cases} \lceil X_i / Z \rceil & \text{when } Z \neq \text{unlimited} \\ 0 & \text{when } Z = \text{unlimited} \text{ and } X_i = 0 \\ 1 & \text{when } Z = \text{unlimited} \text{ and } X_i \neq 0 \end{cases}$$

Number of bits in each code block (applicable for $C_i \neq 0$ only):

if $X_i < 40$ and Turbo coding is used, then

$$K_i = 40$$

else

$$K_i = \lceil X_i / C_i \rceil$$

end if

Number of filler bits: $Y_i = C_i K_i - X_i$

for $k = 1$ to Y_i -- Insertion of filler bits

$o_{ilk} = 0$

end for

for $k = Y_i + 1$ to K_i

$o_{ilk} = x_{i,(k-Y_i)}$

end for

$r = 2$ -- Segmentation

while $r \leq C_i$

for $k = 1$ to K_i

$o_{irk} = x_{i,(k+(r-1)K_i-Y_i)} I$

end for

$r = r + 1$

end while

4.2.3 Channel coding

Code blocks are delivered to the channel coding block. They are denoted by $o_{ir1}, o_{ir2}, o_{ir3}, \dots, o_{irK_i}$, where i is the TrCH number, r is the code block number, and K_i is the number of bits in each code block. The number of code blocks on TrCH i is denoted by C_i . After encoding the bits are denoted by $y_{ir1}, y_{ir2}, y_{ir3}, \dots, y_{irY_i}$, where Y_i is the number of encoded bits. The relation between o_{irk} and y_{irk} and between K_i and Y_i is dependent on the channel coding scheme.

The following channel coding schemes can be applied to TrCHs:

- convolutional coding;
- turbo coding;
- no coding.

Usage of coding scheme and coding rate for the different types of TrCH is shown in table 1.

The values of Y_i in connection with each coding scheme:

- convolutional coding with rate 1/2: $Y_i = 2 * K_i + 16$; rate 1/3: $Y_i = 3 * K_i + 24$;
- turbo coding with rate 1/3: $Y_i = 3 * K_i + 12$;
- no coding: $Y_i = K_i$.

Table 1: Usage of channel coding scheme and coding rate

Type of TrCH	Coding scheme	Coding rate
BCH	Convolutional coding	1/2
PCH		
RACH		
CPCH, DCH, DSCH, FACH	Turbo coding	1/3, 1/2
	No coding	1/3

4.2.3.1 Convolutional coding

Convolutional codes with constraint length 9 and coding rates 1/3 and 1/2 are defined.

The configuration of the convolutional coder is presented in figure 3.

Output from the rate 1/3 convolutional coder shall be done in the order output0, output1, output2, output0, output1, output 2, output 0,...,output2. Output from the rate 1/2 convolutional coder shall be done in the order output 0, output 1, output 0, output 1, output 0, ..., output 1.

8 tail bits with binary value 0 shall be added to the end of the code block before encoding.

The initial value of the shift register of the coder shall be "all 0" when starting to encode the input bits.

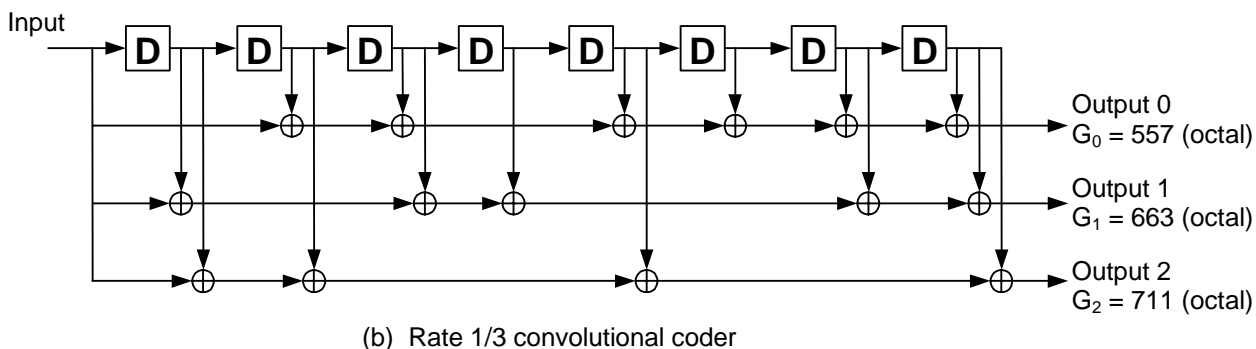
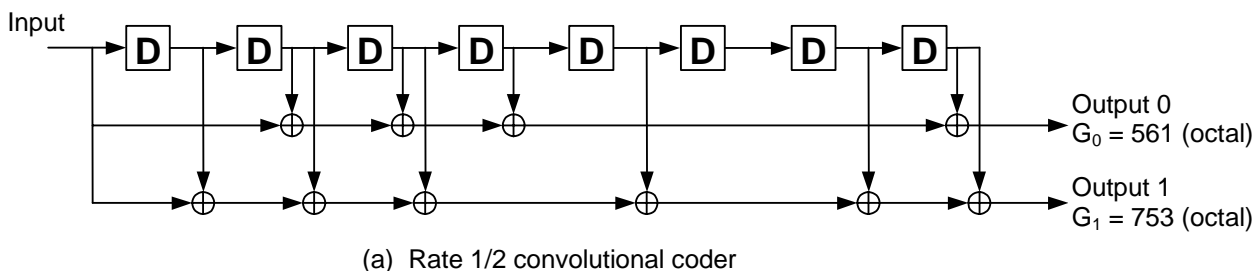


Figure 3: Rate 1/2 and rate 1/3 convolutional coders

4.2.3.2 Turbo coding

4.2.3.2.1 Turbo coder

The scheme of Turbo coder is a Parallel Concatenated Convolutional Code (PCCC) with two 8-state constituent encoders and one Turbo code internal interleaver. The coding rate of Turbo coder is 1/3. The structure of Turbo coder is illustrated in figure 4.

The transfer function of the 8-state constituent code for PCCC is:

$$G(D) = \left[1, \frac{g_1(D)}{g_0(D)} \right],$$

where

$$g_0(D) = 1 + D^2 + D^3,$$

$$g_1(D) = 1 + D + D^3.$$

The initial value of the shift registers of the 8-state constituent encoders shall be all zeros when starting to encode the input bits.

Output from the Turbo coder is

$$x_1, z_1, z'_1, x_2, z_2, z'_2, \dots, x_K, z_K, z'_K,$$

where x_1, x_2, \dots, x_K are the bits input to the Turbo coder i.e. both first 8-state constituent encoder and Turbo code internal interleaver, and K is the number of bits, and z_1, z_2, \dots, z_K and z'_1, z'_2, \dots, z'_K are the bits output from first and second 8-state constituent encoders, respectively.

The bits output from Turbo code internal interleaver are denoted by x'_1, x'_2, \dots, x'_K , and these bits are to be input to the second 8-state constituent encoder.

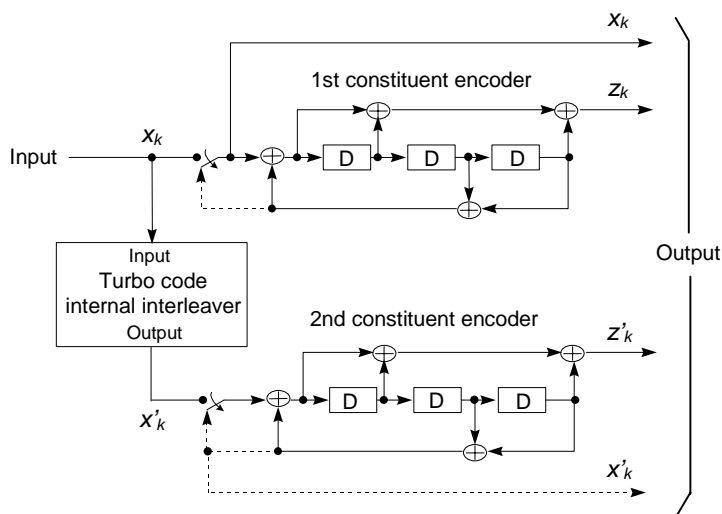


Figure 4: Structure of rate 1/3 Turbo coder (dotted lines apply for trellis termination only)

4.2.3.2.2 Trellis termination for Turbo coder

Trellis termination is performed by taking the tail bits from the shift register feedback after all information bits are encoded. Tail bits are padded after the encoding of information bits.

The first three tail bits shall be used to terminate the first constituent encoder (upper switch of figure 4 in lower position) while the second constituent encoder is disabled. The last three tail bits shall be used to terminate the second constituent encoder (lower switch of figure 4 in lower position) while the first constituent encoder is disabled.

The transmitted bits for trellis termination shall then be:

$$x_{K+1}, z_{K+1}, x_{K+2}, z_{K+2}, x_{K+3}, z_{K+3}, x'_{K+1}, z'_{K+1}, x'_{K+2}, z'_{K+2}, x'_{K+3}, z'_{K+3}.$$

4.2.3.2.3 Turbo code internal interleaver

The Turbo code internal interleaver consists of bits-input to a rectangular matrix with padding, intra-row and inter-row permutations of the rectangular matrix, and bits-output from the rectangular matrix with pruning. The bits input to the Turbo code internal interleaver are denoted by $x_1, x_2, x_3, \dots, x_K$, where K is the integer number of the bits and takes one value of $40 \leq K \leq 5114$. The relation between the bits input to the Turbo code internal interleaver and the bits input to the channel coding is defined by $x_k = o_{irk}$ and $K = K_i$.

The following subclause specific symbols are used in subclauses 4.2.3.2.3.1 to 4.2.3.2.3.3:

- K Number of bits input to Turbo code internal interleaver
- R Number of rows of rectangular matrix

C	Number of columns of rectangular matrix
p	Prime number
v	Primitive root
$\langle s(j) \rangle_{j \in \{0,1,\dots,p-2\}}$	Base sequence for intra-row permutation
q_i	Minimum prime integers
r_i	Permuted prime integers
$\langle T(i) \rangle_{i \in \{0,1,\dots,R-1\}}$	Inter-row permutation pattern
$\langle U_i(j) \rangle_{j \in \{0,1,\dots,C-1\}}$	Intra-row permutation pattern of i -th row
i	Index of row number of rectangular matrix
j	Index of column number of rectangular matrix
k	Index of bit sequence

4.2.3.2.3.1 Bits-input to rectangular matrix with padding

The bit sequence $x_1, x_2, x_3, \dots, x_K$ input to the Turbo code internal interleaver is written into the rectangular matrix as follows.

(1) Determine the number of rows of the rectangular matrix, R , such that:

$$R = \begin{cases} 5, & \text{if } (40 \leq K \leq 159) \\ 10, & \text{if } ((160 \leq K \leq 200) \text{ or } (481 \leq K \leq 530)) \\ 20, & \text{if } (K = \text{any other value}) \end{cases} .$$

The rows of rectangular matrix are numbered $0, 1, \dots, R - 1$ from top to bottom.

(2) Determine the prime number to be used in the intra-permutation, p , and the number of columns of rectangular matrix, C , such that:

if $(481 \leq K \leq 530)$ then

$$p = 53 \text{ and } C = p.$$

else

Find minimum prime number p from table 2 such that

$$K \leq R \times (p + 1),$$

and determine C such that

$$C = \begin{cases} p - 1 & \text{if } K \leq R \times (p - 1) \\ p & \text{if } R \times (p - 1) < K \leq R \times p \\ p + 1 & \text{if } R \times p < K \end{cases} .$$

end if

The columns of rectangular matrix are numbered $0, 1, \dots, C - 1$ from left to right.

Table 2: List of prime number p and associated primitive root v

p	v	p	v	p	v	p	v	p	v
7	3	47	5	101	2	157	5	223	3
11	2	53	2	103	5	163	2	227	2
13	2	59	2	107	2	167	5	229	6
17	3	61	2	109	6	173	2	233	3
19	2	67	2	113	3	179	2	239	7
23	5	71	7	127	3	181	2	241	7
29	2	73	5	131	2	191	19	251	6
31	3	79	3	137	3	193	5	257	3
37	2	83	2	139	2	197	2		
41	6	89	3	149	2	199	3		
43	3	97	5	151	6	211	2		

(3) Write the input bit sequence $x_1, x_2, x_3, \dots, x_K$ into the $R \times C$ rectangular matrix row by row starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} y_1 & y_2 & y_3 & \dots & y_C \\ y_{(C+1)} & y_{(C+2)} & y_{(C+3)} & \dots & y_{2C} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{((R-1)C+1)} & y_{((R-1)C+2)} & y_{((R-1)C+3)} & \dots & y_{R \times C} \end{bmatrix}$$

where $y_k = x_k$ for $k = 1, 2, \dots, K$ and if $R \times C > K$, the dummy bits are padded such that $y_k = 0$ or 1 for $k = K + 1, K + 2, \dots, R \times C$. These dummy bits are pruned away from the output of the rectangular matrix after intra-row and inter-row permutations.

4.2.3.2.3.2 Intra-row and inter-row permutations

After the bits-input to the $R \times C$ rectangular matrix, the intra-row and inter-row permutations for the $R \times C$ rectangular matrix are performed stepwise by using the following algorithm with steps (1) – (6):

(1) Select a primitive root v from table 2 in section 4.2.3.2.3.1, which is indicated on the right side of the prime number p .

(2) Construct the base sequence $\langle s(j) \rangle_{j \in \{0, 1, \dots, p-2\}}$ for intra-row permutation as:

$$s(j) = (v \times s(j-1)) \bmod p, \quad j = 1, 2, \dots, (p-2), \text{ and } s(0) = 1.$$

(3) Assign $q_0 = 1$ to be the first prime integer in the sequence $\langle q_i \rangle_{i \in \{0, 1, \dots, R-1\}}$, and determine the prime integer q_i in the sequence $\langle q_i \rangle_{i \in \{0, 1, \dots, R-1\}}$ to be a least prime integer such that $\text{g.c.d}(q_i, p-1) = 1$, $q_i > 6$, and $q_i > q_{(i-1)}$ for each $i = 1, 2, \dots, R-1$. Here g.c.d. is greatest common divisor.

(4) Permute the sequence $\langle q_i \rangle_{i \in \{0, 1, \dots, R-1\}}$ to make the sequence $\langle r_i \rangle_{i \in \{0, 1, \dots, R-1\}}$ such that

$$r_{T(i)} = q_i, \quad i = 0, 1, \dots, R-1,$$

where $\langle T(i) \rangle_{i \in \{0, 1, \dots, R-1\}}$ is the inter-row permutation pattern defined as the one of the four kind of patterns, which are shown in table 3, depending on the number of input bits K .

Table 3: Inter-row permutation patterns for Turbo code internal interleaver

Number of input bits K	Number of rows R	Inter-row permutation patterns $\langle T(0), T(1), \dots, T(R-1) \rangle$
$(40 \leq K \leq 159)$	5	$\langle 4, 3, 2, 1, 0 \rangle$
$(160 \leq K \leq 200)$ or $(481 \leq K \leq 530)$	10	$\langle 9, 8, 7, 6, 5, 4, 3, 2, 1, 0 \rangle$

$(2281 \leq K \leq 2480)$ or $(3161 \leq K \leq 3210)$	20	<19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 16, 13, 17, 15, 3, 1, 6, 11, 8, 10>
$K = \text{any other value}$	20	<19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 10, 8, 13, 17, 3, 1, 16, 6, 15, 11>

(5) Perform the i -th ($i = 0, 1, \dots, R - 1$) intra-row permutation as:

if ($C = p$) then

$$U_i(j) = s((j \times r_i) \bmod (p - 1)), \quad j = 0, 1, \dots, (p - 2), \text{ and } U_i(p - 1) = 0,$$

where $U_i(j)$ is the original bit position of j -th permuted bit of i -th row.

end if

if ($C = p + 1$) then

$$U_i(j) = s((j \times r_i) \bmod (p - 1)), \quad j = 0, 1, \dots, (p - 2). \quad U_i(p - 1) = 0, \text{ and } U_i(p) = p,$$

where $U_i(j)$ is the original bit position of j -th permuted bit of i -th row, and

if ($K = R \times C$) then

Exchange $U_{R-1}(p)$ with $U_{R-1}(0)$.

end if

end if

if ($C = p - 1$) then

$$U_i(j) = s((j \times r_i) \bmod (p - 1)) - 1, \quad j = 0, 1, \dots, (p - 2),$$

where $U_i(j)$ is the original bit position of j -th permuted bit of i -th row.

end if

(6) Perform the inter-row permutation for the rectangular matrix based on the pattern $\langle T(i) \rangle_{i \in \{0, 1, \dots, R-1\}}$,

where $T(i)$ is the original row position of the i -th permuted row.

4.2.3.2.3.3 Bits-output from rectangular matrix with pruning

After intra-row and inter-row permutations, the bits of the permuted rectangular matrix are denoted by y'_k :

$$\begin{bmatrix} y'_1 & y'_{(R+1)} & y'_{(2R+1)} & \cdots & y'_{((C-1)R+1)} \\ y'_2 & y'_{(R+2)} & y'_{(2R+2)} & \cdots & y'_{((C-1)R+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y'_R & y'_{2R} & y'_{3R} & \cdots & y'_{C \times R} \end{bmatrix}$$

The output of the Turbo code internal interleaver is the bit sequence read out column by column from the intra-row and inter-row permuted $R \times C$ rectangular matrix starting with bit y'_1 in row 0 of column 0 and ending with bit y'_{CR} in row $R - 1$ of column $C - 1$. The output is pruned by deleting dummy bits that were padded to the input of the rectangular matrix before intra-row and inter row permutations, i.e. bits y'_k that corresponds to bits y_k with $k > K$ are removed from the output. The bits output from Turbo code internal interleaver are denoted by x'_1, x'_2, \dots, x'_K , where x'_1 corresponds to the bit y'_k with smallest index k after pruning, x'_2 to the bit y'_k with second smallest index k after pruning, and so on. The number of bits output from Turbo code internal interleaver is K and the total number of pruned bits is:

$$R \times C - K.$$

4.2.3.3 Concatenation of encoded blocks

After the channel coding for each code block, if C_i is greater than 1, the encoded blocks are serially concatenated so that the block with lowest index r is output first from the channel coding block, otherwise the encoded block is output from channel coding block as it is. The bits output are denoted by $c_{i1}, c_{i2}, c_{i3}, \dots, c_{iE_i}$, where i is the TrCH number and $E_i = C_i Y_i$. The output bits are defined by the following relations:

$$c_{ik} = y_{i1k} \quad k = 1, 2, \dots, Y_i$$

$$c_{ik} = y_{i,2,(k-Y_i)} \quad k = Y_i + 1, Y_i + 2, \dots, 2Y_i$$

$$c_{ik} = y_{i,3,(k-2Y_i)} \quad k = 2Y_i + 1, 2Y_i + 2, \dots, 3Y_i$$

...

$$c_{ik} = y_{i,C_i,(k-(C_i-1)Y_i)} \quad k = (C_i - 1)Y_i + 1, (C_i - 1)Y_i + 2, \dots, C_i Y_i$$

If no code blocks are input to the channel coding ($C_i = 0$), no bits shall be output from the channel coding, i.e. $E_i = 0$.

4.2.4 Radio frame size equalisation

Radio frame size equalisation is padding the input bit sequence in order to ensure that the output can be segmented in F_i data segments of same size as described in subclause 4.2.7. Radio frame size equalisation is only performed in the UL.

The input bit sequence to the radio frame size equalisation is denoted by $c_{i1}, c_{i2}, c_{i3}, \dots, c_{iE_i}$, where i is TrCH number and E_i the number of bits. The output bit sequence is denoted by $t_{i1}, t_{i2}, t_{i3}, \dots, t_{iT_i}$, where T_i is the number of bits. The output bit sequence is derived as follows:

- $t_{ik} = c_{ik}$, for $k = 1 \dots E_i$; and
- $t_{ik} = \{0, 1\}$ for $k = E_i + 1 \dots T_i$, if $E_i < T_i$;

where

- $T_i = F_i * N_i$; and
- $N_i = \lceil E_i / F_i \rceil$ is the number of bits per segment after size equalisation.

4.2.5 1st interleaving

In Compressed Mode by puncturing, bits marked with a fourth value on top of $\{0, 1, \delta\}$ and noted p, are introduced in the radio frames to be compressed, in positions corresponding to the first bits of the radio frames. They will be removed in a later stage of the multiplexing chain to create the actual gap. Additional puncturing has been performed in the rate matching step, over the TTI containing the compressed radio frame, to create room for these p-bits. The following subclause describes this feature.

4.2.5.1 Insertion of marked bits in the sequence to be input in first interleaver

In normal mode, compressed mode by higher layer scheduling, and compressed mode by spreading factor reduction:

$$x_{i,k} = z_{i,k} \text{ and } X_i = Z_i$$

In case the TTI contains a radio frame that is compressed by puncturing and fixed positions are used, sequence $x_{i,k}$ which will be input to first interleaver for TrCH i and TTI m within largest TTI, is built from bits $z_{i,k}$, $k = 1, \dots, Z_i$, plus $Np_{i,\max}^{TTI,m}$ bits marked p and $X_i = Z_i + Np_{i,\max}^{TTI,m}$, as is described thereafter.

$Np_{i,\max}^{TTI,m}$ is defined in the Rate Matching subclause 4.2.7.

- (3) Write the input bit sequence into the $R1 \times C1$ matrix row by row starting with bit $x_{i,1}$ in column 0 of row 0 and ending with bit $x_{i,(R1 \times C1)}$ in column $C1 - 1$ of row $R1 - 1$:

$$\begin{bmatrix} x_{i,1} & x_{i,2} & x_{i,3} & \cdots & x_{i,C1} \\ x_{i,(C1+1)} & x_{i,(C1+2)} & x_{i,(C1+3)} & \cdots & x_{i,(2 \times C1)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ x_{i,((R1-1) \times C1+1)} & x_{i,((R1-1) \times C1+2)} & x_{i,((R1-1) \times C1+3)} & \cdots & x_{i,(R1 \times C1)} \end{bmatrix}$$

- (4) Perform the inter-column permutation for the matrix based on the pattern $\langle P1_{C1}(j) \rangle_{j \in \{0,1,\dots,C1-1\}}$ shown in table 4, where $P1_{C1}(j)$ is the original column position of the j -th permuted column. After permutation of the columns, the bits are denoted by y_{ik} :

$$\begin{bmatrix} y_{i,1} & y_{i,(R1+1)} & y_{i,(2 \times R1+1)} & \cdots & y_{i,((C1-1) \times R1+1)} \\ y_{i,2} & y_{i,(R1+2)} & y_{i,(2 \times R1+2)} & \cdots & y_{i,((C1-1) \times R1+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{i,R1} & y_{i,(2 \times R1)} & y_{i,(3 \times R1)} & \cdots & y_{i,(C1 \times R1)} \end{bmatrix}$$

- (5) Read the output bit sequence $y_{i,1}, y_{i,2}, y_{i,3}, \dots, y_{i,(C1 \times R1)}$ of the block interleaver column by column from the inter-column permuted $R1 \times C1$ matrix. Bit $y_{i,1}$ corresponds to row 0 of column 0 and bit $y_{i,(R1 \times C1)}$ corresponds to row $R1 - 1$ of column $C1 - 1$.

Table 4 Inter-column permutation patterns for 1st interleaving

TTI	Number of columns C1	Inter-column permutation patterns $\langle P1_{C1}(0), P1_{C1}(1), \dots, P1_{C1}(C1-1) \rangle$
10 ms	1	$\langle 0 \rangle$
20 ms	2	$\langle 0, 1 \rangle$
40 ms	4	$\langle 0, 2, 1, 3 \rangle$
80 ms	8	$\langle 0, 4, 2, 6, 1, 5, 3, 7 \rangle$

4.2.5.3 Relation between input and output of 1st interleaving in uplink

The bits input to the 1st interleaving are denoted by $t_{i,1}, t_{i,2}, t_{i,3}, \dots, t_{i,T_i}$, where i is the TrCH number and T_i the number of bits. Hence, $z_{i,k} = t_{i,k}$ and $Z_i = T_i$.

The bits output from the 1st interleaving are denoted by $d_{i,1}, d_{i,2}, d_{i,3}, \dots, d_{i,T_i}$, and $d_{i,k} = y_{i,k}$.

4.2.5.4 Relation between input and output of 1st interleaving in downlink

If fixed positions of the TrCHs in a radio frame is used then the bits input to the 1st interleaving are denoted by $h_{i,1}, h_{i,2}, h_{i,3}, \dots, h_{i,D_i}$, where i is the TrCH number. Hence, $z_{i,k} = h_{i,k}$ and $Z_i = D_i$.

If flexible positions of the TrCHs in a radio frame is used then the bits input to the 1st interleaving are denoted by $g_{i,1}, g_{i,2}, g_{i,3}, \dots, g_{i,G_i}$, where i is the TrCH number. Hence, $z_{i,k} = g_{i,k}$ and $Z_i = G_i$.

The bits output from the 1st interleaving are denoted by $q_{i,1}, q_{i,2}, q_{i,3}, \dots, q_{i,Q_i}$, where i is the TrCH number and Q_i is the number of bits. Hence, $q_{i,k} = y_{i,k}$, $Q_i = F_i H_i$ if fixed positions are used, and $Q_i = G_i$ if flexible positions are used.

4.2.6 Radio frame segmentation

When the transmission time interval is longer than 10 ms, the input bit sequence is segmented and mapped onto consecutive F_i radio frames. Following rate matching in the DL and radio frame size equalisation in the UL the input bit sequence length is guaranteed to be an integer multiple of F_i .

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \dots, x_{iX_i}$ where i is the TrCH number and X_i is the number bits. The F_i output bit sequences per TTI are denoted by $y_{i,n_i1}, y_{i,n_i2}, y_{i,n_i3}, \dots, y_{i,n_iY_i}$ where n_i is the radio frame number in current TTI and Y_i is the number of bits per radio frame for TrCH i . The output sequences are defined as follows:

$$y_{i,n_i,k} = x_{i,((n_i-1)Y_i)+k}, n_i = 1 \dots F_i, k = 1 \dots Y_i$$

where

$$Y_i = (X_i / F_i) \text{ is the number of bits per segment.}$$

The n_i -th segment is mapped to the n_i -th radio frame of the transmission time interval.

4.2.6.1 Relation between input and output of the radio frame segmentation block in uplink

The input bit sequence to the radio frame segmentation is denoted by $d_{i1}, d_{i2}, d_{i3}, \dots, d_{iT_i}$, where i is the TrCH number and T_i the number of bits. Hence, $x_{ik} = d_{ik}$ and $X_i = T_i$.

The output bit sequence corresponding to radio frame n_i is denoted by $e_{i1}, e_{i2}, e_{i3}, \dots, e_{iN_i}$, where i is the TrCH number and N_i is the number of bits. Hence, $e_{i,k} = y_{i,n_i,k}$ and $N_i = Y_i$.

4.2.6.2 Relation between input and output of the radio frame segmentation block in downlink

The bits input to the radio frame segmentation are denoted by $q_{i1}, q_{i2}, q_{i3}, \dots, q_{iQ_i}$, where i is the TrCH number and Q_i the number of bits. Hence, $x_{ik} = q_{ik}$ and $X_i = Q_i$.

The output bit sequence corresponding to radio frame n_i is denoted by $f_{i1}, f_{i2}, f_{i3}, \dots, f_{iV_i}$, where i is the TrCH number and V_i is the number of bits. Hence, $f_{i,k} = y_{i,n_i,k}$ and $V_i = Y_i$.

4.2.7 Rate matching

Rate matching means that bits on a transport channel are repeated or punctured. Higher layers assign a rate-matching attribute for each transport channel. This attribute is semi-static and can only be changed through higher layer signalling. The rate-matching attribute is used when the number of bits to be repeated or punctured is calculated.

The number of bits on a transport channel can vary between different transmission time intervals. In the downlink the transmission is interrupted if the number of bits is lower than maximum. When the number of bits between different transmission time intervals in uplink is changed, bits are repeated or punctured to ensure that the total bit rate after TrCH multiplexing is identical to the total channel bit rate of the allocated dedicated physical channels.

If no bits are input to the rate matching for all TrCHs within a CCTrCH, the rate matching shall output no bits for all TrCHs within the CCTrCH and no uplink DPDCH will be selected in the case of uplink rate matching.

Notation used in subclause 4.2.7 and subclauses:

$N_{i,j}$: For uplink: Number of bits in a radio frame before rate matching on TrCH i with transport format combination j .

For downlink: An intermediate calculation variable (not an integer but a multiple of 1/8).

- $N_{i,l}^{TTI}$: Number of bits in a transmission time interval before rate matching on TrCH i with transport format l .
Used in downlink only.
- $\Delta N_{i,j}$: For uplink: If positive - number of bits that should be repeated in each radio frame on TrCH i with transport format combination j .
If negative - number of bits that should be punctured in each radio frame on TrCH i with transport format combination j .
For downlink : An intermediate calculation variable (not an integer but a multiple of 1/8).
- $\Delta N_{i,l}^{TTI}$: If positive - number of bits to be repeated in each transmission time interval on TrCH i with transport format l .
If negative - number of bits to be punctured in each transmission time interval on TrCH i with transport format l .
Used in downlink only.
- $Np_{i,l}^{TTI,m}$, $m=0$ to $(F_{max}/F_i) - 1$: Positive or null: number of bits to be removed in TTI number m within the largest TTI, to create the required gaps in the compressed radio frames of this TTI, in case of compressed mode by puncturing, for TrCH i with transport format l . In case of fixed positions and compressed mode by puncturing, this value is noted $Np_{i,max}^{TTI,m}$ since it is calculated for all TrCH with their maximum number of bits; thus it is the same for all TFCs
Used in downlink only.
- $Np_{i,l}^n$, $n=0$ to $F_{max}-1$: Positive or null: number of bits, in radio frame number n within the largest TTI, corresponding to the gap for compressed mode in this radio frame, for TrCH i with transport format l . The value will be null for the radio frames not overlapping with a transmission gap. In case of fixed positions and compressed mode by puncturing, this value is noted $Np_{i,max}^n$ since it is calculated for all TrCHs with their maximum number of bits; thus it is the same for all TFCs
Used in downlink only.
- $N_{TGL}[k]$, $k=0$ to $F_{max}-1$: Positive or null: number of bits in each radio frame corresponding to the gap for compressed mode for the CCTrCH.
- RM_i : Semi-static rate matching attribute for transport channel i . RM_i is provided by higher layers or takes a value as indicated in section 4.2.13.
- PL : Puncturing limit for uplink. This value limits the amount of puncturing that can be applied in order to avoid multicode or to enable the use of a higher spreading factor. Signalled from higher layers. The allowed puncturing in % is actually equal to $(1-PL)*100$.
- $N_{data,j}$: Total number of bits that are available for the CCTrCH in a radio frame with transport format combination j .
- I : Number of TrCHs in the CCTrCH.
- $Z_{i,j}$: Intermediate calculation variable.
- F_i : Number of radio frames in the transmission time interval of TrCH i .
- F_{max} : Maximum number of radio frames in a transmission time interval used in the CCTrCH :
- $$F_{max} = \max_{1 \leq i \leq I} F_i$$
- n_i : Radio frame number in the transmission time interval of TrCH i ($0 \leq n_i < F_i$).

- q : Average puncturing or repetition distance (normalised to only show the remaining rate matching on top of an integer number of repetitions). Used in uplink only.
- $P1_F(n_i)$: The column permutation function of the 1st interleaver, $P1_F(x)$ is the original position of column with number x after permutation. $P1$ is defined on table 4 of section 4.2.5.2 (note that the $P1_F$ is self-inverse). Used for rate matching in uplink only.
- $S[n]$: The shift of the puncturing or repetition pattern for radio frame n_i when $n = P1_{F_i}(n_i)$. Used in uplink only.
- $TF_i(j)$: Transport format of TrCH i for the transport format combination j .
- $TFS(i)$: The set of transport format indexes l for TrCH i .
- $TFCS$: The set of transport format combination indexes j .
- e_{ini} : Initial value of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.5.
- e_{plus} : Increment of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.5.
- e_{minus} : Decrement of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.5.
- b : Indicates systematic and parity bits
- $b=1$: Systematic bit. x_k in subclause 4.2.3.2.1.
- $b=2$: 1st parity bit (from the upper Turbo constituent encoder). z_k in subclause 4.2.3.2.1.
- $b=3$: 2nd parity bit (from the lower Turbo constituent encoder). z'_k in subclause 4.2.3.2.1.

The * (star) notation is used to replace an index x when the indexed variable X_x does not depend on the index x . In the left wing of an assignment the meaning is that " $X_* = Y$ " is equivalent to "for all x do $X_x = Y$ ". In the right wing of an assignment, the meaning is that " $Y = X_*$ " is equivalent to "take any x and do $Y = X_x$ ".

The following relations, defined for all TFC j , are used when calculating the rate matching parameters:

$$Z_{0,j} = 0$$

$$Z_{i,j} = \left\lfloor \frac{\left(\left(\sum_{m=1}^i RM_m \times N_{m,j} \right) \times N_{data,j} \right)}{\sum_{m=1}^I RM_m \times N_{m,j}} \right\rfloor \text{ for all } i = 1 \dots I \quad (1)$$

$$\Delta N_{i,j} = Z_{i,j} - Z_{i-1,j} - N_{i,j} \text{ for all } i = 1 \dots I$$

4.2.7.1 Determination of rate matching parameters in uplink

4.2.7.1.1 Determination of SF and number of PhCHs needed

In uplink, puncturing can be applied to match the CCTrCH bit rate to the PhCH bit rate. The bit rate of the PhCH(s) is limited by the UE capability and restrictions imposed by UTRAN, through limitations on the PhCH spreading factor. The maximum amount of puncturing that can be applied is 1-PL, PL is signalled from higher layers. The number of available bits in the radio frames of one PhCH for all possible spreading factors is given in [2]. Denote these values by N_{256} , N_{128} , N_{64} , N_{32} , N_{16} , N_8 , and N_4 , where the index refers to the spreading factor. The possible number of bits available to the CCTrCH on all PhCHs, N_{data} , then are $\{ N_{256}, N_{128}, N_{64}, N_{32}, N_{16}, N_8, N_4, 2 \times N_4, 3 \times N_4, 4 \times N_4, 5 \times N_4, 6 \times N_4 \}$.

For a RACH CCTrCH SET0 represents the set of N_{data} values allowed by the UTRAN, as set by the minimum SF provided by higher layers. SET0 may be a sub-set of $\{ N_{256}, N_{128}, N_{64}, N_{32} \}$. SET0 does not take into account the UE's capability.

For other CCTrCHs, SET0 denotes the set of N_{data} values allowed by the UTRAN and supported by the UE, as part of the UE's capability. SET0 can be a subset of $\{N_{256}, N_{128}, N_{64}, N_{32}, N_{16}, N_8, N_4, 2 \times N_4, 3 \times N_4, 4 \times N_4, 5 \times N_4, 6 \times N_4\}$. $N_{data,j}$ for the transport format combination j is determined by executing the following algorithm:

$$\text{SET1} = \{ N_{data} \text{ in SET0 such that } \left(\min_{1 \leq y \leq I} \{ RM_y \} \right) \times N_{data} - \sum_{x=1}^I RM_x \times N_{x,j} \text{ is non negative} \}$$

If SET1 is not empty and the smallest element of SET1 requires just one PhCH then

$$N_{data,j} = \min \text{SET1}$$

else

$$\text{SET2} = \{ N_{data} \text{ in SET0 such that } \left(\min_{1 \leq y \leq I} \{ RM_y \} \right) \times N_{data} - PL \times \sum_{x=1}^I RM_x \times N_{x,j} \text{ is non negative} \}$$

Sort SET2 in ascending order

$$N_{data} = \min \text{SET2}$$

While N_{data} is not the max of SET2 and the follower of N_{data} requires no additional PhCH do

$$N_{data} = \text{follower of } N_{data} \text{ in SET2}$$

End while

$$N_{data,j} = N_{data}$$

End if

For a RACH CCTrCH, if $N_{data,j}$ is not part of the UE's capability then the TFC j cannot be used.

4.2.7.1.2 Determination of parameters needed for calculating the rate matching pattern

The number of bits to be repeated or punctured, $\Delta N_{i,j}$, within one radio frame for each TrCH i is calculated with equation 1 for all possible transport format combinations j and selected every radio frame. $N_{data,j}$ is given from subclause 4.2.7.1.1.

In a compressed radio frame, $N_{data,j}$ is replaced by $N_{data,j}^{cm}$ in Equation 1. $N_{data,j}^{cm}$ is given as follows:

In a radio frame compressed by higher layer scheduling, $N_{data,j}^{cm}$ is obtained by executing the algorithm in subclause

4.2.7.1.1 but with the number of bits in one radio frame of one PhCH reduced to $\frac{N_{tr}}{15}$ of the value in normal mode.

N_{tr} is the number of transmitted slots in a compressed radio frame and is defined by the following relation:

$$N_{tr} = \begin{cases} 15 - TGL, & \text{if } N_{first} + TGL \leq 15 \\ N_{first}, & \text{in first frame if } N_{first} + TGL > 15 \\ 30 - TGL - N_{first}, & \text{in second frame if } N_{first} + TGL > 15 \end{cases}$$

N_{first} and TGL are defined in subclause 4.4.

In a radio frame compressed by spreading factor reduction, $N_{data,j}^{cm} = 2 \times (N_{data,j} - N_{TGL})$, where

$$N_{TGL} = \frac{15 - N_{tr}}{15} \times N_{data,j}$$

If $\Delta N_{i,j} = 0$ then the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.5 does not need to be executed.

If $\Delta N_{i,j} \neq 0$ the parameters listed in subclauses 4.2.7.1.2.1 and 4.2.7.1.2.2 shall be used for determining e_{minus} , e_{plus} , and e_{minus} (regardless if the radio frame is compressed or not).

4.2.7.1.2.1 Uncoded and convolutionally encoded TrCHs

$R = \Delta N_{i,j} \bmod N_{i,j}$ -- note: in this context $\Delta N_{i,j} \bmod N_{i,j}$ is in the range of 0 to $N_{i,j}-1$ i.e. $-1 \bmod 10 = 9$.

if $R \neq 0$ and $2 \times R \leq N_{i,j}$

then $q = \lceil N_{i,j} / R \rceil$

else

$q = \lceil N_{i,j} / (R - N_{i,j}) \rceil$

endif

-- note: q is a signed quantity.

if q is even

then $q' = q + \text{gcd}(|q|, F_i) / F_i$ -- where $\text{gcd}(|q|, F_i)$ means greatest common divisor of $|q|$ and F_i

-- note that q' is not an integer, but a multiple of $1/8$

else

$q' = q$

endif

for $x = 0$ to $F_i - 1$

$S[\lfloor x \times q' \rfloor \bmod F_i] = (\lfloor x \times q' \rfloor \text{ div } F_i)$

end for

$\Delta N_i = \Delta N_{i,j}$

$a = 2$

For each radio frame, the rate-matching pattern is calculated with the algorithm in subclause 4.2.7.5, where :

$X_i = N_{i,j}$, and

$e_{\text{minus}} = (a \times S[\text{P1}_{F_i}(n_i)] \times |\Delta N_i| + 1) \bmod (a \cdot N_{i,j})$.

$e_{\text{plus}} = a \times N_{i,j}$

$e_{\text{minus}} = a \times |\Delta N_i|$

puncturing for $\Delta N < 0$, repetition otherwise.

4.2.7.1.2.2 Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{i,j} > 0$, the parameters in subclause 4.2.7.1.2.1 are used.

If puncturing is to be performed, the parameters below shall be used. Index b is used to indicate systematic ($b=1$), 1st parity ($b=2$), and 2nd parity bit ($b=3$).

$a=2$ when $b=2$

$a=1$ when $b=3$

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{i,j} / 2 \rfloor, & b = 2 \\ \lfloor \Delta N_{i,j} / 2 \rfloor, & b = 3 \end{cases}$$

If ΔN_i is calculated as 0 for $b=2$ or $b=3$, then the following procedure and the rate matching algorithm of subclause 4.2.7.5 don't need to be performed for the corresponding parity bit stream.

$$X_i = \lfloor N_{i,j} / 3 \rfloor,$$

$$q = \lfloor X_i / |\Delta N_i| \rfloor$$

if($q \leq 2$)

for $r=0$ to F_i-1

$$S[(3 \times r + b - 1) \bmod F_i] = r \bmod 2;$$

end for

else

if q is even

then $q' = q - \text{gcd}(q, F_i) / F_i$ -- where $\text{gcd}(q, F_i)$ means greatest common divisor of q and F_i
-- note that q' is not an integer, but a multiple of $1/8$

else $q' = q$

endif

for $x=0$ to $F_i - 1$

$$r = \lceil x \times q' \rceil \bmod F_i;$$

$$S[(3 \times r + b - 1) \bmod F_i] = \lceil x \times q' \rceil \text{div } F_i;$$

endfor

endif

For each radio frame, the rate-matching pattern is calculated with the algorithm in subclause 4.2.7.5, where:

X_i is as above:

$$e_{\text{ini}} = (a \times S[P1_{F_i}(n_i)] \times |\Delta N_i| + X_i) \bmod (a \times X_i), \text{ if } e_{\text{ini}} = 0 \text{ then } e_{\text{ini}} = a \times X_i$$

$$e_{\text{plus}} = a \times X_i$$

$$e_{\text{minus}} = a \times |\Delta N_i|$$

4.2.7.2 Determination of rate matching parameters in downlink

For downlink channels other than the downlink shared channel(s) (DSCH), $N_{\text{data},j}$ does not depend on the transport format combination j . $N_{\text{data},*}$ is given by the channelization code(s) assigned by higher layers.

Denote the number of physical channels used for the CCTrCH by P . $N_{\text{data},*}$ is the number of bits available to the CCTrCH in one radio frame and defined as $N_{\text{data},*} = P \times 15 \times (N_{\text{data}1} + N_{\text{data}2})$, where $N_{\text{data}1}$ and $N_{\text{data}2}$ are defined in [2]. Note that contrary to the uplink, the same rate matching patterns are used in TTIs containing no compressed radio frames and in TTIs containing radio frames compressed by spreading factor reduction or higher layer scheduling.

For a DSCH CCTrCH, different sets of channelisation codes may be configured by higher layers resulting in possibly multiple $N_{\text{data},*}$ values, where $N_{\text{data},*}$ is the number of bits available to the CCTrCH in one radio frame and is given by $N_{\text{data},*} = P \times 15 \times (N_{\text{data}1} + N_{\text{data}2})$, where $N_{\text{data}1}$ and $N_{\text{data}2}$ are defined in [2]. Each $N_{\text{data},*}$ corresponds to a sub-set of the Transport format combinations configured as part of the TFCS. For a DSCH CCTrCH only flexible positions apply. The rate matching calculations as specified in section 4.2.7.2.2 shall be performed for each $N_{\text{data},*}$, where the TFCS

taken into account in the calculations is restricted to the set of TFCs associated with $N_{data,*}$, as configured by higher layers. Therefore the amount of rate matching for a transport channel i for a TTI interval is a function of the $N_{data,*}$ value which shall be constant over the entire TTI as specified in section 4.2.14.

In the following, the total amount of puncturing or repetition for the TTI is calculated.

Additional calculations for TTIs containing radio frames compressed by puncturing in case fixed positions are used, are performed to determine this total amount of rate matching needed.

For compressed mode by puncturing, in TTIs where some compressed radio frames occur, the puncturing is increased or the repetition is decreased compared to what is calculated according to the rate matching parameters provided by higher layers. This allows to cope with reduction of available data bits on the physical channel(s) if the slot format for the compressed frame(s) contains fewer data bits than for the normal frames(s), and to create room for later insertion of marked bits, noted p-bits, which will identify the positions of the gaps in the compressed radio frames.

The amount of additional puncturing corresponds to the number of bits to create the gap in the TTI for TrCH i , plus the difference between the number of data bits available in normal frames and in compressed frames, due to slot format change. In case of fixed positions, it is calculated in addition to the amount of rate matching indicated by higher layers.

It is noted $Np_{i,max}^{TTI,m}$.

In fixed positions case, to obtain the total rate matching $\Delta N_{i,max}^{TTI,cm,m}$ to be performed on the TTI m , $Np_{i,max}^{TTI,m}$ is subtracted from $\Delta N_{i,max}^{TTI,m}$ (calculated based on higher layers RM parameters as for normal rate matching). This allows to create room for the $Np_{i,max}^{TTI,m}$ bits p to be inserted later. If the result is null, i.e. the amount of repetition matches exactly the amount of additional puncturing needed, then no rate matching is necessary.

In case of compressed mode by puncturing and fixed positions, for some calculations, $N'_{data,*}$ is used for radio frames with gap instead of $N_{data,*}$, where $N'_{data,*} = P \times 15 \times (N'_{data1} + N'_{data2})$. N'_{data1} and N'_{data2} are the number of bits in the data fields of the slot format used for the frames compressed by puncturing.

4.2.7.2.1 Determination of rate matching parameters for fixed positions of TrCHs

4.2.7.2.1.1 Calculation of $\Delta N_{i,max}$ for normal mode and compressed mode by spreading factor reduction

First an intermediate calculation variable $N_{i,*}$ is calculated for all transport channels i by the following formula:

$$N_{i,*} = \frac{1}{F_i} \times \left(\max_{l \in TFS(i)} N_{i,l}^{TTI} \right)$$

In order to compute the $\Delta N_{i,l}^{TTI}$ parameters for all TrCH i and all TF l , we first compute an intermediate parameter $\Delta N_{i,max}$ by the following formula, where $\Delta N_{i,*}$ is derived from $N_{i,*}$ by the formula given at subclause 4.2.7:

$$\Delta N_{i,max} = F_i \times \Delta N_{i,*}$$

If $\Delta N_{i,max} = 0$ then, for TrCH i , the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.5 does not need to be executed. In this case we have :

$$\forall l \in TFS(i) \Delta N_{i,l}^{TTI} = 0$$

If $\Delta N_{i,max} \neq 0$ the parameters listed in subclauses 4.2.7.2.1.3 and 4.2.7.2.1.4 shall be used for determining e_{ini} , e_{plus} , and e_{minus} and $\Delta N_{i,l}^{TTI}$.

4.2.7.2.1.2 Calculations for compressed mode by puncturing

Calculations of $\Delta N_{i,\max}^{TTI,m}$ for all TTI m within largest TTI, for all TrCH i

First an intermediate calculation variable $N_{i,*}$ is calculated for all transport channels i by the following formula:

$$N_{i,*} = \frac{1}{F_i} \times \left(\max_{l \in TFS(i)} N_{i,l}^{TTI} \right)$$

Then an intermediate calculation variable $\Delta N_{i,*}$ is derived from $N_{i,*}$ by the formula given at subclause 4.2.7, for all TrCH i .

In order to compute the $\Delta N_{i,l}^{TTI,m}$ parameters for all TrCH i , all TF l and all TTI with number m in the largest TTI, we first compute an intermediate parameter $\Delta N_{i,\max}^m$ by the following formula :

$$\Delta N_{i,\max}^m = F_i \times \Delta N_{i,*}$$

Calculations of $Np_{i,\max}^n$ and $Np_{i,\max}^{TTI,m}$

Let $Np_{i,\max}^n$ be the number of bits to eliminate on TrCH i to create the gap for compressed mode and to cope for the reduction of the number of available data bits in the compressed frame if the changed slot format contains fewer data bits than for normal frame, in each radio frame n of the TTI, calculated for the Transport Format Combination of TrCH i , in which the number of bits of TrCH i is at its maximum.

$Np_{i,\max}^n$ is calculated for each radio frame n of the TTI in the following way.

Intermediate variables Z_i for $i = 1$ to I are calculated using the formula (1) in 4.2.7, by replacing $N_{data,j}$ in the frames compressed by puncturing with $(N_{TGL}[n] + (N_{data,*} - N'_{data,*}))$.

The number of bits corresponding to the gap for TrCH i , in each radio frame of its TTI is calculated using the number of bits to remove on all Physical Channels $N_{TGL}[k]$, where k is the radio frame number in the largest TTI.

For each radio frame k of the largest TTI that is overlapping with a transmission gap, $N_{TGL}[k]$ is given by the relation:

$$N_{TGL} = \begin{cases} \frac{TGL}{15} \times N'_{data,*} & , \text{ if } N_{first} + TGL \leq 15 \\ \frac{15 - N_{first}}{15} \times N'_{data,*} & , \text{ in first radio frame of the gap if } N_{first} + TGL > 15 \\ \frac{TGL - (15 - N_{first})}{15} \times N'_{data,*} & , \text{ in second radio frame of the gap if } N_{first} + TGL > 15 \end{cases}$$

N_{first} and TGL are defined in subclause 4.4.

Note that $N_{TGL}[k] = 0$ if radio frame k is not overlapping with a transmission gap.

Then $Np_{i,\max}^n = (Z_i - Z_{i-1})$ for $i = 1$ to I

The total number of bits $Np_{i,\max}^{TTI,m}$ corresponding to the gaps for compressed mode for TrCH i in the TTI is calculated as:

$$Np_{i,\max}^{TTI,m} = \sum_{n=m \times F_i}^{n=(m+1) \times F_i - 1} Np_{i,\max}^n$$

The amount of rate matching $\Delta N_{i,\max}^{TTI,cm,m}$ for the highest TrCH bit rate is then computed by the following formula :

$$\Delta N_{i,\max}^{TTI,cm,m} = \Delta N_{i,\max}^m - Np_{i,\max}^{TTI,m}$$

If $\Delta N_{i,\max}^{TTI,cm,m} = 0$, then, for TrCH i , the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.5 does not need to be executed.

If $\Delta N_{i,\max}^{TTI,cm,m} \neq 0$, then, for TrCH i , the rate matching algorithm of subclause 4.2.7.5 needs to be executed, and the parameters listed in subclauses 4.2.7.2.1.3 and 4.2.7.2.1.4 shall be used for determining e_{ini} , e_{plus} , and e_{minus} , and $\Delta N_{i,l}^{TTI,m}$.

4.2.7.2.1.3 Determination of rate matching parameters for uncoded and convolutionally encoded TrCHs

$$\Delta N_i = \Delta N_{i,\max}$$

For compressed mode by puncturing, ΔN_i is defined as: $\Delta N_i = \Delta N_{i,\max}^{TTI,cm,m}$, instead of the previous relation.

$$a=2$$

$$N_{max} = \max_{l \in TFS(i)} N_{il}^{TTI}$$

For each transmission time interval of TrCH i with TF l , the rate-matching pattern is calculated with the algorithm in subclause 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI}$$

$$e_{ini} = 1$$

$$e_{plus} = a \times N_{max}$$

$$e_{minus} = a \times |\Delta N_i|$$

Puncturing if $\Delta N_i < 0$, repetition otherwise. The values of $\Delta N_{i,l}^{TTI}$ may be computed by counting repetitions or puncturing when the algorithm of subclause 4.2.7.5 is run. The resulting values of $\Delta N_{i,l}^{TTI}$ can be represented with following expression.

$$\Delta N_{i,l}^{TTI} = \left\lceil \frac{|\Delta N_i| \times X_i}{N_{max}} \right\rceil \times \text{sgn}(\Delta N_i)$$

For compressed mode by puncturing, the above formula produces $\Delta N_{i,l}^{TTI,m}$ instead of $\Delta N_{i,l}^{TTI}$.

4.2.7.2.1.4 Determination of rate matching parameters for Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{i,\max} > 0$, the parameters in subclause 4.2.7.2.1.3 are used.

If puncturing is to be performed, the parameters below shall be used. Index b is used to indicate systematic ($b=1$), 1st parity ($b=2$), and 2nd parity bit ($b=3$).

$$a=2 \text{ when } b=2$$

$$a=1 \text{ when } b=3$$

The bits indicated by $b=1$ shall not be punctured.

$$\Delta N_i^b = \begin{cases} \left\lfloor \frac{\Delta N_{i,max}}{2} \right\rfloor, & \text{for } b = 2 \\ \left\lceil \frac{\Delta N_{i,max}}{2} \right\rceil, & \text{for } b = 3 \end{cases}$$

In Compressed Mode by puncturing, the following relations are used instead of the previous ones:

$$\Delta N_i^b = \left\lfloor \frac{\Delta N_{i,max}^{TTI,cm,m}}{2} \right\rfloor, \text{ for } b=2$$

$$\Delta N_{i,l}^b = \left\lceil \frac{\Delta N_{i,max}^{TTI,cm,m}}{2} \right\rceil, \text{ for } b=3$$

$$N_{max} = \max_{l \in TFS(i)} (N_{il}^{TTI} / 3)$$

For each transmission time interval of TrCH i with TF l , the rate-matching pattern is calculated with the algorithm in subclause 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI} / 3$$

$$e_{ini} = N_{max}$$

$$e_{plus} = a \times N_{max}$$

$$e_{minus} = a \times |\Delta N_i^b|$$

The values of $\Delta N_{i,l}^{TTI}$ may be computed by counting puncturing when the algorithm of subclause 4.2.7.5 is run. The resulting values of $\Delta N_{i,l}^{TTI}$ can be represented with following expression.

$$\Delta N_{i,l}^{TTI} = - \left\lfloor \frac{|\Delta N_i^2| \times X_i}{N_{max}} + 0.5 \right\rfloor - \left\lfloor \frac{|\Delta N_i^3| \times X_i}{N_{max}} \right\rfloor$$

In the above equation, the first term of the right hand side represents the amount of puncturing for $b=2$ and the second term represents the amount of puncturing for $b=3$.

For compressed mode by puncturing, the above formula produces $\Delta N_{i,l}^{TTI,m}$ instead of $\Delta N_{i,l}^{TTI}$.

4.2.7.2.2 Determination of rate matching parameters for flexible positions of TrCHs

4.2.7.2.2.1 Calculations for normal mode, compressed mode by higher layer scheduling, and compressed mode by spreading factor reduction

First an intermediate calculation variable N_{ij} is calculated for all transport channels i and all transport format combinations j by the following formula:

$$N_{i,j} = \frac{1}{F_i} \times N_{i,TF_i(j)}^{TTI}$$

Then rate matching ratios RF_i are calculated for each the transport channel i in order to minimise the number of DTX bits when the bit rate of the CCTrCH is maximum. The RF_i ratios are defined by the following formula:

$$RF_i = \frac{N_{data,*}}{\max_{j \in TFCS} \sum_{i=1}^{i=I} (RM_i \times N_{i,j})} \times RM_i$$

The computation of $\Delta N_{i,l}^{TTI}$ parameters is then performed in two phases. In a first phase, tentative temporary values of $\Delta N_{i,l}^{TTI}$ are computed, and in the second phase they are checked and corrected. The first phase, by use of the RF_i ratios, ensures that the number of DTX indication bits inserted is minimum when the CCTrCH bit rate is maximum, but it does not ensure that the maximum CCTrCH bit rate is not greater than $N_{data,*}$ per 10ms. The latter condition is ensured through the checking and possible corrections carried out in the second phase.

At the end of the second phase, the latest value of $\Delta N_{i,l}^{TTI}$ is the definitive value.

The first phase defines the tentative temporary $\Delta N_{i,l}^{TTI}$ for all transport channel i and any of its transport format l by use of the following formula:

$$\Delta N_{i,l}^{TTI} = F_i \times \left[\frac{RF_i \times N_{i,l}^{TTI}}{F_i} \right] - N_{i,l}^{TTI} = F_i \times \left[\frac{N_{data,*} \times RM_i \times N_{i,l}^{TTI}}{F_i \times \max_{j \in TFCS} \sum_{i=1}^I (RM_i \times N_{i,j})} \right] - N_{i,l}^{TTI}$$

The second phase is defined by the following algorithm:

for all j in $TFCS$ in ascending order of TFCI do -- for all TFC

$$D = \sum_{i=1}^{i=I} \frac{N_{i,TF_i(j)}^{TTI} + \Delta N_{i,TF_i(j)}^{TTI}}{F_i} \quad \text{-- CCTrCH bit rate (bits per 10ms) for TFC } j$$

if $D > N_{data,*}$ then

for $i = 1$ to I do -- for all TrCH

$$\Delta N = F_i \times \Delta N_{i,j} \quad \text{-- } \Delta N_{i,j} \text{ is derived from } N_{i,j} \text{ by the formula given at subclause 4.2.7.}$$

if $\Delta N_{i,TF_i(j)}^{TTI} > \Delta N$ then

$$\Delta N_{i,TF_i(j)}^{TTI} = \Delta N$$

end-if

end-for

end-if

end-for

If $\Delta N_{i,l}^{TTI} = 0$ then, for TrCH i at TF l , the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.5 does not need to be executed.

If $\Delta N_{i,l}^{TTI} \neq 0$ the parameters listed in subclauses 4.2.7.2.2.2 and 4.2.7.2.2.3 shall be used for determining e_{minus} , e_{plus} , and e_{minus} .

4.2.7.2.2.2 Determination of rate matching parameters for uncoded and convolutionally encoded TrCHs

$$\Delta N_i = \Delta N_{il}^{TTI}$$

$$a=2$$

For each transmission time interval of TrCH i with TF l , the rate-matching pattern is calculated with the algorithm in subclause 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI}$$

$$e_{ini} = 1$$

$$e_{plus} = a \times N_{il}^{TTI}$$

$$e_{minus} = a \times |\Delta N_i|$$

puncturing for $\Delta N_i < 0$, repetition otherwise.

4.2.7.2.2.3 Determination of rate matching parameters for Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{il}^{TTI} > 0$, the parameters in subclause 4.2.7.2.2.2 are used.

If puncturing is to be performed, the parameters below shall be used. Index b is used to indicate systematic ($b=1$), 1st parity ($b=2$), and 2nd parity bit ($b=3$).

$$a=2 \text{ when } b=2$$

$$a=1 \text{ when } b=3$$

The bits indicated by $b=1$ shall not be punctured.

$$\Delta N_i = \begin{cases} \left\lfloor \frac{\Delta N_{il}^{TTI}}{2} \right\rfloor, & b = 2 \\ \left\lfloor \frac{\Delta N_{il}^{TTI}}{2} \right\rfloor, & b = 3 \end{cases}$$

For each transmission time interval of TrCH i with TF l , the rate-matching pattern is calculated with the algorithm in subclause 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI} / 3,$$

$$e_{ini} = X_i,$$

$$e_{plus} = a \times X_i$$

$$e_{minus} = a \times |\Delta N_i|$$

4.2.7.3 Bit separation and collection in uplink

The systematic bits of turbo encoded TrCHs shall not be punctured, the other bits may be punctured. The systematic bits, first parity bits, and second parity bits in the bit sequence input to the rate matching block are therefore separated into three sequences.

The first sequence contains:

- All of the systematic bits that are from turbo encoded TrCHs.

- From 0 to 2 first and/or second parity bits that are from turbo encoded TrCHs. These bits come into the first sequence when the total number of bits in a block after radio frame segmentation is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The second sequence contains:

- All of the first parity bits that are from turbo encoded TrCHs, except those that go into the first sequence when the total number of bits is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The third sequence contains:

- All of the second parity bits that are from turbo encoded TrCHs, except those that go into the first sequence when the total number of bits is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The second and third sequences shall be of equal length, whereas the first sequence can contain from 0 to 2 more bits. Puncturing is applied only to the second and third sequences. The bit separation function is transparent for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition. The bit separation and bit collection are illustrated in figures 5 and 6.

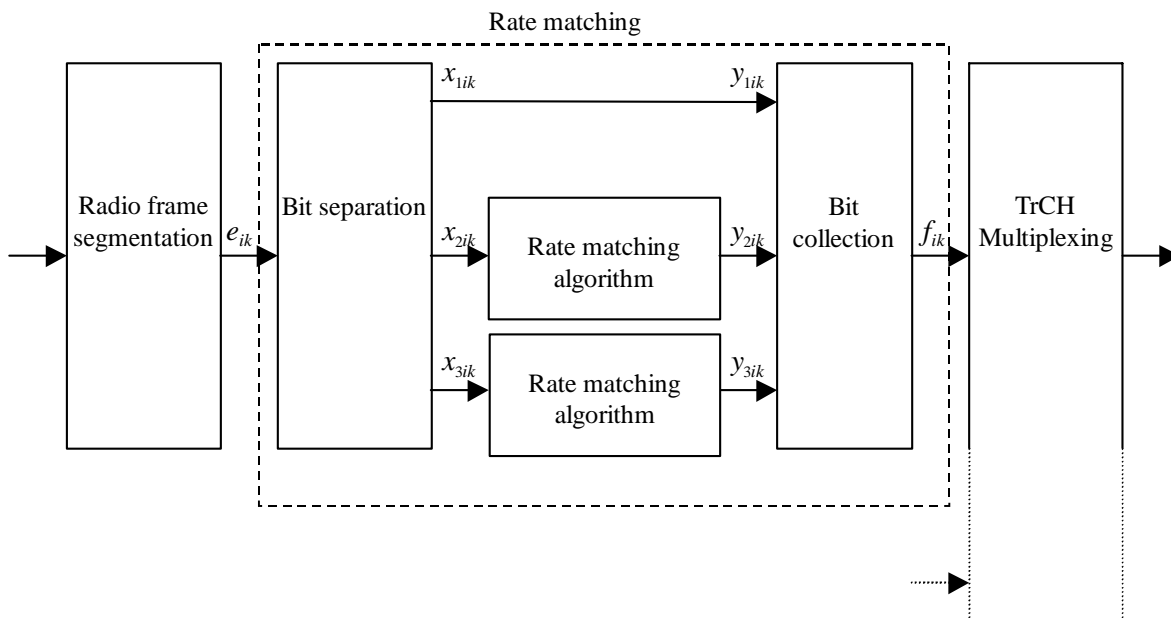


Figure 5: Puncturing of turbo encoded TrCHs in uplink

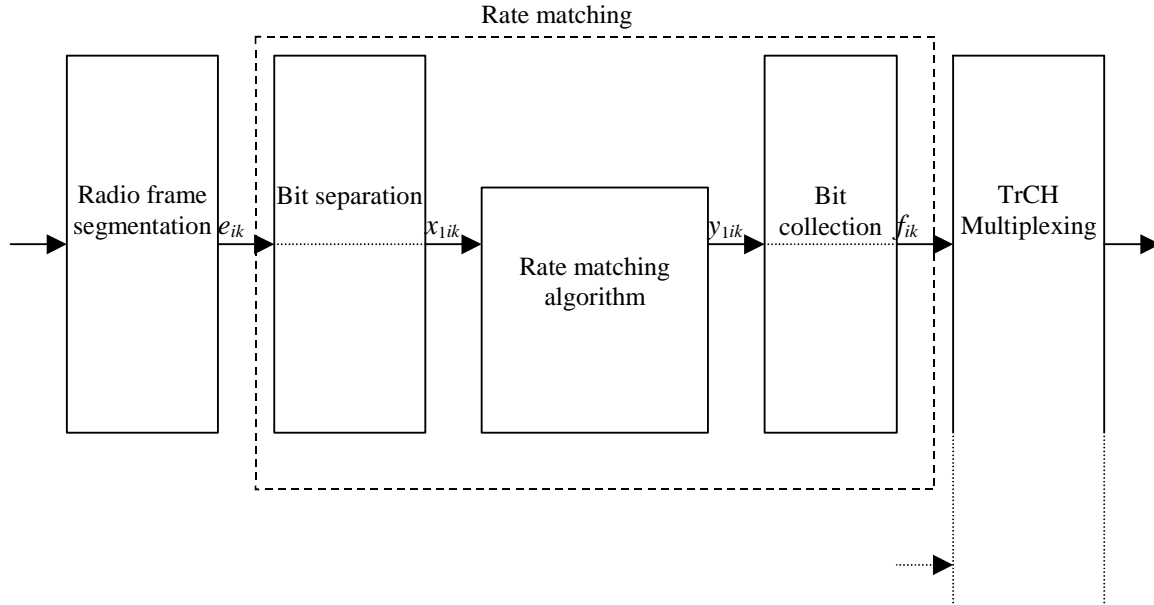


Figure 6: Rate matching for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition in uplink

The bit separation is dependent on the 1st interleaving and offsets are used to define the separation for different TTIs. b indicates the three sequences defined in this section, with $b=1$ indicating the first sequence, $b = 2$ the second one, and $b = 3$ the third one. The offsets α_b for these sequences are listed in table 5.

Table 5: TTI dependent offset needed for bit separation

TTI (ms)	α_1	α_2	α_3
10, 40	0	1	2
20, 80	0	2	1

The bit separation is different for different radio frames in the TTI. A second offset is therefore needed. The radio frame number for TrCH i is denoted by n_i . and the offset by β_{n_i} .

Table 6: Radio frame dependent offset needed for bit separation

TTI (ms)	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7
10	0	NA	NA	NA	NA	NA	NA	NA
20	0	1	NA	NA	NA	NA	NA	NA
40	0	1	2	0	NA	NA	NA	NA
80	0	1	2	0	1	2	0	1

4.2.7.3.1 Bit separation

The bits input to the rate matching are denoted by $e_{i1}, e_{i2}, e_{i3}, \dots, e_{iN_i}$, where i is the TrCH number and N_i is the number of bits input to the rate matching block. Note that the transport format combination number j for simplicity has been left out in the bit numbering, i.e. $N_i=N_{ij}$. The bits after separation are denoted by $x_{bi1}, x_{bi2}, x_{bi3}, \dots, x_{biX_i}$. For turbo encoded TrCHs with puncturing, b indicates the three sequences defined in section 4.2.7.3, with $b=1$ indicating the first sequence, and so forth. For all other cases b is defined to be 1. X_i is the number of bits in each separated bit sequence. The relation between e_{ik} and x_{bik} is given below.

For turbo encoded TrCHs with puncturing:

$$x_{1,i,k} = e_{i,3(k-1)+1+(\alpha_1+\beta_{n_i})\text{mod}3} \quad k = 1, 2, 3, \dots, X_i \quad X_i = \lfloor N_i / 3 \rfloor$$

$$x_{1,i,\lfloor N_i/3 \rfloor+k} = e_{i,3\lfloor N_i/3 \rfloor+k} \quad k = 1, \dots, N_i \bmod 3 \quad \text{Note: When } (N_i \bmod 3) = 0 \text{ this row is not needed.}$$

$$x_{2,i,k} = e_{i,3(k-1)+1+(\alpha_2+\beta_{n_i}) \bmod 3} \quad k = 1, 2, 3, \dots, X_i \quad X_i = \lfloor N_i/3 \rfloor$$

$$x_{3,i,k} = e_{i,3(k-1)+1+(\alpha_3+\beta_{n_i}) \bmod 3} \quad k = 1, 2, 3, \dots, X_i \quad X_i = \lfloor N_i/3 \rfloor$$

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$$x_{1,i,k} = e_{i,k} \quad k = 1, 2, 3, \dots, X_i \quad X_i = N_i$$

4.2.7.3.2 Bit collection

The bits x_{bik} are input to the rate matching algorithm described in subclause 4.2.7.5. The bits output from the rate matching algorithm are denoted $y_{bi1}, y_{bi2}, y_{bi3}, \dots, y_{biY_i}$.

Bit collection is the inverse function of the separation. The bits after collection are denoted by $z_{bi1}, z_{bi2}, z_{bi3}, \dots, z_{biY_i}$. After bit collection, the bits indicated as punctured are removed and the bits are then denoted by $f_{i1}, f_{i2}, f_{i3}, \dots, f_{iV_i}$, where i is the TrCH number and $V_i = N_i + \Delta N_{ij}$. The relations between y_{bik}, z_{bik} , and f_{ik} are given below.

For turbo encoded TrCHs with puncturing ($Y_i = X_i$):

$$z_{i,3(k-1)+1+(\alpha_1+\beta_{n_i}) \bmod 3} = y_{1,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

$$z_{i,3\lfloor N_i/3 \rfloor+k} = y_{1,i,\lfloor N_i/3 \rfloor+k} \quad k = 1, \dots, N_i \bmod 3 \quad \text{Note: When } (N_i \bmod 3) = 0 \text{ this row is not needed.}$$

$$z_{i,3(k-1)+1+(\alpha_2+\beta_{n_i}) \bmod 3} = y_{2,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

$$z_{i,3(k-1)+1+(\alpha_3+\beta_{n_i}) \bmod 3} = y_{3,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

After the bit collection, bits $z_{i,k}$ with value δ , where $\delta \notin \{0, 1\}$, are removed from the bit sequence. Bit $f_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $f_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$$z_{i,k} = y_{1,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

When repetition is used, $f_{i,k} = z_{i,k}$ and $Y_i = V_i$.

When puncturing is used, $Y_i = X_i$ and bits $z_{i,k}$ with value δ , where $\delta \notin \{0, 1\}$, are removed from the bit sequence. Bit $f_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $f_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

4.2.7.4 Bit separation and collection in downlink

The systematic bits of turbo encoded TrCHs shall not be punctured, the other bits may be punctured.

The systematic bits, first parity bits and second parity bits in the bit sequence input to the rate matching block are therefore separated into three sequences of equal lengths.

The first sequence contains :

- All of the systematic bits that are from turbo encoded TrCHs.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The second sequence contains:

- All of the first parity bits that are from turbo encoded TrCHs.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The third sequence contains:

- All of the second parity bits that are from turbo encoded TrCHs.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

Puncturing is applied only to the second and third sequences.

The bit separation function is transparent for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition. The bit separation and bit collection are illustrated in figures 7 and 8.

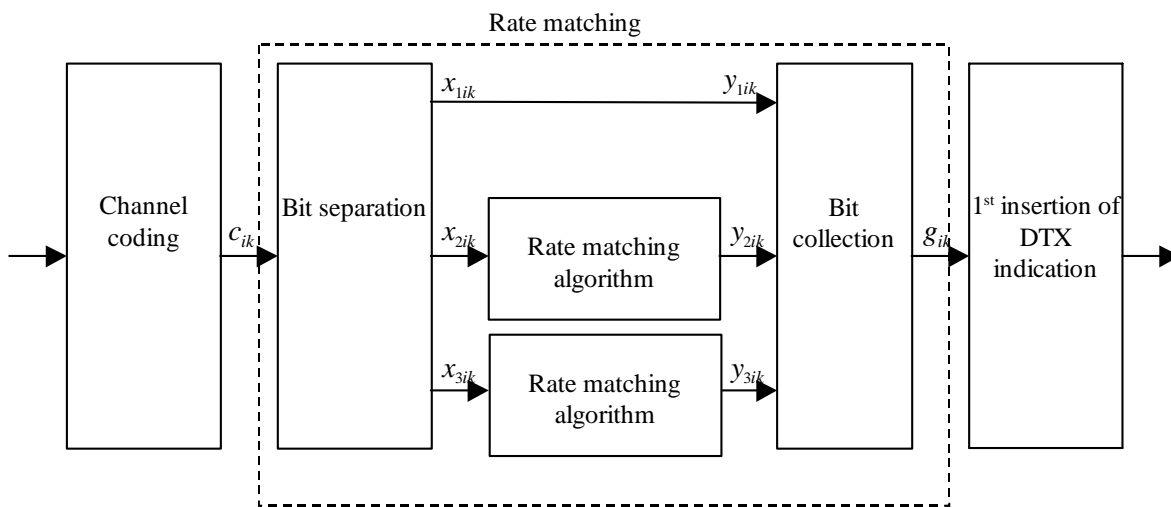


Figure 7: Puncturing of turbo encoded TrCHs in downlink

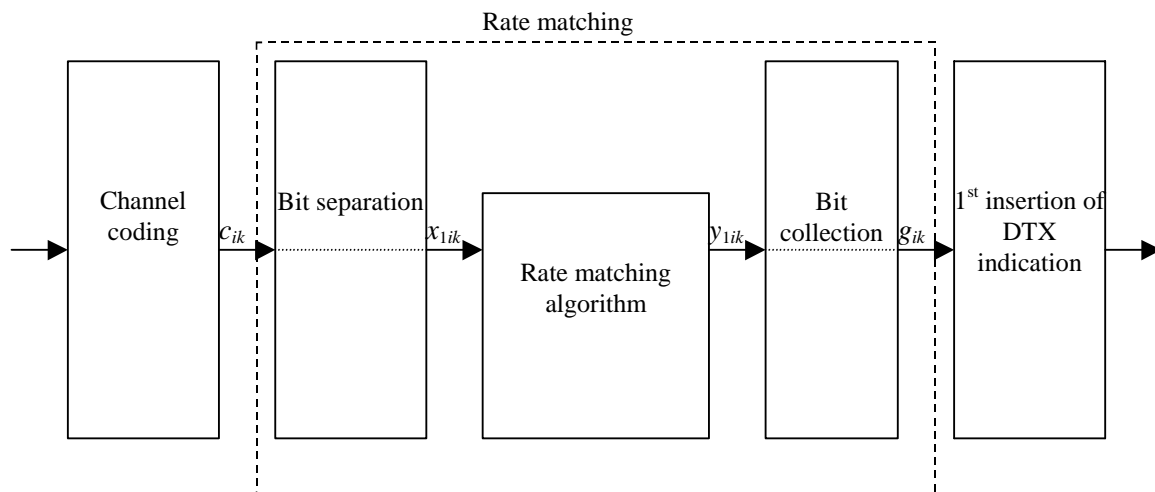


Figure 8: Rate matching for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition in downlink

4.2.7.4.1 Bit separation

The bits input to the rate matching are denoted by $c_{i1}, c_{i2}, c_{i3}, \dots, c_{iE_i}$, where i is the TrCH number and E_i is the number of bits input to the rate matching block. Note that E_i is a multiple of 3 for turbo encoded TrCHs and that the transport format l for simplicity has been left out in the bit numbering, i.e. $E_i = N_{il}^{TTI}$. The bits after separation are

denoted by $x_{bi1}, x_{bi2}, x_{bi3}, \dots, x_{biX_i}$. For turbo encoded TrCHs with puncturing, b indicates the three sequences defined in section 4.2.7.4, with $b=1$ indicating the first sequence, and so forth. For all other cases b is defined to be 1. X_i is the number of bits in each separated bit sequence. The relation between c_{ik} and x_{bik} is given below.

For turbo encoded TrCHs with puncturing:

$$x_{1,i,k} = c_{i,3(k-1)+1} \quad k = 1, 2, 3, \dots, X_i \quad X_i = E_i/3$$

$$x_{2,i,k} = c_{i,3(k-1)+2} \quad k = 1, 2, 3, \dots, X_i \quad X_i = E_i/3$$

$$x_{3,i,k} = c_{i,3(k-1)+3} \quad k = 1, 2, 3, \dots, X_i \quad X_i = E_i/3$$

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$$x_{1,i,k} = c_{i,k} \quad k = 1, 2, 3, \dots, X_i \quad X_i = E_i$$

4.2.7.4.2 Bit collection

The bits x_{bik} are input to the rate matching algorithm described in subclause 4.2.7.5. The bits output from the rate matching algorithm are denoted $y_{bi1}, y_{bi2}, y_{bi3}, \dots, y_{biY_i}$.

Bit collection is the inverse function of the separation. The bits after collection are denoted by $z_{bi1}, z_{bi2}, z_{bi3}, \dots, z_{biY_i}$.

After bit collection, the bits indicated as punctured are removed and the bits are then denoted by $g_{i1}, g_{i2}, g_{i3}, \dots, g_{iG_i}$,

where i is the TrCH number and $G_i = N_{il}^{TTI} + \Delta N_{il}^{TTI}$. The relations between y_{bik} , z_{bik} , and g_{ik} are given below.

For turbo encoded TrCHs with puncturing ($Y_i=X_i$):

$$z_{i,3(k-1)+1} = y_{1,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

$$z_{i,3(k-1)+2} = y_{2,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

$$z_{i,3(k-1)+3} = y_{3,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

After the bit collection, bits $z_{i,k}$ with value δ , where $\delta \notin \{0, 1\}$, are removed from the bit sequence. Bit $g_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $g_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$$z_{i,k} = y_{1,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

When repetition is used, $g_{i,k}=z_{i,k}$ and $Y_i=G_i$.

When puncturing is used, $Y_i=X_i$ and bits $z_{i,k}$ with value δ , where $\delta \notin \{0, 1\}$, are removed from the bit sequence. Bit $g_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $g_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

4.2.7.5 Rate matching pattern determination

Denote the bits before rate matching by:

$x_{i1}, x_{i2}, x_{i3}, \dots, x_{iX_i}$, where i is the TrCH number and the sequence is defined in 4.2.7.3 for uplink or in 4.2.7.4 for downlink. Parameters X_i , e_{ini} , e_{plus} , and e_{minus} are given in 4.2.7.1 for uplink or in 4.2.7.2 for downlink.

The rate matching rule is as follows:

if puncturing is to be performed

$e = e_{ini}$ -- initial error between current and desired puncturing ratio

$m = 1$ -- index of current bit

do while $m \leq X_i$

$e = e - e_{minus}$ -- update error

if $e \leq 0$ then -- check if bit number m should be punctured

 set bit $x_{i,m}$ to δ where $\delta \in \{0, 1\}$

$e = e + e_{plus}$ -- update error

end if

$m = m + 1$ -- next bit

end do

else

$e = e_{ini}$ -- initial error between current and desired puncturing ratio

$m = 1$ -- index of current bit

do while $m \leq X_i$

$e = e - e_{minus}$ -- update error

do while $e \leq 0$ -- check if bit number m should be repeated

 repeat bit $x_{i,m}$

$e = e + e_{plus}$ -- update error

end do

$m = m + 1$ -- next bit

end do

end if

A repeated bit is placed directly after the original one.

4.2.8 TrCH multiplexing

Every 10 ms, one radio frame from each TrCH is delivered to the TrCH multiplexing. These radio frames are serially multiplexed into a coded composite transport channel (CCTrCH).

The bits input to the TrCH multiplexing are denoted by $f_{i1}, f_{i2}, f_{i3}, \dots, f_{iV_i}$, where i is the TrCH number and V_i is the number of bits in the radio frame of TrCH i . The number of TrCHs is denoted by I . The bits output from TrCH multiplexing are denoted by $s_1, s_2, s_3, \dots, s_S$, where S is the number of bits, i.e. $S = \sum_i V_i$. The TrCH multiplexing is defined by the following relations:

$$s_k = f_{1k} \quad k = 1, 2, \dots, V_1$$

$$s_k = f_{2,(k-V_1)} \quad k = V_1+1, V_1+2, \dots, V_1+V_2$$

$$s_k = f_{3,(k-(V_1+V_2))} \quad k = (V_1+V_2)+1, (V_1+V_2)+2, \dots, (V_1+V_2)+V_3$$

...

$$s_k = f_{I,(k-(V_1+V_2+\dots+V_{I-1}))} \quad k = (V_1+V_2+\dots+V_{I-1})+1, (V_1+V_2+\dots+V_{I-1})+2, \dots, (V_1+V_2+\dots+V_{I-1})+V_I$$

4.2.9 Insertion of discontinuous transmission (DTX) indication bits

In the downlink, DTX is used to fill up the radio frame with bits. The insertion point of DTX indication bits depends on whether fixed or flexible positions of the TrCHs in the radio frame are used. It is up to the UTRAN to decide for each CTrCH whether fixed or flexible positions are used during the connection. DTX indication bits only indicate when the transmission should be turned off, they are not transmitted.

4.2.9.1 1st insertion of DTX indication bits

This step of inserting DTX indication bits is used only if the positions of the TrCHs in the radio frame are fixed. With fixed position scheme a fixed number of bits is reserved for each TrCH in the radio frame.

The bits from rate matching are denoted by $g_{i1}, g_{i2}, g_{i3}, \dots, g_{iG_i}$, where G_i is the number of bits in one TTI of TrCH i . Denote the number of bits in one radio frame of TrCH i by H_i . Denote D_i the number of bits output of the first DTX insertion block.

In TTIs containing no compressed frames or frames compressed by spreading factor reduction, H_i is constant and corresponds to the maximum number of bits from TrCH i in one radio frame for any transport format of TrCH i and $D_i = F_i \times H_i$.

In TTIs containing frames compressed by puncturing, additional puncturing is performed in the rate matching block. The empty positions resulting from the additional puncturing are used to insert p-bits in the first interleaving block, the DTX insertion is therefore limited to allow for later insertion of p-bits. Thus DTX bits are inserted until the total number of bits is D_i where $D_i = F_i \times H_i - Np^{TTI, m}_{i, max}$ and $H_i = N_{i,*} + \Delta N_{i,*}$.

The bits output from the DTX insertion are denoted by $h_{i1}, h_{i2}, h_{i3}, \dots, h_{iD_i}$. Note that these bits are three valued. They are defined by the following relations:

$$h_{ik} = g_{ik} \quad k = 1, 2, 3, \dots, G_i$$

$$h_{ik} = \delta \quad k = G_i+1, G_i+2, G_i+3, \dots, D_i$$

where DTX indication bits are denoted by δ . Here $g_{ik} \in \{0, 1\}$ and $\delta \notin \{0, 1\}$.

4.2.9.2 2nd insertion of DTX indication bits

The DTX indication bits inserted in this step shall be placed at the end of the radio frame. Note that the DTX will be distributed over all slots after 2nd interleaving.

The bits input to the DTX insertion block are denoted by $s_1, s_2, s_3, \dots, s_S$, where S is the number of bits from TrCH multiplexing. The number of PhCHs is denoted by P and the number of bits in one radio frame, including DTX indication bits, for each PhCH by R .

In non-compressed frames, $R = \frac{N_{data,*}}{P} = 15 \times (N_{data1} + N_{data2})$, where N_{data1} and N_{data2} are defined in [2].

For compressed frames, $N'_{data,*}$ is defined as $N'_{data,*} = P \times 15 \times (N'_{data1} + N'_{data2})$. N'_{data1} and N'_{data2} are the number of bits in the data fields of the slot format used for the current compressed frame, i.e. slot format A or B as defined in [2] corresponding to the spreading factor and the number of transmitted slots in use.

In frames compressed by puncturing and when fixed positions are used, no DTX shall be inserted, since the exact room for the gap is already reserved thanks to the earlier insertion of the p-bits.

In frames compressed by higher layer scheduling, additional DTX with respect to normal mode shall be inserted if the transmission time reduction does not exactly create a transmission gap of the desired TGL .

The number of bits available to the CCTrCH in one radio frame compressed by spreading factor reduction or by higher layer scheduling is denoted by $N_{data,*}^{cm}$ and $R = \frac{N_{data,*}^{cm}}{P}$.

For frames compressed by spreading factor reduction $N_{data,*}^{cm} = \frac{N'_{data,*}}{2}$.

For frames compressed by higher layer scheduling the exact value of $N_{data,*}^{cm}$ is dependent on the TGL which is signalled from higher layers. It can be calculated as $N_{data,*}^{cm} = N'_{data,*} - N_{TGL}$.

N_{TGL} is the number of bits that are located within the transmission gap and defined as:

$$N_{TGL} = \begin{cases} \frac{TGL}{15} \times N'_{data,*}, & \text{if } N_{first} + TGL \leq 15 \\ \frac{15 - N_{first}}{15} \times N'_{data,*}, & \text{in first frame if } N_{first} + TGL > 15 \\ \frac{TGL - (15 - N_{first})}{15} \times N'_{data,*}, & \text{in second frame if } N_{first} + TGL > 15 \end{cases}$$

N_{first} and TGL are defined in subclause 4.4.

The bits output from the DTX insertion block are denoted by $w_1, w_2, w_3, \dots, w_{(PR)}$. Note that these bits are four valued in case of compressed mode by puncturing, and three valued otherwise. They are defined by the following relations:

$$w_k = s_k \quad k = 1, 2, 3, \dots, S$$

$$w_k = \delta \quad k = S+1, S+2, S+3, \dots, PR$$

where DTX indication bits are denoted by δ . Here $s_k \in \{0, 1, p\}$ and $\delta \notin \{0, 1\}$.

4.2.10 Physical channel segmentation

When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $x_1, x_2, x_3, \dots, x_X$, where X is the number of bits input to the physical channel segmentation block. The number of PhCHs is denoted by P .

The bits after physical channel segmentation are denoted $u_{p1}, u_{p2}, u_{p3}, \dots, u_{pU}$, where p is PhCH number and U is the number of bits in one radio frame for each PhCH, i.e. $U = (X - N_{TGL} - (N_{data,*} - N'_{data,*})) / P$ for compressed mode by puncturing, and $U = \frac{X}{P}$ otherwise. The relation between x_k and u_{pk} is given below.

For all modes, some bits of the input flow are mapped to each code until the number of bits on the code is U . For modes other than compressed mode by puncturing, all bits of the input flow are taken to be mapped to the codes. For compressed mode by puncturing, only the bits of the input flow not corresponding to bits p are taken to be mapped to the codes, each bit p is removed to ensure creation the gap required by the compressed mode, as described below.

Bits on first PhCH after physical channel segmentation:

$$u_{1,k} = x_{f(k)} \quad k = 1, 2, \dots, U$$

Bits on second PhCH after physical channel segmentation:

$$u_{2,k} = x_{f(k+U)} \quad k = 1, 2, \dots, U$$

...

Bits on the P^{th} PhCH after physical channel segmentation:

$$u_{p,k} = x_{f(k+(P-1) \times U)} \quad k = 1, 2, \dots, U$$

where f is such that :

- for modes other than compressed mode by puncturing, $x_{f(k)} = x_k$, i.e. $f(k) = k$, for all k .
- for compressed mode by puncturing, bit $u_{1,1}$ corresponds to the bit x_k with smallest index k when the bits p are not counted, bit $u_{1,2}$ corresponds to the bit x_k with second smallest index k when the bits p are not counted, and so on for bits $u_{1,3}, \dots, u_{1,U}, u_{2,1}, u_{2,2}, \dots, u_{2,U}, \dots, u_{p,1}, u_{p,2}, \dots, u_{p,U}$.

4.2.10.1 Relation between input and output of the physical segmentation block in uplink

The bits input to the physical segmentation are denoted by $s_1, s_2, s_3, \dots, s_S$. Hence, $x_k = s_k$ and $Y = S$.

4.2.10.2 Relation between input and output of the physical segmentation block in downlink

The bits input to the physical segmentation are denoted by $w_1, w_2, w_3, \dots, w_{(PU)}$. Hence, $x_k = w_k$ and $Y = PU$.

4.2.11 2nd interleaving

The 2nd interleaving is a block interleaver and consists of bits input to a matrix with padding, the inter-column permutation for the matrix and bits output from the matrix with pruning. The bits input to the block interleaver are denoted by $u_{p,1}, u_{p,2}, u_{p,3}, \dots, u_{p,U}$, where p is PhCH number and U is the number of bits in one radio frame for one PhCH. The output bit sequence from the block interleaver is derived as follows:

- (1) Assign $C2 = 30$ to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, ..., $C2 - 1$ from left to right.
- (2) Determine the number of rows of the matrix, $R2$, by finding minimum integer $R2$ such that:

$$U \leq R2 \times C2.$$

The rows of rectangular matrix are numbered 0, 1, 2, ..., $R2 - 1$ from top to bottom.

- (3) Write the input bit sequence $u_{p,1}, u_{p,2}, u_{p,3}, \dots, u_{p,U}$ into the $R2 \times C2$ matrix row by row starting with bit $y_{p,1}$ in column 0 of row 0:

$$\begin{bmatrix} y_{p,1} & y_{p,2} & y_{p,3} & \dots & y_{p,C2} \\ y_{p,(C2+1)} & y_{p,(C2+2)} & y_{p,(C2+3)} & \dots & y_{p,(2 \times C2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{p,((R2-1) \times C2+1)} & y_{p,((R2-1) \times C2+2)} & y_{p,((R2-1) \times C2+3)} & \dots & y_{p,(R2 \times C2)} \end{bmatrix}$$

where $y_{p,k} = u_{p,k}$ for $k = 1, 2, \dots, U$ and if $R2 \times C2 > U$, the dummy bits are padded such that $y_{p,k} = 0$ or 1 for $k = U + 1, U + 2, \dots, R2 \times C2$. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

- (4) Perform the inter-column permutation for the matrix based on the pattern $\langle P2(j) \rangle_{j \in \{0,1,\dots,C2-1\}}$ that is shown in table 7, where $P2(j)$ is the original column position of the j -th permuted column. After permutation of the columns, the bits are denoted by $y'_{p,k}$.

$$\begin{bmatrix} y'_{p,1} & y'_{p,(R2+1)} & y'_{p,(2 \times R2+1)} & \cdots & y'_{p,((C2-1) \times R2+1)} \\ y'_{p,2} & y'_{p,(R2+2)} & y'_{p,(2 \times R2+2)} & \cdots & y'_{p,((C2-1) \times R2+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y'_{p,R2} & y'_{p,(2 \times R2)} & y'_{p,(3 \times R2)} & \cdots & y'_{p,(C2 \times R2)} \end{bmatrix}$$

- (5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted $R2 \times C2$ matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits $y'_{p,k}$ that corresponds to bits $y_{p,k}$ with $k > U$ are removed from the output. The bits after 2nd interleaving are denoted by $v_{p,1}, v_{p,2}, \dots, v_{p,U}$, where $v_{p,1}$ corresponds to the bit $y'_{p,k}$ with smallest index k after pruning, $v_{p,2}$ to the bit $y'_{p,k}$ with second smallest index k after pruning, and so on.

Table 7 Inter-column permutation pattern for 2nd interleaving

Number of columns C2	Inter-column permutation pattern $\langle P2(0), P2(1), \dots, P2(C2-1) \rangle$
30	$\langle 0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17 \rangle$

4.2.12 Physical channel mapping

The PhCH for both uplink and downlink is defined in [2]. The bits input to the physical channel mapping are denoted by $v_{p1}, v_{p2}, \dots, v_{pU}$, where p is the PhCH number and U is the number of bits in one radio frame for one PhCH. The bits v_{pk} are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k .

In compressed mode, no bits are mapped to certain slots of the PhCH(s). If $N_{first} + TGL \leq 15$, no bits are mapped to slots N_{first} to N_{last} . If $N_{first} + TGL > 15$, i.e. the transmission gap spans two consecutive radio frames, the mapping is as follows:

- In the first radio frame, no bits are mapped to slots $N_{first}, N_{first}+1, N_{first}+2, \dots, 14$.
- In the second radio frame, no bits are mapped to the slots $0, 1, 2, \dots, N_{last}$.

TGL , N_{first} , and N_{last} are defined in subclause 4.4.

4.2.12.1 Uplink

In uplink, the PhCHs used during a radio frame are either completely filled with bits that are transmitted over the air or not used at all. The only exception is when the UE is in compressed mode. The transmission can then be turned off during consecutive slots of the radio frame.

4.2.12.2 Downlink

In downlink, the PhCHs do not need to be completely filled with bits that are transmitted over the air. Bits $v_{pk} \notin \{0, 1\}$ are not transmitted.

During compressed mode by reducing the spreading factor by 2, the data bits are always mapped into 7.5 slots within a compressed frame. No bits are mapped to the DPDCH field as follows:

If $N_{first} + TGL \leq 15$, i.e. the transmission gap spans one radio frame,

if $N_{first} + 7 \leq 14$

no bits are mapped to slots $N_{first}, N_{first} + 1, N_{first} + 2, \dots, N_{first} + 6$

no bits are mapped to the first $(N_{Data1} + N_{Data2})/2$ bit positions of slot $N_{first} + 7$

else

no bits are mapped to slots $N_{first}, N_{first} + 1, N_{first} + 2, \dots, 14$

no bits are mapped to slots $N_{first} - 1, N_{first} - 2, N_{first} - 3, \dots, 8$

no bits are mapped to the last $(N_{Data1} + N_{Data2})/2$ bit positions of slot 7

end if

If $N_{first} + TGL > 15$, i.e. the transmission gap spans two consecutive radio frames,

In the first radio frame, no bits are mapped to last $(N_{Data1} + N_{Data2})/2$ bit positions in slot 7 as well as to slots 8, 9, 10, ..., 14.

In the second radio frame, no bits are mapped to slots 0, 1, 2, ..., 6 as well as to first $(N_{Data1} + N_{Data2})/2$ bit positions in slot 7.

N_{Data1} and N_{Data2} are defined in [2].

4.2.13 Restrictions on different types of CCTrCHs

Restrictions on the different types of CCTrCHs are described in general terms in TS 25.302[11]. In this subclause those restrictions are given with layer 1 notation.

4.2.13.1 Uplink Dedicated channel (DCH)

The maximum value of the number of TrCHs I in a CCTrCH, the maximum value of the number of transport blocks M_i on each transport channel, and the maximum value of the number of DPDCHs P are given from the UE capability class.

4.2.13.2 Random Access Channel (RACH)

- There can only be one TrCH in each RACH CCTrCH, i.e. $I=1$, $s_k = f_{1k}$ and $S = V_1$.
- The maximum value of the number of transport blocks M_1 on the transport channel is given from the UE capability class.
- The transmission time interval is either 10 ms or 20 ms.
- Only one PRACH is used, i.e. $P=1$, $u_{1k} = s_k$, and $U = S$.
- The Static rate matching parameter RM_1 is not provided by higher layer signalling on the System information as the other transport channel parameters. Any value may be used as there is one transport channel in the CCTrCH, hence one transport channel per Transport Format Combination and no need to do any balancing between multiple transport channels.

4.2.13.3 Common Packet Channel (CPCH)

- There can only be one TrCH in each CPCH CCTrCH, i.e. $I=1$, $s_k = f_{1k}$ and $S = V_1$.
- The maximum value of the number of transport blocks M_1 on the transport channel is given from the UE capability class.
- Only one PCPCH is used, i.e. $P=1$, $u_{1k} = s_k$, and $U = S$.

4.2.13.4 Downlink Dedicated Channel (DCH)

The maximum value of the number of TrCHs I in a CCTrCH, the maximum value of the number of transport blocks M_i on each transport channel, and the maximum value of the number of DPCHs P are given from the UE capability class.

4.2.13.5 Downlink Shared Channel (DSCH) associated with a DCH

- The spreading factor is indicated with the TFCI of the associated DPCH.
- The maximum value of the number of TrCHs I in a CCTrCH, the maximum value of the number of transport blocks M_i on the transport channel and the maximum value of the number of PDSCHs P are given from the UE capability class.

4.2.13.6 Broadcast channel (BCH)

- There can only be one TrCH in the BCH CCTrCH, i.e. $I=1$, $S_k = f_{1k}$, and $S = V_1$.
- There can only be one transport block in each transmission time interval, i.e. $M_1 = 1$.
- All transport format attributes have predefined values which are provided in [11] apart from the rate matching RM_1 .
- The Static rate matching parameter RM_1 is not provided by higher layer signalling neither fixed. Any value may be used as there is one transport channel in the CCTrCH, hence one transport channel per Transport Format Combination and no need to do any balancing between multiple transport channels.
- Only one primary CCPCCH is used, i.e. $P=1$.

4.2.13.7 Forward access and paging channels (FACH and PCH)

- The maximum value of the number of TrCHs I in a CCTrCH and the maximum value of the number of transport blocks M_i on each transport channel are given from the UE capability class.
- The transmission time interval for TrCHs of PCH type is always 10 ms.
- Only one secondary CCPCCH is used per CCTrCH, i.e. $P=1$.

4.2.14 Multiplexing of different transport channels into one CCTrCH, and mapping of one CCTrCH onto physical channels

The following rules shall apply to the different transport channels which are part of the same CCTrCH:

- 1) Transport channels multiplexed into one CCTrCh shall have co-ordinated timings. When the TFCS of a CCTrCH is changed because one or more transport channels are added to the CCTrCH or reconfigured within the CCTrCH, or removed from the CCTrCH, the change may only be made at the start of a radio frame with CFN fulfilling the relation

$$\text{CFN mod } F_{\max} = 0,$$

where F_{\max} denotes the maximum number of radio frames within the transmission time intervals of all transport channels which are multiplexed into the same CCTrCH, including any transport channels i which are added, reconfigured or have been removed, and CFN denotes the connection frame number of the first radio frame of the changed CCTrCH.

After addition or reconfiguration of a transport channel i within a CCTrCH, the TTI of transport channel i may only start in radio frames with CFN fulfilling the relation:

$$\text{CFN mod } F_i = 0.$$

For a CCTrCH of DSCH type, a modification of number of bits $N_{data,*}$ allocated on a radio frame is allowed if the CFN verifies $\text{CFN mod } F_{\max} = 0$, where F_{\max} denotes the maximum number of radio frames within the transmission time intervals of all the transport channels with a non zero transport block transport format multiplexed into the CCTrCH in the previous radio frame.

- 2) Only transport channels with the same active set can be mapped onto the same CCTrCH.
- 3) Different CCTrCHs cannot be mapped onto the same PhCH.
- 4) One CCTrCH shall be mapped onto one or several PhCHs. These physical channels shall all have the same SF.
- 5) Dedicated Transport channels and common transport channels cannot be multiplexed into the same CCTrCH.
- 6) For the common transport channels, only the FACH and PCH may belong to the same CCTrCH.

There are hence two types of CCTrCH:

- 1) CCTrCH of dedicated type, corresponding to the result of coding and multiplexing of one or several DCHs.
- 2) CCTrCH of common type, corresponding to the result of the coding and multiplexing of a common channel, RACH in the uplink, DSCH, BCH, or FACH/PCH for the downlink.

4.2.14.1 Allowed CCTrCH combinations for one UE

4.2.14.1.1 Allowed CCTrCH combinations on the uplink

A maximum of one CCTrCH is allowed for one UE on the uplink. It can be either:

- 1) one CCTrCH of dedicated type;
- 2) one CCTrCH of common type.

4.2.14.1.2 Allowed CCTrCH combinations on the downlink

The following CCTrCH combinations for one UE are allowed:

- x CCTrCH of dedicated type + y CCTrCH of common type. The allowed combination of CCTrCHs of dedicated and common type are given from UE radio access capabilities. There can be a maximum on one CCTrCH of common type for DSCH and a maximum of one CCTrCH of common type for FACH. With one CCTrCH of common type for DSCH, there shall be only one CCTrCH of dedicated type.

NOTE 1: There is only one DPCCCH in the uplink, hence one TPC bits flow on the uplink to control possibly the different DPDCHs on the downlink, part of the same or several CCTrCHs.

NOTE 2: There is only one DPCCCH in the downlink, even with multiple CCTrCHs. With multiple CCTrCHs, the DPCCCH is transmitted on one of the physical channels of that CCTrCH which has the smallest SF among the multiple CCTrCHs. Thus there is only one TPC command flow and only one TFCI word in downlink even with multiple CCTrCHs.

NOTE 3: in the current release, only 1 CCTrCH of dedicated type is supported.

4.3 Transport format detection

If the transport format set of a TrCH i contains more than one transport format, the transport format can be detected according to one of the following methods:

- TFCI based detection: This method is applicable when the transport format combination is signalled using the TFCI field;
- explicit blind detection: This method typically consists of detecting the TF of TrCH i by use of channel decoding and CRC check;
- guided detection: This method is applicable when there is at least one other TrCH i' , hereafter called guiding TrCH, such that:
 - the guiding TrCH has the same TTI duration as the TrCH under consideration, i.e. $F_T = F_i$;
 - different TFs of the TrCH under consideration correspond to different TFs of the guiding TrCH;

- explicit blind detection is used on the guiding TrCH.

If the transport format set for a TrCH i does not contain more than one transport format with more than zero transport blocks, no explicit blind transport format detection needs to be performed for this TrCH. The UE can use guided detection for this TrCH or single transport format detection, where the UE always assumes the transport format corresponding to more than zero transport blocks for decoding.

For uplink, blind transport format detection is a network controlled option. For downlink, the UE shall be capable of performing blind transport format detection, if certain restrictions on the configured transport channels are fulfilled.

For a DPCH associated with a PDSCH, the DPCCH shall include TFCI.

4.3.1 Blind transport format detection

When no TFCI is available then explicit blind detection or guided detection shall be performed on all TrCHs within the CCTrCH that have more than one transport format and that do not use single transport format detection. The UE shall only be required to support blind transport format detection if all of the following restrictions are fulfilled:

1. only one CCTrCH is received by the UE;
2. the number of CCTrCH bits received per radio frame is 600 or less;
3. the number of transport format combinations of the CCTrCH is 64 or less;
4. fixed positions of the transport channels is used on the CCTrCH to be detectable;
5. convolutional coding is used on all explicitly detectable TrCHs;
6. CRC with non-zero length is appended to all transport blocks on all explicitly detectable TrCHs;
7. at least one transport block shall be transmitted per TTI on each explicitly detectable TrCH;
8. the number of explicitly detectable TrCHs is 3 or less;
9. for all explicitly detectable TrCHs i , the number of code blocks in one TTI (C_i) shall not exceed 1;
10. the sum of the transport format set sizes of all explicitly detectable TrCHs, is 16 or less. The transport format set size is defined as the number of transport formats within the transport format set;
11. there is at least one TrCH that can be used as the guiding transport channel for all transport channels using guided detection.

Examples of blind transport format detection methods are given in annex A.

4.3.2 Transport format detection based on TFCI

If a TFCI is available, then TFCI based detection shall be applicable to all TrCHs within the CCTrCH. The TFCI informs the receiver about the transport format combination of the CCTrCHs. As soon as the TFCI is detected, the transport format combination, and hence the transport formats of the individual transport channels are known.

4.3.3 Coding of Transport-Format-Combination Indicator (TFCI)

The TFCI is encoded using a (32, 10) sub-code of the second order Reed-Muller code. The coding procedure is as shown in figure 9.

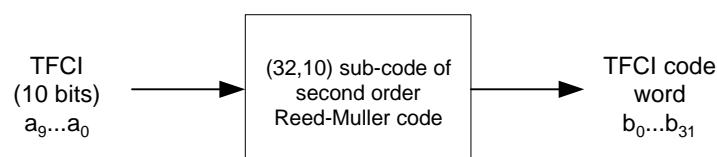


Figure 9: Channel coding of TFCI information bits

If the TFCI consist of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. The length of the TFCI code word is 32 bits.

The code words of the (32,10) sub-code of second order Reed-Muller code are linear combination of 10 basis sequences. The basis sequences are as in the following table 8.

Table 8: Basis sequences for (32,10) TFCI code

i	M_{i,0}	M_{i,1}	M_{i,2}	M_{i,3}	M_{i,4}	M_{i,5}	M_{i,6}	M_{i,7}	M_{i,8}	M_{i,9}
0	1	0	0	0	0	1	0	0	0	0
1	0	1	0	0	0	1	1	0	0	0
2	1	1	0	0	0	1	0	0	0	1
3	0	0	1	0	0	1	1	0	1	1
4	1	0	1	0	0	1	0	0	0	1
5	0	1	1	0	0	1	0	0	1	0
6	1	1	1	0	0	1	0	1	0	0
7	0	0	0	1	0	1	0	1	1	0
8	1	0	0	1	0	1	1	1	1	0
9	0	1	0	1	0	1	1	0	1	1
10	1	1	0	1	0	1	0	0	1	1
11	0	0	1	1	0	1	0	1	1	0
12	1	0	1	1	0	1	0	1	0	1
13	0	1	1	1	0	1	1	0	0	1
14	1	1	1	1	0	1	1	1	1	1
15	1	0	0	0	1	1	1	1	0	0
16	0	1	0	0	1	1	1	1	0	1
17	1	1	0	0	1	1	1	0	1	0
18	0	0	1	0	1	1	0	1	1	1
19	1	0	1	0	1	1	0	1	0	1
20	0	1	1	0	1	1	0	0	1	1
21	1	1	1	0	1	1	0	1	1	1
22	0	0	0	1	1	1	0	1	0	0
23	1	0	0	1	1	1	1	1	0	1
24	0	1	0	1	1	1	1	0	1	0
25	1	1	0	1	1	1	1	0	0	1
26	0	0	1	1	1	1	0	0	1	0
27	1	0	1	1	1	1	1	1	0	0
28	0	1	1	1	1	1	1	1	1	0
29	1	1	1	1	1	1	1	1	1	1
30	0	0	0	0	0	1	0	0	0	0
31	0	0	0	0	1	1	1	0	0	0

The TFCI information bits $a_0, a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9$ (where a_0 is LSB and a_9 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output code word bits b_i are given by:

$$b_i = \sum_{n=0}^9 (a_n \times M_{i,n}) \bmod 2$$

where $i = 0, \dots, 31$.

The output bits are denoted by $b_k, k = 0, 1, 2, \dots, 31$.

In downlink, when the SF < 128 the encoded TFCI code words are repeated yielding 8 encoded TFCI bits per slot in normal mode and 16 encoded TFCI bits per slot in compressed mode. Mapping of repeated bits to slots is explained in subclause 4.3.5.

4.3.4 Operation of Transport-Format-Combination Indicator (TFCI) in Split Mode

If one of the DCH is associated with a DSCH, the TFCI code word may be split in such a way that the code word relevant for TFCI activity indication is not transmitted from every cell. The use of such a functionality shall be indicated by higher layer signalling.

The TFCI is encoded using a (16, 5) bi-orthogonal (or first order Reed-Muller) code. The coding procedure is as shown in figure 10.

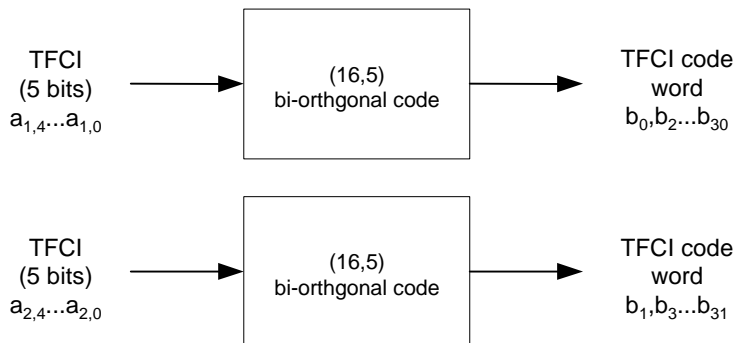


Figure 10: Channel coding of split mode TFCI information bits

The code words of the (16,5) bi-orthogonal code are linear combinations of 5 basis sequences as defined in table 9.

Table 9: Basis sequences for (16,5) TFCI code

i	M _{i,0}	M _{i,1}	M _{i,2}	M _{i,3}	M _{i,4}
0	1	0	0	0	1
1	0	1	0	0	1
2	1	1	0	0	1
3	0	0	1	0	1
4	1	0	1	0	1
5	0	1	1	0	1
6	1	1	1	0	1
7	0	0	0	1	1
8	1	0	0	1	1
9	0	1	0	1	1
10	1	1	0	1	1
11	0	0	1	1	1
12	1	0	1	1	1
13	0	1	1	1	1
14	1	1	1	1	1
15	0	0	0	0	1

The first set of TFCI information bits (a_{1,0}, a_{1,1}, a_{1,2}, a_{1,3}, a_{1,4} where a_{1,0} is LSB and a_{1,4} is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the DCH CCTrCH in the associated DPCH radio frame.

The second set of TFCI information bits (a_{2,0}, a_{2,1}, a_{2,2}, a_{2,3}, a_{2,4} where a_{2,0} is LSB and a_{2,4} is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the associated DSCH CCTrCH in the corresponding PDSCH radio frame.

The output code word bits b_k are given by:

$$b_{2i} = \sum_{n=0}^4 (a_{1,n} \times M_{i,n}) \text{ mod } 2; \quad b_{2i+1} = \sum_{n=0}^4 (a_{2,n} \times M_{i,n}) \text{ mod } 2$$

where i = 0, ..., 15.

The output bits are denoted by b_k, k = 0, 1, 2, ..., 31.

4.3.5 Mapping of TFCI words

4.3.5.1 Mapping of TFCI word in normal mode

The bits of the code word are directly mapped to the slots of the radio frame. Within a slot the bit with lower index is transmitted before the bit with higher index. The coded bits b_k , are mapped to the transmitted TFCI bits d_k , according to the following formula:

$$d_k = b_{k \bmod 32}$$

For uplink physical channels regardless of the SF and downlink physical channels, if $SF \geq 128$, $k = 0, 1, 2, \dots, 29$. Note that this means that bits b_{30} and b_{31} are not transmitted.

For downlink physical channels whose $SF < 128$, $k = 0, 1, 2, \dots, 119$. Note that this means that bits b_0 to b_{23} are transmitted four times and bits b_{24} to b_{31} are transmitted three times.

4.3.5.2 Mapping of TFCI word in compressed mode

The mapping of the TFCI bits in compressed mode is different for uplink, downlink with $SF \geq 128$ and downlink with $SF < 128$.

4.3.5.2.1 Uplink compressed mode

For uplink compressed mode, the slot format is changed so that no TFCI coded bits are lost. The different slot formats in compressed mode do not match the exact number of TFCI coded bits for all possible TGLs. Repetition of the TFCI bits is therefore used.

Denote the number of bits available in the TFCI fields of one compressed radio frame by D and the number of bits in the TFCI field in a slot by N_{TFCI} . The parameter E is used to determine the number of the first TFCI bit to be repeated.

$E = N_{\text{first}} N_{\text{TFCI}}$, if the start of the transmission gap is allocated to the current frame.

$E = 0$, if the start of the transmission gap is allocated to the previous frame and the end of the transmission gap is allocated to the current frame.

The TFCI coded bits b_k are mapped to the bits in the TFCI fields d_k . The following relations define the mapping for each compressed frame.

$$d_k = b_k$$

where $k = 0, 1, 2, \dots, \min(31, D-1)$.

If $D > 32$, the remaining positions are filled by repetition (in reversed order):

$$d_{D-k-1} = b_{(E+k) \bmod 32}$$

where $k = 0, \dots, D-33$.

4.3.5.2.2 Downlink compressed mode

For downlink compressed mode, the slot format is changed so that no TFCI coded bits are lost. The different slot formats in compressed mode do not match the exact number of TFCI bits for all possible TGLs. DTX is therefore used if the number of bits available in the TFCI fields in one compressed frame exceeds the number of TFCI bits given from the slot format. The block of bits in the TFCI fields where DTX is used starts on the first TFCI field after the transmission gap. If there are more bits available in the TFCI fields before the transmission gap than TFCI bits, DTX is also used on the bits in the last TFCI fields before the transmission gap.

Denote the number of bits available in the TFCI fields of one compressed radio frame by D and the number of bits in the TFCI field in a slot by N_{TFCI} . The parameter E is used to determine the position of the first bit in the TFCI field on which DTX is used.

$E = N_{\text{first}} N_{\text{TFCI}}$, if the start of the transmission gap is allocated to the current frame.

$E = 0$, if the start of the transmission gap is allocated to the previous frame and the end of the transmission gap is allocated to the current frame.

Denote the total number of TFCI bits to be transmitted by F . $F = 32$ for slot formats nA or nB , where $n = 0, 1, \dots, 11$ (see table 11 in [2]). Otherwise, $F = 128$. The TFCI coded bits b_k are mapped to the bits in the TFCI fields d_k . The following relations define the mapping for each compressed frame.

If $E > 0$,

$$d_k = b_{k \bmod 32}$$

where $k = 0, 1, 2, \dots, \min(E, F)-1$.

If $E < F$,

$$d_{k+D-F} = b_{k \bmod 32}$$

where $k = E, \dots, F-1$.

DTX is used on d_k where $k = \min(E, F), \dots, \min(E, F) + D - F - 1$.

4.4 Compressed mode

In compressed frames, TGL slots from N_{first} to N_{last} are not used for transmission of data. As illustrated in figure 11, the instantaneous transmit power is increased in the compressed frame in order to keep the quality (BER, FER, etc.) unaffected by the reduced processing gain. The amount of power increase depends on the transmission time reduction method (see subclause 4.4.3). What frames are compressed, are decided by the network. When in compressed mode, compressed frames can occur periodically, as illustrated in figure 11, or requested on demand. The rate and type of compressed frames is variable and depends on the environment and the measurement requirements.

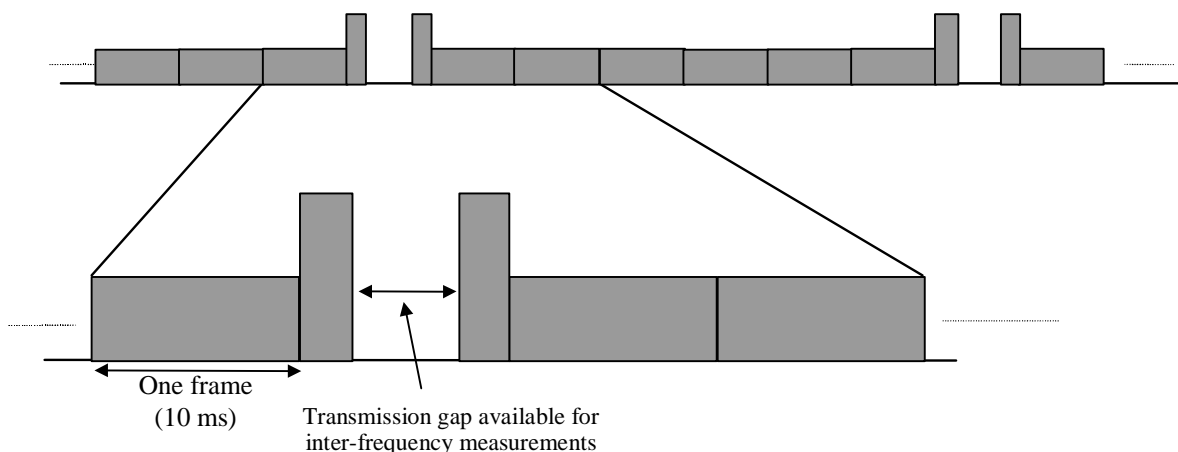


Figure 11: Compressed mode transmission

4.4.1 Frame structure in the uplink

The frame structure for uplink compressed frames is illustrated in figure 12.

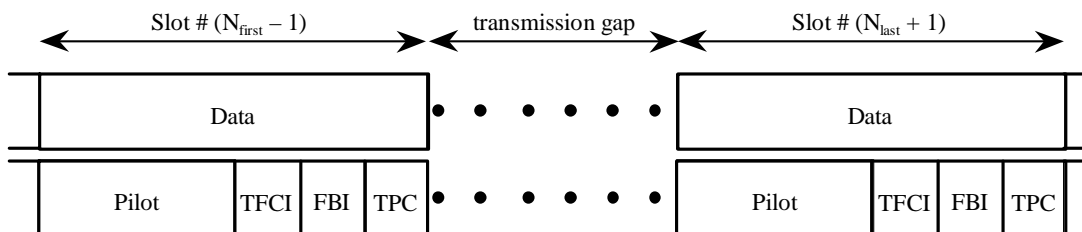


Figure 12: Frame structure in uplink compressed transmission

4.4.2 Frame structure types in the downlink

There are two different types of frame structures defined for downlink compressed frames. Type A maximises the transmission gap length and type B is optimised for power control. The frame structure type A or B is set by higher layers independent from the downlink slot format type A or B.

- With frame structure of type A, the pilot field of the last slot in the transmission gap is transmitted. Transmission is turned off during the rest of the transmission gap (figure 13(a)).
- With frame structure of type B, the TPC field of the first slot in the transmission gap and the pilot field of the last slot in the transmission gap is transmitted. Transmission is turned off during the rest of the transmission gap (figure 13(b)).

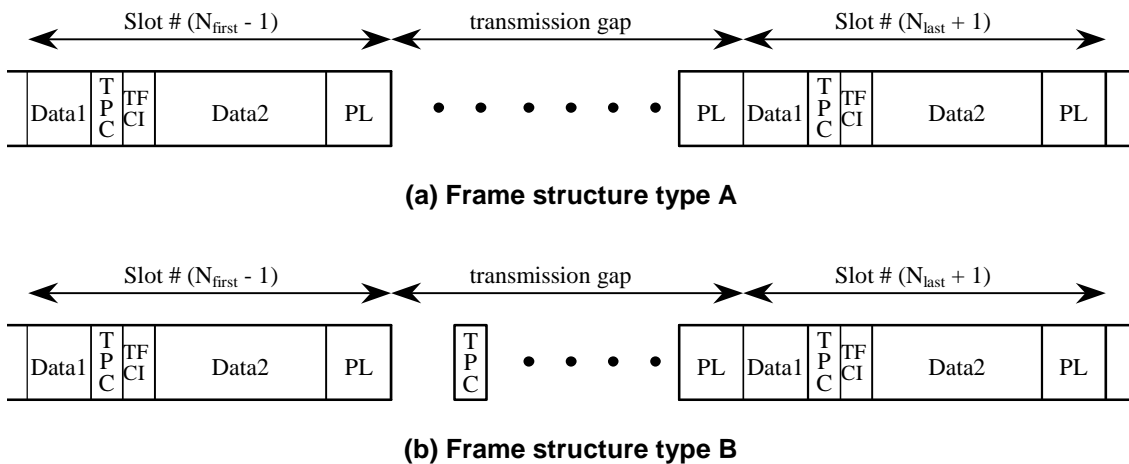


Figure 13: Frame structure types in downlink compressed transmission

4.4.3 Transmission time reduction method

When in compressed mode, the information normally transmitted during a 10 ms frame is compressed in time. The mechanisms provided for achieving this are puncturing, reduction of the spreading factor by a factor of two, and higher layer scheduling. In the downlink, all methods are supported while compressed mode by puncturing is not used in the uplink. The maximum idle length is defined to be 7 slots per one 10 ms frame. The slot formats that are used in compressed frames are listed in [2].

4.4.3.1 Compressed mode by puncturing

Rate matching is applied for creating a transmission gap in one or two frames. The algorithm for rate matching as described in subclause 4.2.7 is used.

4.4.3.2 Compressed mode by reducing the spreading factor by 2

The spreading factor (SF) can be reduced by 2 during one compressed radio frame to enable the transmission of the information bits in the remaining time slots of the compressed frame. This method is not supported for SF=4.

On the downlink, UTRAN can also order the UE to use a different scrambling code in a compressed frame than in a non-compressed frame. If the UE is ordered to use a different scrambling code in a compressed frame, then there is a one-to-one mapping between the scrambling code used in the non-compressed frame and the one used in the compressed frame, as described in [3] subclause 5.2.1.

4.4.3.3 Compressed mode by higher layer scheduling

Compressed frames can be obtained by higher layer scheduling. Higher layers then set restrictions so that only a subset of the allowed TFCs are used in a compressed frame. The maximum number of bits that will be delivered to the physical layer during the compressed radio frame is then known and a transmission gap can be generated. Note that in the downlink, the TFCI field is expanded on the expense of the data fields and this shall be taken into account by higher

layers when setting the restrictions on the TFCs. Compressed mode by higher layer scheduling shall not be used with fixed starting positions of the TrCHs in the radio frame.

4.4.4 Transmission gap position

Transmission gaps can be placed at different positions as shown in figures 14 and 15 for each purpose such as interfrequency power measurement, acquisition of control channel of other system/carrier, and actual handover operation.

When using single frame method, the transmission gap is located within the compressed frame depending on the transmission gap length (TGL) as shown in figure 14 (1). When using double frame method, the transmission gap is located on the center of two connected frames as shown in figure 14 (2).

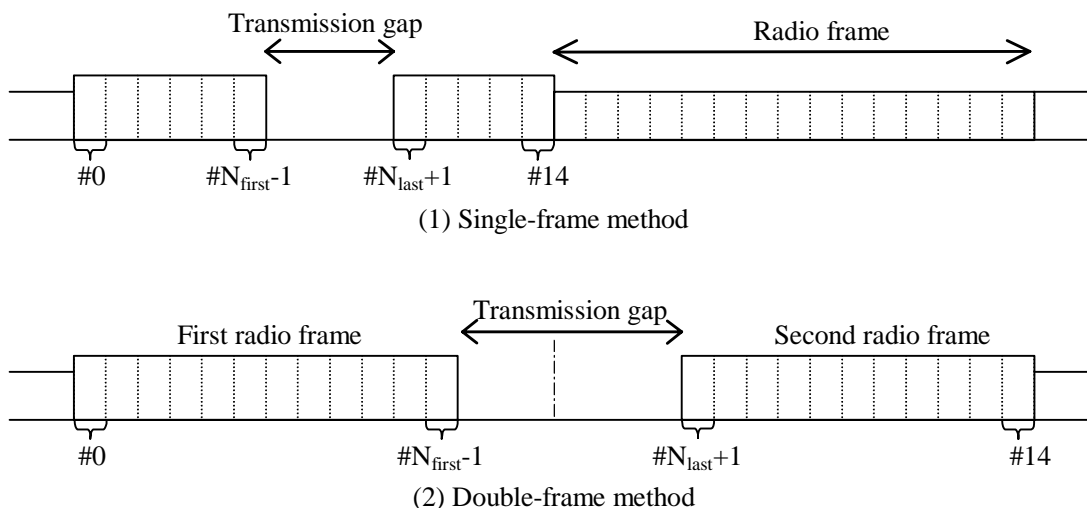


Figure 14: Transmission gap position

Parameters of the transmission gap positions are calculated as follows.

TGL is the number of consecutive idle slots during the compressed mode transmission gap:

$$TGL = 3, 4, 5, 7, 10, 14$$

N_{first} specifies the starting slot of the consecutive idle slots,

$$N_{first} = 0, 1, 2, 3, \dots, 14.$$

N_{last} shows the number of the final idle slot and is calculated as follows;

$$\text{If } N_{first} + TGL \leq 15, \text{ then } N_{last} = N_{first} + TGL - 1 \text{ (in the same frame),}$$

$$\text{If } N_{first} + TGL > 15, \text{ then } N_{last} = (N_{first} + TGL - 1) \text{ mod } 15 \text{ (in the next frame).}$$

When the transmission gap spans two consecutive radio frames, N_{first} and TGL must be chosen so that at least 8 slots in each radio frame are transmitted.

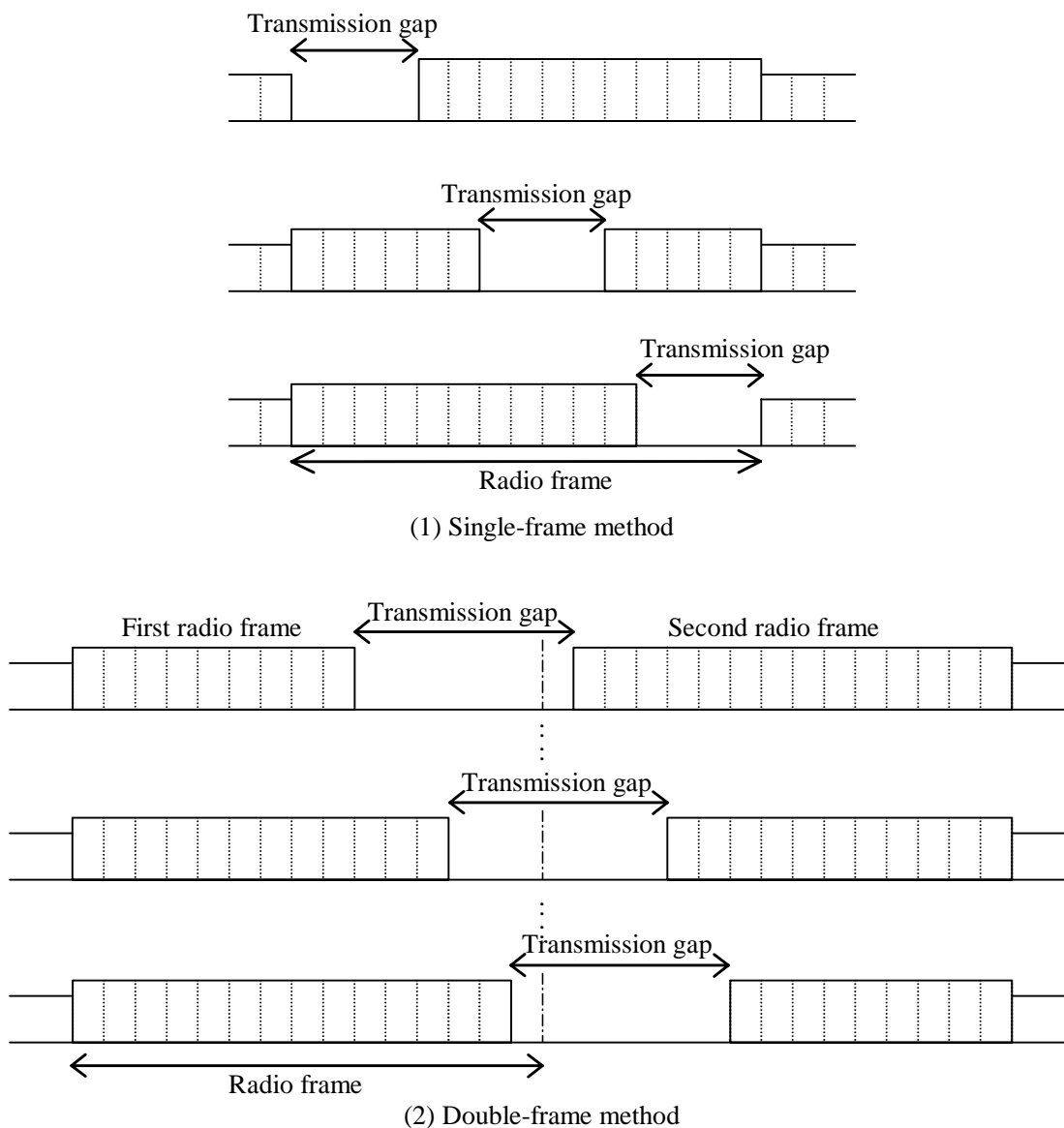


Figure 15: Transmission gap positions with different N_{first}

4.5 Coding for HS-DSCH

Data arrives to the coding unit in form of a maximum of one transport block once every transmission time interval. The transmission time interval is 2 ms which is mapped to a radio sub-frame of 3 slots.

The following coding steps can be identified:

- add CRC to each transport block (see subclause 4.5.1);
- code block segmentation (see subclause 4.5.2);
- channel coding (see subclause 4.5.3);
- hybrid ARQ (see subclause 4.5.4);
- physical channel segmentation (see subclause 4.5.5);
- interleaving for HS-DSCH (see subclause 4.5.6);
- mapping to physical channels (see subclause 4.5.7);

- constellation re-arrangement for 16 QAM (see subclause 4.5.8).

The coding steps for HS-DSCH are shown in the figure below.

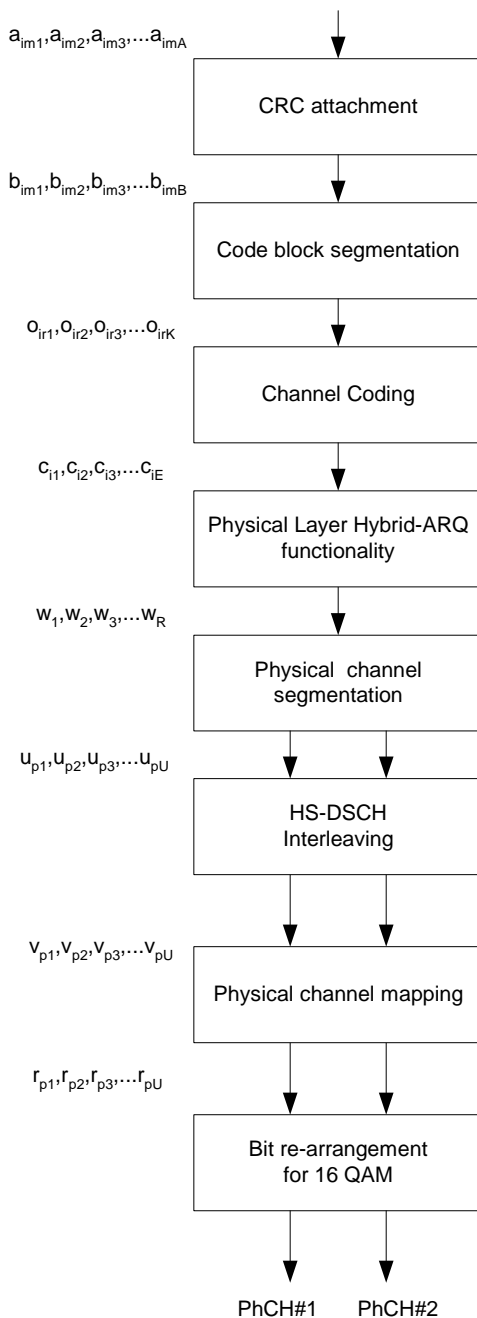


Figure 16 - Transport channel multiplexing structure for HS-DSCH

In the following the number of transport blocks and the number of transport channels is always one. When referencing non HS-DSCH formulae which are used in correspondence with HS-DSCH formulae the convention is used that transport block subscripts may be omitted (e.g. X₁ may be written X).

4.5.1 CRC attachment for HS-DSCH

CRC attachment for the HS-DSCH transport channel shall be done using the general method described in 4.2.1 above with the following specific parameters.

There will be a maximum of one transport block, i=1. The CRC length shall always be L₁ = 24 bits.

4.5.2 Code block segmentation for HS-DSCH

Code block segmentation for the HS-DSCH transport channel shall be done with the general method described in 4.2.2.2 above with the following specific parameters.

There will be a maximum of one transport block, $i=1$. The bits $b_{im1}, b_{im2}, b_{im3}, \dots, b_{imB}$ input to the block are mapped to the bits $x_{i1}, x_{i2}, x_{i3}, \dots, x_{iXi}$ directly. It follows that $X_1 = B$. Note that the bits x referenced here refer only to the internals of the code block segmentation function.

The value of $Z = 5114$ for turbo coding shall be used.

4.5.3 Channel coding for HS-DSCH

Channel coding for the HS-DSCH transport channel shall be done with the general method described in 4.2.3 above with the following specific parameters.

There will be a maximum of one transport block, $i=1$. The rate 1/3 turbo coding shall be used.

4.5.4 Hybrid ARQ for HS-DSCH

The hybrid ARQ functionality matches the number of bits at the output of the channel coder to the total number of bits of the HS-PDSCH set to which the HS-DSCH is mapped. The hybrid ARQ functionality is controlled by the redundancy version (RV) parameters. The exact set of bits at the output of the hybrid ARQ functionality depends on the number of input bits, the number of output bits, and the RV parameters.

The hybrid ARQ functionality consists of two rate-matching stages and a buffer as shown in the figure below.

The first rate matching stage matches the number of input bits to the virtual IR buffer, information about which is provided by higher layers. Note that, if the number of input bits does not exceed the virtual IR buffering capability, the first rate-matching stage is transparent.

The second rate matching stage matches the number of bits after first rate matching stage to the number of physical channel bits available in the HS-PDSCH set in the TTI.

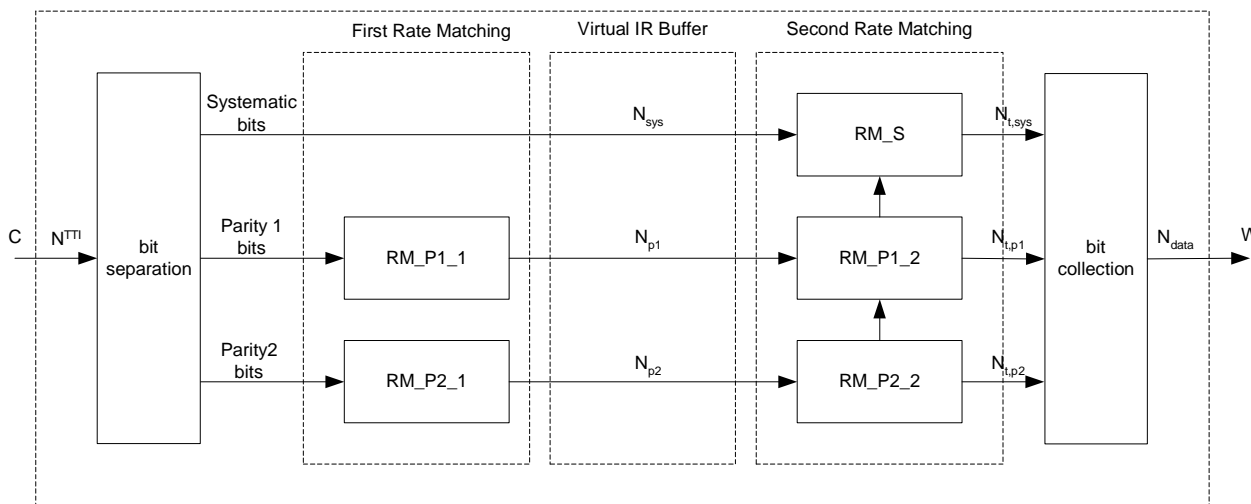


Figure 17 - HS-DSCH hybrid ARQ functionality

4.5.4.1 HARQ bit separation

The HARQ bit separation function shall be performed in the same way as bit separation for turbo encoded TrCHs in 4.2.7.4 above.

4.5.4.2 HARQ First Rate Matching Stage

HARQ first stage rate matching for the HS-DSCH transport channel shall be done with the general method described in 4.2.7.2.2.3 above with the following specific parameters.

The maximum number of soft bits available in the virtual IR buffer is N_{IR} which is signalled from higher layers for each HARQ process. The number of coded bits in a TTI before rate matching is N^{TTI} this is deduced from information signalled from higher layers and parameters signalled on the HS-SCCH for each TTI. Note that HARQ processing and physical layer storage occurs independently for each HARQ process currently active.

If N_{IR} is greater than or equal to N^{TTI} (i.e. all coded bits of the corresponding TTI can be stored) the first rate matching stage shall be transparent. This can, for example, be achieved by setting $e_{minus} = 0$. Note that no repetition is performed.

If N_{IR} is smaller than N^{TTI} the parity bit streams are punctured as in 4.2.7.2.2.3 above by setting the rate matching parameter $\Delta N_{il}^{TTI} = N_{IR} - N^{TTI}$ where the subscripts i and l refer to transport channel and transport format in the referenced sub-clause. Note the negative value is expected when the rate matching implements puncturing. Bits selected for puncturing which appear as δ in the algorithm in 4.2.7 above shall be discarded and not counted in the totals for the streams through the virtual IR buffer.

4.5.4.3 HARQ Second Rate Matching Stage

HARQ second stage rate matching for the HS-DSCH transport channel shall be done with the general method described in 4.2.7.5 above with the following specific parameters.

The parameters of the second rate matching stage depend on the value of the RV parameters s and r . The parameter s can take the value 0 or 1 to distinguish self-decodable ($s = 1$) and non self-decodable ($s = 0$) transmissions. The parameter r (range 0 to r_{max}) changes the initial error variable e_{ini} in the case of puncturing. In case of repetition both parameters r and s change the initial error variable e_{ini} . The parameters X , e_{plus} and e_{minus} are calculated as per table 10 below.

Denote the number of bits before second rate matching as N_{sys} for the systematic bits, N_{p1} for the parity 1 bits, and N_{p2} for the parity 2 bits, respectively. Denote the number of physical channels used for the CCTrCH by P . N_{data} is the number of bits available to the CCTrCH in one radio frame and defined as $N_{data} = P \times 3 \times N_{data1}$, where N_{data1} is defined in [2]. The rate matching parameters are determined as follows.

For $N_{data} \leq N_{sys} + N_{p1} + N_{p2}$, puncturing is performed in the second rate matching stage. The number of transmitted systematic bits in a retransmission is $N_{t,sys} = \min\{N_{sys}, N_{data}\}$ for a transmission of self-decodable type and $N_{t,sys} = \max\{N_{data} - (N_{p1} + N_{p2}), 0\}$ in the non self-decodable case.

For $N_{data} > N_{sys} + N_{p1} + N_{p2}$ repetition is performed in the second rate matching stage. A similar repetition rate in

all bit streams is achieved by setting the number of transmitted systematic bits to $N_{t,sys} = \left\lfloor N_{sys} \cdot \frac{N_{data}}{N_{sys} + 2N_{p2}} \right\rfloor$.

The number of parity bits in a transmission is: $N_{t,p1} = \left\lfloor \frac{N_{data} - N_{t,sys}}{2} \right\rfloor$ and $N_{t,p2} = \left\lfloor \frac{N_{data} - N_{t,sys}}{2} \right\rfloor$ for the parity 1 and parity 2 bits, respectively.

Table 10 below summarizes the resulting parameter choice for the second rate matching stage. The parameter a in the table is chosen using $a = 2$ for parity 1 and $a = 1$ for parity 2.

Table 10 - Parameters for HARQ second rate matching

	X_i	e_{plus}	e_{minus}
Systematic RM S	N_{sys}	N_{sys}	$ N_{sys} - N_{t,sys} $
Parity 1 RM P1_2	N_{p1}	$a \cdot N_{p1}$	$a \cdot N_{p1} - N_{t,p1} $
Parity 2 RM P2_2	N_{p2}	$a \cdot N_{p2}$	$a \cdot N_{p2} - N_{t,p2} $

The rate matching parameter e_{ini} is calculated for each bit stream according to the RV parameters r and s using

$$e_{ini}(r) = \left\{ \left[X_i - \left(r \cdot e_{plus} / r_{max} \right) - 1 \right] \bmod e_{plus} \right\} + 1 \text{ in the case of puncturing, i.e., } N_{data} \leq N_{sys} + N_{p1} + N_{p2},$$

and

$$e_{ini}(r) = \left\{ \left[X_i - \left((s + 2 \cdot r) \cdot e_{plus} / (2 \cdot r_{max}) \right) - 1 \right] \bmod e_{plus} \right\} + 1 \text{ for repetition, i.e., } N_{data} > N_{sys} + N_{p1} + N_{p2}.$$

Where $r \in \{0, 1, \dots, r_{max} - 1\}$ and r_{max} is the total number of redundancy versions allowed by varying r . Note that r_{max} varies depending on the modulation mode.

Note: For the modulo operation the following clarification is used: the value of $(x \bmod y)$ is strictly in the range of 0 to $y-1$ (i.e. $-1 \bmod 10 = 9$).

4.5.4.4 HARQ bit collection

The HARQ bit collection is achieved using a rectangular interleaver of size $N_{row} \times N_{col}$.

The number of rows and columns are determined from:

$$N_{row} = \log_2(M)$$

$$N_{col} = F / N_{row}$$

where M is the modulation size and F is the number of coded and rate-matched bits to be transmitted.

Data is written into the interleaver column by column, and read out of the interleaver column by column.

$N_{t,sys}$ is the number of transmitted systematic bits. Intermediate values N_r and N_c are calculated using:

$$N_r = \left\lfloor \frac{N_{t,sys}}{N_{col}} \right\rfloor \text{ and } N_c = \left(\frac{N_{t,sys}}{N_{col}} - N_r \right) \cdot N_{col}.$$

If $N_c=0$, the systematic bits are written into rows $1 \dots N_r$.

Otherwise systematic bits are written into rows $1 \dots N_r+1$ in the first N_c columns and rows $1 \dots N_r$ in the remaining N_c columns. The remaining space is filled with parity bits. The parity bits are written column wise into the remaining rows of the respective columns. Parity 1 and 2 bits are written in alternating order.

In the case of 16QAM for each column the bits are read out of the interleaver in the order row 1, row 3, row 2, row 4. In the case of QPSK for each column the bits are read out of the interleaver in the order row1, row2.

4.5.5 Physical channel segmentation for HS-DSCH

When more than one HS-PDSCH is used, physical channel segmentation divides the bits among the different physical channels. The bits input to the physical channel segmentation are denoted by $w_1, w_2, w_3, \dots, w_R$, where R is the number of bits input to the physical channel segmentation block. The number of PhCHs is denoted by P .

The bits after physical channel segmentation are denoted $u_{p1}, u_{p2}, u_{p3}, \dots, u_{pU}$, where p is PhCH number and U is the

number of bits in one radio sub-frame for each HS-PDCSH, i.e. $U = \frac{R}{P}$. The relation between w_k and u_{pk} is given below.

For all modes, some bits of the input flow are mapped to each code until the number of bits on the code is U .

Bits on first PhCH after physical channel segmentation:

$$u_{1,k} = w_k \quad k = 1, 2, \dots, U$$

Bits on second PhCH after physical channel segmentation:

$$u_{2,k} = w_{k+U} \quad k = 1, 2, \dots, U$$

...

Bits on the P^{th} PhCH after physical channel segmentation:

$$u_{p,k} = w_{k+(P-1) \times U} \quad k = 1, 2, \dots, U$$

4.5.6 Interleaving for HS-DSCH

The interleaving for FDD is done as shown in figure 18 below, separately for each physical channel. The bits input to the block interleaver are denoted by $u_{p,1}, u_{p,2}, u_{p,3}, \dots, u_{p,U}$, where p is PhCH number and U is the number of bits in one TTI for one PhCH. For QPSK $U = 960$ and for 16QAM $U = 1920$. For QPSK the interleaver is the same as Rel99 2nd interleaver described in Section 4.2.11. The interleaver is of fixed size: R2=32 rows and C2=30 columns.

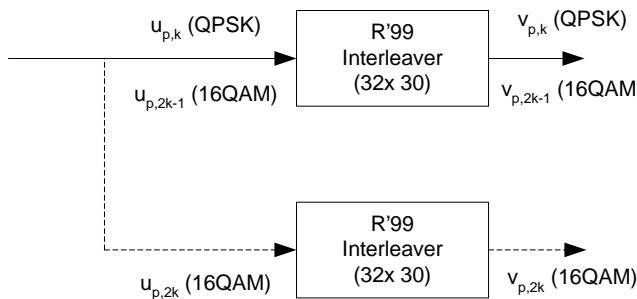


Figure 18 - Interleaver structure for HSDPA

For 16QAM, there are two identical interleavers of the same fixed size $R2 \times C2 = 32 \times 30$. The output bits from the physical channel segmentation are divided between the interleavers: all odd numbered bits to interleaver one and all even numbered bits to interleaver two.

4.5.7 Physical channel mapping for HS-DSCH

The HS-PDSCH is defined in [2]. The bits input to the physical channel mapping are denoted by $v_{p1}, v_{p2}, \dots, v_{pU}$, where p is the physical channel number and U is the number of bits in one radio sub-frame for one HS-PDSCH. The bits v_{pk} are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k .

4.5.8 Constellation re-arrangement for 16 QAM

This function only applies to 16 QAM modulated bits. In case of QPSK it is transparent.

The following table describes the operations that produce the different rearrangements.

The bits of the input sequence are mapped in groups of 4 so that $v_{pk}, v_{pk+1}, v_{pk+2}, v_{pk+3}$ map to $i_a i_b q_a q_b$, where $k \bmod 4 = 0$.

Table 11 – Constellation re-arrangement for 16 QAM

constellation version parameter b	Output bit sequence	Operation
0	$i_a q_a i_b q_b$	None
1	$i_b q_b i_a q_a$	Swapping i_a with i_b and q_a with q_b
2	$i_a q_a \overline{i_b q_b}$	XOR with 0011 (equivalent to inversion of the logical values of i_b and q_b)
3	$i_b q_b \overline{i_a q_a}$	Swapping i_a with i_b and q_a with q_b and XOR with 0011

The output bit sequences from the table above map to the output bits in groups of 4, i.e. $r_{pk}, r_{pk+1}, r_{pk+2}, r_{pk+3}$, where $k \bmod 4 = 0$.

4.6 Coding for HS-SCCH

The following information is transmitted by means of the HS-SCCH physical channel.

- Channelization-code-set information (7 bits): $x_{ccs,1}, x_{ccs,2}, \dots, x_{ccs,7}$
- Modulation scheme information (1 bit): $x_{ms,1}$
- Transport-block size information (6 bits): $x_{tbs,1}, x_{tbs,2}, \dots, x_{tbs,6}$
- Hybrid-ARQ process information (3 bits): $x_{hap,1}, x_{hap,2}, x_{hap,3}$
- Redundancy and constellation version: r, s, b
- New data indicator (1 bit): $x_{nd,1}$
- UE identity (10 bits) $x_{ue,1}, x_{ue,2}, \dots, x_{ue,10}$

4.6.1 Overview

Figure 19 below illustrates the overall coding chain for HS-SCCH.

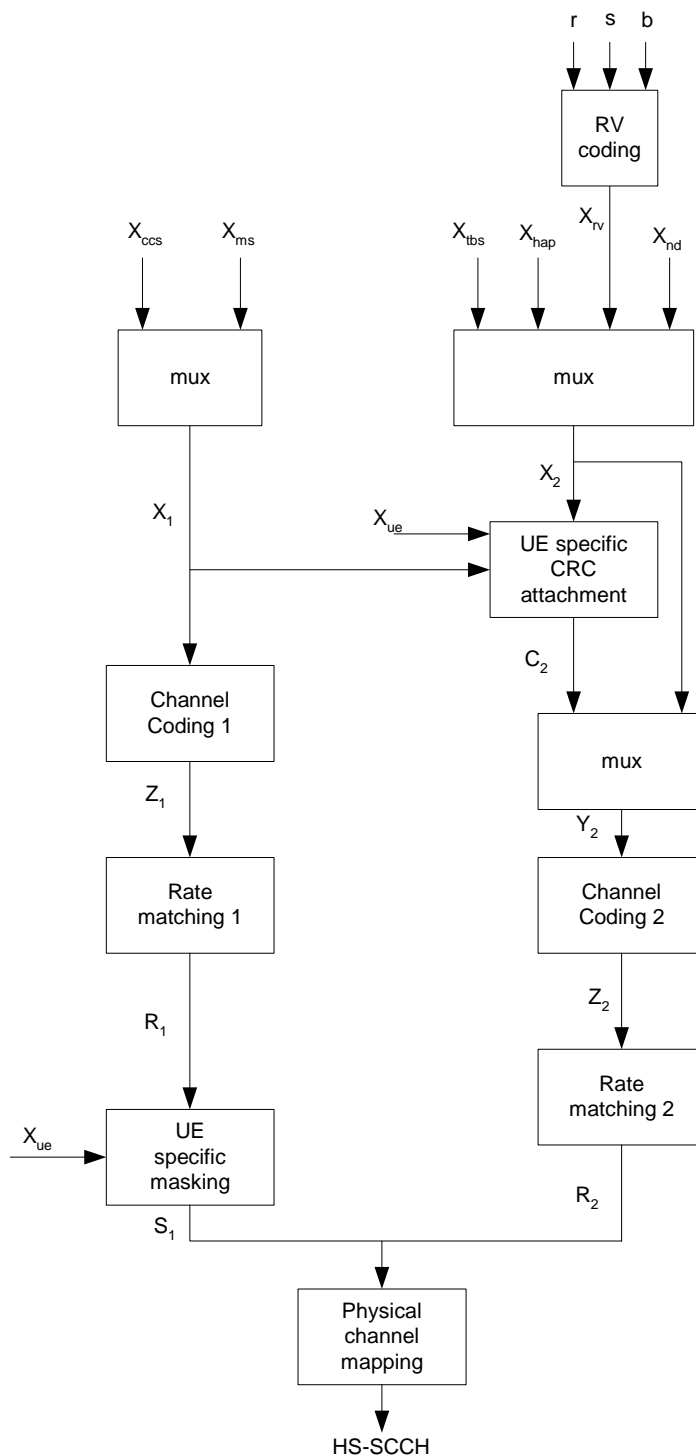


Figure 19 - Coding chain for HS-SCCH

4.6.2 Redundancy and constellation version coding

The redundancy version (RV) parameters r , s and constellation version parameter b are coded jointly to produce the value X_{rv} . X_{rv} is alternatively represented as the sequence $x_{rv,1}, x_{rv,2}, x_{rv,3}$ where $x_{rv,1}$ is the msb. This is done according to the following tables according to the modulation mode used:

Table 12 – RV coding for 16 QAM

X_{rv} (value)	s	r	b
0	1	0	0
1	0	0	0
2	1	1	1
3	0	1	1
4	1	0	1
5	1	0	2
6	1	0	3
7	1	1	0

Table 13 – RV coding for QPSK

X_{rv} (value)	s	r
0	1	0
1	0	0
2	1	1
3	0	1
4	1	2
5	0	2
6	1	3
7	0	3

4.6.3 Multiplexing of HS-SCCH information

The channelization-code-set information $x_{ccs,1}, x_{ccs,2}, \dots, x_{ccs,7}$ and modulation-scheme information $x_{m,1}$ are multiplexed together. This gives a sequence of bits $x_{1,1}, x_{1,2}, \dots, x_{1,8}$ where

$$x_{1,i} = x_{ccs,i} \quad i=1,2,\dots,7$$

$$x_{1,i} = x_{ms,i-7} \quad i=8$$

The transport-block-size information $x_{tbs,1}, x_{tbs,2}, \dots, x_{tbs,6}$, Hybrid-ARQ-process information $x_{hap,1}, x_{hap,2}, x_{hap,3}$, redundancy-version information $x_{rv,1}, x_{rv,2}, x_{rv,3}$ and new-data indicator $x_{nd,1}$ are multiplexed together. This gives a sequence of bits $x_{2,1}, x_{2,2}, \dots, x_{2,13}$ where

$$x_{2,i} = x_{tbs,i} \quad i=1,2,\dots,6$$

$$x_{2,i} = x_{hap,i-6} \quad i=7,8,9$$

$$x_{2,i} = x_{rv,i-9} \quad i=10,11,12$$

$$x_{2,i} = x_{nd,i-12} \quad i=13$$

4.6.4 CRC attachment for HS-SCCH

From the sequence of bits $x_{1,1}, x_{1,2}, \dots, x_{1,8}, x_{2,1}, x_{2,2}, \dots, x_{2,13}$ a 16 bits CRC is calculated according to Section 4.2.1.1. This gives a sequence of bits c_1, c_2, \dots, c_{16} . This sequence of bits is then masked with the UE ID $x_{ue,1}, x_{ue,2}, \dots, x_{ue,10}$ and then appended to the sequence if bits $x_{2,1}, x_{2,2}, \dots, x_{2,13}$. This gives a sequence of bits y_1, y_2, \dots, y_{29} , where

$$y_i = x_{2,i} \quad i=1,2,\dots,13$$

$$y_i = c_{i-13} \wedge x_{ue,i-13} \quad i=14,15,\dots,23$$

$$y_i = c_{i-13} \quad i=24,25,\dots,29$$

4.6.5 Channel coding for HS-SCCH

Rate $\frac{1}{2}$ convolutional coding, as described in Section 4.2.3.1, is applied to the sequence of bits $x_{1,1}, x_{1,2}, \dots, x_{1,8}$. This gives a sequence of bits $z_{1,1}, z_{1,2}, \dots, z_{1,32}$.

Rate $\frac{1}{2}$ convolutional coding, as described in Section 4.2.3.1, is applied to the sequence of bits y_1, y_2, \dots, y_{29} . This gives a sequence of bits $z_{2,1}, z_{2,2}, \dots, z_{2,73}$.

4.6.6 Rate matching for HS-SCCH

Rate matching for HS-SCCH shall be done with the general method described in 4.2.7.5.

4.6.7 UE specific masking for HS-SCCH

The rate matched bits $r_{1,1}, r_{1,2}, \dots, r_{1,40}$ shall be masked in an UE specific way using the UE ID $x_{ue,1}, x_{ue,2}, \dots, x_{ue,10}$ to produce the bits $s_{1,1}, s_{1,2}, \dots, s_{1,40}$.

Define intermediate code word bits b_i by:

$$b_i = \sum_{n=0}^9 (x_{ue,n} \times M_{i,n}) \bmod 2$$

where $i = 0, \dots, 31$ and the values of $M_{i,n}$ are taken from table 8.

The mask output bits are denoted by $r_k, k = 1, 2, \dots, 40$ and are calculated as follows:

$$r_k = b_{k-1} \quad \text{for } k = 1, 2, \dots, 32$$

$$r_k = b_{k-33} \quad \text{for } k = 33, 34, \dots, 40$$

4.6.8 Physical channel mapping for HS-SCCH

The HS-SCCH sub-frame is described in [2].

The sequence of bits $s_{1,1}, s_{1,2}, \dots, s_{1,40}$ is mapped to the first slot of the HS-SCCH sub frame. The bits $s_{1,k}$ are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k .

The sequence of bits $r_{2,1}, r_{2,2}, \dots, r_{2,80}$ is mapped to the second and third slot of the HS-SCCH sub frame. The bits $r_{2,k}$ are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k .

Note that compressed mode is used for the HS-SCCH.

4.7 Coding for HS-DPCCH

Data arrives to the coding unit in form of indicators for measurement indication and HARQ acknowledgement.

The following coding/multiplexing steps can be identified:

- channel coding (see subclause 4.7.1);
- mapping to physical channels (see subclause 4.7.2).

The general coding flow is shown in the figure below. This is done in parallel for the HARQ-ACK and CQI as the flows are not directly multiplexed but are transmitted at different times.

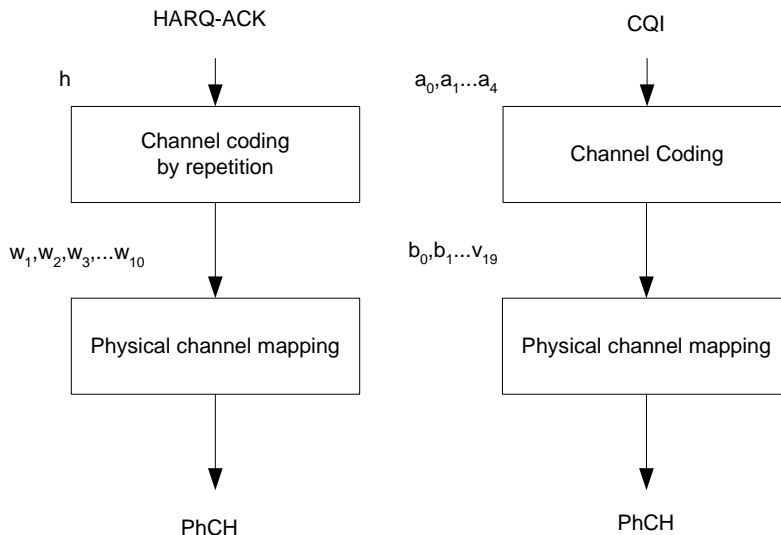


Figure 20 – Coding for HS-DPCCH

4.7.1 Channel coding for HS-DPCCH

Two forms of channel coding are used, one for the channel quality information (CQI) and another for HARQ-ACK (acknowledgement).

4.7.1.1 Channel coding for HS-DPCCH HARQ-ACK

The 1 bit HARQ acknowledgement shall be repetition coded to 10 bits. The output is denoted w_1, w_2, \dots, w_{10} .

4.7.1.2 Channel coding for HS-DPCCH channel quality information

The channel quality information is coded using a (20,5) code. The code words of the (20,5) code are a linear combination of the 5 basis sequences denoted $M_{i,n}$ defined in the table below.

Table 14: Basis sequences for (20,5) code

I	M_{i,0}	M_{i,1}	M_{i,2}	M_{i,3}	M_{i,4}
0	1	0	0	0	1
1	0	1	0	0	1
2	1	1	0	0	1
3	0	0	1	0	1
4	1	0	1	0	1
5	0	1	1	0	1
6	1	1	1	0	1
7	0	0	0	1	1
8	1	0	0	1	1
9	0	1	0	1	1
10	1	1	0	1	1
11	0	0	1	1	1
12	1	0	1	1	1
13	0	1	1	1	1
14	1	1	1	1	1
15	0	0	0	0	1
16	0	0	0	0	1
17	0	0	0	0	1
18	0	0	0	0	1
19	0	0	0	1	0

The channel quality information bits are a_0, a_1, a_2, a_3, a_4 (where a_0 is LSB and a_4 is MSB). The output code word bits b_i are given by:

$$b_i = \sum_{n=0}^4 (a_n \times M_{i,n}) \bmod 2$$

where $i = 0, \dots, 19$.

4.7.2 Physical channel mapping for HS-DPCCH

The HS-DPCCH physical channel mapping function shall map the input bits w_k directly to physical channel bits in increasing order of k .

The HS-DPCCH physical channel mapping function shall map the input bits b_k directly to physical channel bits in increasing order of k .

Annex A (informative): Blind transport format detection

A.1 Blind transport format detection using fixed positions

A.1.1 Blind transport format detection using received power ratio

For the dual transport format case (the possible data rates are 0 and full rate, and CRC is only transmitted for full rate), blind transport format detection using received power ratio can be used.

The transport format detection is then done using average received power ratio of DPDCH to DPCCH. Define the following:

- P_c : Received power per bit of DPCCH calculated from all pilot and TPC bits per slot over a radio frame;
- P_d : Received power per bit of DPDCH calculated from X bits per slot over a radio frame;
- X : the number of DPDCH bits per slot when transport format corresponds to full rate;
- T : Threshold of average received power ratio of DPDCH to DPCCH for transport format detection.

The decision rule can then be formulated as:

If $P_d/P_c > T$ then:

- full rate transport format detected;
- else
- zero rate transport format detected.

A.1.2 Blind transport format detection using CRC

For the multiple transport format case (the possible data rates are 0, ..., (full rate)/ r , ..., full rate, and CRC is transmitted for all transport formats), blind transport format detection using CRC can be used.

At the transmitter, the data stream with variable number of bits from higher layers is block-encoded using a cyclic redundancy check (CRC) and then convolutionally encoded. CRC parity bits are attached just after the data stream with variable number of bits as shown in figure A.1.

The receiver knows only the possible transport formats (or the possible end bit position $\{n_{\text{end}}\}$) by Layer-3 negotiation. The receiver performs Viterbi-decoding on the soft decision sample sequence. The correct trellis path of the Viterbi-decoder ends at the zero state at the correct end bit position.

The blind transport format detection method using CRC traces back the surviving trellis path ending at the zero state (hypothetical trellis path) at each possible end bit position to recover the data sequence. For each recovered data sequence error-detection is performed by checking the CRC, and if there is no error, the recovered sequence is declared to be correct.

The following variable is defined:

$$s(n_{\text{end}}) = -10 \log \left(\frac{a_0(n_{\text{end}}) - a_{\min}(n_{\text{end}})}{a_{\max}(n_{\text{end}}) - a_{\min}(n_{\text{end}})} \right) \text{ [dB]} \quad (\text{Eq. 1})$$

where $a_{\max}(n_{\text{end}})$ and $a_{\min}(n_{\text{end}})$ are the maximum and minimum path-metric values among all survivors at end bit position n_{end} , and $a_0(n_{\text{end}})$ is the path-metric value at zero state.

In order to reduce the probability of false detection (this happens if the selected path is wrong but the CRC misses the error detection), a path selection threshold D is introduced. The threshold D determines whether the hypothetical trellis path connected to the zero state should be traced back or not at each end bit position n_{end} . If the hypothetical trellis path connected to the zero state that satisfies:

$$s(n_{end}) \leq D \quad (\text{Eq. 2})$$

is found, the path is traced back to recover the frame data, where D is the path selection threshold and a design parameter.

If more than one end bit positions satisfying Eq. 2 is found, the end bit position which has minimum value of $s(n_{end})$ is declared to be correct. If no path satisfying Eq. 2 is found even after all possible end bit positions have been exhausted, the received frame data is declared to be in error.

Figure A-2 shows the procedure of blind transport format detection using CRC.

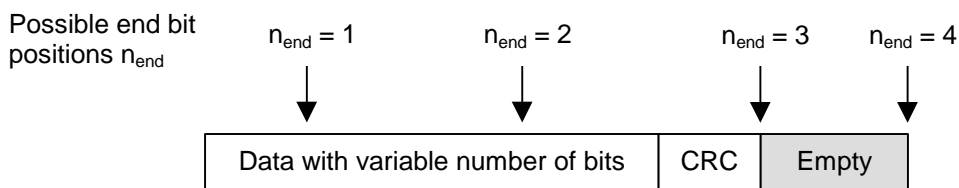
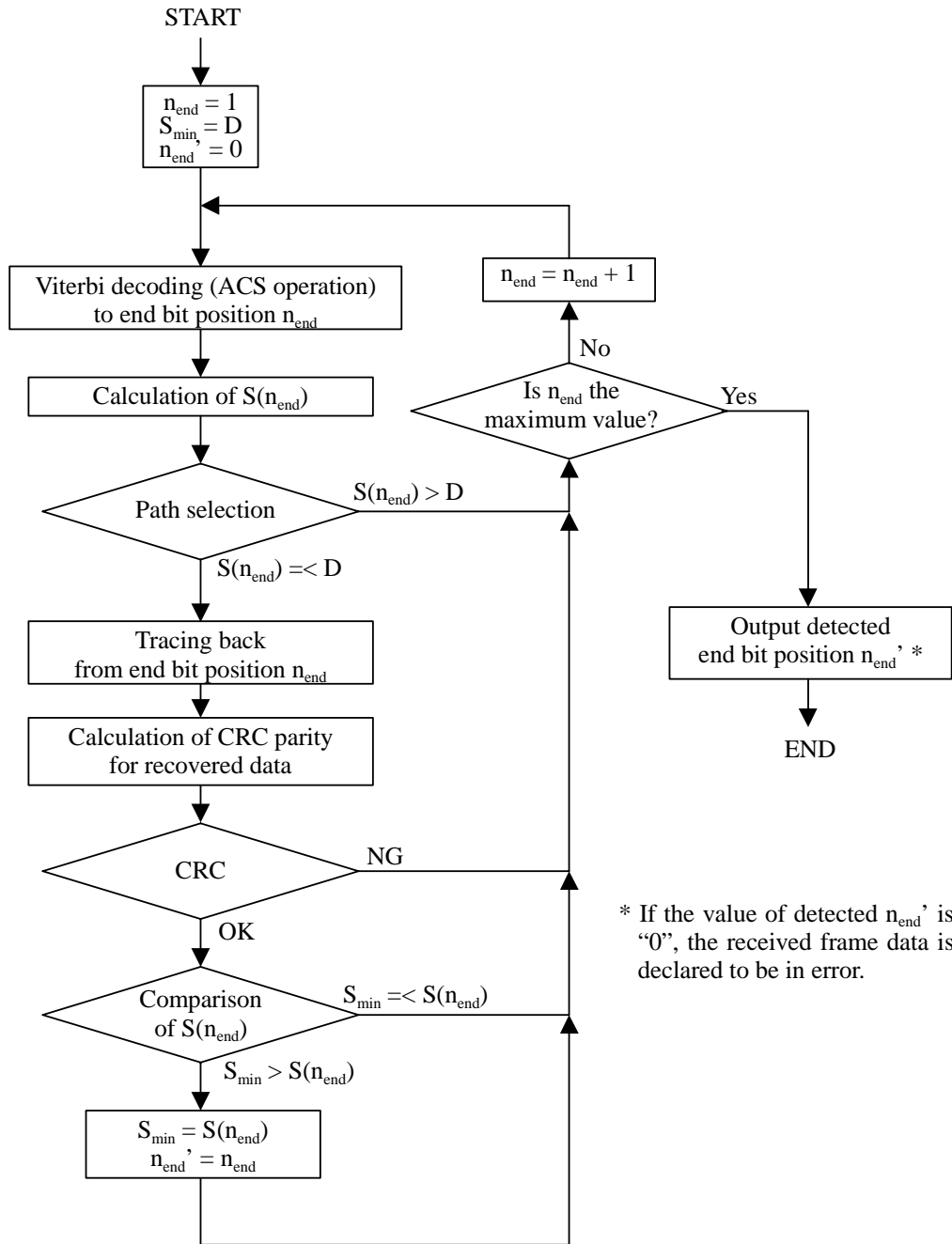


Figure A.1: An example of data with variable number of bits. Four possible transport formats, and transmitted end bit position $n_{end} = 3$



* If the value of detected n_{end}' is "0", the received frame data is declared to be in error.

Figure A.2: Basic processing flow of blind transport format detection

Annex B (informative): Compressed mode idle lengths

The tables 9-11 show the resulting idle lengths for different transmission gap lengths, UL/DL modes and DL frame types. The idle lengths given are calculated purely from the slot and frame structures and the UL/DL offset. They do not contain margins for e.g. synthesizer switching.

B.1 Idle lengths for DL, UL and DL+UL compressed mode

Table 9: Parameters for DL compressed mode

TGL	DL Frame Type	Spreading Factor	Idle length [ms]	Transmission time Reduction method	Idle frame Combining
3	A	512 – 4	1.73 – 1.99	Puncturing, Spreading factor division by 2 or Higher layer scheduling	(S) (D) =(1,2) or (2,1)
	B		1.60 – 1.86		(S) (D) =(1,3), (2,2) or (3,1)
4	A		2.40 – 2.66		(S) (D) = (1,4), (2,3), (3, 2) or (4,1)
	B		2.27 – 2.53		(S) (D)=(1,6), (2,5), (3,4), (4,3), (5,2) or (6,1)
5	A		3.07 – 3.33		(D)=(3,7), (4,6), (5,5), (6,4) or (7,3)
	B		2.93 – 3.19		(D) =(7,7)
7	A		4.40 – 4.66		
	B		4.27 – 4.53		
10	A		6.40 – 6.66		
	B		6.27 – 6.53		
14	A		9.07 – 9.33		
	B		8.93 – 9.19		

Table 10: Parameters for UL compressed mode

TGL	Spreading Factor	Idle length [ms]	Transmission time Reduction method	Idle frame Combining
3	256 – 4	2.00	Spreading factor division by 2 or Higher layer scheduling	(S) (D) =(1,2) or (2,1)
4		2.67		(S) (D) =(1,3), (2,2) or (3,1)
5		3.33		(S) (D) = (1,4), (2,3), (3, 2) or (4,1)
7		4.67		(S) (D)=(1,6), (2,5), (3,4), (4,3), (5,2) or (6,1)
10		6.67		(D)=(3,7), (4,6), (5,5), (6,4) or (7,3)
14		9.33		(D) =(7,7)

Table 11: Parameters for combined UL/DL compressed mode

TGL	DL Frame Type	Spreading Factor	Idle length [ms]	Transmission time Reduction method	Idle frame Combining
3	A or B	DL: 512 – 4	1.47 – 1.73	DL: Puncturing, Spreading factor division by 2 or Higher layer scheduling UL: Spreading factor division by 2 or Higher layer scheduling	(S) (D) =(1,2) or (2,1)
4			2.13 – 2.39		(S) (D) =(1,3), (2,2) or (3,1)
5		UL: 256 – 4	2.80 – 3.06		(S) (D) = (1,4), (2,3), (3, 2) or (4,1)
7			4.13 – 4.39		(S) (D)=(1,6), (2,5), (3,4), (4,3), (5,2) or (6,1)
10		6.13 – 6.39	(D)=(3,7), (4,6), (5,5), (6,4) or (7,3)		
14		8.80 – 9.06	(D) =(7,7)		

(S): Single-frame method as shown in figure 14 (1).

(D): Double-frame method as shown in figure 14 (2). (x,y) indicates x: the number of idle slots in the first frame, y: the number of idle slots in the second frame.

NOTE: Compressed mode by spreading factor reduction is not supported when SF=4 is used in normal mode

Annex C (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
	RAN_05	RP-99588	-		Approved at TSG RAN #5 and placed under Change Control	-	3.0.0
14/01/00	RAN_06	RP-99680	001	3	Correction of rate matching parameters for repetition after 1st interleaving in 25.212	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	004	-	Changing the initial offset value for convolutional code rate matching	3.0.0	3.1.0
14/01/00	RAN_06	RP-99681	005	1	Introduction of compressed mode by higher layer scheduling	3.0.0	3.1.0
14/01/00	RAN_06	RP-99679	008	-	Editorial corrections to TS 25.212	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	009	-	Removal of SFN multiplexing	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	010	1	Clarification of bit separation and collection	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	011	2	Connection between TTI and CFN	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	012	2	Zero length transport blocks	3.0.0	3.1.0
14/01/00	RAN_06	RP-99679	014	-	Update of channel coding sections	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	016	-	Removal of TrCH restriction in DSCH CTrCH	3.0.0	3.1.0
14/01/00	RAN_06	RP-99681	017	-	20 ms RACH message length	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	018	-	Minimum SF in UL	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	024	-	Rate matching parameter determination in DL and fixed positions	3.0.0	3.1.0
14/01/00	RAN_06	RP-99680	026	1	Corrections to TS 25.212	3.0.0	3.1.0
14/01/00	RAN_06	RP-99679	027	-	Modification of BTFD description in 25.212 Annex	3.0.0	3.1.0
14/01/00	RAN_06	RP-99681	028	-	TFCI coding and mapping including compressed mode	3.0.0	3.1.0
14/01/00	-	-	-	-	Change history was added by the editor	3.1.0	3.1.1
31/03/00	RAN_07	RP-000061	025	2	CR for parity bit attachment to 0 bit transport block	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	029	1	Limitations of blind transport format detection	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	034	1	Clarification of fixed position rate matching	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	035	1	Clarification of DL compressed mode	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	036	-	Reconfiguration of TFCS	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	037	1	Removal of fixed gap position in 25.212	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	038	2	Definition clarification for TS 25.212	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	039	1	Clarification on TFCI coding input	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	041	2	Correction of UL compressed mode by higher layer scheduling	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	042	5	Downlink Compressed Mode by puncturing	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	044	-	Modification of Turbo code internal interleaver	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	045	-	Editorial corrections	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	046	-	SF/2 method: DTX insertion after 2nd interleaver	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	047	1	TFCI coding for FDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	048	-	Mapping of TFCI in downlink compressed mode	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	049	-	Editorial changes to Annex A	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	050	-	Removal of rate matching attribute setting for RACH	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	052	-	Padding Function for Turbo coding of small blocks	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	055	2	Clarifications relating to DSCH	3.1.1	3.2.0
31/03/00	RAN_07	RP-000061	056	-	Editorial modification of uplink shifting parameter calculation for turbo code puncturing	3.1.1	3.2.0
31/03/00	RAN_07	RP-000062	059	1	Revision: Editorial correction to the calculation of Rate Matching parameters	3.1.1	3.2.0
31/03/00	RAN_07	RP-000062	060	1	Editorial changes of channel coding section	3.1.1	3.2.0
31/03/00	RAN_07	RP-000062	061	-	Removal of DL compressed mode by higher layer scheduling with fixed positions	3.1.1	3.2.0
26/06/00	RAN_08	RP-000266	066	1	Section 4.4.5 and table 9 is moved to informative annex	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	068	-	Editorial modifications of 25.212	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	069	-	Removal of BTFD for flexible positions in Release 99	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	070	1	Editorial modifications	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	071	1	Corrections and editorial modifications of 25.212 for 2nd insertion of DTX bits for CM	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	072	4	Corrections to 25.212 (Rate Matching, p-bit insertion, PhCH segmentation)	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	073	-	Editorial correction in 25.212 coding/multiplexing	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	074	2	Bit separation of the Turbo encoded data	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	076	1	Revision of code block segmentation description	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	077	-	Clarifications for TFCI coding	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	078	2	Clarifying the rate matching parameter setting for the RACH and BCH	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	080	-	Clarification on BTFD utilisation (single CTrCH)	3.2.0	3.3.0

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
26/06/00	RAN_08	RP-000266	081	-	Correction of order of checking TFC during flexible position RM parameter determination	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	082	-	Editorial corrections in channel coding section	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	083	-	Correction for bit separation and bit collection	3.2.0	3.3.0
26/06/00	RAN_08	RP-000266	084	1	Correction on the spreading factor selection for the RACH	3.2.0	3.3.0
23/09/00	RAN_09	RP-000341	079	-	Clarification of compressed mode terminology	3.3.0	3.4.0
23/09/00	RAN_09	RP-000341	085	1	Editorial corrections in Turbo code internal interleaver section	3.3.0	3.4.0
23/09/00	RAN_09	RP-000341	086	1	Clarification on DL slot format for compressed mode by SF/2	3.3.0	3.4.0
23/09/00	RAN_09	RP-000341	087	-	Corrections	3.3.0	3.4.0
23/09/00	RAN_09	RP-000341	088	1	Clarifications to TS 25.212	3.3.0	3.4.0
23/09/00	RAN_09	RP-000341	089	-	Correction regarding DSCH	3.3.0	3.4.0
23/09/00	RAN_09	RP-000341	090	-	Correction regarding CPCH	3.3.0	3.4.0
23/09/00	RAN_09	RP-000341	092	1	Bit separation and collection for rate matching	3.3.0	3.4.0
23/09/00	RAN_09	RP-000341	093	-	Puncturing Limit definition in WG1 specification	3.3.0	3.4.0
15/12/00	RAN_10	RP-000538	094	2	Correction of BTFD limitations	3.4.0	3.5.0
15/12/00	RAN_10	RP-000538	096	-	Compressed mode by puncturing	3.4.0	3.5.0
15/12/00	RAN_10	RP-000538	097	-	Clarification on the Ci formula	3.4.0	3.5.0
15/12/00	RAN_10	RP-000538	099	-	Editorial modification in RM section	3.4.0	3.5.0
15/12/00	RAN_10	RP-000538	100	1	Editorial corrections in TS 25.212	3.4.0	3.5.0
15/12/00	RAN_10	RP-000538	101	-	Correction to code block segmentation	3.4.0	3.5.0
16/03/01	RAN_11	-	-	-	Approved as Release 4 specification (v4.0.0) at TSG RAN #11	3.5.0	4.0.0
15/06/01	RAN_12	RP-010332	106	-	Correction of compressed mode by puncturing	4.0.0	4.1.0
15/06/01	RAN_12	RP-010332	108	1	Dual transport format detection	4.0.0	4.1.0
15/06/01	RAN_12	RP-010332	112	1	Correction for downlink rate matching for the DSCH	4.0.0	4.1.0
21/09/01	RAN_13	RP-010519	115	-	Correction of PDSCH spreading factor signalling	4.1.0	4.2.0
14/12/01	RAN_14	RP-010737	118	-	Clarification of compressed mode	4.2.0	4.3.0
14/12/01	RAN_14	RP-010737	122	-	Support of multiple CCTrChs of dedicated type	4.2.0	4.3.0

CHANGE REQUEST

⌘ **25.213 CR 049** ⌘ rev **-** ⌘ Current version: **4.2.0** ⌘

For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.

Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ The inclusion of HSDPA into 25.213		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ 22, Feb, 2002
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories:		Use <u>one</u> of the following releases:
	F (correction)		2 (GSM Phase 2)
	A (corresponds to a correction in an earlier release)		R96 (Release 1996)
	B (addition of feature),		R97 (Release 1997)
	C (functional modification of feature)		R98 (Release 1998)
	D (editorial modification)		R99 (Release 1999)
	Detailed explanations of the above categories can be found in 3GPP TR 21.900.		REL-4 (Release 4)
			REL-5 (Release 5)

Reason for change:	⌘ - To add function of HSDPA
Summary of change:	⌘ - HSDPA related topics area updated.
Consequences if not approved:	⌘ - Work item for HSDPA-Phys will not be part of REL-5.

Clauses affected:	⌘ - 4, 5	
Other specs affected:	⌘ <input checked="" type="checkbox"/> Other core specifications	⌘ 25.201, 25.211, 25.212, 25.214, 25.215
	<input type="checkbox"/> Test specifications	
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3G TS 25.213 V4.2.05.0.0 (20024-312)

Technical Specification

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Spreading and modulation (FDD) (Release 54)



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Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document describes spreading and modulation for UTRA Physical Layer FDD mode.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TS 25.201: "Physical layer - general description".
- [2] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)."
- [3] 3GPP TS 25.101: "UE Radio transmission and Reception (FDD)".
- [4] 3GPP TS 25.104: "UTRA (BS) FDD; Radio transmission and Reception".
- [5] 3GPP TS 25.308: "UTRA High Speed Downlink Packet Access (HSDPA); Overall description".

3 Symbols and abbreviations

3.1 Symbols

For the purposes of the present document, the following symbols apply:

$C_{ch,SF,n}$:	n :th channelization code with spreading factor SF
$C_{pre,n,s}$:	PRACH preamble code for n :th preamble scrambling code and signature s
$C_{c-acc,n,s}$:	PCPCH access preamble code for n :th preamble scrambling code and signature s
$C_{c-cd,n,s}$:	PCPCH CD preamble code for n :th preamble scrambling code and signature s
$C_{sig,s}$:	PRACH/PCPCH signature code for signature s
$S_{dpch,n}$:	n :th DPCCH/DPDCH uplink scrambling code
$S_{r-pre,n}$:	n :th PRACH preamble scrambling code

$S_{r\text{-msg},n}$:	n :th PRACH message scrambling code
$S_{c\text{-acc}}$:	n :th PCPCH access preamble scrambling code
$S_{c\text{-cd}}$:	n :th PCPCH CD preamble scrambling code
$S_{c\text{-msg},n}$:	n :th PCPCH message scrambling code
$S_{dl,n}$:	DL scrambling code
C_{psc} :	PSC code
$C_{ssc,n}$:	n :th SSC code

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

16QAM	16 Quadrature Amplitude Modulation
AICH	Acquisition Indicator Channel
AP	Access Preamble

BCH	Broadcast Control Channel
CCPCH	Common Control Physical Channel
CD	Collision Detection
CPCH	Common Packet Channel
CPICH	Common Pilot Channel
DCH	Dedicated Channel
DPCH	Dedicated Physical Channel
DPCCH	Dedicated Physical Control Channel
HS-DPCCH	Dedicated Physical Control Channel (uplink) for HS-DSCH
DPDCH	Dedicated Physical Data Channel
FDD	Frequency Division Duplex
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	Shared Control Physical Channel for HS-DSCH
Mcps	Mega Chip Per Second
OVSF	Orthogonal Variable Spreading Factor (codes)

PDSCH	Physical Dedicated Shared Channel
PICH	Page Indication Channel
PRACH	Physical Random Access Channel
PSC	Primary Synchronisation Code
RACH	Random Access Channel
SCH	Synchronisation Channel
SSC	Secondary Synchronisation Code
SF	Spreading Factor
UE	User Equipment

4 Uplink spreading and modulation

4.1 Overview

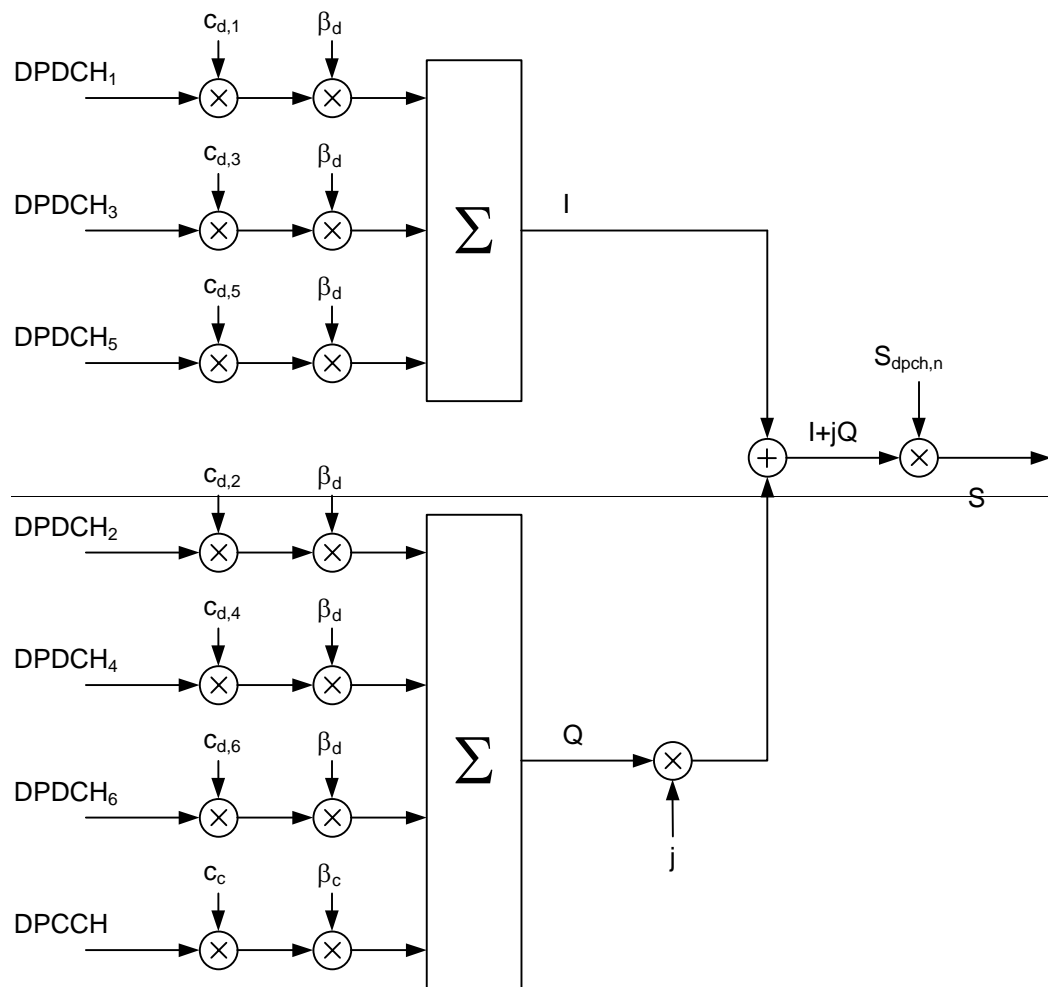
Spreading is applied to the physical channels. It consists of two operations. The first is the channelization operation, which transforms every data symbol into a number of chips, thus increasing the bandwidth of the signal. The number of chips per data symbol is called the Spreading Factor (SF). The second operation is the scrambling operation, where a scrambling code is applied to the spread signal.

With the channelization, data symbols on so-called I- and Q-branches are independently multiplied with an OVSF code. With the scrambling operation, the resultant signals on the I- and Q-branches are further multiplied by complex-valued scrambling code, where I and Q denote real and imaginary parts, respectively.

4.2 Spreading

4.2.1 DPCCH/DPDCH/HS-DPCCH

Figure 1 illustrates the principle of the uplink spreading of DPCCH, and DPDCHs and HS-DPCCH. The binary DPCCH, and DPDCHs and HS-DPCCH to be spread are represented by real-valued sequences, i.e. the binary value "0" is mapped to the real value +1, while the binary value "1" is mapped to the real value -1. The DPCCH is spread to the chip rate by the channelization code $c_{c,7}$ while the n :th DPDCH called $DPDCH_n$ is spread to the chip rate by the channelization code $c_{d,n}$. The HS-DPCCH is spread to the chip rate by the channelization code C_{HS} . One DPCCH, and up to six parallel DPDCHs, and one HS-DPCCH can be transmitted simultaneously, i.e. $1 \leq n \leq 6$.



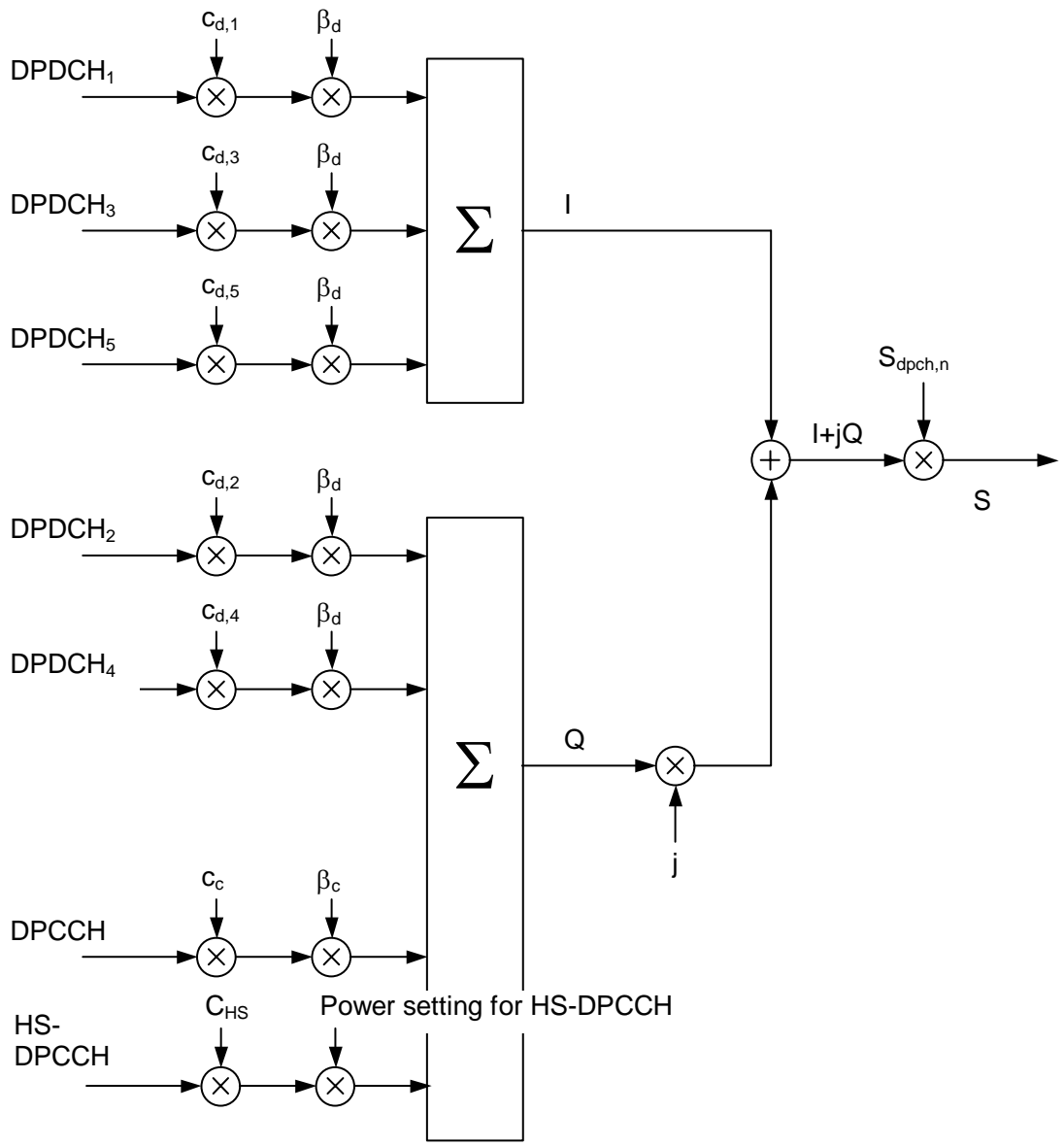


Figure 1: Spreading for uplink DPCCH and DPDCHs

After channelization, the real-valued spread signals are weighted by gain factors, β_c for DPCCH and β_d for all DPDCHs.

At every instant in time, at least one of the values β_c and β_d has the amplitude 1.0. The β -values are quantized into 4 bit words. The quantization steps are given in table 1.

Table 1: The quantization of the gain parameters

Signalling values for β_c and β_d	Quantized amplitude ratios β_c and β_d
15	1.0
14	14/15
13	13/15
12	12/15
11	11/15
10	10/15
9	9/15
8	8/15
7	7/15
6	6/15
5	5/15
4	4/15
3	3/15

2	2/15
1	1/15
0	Switch off

After the weighting, the stream of real-valued chips on the I- and Q-branches are then summed and treated as a complex-valued stream of chips. This complex-valued signal is then scrambled by the complex-valued scrambling code $S_{\text{dpcch},n}$. The scrambling code is applied aligned with the radio frames, i.e. the first scrambling chip corresponds to the beginning of a radio frame. HS-DPCCH is mapped to Q branch.

4.2.2 PRACH

4.2.2.1 PRACH preamble part

The PRACH preamble part consists of a complex-valued code, described in section 4.3.3.

4.2.2.2 PRACH message part

Figure 2 illustrates the principle of the spreading and scrambling of the PRACH message part, consisting of data and control parts. The binary control and data parts to be spread are represented by real-valued sequences, i.e. the binary value "0" is mapped to the real value +1, while the binary value "1" is mapped to the real value -1 . The control part is spread to the chip rate by the channelization code c_c , while the data part is spread to the chip rate by the channelization code c_d .

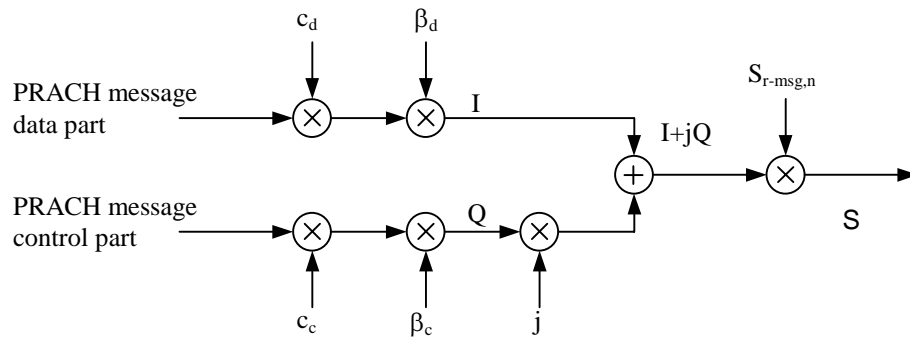


Figure 2: Spreading of PRACH message part

After channelization, the real-valued spread signals are weighted by gain factors, β_c for the control part and β_d for the data part. At every instant in time, at least one of the values β_c and β_d has the amplitude 1.0. The β -values are quantized into 4 bit words. The quantization steps are given in section 4.2.1.

After the weighting, the stream of real-valued chips on the I- and Q-branches are treated as a complex-valued stream of chips. This complex-valued signal is then scrambled by the complex-valued scrambling code $S_{r\text{-msg},n}$. The 10 ms scrambling code is applied aligned with the 10 ms message part radio frames, i.e. the first scrambling chip corresponds to the beginning of a message part radio frame.

4.2.3 PCPCH

4.2.3.1 PCPCH preamble part

The PCPCH preamble part consists of a complex-valued code, described in section 4.3.4.

4.2.3.2 PCPCH message part

Figure 3 illustrates the principle of the spreading of the PCPCH message part, consisting of data and control parts. The binary control and data parts to be spread are represented by real-valued sequences, i.e. the binary value "0" is mapped to the real value +1, while the binary value "1" is mapped to the real value -1 . The control part is spread to the chip rate by the channelization code c_c , while the data part is spread to the chip rate by the channelization code c_d .

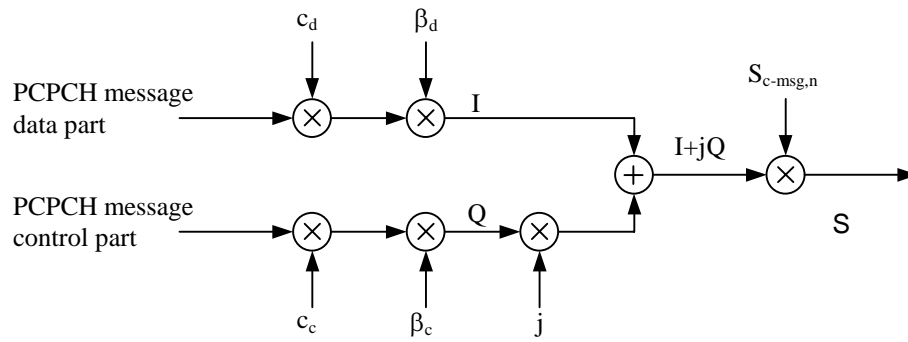


Figure 3: Spreading of PCPCH message part

After channelization, the real-valued spread signals are weighted by gain factors, β_c for the control part and β_d for the data part. At every instant in time, at least one of the values β_c and β_d has the amplitude 1.0. The β -values are quantized into 4 bit words. The quantization steps are given in section 4.2.1.

After the weighting, the stream of real-valued chips on the I- and Q-branches are treated as a complex-valued stream of chips. This complex-valued signal is then scrambled by the complex-valued scrambling code $S_{c\text{-msg},n}$. The 10 ms scrambling code is applied aligned with the 10 ms message part radio frames, i.e. the first scrambling chip corresponds to the beginning of a message part radio frame.

4.3 Code generation and allocation

4.3.1 Channelization codes

4.3.1.1 Code definition

The channelization codes of figure 1 are Orthogonal Variable Spreading Factor (OVSF) codes that preserve the orthogonality between a user's different physical channels. The OVSF codes can be defined using the code tree of figure 4.

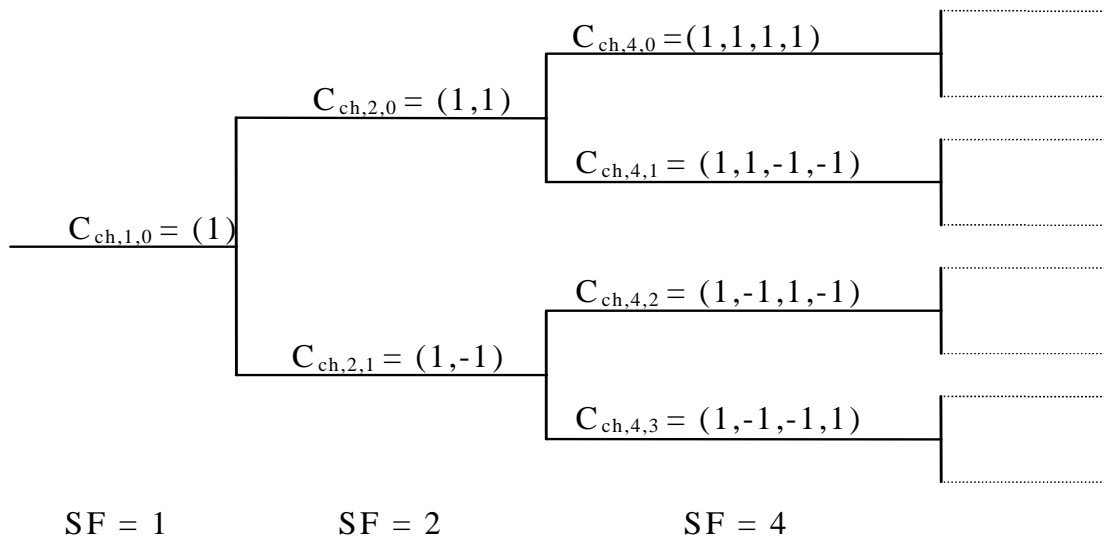


Figure 4: Code-tree for generation of Orthogonal Variable Spreading Factor (OVSF) codes

In figure 4, the channelization codes are uniquely described as $C_{ch,SF,k}$, where SF is the spreading factor of the code and k is the code number, $0 \leq k \leq SF-1$.

Each level in the code tree defines channelization codes of length SF, corresponding to a spreading factor of SF in figure 4.

The generation method for the channelization code is defined as:

$$C_{ch,1,0} = 1,$$
$$\begin{bmatrix} C_{ch,2,0} \\ C_{ch,2,1} \end{bmatrix} = \begin{bmatrix} C_{ch,1,0} & C_{ch,1,0} \\ C_{ch,1,0} & -C_{ch,1,0} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$\begin{bmatrix}
C_{ch,2^{(n+1)},0} \\
C_{ch,2^{(n+1)},1} \\
C_{ch,2^{(n+1)},2} \\
C_{ch,2^{(n+1)},3} \\
\vdots \\
C_{ch,2^{(n+1)},2^{(n+1)}-2} \\
C_{ch,2^{(n+1)},2^{(n+1)}-1}
\end{bmatrix}
=
\begin{bmatrix}
C_{ch,2^n,0} & C_{ch,2^n,0} \\
C_{ch,2^n,0} & -C_{ch,2^n,0} \\
C_{ch,2^n,1} & C_{ch,2^n,1} \\
C_{ch,2^n,1} & -C_{ch,2^n,1} \\
\vdots & \vdots \\
C_{ch,2^n,2^n-1} & C_{ch,2^n,2^n-1} \\
C_{ch,2^n,2^n-1} & -C_{ch,2^n,2^n-1}
\end{bmatrix}$$

The leftmost value in each channelization code word corresponds to the chip transmitted first in time.

4.3.1.2 Code allocation for DPCCH/DPDCH/HS-DPCCH

For the DPCCH, and DPDCHs and HS-DPCCH the following applies:

- The DPCCH is always spread by code $c_c = C_{ch,256,0}$.
- The HS-DPCCH is spread by $c_c = C_{ch,256,64}$.
- When only one DPDCH is to be transmitted, $DPDCH_1$ is spread by code $c_{d,1} = C_{ch,SF,k}$ where SF is the spreading factor of $DPDCH_1$ and $k = SF / 4$.
- When more than one DPDCH is to be transmitted, all DPDCHs have spreading factors equal to 4. $DPDCH_n$ is spread by the code $c_{d,n} = C_{ch,4,k}$, where $k = 1$ if $n \in \{1, 2\}$, $k = 3$ if $n \in \{3, 4\}$, and $k = 2$ if $n \in \{5, 6\}$.

If a power control preamble is used to initialise a DCH, the channelization code for the DPCCH during the power control preamble shall be the same as that to be used afterwards.

4.3.1.3 Code allocation for PRACH message part

The preamble signature s , $0 \leq s \leq 15$, points to one of the 16 nodes in the code-tree that corresponds to channelization codes of length 16. The sub-tree below the specified node is used for spreading of the message part. The control part is spread with the channelization code c_c (as shown in section 4.2.2.2) of spreading factor 256 in the lowest branch of the sub-tree, i.e. $c_c = C_{ch,256,m}$ where $m = 16 \times s + 15$. The data part uses any of the channelization codes from spreading factor 32 to 256 in the uppermost branch of the sub-tree. To be exact, the data part is spread by channelization code $c_d = C_{ch,SF,m}$ and SF is the spreading factor used for the data part and $m = SF \times s / 16$.

4.3.1.4 Code allocation for PCPCH message part

For the control part and data part the following applies:

- The control part is always spread by code $c_c = C_{ch,256,0}$.
- The data part is spread by code $c_d = C_{ch,SF,k}$ where SF is the spreading factor of the data part and $k = SF/4$.

The data part may use the code from spreading factor 4 to 256. A UE is allowed to increase SF during the message transmission on a frame by frame basis.

4.3.1.5 Channelization code for PCPCH power control preamble

The channelization code for the PCPCH power control preamble is the same as that used for the control part of the message part, as described in section 4.3.1.4 above.

4.3.2 Scrambling codes

4.3.2.1 General

All uplink physical channels are subjected to scrambling with a complex-valued scrambling code. The DPCCH/DPDCH/HS-DPCCH may be scrambled by either long or short scrambling codes, defined in section 4.3.2.4. The PRACH message part is

scrambled with a long scrambling code, defined in section 4.3.2.5. Also the PCPCH message part is scrambled with a long scrambling code, defined in section 4.3.2.6.

There are 2^{24} long and 2^{24} short uplink scrambling codes. Uplink scrambling codes are assigned by higher layers.

The long scrambling code is built from constituent long sequences defined in section 4.3.2.2, while the constituent short sequences used to build the short scrambling code are defined in section 4.3.2.3.

4.3.2.2 Long scrambling sequence

The long scrambling sequences $c_{\text{long},1,n}$ and $c_{\text{long},2,n}$ are constructed from position wise modulo 2 sum of 38400 chip segments of two binary m -sequences generated by means of two generator polynomials of degree 25. Let x , and y be the two m -sequences respectively. The x sequence is constructed using the primitive (over GF(2)) polynomial $X^{25}+X^3+1$. The y sequence is constructed using the polynomial $X^{25}+X^3+X^2+X+1$. The resulting sequences thus constitute segments of a set of Gold sequences.

The sequence $c_{\text{long},2,n}$ is a 16777232 chip shifted version of the sequence $c_{\text{long},1,n}$.

Let $n_{23} \dots n_0$ be the 24 bit binary representation of the scrambling sequence number n with n_0 being the least significant bit. The x sequence depends on the chosen scrambling sequence number n and is denoted x_n , in the sequel. Furthermore, let $x_n(i)$ and $y(i)$ denote the i :th symbol of the sequence x_n and y , respectively.

The m -sequences x_n and y are constructed as:

Initial conditions:

- $x_n(0)=n_0, x_n(1)=n_1, \dots, x_n(22)=n_{22}, x_n(23)=n_{23}, x_n(24)=1.$
- $y(0)=y(1)=\dots=y(23)=y(24)=1.$

Recursive definition of subsequent symbols:

- $x_n(i+25) = x_n(i+3) + x_n(i) \text{ modulo } 2, i=0, \dots, 2^{25}-27.$

$$- y(i+25) = y(i+3) + y(i+2) + y(i+1) + y(i) \text{ modulo } 2, i=0, \dots, 2^{25}-27.$$

Define the binary Gold sequence z_n by:

$$- z_n(i) = x_n(i) + y(i) \text{ modulo } 2, i = 0, 1, 2, \dots, 2^{25}-2.$$

The real valued Gold sequence Z_n is defined by:

$$Z_n(i) = \begin{cases} +1 & \text{if } z_n(i) = 0 \\ -1 & \text{if } z_n(i) = 1 \end{cases} \text{ for } i = 0, 1, \dots, 2^{25} - 2.$$

Now, the real-valued long scrambling sequences $c_{\text{long},1,n}$ and $c_{\text{long},2,n}$ are defined as follows:

$$c_{\text{long},1,n}(i) = Z_n(i), i = 0, 1, 2, \dots, 2^{25} - 2 \text{ and}$$

$$c_{\text{long},2,n}(i) = Z_n((i + 16777232) \text{ modulo } (2^{25} - 1)), i = 0, 1, 2, \dots, 2^{25} - 2.$$

Finally, the complex-valued long scrambling sequence $C_{long, n}$, is defined as:

$$C_{long, n}(i) = c_{long, 1, n}(i) \left(1 + j(-1)^i c_{long, 2, n}(2 \lfloor i/2 \rfloor) \right)$$

where $i = 0, 1, \dots, 2^{25} - 2$ and $\lfloor \cdot \rfloor$ denotes rounding to nearest lower integer.

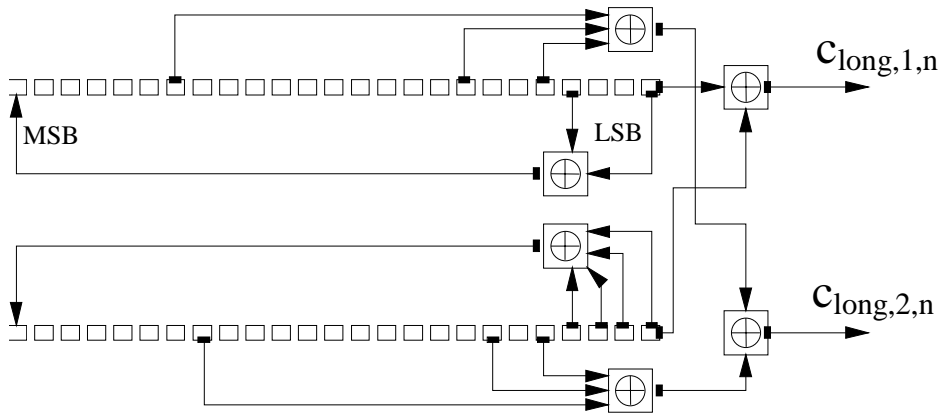


Figure 5: Configuration of uplink scrambling sequence generator

4.3.2.3 Short scrambling sequence

The short scrambling sequences $c_{\text{short},1,n}(i)$ and $c_{\text{short},2,n}(i)$ are defined from a sequence from the family of periodically extended S(2) codes.

Let $n_{23}n_{22}\dots n_0$ be the 24 bit binary representation of the code number n .

The n :th quaternary S(2) sequence $z_n(i)$, $0 \leq i \leq 16777215$, is obtained by modulo 4 addition of three sequences, a quaternary sequence $a(i)$ and two binary sequences $b(i)$ and $d(i)$, where the initial loading of the three sequences is determined from the code number n . The sequence $z_n(i)$ of length 255 is generated according to the following relation:

$$- z_n(i) = a(i) + 2b(i) + 2d(i) \text{ modulo } 4, i = 0, 1, \dots, 254;$$

where the quaternary sequence $a(i)$ is generated recursively by the polynomial $g_0(x) = x^8 + x^5 + 3x^3 + x^2 + 2x + 1$ as:

$$- a(0) = 2n_0 + 1 \text{ modulo } 4;$$

- $a(i) = 2n_i$ modulo 4, $i = 1, 2, \dots, 7$;

- $a(i) = 3a(i-3) + a(i-5) + 3a(i-6) + 2a(i-7) + 3a(i-8)$ modulo 4, $i = 8, 9, \dots, 254$;

and the binary sequence $b(i)$ is generated recursively by the polynomial $g_1(x) = x^8 + x^7 + x^5 + x + 1$ as

$$b(i) = n_{8+i} \text{ modulo } 2, i = 0, 1, \dots, 7,$$

$$b(i) = b(i-1) + b(i-3) + b(i-7) + b(i-8) \text{ modulo } 2, i = 8, 9, \dots, 254,$$

and the binary sequence $d(i)$ is generated recursively by the polynomial $g_2(x) = x^8 + x^7 + x^5 + x^4 + 1$ as:

$$d(i) = n_{16+i} \text{ modulo } 2, i = 0, 1, \dots, 7;$$

$$d(i) = d(i-1) + d(i-3) + d(i-4) + d(i-8) \text{ modulo } 2, i = 8, 9, \dots, 254.$$

The sequence $z_n(i)$ is extended to length 256 chips by setting $z_n(255) = z_n(0)$.

The mapping from $z_n(i)$ to the real-valued binary sequences $c_{short,1,n}(i)$ and $c_{short,2,n}(i)$, $i = 0, 1, \dots, 255$ is defined in Table 2.

Table 2: Mapping from $z_n(i)$ to $c_{short,1,n}(i)$ and $c_{short,2,n}(i)$, $i = 0, 1, \dots, 255$

$z_n(i)$	$c_{short,1,n}(i)$	$c_{short,2,n}(i)$
0	+1	+1
1	-1	+1
2	-1	-1
3	+1	-1

Finally, the complex-valued short scrambling sequence $C_{short, n}$ is defined as:

$$C_{short,n}(i) = c_{short,1,n}(i \bmod 256) \left(1 + j(-1)^i c_{short,2,n}(2 \lfloor (i \bmod 256) / 2 \rfloor) \right)$$

where $i = 0, 1, 2, \dots$ and $\lfloor \cdot \rfloor$ denotes rounding to nearest lower integer.

An implementation of the short scrambling sequence generator for the 255 chip sequence to be extended by one chip is shown in Figure 6.

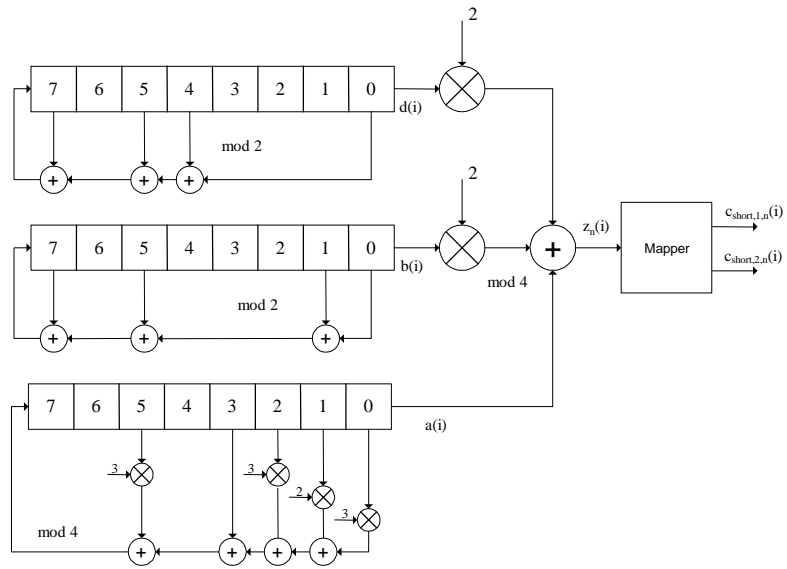
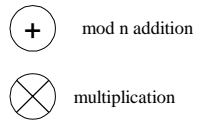


Figure 6: Uplink short scrambling sequence generator for 255 chip sequence

4.3.2.4 DPCCH/DPDCH/HS-DPCCH scrambling code

The code used for scrambling of the uplink DPCCH/DPDCH/HS-DPCCH may be of either long or short type. When the scrambling code is formed, different constituent codes are used for the long and short type as defined below.

The n :th uplink scrambling code for DPCCH/DPDCH/HS-DPCCH, denoted $S_{\text{dpch}, n}$, is defined as:

$$S_{\text{dpch}, n}(i) = C_{\text{long}, n}(i), \quad i = 0, 1, \dots, 38399, \text{ when using long scrambling codes;}$$

where the lowest index corresponds to the chip transmitted first in time and $C_{\text{long}, n}$ is defined in section 4.3.2.2.

The n :th uplink scrambling code for DPCCH/DPDCH/HS-DPCCH, denoted $S_{\text{dpch}, n}$, is defined as:

$$S_{\text{dpch}, n}(i) = C_{\text{short}, n}(i), \quad i = 0, 1, \dots, 38399, \text{ when using short scrambling codes;}$$

where the lowest index corresponds to the chip transmitted first in time and $C_{\text{short},n}$ is defined in section 4.3.2.3.

4.3.2.5 PRACH message part scrambling code

The scrambling code used for the PRACH message part is 10 ms long, and there are 8192 different PRACH scrambling codes defined.

The n :th PRACH message part scrambling code, denoted $S_{\text{r-msg},n}$, where $n = 0, 1, \dots, 8191$, is based on the long scrambling sequence and is defined as:

$$S_{\text{r-msg},n}(i) = C_{\text{long},n}(i + 4096), \quad i = 0, 1, \dots, 38399$$

where the lowest index corresponds to the chip transmitted first in time and $C_{\text{long},n}$ is defined in section 4.3.2.2.

The message part scrambling code has a one-to-one correspondence to the scrambling code used for the preamble part. For one PRACH, the same code number is used for both scrambling codes, i.e. if the PRACH preamble scrambling code used is $S_{r\text{-pre},m}$ then the PRACH message part scrambling code is $S_{r\text{-msg},m}$, where the number m is the same for both codes.

4.3.2.6 PCPCH message part scrambling code

The set of scrambling codes used for the PCPCH message part are 10 ms long, cell-specific, and each scrambling code has a one-to-one correspondence to the signature sequence and the access sub-channel used by the access preamble part. Both long or short scrambling codes can be used to scramble the CPCH message part. There are 64 uplink scrambling codes defined per cell and 32768 different PCPCH scrambling codes defined in the system.

The n :th PCPCH message part scrambling code, denoted $S_{c\text{-msg},n}$, where $n = 8192, 8193, \dots, 40959$ is based on the scrambling sequence and is defined as:

In the case when the long scrambling codes are used:

$$S_{c\text{-msg},n}(i) = C_{\text{long},n}(i), \quad i = 0, 1, \dots, 38399$$

where the lowest index corresponds to the chip transmitted first in time and $C_{\text{long},n}$ is defined in section 4.3.2.2.

In the case the short scrambling codes are used:

$$S_{c\text{-msg},n}(i) = C_{\text{short},n}(i), \quad i = 0, 1, \dots, 38399$$

The 32768 PCPCH scrambling codes are divided into 512 groups with 64 codes in each group. There is a one-to-one correspondence between the group of PCPCH preamble scrambling codes in a cell and the primary scrambling code used in the downlink of the cell. The k :th PCPCH scrambling code within the cell with downlink primary scrambling code m , $k = 16, 17, \dots, 79$ and $m = 0, 1, 2, \dots, 511$, is $S_{c\text{-msg},n}$ as defined above with $n = 64 \times m + k + 8176$.

4.3.2.7 PCPCH power control preamble scrambling code

The scrambling code for the PCPCH power control preamble is the same as for the PCPCH message part, as described in section 4.3.2.6 above. The phase of the scrambling code shall be such that the end of the code is aligned with the frame boundary at the end of the power control preamble.

4.3.3 PRACH preamble codes

4.3.3.1 Preamble code construction

The random access preamble code $C_{\text{pre},n}$ is a complex valued sequence. It is built from a preamble scrambling code $S_{\text{r-pre},n}$ and a preamble signature $C_{\text{sig},s}$ as follows:

$$- C_{\text{pre},n,s}(k) = S_{\text{r-pre},n}(k) \times C_{\text{sig},s}(k) \times e^{j\left(\frac{\pi}{4} + \frac{\pi}{2}k\right)}, k = 0, 1, 2, 3, \dots, 4095;$$

where $k=0$ corresponds to the chip transmitted first in time and $S_{r\text{-pre},n}$ and $C_{\text{sig},s}$ are defined in 4.3.3.2 and 4.3.3.3 below respectively.

4.3.3.2 Preamble scrambling code

The scrambling code for the PRACH preamble part is constructed from the long scrambling sequences. There are 8192 PRACH preamble scrambling codes in total.

The n :th preamble scrambling code, $n = 0, 1, \dots, 8191$, is defined as:

$$S_{r\text{-pre},n}(i) = c_{\text{long},1,n}(i), i = 0, 1, \dots, 4095;$$

where the sequence $c_{\text{long},1,n}$ is defined in section 4.3.2.2.

The 8192 PRACH preamble scrambling codes are divided into 512 groups with 16 codes in each group. There is a one-to-one correspondence between the group of PRACH preamble scrambling codes in a cell and the primary scrambling code used in the downlink of the cell. The k :th PRACH preamble scrambling code within the cell with downlink primary scrambling code m , $k = 0, 1, 2, \dots, 15$ and $m = 0, 1, 2, \dots, 511$, is $S_{r\text{-pre},n}(i)$ as defined above with $n = 16 \times m + k$.

4.3.3.3 Preamble signature

The preamble signature corresponding to a signature s consists of 256 repetitions of a length 16 signature $P_s(n)$, $n=0\dots15$. This is defined as follows:

- $C_{\text{sig},s}(i) = P_s(i \text{ modulo } 16)$, $i = 0, 1, \dots, 4095$.

The signature $P_s(n)$ is from the set of 16 Hadamard codes of length 16. These are listed in table 3.

Table 3: Preamble signatures

Preamble signature	Value of n															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$P_0(n)$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
$P_1(n)$	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1
$P_2(n)$	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1
$P_3(n)$	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1
$P_4(n)$	1	1	1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1
$P_5(n)$	1	-1	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1
$P_6(n)$	1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1	1	1
$P_7(n)$	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1	1	-1
$P_8(n)$	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1
$P_9(n)$	1	-1	1	-1	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1
$P_{10}(n)$	1	1	-1	-1	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1
$P_{11}(n)$	1	-1	-1	1	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1
$P_{12}(n)$	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	1

$P_{13}(n)$	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1	1	-1	1	-1
$P_{14}(n)$	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1	1	1	-1	-1
$P_{15}(n)$	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1	1	-1	-1	1

4.3.4 PCPCH preamble codes

4.3.4.1 Access preamble

4.3.4.1.1 Access preamble code construction

Similar to PRACH access preamble codes, the PCPCH access preamble codes $C_{c\text{-acc},n,s}$ are complex valued sequences. The PCPCH access preamble codes are built from the preamble scrambling codes $S_{c\text{-acc},n}$ and a preamble signature $C_{\text{sig},s}$ as follows:

- $C_{c\text{-acc},n,s}(k) = S_{c\text{-acc},n}(k) \times C_{\text{sig},s}(k) \times e^{j\left(\frac{\pi}{4} + \frac{\pi}{2}k\right)}$, $k = 0, 1, 2, 3, \dots, 4095$;
- where $S_{c\text{-acc},n}$ and $C_{\text{sig},s}$ are defined in section 4.3.4.1.2 and 4.3.4.1.3 below respectively.

4.3.4.1.2 Access preamble scrambling code

The scrambling code for the PCPCH preamble part is constructed from the long scrambling sequences. There are 40960 PCPCH access preamble scrambling codes in total.

The n :th PCPCH access preamble scrambling code, where $n = 0, \dots, 40959$ is defined as:

- $S_{c\text{-acc},n}(i) = c_{\text{long},1,n}(i)$, $i = 0, 1, \dots, 4095$;

where the sequence $c_{\text{long},1,n}$ is defined in section 4.3.2.2.

The 40960 PCPCH access preamble scrambling codes are divided into 512 groups with 80 codes in each group. There is a one-to-one correspondence between the group of PCPCH access preamble scrambling codes in a cell and the primary scrambling code used in the downlink of the cell. The k :th PCPCH scrambling code within the cell with downlink primary scrambling code m , for $k = 0, \dots, 79$ and $m = 0, 1, 2, \dots, 511$, is $S_{c\text{-acc}, n}$ as defined above with $n = 16 \times m + k$ for $k = 0, \dots, 15$ and $n = 64 \times m + (k - 16) + 8192$ for $k = 16, \dots, 79$.

The index $k = 0, \dots, 15$ may only be used as a PCPCH access preamble part scrambling code if the same code is also used for a PRACH.

The index $k = 16, \dots, 79$ correspond to PCPCH access preamble scrambling codes which are not shared together with a PRACH. This leads to 32768 PCPCH specific preamble scrambling codes divided into 512 groups with 64 elements.

4.3.4.1.3 Access preamble signature

The access preamble part of the CPCH-access burst carries one of the sixteen different orthogonal complex signatures identical to the ones used by the preamble part of the random-access burst.

4.3.4.2 CD preamble

4.3.4.2.1 CD preamble code construction

Similar to PRACH access preamble codes, the PCPCH CD preamble codes $C_{c\text{-cd},n,s}$ are complex valued sequences. The PCPCH CD preamble codes are built from the preamble scrambling codes $S_{c\text{-cd},n}$ and a preamble signature $C_{\text{sig},s}$ as follows:

$$- C_{c\text{-cd},n,s}(k) = S_{c\text{-cd},n}(k) \times C_{\text{sig},s}(k) \times e^{j\left(\frac{\pi}{4} + \frac{\pi}{2}k\right)}, k = 0, 1, 2, 3, \dots, 4095;$$

where $S_{c\text{-cd},n}$ and $C_{\text{sig},s}$ are defined in sections 4.3.4.2.2 and 4.3.4.2.3 below respectively.

4.3.4.2.2 CD preamble scrambling code

There are 40960 PCPCH-CD preamble scrambling codes in total.

The n :th PCPCH CD access preamble scrambling code, where $n = 0, \dots, 40959$, is defined as:

$$- S_{c-cd,n}(i) = c_{\text{long},1,n}(i), i = 0, 1, \dots, 4095;$$

where the sequence $c_{\text{long},1,n}$ is defined in section 4.3.2.2.

The 40960 PCPCH scrambling codes are divided into 512 groups with 80 codes in each group. There is a one-to-one correspondence between the group of PCPCH CD preamble scrambling codes in a cell and the primary scrambling code used in the downlink of the cell. The k :th PCPCH scrambling code within the cell with downlink primary scrambling code m , $k = 0, 1, \dots, 79$ and $m = 0, 1, 2, \dots, 511$, is $S_{c-cd,n}$ as defined above with $n=16 \times m + k$ for $k = 0, \dots, 15$ and $n = 64 \times m + (k-16) + 8192$ for $k=16, \dots, 79$.

The index $k=0, \dots, 15$ may only be used as a PCPCH CD preamble part scrambling code if the same code is also used for a PRACH.

The index $k=16, \dots, 79$ correspond to PCPCH CD preamble scrambling codes which are not shared together with a PRACH. This leads to 32768 PCPCH specific preamble scrambling codes divided into 512 groups with 64 elements.

4.3.4.2.3 CD preamble signature

The CD-preamble part of the CPCH-access burst carries one of sixteen different orthogonal complex signatures identical to the ones used by the preamble part of the random-access burst.

4.4 Modulation

4.4.1 Modulating chip rate

The modulating chip rate is 3.84 Mcps.

4.4.2 Modulation

In the uplink, the complex-valued chip sequence generated by the spreading process is QPSK modulated as shown in Figure 7 below:

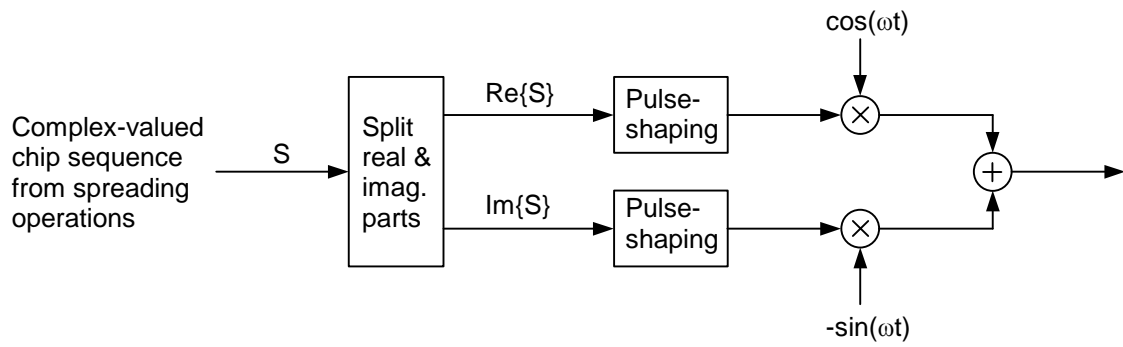


Figure 7: Uplink modulation

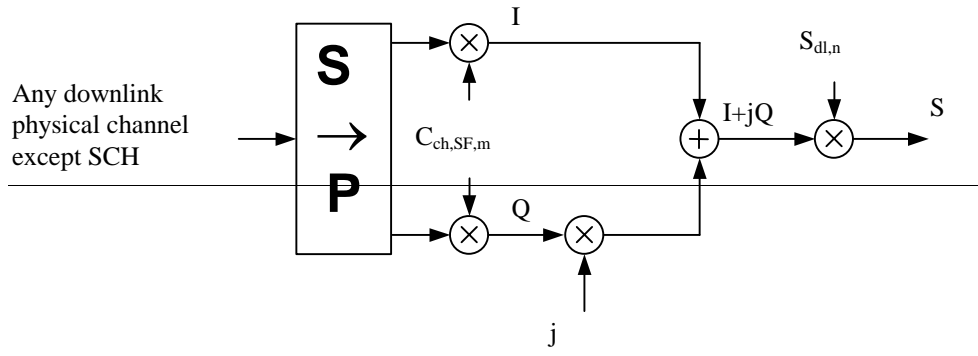
The pulse-shaping characteristics are described in [3].

5 Downlink spreading and modulation

5. 1 Spreading

Figure 8 illustrates the spreading operation for the physical channel except SCH. The behaviour of the modulation mapper is different between QPSK and 16QAM. The physical channel using QPSK are all downlink physical channels except SCH, i.e. for P-CCPCH, S-CCPCH, CPICH, AICH, AP-AICH, CSICH, CD/CA-ICH, PICH, PDSCH, HS-SCCH and downlink DPCH. The SCH non-spread physical channel consists of a sequence of real-valued symbols. The physical channel using both QPSK and 16 QAM is HS-DSCH. For all channels except the indicator channels using signatures (AICH, AP-AICH and CD/CA-ICH) and HS-PDSCH the symbols can take the three values +1, -1, and 0, where 0 indicates DTX. For the indicator channels using signatures AICH, the symbol values depend on the exact combination of acquisition indicators to be transmitted, compare [2] Sections 5.3.3.7, 5.3.3.8 and 5.3.3.9.

For physical channel using QPSK eEach pair of two consecutive symbols is first serial-to-parallel converted and mapped to an I and Q branch. The behaviour of the modulation mappermapping is such that even and odd numbered symbols are mapped to the I and Q branch respectively. For all channels using QPSK except the indicator channels using signaturesAICH, symbol number zero is defined as the first symbol in each frame. For the indicator channels using signaturesAICH, symbol number zero is defined as the first symbol in each access slot. The I and Q branches are then both spread to the chip rate by the same real-valued channelization code $C_{ch,SF,m}$. The channelization code sequence shall be aligned in time with the symbol boundary. The sequences of real-valued chips on the I and Q branch are then treated as a single complex-valued sequence of chips. This sequence of chips is scrambled (complex chip-wise multiplication) by a complex-valued scrambling code $S_{dl,n}$. In case of P-CCPCH, the scrambling code is applied aligned with the P-CCPCH frame boundary, i.e. the first complex chip of the spread P-CCPCH frame is multiplied with chip number zero of the scrambling code. In case of other downlink channels, the scrambling code is applied aligned with the scrambling code applied to the P-CCPCH. In this case, the scrambling code is thus not necessarily applied aligned with the frame boundary of the physical channel to be scrambled.



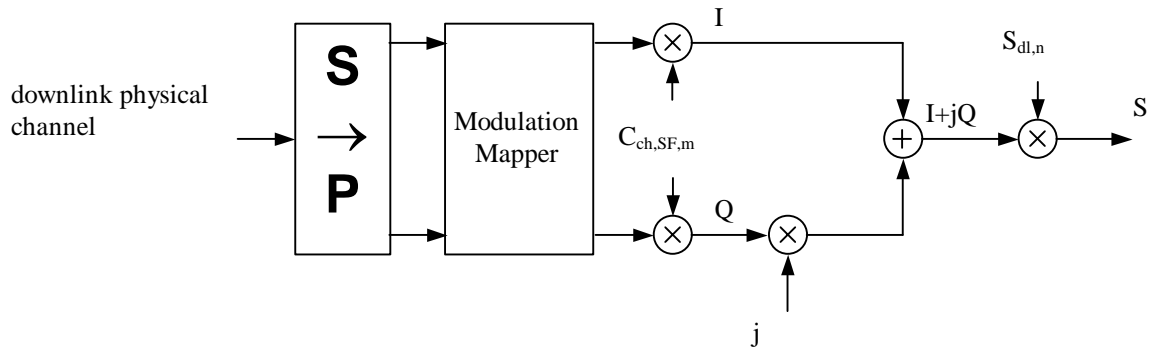


Figure 8: Spreading for all downlink physical channels except SCH

For physical channel using 16QAM, a set of consecutive symbols is serial-to-parallel converted and then mapped to 16QAM by Modulation mapper. The I and Q branches are then both spread to the chip rate by the same real-valued channelization code $C_{ch,16,m}$. The channelization code sequence shall be aligned in time with the symbol boundary. The sequences of real-valued chips on the I and Q branch are then treated as a single complex-valued sequence of chips. This sequence of chips from all multi-codes is summed and then scrambled (complex chip-wise multiplication) by a complex-valued scrambling code $S_{dl,n}$. The scrambling code is applied aligned with the scrambling code applied to the P-CCPCH.

The serial to parallel conversion uses four bits which result in index bits allocated to I and Q according to table 4. These index bits are mapped to the modulated constellation symbols as illustrated in figure xx.

i	0	1	2	3
b(i)	i_1	q_1	i_2	q_2

Table 4: 16 QAM index bits

		\mathbf{i}_1				\mathbf{i}_2	
		\mathbf{i}_2					\mathbf{i}_2
\mathbf{q}_2	1011	●	●	0001	●	●	0011
	1010	●	●	0000	●	●	0010
\mathbf{q}_1	1110	●	●	0100	●	●	0110
	1111	●	●	0101	●	●	0111

0.9487

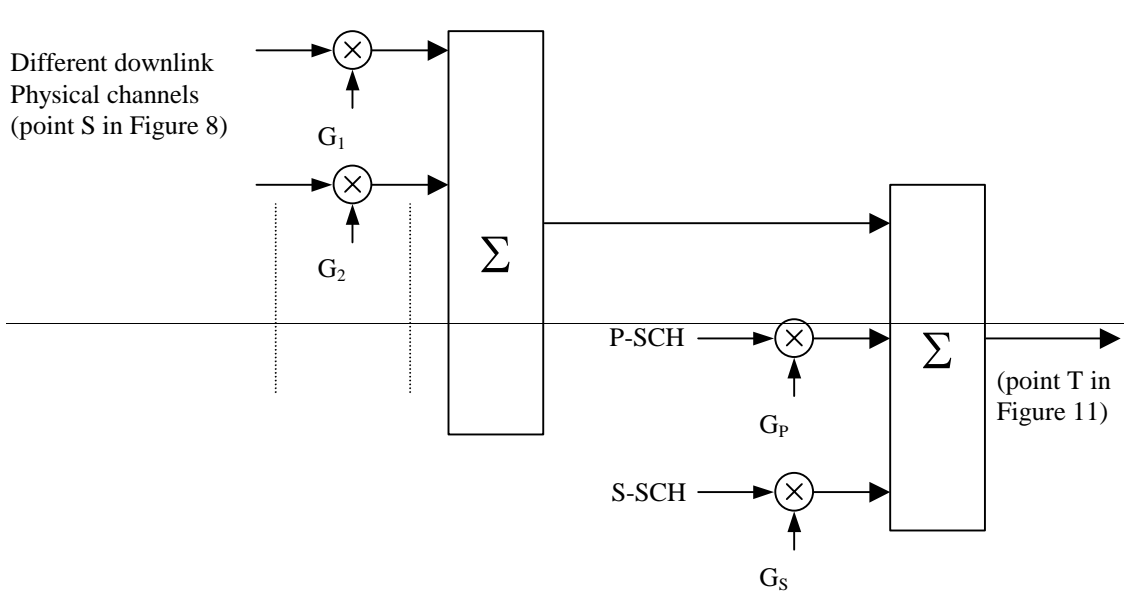
0.3162

0.3162

0.9487

Figure xx: 16 QAM constellation

Figure 9 illustrates how different downlink channels are combined. Each complex-valued spread channel, corresponding to point S in Figure 8, is separately weighted by a weight factor G_i . The complex-valued P-SCH and S-SCH, as described in [2], section 5.3.3.4, are separately weighted by weight factors G_p and G_s . All downlink physical channels are then combined using complex addition.



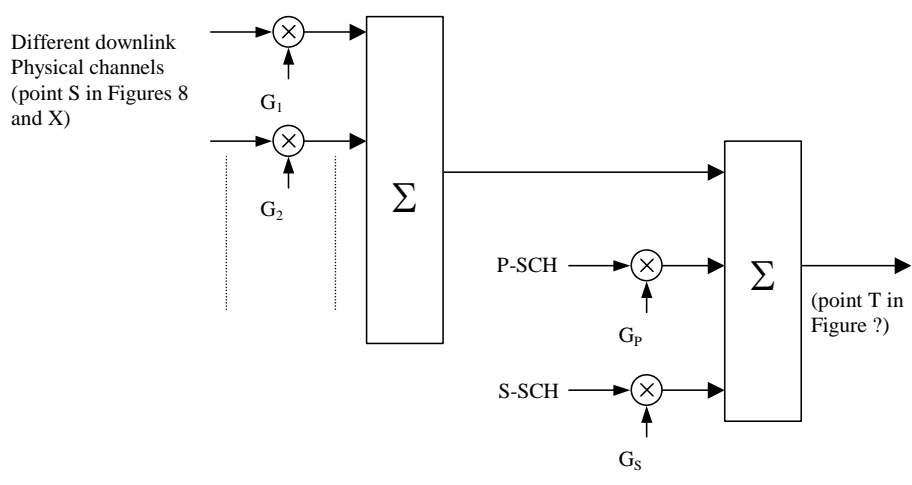


Figure 9: Spreading and modulation for SCH and P-CCPCH

5.2 Code generation and allocation

5.2.1 Channelization codes

The channelization codes of figure 8 are the same codes as used in the uplink, namely Orthogonal Variable Spreading Factor (OVSF) codes that preserve the orthogonality between downlink channels of different rates and spreading factors. The OVSF codes are defined in figure 4 in section 4.3.1.

The channelization code for the Primary CPICH is fixed to $C_{ch,256,0}$ and the channelization code for the Primary CCPCH is fixed to $C_{ch,256,1}$. The channelization codes for all other physical channels are assigned by UTRAN.

With the spreading factor 512 a specific restriction is applied. When the code word $C_{ch,512,n}$, with $n=0,2,4,\dots,510$, is used in soft handover, then the code word $C_{ch,512,n+1}$ is not allocated in the cells where timing adjustment is to be used. Respectively if

$C_{ch,512,n}$, with $n=1,3,5,\dots,511$ is used, then the code word $C_{ch,512,n-1}$ is not allocated in the cells where timing adjustment is to be used. This restriction shall not apply in cases where timing adjustments in soft handover are not used with spreading factor 512.

When compressed mode is implemented by reducing the spreading factor by 2, the OVSF code used for compressed frames is:

- $C_{ch,SF/2,\lfloor n/2 \rfloor}$ if ordinary scrambling code is used.
- $C_{ch,SF/2,n \bmod SF/2}$ if alternative scrambling code is used (see section 5.2.2);

where $C_{ch,SF,n}$ is the channelization code used for non-compressed frames.

In case the OVSF code on the PDSCH varies from frame to frame, the OVSF codes shall be allocated in such a way that the OVSF code(s) below the smallest spreading factor will be from the branch of the code tree pointed by the code with smallest spreading factor used for the connection which is called PDSCH root channelisation code. This means that all the codes for this UE for the PDSCH connection can be generated according to the OVSF code generation principle from the PDSCH root channelisation code i.e. the code with smallest spreading factor used by the UE on PDSCH.

In case of mapping the DSCH to multiple parallel PDSCHs, the same rule applies, but all of the branches identified by the multiple codes, corresponding to the smallest spreading factor, may be used for higher spreading factor allocation i.e. the multiple codes with smallest spreading factor can be considered as PDSCH root channelization codes.

For HS-PDSCH, the spreading factor is always 16.

For HS-SCCH, the spreading factor is always 128.

Channelization-code-set information over HS-SCCH is mapped in following manner: the OVSF codes shall be allocated in such a way that they are positioned in sequence in the code tree. That is, for M multicodes at offset P the following codes are allocated:

$$C_{ch,P,16} - C_{ch,P+M-1,16}$$

The number of multicodes and the corresponding offset for a given HS-DSCH is signaled on the HS-SCCH, where the following algorithm is used for the encoding using 7 information bits:

Three first bits (Code group indicator): $[x_{ccs,1}, x_{ccs,2}, x_{ccs,3}] = \min(M-1, 15-M)$

Four last bits: (Code offset indicator): $[x_{ccs,4}, x_{ccs,5}, x_{ccs,6}, x_{ccs,7}] = |P-1-\lfloor M/8 \rfloor * 15|$

where $\lfloor \cdot \rfloor$ denotes rounding to nearest lower integer.

5.2.2 Scrambling code

A total of $2^{18}-1 = 262,143$ scrambling codes, numbered $0 \dots 262,142$ can be generated. However not all the scrambling codes are used. The scrambling codes are divided into 512 sets each of a primary scrambling code and 15 secondary scrambling codes.

The primary scrambling codes consist of scrambling codes $n=16*i$ where $i=0 \dots 511$. The i :th set of secondary scrambling codes consists of scrambling codes $16*i+k$, where $k=1 \dots 15$.

There is a one-to-one mapping between each primary scrambling code and 15 secondary scrambling codes in a set such that i :th primary scrambling code corresponds to i :th set of secondary scrambling codes.

Hence, according to the above, scrambling codes $k = 0, 1, \dots, 8191$ are used. Each of these codes are associated with a left alternative scrambling code and a right alternative scrambling code, that may be used for compressed frames. The left alternative scrambling code corresponding to scrambling code k is scrambling code number $k + 8192$, while the right alternative scrambling code corresponding to scrambling code k is scrambling code number $k + 16384$. The alternative scrambling codes can be used for compressed frames. In this case, the left alternative scrambling code is used if $n < SF/2$ and the right alternative scrambling code is used if $n \geq SF/2$, where $c_{ch,SF,n}$ is the channelization code used for non-compressed frames. The usage of alternative scrambling code for compressed frames is signalled by higher layers for each physical channel respectively.

The set of primary scrambling codes is further divided into 64 scrambling code groups, each consisting of 8 primary scrambling codes. The j :th scrambling code group consists of primary scrambling codes $16 \cdot 8 \cdot j + 16 \cdot k$, where $j = 0..63$ and $k = 0..7$.

Each cell is allocated one and only one primary scrambling code. The primary CCPCH, primary CPICH, PICH, AICH, AP-AICH, CD/CA-ICH, CSICH and S-CCPCH carrying PCH are always transmitted using the primary scrambling code. The other downlink physical channels can be transmitted with either the primary scrambling code or a secondary scrambling code from the set associated with the primary scrambling code of the cell.

The mixture of primary scrambling code and secondary scrambling code for one CCTrCH is allowable. However, in the case of the CCTrCH of type DSCH then all the PDSCH channelization codes that a single UE may receive shall be under a single scrambling code (either the primary or a secondary scrambling code). In the case of CCTrCH of type of HS-DSCH then all the HS-PDSCH channelization codes and HS-SCCH that a single UE may receive shall be under a single scrambling code (either the primary or a secondary scrambling code).

The scrambling code sequences are constructed by combining two real sequences into a complex sequence. Each of the two real sequences are constructed as the position wise modulo 2 sum of 38400 chip segments of two binary m -sequences generated by means of two generator polynomials of degree 18. The resulting sequences thus constitute segments of a set of Gold sequences. The scrambling codes are repeated for every 10 ms radio frame. Let x and y be the two sequences

respectively. The x sequence is constructed using the primitive (over $\text{GF}(2)$) polynomial $1+X^7+X^{18}$. The y sequence is constructed using the polynomial $1+X^5+X^7+X^{10}+X^{18}$.

The sequence depending on the chosen scrambling code number n is denoted z_n , in the sequel. Furthermore, let $x(i)$, $y(i)$ and $z_n(i)$ denote the i :th symbol of the sequence x , y , and z_n , respectively.

The m -sequences x and y are constructed as:

Initial conditions:

- x is constructed with $x(0)=1, x(1)=x(2)=\dots=x(16)=x(17)=0$.
- $y(0)=y(1)=\dots=y(16)=y(17)=1$.

Recursive definition of subsequent symbols:

- $x(i+18)=x(i+7)+x(i)$ modulo 2, $i=0,\dots,2^{18}-20$.

$$- y(i+18) = y(i+10)+y(i+7)+y(i+5)+y(i) \text{ modulo } 2, i=0, \dots, 2^{18}-20.$$

The n :th Gold code sequence z_n , $n=0, 1, 2, \dots, 2^{18}-2$, is then defined as:

$$- z_n(i) = x((i+n) \text{ modulo } (2^{18} - 1)) + y(i) \text{ modulo } 2, i=0, \dots, 2^{18}-2.$$

These binary sequences are converted to real valued sequences Z_n by the following transformation:

$$Z_n(i) = \begin{cases} +1 & \text{if } z_n(i) = 0 \\ -1 & \text{if } z_n(i) = 1 \end{cases} \text{ for } i = 0, 1, \dots, 2^{18} - 2.$$

Finally, the n :th complex scrambling code sequence $S_{dl,n}$ is defined as:

$$- S_{dl,n}(i) = Z_n(i) + j Z_n((i+131072) \text{ modulo } (2^{18}-1)), i=0, 1, \dots, 38399.$$

Note that the pattern from phase 0 up to the phase of 38399 is repeated.

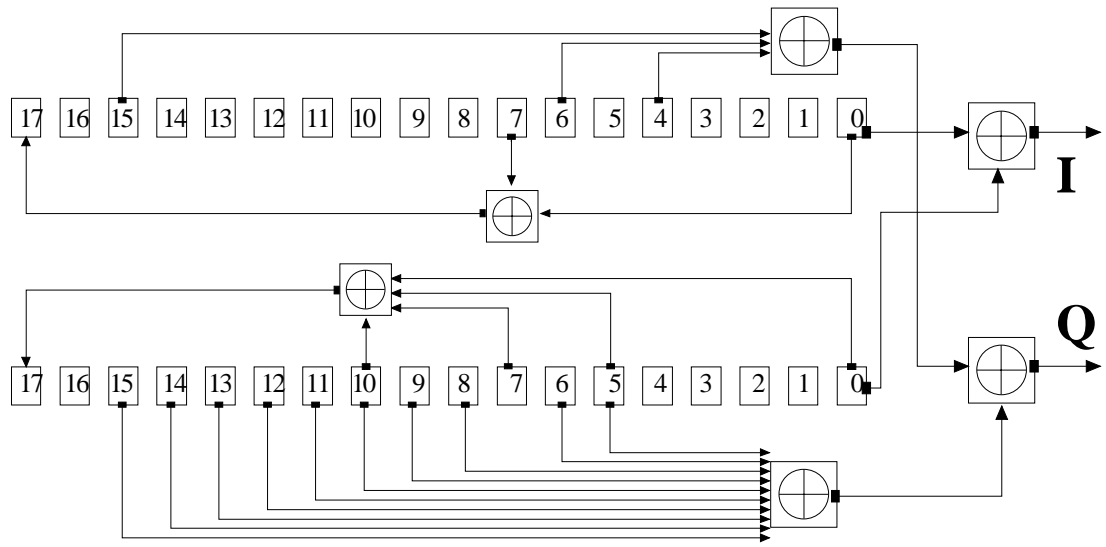


Figure 10: Configuration of downlink scrambling code generator

5.2.3 Synchronisation codes

5.2.3.1 Code generation

The primary synchronisation code (PSC), C_{psc} is constructed as a so-called generalised hierarchical Golay sequence. The PSC is furthermore chosen to have good aperiodic auto correlation properties.

Define:

$$a = \langle x_1, x_2, x_3, \dots, x_{16} \rangle = \langle 1, 1, 1, 1, 1, 1, -1, -1, 1, -1, 1, -1, -1, 1 \rangle$$

The PSC is generated by repeating the sequence a modulated by a Golay complementary sequence, and creating a complex-valued sequence with identical real and imaginary components. The PSC C_{psc} is defined as:

- $C_{psc} = (1 + j) \times \langle a, a, a, -a, -a, a, -a, -a, a, a, a, -a, a, -a, a, a \rangle$;

where the leftmost chip in the sequence corresponds to the chip transmitted first in time.

The 16 secondary synchronization codes (SSCs), $\{C_{ssc,1}, \dots, C_{ssc,16}\}$, are complex-valued with identical real and imaginary components, and are constructed from position wise multiplication of a Hadamard sequence and a sequence z , defined as:

- $z = \langle b, b, b, -b, b, b, -b, -b, b, -b, b, -b, -b, -b, -b \rangle$, where
- $b = \langle x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, -x_9, -x_{10}, -x_{11}, -x_{12}, -x_{13}, -x_{14}, -x_{15}, -x_{16} \rangle$ and $x_1, x_2, \dots, x_{15}, x_{16}$, are same as in the definition of the sequence a above.

The Hadamard sequences are obtained as the rows in a matrix H_8 constructed recursively by:

$$H_0 = (1)$$

$$H_k = \begin{pmatrix} H_{k-1} & H_{k-1} \\ H_{k-1} & -H_{k-1} \end{pmatrix}, \quad k \geq 1$$

The rows are numbered from the top starting with row 0 (the all ones sequence).

Denote the n :th Hadamard sequence as a row of H_8 numbered from the top, $n = 0, 1, 2, \dots, 255$, in the sequel.

Furthermore, let $h_n(i)$ and $z(i)$ denote the i :th symbol of the sequence h_n and z , respectively where $i = 0, 1, 2, \dots, 255$ and $i = 0$ corresponds to the leftmost symbol.

The k :th SSC, $C_{\text{SSC},k}$, $k = 1, 2, 3, \dots, 16$ is then defined as:

$$- C_{\text{SSC},k} = (1 + j) \times \langle h_m(0) \times z(0), h_m(1) \times z(1), h_m(2) \times z(2), \dots, h_m(255) \times z(255) \rangle;$$

where $m = 16 \times (k - 1)$ and the leftmost chip in the sequence corresponds to the chip transmitted first in time.

5.2.3.2 Code allocation of SSC

The 64 secondary SCH sequences are constructed such that their cyclic-shifts are unique, i.e., a non-zero cyclic shift less than 15 of any of the 64 sequences is not equivalent to some cyclic shift of any other of the 64 sequences. Also, a non-zero cyclic shift less than 15 of any of the sequences is not equivalent to itself with any other cyclic shift less than 15. Table 4 describes the sequences of SSCs used to encode the 64 different scrambling code groups. The entries in table 4 denote what SSC to use in the different slots for the different scrambling code groups, e.g. the entry "7" means that SSC $C_{SSC,7}$ shall be used for the corresponding scrambling code group and slot.

Table 4: Allocation of SSCs for secondary SCH

Scrambling Code Group	slot number														
	#0	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
Group 0	1	1	2	8	9	10	15	8	10	16	2	7	15	7	16
Group 1	1	1	5	16	7	3	14	16	3	10	5	12	14	12	10
Group 2	1	2	1	15	5	5	12	16	6	11	2	16	11	15	12
Group 3	1	2	3	1	8	6	5	2	5	8	4	4	6	3	7
Group 4	1	2	16	6	6	11	15	5	12	1	15	12	16	11	2
Group 5	1	3	4	7	4	1	5	5	3	6	2	8	7	6	8
Group 6	1	4	11	3	4	10	9	2	11	2	10	12	12	9	3
Group 7	1	5	6	6	14	9	10	2	13	9	2	5	14	1	13
Group 8	1	6	10	10	4	11	7	13	16	11	13	6	4	1	16
Group 9	1	6	13	2	14	2	6	5	5	13	10	9	1	14	10

Scrambling Code Group	slot number														
	#0	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
Group 10	1	7	8	5	7	2	4	3	8	3	2	6	6	4	5
Group 11	1	7	10	9	16	7	9	15	1	8	16	8	15	2	2
Group 12	1	8	12	9	9	4	13	16	5	1	13	5	12	4	8
Group 13	1	8	14	10	14	1	15	15	8	5	11	4	10	5	4
Group 14	1	9	2	15	15	16	10	7	8	1	10	8	2	16	9
Group 15	1	9	15	6	16	2	13	14	10	11	7	4	5	12	3
Group 16	1	10	9	11	15	7	6	4	16	5	2	12	13	3	14
Group 17	1	11	14	4	13	2	9	10	12	16	8	5	3	15	6
Group 18	1	12	12	13	14	7	2	8	14	2	1	13	11	8	11
Group 19	1	12	15	5	4	14	3	16	7	8	6	2	10	11	13
Group 20	1	15	4	3	7	6	10	13	12	5	14	16	8	2	11
Group 21	1	16	3	12	11	9	13	5	8	2	14	7	4	10	15

Scrambling Code Group	slot number														
	#0	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
Group 22	2	2	5	10	16	11	3	10	11	8	5	13	3	13	8
Group 23	2	2	12	3	15	5	8	3	5	14	12	9	8	9	14
Group 24	2	3	6	16	12	16	3	13	13	6	7	9	2	12	7
Group 25	2	3	8	2	9	15	14	3	14	9	5	5	15	8	12
Group 26	2	4	7	9	5	4	9	11	2	14	5	14	11	16	16
Group 27	2	4	13	12	12	7	15	10	5	2	15	5	13	7	4
Group 28	2	5	9	9	3	12	8	14	15	12	14	5	3	2	15
Group 29	2	5	11	7	2	11	9	4	16	7	16	9	14	14	4
Group 30	2	6	2	13	3	3	12	9	7	16	6	9	16	13	12
Group 31	2	6	9	7	7	16	13	3	12	2	13	12	9	16	6
Group 32	2	7	12	15	2	12	4	10	13	15	13	4	5	5	10
Group 33	2	7	14	16	5	9	2	9	16	11	11	5	7	4	14

Scrambling Code Group	slot number														
	#0	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
Group 34	2	8	5	12	5	2	14	14	8	15	3	9	12	15	9
Group 35	2	9	13	4	2	13	8	11	6	4	6	8	15	15	11
Group 36	2	10	3	2	13	16	8	10	8	13	11	11	16	3	5
Group 37	2	11	15	3	11	6	14	10	15	10	6	7	7	14	3
Group 38	2	16	4	5	16	14	7	11	4	11	14	9	9	7	5
Group 39	3	3	4	6	11	12	13	6	12	14	4	5	13	5	14
Group 40	3	3	6	5	16	9	15	5	9	10	6	4	15	4	10
Group 41	3	4	5	14	4	6	12	13	5	13	6	11	11	12	14
Group 42	3	4	9	16	10	4	16	15	3	5	10	5	15	6	6
Group 43	3	4	16	10	5	10	4	9	9	16	15	6	3	5	15
Group 44	3	5	12	11	14	5	11	13	3	6	14	6	13	4	4
Group 45	3	6	4	10	6	5	9	15	4	15	5	16	16	9	10

Scrambling Code Group	slot number														
	#0	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
Group 46	3	7	8	8	16	11	12	4	15	11	4	7	16	3	15
Group 47	3	7	16	11	4	15	3	15	11	12	12	4	7	8	16
Group 48	3	8	7	15	4	8	15	12	3	16	4	16	12	11	11
Group 49	3	8	15	4	16	4	8	7	7	15	12	11	3	16	12
Group 50	3	10	10	15	16	5	4	6	16	4	3	15	9	6	9
Group 51	3	13	11	5	4	12	4	11	6	6	5	3	14	13	12
Group 52	3	14	7	9	14	10	13	8	7	8	10	4	4	13	9
Group 53	5	5	8	14	16	13	6	14	13	7	8	15	6	15	7
Group 54	5	6	11	7	10	8	5	8	7	12	12	10	6	9	11
Group 55	5	6	13	8	13	5	7	7	6	16	14	15	8	16	15
Group 56	5	7	9	10	7	11	6	12	9	12	11	8	8	6	10
Group 57	5	9	6	8	10	9	8	12	5	11	10	11	12	7	7

Scrambling Code Group	slot number														
	#0	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
Group 58	5	10	10	12	8	11	9	7	8	9	5	12	6	7	6
Group 59	5	10	12	6	5	12	8	9	7	6	7	8	11	11	9
Group 60	5	13	15	15	14	8	6	7	16	8	7	13	14	5	16
Group 61	9	10	13	10	11	15	15	9	16	12	14	13	16	14	11
Group 62	9	11	12	15	12	9	13	13	11	14	10	16	15	14	16
Group 63	9	12	10	15	13	14	9	14	15	11	11	13	12	16	10

5.3 Modulation

5.3.1 Modulating chip rate

The modulating chip rate is 3.84 Mcps.

5.3.2 Modulation

In the downlink, the complex-valued chip sequence generated by the spreading process is QPSK modulated as shown in Figure 11 below.

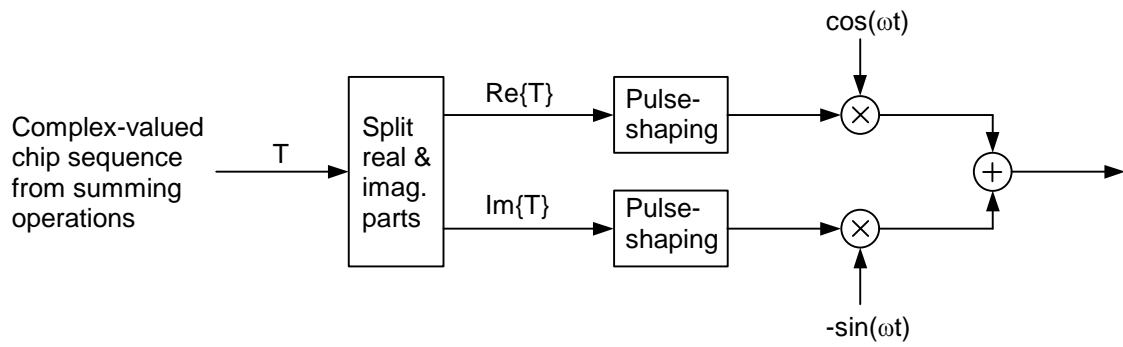


Figure 11: Downlink modulation

The pulse-shaping characteristics are described in [4].

Annex A (informative): Generalised Hierarchical Golay Sequences

A.1 Alternative generation

The generalised hierarchical Golay sequences for the PSC described in 5.2.3.1 may be also viewed as generated (in real valued representation) by the following methods:

Method 1.

The sequence y is constructed from two constituent sequences x_1 and x_2 of length n_1 and n_2 respectively using the following formula:

- $y(i) = x_2(i \bmod n_2) * x_1(i \text{ div } n_2), i = 0 \dots (n_1 * n_2) - 1.$

The constituent sequences x_1 and x_2 are chosen to be the following length 16 (i.e. $n_1 = n_2 = 16$) sequences:

- x_1 is defined to be the length 16 ($N^{(1)}=4$) Golay complementary sequence obtained by the delay matrix $D^{(1)} = [8, 4, 1, 2]$ and weight matrix $W^{(1)} = [1, -1, 1, 1]$.
- x_2 is a generalised hierarchical sequence using the following formula, selecting $s=2$ and using the two Golay complementary sequences x_3 and x_4 as constituent sequences. The length of the sequence x_3 and x_4 is called n_3 respectively n_4 .
- $x_2(i) = x_4(i \bmod s + s*(i \text{ div } n_3)) * x_3((i \text{ div } s) \bmod n_3), i = 0 \dots (n_3 * n_4) - 1.$
- x_3 and x_4 are defined to be identical and the length 4 ($N^{(3)}=N^{(4)}=2$) Golay complementary sequence obtained by the delay matrix $D^{(3)} = D^{(4)} = [1, 2]$ and weight matrix $W^{(3)} = W^{(4)} = [1, 1]$.

The Golay complementary sequences x_1, x_3 and x_4 are defined using the following recursive relation:

$$a_0(k) = \delta(k) \text{ and } b_0(k) = \delta(k);$$

$$a_n(k) = a_{n-1}(k) + W_n^{(j)} \cdot b_{n-1}(k - D_n^{(j)});$$

$$b_n(k) = a_{n-1}(k) - W_n^{(j)} \cdot b_{n-1}(k - D_n^{(j)});$$

$$k = 0, 1, 2, \dots, 2^{**}N^{(j)} - 1;$$

$$n = 1, 2, \dots, N^{(j)}.$$

The wanted Golay complementary sequence x_j is defined by a_n assuming $n=N^{(j)}$. The Kronecker delta function is described by δ , k, j and n are integers.

Method 2

The sequence y can be viewed as a pruned Golay complementary sequence and generated using the following parameters which apply to the generator equations for a and b above:

(a) Let $j = 0$, $N^{(0)} = 8$.

(b) $[D_1^0, D_2^0, D_3^0, D_4^0, D_5^0, D_6^0, D_7^0, D_8^0] = [128, 64, 16, 32, 8, 1, 4, 2]$.

(c) $[W_1^0, W_2^0, W_3^0, W_4^0, W_5^0, W_6^0, W_7^0, W_8^0] = [1, -1, 1, 1, 1, 1, 1, 1]$.

(d) For $n = 4, 6$, set $b_4(k) = a_4(k)$, $b_6(k) = a_6(k)$.

Annex B (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
14/01/00	RAN_05	RP-99589	-		Approved at TSG RAN #5 and placed under Change Control	-	3.0.0
14/01/00	RAN_06	RP-99682	005	1	Harmonization of notations for downlink scrambling codes	3.0.0	3.1.0
14/01/00	RAN_06	RP-99683	006	-	Update of downlink spreading description	3.0.0	3.1.0
14/01/00	RAN_06	RP-99682	007	1	Update of TS 25.213 uplink parts	3.0.0	3.1.0
14/01/00	RAN_06	RP-99683	008	-	Updated modulation description	3.0.0	3.1.0
14/01/00	RAN_06	RP-99683	009	-	Restriction for spreading factor 512 allocation in the UTRA FDD Downlink	3.0.0	3.1.0
14/01/00	RAN_06	RP-99683	011	1	CPCH codes in power control preamble	3.0.0	3.1.0
14/01/00	RAN_06	RP-99683	012	2	Support of short codes for CPCH	3.0.0	3.1.0

14/01/00	RAN_06	RP-99682	014	1	Editorial Change	3.0.0	3.1.0
14/01/00	RAN_06	RP-99683	016	-	Channelization Code Allocation for USTS	3.0.0	3.1.0
14/01/00	RAN_06	RP-99683	017	1	Correction (Editorial Change)	3.0.0	3.1.0
14/01/00	RAN_06	RP-99683	019	-	Correction to code allocation for compressed mode	3.0.0	3.1.0
14/01/00	-	-	-	-	Change history was added by the editor	3.1.0	3.1.1
31/03/00	RAN_07	RP-000063	020	1	Consistent numbering of scrambling code groups	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	021	-	Downlink signal flow corrections	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	022	-	Uplink signal flow corrections	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	023	1	Number of RACH scrambling codes	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	024	1	Editorial changes to 25.213	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	025	3	Number of PCPCH scrambling codes per cell	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	027	-	A typo correction for 5.2.2 and clarification for 5.2.3.1 of TS 25.213V3.1.1	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	028	2	Channelization code allocation method for PCPCH message part	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	029	-	Clarifications to DSCH scrambling and modulation in 25.213	3.1.1	3.2.0
31/03/00	RAN_07	RP-000063	032	-	Clean up of USTS related specifications	3.1.1	3.2.0

CHANGE REQUEST

⌘ **25.214 CR 237** ⌘ rev **2** ⌘ Current version: **4.3.0** ⌘

For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.

Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ Introduction of HSDPA feature to TS25.214		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ 22.02.2002
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories: F (correction) A (corresponds to a correction in an earlier release) B (addition of feature), C (functional modification of feature) D (editorial modification) Detailed explanations of the above categories can be found in 3GPP TR 21.900 .		Use <u>one</u> of the following releases: 2 (GSM Phase 2) R96 (Release 1996) R97 (Release 1997) R98 (Release 1998) R99 (Release 1999) REL-4 (Release 4) REL-5 (Release 5)

Reason for change:	⌘ Introduces changes that are needed for HSDPA description in the specification
Summary of change:	⌘ HSDPA link adaptation, measurement feedback description added.
Consequences if not approved:	⌘ Work item HSDPA-phys will not be part of Release 5.

Clauses affected:	⌘ 7		
Other specs affected:	<input type="checkbox"/> Other core specifications <input type="checkbox"/> Test specifications <input type="checkbox"/> O&M Specifications	⌘	
Other comments:	⌘		

How to create CRs using this form:

Comprehensive information and tips about how to create CRs can be found at: http://www.3gpp.org/3G_Specs/CRs.htm. Below is a brief summary:

- 1) Fill out the above form. The symbols above marked ⌘ contain pop-up help information about the field that they are closest to.
- 2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under [ftp://ftp.3gpp.org/specs/](http://ftp.3gpp.org/specs/). For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.
- 3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

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Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of this present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
 - 2 presented to TSG for approval;
 - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies and establishes the characteristics of the physicals layer procedures in the FDD mode of UTRA.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".
- [2] 3GPP TS 25.212: "Multiplexing and channel coding (FDD)".
- [3] 3GPP TS 25.213: "Spreading and modulation (FDD)".
- [4] 3GPP TS 25.215: "Physical layer – Measurements (FDD)".
- [5] 3GPP TS 25.331: "RRC Protocol Specification".
- [6] 3GPP TS 25.433: "UTRAN Iub Interface NBAP Signalling".
- [7] 3GPP TS 25.101: "UE Radio transmission and Reception (FDD)".
- [8] 3GPP TS 25.133: "Requirements for Support of Radio Resource Management (FDD)".
- [9] 3GPP TS 25.321: " MAC protocol specification".

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACK	Acknowledgement
AICH	Acquisition Indicator Channel
ASC	Access Service Class
AP	Access Preamble
BCH	Broadcast Channel
CA	Channel Assignment
CCC	CPCH Control Command
CCPCH	Common Control Physical Channel
CCTrCH	Coded Composite Transport Channel
CD	Collision Detection
CPCH	Common Packet Channel
CPICH	Common Pilot Channel
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CSICH	CPCH Status Indicator Channel
DCH	Dedicated Channel
DL	Downlink

DPCCH	Dedicated Physical Control Channel
DPCH	Dedicated Physical Channel
DPDCH	Dedicated Physical Data Channel
DTX	Discontinuous Transmission
HSDPA	High Speed Downlink Packet Access
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	High Speed Physical Downlink Shared Control Channel
NACK	Negative Acknowledgement
P-CCPCH	Primary Common Control Physical Channel
PCA	Power Control Algorithm
PCPCH	Physical Common Packet Channel
PDSCH	Physical Downlink Shared Channel
PICH	Paging Indicator Channel
PRACH	Physical Random Access Channel
RACH	Random Access Channel
RL	Radio Link
RPL	Recovery Period Length
RSCP	Received Signal Code Power
S-CCPCH	Secondary Common Control Physical Channel
SCH	Synchronisation Channel
SFN	System Frame Number
SIR	Signal-to-Interference Ratio
SNIR	Signal to Noise Interference Ratio
SSDT	Site Selection Diversity TPC
TFC	Transport Format Combination
TFRC	Transport Format and Resource Combination
TPC	Transmit Power Control
TrCH	Transport Channel
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UTRAN	UMTS Terrestrial Radio Access Network

4 Synchronisation procedures

4.1 Cell search

During the cell search, the UE searches for a cell and determines the downlink scrambling code and common channel frame synchronisation of that cell. How cell search is typically done is described in Annex C.

4.2 Common physical channel synchronisation

The radio frame timing of all common physical channels can be determined after cell search. The P-CCPCH radio frame timing is found during cell search and the radio frame timing of all common physical channel are related to that timing as described in [1].

4.3 DPCCH/DPDCH synchronisation

4.3.1 Synchronisation primitives

4.3.1.1 General

For the dedicated channels, synchronisation primitives are used to indicate the synchronisation status of radio links, both in uplink and downlink. The definition of the primitives is given in the following subclauses.

4.3.1.2 Downlink synchronisation primitives

Layer 1 in the UE shall every radio frame check synchronisation status of the downlink dedicated channels. Synchronisation status is indicated to higher layers using the CPHY-Sync-IND and CPHY-Out-of-Sync-IND primitives.

The criteria for reporting synchronisation status are defined in two different phases.

The first phase starts when higher layers initiate physical dedicated channel establishment (as described in [5]) and lasts until 160 ms after the downlink dedicated channel is considered established by higher layers (physical channel establishment is defined in [5]). During this time out-of-sync shall not be reported and in-sync shall be reported using the CPHY-Sync-IND primitive if the following criterion is fulfilled:

- The UE estimates the DPCCH quality over the previous 40 ms period to be better than a threshold Q_{in} . This criterion shall be assumed not to be fulfilled before 40 ms of DPCCH quality measurements have been collected. Q_{in} is defined implicitly by the relevant tests in [7].

The second phase starts 160 ms after the downlink dedicated channel is considered established by higher layers. During this phase both out-of-sync and in-sync are reported as follows.

Out-of-sync shall be reported using the CPHY-Out-of-Sync-IND primitive if any of the following criteria is fulfilled:

- The UE estimates the DPCCH quality over the previous 160 ms period to be worse than a threshold Q_{out} . Q_{out} is defined implicitly by the relevant tests in [7].
- The 20 most recently received transport blocks with a non-zero length CRC attached, as observed on all TrCHs using non-zero length CRC, have been received with incorrect CRC. In addition, over the previous 160 ms, all transport blocks with a non-zero length CRC attached have been received with incorrect CRC. In case no TFCI is used this criterion shall not be considered for the TrCH(s) not using guided detection if they do not use a non-zero length CRC in all transport formats. If no transport blocks with a non-zero length CRC attached are received over the previous 160 ms this criterion shall not be assumed to be fulfilled.

In-sync shall be reported using the CPHY-Sync-IND primitive if both of the following criteria are fulfilled:

- The UE estimates the DPCCH quality over the previous 160 ms period to be better than a threshold Q_{in} . Q_{in} is defined implicitly by the relevant tests in [7].
- At least one transport block with a non-zero length CRC attached, as observed on all TrCHs using non-zero length CRC, is received in a TTI ending in the current frame with correct CRC. If no transport blocks are received, or no transport block has a non-zero length CRC attached in a TTI ending in the current frame and in addition over the previous 160 ms at least one transport block with a non-zero length CRC attached has been received with a correct CRC, this criterion shall be assumed to be fulfilled. If no transport blocks with a non-zero length CRC attached are received over the previous 160 ms this criterion shall also be assumed to be fulfilled. In case no TFCI is used this criterion shall not be considered for the TrCH(s) not using guided detection if they do not use a non-zero length CRC in all transport formats.

How the primitives are used by higher layers is described in [5]. The above definitions may lead to radio frames where neither the in-sync nor the out-of-sync primitives are reported.

4.3.1.3 Uplink synchronisation primitives

Layer 1 in the Node B shall every radio frame check synchronisation status of all radio link sets. Synchronisation status is indicated to the RL Failure/Restored triggering function using either the CPHY-Sync-IND or CPHY-Out-of-Sync-IND primitive. Hence, only one synchronisation status indication shall be given per radio link set.

The exact criteria for indicating in-sync/out-of-sync is not subject to specification, but could e.g. be based on received DPCCH quality or CRC checks. One example would be to have the same criteria as for the downlink synchronisation status primitives.

4.3.2 Radio link establishment and physical layer reconfiguration for dedicated channels

4.3.2.1 General

Two synchronisation procedures are defined in order to obtain physical layer synchronisation of dedicated channels between UE and UTRAN:

- Synchronisation procedure A : This procedure shall be used when at least one downlink dedicated physical channel and one uplink dedicated physical channel are to be set up on a frequency and none of the radio links after the establishment/reconfiguration existed prior to the establishment/reconfiguration which also includes the following cases :
 - the UE was previously on another RAT i.e. inter-RAT handover
 - the UE was previously on another frequency i.e. inter-frequency hard handover
 - the UE has all its previous radio links removed and replaced by other radio links i.e. intra-frequency hard-handover
- Synchronisation procedure B : This procedure shall be used when one or several radio links are added to the active set and at least one of the radio links prior to the establishment/reconfiguration still exists after the establishment/reconfiguration.

For existing radio links, the reconfiguration of downlink phase reference from P-CPICH or S-CPICH to dedicated pilots is not supported. For all other physical layer reconfigurations not listed above, the UE and UTRAN shall not perform any of the synchronisation procedures listed above.

The two synchronisation procedures are described in subclauses 4.3.2.3 and 4.3.2.4 respectively.

4.3.2.2 Node B radio link set state machine

In Node B, each radio link set can be in three different states: initial state, out-of-sync state and in-sync state. Transitions between the different states is shown in figure 1 below. The state of the Node B at the start of radio link establishment is described in the following subclauses. Transitions between initial state and in-sync state are described in subclauses 4.3.2.3 and 4.3.2.4 and transitions between the in-sync and out-of-sync states are described in subclause 4.3.3.2.

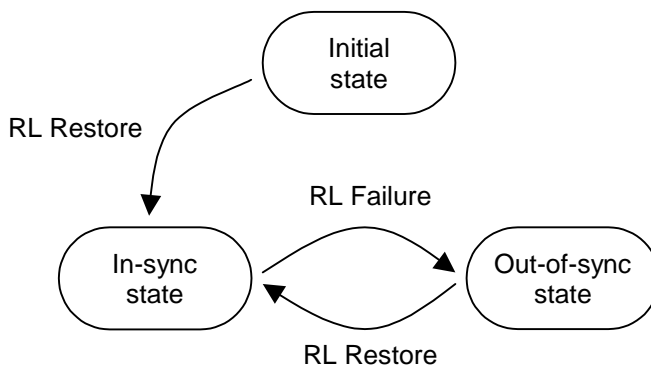


Figure 1: Node B radio link set states and transitions

4.3.2.3 Synchronisation procedure A

The synchronisation establishment procedure, which begins at the time indicated by higher layers (either immediately at receipt of upper layer signalling, or at an indicated activation time), is as follows:

- a) Each Node B involved in the procedure sets all the radio link sets which are to be set-up for this UE in the initial state.

- b) UTRAN shall start the transmission of the downlink DPCCH and may start the transmission of DPDCH if any data is to be transmitted. The initial downlink DPCCH transmit power is set by higher layers [6]. Downlink TPC commands are generated as described in 5.1.2.2.1.2.
- c) The UE establishes downlink chip and frame synchronisation of DPCCH, using the P-CCPCH timing and timing offset information notified from UTRAN. Frame synchronisation can be confirmed using the frame synchronisation word. Downlink synchronisation status is reported to higher layers every radio frame according to subclause 4.3.1.2.
- d) The UE shall not transmit on uplink until higher layers consider the downlink physical channel established. If no activation time for uplink DPCCH has been signalled to the UE, uplink DPCCH transmission shall start when higher layers consider the downlink physical channel established. If an activation time has been given, uplink DPCCH transmission shall not start before the downlink physical channel has been established and the activation time has been reached. Physical channel establishment and activation time are defined in [5]. The initial uplink DPCCH transmit power is set by higher layers [5]. In case of physical layer reconfiguration the uplink DPCCH power is kept unchanged between before and after the reconfiguration except for inner loop power control adjustments. A power control preamble shall be applied as indicated by higher layers. The transmission of the uplink DPCCH power control preamble shall start N_{pcp} radio frames prior to the start of uplink DPDCH transmission, where N_{pcp} is a higher layer parameter set by UTRAN [5]. Note that the transmission start delay between DPCCH and DPDCH may be cancelled using a power control preamble of 0 length. The starting time for transmission of DPDCHs shall also satisfy the constraints on adding transport channels to a CCTrCH, as defined in [2] sub-clause 4.2.14, independently of whether there are any bits mapped to the DPDCHs. During the uplink DPCCH power control preamble, independently of the selected TFC, no transmission is done on the DPDCH.
- e) UTRAN establishes uplink chip and frame synchronisation. Frame synchronisation can be confirmed using the frame synchronisation word. Radio link sets remain in the initial state until N_INSYNC_IND successive in-sync indications are received from layer 1, when Node B shall trigger the RL Restore procedure indicating which radio link set has obtained synchronisation. When RL Restore has been triggered the radio link set shall be considered to be in the in-sync state. The parameter value of N_INSYNC_IND is configurable, see [6]. The RL Restore procedure may be triggered several times, indicating when synchronisation is obtained for different radio link sets.

Note: The total signalling response delay for the establishment of a new DPCH shall not exceed the requirements given in [5] sub-clause 13.5.

4.3.2.4 Synchronisation procedure B

The synchronisation procedure B, which begins at the time indicated by higher layers (either immediately at receipt of upper layer signalling, or at an indicated activation time) is as follows:

- a) The following applies to each Node B involved in the procedure:
 - New radio link sets are set up to be in initial state.
 - If one or several radio links are added to an existing radio link set, this radio link set shall be considered to be in the state the radio link set was prior to the addition of the radio link, i.e. if the radio link set was in the in-sync state before the addition of the radio link it shall remain in that state.
- b) UTRAN starts the transmission of the downlink DPCCH/DPDCH for each new radio link at a frame timing such that the frame timing received at the UE will be within $T_0 \pm 148$ chips prior to the frame timing of the uplink DPCCH/DPDCH at the UE. Simultaneously, UTRAN establishes uplink chip and frame synchronisation of each new radio link. Frame synchronisation can be confirmed using the frame synchronization word. Radio link sets considered to be in the initial state shall remain in the initial state until N_INSYNC_IND successive in-sync indications are received from layer 1, when Node B shall trigger the RL Restore procedure indicating which radio link set has obtained synchronisation. When RL Restore is triggered the radio link set shall be considered to be in the in-sync state. The parameter value of N_INSYNC_IND is configurable, see [6]. The RL Restore procedure may be triggered several times, indicating when synchronisation is obtained for different radio link sets.
- c) The UE establishes chip and frame synchronisation of each new radio link. Layer 1 in the UE keeps reporting downlink synchronisation status to higher layers every radio frame according to the second phase of sub-clause 4.3.1.2. Frame synchronisation can be confirmed using the frame synchronization word.

4.3.3 Radio link monitoring

4.3.3.1 Downlink radio link failure

The downlink radio links shall be monitored by the UE, to trigger radio link failure procedures. The downlink radio link failure criteria is specified in [5], and is based on the synchronisation status primitives CPHY-Sync-IND and CPHY-Out-of-Sync-IND, indicating in-sync and out-of-sync respectively.

4.3.3.2 Uplink radio link failure/restore

The uplink radio link sets are monitored by the Node B, to trigger radio link failure/restore procedures. Once the radio link sets have been established, they will be in the in-sync or out-of-sync states as shown in figure 1 in subclause 4.3.2.1. Transitions between those two states are described below.

The uplink radio link failure/restore criteria is based on the synchronisation status primitives CPHY-Sync-IND and CPHY-Out-of-Sync-IND, indicating in-sync and out-of-sync respectively. Note that only one synchronisation status indication shall be given per radio link set.

When the radio link set is in the in-sync state, Node B shall start timer T_RLFAILURE after receiving N_OUTSYNC_IND consecutive out-of-sync indications. Node B shall stop and reset timer T_RLFAILURE upon receiving successive N_INSYNC_IND in-sync indications. If T_RLFAILURE expires, Node B shall trigger the RL Failure procedure and indicate which radio link set is out-of-sync. When the RL Failure procedure is triggered, the state of the radio link set change to the out-of-sync state.

When the radio link set is in the out-of-sync state, after receiving N_INSYNC_IND successive in-sync indications Node B shall trigger the RL Restore procedure and indicate which radio link set has re-established synchronisation. When the RL Restore procedure is triggered, the state of the radio link set change to the in-sync state.

The specific parameter settings (values of T_RLFAILURE, N_OUTSYNC_IND, and N_INSYNC_IND) are configurable, see [6].

4.3.4 Transmission timing adjustments

During a connection the UE may adjust its DPDCH/DPCCH transmission time instant.

If the receive timing for any downlink DPCCH/DPDCH in the current active set has drifted, so the time between reception of the downlink DPCCH/DPDCH in question and transmission of uplink DPCCH/DPDCH lies outside the valid range, L1 shall inform higher layers of this, so that the network can be informed of this and downlink timing can be adjusted by the network.

NOTE: The maximum rate of uplink TX time adjustment, and the valid range for the time between downlink DPCCH/DPDCH reception and uplink DPCCH/DPDCH transmission in the UE is to be specified by RAN WG4.

5 Power control

5.1 Uplink power control

5.1.1 PRACH

5.1.1.1 General

The power control during the physical random access procedure is described in clause 6. The setting of power of the message control and data parts is described in the next subclause.

5.1.1.2 Setting of PRACH control and data part power difference

The message part of the uplink PRACH channel shall employ gain factors to control the control/data part relative power similar to the uplink dedicated physical channels. Hence, subclause 5.1.2.5 applies also for the RACH message part, with the differences that:

- β_c is the gain factor for the control part (similar to DPCCH);
- β_d is the gain factor for the data part (similar to DPDCH);
- no inner loop power control is performed.

5.1.2 DPCCH/DPDCH

5.1.2.1 General

The initial uplink DPCCH transmit power is set by higher layers. Subsequently the uplink transmit power control procedure simultaneously controls the power of a DPCCH and its corresponding DPDCHs (if present). The relative transmit power offset between DPCCH and DPDCHs is determined by the network and is computed according to subclause 5.1.2.5 using the gain factors signalled to the UE using higher layer signalling.

The operation of the inner power control loop, described in sub clause 5.1.2.2, adjusts the power of the DPCCH and DPDCHs by the same amount, provided there are no changes in gain factors. Additional adjustments to the power of the DPCCH associated with the use of compressed mode are described in sub clause 5.1.2.3.

Any change in the uplink DPCCH transmit power shall take place immediately before the start of the pilot field on the DPCCH. The change in DPCCH power with respect to its previous value is derived by the UE and is denoted by Δ_{DPCCH} (in dB). The previous value of DPCCH power shall be that used in the previous slot, except in the event of an interruption in transmission due to the use of compressed mode, when the previous value shall be that used in the last slot before the transmission gap.

During the operation of the uplink power control procedure the UE transmit power shall not exceed a maximum allowed value which is the lower out of the maximum output power of the terminal power class and a value which may be set by higher layer signalling.

Uplink power control shall be performed while the UE transmit power is below the maximum allowed output power.

The provisions for power control at the maximum allowed value and below the required minimum output power (as defined in [7]) are described in sub-clause 5.1.2.6.

5.1.2.2 Ordinary transmit power control

5.1.2.2.1 General

The uplink inner-loop power control adjusts the UE transmit power in order to keep the received uplink signal-to-interference ratio (SIR) at a given SIR target, $\text{SIR}_{\text{target}}$.

The serving cells (cells in the active set) should estimate signal-to-interference ratio SIR_{est} of the received uplink DPCH. The serving cells should then generate TPC commands and transmit the commands once per slot according to the following rule: if $\text{SIR}_{\text{est}} > \text{SIR}_{\text{target}}$ then the TPC command to transmit is "0", while if $\text{SIR}_{\text{est}} < \text{SIR}_{\text{target}}$ then the TPC command to transmit is "1".

Upon reception of one or more TPC commands in a slot, the UE shall derive a single TPC command, TPC_{cmd} , for each slot, combining multiple TPC commands if more than one is received in a slot. This is also valid when SSDT transmission is used in the downlink. Two algorithms shall be supported by the UE for deriving a TPC_{cmd} . Which of these two algorithms is used is determined by a UE-specific higher-layer parameter, "PowerControlAlgorithm", and is under the control of the UTRAN. If "PowerControlAlgorithm" indicates "algorithm1", then the layer 1 parameter PCA shall take the value 1 and if "PowerControlAlgorithm" indicates "algorithm2" then PCA shall take the value 2.

If PCA has the value 1, Algorithm 1, described in subclause 5.1.2.2.2, shall be used for processing TPC commands.

If PCA has the value 2, Algorithm 2, described in subclause 5.1.2.2.3, shall be used for processing TPC commands.

The step size Δ_{TPC} is a layer 1 parameter which is derived from the UE-specific higher-layer parameter "TPC-StepSize" which is under the control of the UTRAN. If "TPC-StepSize" has the value "dB1", then the layer 1 parameter Δ_{TPC} shall take the value 1 dB and if "TPC-StepSize" has the value "dB2", then Δ_{TPC} shall take the value 2 dB. The parameter "TPC-StepSize" only applies to Algorithm 1 as stated in [5]. For Algorithm 2 Δ_{TPC} shall always take the value 1 dB.

After deriving of the combined TPC command TPC_cmd using one of the two supported algorithms, the UE shall adjust the transmit power of the uplink DPCCCH with a step of Δ_{DPCCCH} (in dB) which is given by:

$$\Delta_{\text{DPCCCH}} = \Delta_{\text{TPC}} \times \text{TPC_cmd}.$$

5.1.2.2.1.1 Out of synchronisation handling

After 160 ms after physical channel establishment (defined in [5]), the UE shall control its transmitter according to a downlink DPCCCH quality criterion as follows:

- The UE shall shut its transmitter off when the UE estimates the DPCCCH quality over the last 160 ms period to be worse than a threshold Q_{out} . Q_{out} is defined implicitly by the relevant tests in [7].
- The UE can turn its transmitter on again when the UE estimates the DPCCCH quality over the last 160 ms period to be better than a threshold Q_{in} . Q_{in} is defined implicitly by the relevant tests in [7]. When transmission is resumed, the power of the DPCCCH shall be the same as when the UE transmitter was shut off.

5.1.2.2.1.2 TPC command generation on downlink during RL initialisation

When commanded by higher layers the TPC commands sent on a downlink radio link from Node Bs that have not yet achieved uplink synchronisation shall follow a pattern as follows:

If higher layers indicate by "First RLS indicator" that the radio link is part of the first radio link set sent to the UE and the value 'n' obtained from the parameter "DL TPC pattern 01 count" passed by higher layers is different from 0 then :

- the TPC pattern shall consist of n instances of the pair of TPC commands ("0", "1"), followed by one instance of TPC command "1", where ("0", "1") indicates the TPC commands to be transmitted in 2 consecutive slots,
- the TPC pattern continuously repeat but shall be forcibly re-started at the beginning of each frame where $\text{CFN} \bmod 4 = 0$.

else

- The TPC pattern shall consist only of TPC commands "1".

The TPC pattern shall terminate once uplink synchronisation is achieved.

5.1.2.2.2 Algorithm 1 for processing TPC commands

5.1.2.2.2.1 Derivation of TPC_cmd when only one TPC command is received in each slot

When a UE is not in soft handover, only one TPC command will be received in each slot. In this case, the value of TPC_cmd shall be derived as follows:

- If the received TPC command is equal to 0 then TPC_cmd for that slot is -1.
- If the received TPC command is equal to 1, then TPC_cmd for that slot is 1.

5.1.2.2.2.2 Combining of TPC commands from radio links of the same radio link set

When a UE is in soft handover, multiple TPC commands may be received in each slot from different cells in the active set. In some cases, the UE has the knowledge that some of the transmitted TPC commands in a slot are the same. This is the case when the radio links are in the same radio link set. For these cases, the TPC commands from the same radio link set shall be combined into one TPC command, to be further combined with other TPC commands as described in subclause 5.1.2.2.2.3.

5.1.2.2.2.3 Combining of TPC commands from radio links of different radio link sets

This subclause describes the general scheme for combination of the TPC commands from radio links of different radio link sets.

First, the UE shall conduct a soft symbol decision W_i on each of the power control commands TPC_i , where $i = 1, 2, \dots, N$, where N is greater than 1 and is the number of TPC commands from radio links of different radio link sets, that may be the result of a first phase of combination according to subclause 5.1.2.2.2.

Finally, the UE derives a combined TPC command, TPC_cmd , as a function γ of all the N soft symbol decisions W_i :

- $TPC_cmd = \gamma (W_1, W_2, \dots, W_N)$, where TPC_cmd can take the values 1 or -1.

The function γ shall fulfil the following criteria:

If the N TPC_i commands are random and uncorrelated, with equal probability of being transmitted as "0" or "1", the probability that the output of γ is equal to 1 shall be greater than or equal to $1/(2^N)$, and the probability that the output of γ is equal to -1 shall be greater than or equal to 0.5. Further, the output of γ shall equal 1 if the TPC commands from all the radio link sets are reliably "1", and the output of γ shall equal -1 if a TPC command from any of the radio link sets is reliably "0".

5.1.2.2.3 Algorithm 2 for processing TPC commands

NOTE: Algorithm 2 makes it possible to emulate smaller step sizes than the minimum power control step specified in subclause 5.1.2.2.1, or to turn off uplink power control by transmitting an alternating series of TPC commands.

5.1.2.2.3.1 Derivation of TPC_cmd when only one TPC command is received in each slot

When a UE is not in soft handover, only one TPC command will be received in each slot. In this case, the UE shall process received TPC commands on a 5-slot cycle, where the sets of 5 slots shall be aligned to the frame boundaries and there shall be no overlap between each set of 5 slots.

The value of TPC_cmd shall be derived as follows:

- For the first 4 slots of a set, $TPC_cmd = 0$.
- For the fifth slot of a set, the UE uses hard decisions on each of the 5 received TPC commands as follows:
 - If all 5 hard decisions within a set are 1 then $TPC_cmd = 1$ in the 5th slot.
 - If all 5 hard decisions within a set are 0 then $TPC_cmd = -1$ in the 5th slot.
 - Otherwise, $TPC_cmd = 0$ in the 5th slot.

5.1.2.2.3.2 Combining of TPC commands from radio links of the same radio link set

When a UE is in soft handover, multiple TPC commands may be received in each slot from different cells in the active set. In some cases, the UE has the knowledge that some of the transmitted TPC commands in a slot are the same. This is the case when the radio links are in the same radio link set. For these cases, the TPC commands from radio links of the same radio link set shall be combined into one TPC command, to be processed and further combined with any other TPC commands as described in subclause 5.1.2.2.3.3.

5.1.2.2.3.3 Combining of TPC commands from radio links of different radio link sets

This subclause describes the general scheme for combination of the TPC commands from radio links of different radio link sets.

The UE shall make a hard decision on the value of each TPC_i , where $i = 1, 2, \dots, N$ and N is the number of TPC commands from radio links of different radio link sets, that may be the result of a first phase of combination according to subclause 5.1.2.2.3.2.

The UE shall follow this procedure for 5 consecutive slots, resulting in N hard decisions for each of the 5 slots.

The sets of 5 slots shall be aligned to the frame boundaries and there shall be no overlap between each set of 5 slots.

The value of TPC_cmd is zero for the first 4 slots. After 5 slots have elapsed, the UE shall determine the value of TPC_cmd for the fifth slot in the following way:

The UE first determines one temporary TPC command, TPC_temp_i, for each of the N sets of 5 TPC commands as follows:

- If all 5 hard decisions within a set are "1", TPC_temp_i = 1.
- If all 5 hard decisions within a set are "0", TPC_temp_i = -1.
- Otherwise, TPC_temp_i = 0.

Finally, the UE derives a combined TPC command for the fifth slot, TPC_cmd, as a function γ of all the N temporary power control commands TPC_temp_i:

TPC_cmd(5th slot) = γ (TPC_temp₁, TPC_temp₂, ..., TPC_temp_N), where TPC_cmd(5th slot) can take the values 1, 0 or -1, and γ is given by the following definition:

- TPC_cmd is set to 1 if $\frac{1}{N} \sum_{i=1}^N TPC_temp_i > 0.5$.
- TPC_cmd is set to -1 if $\frac{1}{N} \sum_{i=1}^N TPC_temp_i < -0.5$.

Otherwise, TPC_cmd is set to 0.

5.1.2.3 Transmit power control in compressed mode

In compressed mode, one or more transmission gap pattern sequences are active. Therefore some frames are compressed and contain transmission gaps. The uplink power control procedure is as specified in clause 5.1.2.2, using the same UTRAN supplied parameters for Power Control Algorithm and step size (Δ_{TPC}), but with additional features which aim to recover as rapidly as possible a signal-to-interference ratio (SIR) close to the target SIR after each transmission gap.

The serving cells (cells in the active set) should estimate signal-to-interference ratio SIR_{est} of the received uplink DPCH. The serving cells should then generate TPC commands and transmit the commands once per slot, except during downlink transmission gaps, according to the following rule: if SIR_{est} > SIR_{cm_target} then the TPC command to transmit is "0", while if SIR_{est} < SIR_{cm_target} then the TPC command to transmit is "1".

SIR_{cm_target} is the target SIR during compressed mode and fulfils

$$SIR_{cm_target} = SIR_{target} + \Delta SIR_{PILOT} + \Delta SIR1_coding + \Delta SIR2_coding,$$

where $\Delta SIR1_coding$ and $\Delta SIR2_coding$ are computed from uplink parameters DeltaSIR1, DeltaSIR2, DeltaSIRafter1, DeltaSIRafter2 signalled by higher layers as:

- $\Delta SIR1_coding$ = DeltaSIR1 if the start of the first transmission gap in the transmission gap pattern is within the current uplink frame.
- $\Delta SIR1_coding$ = DeltaSIRafter1 if the current uplink frame just follows a frame containing the start of the first transmission gap in the transmission gap pattern.
- $\Delta SIR2_coding$ = DeltaSIR2 if the start of the second transmission gap in the transmission gap pattern is within the current uplink frame.
- $\Delta SIR2_coding$ = DeltaSIRafter2 if the current uplink frame just follows a frame containing the start of the second transmission gap in the transmission gap pattern.
- $\Delta SIR1_coding$ = 0 dB and $\Delta SIR2_coding$ = 0 dB in all other cases.

$\Delta\text{SIR}_{\text{PILOT}}$ is defined as: $\Delta\text{SIR}_{\text{PILOT}} = 10\text{Log}_{10} (N_{\text{pilot},N}/N_{\text{pilot,curr_frame}})$,

where $N_{\text{pilot,curr_frame}}$ is the number of pilot bits per slot in the current uplink frame, and $N_{\text{pilot},N}$ is the number of pilot bits per slot in a normal uplink frame without a transmission gap.

In the case of several compressed mode pattern sequences being used simultaneously, $\Delta\text{SIR1_coding}$ and $\Delta\text{SIR2_coding}$ offsets are computed for each compressed mode pattern and all $\Delta\text{SIR1_coding}$ and $\Delta\text{SIR2_coding}$ offsets are summed together.

In compressed mode, compressed frames may occur in either the uplink or the downlink or both. In uplink compressed frames, the transmission of uplink DPDCH(s) and DPCCH shall both be stopped during transmission gaps.

Due to the transmission gaps in compressed frames, there may be missing TPC commands in the downlink. If no downlink TPC command is transmitted, the corresponding TPC_cmd derived by the UE shall be set to zero.

Compressed and non-compressed frames in the uplink DPCCH may have a different number of pilot bits per slot. A change in the transmit power of the uplink DPCCH would be needed in order to compensate for the change in the total pilot energy. Therefore at the start of each slot the UE shall derive the value of a power offset Δ_{PILOT} . If the number of pilot bits per slot in the uplink DPCCH is different from its value in the most recently transmitted slot, Δ_{PILOT} (in dB) shall be given by:

$$\Delta_{\text{PILOT}} = 10\text{Log}_{10} (N_{\text{pilot,prev}}/N_{\text{pilot,curr}});$$

where $N_{\text{pilot,prev}}$ is the number of pilot bits in the most recently transmitted slot, and $N_{\text{pilot,curr}}$ is the number of pilot bits in the current slot. Otherwise, including during transmission gaps in the downlink, Δ_{PILOT} shall be zero.

Unless otherwise specified, in every slot during compressed mode the UE shall adjust the transmit power of the uplink DPCCH with a step of Δ_{DPCCH} (in dB) which is given by:

$$\Delta_{\text{DPCCH}} = \Delta_{\text{TPC}} \times \text{TPC_cmd} + \Delta_{\text{PILOT}}.$$

At the start of the first slot after an uplink or downlink transmission gap the UE shall apply a change in the transmit power of the uplink DPCCH by an amount Δ_{DPCCH} (in dB), with respect to the uplink DPCCH power in the most recently transmitted uplink slot, where:

$$\Delta_{\text{DPCCH}} = \Delta_{\text{RESUME}} + \Delta_{\text{PILOT}}.$$

The value of Δ_{RESUME} (in dB) shall be determined by the UE according to the Initial Transmit Power mode (ITP). The ITP is a UE specific parameter, which is signalled by the network with the other compressed mode parameters (see [4]). The different modes are summarised in table 1.

Table 1: Initial Transmit Power modes during compressed mode

Initial Transmit Power mode	Description
0	$\Delta_{\text{RESUME}} = \Delta_{\text{TPC}} \times \text{TPC_cmd}_{\text{gap}}$
1	$\Delta_{\text{RESUME}} = \delta_{\text{last}}$

In the case of a transmission gap in the uplink, $\text{TPC_cmd}_{\text{gap}}$ shall be the value of TPC_cmd derived in the first slot of the uplink transmission gap, if a downlink TPC_command is transmitted in that slot. Otherwise $\text{TPC_cmd}_{\text{gap}}$ shall be zero.

δ_{last} shall be equal to the most recently computed value of δ_i . δ_i shall be updated according to the following recursive relations, which shall be executed in all slots in which both the uplink DPCCH and a downlink TPC command are transmitted, and in the first slot of an uplink transmission gap if a downlink TPC command is transmitted in that slot:

$$\begin{aligned} \delta_i &= 0.9375\delta_{i-1} - 0.96875\text{TPC_cmd}_i \Delta_{\text{TPC}} k_{sc} \\ \delta_{i-1} &= \delta_i \end{aligned}$$

where: TPC_cmd_i is the power control command derived by the UE in that slot;

$k_{sc} = 0$ if additional scaling is applied in the current slot and the previous slot as described in sub-clause 5.1.2.6, and $k_{sc} = 1$ otherwise.

δ_{i-1} is the value of δ_i computed for the previous slot. The value of δ_{i-1} shall be initialised to zero when the uplink DPCCH is activated, and also at the end of the first slot after each uplink transmission gap, and also at the end of the first slot after each downlink transmission gap. The value of δ_i shall be set to zero at the end of the first slot after each uplink transmission gap.

After a transmission gap in either the uplink or the downlink, the period following resumption of simultaneous uplink and downlink DPCCH transmission is called a recovery period. RPL is the recovery period length and is expressed as a number of slots. RPL is equal to the minimum value out of the transmission gap length and 7 slots. If a transmission gap is scheduled to start before RPL slots have elapsed, then the recovery period shall end at the start of the gap, and the value of RPL shall be reduced accordingly.

During the recovery period, 2 modes are possible for the power control algorithm. The Recovery Period Power control mode (RPP) is signalled with the other compressed mode parameters (see [4]). The different modes are summarised in the table 2:

Table 2: Recovery Period Power control modes during compressed mode

Recovery Period power control mode	Description
0	Transmit power control is applied using the algorithm determined by the value of PCA, as in subclause 5.1.2.2 with step size Δ_{TPC} .
1	Transmit power control is applied using algorithm 1 (see subclause 5.1.2.2.2) with step size Δ_{RP-TPC} during RPL slots after each transmission gap.

For RPP mode 0, the step size is not changed during the recovery period and ordinary transmit power control is applied (see subclause 5.1.2.2), using the algorithm for processing TPC commands determined by the value of PCA (see subclauses 5.1.2.2.2 and 5.1.2.2.3).

For RPP mode 1, during RPL slots after each transmission gap, power control algorithm 1 is applied with a step size Δ_{RP-TPC} instead of Δ_{TPC} , regardless of the value of PCA. Therefore, the change in uplink DPCCH transmit power at the start of each of the RPL+1 slots immediately following the transmission gap (except for the first slot after the transmission gap) is given by:

$$\Delta_{DPCCH} = \Delta_{RP-TPC} \times TPC_cmd + \Delta_{PILOT}$$

Δ_{RP-TPC} is called the recovery power control step size and is expressed in dB. If PCA has the value 1, Δ_{RP-TPC} is equal to the minimum value of 3 dB and $2\Delta_{TPC}$. If PCA has the value 2, Δ_{RP-TPC} is equal to 1 dB.

After the recovery period, ordinary transmit power control resumes using the algorithm specified by the value of PCA and with step size Δ_{TPC} .

If PCA has the value 2, the sets of slots over which the TPC commands are processed shall remain aligned to the frame boundaries in the compressed frame. For both RPP mode 0 and RPP mode 1, if the transmission gap or the recovery period results in any incomplete sets of TPC commands, TPC_cmd shall be zero for those sets of slots which are incomplete.

5.1.2.4 Transmit power control in the uplink DPCCH power control preamble

An uplink DPCCH power control preamble is a period of uplink DPCCH transmission prior to the start of the uplink DPDCH transmission. The downlink DPCCH shall also be transmitted during an uplink DPCCH power control preamble.

The length of the uplink DPCCH power control preamble is a higher layer parameter signalled by the network as defined in [5]. The uplink DPDCH transmission shall commence after the end of the uplink DPCCH power control preamble.

During the uplink DPCCH power control preamble the change in uplink DPCCH transmit power shall be given by:

$$\Delta_{DPCCH} = \Delta_{TPC} \times TPC_cmd.$$

During the uplink DPCCH power control preamble TPC_cmd is derived according to algorithm 1 as described in sub clause 5.1.2.2.1, regardless of the value of PCA.

Ordinary power control (see subclause 5.1.2.2), with the power control algorithm determined by the value of PCA and step size Δ_{TPC} , shall be used after the end of the uplink DPCCH power control preamble.

5.1.2.5 Setting of the uplink DPCCH/DPDCH power difference

5.1.2.5.1 General

The uplink DPCCH and DPDCH(s) are transmitted on different codes as defined in subclause 4.2.1 of [3]. The gain factors β_c and β_d may vary for each TFC. There are two ways of controlling the gain factors of the DPCCH code and the DPDCH codes for different TFCs in normal (non-compressed) frames:

- β_c and β_d are signalled for the TFC, or
- β_c and β_d is computed for the TFC, based on the signalled settings for a reference TFC.

Combinations of the two above methods may be used to associate β_c and β_d values to all TFCs in the TFCS. The two methods are described in subclauses 5.1.2.5.2 and 5.1.2.5.3 respectively. Several reference TFCs may be signalled from higher layers.

The gain factors may vary on radio frame basis depending on the current TFC used. Further, the setting of gain factors is independent of the inner loop power control.

After applying the gain factors, the UE shall scale the total transmit power of the DPCCH and DPDCH(s), such that the DPCCH output power follows the changes required by the power control procedure with power adjustments of Δ_{DPCCH} dB, subject to the provisions of sub-clause 5.1.2.6.

The gain factors during compressed frames are based on the nominal power relation defined in normal frames, as specified in subclause 5.1.2.5.4.

5.1.2.5.2 Signalled gain factors

When the gain factors β_c and β_d are signalled by higher layers for a certain TFC, the signalled values are used directly for weighting of DPCCH and DPDCH(s). The variable A_j , called the nominal power relation is then computed as:

$$A_j = \frac{\beta_d}{\beta_c}.$$

5.1.2.5.3 Computed gain factors

The gain factors β_c and β_d may also be computed for certain TFCs, based on the signalled settings for a reference TFC.

Let $\beta_{c,ref}$ and $\beta_{d,ref}$ denote the signalled gain factors for the reference TFC. Further, let $\beta_{c,j}$ and $\beta_{d,j}$ denote the gain factors used for the j :th TFC. Also let L_{ref} denote the number of DPDCHs used for the reference TFC and L_j denote the number of DPDCHs used for the j :th TFC.

Define the variable

$$K_{ref} = \sum_i RM_i \cdot N_i ;$$

where RM_i is the semi-static rate matching attribute for transport channel i (defined in [2] subclause 4.2.7), N_i is the number of bits output from the radio frame segmentation block for transport channel i (defined in [2] subclause 4.2.6.1), and the sum is taken over all the transport channels i in the reference TFC.

Similarly, define the variable

$$K_j = \sum_i RM_i \cdot N_i ;$$

where the sum is taken over all the transport channels i in the j :th TFC.

The variable A_j , called the nominal power relation is then computed as:

$$A_j = \frac{\beta_{d,ref}}{\beta_{c,ref}} \cdot \sqrt{\frac{L_{ref}}{L_j}} \sqrt{\frac{K_j}{K_{ref}}}$$

The gain factors for the j :th TFC are then computed as follows:

- If $A_j > 1$, then $\beta_{d,j} = 1.0$ and $\beta_{c,j}$ is the largest quantized β -value, for which the condition $\beta_{c,j} \leq 1 / A_j$ holds. Since $\beta_{c,j}$ may not be set to zero, if the above rounding results in a zero value, $\beta_{c,j}$ shall be set to the lowest quantized amplitude ratio of 1/15 as specified in [3].
- If $A_j \leq 1$, then $\beta_{d,j}$ is the smallest quantized β -value, for which the condition $\beta_{d,j} \geq A_j$ holds and $\beta_{c,j} = 1.0$.

The quantized β -values are defined in [3] subclause 4.2.1, table 1.

5.1.2.5.4 Setting of the uplink DPCCH/DPDCH power difference in compressed mode

The gain factors used during a compressed frame for a certain TFC are calculated from the nominal power relation used in normal (non-compressed) frames for that TFC. Let A_j denote the nominal power relation for the j :th TFC in a normal frame. Further, let $\beta_{c,C,j}$ and $\beta_{d,C,j}$ denote the gain factors used for the j :th TFC when the frame is compressed. The variable $A_{C,j}$ is computed as:

$$A_{C,j} = A_j \cdot \sqrt{\frac{15 \cdot N_{pilot,C}}{N_{slots,C} \cdot N_{pilot,N}}}$$

where $N_{pilot,C}$ is the number of pilot bits per slot when in compressed mode, and $N_{pilot,N}$ is the number of pilot bits per slot in normal mode. $N_{slots,C}$ is the number of slots in the compressed frame used for transmitting the data.

The gain factors for the j :th TFC in a compressed frame are computed as follows:

If $A_{C,j} > 1$, then $\beta_{d,C,j} = 1.0$ and $\beta_{c,C,j}$ is the largest quantized β -value, for which the condition $\beta_{c,C,j} \leq 1 / A_{C,j}$ holds. Since $\beta_{c,C,j}$ may not be set to zero, if the above rounding results in a zero value, $\beta_{c,C,j}$ shall be set to the lowest quantized amplitude ratio of 1/15 as specified in [3].

If $A_{C,j} \leq 1$, then $\beta_{d,C,j}$ is the smallest quantized β -value, for which the condition $\beta_{d,C,j} \geq A_{C,j}$ holds and $\beta_{c,C,j} = 1.0$.

The quantized β -values are defined in [3] subclause 4.2.1, table 1.

5.1.2.6 Maximum and minimum power limits

In the case that the total UE transmit power (after applying DPCCH power adjustments and gain factors) would exceed the maximum allowed value, the UE shall apply additional scaling to the total transmit power so that it is equal to the maximum allowed power. This additional scaling shall be such that the power ratio between DPCCH and DPDCH remains as required by sub-clause 5.1.2.5.

When transmitting on a DPCH the UE is not required to be capable of reducing its total transmit power below the minimum level required in [7]. However, it may do so, provided that the power ratio between DPCCH and DPDCH remains as specified in sub clause 5.1.2.5. Some further regulations also apply as follows: In the case that the total UE transmit power (after applying DPCCH power adjustments and gain factors) would be at or below the total transmit power in the previously transmitted slot and also at or below the required minimum power specified in [7], the UE may apply additional scaling to the total transmit power, subject to the following restrictions:

- The total transmit power after applying any additional scaling shall not exceed the required minimum power, nor the total transmit power in the previously transmitted slot;
- The magnitude of any reduction in total transmit power between slots after applying any additional scaling shall not exceed the magnitude of the calculated power reduction before the additional scaling.

In the case that the total UE transmit power in the previously transmitted slot is at or below the required minimum power specified in [7] and the DPCCCH power adjustment and gain factors for the current slot would result in an increase in total power, then no additional scaling shall be used (i.e. power control shall operate as normal).

If the UE applies any additional scaling to the total transmit power as described above, this scaling shall be included in the computation of any DPCCCH power adjustments to be applied in the next transmitted slot.

5.1.3 PCPCH

5.1.3.1 General

The power control during the CPCH access procedure is described in clause 6.2. The inner loop power control for the PCPCH is described in the following sub-clauses.

5.1.3.2 Power control in the message part

The uplink transmit power control procedure simultaneously controls the power of a PCPCH control part and its corresponding PCPCH data part. The relative transmit power offset between the PCPCH control part and the PCPCH data part is determined by the network and is computed according to sub-clause 5.1.2.5 using the gain factors signalled to the UE using higher-layer signalling, with the difference that:

- β_c is the gain factor for the PCPCH control part (similar to DPCCCH);
- β_d is the gain factor for the PCPCH data part (similar to DPDCH).

The gain factors are applied as shown in sub clause 4.2.3.2 of [3].

The operation of the inner power control loop adjusts the power of the PCPCH control part and PCPCH data part by the same amount, provided there are no changes in gain factors.

Any change in the uplink PCPCH control part transmit power shall take place immediately before the start of the pilot field on the control part of the message part. The change in PCPCH control part power with respect to its value in the previous slot is derived by the UE and is denoted by $\Delta_{\text{PCPCH-CP}}$ (in dB).

During the operation of the uplink power control procedure the UE transmit power shall not exceed a maximum allowed value which is the lower out of the maximum output power of the terminal power class and a value which may be set by higher layer signalling.

Uplink power control shall be performed while the UE transmit power is below the maximum allowed output power.

The provisions for power control at the maximum allowed value and below the required minimum output power (as defined in [7]) are described in sub-clause 5.1.2.6.

The uplink inner-loop power control adjusts the UE transmit power in order to keep the received uplink signal-to-interference ratio (SIR) at a given SIR target, $\text{SIR}_{\text{target}}$, which is set by the higher layer outer loop.

The network should estimate the signal-to-interference ratio SIR_{est} of the received PCPCH. The network should then generate TPC commands and transmit the commands once per slot according to the following rule: if $\text{SIR}_{\text{est}} > \text{SIR}_{\text{target}}$ then the TPC command to transmit is "0", while if $\text{SIR}_{\text{est}} < \text{SIR}_{\text{target}}$ then the TPC command to transmit is "1".

The UE derives a TPC command, TPC_cmd , for each slot. Two algorithms shall be supported by the UE for deriving a TPC_cmd . Which of these two algorithms is used is determined by a higher-layer parameter, "PowerControlAlgorithm", and is under the control of the UTRAN. If "PowerControlAlgorithm" indicates "algorithm1", then the layer 1 parameter PCA shall take the value 1 and if "PowerControlAlgorithm" indicates "algorithm2" then PCA shall take the value 2.

If PCA has the value 1, Algorithm 1, described in subclause 5.1.2.2.2, shall be used for processing TPC commands.

If PCA has the value 2, Algorithm 2, described in subclause 5.1.2.2.3, shall be used for processing TPC commands.

The step size Δ_{TPC} is a layer 1 parameter which is derived from the higher-layer parameter "TPC-StepSize" which is under the control of the UTRAN. If "TPC-StepSize" has the value "dB1", then the layer 1 parameter Δ_{TPC} shall take the value 1 dB and if "TPC-StepSize" has the value "dB2", then Δ_{TPC} shall take the value 2 dB.

After deriving the TPC command TPC_cmd using one of the two supported algorithms, the UE shall adjust the transmit power of the uplink PCPCH control part with a step of $\Delta_{\text{PCPCH-CP}}$ (in dB) which is given by:

$$\Delta_{\text{PCPCH-CP}} = \Delta_{\text{TPC}} \times \text{TPC_cmd}$$

5.1.3.3 Power control in the power control preamble

A PCPCH power control preamble is a period when both the UL PCPCH control part and the associated DL DPCCH are transmitted prior to the start of the uplink PCPCH data part.

The length of the power control preamble is a higher layer parameter, $L_{\text{pc-preamble}}$ (see section 6.2), and can take the value 0 slots or 8 slots. The uplink PCPCH data part shall not commence before the end of the power control preamble.

If $L_{\text{pc-preamble}} > 0$, the details of power control used during the power control preamble differ from the ordinary power control which is used afterwards. After the first slot of the power control preamble the change in uplink PCPCH control part transmit power shall initially be given by:

$$\Delta_{\text{PCPCH-CP}} = \Delta_{\text{TPC-init}} \times \text{TPC_cmd}$$

If the value of PCA is 1 then $\Delta_{\text{TPC-init}}$ is equal to the minimum value out of 3 dB and $2\Delta_{\text{TPC}}$.

If the value of PCA is 2 then $\Delta_{\text{TPC-init}}$ is equal to 2dB.

TPC_cmd is derived according to algorithm 1 as described in sub clause 5.1.2.2.2, regardless of the value of PCA.

Power control as defined for the message part (see sub-clause 5.1.3.2), with the power control algorithm determined by the value of PCA and step size Δ_{TPC} , shall be used as soon as the sign of TPC_cmd reverses for the first time, or at the end of the power control preamble if the power control preamble ends first.

5.2 Downlink power control

The transmit power of the downlink channels is determined by the network. In general the ratio of the transmit power between different downlink channels is not specified and may change with time. However, regulations exist as described in the following subclauses.

Higher layer power settings shall be interpreted as setting of the total power, i.e. the sum of the power from the two antennas in case of transmit diversity.

5.2.1 DPCCH/DPDCH

5.2.1.1 General

The downlink transmit power control procedure controls simultaneously the power of a DPCCH and its corresponding DPDCHs. The power control loop adjusts the power of the DPCCH and DPDCHs with the same amount, i.e. the relative power difference between the DPCCH and DPDCHs is not changed.

The relative transmit power offset between DPCCH fields and DPDCHs is determined by the network. The TFCI, TPC and pilot fields of the DPCCH are offset relative to the DPDCHs power by PO1, PO2 and PO3 dB respectively. The power offsets may vary in time. The method for controlling the power offsets within UTRAN is specified in [6]

5.2.1.2 Ordinary transmit power control

5.2.1.2.1 UE behaviour

The UE shall generate TPC commands to control the network transmit power and send them in the TPC field of the uplink DPCCCH. An example on how to derive the TPC commands is given in Annex B.2.

The UE shall check the downlink power control mode (DPC_MODE) before generating the TPC command:

- if DPC_MODE = 0 : the UE sends a unique TPC command in each slot and the TPC command generated is transmitted in the first available TPC field in the uplink DPCCCH;
- if DPC_MODE = 1 : the UE repeats the same TPC command over 3 slots and the new TPC command is transmitted such that there is a new command at the beginning of the frame.

The DPC_MODE parameter is a UE specific parameter controlled by the UTRAN.

The UE shall not make any assumptions on how the downlink power is set by UTRAN, in order to not prohibit usage of other UTRAN power control algorithms than what is defined in subclause 5.2.1.2.2.

5.2.1.2.2 UTRAN behaviour

Upon receiving the TPC commands UTRAN shall adjust its downlink DPCCCH/DPDCH power accordingly. For DPC_MODE = 0, UTRAN shall estimate the transmitted TPC command TPC_{est} to be 0 or 1, and shall update the power every slot. If DPC_MODE = 1, UTRAN shall estimate the transmitted TPC command TPC_{est} over three slots to be 0 or 1, and shall update the power every three slots.

After estimating the k :th TPC command, UTRAN shall adjust the current downlink power $P(k-1)$ [dB] to a new power $P(k)$ [dB] according to the following formula:

$$P(k) = P(k-1) + P_{TPC}(k) + P_{bal}(k),$$

where $P_{TPC}(k)$ is the k :th power adjustment due to the inner loop power control, and $P_{bal}(k)$ [dB] is a correction according to the downlink power control procedure for balancing radio link powers towards a common reference power. The power balancing procedure and control of the procedure is described in [6].

$P_{TPC}(k)$ is calculated according to the following.

If the value of *Limited Power Increase Used* parameter is 'Not used', then

$$P_{TPC}(k) = \begin{cases} +\Delta_{TPC} & \text{if } TPC_{est}(k) = 1 \\ -\Delta_{TPC} & \text{if } TPC_{est}(k) = 0 \end{cases}, [\text{dB}]. \quad (1)$$

If the value of *Limited Power Increase Used* parameter is 'Used', then the k :th inner loop power adjustment shall be calculated as:

$$P_{TPC}(k) = \begin{cases} +\Delta_{TPC} & \text{if } TPC_{est}(k) = 1 \text{ and } \Delta_{sum}(k) + \Delta_{TPC} < \text{Power_Raise_Limit} \\ 0 & \text{if } TPC_{est}(k) = 1 \text{ and } \Delta_{sum}(k) + \Delta_{TPC} \geq \text{Power_Raise_Limit} \\ -\Delta_{TPC} & \text{if } TPC_{est}(k) = 0 \end{cases}, [\text{dB}] \quad (2)$$

where

$$\Delta_{sum}(k) = \sum_{i=k-DL_Power_Averaging_Window_Size}^{k-1} P_{TPC}(i)$$

is the temporary sum of the last *DL_Power_Averaging_Window_Size* inner loop power adjustments (in dB).

For the first (*DL_Power_Averaging_Window_Size* - 1) adjustments after the activation of the limited power increase method, formula (1) shall be used instead of formula (2). *Power_Raise_Limit* and *DL_Power_Averaging_Window_Size* are parameters configured in the UTRAN.

The power control step size Δ_{TPC} can take four values: 0.5, 1, 1.5 or 2 dB. It is mandatory for UTRAN to support Δ_{TPC} of 1 dB, while support of other step sizes is optional.

In addition to the above described formulas on how the downlink power is updated, the restrictions below apply.

In case of congestion (commanded power not available), UTRAN may disregard the TPC commands from the UE.

The average power of transmitted DPDCH symbols over one timeslot shall not exceed Maximum_DL_Power (dB), nor shall it be below Minimum_DL_Power (dB). Transmitted DPDCH symbol means here a complex QPSK symbol before spreading which does not contain DTX. Maximum_DL_Power (dB) and Minimum_DL_Power (dB) are power limits for one channelisation code, relative to the primary CPICH power [6].

5.2.1.3 Power control in compressed mode

The aim of downlink power control in uplink or/and downlink compressed mode is to recover as fast as possible a signal-to-interference ratio (SIR) close to the target SIR after each transmission gap.

The UE behaviour is the same in compressed mode as in normal mode, described in subclause 5.2.1.2, except that the target SIR is offset by higher layer signalling. However due to transmission gaps in uplink compressed frames there may be incomplete sets of TPC commands when DPC_MODE=1.

UTRAN behaviour is as stated in section 5.2.1.2.2 except for DPC_MODE = 1 where missing TPC commands in the UL may lead the UTRAN to changing its power more frequently than every 3 slots.

In compressed mode, compressed frames may occur in either the uplink or the downlink or both. In compressed frames, the transmission of downlink DPDCH(s) and DPCCH shall be stopped during transmission gaps.

The power of the DPCCH and DPDCH in the first slot after the transmission gap should be set to the same value as in the slot just before the transmission gap.

During compressed mode except during downlink transmission gaps, UTRAN shall estimate the k :th TPC command and adjust the current downlink power $P(k-1)$ [dB] to a new power $P(k)$ [dB] according to the following formula:

$$P(k) = P(k - 1) + P_{TPC}(k) + P_{SIR}(k) + P_{bal}(k),$$

where $P_{TPC}(k)$ is the k :th power adjustment due to the inner loop power control, $P_{SIR}(k)$ is the k -th power adjustment due to the downlink target SIR variation, and $P_{bal}(k)$ [dB] is a correction according to the downlink power control procedure for balancing radio link powers towards a common reference power. The power balancing procedure and control of the procedure is described in [6].

Due to transmission gaps in uplink compressed frames, there may be missing TPC commands in the uplink.

For DPC_MODE = 0 if no uplink TPC command is received, $P_{TPC}(k)$ derived by the Node B shall be set to zero. Otherwise, $P_{TPC}(k)$ is calculated the same way as in normal mode (see sub-clause 5.2.1.2.2) but with a step size Δ_{STEP} instead of Δ_{TPC} .

For DPC_MODE = 1, the sets of slots over which the TPC commands are processed shall remain aligned to the frame boundaries in the compressed frame. If this results in an incomplete set of TPC commands, the UE shall transmit the same TPC commands in all slots of the incomplete set.

The power control step size $\Delta_{STEP} = \Delta_{RP-TPC}$ during RPL slots after each transmission gap and $\Delta_{STEP} = \Delta_{TPC}$ otherwise, where:

- RPL is the recovery period length and is expressed as a number of slots. RPL is equal to the minimum value out of the transmission gap length and 7 slots. If a transmission gap is scheduled to start before RPL slots have elapsed, then the recovery period shall end at the start of the gap, and the value of RPL shall be reduced accordingly.
- Δ_{RP-TPC} is called the recovery power control step size and is expressed in dB. Δ_{RP-TPC} is equal to the minimum value of 3 dB and $2\Delta_{TPC}$.

The power offset $P_{SIR}(k) = \delta P_{curr} - \delta P_{prev}$, where δP_{curr} and δP_{prev} are respectively the value of δP in the current slot and the most recently transmitted slot and δP is computed as follows:

$$\delta P = \max(\Delta P1_compression, \dots, \Delta Pn_compression) + \Delta P1_coding + \Delta P2_coding$$

where n is the number of different TTI lengths amongst TTIs of all TrChs of the CCTrCh, where $\Delta P1_coding$ and $\Delta P2_coding$ are computed from uplink parameters $\Delta P1_coding$, $\Delta P2_coding$, $\Delta P1_coding$, $\Delta P2_coding$ signaled by higher layers as:

- $\Delta P1_coding = \Delta P1_coding$ if the start of the first transmission gap in the transmission gap pattern is within the current frame.
- $\Delta P1_coding = \Delta P1_coding$ if the current frame just follows a frame containing the start of the first transmission gap in the transmission gap pattern.
- $\Delta P2_coding = \Delta P2_coding$ if the start of the second transmission gap in the transmission gap pattern is within the current frame.
- $\Delta P2_coding = \Delta P2_coding$ if the current frame just follows a frame containing the start of the second transmission gap in the transmission gap pattern.
- $\Delta P1_coding = 0$ dB and $\Delta P2_coding = 0$ dB in all other cases.

and $\Delta P_i_compression$ is defined by :

- $\Delta P_i_compression = 3$ dB for downlink frames compressed by reducing the spreading factor by 2.
- $\Delta P_i_compression = 10 \log (15 \cdot F_i / (15 \cdot F_i - TGL_i))$ if there is a transmission gap created by puncturing method within the current TTI of length F_i frames, where TGL_i is the gap length in number of slots (either from one gap or a sum of gaps) in the current TTI of length F_i frames.
- $\Delta P_i_compression = 0$ dB in all other cases.

In case several compressed mode patterns are used simultaneously, a δP offset is computed for each compressed mode pattern and the sum of all δP offsets is applied to the frame.

For all time slots except those in transmissions gaps, the average power of transmitted DPDCH symbols over one timeslot shall not exceed $Maximum_DL_Power$ (dB) by more than P_{SIR} , nor shall it be below $Minimum_DL_Power$ (dB). Transmitted DPDCH symbol means here a complex QPSK symbol before spreading which does not contain DTX. $Maximum_DL_Power$ (dB) and $Minimum_DL_Power$ (dB) are power limits for one channelisation code, relative to the primary CPICH power [6].

5.2.1.4 Site selection diversity transmit power control

5.2.1.4.1 General

Site selection diversity transmit power control (SSDT) is another macro diversity method in soft handover mode. This method is optional in UTRAN.

Operation is summarised as follows. The UE selects one of the cells from its active set to be 'primary', all other cells are classed as 'non primary'. The main objective is to transmit on the downlink from the primary cell, thus reducing the interference caused by multiple transmissions in a soft handover mode. A second objective is to achieve fast site selection without network intervention, thus maintaining the advantage of the soft handover. In order to select a primary cell, each cell is assigned a temporary identification (ID) and UE periodically informs a primary cell ID to the connecting cells. The non-primary cells selected by UE switch off the transmission power. The primary cell ID is delivered by UE to the active cells via uplink FBI field. SSDT activation, SSDT termination and ID assignment are all carried out by higher layer signalling.

SSDT is only supported when the P-CPICH is used as the downlink phase reference and closed loop mode transmit diversity is not used simultaneously.

UTRAN may also command UE to use SSDT signalling in the uplink although cells would transmit the downlink as without SSDT active. In case SSDT is used in the uplink direction only, the processing in the UE for the radio links received in the downlink is as with macro diversity in non-SSDT case. The downlink operation mode for SSDT is set by higher layers. UTRAN may use the SSDT information for the PDSCH power control as specified in section 5.2.2.

NOTE: This feature of SSDT limited to uplink only applies to terminals that are DSCH capable.

5.2.1.4.1.1 Definition of temporary cell identification

Each cell is given a temporary ID during SSDT and the ID is utilised as site selection signal. The ID is given a binary bit sequence. There are three different lengths of coded ID available denoted as "long", "medium" and "short". The network decides which length of coded ID is used. Settings of ID codes for 1-bit and 2-bit FBI are exhibited in table 3 and table 4, respectively.

Table 3: Settings of ID codes for 1 bit FBI

ID label	ID code		
	"long"	"medium"	"short"
a	0000000000000000	(0)0000000	00000
b	101010101010101	(0)1010101	01001
c	011001100110011	(0)0110011	11011
d	110011001100110	(0)1100110	10010
e	000111100001111	(0)0001111	00111
f	101101001011010	(0)1011010	01110
g	011110000111100	(0)0111100	11100
h	110100101101001	(0)1101001	10101

Table 4: Settings of ID codes for 2 bit FBI

ID label	ID code (Column and Row denote slot position and FBI-bit position.)		
	"long"	"medium"	"short"
a	(0)0000000	(0)000	000
	(0)0000000	(0)000	000
b	(0)0000000	(0)000	000
	(1)1111111	(1)111	111
c	(0)1010101	(0)101	101
	(0)1010101	(0)101	101
d	(0)1010101	(0)101	101
	(1)0101010	(1)010	010
e	(0)0110011	(0)011	011
	(0)0110011	(0)011	011
f	(0)0110011	(0)011	011
	(1)1001100	(1)100	100
g	(0)1100110	(0)110	110
	(0)1100110	(0)110	110
h	(0)1100110	(0)110	110
	(1)0011001	(1)001	001

The ID code bits shown in table 3 and table 4 are transmitted from left to right. In table 4, the first row gives the first FBI bit in each slot, the second row gives the 2nd FBI bit in each slot. The ID code(s) are transmitted aligned to the radio frame structure (i.e. ID codes shall be terminated within a frame). If FBI space for sending the last ID code within a frame cannot be obtained, the first bit(s) from that ID code are punctured. The bit(s) to be punctured are shown in brackets in table 3 and table 4.

The alignment of the ID codes to the radio frame structure is not affected by transmission gaps resulting from uplink compressed mode.

5.2.1.4.2 TPC procedure in UE

The UE shall generate TPC commands to control the network transmit power and send them in the TPC field of the uplink DPCCCH based on the downlink signals from the primary cell only. An example on how to derive the TPC commands is given in Annex B.2.

5.2.1.4.3 Selection of primary cell

The UE selects a primary cell periodically by measuring the RSCP of P-CPICHs transmitted by the active cells. The cell with the highest P-CPICH RSCP is detected as a primary cell.

5.2.1.4.4 Delivery of primary cell ID

The UE periodically sends the ID code of the primary cell via portion of the uplink FBI field assigned for SSdT use (FBI S field). A cell recognises its state as non-primary if the following conditions are fulfilled simultaneously:

- The received ID code does not match with the own ID code.
- The received uplink signal quality satisfies a quality threshold, Q_{th} , a parameter defined by the network.
- If uplink compressed mode is used, and less than $\lfloor N_{ID}/3 \rfloor$ bits are lost from the ID code (as a result of uplink compressed mode), where N_{ID} is the number of bits in the ID code (after puncturing according to clause 5.2.1.4.1.1, if puncturing has been done).

Otherwise the cell recognises its state as primary.

The state of the cells (primary or non-primary) in the active set is updated synchronously. If a cell receives the last portion of the coded ID in uplink slot j , the state of cell is updated in downlink slot $(j+1+T_{os}) \bmod 15$, where T_{os} is defined as a constant of 2 time slots. The updating of the cell state is not influenced by the operation of downlink compressed mode.

At the UE, the primary ID code to be sent to the cells is segmented into a number of portions. These portions are distributed in the uplink FBI S-field. The cell in SSdT collects the distributed portions of the primary ID code and then detects the transmitted ID. The period of the primary cell update depends on the settings of the code length and the number of FBI bits assigned for SSdT use as shown in table 5.

Table 5: Period of primary cell update

code length	The number of FBI bits per slot assigned for SSdT	
	1	2
"long"	1 update per frame	2 updates per frame
"medium"	2 updates per frame	4 updates per frame
"short"	3 updates per frame	5 updates per frame

5.2.1.4.5 TPC procedure in the network

In SSdT, a non-primary cell can switch off its DPDCH output (i.e. no transmissions).

The cell manages two downlink transmission power levels, P1, and P2. Power level P1 is used for downlink DPCCH transmission power level and this level is updated in the same way with the downlink DPCCH power adjustment specified in 5.2.1.2.2 (for normal mode) and 5.2.1.3 (for compressed mode) regardless of the selected state (primary or non-primary). The actual transmission power of TFCI, TPC and pilot fields of DPCCH is set by adding P1 and the offsets PO1, PO2 and PO3, respectively, as specified in 5.2.1.1. P2 is used for downlink DPDCH transmission power level and this level is set to P1 if the cell is selected as primary, otherwise P2 is switched off. The cell updates P1 first and P2 next, and then the two power settings P1 and P2 are maintained within the power control dynamic range. Table 6 summarizes the updating method of P1 and P2.

Table 6: Updating of P1 and P2

State of cell	P1 (DPCCH)	P2 (DPDCH)
non primary	Updated in the same way with the downlink DPCCH power adjustment specified in 5.2.1.2.2 and 5.2.1.3	Switched off
primary		= P1

5.2.2 PDSCH

The PDSCH power control can be based on any of the following solutions:

- Inner-loop power control based on the power control commands sent by the UE on the uplink DPCCH.
- Other power control procedures applied by the network.

UTRAN may use the SSdT signalling to determine what power offset to use for PDSCH with respect to the associated downlink DCH when more than one cell may be in the active set. The support for a combination where SSdT signaling is used in the uplink, but SSdT is not necessarily used in the downlink, is required only from the UEs that support the use of DSCH.

If the downlink direction uses SSdT for the DCH transmission, then the TPC procedure in the UE to generate TPC commands to control the network transmit power is as specified in 5.2.1.4.2.

If the downlink transmission does not use SSdT operation, then the TPC procedure in the UE to generate TPC commands to control the network transmit power is as specified in 5.2.1.2.1.

The PDSCH power offset to be used with respect to the associated DCH depends on whether the cell transmitting PDSCH is determined to be a primary one or not.

The SSdT commands sent by the UE are averaged in UTRAN side over one or more frames. The averaging window length parameter as the number of frames to average over, *SSdT_aveg_window*, and the parameter for the required number of received primary SSdT commands, *SSdT_primary_commands*, during the averaging window for declaring primary status for a cell are given by UTRAN.

If the number of primary ID codes in the uplink received during the averaging window is less than the parameter *SSdT_primary_commands*, then a cell shall consider itself as non-primary and uses the power offset given from UTRAN to the cell with the data for the PDSCH.

If the number of primary ID codes in the uplink received during the averaging window is equal or more than the parameter *SSdT_primary_commands* defines, the cell shall use the power control parameterisation for the primary case. When the cell considers itself as primary it uses both the power offset for the PDSCH frame for the given UE and the *Enhanced DSCH Power Offset* parameter given by the UTRAN for the primary case.

The cell status (primary/non-primary) obtained from the rules above may differ from the cell status for SSdT transmission in the downlink depending on the values given by UTRAN for the parameters for averaging window length and the required number of received primary SSdT commands for cell status determination.

5.2.3 DL-DPCCH for CPCH

5.2.3.1 UE behaviour

The UE shall generate TPC commands to control the network transmit power and send them in the TPC field of the uplink DPCCH. The UE shall send a unique TPC command in each slot as in the DPCCH/DPDCH case for *DPC_MODE=0*.

The TPC commands setting may be based on the example provided in Annex B.2 for the DPCCH/DPDCH. However in the DL-DPCCH for CPCH case, the setting of the *SIR_target* by the outer loop power control is based on a DL-DPCCH for CPCH BER target provided by the UTRAN rather than a TrCH BLER. Also there is no soft handover, neither SSdT, used in combination with the CPCH.

The UE shall not make any assumptions on how the downlink power is set by UTRAN, in order to not prohibit usage of other UTRAN power control algorithms than what is defined in sub-clause 5.2.1.2.2.

5.2.3.2 UTRAN behaviour

The relative transmit power offsets between the different DPCCH fields (TPC and pilot) and CCC field is determined by the network. The power of CCC field in DL DPCCH for CPCH is the same as the power of the pilot field.

The TPC field of the DPCCH is offset relative to the pilot by PO2dB. This power offsets may vary in time. The method for controlling the power offset within UTRAN is specified in [6]

The UTRAN behaviour for the power control is left open to the implementation. As an example it may be based on the UTRAN behaviour for the DPCCH/DPDCH as specified in sub-clause 5.2.1.2.2, with the following exceptions :

DPC_MODE should be set to 0 as there is no DPC_MODE parameter for CPCH and there is no support of Site selection diversity power control for the DL-DPCCH for CPCH as Soft handover is not applicable to the CPCH.

5.2.4 AICH

The UE is informed about the relative transmit power of the AICH (measured as the power per transmitted acquisition indicator) compared to the primary CPICH transmit power by the higher layers.

5.2.5 PICH

The UE is informed about the relative transmit power of the PICH (measured as the power over the paging indicators) compared to the primary CPICH transmit power by the higher layers.

5.2.6 S-CCPCH

The TFCI and pilot fields may be offset relative to the power of the data field. The power offsets may vary in time.

5.2.7 CSICH

The UE is informed about the relative transmit power of the CSICH (measured as the power per transmitted status indicator) compared to the primary CPICH transmit power by the higher layers.

5.2.8 AP-AICH

The UE is informed about the relative transmit power of the AP-AICH (measured as the power per transmitted acquisition indicator) compared to the primary CPICH transmit power by the higher layers.

5.2.9 CA/CD-ICH

The UE is informed about the relative transmit power of the CA/CD-ICH (measured as the power per transmitted acquisition indicator) compared to the primary CPICH transmit power by the higher layers.

6 Random access procedure

6.1 Physical random access procedure

The physical random access procedure described in this subclause is initiated upon request from the MAC sublayer (cf. [9]).

Before the physical random-access procedure can be initiated, Layer 1 shall receive the following information from the higher layers (RRC):

- The preamble scrambling code.
- The message length in time, either 10 or 20 ms.
- The AICH_Transmission_Timing parameter [0 or 1].
- The set of available signatures and the set of available RACH sub-channels for each Access Service Class (ASC). Sub-channels are defined in subclause 6.1.1.
- The power-ramping factor Power Ramp Step [integer > 0].
- The parameter Preamble Retrans Max [integer > 0].
- The initial preamble power Preamble_Initial_Power.

- The Power offset $P_{p-m} = P_{\text{message-control}} - P_{\text{preamble}}$, measured in dB, between the power of the last transmitted preamble and the control part of the random-access message.
- The set of Transport Format parameters. This includes the power offset between the data part and the control part of the random-access message for each Transport Format.

Note that the above parameters may be updated from higher layers before each physical random access procedure is initiated.

At each initiation of the physical random access procedure, Layer 1 shall receive the following information from the higher layers (MAC):

- The Transport Format to be used for the PRACH message part.
- The ASC of the PRACH transmission.
- The data to be transmitted (Transport Block Set).

The physical random-access procedure shall be performed as follows:

- 1 Derive the available uplink access slots, in the next full access slot set, for the set of available RACH sub-channels within the given ASC with the help of subclauses 6.1.1. and 6.1.2. Randomly select one access slot among the ones previously determined. If there is no access slot available in the selected set, randomly select one uplink access slot corresponding to the set of available RACH sub-channels within the given ASC from the next access slot set. The random function shall be such that each of the allowed selections is chosen with equal probability.
- 2 Randomly select a signature from the set of available signatures within the given ASC. The random function shall be such that each of the allowed selections is chosen with equal probability.
- 3 Set the Preamble Retransmission Counter to Preamble Retrans Max.
- 4 Set the parameter Commanded Preamble Power to Preamble_Initial_Power.
- 5 In the case that the Commanded Preamble Power exceeds the maximum allowed value, set the preamble transmission power to the maximum allowed power. In the case that the Commanded Preamble Power is below the minimum level required in [7], set the preamble transmission power to a value, which shall be at or above the Commanded Preamble Power and at or below the required minimum power specified in [7]. Otherwise set the preamble transmission power to the Commanded Preamble Power. Transmit a preamble using the selected uplink access slot, signature, and preamble transmission power.
- 6 If no positive or negative acquisition indicator ($AI \neq +1$ nor -1) corresponding to the selected signature is detected in the downlink access slot corresponding to the selected uplink access slot:
 - 6.1 Select the next available access slot in the set of available RACH sub-channels within the given ASC.
 - 6.2 Randomly select a new signature from the set of available signatures within the given ASC. The random function shall be such that each of the allowed selections is chosen with equal probability.
 - 6.3 Increase the Commanded Preamble Power by $\Delta P_0 = \text{Power Ramp Step [dB]}$. If the Commanded Preamble Power exceeds the maximum allowed power by 6dB, the UE may pass L1 status ("No ack on AICH") to the higher layers (MAC) and exit the physical random access procedure.
 - 6.4 Decrease the Preamble Retransmission Counter by one.
 - 6.5 If the Preamble Retransmission Counter > 0 then repeat from step 5. Otherwise pass L1 status ("No ack on AICH") to the higher layers (MAC) and exit the physical random access procedure.
- 7 If a negative acquisition indicator corresponding to the selected signature is detected in the downlink access slot corresponding to the selected uplink access slot, pass L1 status ("Nack on AICH received") to the higher layers (MAC) and exit the physical random access procedure.
- 8 Transmit the random access message three or four uplink access slots after the uplink access slot of the last transmitted preamble depending on the AICH transmission timing parameter. Transmission power of the control part of the random access message should be P_{p-m} [dB] higher than the power of the last transmitted preamble. Transmission power of the data part of the random access message is set according to subclause 5.1.1.2.

- 9 Pass L1 status "RACH message transmitted" to the higher layers and exit the physical random access procedure.

6.1.1 RACH sub-channels

A RACH sub-channel defines a sub-set of the total set of uplink access slots. There are a total of 12 RACH sub-channels. RACH sub-channel #i (i = 0, ..., 11) consists of the following uplink access slots:

- Uplink access slot #i leading by τ_{p-a} chips the downlink access slot #i contained within the 10 ms interval that is time aligned with P-CCPCH frames for which SFN mod 8 = 0 or SFN mod 8 = 1.
- Every 12th access slot relative to this access slot.

The access slots of different RACH sub-channels are also illustrated in Table 7.

Table 7: The available uplink access slots for different RACH sub-channels

SFN modulo 8 of corresponding P-CCPCH frame	Sub-channel number											
	0	1	2	3	4	5	6	7	8	9	10	11
0	0	1	2	3	4	5	6	7				
1	12	13	14						8	9	10	11
2				0	1	2	3	4	5	6	7	
3	9	10	11	12	13	14						8
4	6	7					0	1	2	3	4	5
5			8	9	10	11	12	13	14			
6	3	4	5	6	7					0	1	2
7						8	9	10	11	12	13	14

6.1.2 RACH access slot sets

The PRACH contains two sets of access slots as shown in Figure 2. Access slot set 1 contains PRACH slots 0 – 7 and starts τ_{p-a} chips before the downlink P-CCPCH frame for which SFN mod 2 = 0. Access slot set 2 contains PRACH slots 8 - 14 and starts ($\tau_{p-a} - 2560$) chips before the downlink P-CCPCH frame for which SFN mod 2 = 1.

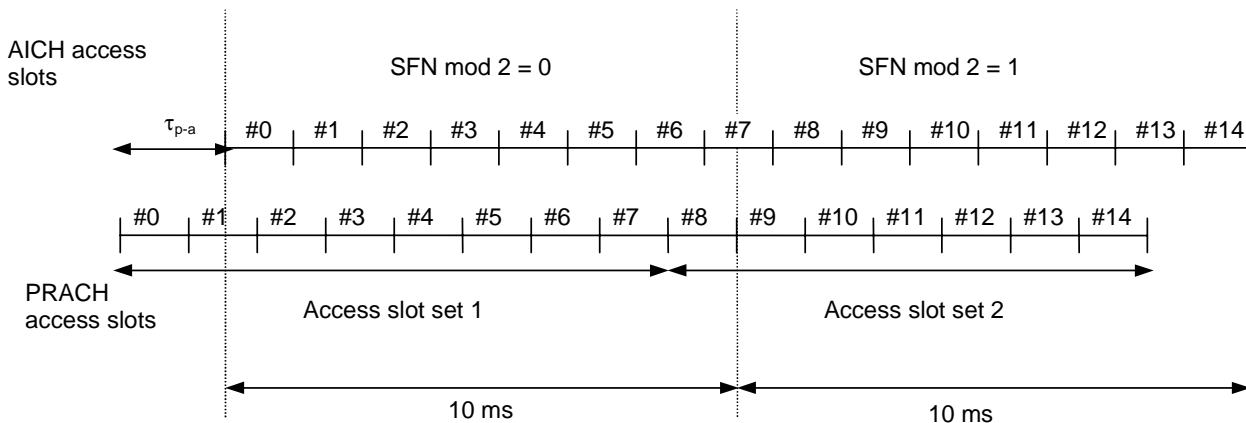


Figure 2: PRACH access slot and downlink AICH relation ($\tau_{p-a} = 7680$ chips)

6.2 CPCH Access Procedures

For each CPCH physical channel in a CPCH set allocated to a cell the following physical layer parameters are included in the System Information message: L1 shall receive the following information from the higher layers (RRC).

- UL Access Preamble (AP) scrambling code.
- UL Access Preamble signature set.

- The Access preamble slot sub-channels group.
- AP- AICH preamble channelization code.
- UL Collision Detection(CD) preamble scrambling code.
- CD Preamble signature set.
- CD preamble slot sub-channels group.
- CD-AICH preamble channelization code.
- CPCH UL scrambling code.
- DPCCH DL channelization code.([512] chip).

NOTE: There may be some overlap between the AP signature set and CD signature set if they correspond to the same scrambling code.

The following physical layer parameters are received from the RRC layer:

- 1) $N_{AP_retrans_max}$ = Maximum Number of allowed consecutive access attempts (retransmitted preambles) if there is no AICH response. This is a CPCH parameter and is equivalent to Preamble Retrans Max in RACH.
- 2) $P_{RACH} = P_{CPCH}$ = Initial open loop power level for the first CPCH access preamble sent by the UE.
 - [RACH/CPCH parameter].
- 3) ΔP_0 = Power step size for each successive CPCH access preamble.
 - [RACH/CPCH parameter].
- 4) $\Delta P_{p-m} = P_{message-control} - P_{cd}$, measured in dB. This is the power offset between the transmit power of the CD preamble and the initial transmit power of the CPCH power control preamble (or the control part of the CPCH message part if the power control preamble length is 0 slots).
 - [CPCH parameter]
- 5) T_{cpch} = CPCH transmission timing parameter: This parameter is identical to PRACH/AICH transmission timing parameter.
 - [RACH/CPCH parameter].
- 6) $L_{pc-preamble}$ = Length of power control preamble (0 or 8 slots).
 - [CPCH parameter].
- 7) $N_{Start_Message}$ = Number of frames for the transmission of Start of Message Indicator in DL-DPCCH for CPCH.
- 8) The set of Transport Format parameters. This includes a Transport Format to PCPCH mapping table.

L1 shall receive the following information from MAC prior to packet transmission:

- 1) Transport Format of the message part.
- 2) The data to be transmitted is delivered to L1 once every TTI until the data buffer is empty.

The overall CPCH -access procedure consists of two parts:

- 1) Upon receipt of a Status-REQ message from the MAC layer, the UE shall start monitoring the CSICH to determine the availability of the transport formats in the transport format subset included in the Status-REQ message. UTRAN transmits availability of each PCPCH or maximum available data rate with availability of each PCPCH over the CSICH in case CA is active. Upper layers will supply the UE with information to map the transport formats to the PCPCHs. The UE shall send a Status-CNF message to the MAC layer containing the transport format subset listing the transport formats of the requested subset which are currently indicated as "available".

The actual access procedure is then:

- 2) Upon receipt of the Access-REQ message from the MAC layer, which contains an identified transport format from the available ones, the following sequence of events occur. The use of step 2a or 2b depends on whether availability of each PCPCH or the Maximum available data rate along with the availability of each PCPCH is transmitted over CSICH. Note that in the first case, each access resource combination (AP signatures and access subchannel group) maps to each PCPCH resource and in the second case each access resource combination maps to each data rate.
- 2a) (In case CA is not Active) The UE shall test the value(s) of the most recent transmission of the CSICH Status Indicator(s) corresponding to the PCPCH channel(s) for the identified transport format included in the Access-REQ message. If this indicates that no channel is 'available' the UE shall abort the access attempt and send a failure message to the MAC layer. The UE shall also retain the availability status of the each PCPCH for further verification in a later phase.
- 2b) (In case CA is active) The CSICH Status Indicators indicate the maximum available data rate along with individual PCPCH availability. The UE shall test the value of the most recent transmission of the Status Indicator(s). If this indicates that the maximum available data rate is less than the requested data rate, the UE shall abort the access attempt and send a failure message to the MAC layer. The PHY provides the availability information to the MAC. The UE shall also retain the availability status of the each PCPCH for further channel assignment message verification in a later phase in case of success.
- 3) The UE sets the preamble transmit power to the value P_{CPCH} which is supplied by the MAC layer for initial power level for this CPCH access attempt.
- 4) The UE sets the AP Retransmission Counter to $N_{\text{AP_Retrans_Max}}$.
- 5a) In the case CA is not active, the uplink access slot and signature to be used for the CPCH-AP transmission are selected in the following steps:
 - a) The UE selects randomly one PCPCH from the set of available PCPCH channel(s) as indicated on the CSICH and supporting the identified transport format included in the Access-REQ message. The random function shall be such that each of the allowed selections is chosen with equal probability.
 - b) The UE randomly selects a CPCH-AP signature from the set of available signatures in the access resource combination corresponding to the selected PCPCH in step a). The random function shall be such that each of the allowed selections is chosen with equal probability.
 - c) Using the AP access slot sub-channel group of the access resource combination corresponding to selected PCPCH in step a), the UE derives the available CPCH-AP access slots with the help of subclauses 6.1.1 and 6.1.2. The UE randomly selects one uplink access slot from the derived available CPCH-AP access slots. If there is no access slot available in the selected set, the UE randomly selects one uplink access slot corresponding to the selected CPCH sub-channel group from the next access slot set. The random function shall be such that each of the allowed selections is chosen with equal probability.
- 5b) In the case CA is active, the uplink access slot and signature to be used for the CPCH-AP transmission are selected in the following steps:
 - a) The UE randomly selects a CPCH-AP signature from the set of available signatures in the access resource combination corresponding to the transport format identified in the Access-REQ message. The random function shall be such that each of the allowed selections is chosen with equal probability.
 - b) Using the AP access slot sub-channel group of the access resource combination corresponding to the transport format identified in the Access-REQ message, the UE derives the available CPCH-AP access slots with the help of subclauses 6.1.1 and 6.1.2. The UE randomly selects one uplink access slot from the derived available CPCH-AP access slots. If there is no access slot available in the selected set, the UE randomly selects one uplink access slot corresponding to the selected CPCH sub-channel group from the next access slot set. The random function shall be such that each of the allowed selections is chosen with equal probability.
- 6) The UE transmits the AP using the selected uplink access slot and signature, and MAC supplied initial preamble transmission power. The following sequence of events occur based on whether availability of each PCPCH or the Maximum available data rate along with the availability of each PCPCH is transmitted over CSICH.
- 6a) (In case CA is not Active) The UE shall test the value of the most recent transmission of the Status Indicator corresponding to the identified CPCH transport channel immediately before AP transmission. If this indicates that the channel is 'not available' the UE shall abort the access attempt and send a failure message to the MAC

layer. Otherwise the UE transmits the AP using the UE selected uplink signature and access slot, and the initial preamble transmission power from step 3, above.

- 6b) (In case CA is active) The Status Indicator indicates the maximum available data rate as well as the availability of each PCPCH. The UE shall test the value of the Status Indicator. If this indicates that the maximum available data rate is less than the requested data rate, the UE shall abort the access attempt and send a failure message to the MAC layer. Otherwise the UE shall transmit the AP using the UE selected uplink access slot, the MAC supplied signature and initial preamble transmission power from step 3, above.
- 7) If the UE does not detect the positive or negative acquisition indicator corresponding to the selected signature in the downlink access slot corresponding to the selected uplink access slot, the UE shall test the value of the most recent transmission of the Status Indicator corresponding to the selected PCPCH immediately before AP transmission. If this indicates that the PCPCH is 'not available' the UE shall abort the access attempt and send a failure message to the MAC layer. Otherwise the following steps shall be executed:
- a) Select the next available access slot in the sub-channel group used. There must be a minimum distance of three or four (per T_{pcch} parameter) access slots from the uplink access slot in which the last preamble was transmitted depending on the CPCH/AICH transmission timing parameter.
 - b) Increases the preamble transmission power with the specified offset ΔP . Power offset ΔP_{0s} is used.
 - c) Decrease the AP Retransmission Counter by one.
 - d) If the AP Retransmission Counter < 0 , the UE aborts the access attempt and sends a failure message to the MAC layer.
- 8) If the UE detects the AP-AICH_nak (negative acquisition indicator) corresponding to the selected signature in the downlink access slot corresponding to the selected uplink access slot, the UE aborts the access attempt and sends a failure message to the MAC layer.
- 9) Upon reception of AP-AICH_ack with matching signature, the access segment ends and the contention resolution segment begins. In this segment, the UE randomly selects a CD signature from the CD signature set and also selects one CD access slot sub-channel from the CD sub-channel group supported in the cell and transmits a CD Preamble at the same power as the last AP, then waits for a CD/CA-ICH and the channel assignment (CA) (in case CA is active) message from the Node B. The slot selection procedure is as follows:
- a) The next available slot when the PRACH and PCPCH scrambling code are not shared. Furthermore, the PCPCH AP preamble scrambling code and CD Preamble scrambling codes are different.
 - b) When the PRACH and PCPCH AP preamble scrambling code and CD preamble scrambling code are shared, the UE randomly selects one of the available access slots in the next 12 access slots. Number of CD sub-channels will be greater than 2.
- 10) If the UE does not receive a CD/CA-ICH in the designated slot, the UE aborts the access attempt and sends a failure message to the MAC layer.
- 11) If the UE receives a CD/CA-ICH in the designated slot with a signature that does not match the signature used in the CD Preamble, the UE aborts the access attempt and sends a failure message to the MAC layer.
- 12a) (In case CA is not Active) If the UE receives a CDI from the CD/CA-ICH with a matching signature, the UE transmits the power control preamble $\tau_{cd-pc-p}$ ms later as measured from initiation of the CD Preamble. The initial transmission power of the power control preamble shall be ΔP_{p-m} [dB] higher than the power of the CD preamble. The inner loop power control in the power control preamble is described in sub clause 5.1.3.3. The transmission of the message portion of the burst starts immediately after the power control preamble. Power control in the message part is described in sub clause 5.1.3.2.
- 12b) (In case CA is active) If the UE receives a CDI from the CD/CA-ICH with a matching signature and CA message that points out to one of the PCPCH's (mapping rule is in [5]) that were indicated to be free by the last received CSICH broadcast, the UE transmits the power control preamble $\tau_{cd-pc-p}$ ms later as measured from initiation of the CD Preamble. The initial transmission power of the power control preamble shall be ΔP_{p-m} [dB] higher than the power of the CD preamble. The inner loop power control in the power control preamble is described in sub clause 5.1.3.3. The transmission of the message portion of the burst starts immediately after the power control preamble. Power control in the message part is described in sub clause 5.1.3.2. If the CA message

received points out the channel that was indicated to be busy on the last status information transmission received on the CSICH, the UE shall abort the access attempt and send a failure message to the MAC layer.

NOTE: If the $L_{\text{pc-preamble}}$ parameter indicates a zero length preamble, then there is no power control preamble and the message portion of the burst starts $\tau_{\text{cd-p-pc-p}}$ ms after the initiation of the CD Preamble. In this case the initial transmission power of the control part of the message part shall be $\Delta P_{\text{p-m}}$ [dB] higher than the power of the CD preamble. Power control in the message part is described in sub clause 5.1.3.2

- 13) The UE shall test the value of Start of Message Indicator received from DL-DPCCH for CPCH during the first $N_{\text{Start_Message}}$ frames after Power Control preamble. Start of Message Indicator is a known sequence repeated on a frame by frame basis. The value of $N_{\text{Start_Message}}$ shall be provided by the higher layers.
- 14) If the UE does not detect Start of Message Indicator in the first $N_{\text{Start_Message}}$ frames of DL-DPCCH for CPCH after Power Control preamble, the UE aborts the access attempt and sends a failure message to the MAC layer. Otherwise, UE continuously transmits the packet data.
- 15) During CPCH Packet Data transmission, the UE and UTRAN perform inner-loop power control on both the CPCH UL and the DPCCH DL, as described in sub clause 5.1.3.
- 16) After the first $N_{\text{Start_Message}}$ frames after Power Control preamble, upon the detection of an Emergency Stop command sent by UTRAN, the UE halts CPCH UL transmission, aborts the access attempt and sends a failure message to the MAC layer.
- 17) If the UE detects loss of DPCCH DL during transmission of the power control preamble or the packet data, the UE halts CPCH UL transmission, aborts the access attempt and sends a failure message to the MAC layer.
- 18) The UE may send empty frames after the end of the packet to indicate the end of transmission. The number of the empty frames is set by higher layers.

7 HS-DSCH-related procedures

7.1 General procedure

Scheduling and transport format selection is controlled by the MAC-hs sublayer in the Node B [9].

The following physical layer parameters are signalled to the UE and the Node B from higher layers:

- 1) HS-SCCH set to be monitored
- 2) Repetition factor of ACK/NACK : $N_{\text{acknack_transmit}}$
- 3) Channel Quality Indicator (CQI) feedback cycle k .
- 4) CQI feedback offset l .
- 5) Repetition factor of CQI: $N_{\text{cqi_transmit}}$

UE procedure for receiving HS-DSCH:

If the UE did not detect control information intended for this UE on any of the HS-SCCHs in the HS-SCCH set in the previous subframe, the UE shall monitor all HS-SCCHs in the HS-SCCH set. If the UE did detect control information intended for this UE in the previous subframe, it is sufficient to only monitor the same HS-SCCH used in the previous subframe.

If a UE detects that one of the monitored HS-SCCHs carries control information intended for this UE, the UE shall start receiving the HS-PDSCHs indicated by this control information.

After decoding the HS-PDSCH data, the UE shall transmit an hybrid ARQ ACK or NACK as determined by the MAC-hs based on the CRC check. The UE shall repeat the transmission of the ACK/NACK information over $N_{\text{acknack_transmit}}$ consecutive HS-DPCCH sub-frames, in the slots allocated to the HARQ-ACK as defined in [1]. When $N_{\text{acknack_transmit}}$ is greater than one, the UE shall not attempt to receive nor decode transport blocks

from the HS-PDSCH in HS-DSCH sub-frames $n + 1$ to $n + (N_{acknack_transmit} - 1)$ where n is the number of the last HS-DSCH sub-frame in which a transport block has been received.

If control information is not detected on any of the HS-SCCHs in the HS-SCCH set, neither ACK, nor NACK, shall be transmitted in the corresponding subframe.

UE procedure for reporting channel quality indication (CQI):

- 1) The UE derives the CQI as defined in 7.2.1 from observations of the P-CPICH (alternatively S-CPICH in case of beamforming with S-CPICH is used).
- 2) The UE shall transmit the CQI on the HS-DPCCH sub frame which satisfies:

$$HSFN \bmod k = l$$

where HSFN is the sub frame counter version of SFN and defined as

$$HSFN = 5 * SFN + \text{HS-DPCCH sub frame}$$

- 3) The UE shall repeat the transmission of the CQI feedback information derived in 1) over $N_{cqi_transmit}$ consecutive HS-DPCCH sub frames in the slots respectively allocated to the CQI as defined in [1].
- 4) The UE shall not transmit the CQI in other subframes than those described in 2) and 3).

7.1.2 Channel quality indicator (CQI) definition

CQI reports one value at a time from the CQI report definition. CQI report definition is a table containing 32 values, each of which is defined with N parameters. These parameters shall consist of one or more of the following : [the transport block size, the coding rate, the number of HS-PDSCH codes, modulation, power offsets, $BLER_{threshold}$, P_{hs} =default power offset between HS-DSCH code channel and CPICH]

8 Closed loop mode transmit diversity

The general transmitter structure to support closed loop mode transmit diversity for DPCCH transmission is shown in figure 34. Channel coding, interleaving and spreading are done as in non-diversity mode. The spread complex valued signal is fed to both TX antenna branches, and weighted with antenna specific weight factors w_1 and w_2 . The weight factors are complex valued signals (i.e., $w_i = a_i + jb_i$), in general.

The weight factors (actually the corresponding phase adjustments in closed loop mode 1 and phase/amplitude adjustments in closed loop mode 2) are determined by the UE, and signalled to the UTRAN access point (=cell transceiver) using the D sub-field of the FBI field of uplink DPCCH.

For the closed loop mode 1 different (orthogonal) dedicated pilot symbols in the DPCCH are sent on the 2 different antennas. For closed loop mode 2 the same dedicated pilot symbols in the DPCCH are sent on both antennas.

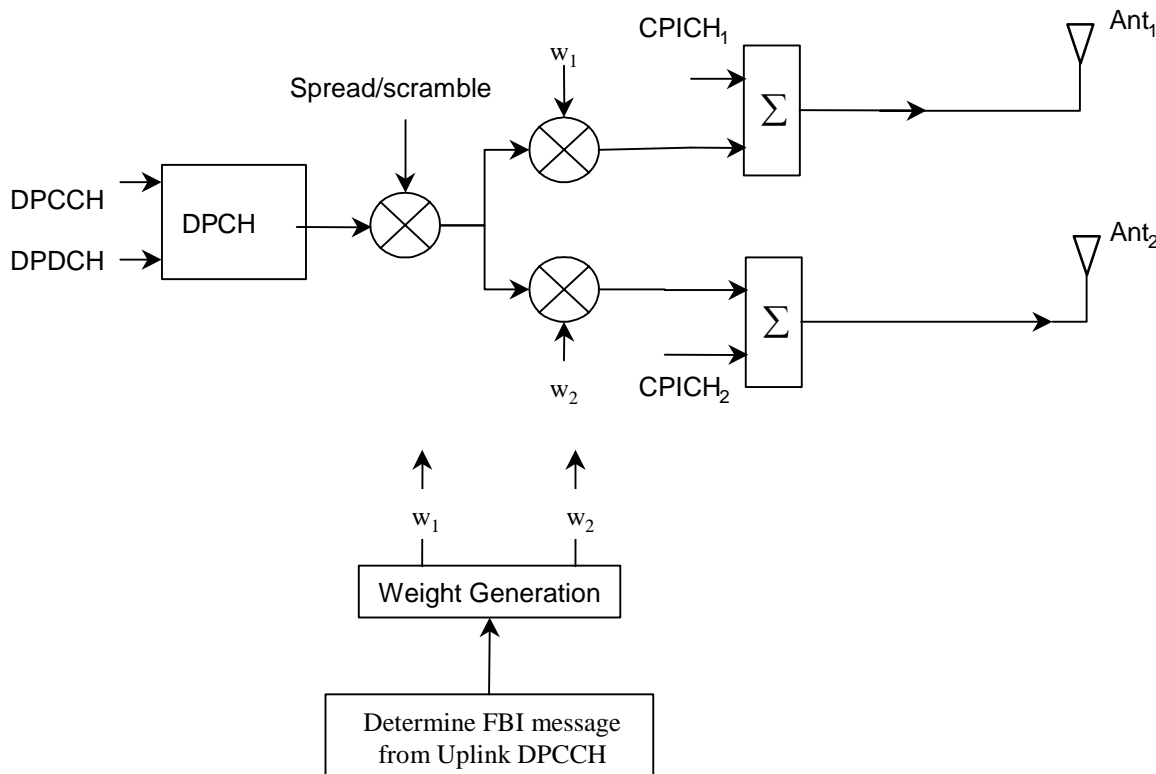


Figure 43: The generic downlink transmitter structure to support closed loop mode transmit diversity for DPCH transmission

There are two closed loop modes whose characteristics are summarised in the table 810. The use of the modes is controlled via higher layer signalling.

Table 8109: Summary of number of feedback information bits per slot, N_{FBD} , feedback command length in slots, N_W , feedback command rate, feedback bit rate, number of phase bits, N_{ph} , per signalling word, number of amplitude bits, N_{po} , per signalling word and amount of constellation rotation at UE for the two closed loop modes

Closed loop mode	N_{FBD}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}	Constellation rotation
1	1	1	1500 Hz	1500 bps	0	1	$\pi/2$
2	1	4	1500 Hz	1500 bps	1	3	N/A

87.1 Determination of feedback information

The UE uses the CPICH to separately estimate the channels seen from each antenna.

Once every slot, the UE computes the phase adjustment, ϕ , and for mode 2 the amplitude adjustment that should be applied at the UTRAN access point to maximise the UE received power. An example of how the computations can be accomplished is given in Annex A.2.

The UE feeds back to the UTRAN access point the information on which phase/power settings to use. Feedback Signalling Message (FSM) bits are transmitted in the portion of FBI field of uplink DPCCH slot(s) assigned to closed loop mode transmit diversity, the FBI D field (see [1]). Each message is of length $N_W = N_{po} + N_{ph}$ bits and its format is shown in the figure 45. The transmission order of bits is from MSB to LSB, i.e. MSB is transmitted first. FSM_{po} and FSM_{ph} subfields are used to transmit the power and phase settings, respectively.

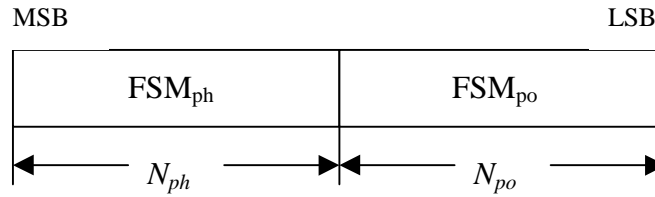


Figure 45: Format of feedback signalling message. FSM_{po} transmits the power setting and FSM_{ph} the phase setting

The adjustments are made by the UTRAN Access Point at the beginning of the downlink DPCCCH pilot field. The downlink slot in which the adjustment is done is signalled to L1 of UE by higher layers. Two possibilities exist:

- 1) When feedback command is transmitted in uplink slot i , which is transmitted approximately 1024 chips in offset from the received downlink slot j , the adjustment is done at the beginning of the pilot field of the downlink slot $(j+1) \bmod 15$.
- 2) When feedback command is transmitted in uplink slot i , which is transmitted approximately 1024 chips in offset from the received downlink slot j , the adjustment is done at the beginning of the pilot field of the downlink slot $(j+2) \bmod 15$.

Thus, adjustment timing at UTRAN Access Point is either according to 1) or 2) as controlled by the higher layers.

In case a PDSCH is associated with a DPCH for which closed-loop transmit diversity is applied, the antenna weights applied to the PDSCH are the same as the antenna weights applied to the associated DPCH. The timing of the weight adjustment of the PDSCH is such that the PDSCH weight adjustment is done at the PDSCH slot border, N chips after the adjustment of the associated DPCH, where $0 \leq N < 2560$.

87.2 Closed loop mode 1

The UE uses the CPICH transmitted both from antenna 1 and antenna 2 to calculate the phase adjustment to be applied at UTRAN access point to maximise the UE received power. In each slot, UE calculates the optimum phase adjustment, ϕ , for antenna 2, which is then quantized into ϕ_Q having two possible values as follows:

$$\phi_Q = \begin{cases} \pi, & \text{if } \pi/2 < \phi - \phi_r(i) \leq 3\pi/2 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

where:

$$\phi_r(i) = \begin{cases} 0, & i = 0,2,4,6,8,10,12,14 \\ \pi/2, & i = 1,3,5,7,9,11,13 \end{cases} \quad (2)$$

If $\phi_Q = 0$, a command '0' is sent to UTRAN using the FSM_{ph} field. Correspondingly, if $\phi_Q = \pi$, command '1' is sent to UTRAN using the FSM_{ph} field.

Due to rotation of the constellation at UE the UTRAN interprets the received commands according to table 911 which shows the mapping between phase adjustment, ϕ_i , and received feedback command for each uplink slot.

Table 911: Phase adjustments, ϕ_i , corresponding to feedback commands for the slots i of the UL radio frame

Slot #	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FSM	0	$\pi/2$	0	$\pi/2$	0	$\pi/2$	0	$\pi/2$	0	$\pi/2$	0	$\pi/2$	0	$\pi/2$	0
	1	π	$-\pi/2$	π	$-\pi/2$	π	$-\pi/2$	π	$-\pi/2$	π	$-\pi/2$	π	$-\pi/2$	π	$-\pi/2$

The weight w_2 is then calculated by averaging the received phases over 2 consecutive slots. Algorithmically, w_2 is calculated as follows:

$$w_2 = \frac{\sum_{i=n-1}^n \cos(\phi_i)}{2} + j \frac{\sum_{i=n-1}^n \sin(\phi_i)}{2} \quad (3)$$

where:

$$\phi_i \in \{0, \pi, \pi / 2, -\pi / 2\} \quad (4)$$

For antenna 1, w_1 is constant:

$$w_1 = 1/\sqrt{2} \quad (5)$$

87.2.1 Mode 1 end of frame adjustment

In closed loop mode 1 at frame borders the averaging operation is slightly modified. Upon reception of the FB command for slot 0 of a frame, the average is calculated based on the command for slot 13 of the previous frame and the command for slot 0 of the current frame, i.e. ϕ_i from slot 14 is not used:

$$w_2 = \frac{\cos(\phi_{13}^{j-1}) + \cos(\phi_0^j)}{2} + j \frac{\sin(\phi_{13}^{j-1}) + \sin(\phi_0^j)}{2} \quad (6)$$

where:

- ϕ_{13}^{j-1} = phase adjustment from frame j-1, slot 13.
- ϕ_0^j = phase adjustment from frame j, slot 0.

87.2.2 Mode 1 normal initialisation

For the first frame of transmission UE determines the feedback commands in a normal way and sends them to UTRAN.

Before the first FB command is received, the UTRAN shall use the initial weight $w_2 = \frac{1}{2}(1 + j)$.

Having received the first FB command the UTRAN calculates w_2 as follows:

$$w_2 = \frac{\cos(\pi / 2) + \cos(\phi_0)}{2} + j \frac{\sin(\pi / 2) + \sin(\phi_0)}{2} \quad (7)$$

where:

ϕ_0 = phase adjustment from slot 0 of the first frame.

87.2.3 Mode 1 operation during compressed mode

87.2.3.1 Downlink in compressed mode and uplink in normal mode

When downlink is in compressed mode but uplink is operating normally (i.e. not compressed) the UTRAN continues its Tx diversity related functions in the same way as in non-compressed downlink mode.

In downlink transmission gaps there are uplink slots for which no new estimate of the phase adjustment is calculated. During these slots the following rules are applied in UE when determining the feedback command:

- 1) If no new estimate of phase adjustment ϕ_i exists corresponding to the feedback command to be sent in uplink slot i :

- If $1 < i < 15$:
 - the feedback command sent in uplink slot $i-2$ is used;
 - else if $i = 0$:
 - the feedback command sent in uplink slot 14 of previous frame is used;
 - else if $i = 1$:
 - the feedback command sent in uplink slot 13 of previous frame is used;
 - end if.
- 2) When transmission in downlink is started again in downlink slot $N_{\text{last}+1}$ (if $N_{\text{last}+1} = 15$, then slot 0 in the next frame) the UE must resume calculating new estimates of the phase adjustment. The feedback command corresponding to the first new estimate of ϕ_i must be sent in the uplink slot which is transmitted approximately 1024 chips in offset from the downlink slot $N_{\text{last}+1}$.

87.2.3.2 Both downlink and uplink in compressed mode

During the uplink transmission gaps no FB commands are sent from UE to UTRAN. When transmission in downlink is started again in downlink slot $N_{\text{last}+1}$ (if $N_{\text{last}+1} = 15$, then slot 0 in the next frame) the UE must resume calculating new estimates of the phase adjustment. The feedback command corresponding to the first new estimate of ϕ_i must be sent in the uplink slot which is transmitted approximately 1024 chips in offset from the downlink slot $N_{\text{last}+1}$.

The UTRAN continues to update the weight w_2 until the uplink transmission gap starts and no more FB commands are received. When the transmission in downlink resumes in slot $N_{\text{last}+1}$, the value of w_2 , calculated after receiving the last FB command before the start of the uplink transmission gap, is applied to antenna 2 signal.

After the UE resumes transmission in uplink and sends the first FB command, the new value of w_2 is calculated as follows:

- $S_1 = \{0, 2, 4, 6, 8, 10, 12, 14\}$.
- $S_2 = \{1, 3, 5, 7, 9, 11, 13\}$.
- i = number of uplink slot at which the transmission resumes.
- j = number of uplink slot at which the last FB command was sent before the start of the uplink transmission gap.
- Do while ($i \in S_1$ and $j \in S_1$) or ($i \in S_2$ and $j \in S_2$):
 - $j = j-1$;
 - if $j < 0$;
 - $j = 14$;
- end if;
- end do;
- calculate w_2 based on FB commands received in uplink slots i and j .

Note that for $N_{\text{last}} = 13$ the end of frame adjustment procedure shall be based on the FB commands for the last odd slot prior to the uplink transmission gap and slot 0.

87.2.3.3 Uplink in compressed mode and downlink in normal mode

The UTRAN continues to update the value of w_2 until the uplink transmission gap starts and no more FB commands are received. Then, the value of w_2 calculated after receiving the last FB command before the uplink transmission gap is applied to the antenna 2 signal. When the UE resumes transmission in uplink, it shall send FB commands according to section 87.2 equations 2 and 3 (normal operation) and the UTRAN Access Point shall interpret the FB commands according to Table 9.

The calculation of w_2 by the UTRAN following the uplink transmission gap, and before the first two FB commands following the gap are received is not specified.

87.2.4 Mode 1 initialisation during compressed mode

87.2.4.1 Downlink in compressed mode

When closed loop mode 1 is initialised during the downlink transmission gap of compressed mode there are slots for which no estimate of the phase adjustment is calculated and no previous feedback command is available.

In this case, if the UE is required to send feedback in the uplink, the FB command to the UTRAN shall be '0'.

When transmission in downlink is started again in slot $N_{\text{last}}+1$ (if $N_{\text{last}}+1 = 15$, then slot 0 in the next frame), the

UTRAN shall use the initial weight $w_2 = \frac{1}{2}(1 + j)$. The UE must start calculating estimates of the phase adjustment.

The feedback command corresponding to the first estimate of ϕ_i must be sent in the uplink slot which is transmitted approximately 1024 chips in offset from the downlink slot $N_{\text{last}}+1$. Having received this feedback command the UTRAN calculates w_2 as follows:

$$w_2 = \frac{\cos(\phi_i) + \cos(\phi_j)}{2} + j \frac{\sin(\phi_i) + \sin(\phi_j)}{2} \quad (8)$$

where:

ϕ_i = phase adjustment in uplink slot i , which is transmitted approximately 1024 chips in offset from the downlink slot $N_{\text{last}}+1$.

$$\phi_j = \frac{\pi}{2}, \text{ if slot } i \text{ is even } (i \in \{0, 2, 4, 6, 8, 10, 12, 14\}) \text{ and}$$

$$\phi_j = 0, \text{ if slot } i \text{ is odd } (i \in \{1, 3, 5, 7, 9, 11, 13\})$$

87.2.4.2 Uplink in compressed mode

Initialisation of closed loop mode 1 operation during uplink compressed mode only is not specified.

87.3 Closed loop mode 2

In closed loop mode 2 there are 16 possible combinations of phase and power adjustment from which the UE selects and transmits the FSM according to table 120 and table 134. As opposed to closed loop Mode 1, no constellation rotation is done at UE and no filtering of the received weights is performed at the UTRAN.

Table 42110: FSM_{po} subfield of closed loop mode 2 signalling message

FSM _{po}	Power_ant1	Power_ant2
0	0.2	0.8
1	0.8	0.2

Table 13.12.1: FSM_{ph} subfield of closed loop mode 2 signalling message

FSM _{ph}	Phase difference between antennas (radians)
000	π
001	$-3\pi/4$
011	$-\pi/2$
010	$-\pi/4$
110	0
111	$\pi/4$
101	$\pi/2$
100	$3\pi/4$

To obtain the best performance, progressive updating is performed at both the UE and the UTRAN Access point. The UE procedure shown below is an example of how to determine FSM at UE. Different implementation is allowed. Every slot time, the UE may refine its choice of FSM, from the set of weights allowed given the previously transmitted bits of the FSM. This is shown in figure 56, where, in this figure b_i ($0 \leq i \leq 3$) are the bits of the FSM (from table 10 and table 11) from the MSB to the LSB and $m=0, 1, 2, 3$ (the end of frame adjustment given in subclause 87.3.1 is not shown here).

At the beginning of a FSM to be transmitted, the UE chooses the best FSM out of the 16 possibilities. Then the UE starts sending the FSM bits from the MSB to the LSB in the portion of FBI field of the uplink DPCCH during 4 (FSM message length) slots. Within the transmission of the FSM the UE refines its choice of FSM. This is defined in the following:

- define the 4 bits of FSM, which are transmitted from slot number k to $k+3$, as $\{b_3(k) b_2(k+1) b_1(k+2) b_0(k+3)\}$, where $k=0, 4, 8, 12$. Define also the estimated received power criteria defined in Equation 1 for a given FSM as $P(\{x_3, x_2, x_1, x_0\})$, where $\{x_3, x_2, x_1, x_0\}$ is one of the 16 possible FSMs which defines an applied phase and power offset according to table 10 and table 11. The $b_i()$ and x_i are 0 or 1.

The bits transmitted during the m 'th FSM of the frame, where $m=0,1,2,3$, are then given by:

$b_3(4m)=X_3$ from the $\{X_3, X_2, X_1, X_0\}$ which maximises $P(\{x_3, x_2, x_1, x_0\})$ over all x_3, x_2, x_1, x_0 (16 possible combinations);

$b_2(4m+1)=X_2$ from the $\{b_3(4m), X_2, X_1, X_0\}$ which maximises $P(\{b_3(4m), x_2, x_1, x_0\})$ over all x_2, x_1, x_0 (8 possible combinations);

$b_1(4m+2)=X_1$ from the $\{b_3(4m), b_2(4m+1), X_1, X_0\}$ which maximises $P(\{b_3(4m), b_2(4m+1), x_1, x_0\})$ over all x_1, x_0 (4 possible combinations);

$b_0(4m+3)=X_0$ from the $\{b_3(4m), b_2(4m+1), b_1(4m+2), X_0\}$ which maximises $P(\{b_3(4m), b_2(4m+1), b_1(4m+2), x_0\})$ over x_0 (2 possible combinations).

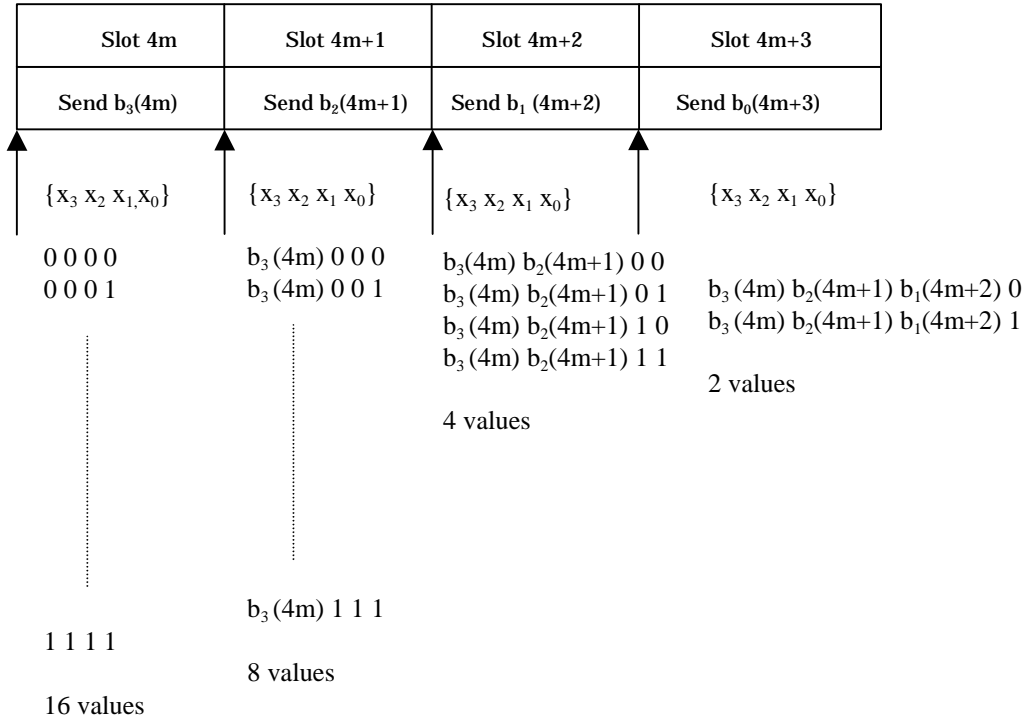


Figure 56: Progressive Refinement at the UE for closed loop mode 2

Every slot time the UTRAN constructs the FSM from the most recently received bits for each position in the word and applies the phase and amplitude (derived from power) as defined by table 10 and table 11. More precisely, the UTRAN operation can be explained as follows. The UTRAN maintains a register $\mathbf{z}=\{z_3 z_2 z_1 z_0\}$, which is updated every slot time according to $z_i=b_i(ns)$ ($i=0:3, ns=0:14$). Every slot time the contents of register \mathbf{z} are used to determine the phase and power adjustments as defined by table 10 and table 11, with $FSM_{ph}=\{z_3 z_2 z_1\}$ and $FSM_{po}=z_0$.

Special procedures for initialisation and end of frame processing are described below.

The weight vector, \underline{w} , is then calculated as:

$$\underline{w} = \begin{bmatrix} \sqrt{power_ant1} \\ \sqrt{power_ant2} \exp(j \text{ phase_diff}) \end{bmatrix} \tag{9}$$

87.3.1 Mode 2 end of frame adjustment

The FSM must be wholly contained within a frame. To achieve this an adjustment is made to the last FSM in the frame where the UE only sends the FSM_{ph} subfield, and the UTRAN takes the power bit FSM_{po} of the previous FSM.

87.3.2 Mode 2 normal initialisation

For the first frame of transmission using closed loop mode 2, the operation is as follows.

The UE starts sending the FSM message from slot 0 in the normal way. The UE may refine its choice of FSM in slots 1 to 3 from the set of weights allowed given the previously transmitted bits of the FSM.

The UTRAN Access Point operation is as follows. Until the first FSM_{po} bit is received and acted upon (depending on the timing control specified via the higher layer parameter described in section 7.1) the power in both antennas shall be set to 0.5. Until the first FSM_{ph} bit is received and acted upon the phase difference between antennas shall be π radians.

The phase offset applied between the antennas is updated according to the number and value of FSM_{ph} bits received as given in table 142.

Table 14213: FSM_{ph} normal initialisation for closed loop mode 2

FSM _{ph}	Phase difference between antennas (radians)
---	π (normal initialisation) or held from previous setting (compressed mode recovery)
0--	π
1--	0
00-	π
01-	$-\pi/2$
11-	0
10-	$\pi/2$
000	π
001	$-3\pi/4$
011	$-\pi/2$
010	$-\pi/4$
110	0
111	$\pi/4$
101	$\pi/2$
100	$3\pi/4$

This operation applies in both the soft handover and non soft handover cases.

87.3.3 Mode 2 operation during compressed mode

87.3.3.1 Downlink in compressed mode and uplink in normal mode

When the downlink is in compressed mode and the uplink is in normal mode, the closed loop mode 2 functions are described below.

When the UE is not listening to the CPICH from antennas 1 and 2 during the downlink transmission gap, the UE sends the last FSM bits calculated before the start of the downlink transmission gap.

Recovery from compressed mode is described in the following. Downlink transmissions commence at the pilot field of slot N_{last} as described in [2].

After a transmission gap, UTRAN Access Point sets the power in both antennas to 0.5 until a FSM_{po} bit is received and acted upon. Until the first FSM_{ph} bit is received and acted upon, UTRAN uses the phase offset, which was applied before the transmission interruption (table 142).

If the uplink slot N_{last}+1 (modulo 15) occurs at the beginning of a FSM period (that is at slot 0,4,8,or 12), the UE sends the FSM message in the normal way, with 3 FSM_{ph} bits and with the FSM_{po} bit on slot 3, 7 or 11, and the UTRAN Access Point acts on the FSM_{ph} bits according to table 142.

If the uplink slot N_{last}+1 (modulo 15) does not occur at the beginning of a FSM period, the following operation is performed. In each of the remaining slots of the partial FSM period, that is from slot N_{last}+1 (modulo 15) until the final slot (slot 3, 7, 11 or 14), and for the first slot of the next full FSM period, the UE sends the first (i.e. MSB) bit of the FSM_{ph} message, and at the UTRAN access point the phase offset applied between the antennas is updated according to the number and value of FSM_{ph} bits received as given in table 135. During the following full FSM period, which starts on slot 0, 4, 8, or 12, the UE sends the FSM message in the normal way, with 3 FSM_{ph} bits and with the FSM_{po} bit on slot 3, 7 or 11, and the UTRAN Access Point acts on the FSM_{ph} bits according to table 142.

Table 15143: FSM_{ph} subfield of closed loop mode 2 in compressed mode recovery period

FSM _{ph}	Phase difference between antennas (radians)
-	held from previous setting
0	π
1	0

87.3.3.2 Both downlink and uplink in compressed mode

During both downlink and uplink compressed mode, the UTRAN and the UE performs the functions of recovery after transmission gaps as described in the previous subclause 87.3.3.1.

87.3.3.3 Uplink in compressed mode and downlink in normal mode

The UTRAN continues to update the weight vector w until the uplink transmission gap starts and no more FSM bits are received. Then, UTRAN Access Point continues to apply the weight vector w , which was used before the transmission gap. When the UE resumes transmission in uplink, it chooses FSM according to normal operation as described in section 87.3 and 87.3.1. If the uplink signalling does not resume at the beginning of a FSM period, the UE shall calculate the remaining FSM bits according to section 87.3, using the last FSM(s) sent before the uplink gap as the "previously transmitted bits of the FSM".

The calculation of the phase adjustment by UTRAN remains unspecified until all 3 FSM_{ph} bits have been received following the uplink transmission gap. The calculation of the power adjustment by UTRAN remains unspecified until an FSM_{po} bit has been received following the uplink transmission gap.

87.3.4 Mode 2 initialisation during compressed mode

87.3.4.1 Downlink in compressed mode

When closed loop mode 2 is initialised during the downlink transmission gap of compressed mode there are slots for which no FSM bit is calculated and no previous sent FSM bit is available.

In this case, if the UE is required to send feedback in the uplink, the FB command to the UTRAN shall be '0'.

The UTRAN and the UE perform the functions of recovery after the downlink transmission gap as described in the previous subclause 87.3.3.1. If no previous phase setting is available, UTRAN shall use the phase offset π , until the first FSM_{ph} bit is received and acted upon.

87.3.4.2 Uplink in compressed mode

Initialisation of closed loop mode 2 operation during uplink compressed mode only is not specified.

98 Idle periods for IPDL location method

98.1 General

To support time difference measurements for location services, idle periods can be created in the downlink (hence the name IPDL) during which time transmission of all channels from a Node B is temporarily seized. During these idle periods the visibility of neighbour cells from the UE is improved.

The idle periods are arranged in a predetermined pseudo random fashion according to higher layer parameters. Idle periods differ from compressed mode in that they are shorter in duration, all channels are silent simultaneously, and no attempt is made to prevent data loss.

In general there are two modes for these idle periods:

- Continuous mode, and
- Burst mode.

In continuous mode the idle periods are active all the time. In burst mode the idle periods are arranged in bursts where each burst contains enough idle periods to allow a UE to make sufficient measurements for its location to be calculated. The bursts are separated by a period where no idle periods occur.

98.2 Parameters of IPDL

The following parameters are signalled to the UE via higher layers:

- IP_Status:** This is a logic value that indicates if the idle periods are arranged in continuous or burst mode.
- IP_Spacing:** The number of 10 ms radio frames between the start of a radio frame that contains an idle period and the next radio frame that contains an idle period. Note that there is at most one idle period in a radio frame.
- IP_Length:** The length of the idle periods, expressed in symbols of the CPICH.
- IP_Offset:** A cell specific offset that can be used to synchronise idle periods from different sectors within a Node B.
- Seed:** Seed for the pseudo random number generator.

Additionally in the case of burst mode operation the following parameters are also communicated to the UE.

- Burst_Start:** Specifies the start of the first burst of idle periods. $256 \times \text{Burst_Start}$ is the SFN where the first burst of idle periods starts.
- Burst_Length:** The number of idle periods in a burst of idle periods.
- Burst_Freq:** Specifies the time between the start of a burst and the start of the next burst. $256 \times \text{Burst_Freq}$ is the number of radio frames of the primary CPICH between the start of a burst and the start of the next burst.

98.3 Calculation of idle period position

In burst mode, burst #0 starts in the radio frame with $\text{SFN} = 256 \times \text{Burst_Start}$. Burst # k starts in the radio frame with $\text{SFN} = 256 \times \text{Burst_Start} + k \times 256 \times \text{Burst_Freq}$ ($k = 0, 1, 2, \dots$). The sequence of bursts according to this formula continues up to and including the radio frame with $\text{SFN} = 4095$. At the start of the radio frame with $\text{SFN} = 0$, the burst sequence is terminated (no idle periods are generated) and at $\text{SFN} = 256 \times \text{Burst_Start}$ the burst sequence is restarted with burst #0 followed by burst #1 etc., as described above.

Continuous mode is equivalent to burst mode, with only one burst spanning the whole SFN cycle of 4096 radio frames, this burst starting in the radio frame with $\text{SFN} = 0$.

Assume that $\text{IP_Position}(x)$ is the position of idle period number x within a burst, where $x = 1, 2, \dots$, and $\text{IP_Position}(x)$ is measured in number of CPICH symbols from the start of the first radio frame of the burst.

The positions of the idle periods within each burst are then given by the following equation:

$$\text{IP_Position}(x) = (x \times \text{IP_Spacing} \times 150) + (\text{rand}(x \text{ modulo } 64) \text{ modulo } (150 - \text{IP_Length})) + \text{IP_Offset};$$

where $\text{rand}(m)$ is a pseudo random generator defined as follows:

$$\text{rand}(0) = \text{Seed};$$

$$\text{rand}(m) = (106 \times \text{rand}(m - 1) + 1283) \text{ modulo } 6075, m = 1, 2, 3, \dots$$

Note that x is reset to $x = 1$ for the first idle period in every burst.

Figure 67 below illustrates the idle periods for the burst mode case.

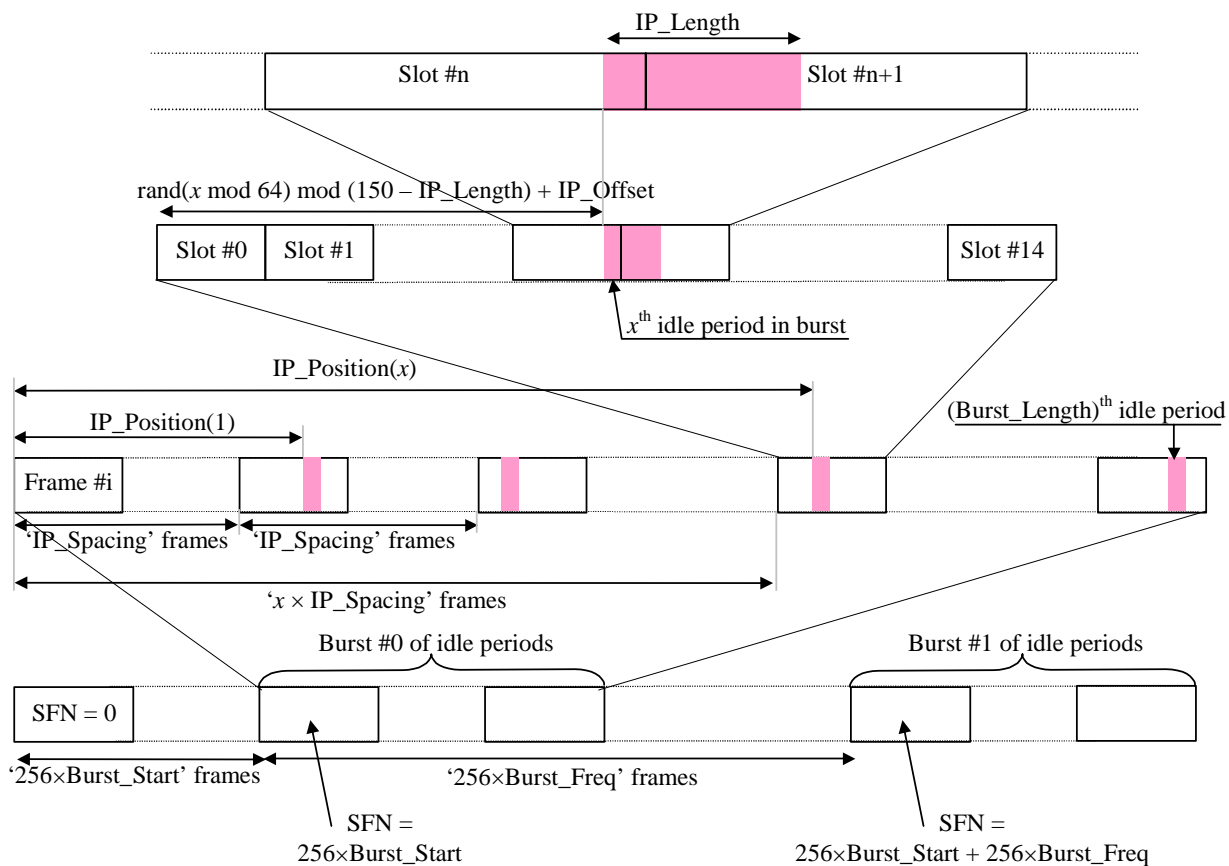


Figure 67: Idle Period placement in the case of burst mode operation

Annex A (informative):

A.1 Antenna verification

In closed loop mode 1, if channel estimates are taken from the Primary CPICH, the performance will also suffer if the UE can not detect errors since the channel estimates will be taken for the incorrect phase settings. To mitigate this problem, antenna verification can be done, which can make use of antenna specific pilot patterns of the dedicated physical channel. The antenna verification can be implemented with several different algorithms. A straightforward algorithm can use a 4-hypothesis test per slot. Alternatively, a simplified beam former verification (SBV) requiring only a 2-hypothesis test per slot can be used. If we have orthogonal pilot patterns on the downlink DPCCH we can apply the SBV as follows:

Consider:

$$2 \sum_{i=1}^{N_{path}} \frac{1}{\sigma_i^2} \left\{ \sqrt{2} \operatorname{Re}(\gamma h_{2,i}^{(d)} h_{2,i}^{(p)*}) \right\} > \ln \left(\frac{\bar{p}(\phi_{Rx} = \pi)}{\bar{p}(\phi_{Rx} = 0)} \right)$$

then define the variable x_0 as, $x_0 = 0$ if the above inequality holds good and $x_0 = \pi$ otherwise.

Similarly consider:

$$-2 \sum_{i=1}^{N_{path}} \frac{1}{\sigma_i^2} \left\{ \sqrt{2} \operatorname{Im}(\gamma h_{2,i}^{(d)} h_{2,i}^{(p)*}) \right\} > \ln \left(\frac{\bar{p}(\phi_{Rx} = -\pi/2)}{\bar{p}(\phi_{Rx} = \pi/2)} \right)$$

then define the variable x_1 as, $x_1 = -\pi/2$ if the above inequality holds good and $x_1 = \pi/2$ otherwise.

Whether x_0 or x_1 is to be calculated for each slot is given by the following table:

Slot	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	x_0	x_1	x_0	x_1	x_0	x_1	x_0	x_1	x_0	x_1	x_0	x_1	x_0	x_1	x_0

The estimate for the transmitted phase is now obtained as:

$$\sin(\phi_{Tx}) + j \cos(\phi_{Tx}) = \frac{\sum_{i=0}^1 \sin(x_i)}{\sqrt{2}} + j \frac{\sum_{i=0}^1 \cos(x_i)}{\sqrt{2}}$$

where:

- the x_i values are used corresponding to the current slot and the next slot, except in the case of slot 14 wherein the slot 14 and slot 1 of the next frame values are used;
- $h_{2,i}^{(p)}$ is the i 'th estimated channel tap of antenna 2 using the CPICH;
- $h_{2,i}^{(d)}$ is the i 'th estimated channel tap of antenna 2 using the DPCCH;
- γ^2 is the DPCH Pilot SNIR/ CPICH SNIR;
- σ_i^2 is the noise plus interference power on the i 'th path.

In normal operation the *a priori* probability for selected pilot pattern is assumed to be 96% (assuming there are 4% of errors in the feedback channel for power control and antenna selection).

A.2 Computation of feedback information for closed loop transmit diversity

In non-soft handover case, the computation of feedback information can be accomplished by e.g. solving for weight vector, \underline{w} , that maximises.

$$P = \underline{w}^H H^H H \underline{w} \quad (1)$$

where

$$H = [\underline{h}_1 \ \underline{h}_2] \text{ and } \underline{w} = [w_1, w_2]^T$$

and where the column vectors \underline{h}_1 and \underline{h}_2 represent the estimated channel impulse responses for the transmission antennas 1 and 2, of length equal to the length of the channel impulse response. The elements of \underline{w} correspond to the adjustments computed by the UE.

During soft handover, the antenna weight vector, \underline{w} can be, for example, determined so as to maximise the criteria function:

$$P = \underline{w}^H (H_1^H H_1 + H_2^H H_2 + \dots) \underline{w} \quad (2)$$

where H_i is an estimated channel impulse response for BS#i. In regular SHO, the set of BS#i corresponds to the active set.

Annex B (Informative): Downlink power control

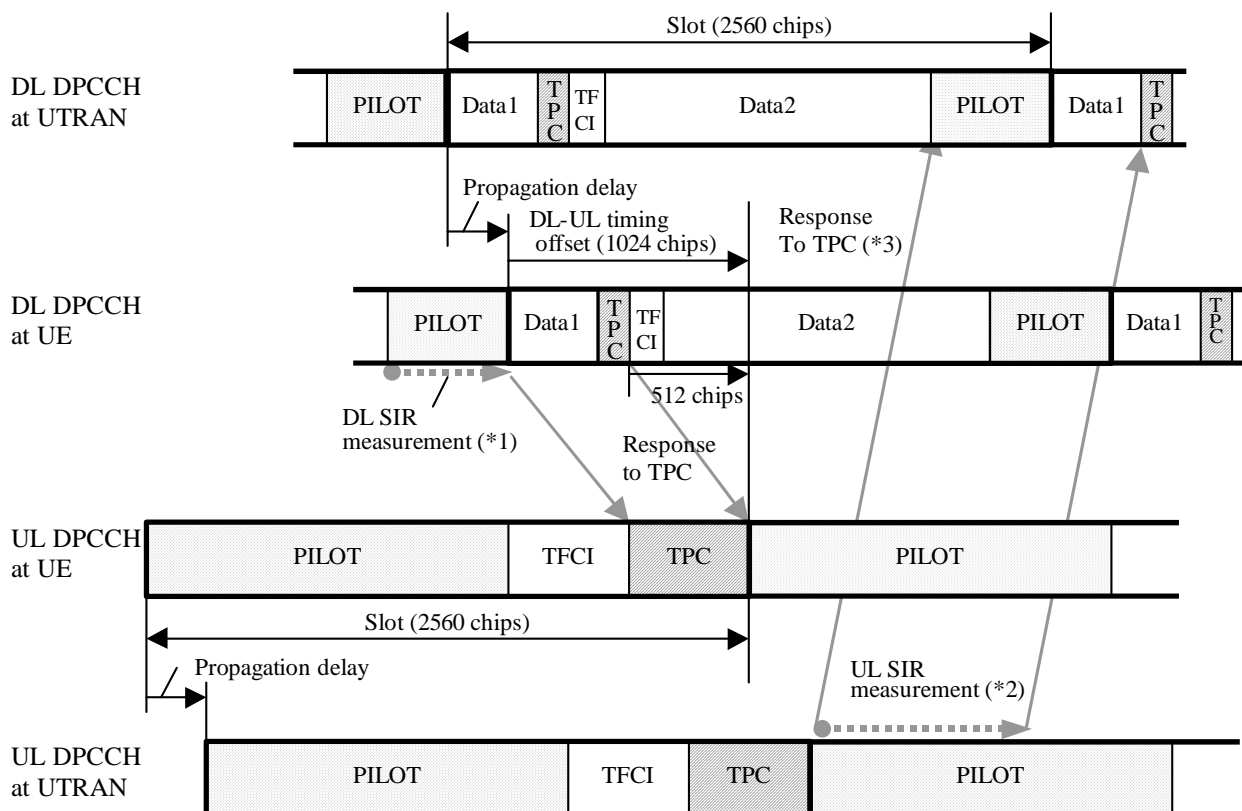
B.1 Power control timing

The power control timing described in this annex should be seen as an example on how the control bits have to be placed in order to permit a short TPC delay.

In order to maximise the cell radius distance within which one-slot control delay is achieved, the frame timing of an uplink DPCH is delayed by 1024 chips from that of the corresponding downlink DPCH measured at the UE antenna.

Responding to a downlink TPC command, the UE shall change its uplink DPCH output power at the beginning of the first uplink pilot field after the TPC command reception. Responding to an uplink TPC command, the UTRAN access point shall change its DPCH output power at the beginning of the next downlink pilot field after the reception of the whole TPC command. Note that in soft handover, the TPC command is sent over one slot when DPC_MODE is 0 and over three slots when DPC_MODE is 1. Note also that the delay from the uplink TPC command reception to the power change timing is not specified for UTRAN. The UE shall decide and send TPC commands on the uplink based on the downlink SIR measurement. The TPC command field on the uplink starts, when measured at the UE antenna, 512 chips after the end of the downlink pilot field. The UTRAN access point shall decide and send TPC commands based on the uplink SIR measurement. However, the SIR measurement periods are not specified either for UE nor UTRAN.

Figure B.1 illustrates an example of transmitter power control timings.



- 1,2 The SIR measurement periods illustrated here are examples. Other ways of measurement are allowed to achieve accurate SIR estimation.
- 3 If there is not enough time for UTRAN to respond to the TPC, the action can be delayed until the next slot.

Figure B.1: Transmitter power control timing

B.2 Example of implementation in the UE

The downlink inner-loop power control adjusts the network transmit power in order to keep the received downlink SIR at a given SIR target, SIR_{target} . A higher layer outer loop adjusts SIR_{target} independently for each connection.

The UE should estimate the received downlink DPCCH/DPDCH power of the connection to be power controlled. Simultaneously, the UE should estimate the received interference and calculate the signal-to-interference ratio, SIR_{est} . SIR_{est} can be calculated as $RSCP/ISCP$, where RSCP refers to the received signal code power on one code and ISCP refers to the non-orthogonal interference signal code power of the received signal on one code. Note that due to the specific SIR target offsets described in [5] that can be applied during compressed frames, the spreading factor shall not be considered in the calculation of SIR_{est} .

The obtained SIR estimate SIR_{est} is then used by the UE to generate TPC commands according to the following rule: if $SIR_{est} > SIR_{target}$ then the TPC command to transmit is "0", requesting a transmit power decrease, while if $SIR_{est} < SIR_{target}$ then the TPC command to transmit is "1", requesting a transmit power increase.

When the UE is in soft handover and SSDT is not activated, the UE should estimate SIR_{est} from the downlink signals of all cells in the active set.

When SSDT is activated, the UE should estimate SIR_{est} from the downlink signals of the primary cell. If the state of the cells (primary or non-primary) in the active set is changed and the UE sends the last portion of the coded ID in uplink slot j , the UE should change the basis for the estimation of SIR_{est} at the beginning of downlink slot $(j+1+T_{os}) \bmod 15$, where T_{os} is defined as a constant of 2 time slots.

Annex C (Informative): Cell search procedure

During the cell search, the UE searches for a cell and determines the downlink scrambling code and frame synchronisation of that cell. The cell search is typically carried out in three steps:

Step 1: Slot synchronisation

During the first step of the cell search procedure the UE uses the SCH's primary synchronisation code to acquire slot synchronisation to a cell. This is typically done with a single matched filter (or any similar device) matched to the primary synchronisation code which is common to all cells. The slot timing of the cell can be obtained by detecting peaks in the matched filter output.

Step 2: Frame synchronisation and code-group identification

During the second step of the cell search procedure, the UE uses the SCH's secondary synchronisation code to find frame synchronisation and identify the code group of the cell found in the first step. This is done by correlating the received signal with all possible secondary synchronisation code sequences, and identifying the maximum correlation value. Since the cyclic shifts of the sequences are unique the code group as well as the frame synchronisation is determined.

Step 3: Scrambling-code identification

During the third and last step of the cell search procedure, the UE determines the exact primary scrambling code used by the found cell. The primary scrambling code is typically identified through symbol-by-symbol correlation over the CPICH with all codes within the code group identified in the second step. After the primary scrambling code has been identified, the Primary CCPCH can be detected. And the system- and cell specific BCH information can be read.

If the UE has received information about which scrambling codes to search for, steps 2 and 3 above can be simplified.

Annex D (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
	RAN_05	RP-99531	-		Approved at TSG RAN #5 and placed under Change Control	-	3.0.0
14/01/00	RAN_06	RP-99686	003	2	Flexible timing of UTRAN response to uplink closed loop Tx diversity feedback commands	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	006	2	CPCH power control preamble length	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	007	-	Removal of open loop power control	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	008	-	Power offset of AICH and PICH	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	009	1	Update of Random Access Procedure	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	010	1	oft symbol combining for uplink power control	3.0.0	3.1.0
14/01/00	RAN_06	RP-99685	011	-	Clarification of closed loop transmit diversity figure in clause 8 and closed loop operation in compressed mode for mode 2 in subclause 8.3 of TS 25.214	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	012	-	Uplink power control maximum TX power	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	013	1	Setting of beta values for multi-code	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	014	-	Consolidation of CPCH Power Control Preamble Information	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	015	1	Consolidation of Power Control Information for DCH Initialisation	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	016	-	Uplink power control in compressed mode	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	018	1	Timing for initialisation procedures	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	021	-	20 ms RACH message length	3.0.0	3.1.0
14/01/00	RAN_06	RP-99684	023	1	Maximum Tx Power at uplink compressed Mode	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	024	2	Setting of power in uplink compressed mode	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	025	-	Cleanup of synchronisation procedures	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	026	2	Downlink power control	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	029	-	Out-of-synch handling	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	030	2	State update rule addition to SSDT specification	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	033	-	Uplink TX timing adjustment	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	036	-	Inclusion of idle periods for the IPDL LCS	3.0.0	3.1.0
14/01/00	RAN_06	RP-99686	041	-	Revision of power control timing text	3.0.0	3.1.0
14/01/00	RAN_06	RP-99687	042	1	Inclusion of adjustment loop in downlink power control	3.0.0	3.1.0
14/01/00	-	-	-	-	Change history was added by the editor	3.1.0	3.1.1
31/03/00	RAN_07	RP-000064	043	1	Optimum ID Codes for SSSD Power Control	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	044	-	Editorial clarification to subclause 5.1.2.2.2	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	047	1	Additional description of TX diversity for PDSCH	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	048	-	Power offset on S-CCPCH	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	050	2	Corrections to uplink power control	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	055	-	Correction of Adjustment loop description	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	056	1	Clarification of TPC command combining for Algorithm 1	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	057	-	Clarification of TPC command combining for Algorithm 2	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	059	2	CPCH:CD subslot-related additions to 6.2	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	061	1	CPCH: editorial changes and clarifications of 6.2	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	062	-	Editorial corrections	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	064	1	Editorial improvement of the IPDL section	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	065	1	PRACH power offset definition	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	066	1	Radio link synchronisation in UTRA/FDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	068	-	Definition for maximum and minimum DL power	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	069	4	Channel assignment and UE channel selection methods of CPCH	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	071	-	Channelization code allocation method for PCPCH message part	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	072	1	Limited power raise used -parameter in DL PC	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	080	-	Downlink power control	3.1.1	3.2.0
31/03/00	RAN_07	RP-000064	081	-	Editorial improvement on SSSD power control section	3.1.1	3.2.0
31/03/00	RAN_07	RP-000065	082	2	Emergency Stop of CPCH transmission and Start of Message Indicator	3.1.1	3.2.0
31/03/00	RAN_07	RP-000065	083	-	Clean up of USTS related specifications	3.1.1	3.2.0
26/06/00	RAN_08	RP-000268	084	-	Addition of CSICH power parameter	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	085	-	Correction to power control in compressed mode recovery period	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	086	1	Revisions to power control for CPCH	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	087	-	Corrections to uplink DCH power control sections	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	090	3	Level of specification of downlink power control	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	091	1	Clarification of TX diversity power setting	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	092	-	PICH undefined bits	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	095	1	DPDCH/DPCCH gain factors	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	096	3	Correction to RACH subchannel definition	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	097	1	The power setting of the CCC field of DL DPCCH for CPCH	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	098	4	Procedure for end of transmission indicator in CPCH	3.2.0	3.3.0

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
26/06/00	RAN_08	RP-000268	099	-	Downlink inner-loop power control in compressed mode	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	100	-	Definition of vector transmission weight entity	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	101	1	Number of slots for DPCCCH power control preamble	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	102	-	Clarification of UTRAN Tx diversity reponse timing description in 25.214	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	103	2	Corrections to transmit diversity section	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	104	1	Corrections to uplink power control in compressed mode	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	105	-	Clarification of downlink power control mode	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	106	-	Clarification of radio link set	3.2.0	3.3.0
26/06/00	RAN_08	RP-000268	107	1	Clarification of radio link synchronisation procedure	3.2.0	3.3.0
26/06/00	RAN_08	RP-000269	108	-	Correctly quantized gainfactors for uplink compressed mode	3.2.0	3.3.0
23/09/00	RAN_09	RP-000342	110	4	Downlink inner-loop power control in compressed mode	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	112	-	Adding reference for power offset variation text in TS 25.214	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	113	-	Combining TPC commands in soft handover	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	115	1	Corrections to power control	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	116	-	Corrections to 25.214	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	117	-	Clarification to downlink power control	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	118	3	Clarification of power control at maximum and minimum power	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	119	-	Clarification of SSdT text	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	120	-	Corrections to CL transmit diversity mode 1	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	121	1	Clarification of SSdT ID code bit transmission order	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	122	1	Clarification on RACH and CPCH subchannel definition	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	123	1	DPCH initialisation procedure	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	124	-	Clarification of closed loop mode TX diversity initialisation	3.3.0	3.4.0
23/09/00	RAN_09	RP-000342	127	2	Uplink power control in compressed mode	3.3.0	3.4.0
15/12/00	RAN_10	RP-000540	128	1	Clarification of downlink quality measurement in SSdT	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	129	-	Formula typography and reference corrections	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	130	1	Radio link establishment and sync status reporting	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	133	-	Correction of RACH/CPCH physical random access procedure	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	134	-	Correction of uplink power control algorithm 2	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	135	1	TPC command generation on downlink during RLS initialisation	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	136	1	Clarification of RACH behaviour at maximum and minimum power	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	137	-	Clarifications on the description of the radio link establishment procedure (when no radio link exists)	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	138	1	Corrections on power control preambles	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	139	1	Clarification of RACH procedure	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	140	-	Uplink power control in compressed mode	3.4.0	3.5.0
15/12/00	RAN_10	RP-000540	141	1	Revision of the abbreviation list	3.4.0	3.5.0
16/03/01	RAN_11	-	-	-	Approved as Release 4 specification (v4.0.0) at TSG RAN #11	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	142	1	Uplink power control in compressed mode	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	144	-	Removal of the power balancing algorithm from TS 25.214	3.5.0	4.0.0
16/03/01	RAN_11	RP-010254	145	2	Clarification of Nid parameter – when SSdT and uplink compressed mode are in operation	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	146	-	Clarification of closed loop transmit diversity mode 1 and mode 2 operation during compressed mode	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	148	1	Clarification of UE SIR estimation	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	150	1	Clarification of the order of SSdT signalling in 2 bit FBI	3.5.0	4.0.0
16/03/01	RAN_11	RP-010244	154	2	Uplink power control preamble	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	155	-	Correction of limited power raise	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	156	-	Clarification of initialisation procedure	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	158	-	Definition of power control step size for algorithm 2	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	161	1	Correction of the UE behaviour in SSdT mode	3.5.0	4.0.0
16/03/01	RAN_11	RP-010060	163	-	Correction on downlink synchronisation primitives	3.5.0	4.0.0
16/03/01	RAN_11	RP-010074	149	1	DSCH Power Control Improvement in soft handover	3.5.0	4.0.0
15/06/01	RAN_12	RP-010334	166	1	Limited power raise: aligning of terminology with TS25.433	4.0.0	4.1.0
15/06/01	RAN_12	RP-010334	167	1	Correction of IPDL burst parameters	4.0.0	4.1.0
15/06/01	RAN_12	RP-010334	169	1	Correction of synchronisation primitives	4.0.0	4.1.0
15/06/01	RAN_12	RP-010334	177	1	Clarification on TPC command generation on downlink during RL initialisation	4.0.0	4.1.0
15/06/01	RAN_12	RP-010482	181	4	Clarification of synchronisation procedures	4.0.0	4.1.0
15/06/01	RAN_12	RP-010334	183	-	Clarification of initialisation of closed loop mode 1 and 2 during compressed mode	4.0.0	4.1.0
15/06/01	RAN_12	RP-010334	186	-	DL maximum power level in compressed mode	4.0.0	4.1.0
15/06/01	RAN_12	RP-010341	164	1	Clarification on the usage of SSdT signaling in uplink	4.0.0	4.1.0
21/09/01	RAN_13	RP-010520	192	-	Corrections and Clarifications for calculation of idle period position in subclause 8.3 in 25.214	4.1.0	4.2.0
21/09/01	RAN_13	RP-010520	194	1	Minor modifications to the CPCH access procedure	4.1.0	4.2.0
21/09/01	RAN_13	RP-010520	197	-	Downlink power control in compressed mode	4.1.0	4.2.0
21/09/01	RAN_13	RP-010520	199	1	Improvements of closed loop TX diversity description	4.1.0	4.2.0
21/09/01	RAN_13	RP-010520	201	1	Correction to Random access procedure (Primitive from MAC)	4.1.0	4.2.0

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
21/09/01	RAN_13	RP-010677	205	1	Proposed CR to TS25.214: Clarification of the SSDT behaviour with beam forming	4.1.0	4.2.0
21/09/01	RAN_13	RP-010527	195	1	Enhanced PDSCH power control clarification	4.1.0	4.2.0
14/12/01	RAN_14	RP-010739	207	1	Power control in compressed mode when DPC_MODE=1	4.2.0	4.3.0
14/12/01	RAN_14	RP-010739	209	-	Clarification of closed loop mode 1 and 2 Tx diversity operation during compressed mode	4.2.0	4.3.0
14/12/01	RAN_14	RP-010739	211	-	Downlink phase reference reconfiguration	4.2.0	4.3.0
14/12/01	RAN_14	RP-010739	219	1	Downlink power control for channels supporting CPCH	4.2.0	4.3.0
14/12/01	RAN_14	RP-010739	223	-	Removal of slow power control from TS 25.214	4.2.0	4.3.0
14/12/01	RAN_14	RP-010775	216	-	Uplink TPC command processing in SHO with SSDT	4.2.0	4.3.0
14/12/01	RAN_14	RP-010744	217	2	DSCH power control clarification	4.2.0	4.3.0
14/12/01	RAN_14	RP-010933	229	-	Restriction to SSDT and closed loop mode transmit diversity combination	4.2.0	4.3.0

CHANGE REQUEST

⌘ **25.214 CR 251** ⌘ rev **-** ⌘ Current version: **4.3.0** ⌘

For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.

Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ Introduction of power control aspects for HSDPA feature in TS25.214		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ 21.02.2002
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories: F (correction) A (corresponds to a correction in an earlier release) B (addition of feature), C (functional modification of feature) D (editorial modification) Detailed explanations of the above categories can be found in 3GPP TR 21.900 .		Use <u>one</u> of the following releases: 2 (GSM Phase 2) R96 (Release 1996) R97 (Release 1997) R98 (Release 1998) R99 (Release 1999) REL-4 (Release 4) REL-5 (Release 5)

Reason for change:	⌘ Introduces changes that are needed for HSDPA description related to power control in the specification		
Summary of change:	⌘ HSDPA power control aspects are added.		
Consequences if not approved:	⌘ Work item HSDPA-phys will not be part of Release 5.		

Clauses affected:	⌘ 5		
Other specs affected:	⌘ <input type="checkbox"/> Other core specifications <input type="checkbox"/> Test specifications <input type="checkbox"/> O&M Specifications	⌘	
Other comments:	⌘		

How to create CRs using this form:

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- 1) Fill out the above form. The symbols above marked ⌘ contain pop-up help information about the field that they are closest to.
- 2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under <ftp://ftp.3gpp.org/specs/>. For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.
- 3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

5.1.2 DPCCH/DPDCH

5.1.2.1 General

The initial uplink DPCCH transmit power is set by higher layers. Subsequently the uplink transmit power control procedure simultaneously controls the power of a DPCCH and its corresponding DPDCHs (if present). The relative transmit power offset between DPCCH and DPDCHs is determined by the network and is computed according to subclause 5.1.2.5 using the gain factors signalled to the UE using higher layer signalling.

The operation of the inner power control loop, described in sub clause 5.1.2.2, adjusts the power of the DPCCH and DPDCHs by the same amount, provided there are no changes in gain factors. Additional adjustments to the power of the DPCCH associated with the use of compressed mode are described in sub clause 5.1.2.3.

Any change in the uplink DPCCH transmit power shall take place immediately before the start of the pilot field on the DPCCH. The change in DPCCH power with respect to its previous value is derived by the UE and is denoted by Δ_{DPCCH} (in dB). The previous value of DPCCH power shall be that used in the previous slot, except in the event of an interruption in transmission due to the use of compressed mode, when the previous value shall be that used in the last slot before the transmission gap.

During the operation of the uplink power control procedure the UE transmit power shall not exceed a maximum allowed value which is the lower out of the maximum output power of the terminal power class and a value which may be set by higher layer signalling.

Uplink power control shall be performed while the UE transmit power is below the maximum allowed output power.

The provisions for power control at the maximum allowed value and below the required minimum output power (as defined in [7]) are described in sub-clause 5.1.2.6.

5.1.2.2 Ordinary transmit power control

5.1.2.2.1 General

The uplink inner-loop power control adjusts the UE transmit power in order to keep the received uplink signal-to-interference ratio (SIR) at a given SIR target, $\text{SIR}_{\text{target}}$.

The serving cells (cells in the active set) should estimate signal-to-interference ratio SIR_{est} of the received uplink DPCH. The serving cells should then generate TPC commands and transmit the commands once per slot according to the following rule: if $\text{SIR}_{\text{est}} > \text{SIR}_{\text{target}}$ then the TPC command to transmit is "0", while if $\text{SIR}_{\text{est}} < \text{SIR}_{\text{target}}$ then the TPC command to transmit is "1".

Upon reception of one or more TPC commands in a slot, the UE shall derive a single TPC command, TPC_{cmd} , for each slot, combining multiple TPC commands if more than one is received in a slot. This is also valid when SSDT transmission is used in the downlink. Two algorithms shall be supported by the UE for deriving a TPC_{cmd} . Which of these two algorithms is used is determined by a UE-specific higher-layer parameter, "PowerControlAlgorithm", and is under the control of the UTRAN. If "PowerControlAlgorithm" indicates "algorithm1", then the layer 1 parameter PCA shall take the value 1 and if "PowerControlAlgorithm" indicates "algorithm2" then PCA shall take the value 2.

If PCA has the value 1, Algorithm 1, described in subclause 5.1.2.2.2, shall be used for processing TPC commands.

If PCA has the value 2, Algorithm 2, described in subclause 5.1.2.2.3, shall be used for processing TPC commands.

The step size Δ_{TPC} is a layer 1 parameter which is derived from the UE-specific higher-layer parameter "TPC-StepSize" which is under the control of the UTRAN. If "TPC-StepSize" has the value "dB1", then the layer 1 parameter Δ_{TPC} shall take the value 1 dB and if "TPC-StepSize" has the value "dB2", then Δ_{TPC} shall take the value 2 dB. The parameter "TPC-StepSize" only applies to Algorithm 1 as stated in [5]. For Algorithm 2 Δ_{TPC} shall always take the value 1 dB.

After deriving of the combined TPC command TPC_{cmd} using one of the two supported algorithms, the UE shall adjust the transmit power of the uplink DPCCH with a step of Δ_{DPCCH} (in dB) which is given by:

$$\Delta_{\text{DPCCH}} = \Delta_{\text{TPC}} \times \text{TPC}_{\text{cmd}}.$$

5.1.2.2.1.1 Out of synchronisation handling

After 160 ms after physical channel establishment (defined in [5]), the UE shall control its transmitter according to a downlink DPCCH quality criterion as follows:

- The UE shall shut its transmitter off when the UE estimates the DPCCH quality over the last 160 ms period to be worse than a threshold Q_{out} . Q_{out} is defined implicitly by the relevant tests in [7].
- The UE can turn its transmitter on again when the UE estimates the DPCCH quality over the last 160 ms period to be better than a threshold Q_{in} . Q_{in} is defined implicitly by the relevant tests in [7]. When transmission is resumed, the power of the DPCCH shall be the same as when the UE transmitter was shut off.

5.1.2.2.1.2 TPC command generation on downlink during RL initialisation

When commanded by higher layers the TPC commands sent on a downlink radio link from Node Bs that have not yet achieved uplink synchronisation shall follow a pattern as follows:

If higher layers indicate by "First RLS indicator" that the radio link is part of the first radio link set sent to the UE and the value 'n' obtained from the parameter "DL TPC pattern 01 count" passed by higher layers is different from 0 then :

- the TPC pattern shall consist of n instances of the pair of TPC commands ("0", "1"), followed by one instance of TPC command "1", where ("0", "1") indicates the TPC commands to be transmitted in 2 consecutive slots,
- the TPC pattern continuously repeat but shall be forcibly re-started at the beginning of each frame where $CFN \bmod 4 = 0$.

else

- The TPC pattern shall consist only of TPC commands "1".

The TPC pattern shall terminate once uplink synchronisation is achieved.

5.1.2.2.2 Algorithm 1 for processing TPC commands

5.1.2.2.2.1 Derivation of TPC_cmd when only one TPC command is received in each slot

When a UE is not in soft handover, only one TPC command will be received in each slot. In this case, the value of TPC_cmd shall be derived as follows:

- If the received TPC command is equal to 0 then TPC_cmd for that slot is -1.
- If the received TPC command is equal to 1, then TPC_cmd for that slot is 1.

5.1.2.2.2.2 Combining of TPC commands from radio links of the same radio link set

When a UE is in soft handover, multiple TPC commands may be received in each slot from different cells in the active set. In some cases, the UE has the knowledge that some of the transmitted TPC commands in a slot are the same. This is the case when the radio links are in the same radio link set. For these cases, the TPC commands from the same radio link set shall be combined into one TPC command, to be further combined with other TPC commands as described in subclause 5.1.2.2.2.3.

5.1.2.2.2.3 Combining of TPC commands from radio links of different radio link sets

This subclause describes the general scheme for combination of the TPC commands from radio links of different radio link sets.

First, the UE shall conduct a soft symbol decision W_i on each of the power control commands TPC_i , where $i = 1, 2, \dots, N$, where N is greater than 1 and is the number of TPC commands from radio links of different radio link sets, that may be the result of a first phase of combination according to subclause 5.1.2.2.2.2.

Finally, the UE derives a combined TPC command, TPC_cmd, as a function γ of all the N soft symbol decisions W_i :

- $TPC_cmd = \gamma (W_1, W_2, \dots, W_N)$, where TPC_cmd can take the values 1 or -1.

The function γ shall fulfil the following criteria:

If the N TPC_{*i*} commands are random and uncorrelated, with equal probability of being transmitted as "0" or "1", the probability that the output of γ is equal to 1 shall be greater than or equal to $1/(2^N)$, and the probability that the output of γ is equal to -1 shall be greater than or equal to 0.5. Further, the output of γ shall equal 1 if the TPC commands from all the radio link sets are reliably "1", and the output of γ shall equal -1 if a TPC command from any of the radio link sets is reliably "0".

5.1.2.2.3 Algorithm 2 for processing TPC commands

NOTE: Algorithm 2 makes it possible to emulate smaller step sizes than the minimum power control step specified in subclause 5.1.2.2.1, or to turn off uplink power control by transmitting an alternating series of TPC commands.

5.1.2.2.3.1 Derivation of TPC_cmd when only one TPC command is received in each slot

When a UE is not in soft handover, only one TPC command will be received in each slot. In this case, the UE shall process received TPC commands on a 5-slot cycle, where the sets of 5 slots shall be aligned to the frame boundaries and there shall be no overlap between each set of 5 slots.

The value of TPC_cmd shall be derived as follows:

- For the first 4 slots of a set, TPC_cmd = 0.
- For the fifth slot of a set, the UE uses hard decisions on each of the 5 received TPC commands as follows:
 - If all 5 hard decisions within a set are 1 then TPC_cmd = 1 in the 5th slot.
 - If all 5 hard decisions within a set are 0 then TPC_cmd = -1 in the 5th slot.
 - Otherwise, TPC_cmd = 0 in the 5th slot.

5.1.2.2.3.2 Combining of TPC commands from radio links of the same radio link set

When a UE is in soft handover, multiple TPC commands may be received in each slot from different cells in the active set. In some cases, the UE has the knowledge that some of the transmitted TPC commands in a slot are the same. This is the case when the radio links are in the same radio link set. For these cases, the TPC commands from radio links of the same radio link set shall be combined into one TPC command, to be processed and further combined with any other TPC commands as described in subclause 5.1.2.2.3.3.

5.1.2.2.3.3 Combining of TPC commands from radio links of different radio link sets

This subclause describes the general scheme for combination of the TPC commands from radio links of different radio link sets.

The UE shall make a hard decision on the value of each TPC_{*i*}, where $i = 1, 2, \dots, N$ and N is the number of TPC commands from radio links of different radio link sets, that may be the result of a first phase of combination according to subclause 5.1.2.2.3.2.

The UE shall follow this procedure for 5 consecutive slots, resulting in N hard decisions for each of the 5 slots.

The sets of 5 slots shall be aligned to the frame boundaries and there shall be no overlap between each set of 5 slots.

The value of TPC_cmd is zero for the first 4 slots. After 5 slots have elapsed, the UE shall determine the value of TPC_cmd for the fifth slot in the following way:

The UE first determines one temporary TPC command, TPC_temp_{*i*}, for each of the N sets of 5 TPC commands as follows:

- If all 5 hard decisions within a set are "1", TPC_temp_{*i*} = 1.
- If all 5 hard decisions within a set are "0", TPC_temp_{*i*} = -1.

- Otherwise, $TPC_temp_i = 0$.

Finally, the UE derives a combined TPC command for the fifth slot, TPC_cmd , as a function γ of all the N temporary power control commands TPC_temp_i :

$TPC_cmd(5^{th} \text{ slot}) = \gamma (TPC_temp_1, TPC_temp_2, \dots, TPC_temp_N)$, where $TPC_cmd(5^{th} \text{ slot})$ can take the values 1, 0 or -1, and γ is given by the following definition:

- TPC_cmd is set to 1 if $\frac{1}{N} \sum_{i=1}^N TPC_temp_i > 0.5$.
- TPC_cmd is set to -1 if $\frac{1}{N} \sum_{i=1}^N TPC_temp_i < -0.5$.

Otherwise, TPC_cmd is set to 0.

5.1.2.3 Transmit power control in compressed mode

In compressed mode, one or more transmission gap pattern sequences are active. Therefore some frames are compressed and contain transmission gaps. The uplink power control procedure is as specified in clause 5.1.2.2, using the same UTRAN supplied parameters for Power Control Algorithm and step size (Δ_{TPC}), but with additional features which aim to recover as rapidly as possible a signal-to-interference ratio (SIR) close to the target SIR after each transmission gap.

The serving cells (cells in the active set) should estimate signal-to-interference ratio SIR_{est} of the received uplink DPCH. The serving cells should then generate TPC commands and transmit the commands once per slot, except during downlink transmission gaps, according to the following rule: if $SIR_{est} > SIR_{cm_target}$ then the TPC command to transmit is "0", while if $SIR_{est} < SIR_{cm_target}$ then the TPC command to transmit is "1".

SIR_{cm_target} is the target SIR during compressed mode and fulfils

$$SIR_{cm_target} = SIR_{target} + \Delta SIR_{PILOT} + \Delta SIR1_coding + \Delta SIR2_coding,$$

where $\Delta SIR1_coding$ and $\Delta SIR2_coding$ are computed from uplink parameters $\Delta SIR1$, $\Delta SIR2$, $\Delta SIRafter1$, $\Delta SIRafter2$ signalled by higher layers as:

- $\Delta SIR1_coding = \Delta SIR1$ if the start of the first transmission gap in the transmission gap pattern is within the current uplink frame.
- $\Delta SIR1_coding = \Delta SIRafter1$ if the current uplink frame just follows a frame containing the start of the first transmission gap in the transmission gap pattern.
- $\Delta SIR2_coding = \Delta SIR2$ if the start of the second transmission gap in the transmission gap pattern is within the current uplink frame.
- $\Delta SIR2_coding = \Delta SIRafter2$ if the current uplink frame just follows a frame containing the start of the second transmission gap in the transmission gap pattern.
- $\Delta SIR1_coding = 0$ dB and $\Delta SIR2_coding = 0$ dB in all other cases.

ΔSIR_{PILOT} is defined as: $\Delta SIR_{PILOT} = 10 \log_{10} (N_{pilot,N} / N_{pilot,curr_frame})$,

where $N_{pilot,curr_frame}$ is the number of pilot bits per slot in the current uplink frame, and $N_{pilot,N}$ is the number of pilot bits per slot in a normal uplink frame without a transmission gap.

In the case of several compressed mode pattern sequences being used simultaneously, $\Delta SIR1_coding$ and $\Delta SIR2_coding$ offsets are computed for each compressed mode pattern and all $\Delta SIR1_coding$ and $\Delta SIR2_coding$ offsets are summed together.

In compressed mode, compressed frames may occur in either the uplink or the downlink or both. In uplink compressed frames, the transmission of uplink DPDCH(s) and DPCCH shall both be stopped during transmission gaps.

Due to the transmission gaps in compressed frames, there may be missing TPC commands in the downlink. If no downlink TPC command is transmitted, the corresponding TPC_cmd derived by the UE shall be set to zero.

Compressed and non-compressed frames in the uplink DPCCH may have a different number of pilot bits per slot. A change in the transmit power of the uplink DPCCH would be needed in order to compensate for the change in the total pilot energy. Therefore at the start of each slot the UE shall derive the value of a power offset Δ_{PILOT} . If the number of pilot bits per slot in the uplink DPCCH is different from its value in the most recently transmitted slot, Δ_{PILOT} (in dB) shall be given by:

$$\Delta_{PILOT} = 10 \log_{10} (N_{pilot,prev} / N_{pilot,curr});$$

where $N_{pilot,prev}$ is the number of pilot bits in the most recently transmitted slot, and $N_{pilot,curr}$ is the number of pilot bits in the current slot. Otherwise, including during transmission gaps in the downlink, Δ_{PILOT} shall be zero.

Unless otherwise specified, in every slot during compressed mode the UE shall adjust the transmit power of the uplink DPCCH with a step of Δ_{DPCCH} (in dB) which is given by:

$$\Delta_{DPCCH} = \Delta_{TPC} \times TPC_cmd + \Delta_{PILOT}.$$

At the start of the first slot after an uplink or downlink transmission gap the UE shall apply a change in the transmit power of the uplink DPCCH by an amount Δ_{DPCCH} (in dB), with respect to the uplink DPCCH power in the most recently transmitted uplink slot, where:

$$\Delta_{DPCCH} = \Delta_{RESUME} + \Delta_{PILOT}.$$

The value of Δ_{RESUME} (in dB) shall be determined by the UE according to the Initial Transmit Power mode (ITP). The ITP is a UE specific parameter, which is signalled by the network with the other compressed mode parameters (see [4]). The different modes are summarised in table 1.

Table 1: Initial Transmit Power modes during compressed mode

Initial Transmit Power mode	Description
0	$\Delta_{RESUME} = \Delta_{TPC} \times TPC_cmd_{gap}$
1	$\Delta_{RESUME} = \delta_{last}$

In the case of a transmission gap in the uplink, TPC_cmd_{gap} shall be the value of TPC_cmd derived in the first slot of the uplink transmission gap, if a downlink TPC_command is transmitted in that slot. Otherwise TPC_cmd_{gap} shall be zero.

δ_{last} shall be equal to the most recently computed value of δ_i . δ_i shall be updated according to the following recursive relations, which shall be executed in all slots in which both the uplink DPCCH and a downlink TPC command are transmitted, and in the first slot of an uplink transmission gap if a downlink TPC command is transmitted in that slot:

$$\begin{aligned} \delta_i &= 0.9375\delta_{i-1} - 0.96875TPC_cmd_i \Delta_{TPC} k_{sc} \\ \delta_{i-1} &= \delta_i \end{aligned}$$

where: TPC_cmd_i is the power control command derived by the UE in that slot;

$k_{sc} = 0$ if additional scaling is applied in the current slot and the previous slot as described in sub-clause 5.1.2.6, and $k_{sc} = 1$ otherwise.

δ_{i-1} is the value of δ_i computed for the previous slot. The value of δ_{i-1} shall be initialised to zero when the uplink DPCCH is activated, and also at the end of the first slot after each uplink transmission gap, and also at the end of the first slot after each downlink transmission gap. The value of δ_i shall be set to zero at the end of the first slot after each uplink transmission gap.

After a transmission gap in either the uplink or the downlink, the period following resumption of simultaneous uplink and downlink DPCCH transmission is called a recovery period. RPL is the recovery period length and is expressed as a number of slots. RPL is equal to the minimum value out of the transmission gap length and 7 slots. If a transmission gap

is scheduled to start before RPL slots have elapsed, then the recovery period shall end at the start of the gap, and the value of RPL shall be reduced accordingly.

During the recovery period, 2 modes are possible for the power control algorithm. The Recovery Period Power control mode (RPP) is signalled with the other compressed mode parameters (see [4]). The different modes are summarised in the table 2:

Table 2: Recovery Period Power control modes during compressed mode

Recovery Period power control mode	Description
0	Transmit power control is applied using the algorithm determined by the value of PCA, as in subclause 5.1.2.2 with step size Δ_{TPC} .
1	Transmit power control is applied using algorithm 1 (see subclause 5.1.2.2.2) with step size $\Delta_{\text{RP-TPC}}$ during RPL slots after each transmission gap.

For RPP mode 0, the step size is not changed during the recovery period and ordinary transmit power control is applied (see subclause 5.1.2.2), using the algorithm for processing TPC commands determined by the value of PCA (see subclauses 5.1.2.2.2 and 5.1.2.2.3).

For RPP mode 1, during RPL slots after each transmission gap, power control algorithm 1 is applied with a step size $\Delta_{\text{RP-TPC}}$ instead of Δ_{TPC} , regardless of the value of PCA. Therefore, the change in uplink DPCCH transmit power at the start of each of the RPL+1 slots immediately following the transmission gap (except for the first slot after the transmission gap) is given by:

$$\Delta_{\text{DPCCH}} = \Delta_{\text{RP-TPC}} \times \text{TPC_cmd} + \Delta_{\text{PILOT}}$$

$\Delta_{\text{RP-TPC}}$ is called the recovery power control step size and is expressed in dB. If PCA has the value 1, $\Delta_{\text{RP-TPC}}$ is equal to the minimum value of 3 dB and $2\Delta_{\text{TPC}}$. If PCA has the value 2, $\Delta_{\text{RP-TPC}}$ is equal to 1 dB.

After the recovery period, ordinary transmit power control resumes using the algorithm specified by the value of PCA and with step size Δ_{TPC} .

If PCA has the value 2, the sets of slots over which the TPC commands are processed shall remain aligned to the frame boundaries in the compressed frame. For both RPP mode 0 and RPP mode 1, if the transmission gap or the recovery period results in any incomplete sets of TPC commands, TPC_cmd shall be zero for those sets of slots which are incomplete.

5.1.2.4 Transmit power control in the uplink DPCCH power control preamble

An uplink DPCCH power control preamble is a period of uplink DPCCH transmission prior to the start of the uplink DPDCH transmission. The downlink DPCCH shall also be transmitted during an uplink DPCCH power control preamble.

The length of the uplink DPCCH power control preamble is a higher layer parameter signalled by the network as defined in [5]. The uplink DPDCH transmission shall commence after the end of the uplink DPCCH power control preamble.

During the uplink DPCCH power control preamble the change in uplink DPCCH transmit power shall be given by:

$$\Delta_{\text{DPCCH}} = \Delta_{\text{TPC}} \times \text{TPC_cmd}.$$

During the uplink DPCCH power control preamble TPC_cmd is derived according to algorithm 1 as described in subclause 5.1.2.2.1, regardless of the value of PCA.

Ordinary power control (see subclause 5.1.2.2), with the power control algorithm determined by the value of PCA and step size Δ_{TPC} , shall be used after the end of the uplink DPCCH power control preamble.

5.1.2.5 Setting of the uplink DPCCH/DPDCH power difference

5.1.2.5.1 General

The uplink DPCCH and DPDCH(s) are transmitted on different codes as defined in subclause 4.2.1 of [3]. The gain factors β_c and β_d may vary for each TFC. There are two ways of controlling the gain factors of the DPCCH code and the DPDCH codes for different TFCs in normal (non-compressed) frames:

- β_c and β_d are signalled for the TFC, or
- β_c and β_d is computed for the TFC, based on the signalled settings for a reference TFC.

Combinations of the two above methods may be used to associate β_c and β_d values to all TFCs in the TFCS. The two methods are described in subclauses 5.1.2.5.2 and 5.1.2.5.3 respectively. Several reference TFCs may be signalled from higher layers.

The gain factors may vary on radio frame basis depending on the current TFC used. Further, the setting of gain factors is independent of the inner loop power control.

After applying the gain factors, the UE shall scale the total transmit power of the DPCCH and DPDCH(s), such that the DPCCH output power follows the changes required by the power control procedure with power adjustments of Δ_{DPCCH} dB, subject to the provisions of sub-clause 5.1.2.6.

The gain factors during compressed frames are based on the nominal power relation defined in normal frames, as specified in subclause 5.1.2.5.4.

5.1.2.5.2 Signalled gain factors

When the gain factors β_c and β_d are signalled by higher layers for a certain TFC, the signalled values are used directly for weighting of DPCCH and DPDCH(s). The variable A_j , called the nominal power relation is then computed as:

$$A_j = \frac{\beta_d}{\beta_c}.$$

5.1.2.5.3 Computed gain factors

The gain factors β_c and β_d may also be computed for certain TFCs, based on the signalled settings for a reference TFC.

Let $\beta_{c,ref}$ and $\beta_{d,ref}$ denote the signalled gain factors for the reference TFC. Further, let $\beta_{c,j}$ and $\beta_{d,j}$ denote the gain factors used for the j :th TFC. Also let L_{ref} denote the number of DPDCHs used for the reference TFC and L_j denote the number of DPDCHs used for the j :th TFC.

Define the variable

$$K_{ref} = \sum_i RM_i \cdot N_i ;$$

where RM_i is the semi-static rate matching attribute for transport channel i (defined in [2] subclause 4.2.7), N_i is the number of bits output from the radio frame segmentation block for transport channel i (defined in [2] subclause 4.2.6.1), and the sum is taken over all the transport channels i in the reference TFC.

Similarly, define the variable

$$K_j = \sum_i RM_i \cdot N_i ;$$

where the sum is taken over all the transport channels i in the j :th TFC.

The variable A_j , called the nominal power relation is then computed as:

$$A_j = \frac{\beta_{d,ref}}{\beta_{c,ref}} \cdot \sqrt{\frac{L_{ref}}{L_j}} \sqrt{\frac{K_j}{K_{ref}}}$$

The gain factors for the j :th TFC are then computed as follows:

- If $A_j > 1$, then $\beta_{d,j} = 1.0$ and $\beta_{c,j}$ is the largest quantized β -value, for which the condition $\beta_{c,j} \leq 1 / A_j$ holds. Since $\beta_{c,j}$ may not be set to zero, if the above rounding results in a zero value, $\beta_{c,j}$ shall be set to the lowest quantized amplitude ratio of 1/15 as specified in [3].
- If $A_j \leq 1$, then $\beta_{d,j}$ is the smallest quantized β -value, for which the condition $\beta_{d,j} \geq A_j$ holds and $\beta_{c,j} = 1.0$.

The quantized β -values are defined in [3] subclause 4.2.1, table 1.

5.1.2.5.4 Setting of the uplink DPCCH/DPDCH power difference in compressed mode

The gain factors used during a compressed frame for a certain TFC are calculated from the nominal power relation used in normal (non-compressed) frames for that TFC. Let A_j denote the nominal power relation for the j :th TFC in a normal frame. Further, let $\beta_{c,C,j}$ and $\beta_{d,C,j}$ denote the gain factors used for the j :th TFC when the frame is compressed. The variable $A_{C,j}$ is computed as:

$$A_{C,j} = A_j \cdot \sqrt{\frac{15 \cdot N_{pilot,C}}{N_{slots,C} \cdot N_{pilot,N}}}$$

where $N_{pilot,C}$ is the number of pilot bits per slot when in compressed mode, and $N_{pilot,N}$ is the number of pilot bits per slot in normal mode. $N_{slots,C}$ is the number of slots in the compressed frame used for transmitting the data.

The gain factors for the j :th TFC in a compressed frame are computed as follows:

- If $A_{C,j} > 1$, then $\beta_{d,C,j} = 1.0$ and $\beta_{c,C,j}$ is the largest quantized β -value, for which the condition $\beta_{c,C,j} \leq 1 / A_{C,j}$ holds. Since $\beta_{c,C,j}$ may not be set to zero, if the above rounding results in a zero value, $\beta_{c,C,j}$ shall be set to the lowest quantized amplitude ratio of 1/15 as specified in [3].
- If $A_{C,j} \leq 1$, then $\beta_{d,C,j}$ is the smallest quantized β -value, for which the condition $\beta_{d,C,j} \geq A_{C,j}$ holds and $\beta_{c,C,j} = 1.0$.

The quantized β -values are defined in [3] subclause 4.2.1, table 1.

5.1.2.6 Setting of the uplink DPCCH/HS-DPCCH power difference

When an HS-DPCCH is active, the relative power offset $\Delta_{HS-DPCCH}$ between the DPCCH and the HS-DPCCH for each HS-DPCCH slot shall be set as follows.

For HS-DPCCH slots carrying HARQ Acknowledgement :

$\Delta_{HS-DPCCH} = \Delta_{ACK}$ if the corresponding HARQ Acknowledgement is equal to 1

$\Delta_{HS-DPCCH} = \Delta_{NACK}$ if the corresponding HARQ Acknowledgement is equal to 0

For HS-DPCCH slots carrying CQI :

$\Delta_{HS-DPCCH} = \Delta_{CQI}$

The values for Δ_{ACK} , Δ_{NACK} and Δ_{CQI} are set by higher layers.

The setting of the power difference between DPCCH and HS-DPCCH is independent of the inner loop power control.

When the HS-DPCCH and the DPCCH are not slot aligned, the reference DPCCH power shall be the one used in the DPCCH slot being transmitted at the beginning i.e. slot boundary of the HS-DPCCH slot.

5.1.2.67 Maximum and minimum power limits

In the case that the total UE transmit power (after applying DPCCH power adjustments and gain factors) would exceed the maximum allowed value, the UE shall apply additional scaling to the total transmit power so that it is equal to the maximum allowed power. This additional scaling shall be such that the power ratio between DPCCH and DPDCH and also DPCCH and HS-DPCCH remains as required by sub-clause 5.1.2.5 and 5.1.2.6.

When transmitting on a DPCH the UE is not required to be capable of reducing its total transmit power below the minimum level required in [7]. However, it may do so, provided that the power ratio between DPCCH and DPDCH and also between DPCCH and HS-DPCCH remains as specified in sub clause 5.1.2.5 and 5.1.2.6. Some further regulations also apply as follows: In the case that the total UE transmit power (after applying DPCCH power adjustments and gain factors) would be at or below the total transmit power in the previously transmitted slot and also at or below the required minimum power specified in [7], the UE may apply additional scaling to the total transmit power, subject to the following restrictions:

- The total transmit power after applying any additional scaling shall not exceed the required minimum power, nor the total transmit power in the previously transmitted slot;
- The magnitude of any reduction in total transmit power between slots after applying any additional scaling shall not exceed the magnitude of the calculated power reduction before the additional scaling.

In the case that the total UE transmit power in the previously transmitted slot is at or below the required minimum power specified in [7] and the DPCCH power adjustment and gain factors for the current slot would result in an increase in total power, then no additional scaling shall be used (i.e. power control shall operate as normal).

If the UE applies any additional scaling to the total transmit power as described above, this scaling shall be included in the computation of any DPCCH power adjustments to be applied in the next transmitted slot.

5.1.3 PCPCH

5.1.3.1 General

The power control during the CPCH access procedure is described in clause 6.2. The inner loop power control for the PCPCH is described in the following sub-clauses.

5.1.3.2 Power control in the message part

The uplink transmit power control procedure simultaneously controls the power of a PCPCH control part and its corresponding PCPCH data part. The relative transmit power offset between the PCPCH control part and the PCPCH data part is determined by the network and is computed according to sub-clause 5.1.2.5 using the gain factors signalled to the UE using higher-layer signalling, with the difference that:

- β_c is the gain factor for the PCPCH control part (similar to DPCCH);
- β_d is the gain factor for the PCPCH data part (similar to DPDCH).

The gain factors are applied as shown in sub clause 4.2.3.2 of [3].

The operation of the inner power control loop adjusts the power of the PCPCH control part and PCPCH data part by the same amount, provided there are no changes in gain factors.

Any change in the uplink PCPCH control part transmit power shall take place immediately before the start of the pilot field on the control part of the message part. The change in PCPCH control part power with respect to its value in the previous slot is derived by the UE and is denoted by $\Delta_{\text{PCPCH-CP}}$ (in dB).

During the operation of the uplink power control procedure the UE transmit power shall not exceed a maximum allowed value which is the lower out of the maximum output power of the terminal power class and a value which may be set by higher layer signalling.

Uplink power control shall be performed while the UE transmit power is below the maximum allowed output power.

The provisions for power control at the maximum allowed value and below the required minimum output power (as defined in [7]) are described in sub-clause 5.1.2.6.

The uplink inner-loop power control adjusts the UE transmit power in order to keep the received uplink signal-to-interference ratio (SIR) at a given SIR target, SIR_{target} , which is set by the higher layer outer loop.

The network should estimate the signal-to-interference ratio SIR_{est} of the received PCPCH. The network should then generate TPC commands and transmit the commands once per slot according to the following rule: if $SIR_{est} > SIR_{target}$ then the TPC command to transmit is "0", while if $SIR_{est} < SIR_{target}$ then the TPC command to transmit is "1".

The UE derives a TPC command, TPC_cmd , for each slot. Two algorithms shall be supported by the UE for deriving a TPC_cmd . Which of these two algorithms is used is determined by a higher-layer parameter, "PowerControlAlgorithm", and is under the control of the UTRAN. If "PowerControlAlgorithm" indicates "algorithm1", then the layer 1 parameter PCA shall take the value 1 and if "PowerControlAlgorithm" indicates "algorithm2" then PCA shall take the value 2.

If PCA has the value 1, Algorithm 1, described in subclause 5.1.2.2.2, shall be used for processing TPC commands.

If PCA has the value 2, Algorithm 2, described in subclause 5.1.2.2.3, shall be used for processing TPC commands.

The step size Δ_{TPC} is a layer 1 parameter which is derived from the higher-layer parameter "TPC-StepSize" which is under the control of the UTRAN. If "TPC-StepSize" has the value "dB1", then the layer 1 parameter Δ_{TPC} shall take the value 1 dB and if "TPC-StepSize" has the value "dB2", then Δ_{TPC} shall take the value 2 dB.

After deriving the TPC command TPC_cmd using one of the two supported algorithms, the UE shall adjust the transmit power of the uplink PCPCH control part with a step of $\Delta_{PCPCH-CP}$ (in dB) which is given by:

$$\Delta_{PCPCH-CP} = \Delta_{TPC} \times TPC_cmd$$

5.1.3.3 Power control in the power control preamble

A PCPCH power control preamble is a period when both the UL PCPCH control part and the associated DL DPCCCH are transmitted prior to the start of the uplink PCPCH data part.

The length of the power control preamble is a higher layer parameter, $L_{pc-preamble}$ (see section 6.2), and can take the value 0 slots or 8 slots. The uplink PCPCH data part shall not commence before the end of the power control preamble.

If $L_{pc-preamble} > 0$, the details of power control used during the power control preamble differ from the ordinary power control which is used afterwards. After the first slot of the power control preamble the change in uplink PCPCH control part transmit power shall initially be given by:

$$\Delta_{PCPCH-CP} = \Delta_{TPC-init} \times TPC_cmd$$

If the value of PCA is 1 then $\Delta_{TPC-init}$ is equal to the minimum value out of 3 dB and $2\Delta_{TPC}$.

If the value of PCA is 2 then $\Delta_{TPC-init}$ is equal to 2dB.

TPC_cmd is derived according to algorithm 1 as described in sub clause 5.1.2.2.2, regardless of the value of PCA.

Power control as defined for the message part (see sub-clause 5.1.3.2), with the power control algorithm determined by the value of PCA and step size Δ_{TPC} , shall be used as soon as the sign of TPC_cmd reverses for the first time, or at the end of the power control preamble if the power control preamble ends first.

5.2 Downlink power control

The transmit power of the downlink channels is determined by the network. In general the ratio of the transmit power between different downlink channels is not specified and may change with time. However, regulations exist as described in the following subclauses.

Higher layer power settings shall be interpreted as setting of the total power, i.e. the sum of the power from the two antennas in case of transmit diversity.

5.2.1 DPCCH/DPDCH

5.2.1.1 General

The downlink transmit power control procedure controls simultaneously the power of a DPCCH and its corresponding DPDCHs. The power control loop adjusts the power of the DPCCH and DPDCHs with the same amount, i.e. the relative power difference between the DPCCH and DPDCHs is not changed.

The relative transmit power offset between DPCCH fields and DPDCHs is determined by the network. The TFCI, TPC and pilot fields of the DPCCH are offset relative to the DPDCHs power by PO1, PO2 and PO3 dB respectively. The power offsets may vary in time. The method for controlling the power offsets within UTRAN is specified in [6].

5.2.1.2 Ordinary transmit power control

5.2.1.2.1 UE behaviour

The UE shall generate TPC commands to control the network transmit power and send them in the TPC field of the uplink DPCCH. An example on how to derive the TPC commands is given in Annex B.2.

The UE shall check the downlink power control mode (DPC_MODE) before generating the TPC command:

- if DPC_MODE = 0 : the UE sends a unique TPC command in each slot and the TPC command generated is transmitted in the first available TPC field in the uplink DPCCH;
- if DPC_MODE = 1 : the UE repeats the same TPC command over 3 slots and the new TPC command is transmitted such that there is a new command at the beginning of the frame.

The DPC_MODE parameter is a UE specific parameter controlled by the UTRAN.

The UE shall not make any assumptions on how the downlink power is set by UTRAN, in order to not prohibit usage of other UTRAN power control algorithms than what is defined in subclause 5.2.1.2.2.

5.2.1.2.2 UTRAN behaviour

Upon receiving the TPC commands UTRAN shall adjust its downlink DPCCH/DPDCH power accordingly. For DPC_MODE = 0, UTRAN shall estimate the transmitted TPC command TPC_{est} to be 0 or 1, and shall update the power every slot. If DPC_MODE = 1, UTRAN shall estimate the transmitted TPC command TPC_{est} over three slots to be 0 or 1, and shall update the power every three slots.

After estimating the k :th TPC command, UTRAN shall adjust the current downlink power $P(k-1)$ [dB] to a new power $P(k)$ [dB] according to the following formula:

$$P(k) = P(k - 1) + P_{TPC}(k) + P_{bal}(k),$$

where $P_{TPC}(k)$ is the k :th power adjustment due to the inner loop power control, and $P_{bal}(k)$ [dB] is a correction according to the downlink power control procedure for balancing radio link powers towards a common reference power. The power balancing procedure and control of the procedure is described in [6].

$P_{TPC}(k)$ is calculated according to the following.

If the value of *Limited Power Increase Used* parameter is 'Not used', then

$$P_{TPC}(k) = \begin{cases} +\Delta_{TPC} & \text{if } TPC_{est}(k) = 1 \\ -\Delta_{TPC} & \text{if } TPC_{est}(k) = 0 \end{cases}, [\text{dB}]. \quad (1)$$

If the value of *Limited Power Increase Used* parameter is 'Used', then the k :th inner loop power adjustment shall be calculated as:

$$P_{TPC}(k) = \begin{cases} +\Delta_{TPC} & \text{if } TPC_{est}(k) = 1 \text{ and } \Delta_{sum}(k) + \Delta_{TPC} < \text{Power_Raise_Limit} \\ 0 & \text{if } TPC_{est}(k) = 1 \text{ and } \Delta_{sum}(k) + \Delta_{TPC} \geq \text{Power_Raise_Limit} \\ -\Delta_{TPC} & \text{if } TPC_{est}(k) = 0 \end{cases}, [\text{dB}] \quad (2)$$

where

$$\Delta_{sum}(k) = \sum_{i=k-DL_Power_Averaging_Window_Size}^{k-1} P_{TPC}(i)$$

is the temporary sum of the last *DL_Power_Averaging_Window_Size* inner loop power adjustments (in dB).

For the first (*DL_Power_Averaging_Window_Size* – 1) adjustments after the activation of the limited power increase method, formula (1) shall be used instead of formula (2). *Power_Raise_Limit* and *DL_Power_Averaging_Window_Size* are parameters configured in the UTRAN.

The power control step size Δ_{TPC} can take four values: 0.5, 1, 1.5 or 2 dB. It is mandatory for UTRAN to support Δ_{TPC} of 1 dB, while support of other step sizes is optional.

In addition to the above described formulas on how the downlink power is updated, the restrictions below apply.

In case of congestion (commanded power not available), UTRAN may disregard the TPC commands from the UE.

The average power of transmitted DPDCH symbols over one timeslot shall not exceed *Maximum_DL_Power* (dB), nor shall it be below *Minimum_DL_Power* (dB). Transmitted DPDCH symbol means here a complex QPSK symbol before spreading which does not contain DTX. *Maximum_DL_Power* (dB) and *Minimum_DL_Power* (dB) are power limits for one channelisation code, relative to the primary CPICH power [6].

5.2.1.3 Power control in compressed mode

The aim of downlink power control in uplink or/and downlink compressed mode is to recover as fast as possible a signal-to-interference ratio (SIR) close to the target SIR after each transmission gap.

The UE behaviour is the same in compressed mode as in normal mode, described in subclause 5.2.1.2, except that the target SIR is offset by higher layer signalling. However due to transmission gaps in uplink compressed frames there may be incomplete sets of TPC commands when *DPC_MODE*=1.

UTRAN behaviour is as stated in section 5.2.1.2.2 except for *DPC_MODE* = 1 where missing TPC commands in the UL may lead the UTRAN to changing its power more frequently than every 3 slots.

In compressed mode, compressed frames may occur in either the uplink or the downlink or both. In compressed frames, the transmission of downlink DPDCH(s) and DPCCH shall be stopped during transmission gaps.

The power of the DPCCH and DPDCH in the first slot after the transmission gap should be set to the same value as in the slot just before the transmission gap.

During compressed mode except during downlink transmission gaps, UTRAN shall estimate the *k*:th TPC command and adjust the current downlink power $P(k-1)$ [dB] to a new power $P(k)$ [dB] according to the following formula:

$$P(k) = P(k-1) + P_{TPC}(k) + P_{SIR}(k) + P_{bal}(k),$$

where $P_{TPC}(k)$ is the *k*:th power adjustment due to the inner loop power control, $P_{SIR}(k)$ is the *k*-th power adjustment due to the downlink target SIR variation, and $P_{bal}(k)$ [dB] is a correction according to the downlink power control procedure for balancing radio link powers towards a common reference power. The power balancing procedure and control of the procedure is described in [6].

Due to transmission gaps in uplink compressed frames, there may be missing TPC commands in the uplink.

For *DPC_MODE* = 0 if no uplink TPC command is received, $P_{TPC}(k)$ derived by the Node B shall be set to zero.

Otherwise, $P_{TPC}(k)$ is calculated the same way as in normal mode (see sub-clause 5.2.1.2.2) but with a step size Δ_{STEP} instead of Δ_{TPC} .

For $DPC_MODE = 1$, the sets of slots over which the TPC commands are processed shall remain aligned to the frame boundaries in the compressed frame. If this results in an incomplete set of TPC commands, the UE shall transmit the same TPC commands in all slots of the incomplete set.

The power control step size $\Delta_{STEP} = \Delta_{RP-TPC}$ during RPL slots after each transmission gap and $\Delta_{STEP} = \Delta_{TPC}$ otherwise, where:

- RPL is the recovery period length and is expressed as a number of slots. RPL is equal to the minimum value out of the transmission gap length and 7 slots. If a transmission gap is scheduled to start before RPL slots have elapsed, then the recovery period shall end at the start of the gap, and the value of RPL shall be reduced accordingly.
- Δ_{RP-TPC} is called the recovery power control step size and is expressed in dB. Δ_{RP-TPC} is equal to the minimum value of 3 dB and $2\Delta_{TPC}$.

The power offset $P_{SIR}(k) = \delta P_{curr} - \delta P_{prev}$, where δP_{curr} and δP_{prev} are respectively the value of δP in the current slot and the most recently transmitted slot and δP is computed as follows:

$$\delta P = \max(\Delta P1_compression, \dots, \Delta Pn_compression) + \Delta P1_coding + \Delta P2_coding$$

where n is the number of different TTI lengths amongst TTIs of all TrChs of the CCTrCh, where $\Delta P1_coding$ and $\Delta P2_coding$ are computed from uplink parameters DeltaSIR1, DeltaSIR2, DeltaSIRafter1, DeltaSIRafter2 signaled by higher layers as:

- $\Delta P1_coding = \text{DeltaSIR1}$ if the start of the first transmission gap in the transmission gap pattern is within the current frame.
- $\Delta P1_coding = \text{DeltaSIRafter1}$ if the current frame just follows a frame containing the start of the first transmission gap in the transmission gap pattern.
- $\Delta P2_coding = \text{DeltaSIR2}$ if the start of the second transmission gap in the transmission gap pattern is within the current frame.
- $\Delta P2_coding = \text{DeltaSIRafter2}$ if the current frame just follows a frame containing the start of the second transmission gap in the transmission gap pattern.
- $\Delta P1_coding = 0$ dB and $\Delta P2_coding = 0$ dB in all other cases.

and $\Delta P_i_compression$ is defined by :

- $\Delta P_i_compression = 3$ dB for downlink frames compressed by reducing the spreading factor by 2.
- $\Delta P_i_compression = 10 \log(15 * F_i / (15 * F_i - TGL_i))$ if there is a transmission gap created by puncturing method within the current TTI of length F_i frames, where TGL_i is the gap length in number of slots (either from one gap or a sum of gaps) in the current TTI of length F_i frames.
- $\Delta P_i_compression = 0$ dB in all other cases.

In case several compressed mode patterns are used simultaneously, a δP offset is computed for each compressed mode pattern and the sum of all δP offsets is applied to the frame.

For all time slots except those in transmissions gaps, the average power of transmitted DPDCH symbols over one timeslot shall not exceed $Maximum_DL_Power$ (dB) by more than P_{SIR} , nor shall it be below $Minimum_DL_Power$ (dB). Transmitted DPDCH symbol means here a complex QPSK symbol before spreading which does not contain DTX. $Maximum_DL_Power$ (dB) and $Minimum_DL_Power$ (dB) are power limits for one channelisation code, relative to the primary CPICH power [6].

5.2.1.4 Site selection diversity transmit power control

5.2.1.4.1 General

Site selection diversity transmit power control (SSDT) is another macro diversity method in soft handover mode. This method is optional in UTRAN.

Operation is summarised as follows. The UE selects one of the cells from its active set to be 'primary', all other cells are classed as 'non primary'. The main objective is to transmit on the downlink from the primary cell, thus reducing the interference caused by multiple transmissions in a soft handover mode. A second objective is to achieve fast site selection without network intervention, thus maintaining the advantage of the soft handover. In order to select a primary cell, each cell is assigned a temporary identification (ID) and UE periodically informs a primary cell ID to the connecting cells. The non-primary cells selected by UE switch off the transmission power. The primary cell ID is delivered by UE to the active cells via uplink FBI field. SSDT activation, SSDT termination and ID assignment are all carried out by higher layer signalling.

SSDT is only supported when the P-CPICH is used as the downlink phase reference and closed loop mode transmit diversity is not used simultaneously.

UTRAN may also command UE to use SSDT signalling in the uplink although cells would transmit the downlink as without SSDT active. In case SSDT is used in the uplink direction only, the processing in the UE for the radio links received in the downlink is as with macro diversity in non-SSDT case. The downlink operation mode for SSDT is set by higher layers. UTRAN may use the SSDT information for the PDSCH power control as specified in section 5.2.2.

NOTE: This feature of SSDT limited to uplink only applies to terminals that are DSCH capable.

5.2.1.4.1.1 Definition of temporary cell identification

Each cell is given a temporary ID during SSDT and the ID is utilised as site selection signal. The ID is given a binary bit sequence. There are three different lengths of coded ID available denoted as "long", "medium" and "short". The network decides which length of coded ID is used. Settings of ID codes for 1-bit and 2-bit FBI are exhibited in table 3 and table 4, respectively.

Table 3: Settings of ID codes for 1 bit FBI

ID label	ID code		
	"long"	"medium"	"short"
a	0000000000000000	(0)0000000	00000
b	101010101010101	(0)1010101	01001
c	011001100110011	(0)0110011	11011
d	110011001100110	(0)1100110	10010
e	000111100001111	(0)0001111	00111
f	101101001011010	(0)1011010	01110
g	011110000111100	(0)0111100	11100
h	110100101101001	(0)1101001	10101

Table 4: Settings of ID codes for 2 bit FBI

ID label	ID code (Column and Row denote slot position and FBI-bit position.)		
	"long"	"medium"	"short"
a	(0)0000000	(0)000	000
	(0)0000000	(0)000	000
b	(0)0000000	(0)000	000
	(1)1111111	(1)111	111
c	(0)1010101	(0)101	101
	(0)1010101	(0)101	101
d	(0)1010101	(0)101	101
	(1)0101010	(1)010	010
e	(0)0110011	(0)011	011
	(0)0110011	(0)011	011
f	(0)0110011	(0)011	011
	(1)1001100	(1)100	100
g	(0)1100110	(0)110	110
	(0)1100110	(0)110	110
h	(0)1100110	(0)110	110
	(1)0011001	(1)001	001

The ID code bits shown in table 3 and table 4 are transmitted from left to right. In table 4, the first row gives the first FBI bit in each slot, the second row gives the 2nd FBI bit in each slot. The ID code(s) are transmitted aligned to the radio frame structure (i.e. ID codes shall be terminated within a frame). If FBI space for sending the last ID code within a frame cannot be obtained, the first bit(s) from that ID code are punctured. The bit(s) to be punctured are shown in brackets in table 3 and table 4.

The alignment of the ID codes to the radio frame structure is not affected by transmission gaps resulting from uplink compressed mode.

5.2.1.4.2 TPC procedure in UE

The UE shall generate TPC commands to control the network transmit power and send them in the TPC field of the uplink DPCCCH based on the downlink signals from the primary cell only. An example on how to derive the TPC commands is given in Annex B.2.

5.2.1.4.3 Selection of primary cell

The UE selects a primary cell periodically by measuring the RSCP of P-CPICHs transmitted by the active cells. The cell with the highest P-CPICH RSCP is detected as a primary cell.

5.2.1.4.4 Delivery of primary cell ID

The UE periodically sends the ID code of the primary cell via portion of the uplink FBI field assigned for SSdT use (FBI S field). A cell recognises its state as non-primary if the following conditions are fulfilled simultaneously:

- The received ID code does not match with the own ID code.
- The received uplink signal quality satisfies a quality threshold, Q_{th} , a parameter defined by the network.
- If uplink compressed mode is used, and less than $\lfloor N_{ID}/3 \rfloor$ bits are lost from the ID code (as a result of uplink compressed mode), where N_{ID} is the number of bits in the ID code (after puncturing according to clause 5.2.1.4.1.1, if puncturing has been done).

Otherwise the cell recognises its state as primary.

The state of the cells (primary or non-primary) in the active set is updated synchronously. If a cell receives the last portion of the coded ID in uplink slot j , the state of cell is updated in downlink slot $(j+1+T_{os}) \bmod 15$, where T_{os} is defined as a constant of 2 time slots. The updating of the cell state is not influenced by the operation of downlink compressed mode.

At the UE, the primary ID code to be sent to the cells is segmented into a number of portions. These portions are distributed in the uplink FBI S-field. The cell in SSdT collects the distributed portions of the primary ID code and then detects the transmitted ID. The period of the primary cell update depends on the settings of the code length and the number of FBI bits assigned for SSdT use as shown in table 5.

Table 5: Period of primary cell update

code length	The number of FBI bits per slot assigned for SSdT	
	1	2
"long"	1 update per frame	2 updates per frame
"medium"	2 updates per frame	4 updates per frame
"short"	3 updates per frame	5 updates per frame

5.2.1.4.5 TPC procedure in the network

In SSdT, a non-primary cell can switch off its DPDCCH output (i.e. no transmissions).

The cell manages two downlink transmission power levels, P1, and P2. Power level P1 is used for downlink DPCCCH transmission power level and this level is updated in the same way with the downlink DPCCCH power adjustment specified in 5.2.1.2.2 (for normal mode) and 5.2.1.3 (for compressed mode) regardless of the selected state (primary or non-primary). The actual transmission power of TFCI, TPC and pilot fields of DPCCCH is set by adding P1 and the

offsets PO1, PO2 and PO3, respectively, as specified in 5.2.1.1. P2 is used for downlink DPDCH transmission power level and this level is set to P1 if the cell is selected as primary, otherwise P2 is switched off. The cell updates P1 first and P2 next, and then the two power settings P1 and P2 are maintained within the power control dynamic range. Table 6 summarizes the updating method of P1 and P2.

Table 6: Updating of P1 and P2

State of cell	P1 (DPCCH)	P2 (DPDCH)
non primary	Updated in the same way with the downlink DPCCH power adjustment specified in 5.2.1.2.2 and 5.2.1.3	Switched off
primary		= P1

5.2.2 PDSCH

The PDSCH power control can be based on any of the following solutions:

- Inner-loop power control based on the power control commands sent by the UE on the uplink DPCCH.
- Other power control procedures applied by the network.

UTRAN may use the SSdT signalling to determine what power offset to use for PDSCH with respect to the associated downlink DCH when more than one cell may be in the active set. The support for a combination where SSdT signalling is used in the uplink, but SSdT is not necessarily used in the downlink, is required only from the UEs that support the use of DSCH.

If the downlink direction uses SSdT for the DCH transmission, then the TPC procedure in the UE to generate TPC commands to control the network transmit power is as specified in 5.2.1.4.2.

If the downlink transmission does not use SSdT operation, then the TPC procedure in the UE to generate TPC commands to control the network transmit power is as specified in 5.2.1.2.1.

The PDSCH power offset to be used with respect to the associated DCH depends on whether the cell transmitting PDSCH is determined to be a primary one or not.

The SSdT commands sent by the UE are averaged in UTRAN side over one or more frames. The averaging window length parameter as the number of frames to average over, *SSdT_aveg_window*, and the parameter for the required number of received primary SSdT commands, *SSdT_primary_commands*, during the averaging window for declaring primary status for a cell are given by UTRAN.

If the number of primary ID codes in the uplink received during the averaging window is less than the parameter *SSdT_primary_commands*, then a cell shall consider itself as non-primary and uses the power offset given from UTRAN to the cell with the data for the PDSCH.

If the number of primary ID codes in the uplink received during the averaging window is equal or more than the parameter *SSdT_primary_commands* defines, the cell shall use the power control parameterisation for the primary case. When the cell considers itself as primary it uses both the power offset for the PDSCH frame for the given UE and the *Enhanced DSCH Power Offset* parameter given by the UTRAN for the primary case.

The cell status (primary/non-primary) obtained from the rules above may differ from the cell status for SSdT transmission in the downlink depending on the values given by UTRAN for the parameters for averaging window length and the required number of received primary SSdT commands for cell status determination.

5.2.3 DL-DPCCH for CPCH

5.2.3.1 UE behaviour

The UE shall generate TPC commands to control the network transmit power and send them in the TPC field of the uplink DPCCH. The UE shall send a unique TPC command in each slot as in the DPCCH/DPDCH case for $DPC_MODE=0$.

The TPC commands setting may be based on the example provided in Annex B.2 for the DPCCH/DPDCH. However in the DL-DPCCH for CPCH case, the setting of the SIR_target by the outer loop power control is based on a DL-DPCCH for CPCH BER target provided by the UTRAN rather than a TrCH BLER. Also there is no soft handover, neither SSdT, used in combination with the CPCH.

The UE shall not make any assumptions on how the downlink power is set by UTRAN, in order to not prohibit usage of other UTRAN power control algorithms than what is defined in sub-clause 5.2.1.2.2.

5.2.3.2 UTRAN behaviour

The relative transmit power offsets between the different DPCCH fields (TPC and pilot) and CCC field is determined by the network. The power of CCC field in DL DPCCH for CPCH is the same as the power of the pilot field.

The TPC field of the DPCCH is offset relative to the pilot by $PO2dB$. This power offsets may vary in time. The method for controlling the power offset within UTRAN is specified in [6]

The UTRAN behaviour for the power control is left open to the implementation. As an example it may be based on the UTRAN behaviour for the DPCCH/DPDCH as specified in sub-clause 5.2.1.2.2, with the following exceptions : DPC_MODE should be set to 0 as there is no DPC_MODE parameter for CPCH and there is no support of Site selection diversity power control for the DL-DPCCH for CPCH as Soft handover is not applicable to the CPCH.

5.2.4 AICH

The UE is informed about the relative transmit power of the AICH (measured as the power per transmitted acquisition indicator) compared to the primary CPICH transmit power by the higher layers.

5.2.5 PICH

The UE is informed about the relative transmit power of the PICH (measured as the power over the paging indicators) compared to the primary CPICH transmit power by the higher layers.

5.2.6 S-CCPCH

The TFCI and pilot fields may be offset relative to the power of the data field. The power offsets may vary in time.

5.2.7 CSICH

The UE is informed about the relative transmit power of the CSICH (measured as the power per transmitted status indicator) compared to the primary CPICH transmit power by the higher layers.

5.2.8 AP-AICH

The UE is informed about the relative transmit power of the AP-AICH (measured as the power per transmitted acquisition indicator) compared to the primary CPICH transmit power by the higher layers.

5.2.9 CA/CD-ICH

The UE is informed about the relative transmit power of the CA/CD-ICH (measured as the power per transmitted acquisition indicator) compared to the primary CPICH transmit power by the higher layers.

5.2.10 HS-SCCH

The HS-SCCH power control is under the control of the node B. It may e.g. follow the power control commands sent by the UE to the node B or any other power control procedure applied by the node B.

5.2.11 HS-PDSCH

The HS-PDSCH power control is under the control of the node B. When the HS-PDSCH is transmitted using 16-QAM, the UE may assume that the power is kept constant during the corresponding HS-DSCH subframe.

In case of multiple HS-PDSCH transmission to one UE, all the HS-PDSCHs intended for that UE should be transmitted with equal power.

CHANGE REQUEST

⌘ **25.221 CR 076** ⌘ rev **1** ⌘ Current version: **4.3.0** ⌘

For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.

Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ CR to include HSDPA in TS25.221		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ 04-01-02
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories:		Use <u>one</u> of the following releases:
	F (correction)	2	(GSM Phase 2)
	A (corresponds to a correction in an earlier release)	R96	(Release 1996)
	B (addition of feature),	R97	(Release 1997)
	C (functional modification of feature)	R98	(Release 1998)
	D (editorial modification)	R99	(Release 1999)
	Detailed explanations of the above categories can be found in 3GPP TR 21.900 .		REL-4 (Release 4)
			REL-5 (Release 5)

Reason for change:	⌘ The changes implement HDSPA functionality and performance in the specification.
Summary of change:	⌘ Acronym list is updated. New sections are added to define HS-DSCH, HS-PDSCH, HS-SCCH, HS-SICH and Timing characteristics related to HSDPA.
Consequences if not approved:	⌘ HSDPA will not be part of REL-5

Clauses affected:	⌘ 2-8	
Other specs affected:	⌘ <input checked="" type="checkbox"/> Other core specifications	⌘ 25.201,25.222, 25.223, 25.224, 25.225
	<input type="checkbox"/> Test specifications	
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3GPP TS 25.221 V4.3.0 (2001-12)

Technical Specification

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (TDD) (Release 4)



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Keywords

UMTS, radio, layer 1

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Foreword

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- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document describes the characteristics of the physical channels and the mapping of the transport channels to physical channels in the TDD mode of UTRA.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

- [1] 3GPP TS 25.201: "Physical layer - general description".
- [2] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".
- [3] 3GPP TS 25.212: "Multiplexing and channel coding (FDD)".
- [4] 3GPP TS 25.213: "Spreading and modulation (FDD)".
- [5] 3GPP TS 25.214: "Physical layer procedures (FDD)".
- [6] 3GPP TS 25.215: "Physical layer – Measurements (FDD)".
- [7] 3GPP TS 25.222: "Multiplexing and channel coding (TDD)".
- [8] 3GPP TS 25.223: "Spreading and modulation (TDD)".
- [9] 3GPP TS 25.224: "Physical layer procedures (TDD)".
- [10] 3GPP TS 25.225: "Physical layer – Measurements (TDD)".
- [11] 3GPP TS 25.301: "Radio Interface Protocol Architecture".
- [12] 3GPP TS 25.302: "Services Provided by the Physical Layer".
- [13] 3GPP TS 25.401: "UTRAN Overall Description".
- [14] 3GPP TS 25.402: "Synchronisation in UTRAN, Stage 2".
- [15] 3GPP TS 25.304: " UE Procedures in Idle Mode and Procedures for Cell Reselection in Connected Mode".
- [16] 3GPP TS 25.427: "UTRAN Iur and Iub interface user plane protocols for DCH data streams".
- [17] 3GPP TS 25.435: "UTRAN I_{ub} Interface User Plane Protocols for Common Transport Channel Data Streams".
- [18] [3GPP TS25.308: High Speed Downlink Packet Access \(HSDPA\); Overall description; Stage 2](#)

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

16QAM	16 Quadrature Amplitude Modulation
BCH	Broadcast Channel
CCPCH	Common Control Physical Channel
CCTrCH	Coded Composite Transport Channel
CDMA	Code Division Multiple Access
CQI	Channel Quality Indicator
DCH	Dedicated Channel
DL	Downlink
DPCH	Dedicated Physical Channel
DRX	Discontinuous Reception
DSCH	Downlink Shared Channel
DTX	Discontinuous Transmission
DwPCH	Downlink Pilot Channel
DwPTS	Downlink Pilot Time Slot
FACH	Forward Access Channel
FDD	Frequency Division Duplex
FEC	Forward Error Correction
GP	Guard Period
GSM	Global System for Mobile Communication
HARQ	Hybrid ARQ
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	Shared Control Channel for HS-DSCH
HS-SICH	Shared Information Channel for HS-DSCH
MIB	Master Information Block
NRT	Non-Real Time
OVSF	Orthogonal Variable Spreading Factor
P-CCPCH	Primary CCPCH
PCH	Paging Channel
PDSCH	Physical Downlink Shared Channel
PI	Paging Indicator (value calculated by higher layers)
PICH	Page Indicator Channel
P_q	Paging Indicator (indicator set by physical layer)
PRACH	Physical Random Access Channel
PUSCH	Physical Uplink Shared Channel
RACH	Random Access Channel
RF	Radio Frame
RT	Real Time
S-CCPCH	Secondary CCPCH
SCH	Synchronisation Channel
SCTD	Space Code Transmit Diversity
SF	Spreading Factor
SFN	Cell System Frame Number
SS	Synchronisation Shift
TCH	Traffic Channel
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TFI	Transport Format Indicator
TPC	Transmitter Power Control
TrCH	Transport Channel
TSTD	Time Switched Transmit Diversity
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UMTS	Universal Mobil Telecommunications System

UpPTS	Uplink Pilot Time Slot
UpPCH	Uplink Pilot Channel
USCH	Uplink Shared Channel
UTRAN	UMTS Terrestrial Radio Access Network

4 Services offered to higher layers

4.1 Transport channels

Transport channels are the services offered by layer 1 to the higher layers. A transport channel is defined by how and with what characteristics data is transferred over the air interface. A general classification of transport channels is into two groups:

- Dedicated Channels, using inherent addressing of UE
- Common Channels, using explicit addressing of UE if addressing is needed

General concepts about transport channels are described in [12].

4.1.1 Dedicated transport channels

The Dedicated Channel (DCH) is an up- or downlink transport channel that is used to carry user or control information between the UTRAN and a UE.

4.1.2 Common transport channels

There are six types of transport channels: BCH, FACH, PCH, RACH, USCH, DSCH

4.1.2.1 BCH - Broadcast Channel

The Broadcast Channel (BCH) is a downlink transport channel that is used to broadcast system- and cell-specific information.

4.1.2.2 FACH – Forward Access Channel

The Forward Access Channel (FACH) is a downlink transport channel that is used to carry control information to a mobile station when the system knows the location cell of the mobile station. The FACH may also carry short user packets.

4.1.2.3 PCH – Paging Channel

The Paging Channel (PCH) is a downlink transport channel that is used to carry control information to a mobile station when the system does not know the location cell of the mobile station.

4.1.2.4 RACH – Random Access Channel

The Random Access Channel (RACH) is an up link transport channel that is used to carry control information from mobile station. The RACH may also carry short user packets.

4.1.2.5 USCH – Uplink Shared Channel

The uplink shared channel (USCH) is an uplink transport channel shared by several UEs carrying dedicated control or traffic data.

4.1.2.6 DSCH – Downlink Shared Channel

The downlink shared channel (DSCH) is a downlink transport channel shared by several UEs carrying dedicated control or traffic data.

4.1.2.7 HS-DSCH – High Speed Downlink Shared Channel

The High Speed Downlink Shared Channel (HS-DSCH) is a downlink transport channel shared by several UEs. The HS-DSCH is associated with one downlink DPCH, and one or several Shared Control Channels (HS-SCCH). The HS-DSCH is transmitted over the entire cell or over only part of the cell using e.g. beam-forming antennas.

4.2 Indicators

Indicators are means of fast low-level signalling entities which are transmitted without using information blocks sent over transport channels. The meaning of indicators is implicit to the receiver.

The indicator(s) defined in the current version of the specifications are: Paging Indicator.

5 Physical channels for the 3.84 Mcps option

All physical channels take three-layer structure with respect to timeslots, radio frames and system frame numbering (SFN), see [14]. Depending on the resource allocation, the configuration of radio frames or timeslots becomes different. All physical channels need a guard period in every timeslot. The time slots are used in the sense of a TDMA component to separate different user signals in the time domain. The physical channel signal format is presented in figure 1.

A physical channel in TDD is a burst, which is transmitted in a particular timeslot within allocated Radio Frames. The allocation can be continuous, i.e. the time slot in every frame is allocated to the physical channel or discontinuous, i.e. the time slot in a subset of all frames is allocated only. A burst is the combination of two data parts, a midamble part and a guard period. The duration of a burst is one time slot. Several bursts can be transmitted at the same time from one transmitter. In this case, the data parts must use different OVSF channelisation codes, but the same scrambling code. The midamble parts are either identically or differently shifted versions of a cell-specific basic midamble code, see section 5.2.3.

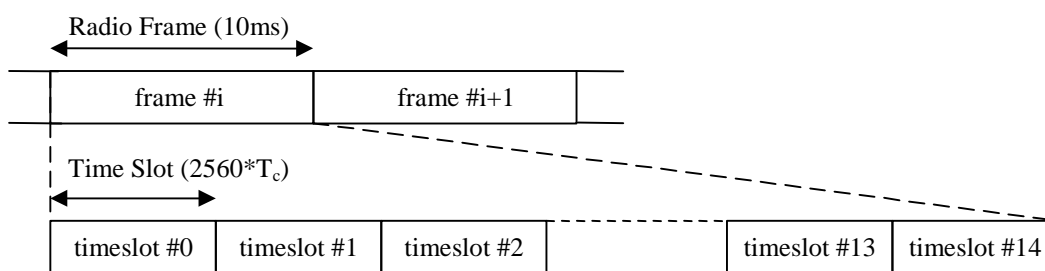


Figure 1: Physical channel signal format

The data part of the burst is spread with a combination of channelisation code and scrambling code. The channelisation code is a OVSF code, that can have a spreading factor of 1, 2, 4, 8, or 16. The data rate of the physical channel is depending on the used spreading factor of the used OVSF code.

The midamble part of the burst can contain two different types of midambles: a short one of length 256 chips, or a long one of 512 chips. The data rate of the physical channel is depending on the used midamble length.

So a physical channel is defined by frequency, timeslot, channelisation code, burst type and Radio Frame allocation. The scrambling code and the basic midamble code are broadcast and may be constant within a cell. When a physical channel is established, a start frame is given. The physical channels can either be of infinite duration, or a duration for the allocation can be defined.

5.1 Frame structure

The TDMA frame has a duration of 10 ms and is subdivided into 15 time slots (TS) of $2560 \cdot T_c$ duration each. A time slot corresponds to 2560 chips. The physical content of the time slots are the bursts of corresponding length as described in subclause 5.2.2.

Each 10 ms frame consists of 15 time slots, each allocated to either the uplink or the downlink (figure 2). With such a flexibility, the TDD mode can be adapted to different environments and deployment scenarios. In any configuration at least one time slot has to be allocated for the downlink and at least one time slot has to be allocated for the uplink.

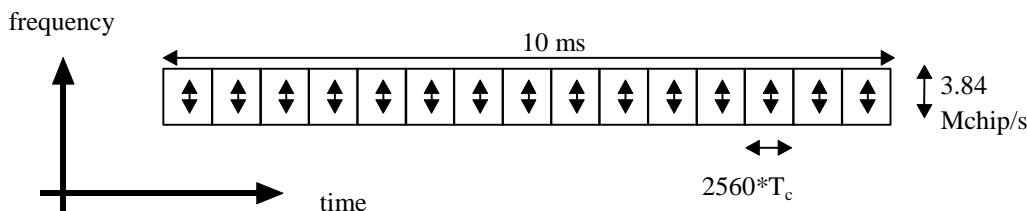


Figure 2: The TDD frame structure

Examples for multiple and single switching point configurations as well as for symmetric and asymmetric UL/DL allocations are given in figure 3.

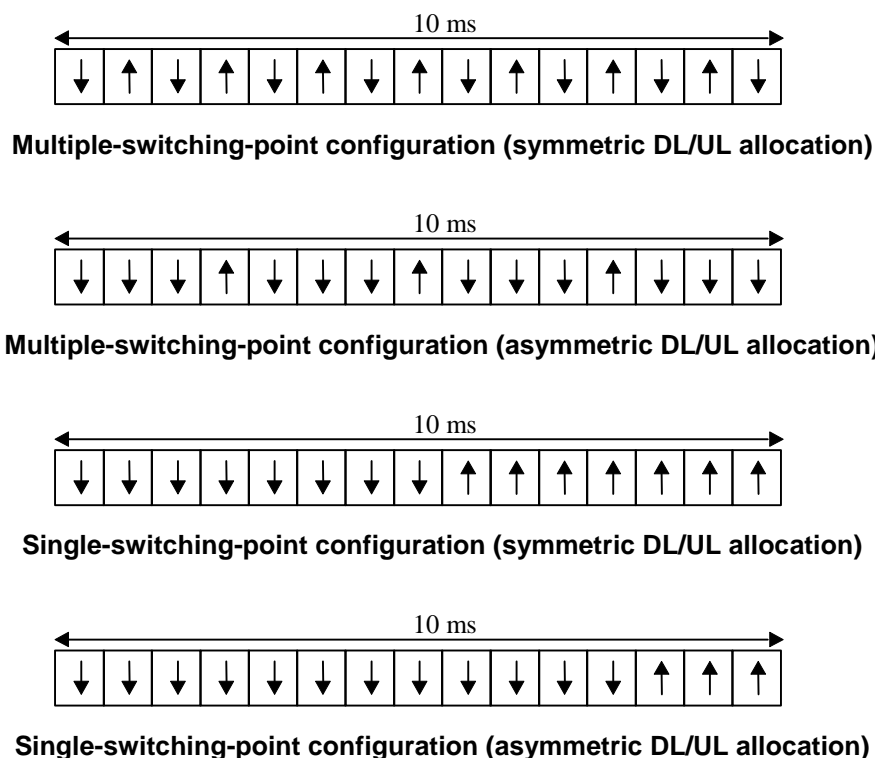


Figure 3: TDD frame structure examples

5.2 Dedicated physical channel (DPCH)

The DCH as described in subclause 4.1.1 is mapped onto the dedicated physical channel.

5.2.1 Spreading

Spreading is applied to the data part of the physical channels and consists of two operations. The first is the channelisation operation, which transforms every data symbol into a number of chips, thus increasing the bandwidth of the signal. The number of chips per data symbol is called the Spreading Factor (SF). The second operation is the scrambling operation, where a scrambling code is applied to the spread signal. Details on channelisation and scrambling operation can be found in [8].

5.2.1.1 Spreading for Downlink Physical Channels

Downlink physical channels shall use SF =16. Multiple parallel physical channels can be used to support higher data rates. These parallel physical channels shall be transmitted using different channelisation codes, see [8]. These codes with SF =16 are generated as described in [8].

Operation with a single code with spreading factor 1 is possible for the downlink physical channels.

5.2.1.2 Spreading for Uplink Physical Channels

The range of spreading factor that may be used for uplink physical channels shall range from 16 down to 1. For each physical channel an individual minimum spreading factor SF_{min} is transmitted by means of the higher layers. There are two options that are indicated by UTRAN:

1. The UE shall use the spreading factor SF_{min} , independent of the current TFC.
2. The UE shall autonomously increase the spreading factor depending on the current TFC.

If the UE autonomously changes the SF, it shall always vary the channelisation code along the lower branch of the allowed OVFSF sub tree, as depicted in [8].

For multicode transmission a UE shall use a maximum of two physical channels per timeslot simultaneously. These two parallel physical channels shall be transmitted using different channelisation codes, see [8].

5.2.2 Burst Types

Three types of bursts for dedicated physical channels are defined. All of them consist of two data symbol fields, a midamble and a guard period, the lengths of which are different for the individual burst types. Thus, the number of data symbols in a burst depends on the SF and the burst type, as depicted in table 1.

Table 1: Number of data symbols (N) for burst type 1, 2, and 3

Spreading factor (SF)	Burst Type 1	Burst Type 2	Burst Type 3
1	1952	2208	1856
2	976	1104	928
4	488	552	464
8	244	276	232
16	122	138	116

The support of all three burst types is mandatory for the UE. The three different bursts defined here are well suited for different applications, as described in the following sections.

5.2.2.1 Burst Type 1

The burst type 1 can be used for uplink and downlink. Due to its longer midamble field this burst type supports the construction of a larger number of training sequences, see 5.2.3. The maximum number of training sequences depend on the cell configuration, see annex A. For the burst type 1 this number may be 4, 8, or 16.

The data fields of the burst type 1 are 976 chips long. The corresponding number of symbols depends on the spreading factor, as indicated in table 1 above. The midamble of burst type 1 has a length of 512 chips. The guard period for the burst type 1 is 96 chip periods long. The burst type 1 is shown in Figure 4. The contents of the burst fields are described in table 2.

Table 2: The contents of the burst type 1 fields

Chip number (CN)	Length of field in chips	Length of field in symbols		Contents of field
0-975	976	Cf table 1		Data symbols
976-1487	512	-		Midamble
1488-2463	976	Cf table 1		Data symbols
2464-2559	96	-		Guard period

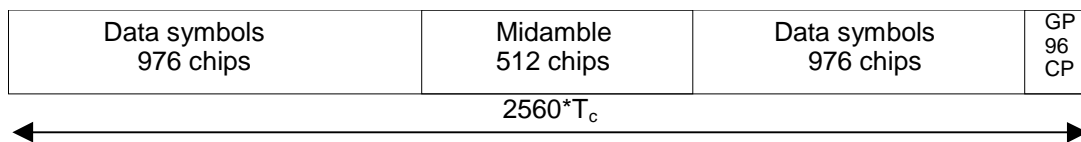


Figure 4: Burst structure of the burst type 1. GP denotes the guard period and CP the chip periods

5.2.2.2 Burst Type 2

The burst type 2 can be used for uplink and downlink. It offers a longer data field than burst type 1 on the cost of a shorter midamble. Due to the shorter midamble field the burst type 2 supports a maximum number of training sequences of 3 or 6 only, depending on the cell configuration, see annex A.

The data fields of the burst type 2 are 1104 chips long. The corresponding number of symbols depends on the spreading factor, as indicated in table 1 above. The guard period for the burst type 2 is 96 chip periods long. The burst type 2 is shown in Figure 5. The contents of the burst fields are described in table 3.

Table 3: The contents of the burst type 2 fields

Chip number (CN)	Length of field in chips	Length of field in symbols		Contents of field
0-1103	1104	cf table 1		Data symbols
1104-1359	256	-		Midamble
1360-2463	1104	cf table 1		Data symbols
2464-2559	96	-		Guard period

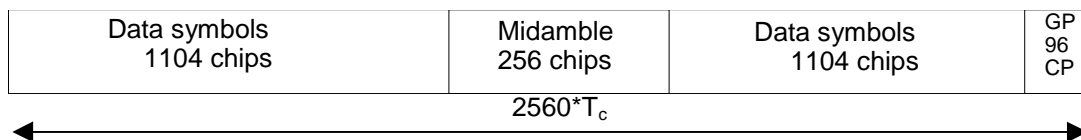


Figure 5: Burst structure of the burst type 2. GP denotes the guard period and CP the chip periods

5.2.2.3 Burst Type 3

The burst type 3 is used for uplink only. Due to the longer guard period it is suitable for initial access or access to a new cell after handover. It offers the same number of training sequences as burst type 1.

The data fields of the burst type 3 have a length of 976 chips and 880 chips, respectively. The corresponding number of symbols depends on the spreading factor, as indicated in table 1 above. The midamble of burst type 3 has a length of 512 chips. The guard period for the burst type 3 is 192 chip periods long. The burst type 3 is shown in Figure 6. The contents of the burst fields are described in table 4.

Table 4: The contents of the burst type 3 fields

Chip number (CN)	Length of field in chips	Length of field in symbols	Contents of field
0-975	976	Cf table 1	Data symbols
976-1487	512	-	Midamble
1488-2367	880	Cf table 1	Data symbols
2368-2559	192	-	Guard period

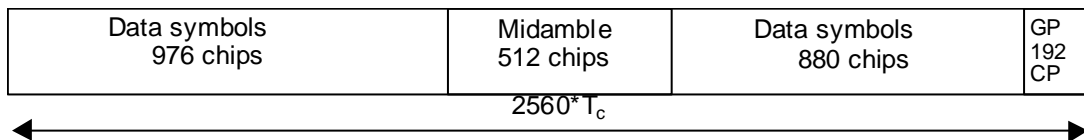


Figure 6: Burst structure of the burst type 3. GP denotes the guard period and CP the chip periods

5.2.2.4 Transmission of TFCI

All burst types 1, 2 and 3 provide the possibility for transmission of TFCI.

The transmission of TFCI is negotiated at call setup and can be re-negotiated during the call. For each CCTrCH it is indicated by higher layer signalling, which TFCI format is applied. Additionally for each allocated timeslot it is signalled individually whether that timeslot carries the TFCI or not. The TFCI is always present in the first timeslot in a radio frame for each CCTrCH. If a time slot contains the TFCI, then it is always transmitted using the first allocated channelisation code in the timeslot, according to the order in the higher layer allocation message.

The transmission of TFCI is done in the data parts of the respective physical channel. In DL the TFCI code word bits and data bits are subject to the same spreading procedure as depicted in [8]. In UL, independent of the SF that is applied to the data symbols in the burst, the data in the TFCI field are always spread with SF=16 using the channelisation code in the lowest branch of the allowed OVSF sub tree, as depicted in [8]. Hence the midamble structure and length is not changed. The TFCI code word is to be transmitted directly adjacent to the midamble, possibly after the TPC. Figure 7 shows the position of the TFCI code word in a traffic burst in downlink. Figure 8 shows the position of the TFCI code word in a traffic burst in uplink.

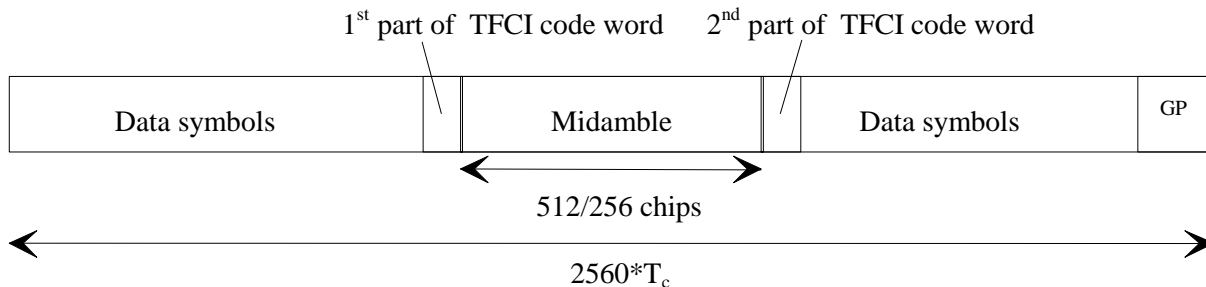


Figure 7: Position of the TFCI code word in the traffic burst in case of downlink

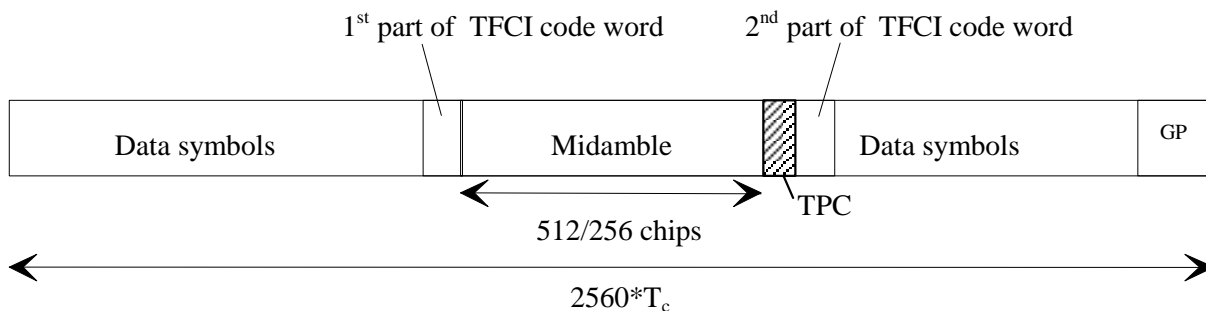


Figure 8: Position of the TFCI code word in the traffic burst in case of uplink

Two examples of TFCI transmission in the case of multiple DPCHs used for a connection are given in the Figure 9 and Figure 10 below. Combinations of the two schemes shown are also applicable.

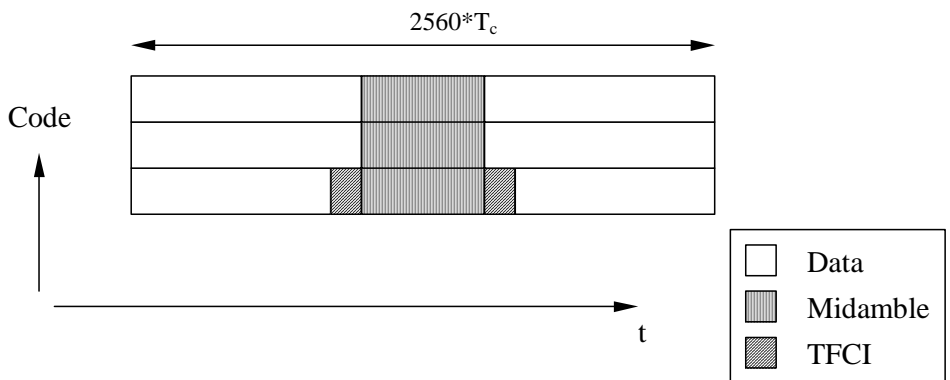


Figure 9: Example of TFCI transmission with physical channels multiplexed in code domain

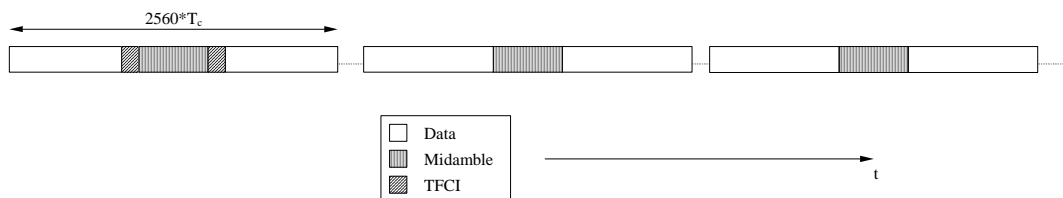


Figure 10: Example of TFCI transmission with physical channels multiplexed in time domain

In case the Node B receives an invalid TFI combination on the DPCHs mapped to one CCTrCH the procedure described in [16] shall be applied. According to this procedure DTX shall be applied to all DPCHs to which the CCTrCH is mapped to.

5.2.2.5 Transmission of TPC

All burst types 1, 2 and 3 for dedicated channels provide the possibility for transmission of TPC in uplink.

The transmission of TPC is done in the data parts of the traffic burst. Independent of the SF that is applied to the data symbols in the burst, the data in the TPC field are always spread with SF=16 using the channelisation code in the lowest branch of the allowed OVSF sub tree, as depicted in [8]. Hence the midamble structure and length is not changed. The TPC information is to be transmitted directly after the midamble. Figure 11 shows the position of the TPC in a traffic burst.

For every user the TPC information shall be transmitted at least once per transmitted frame. If a TFCI is applied for a CCTrCH, TPC shall be transmitted with the same channelization codes and in the same timeslots as the TFCI. If no TFCI is applied for a CCTrCH, TPC shall be transmitted using the first allocated channelisation code and the first allocated timeslot, according to the order in the higher layer allocation message.

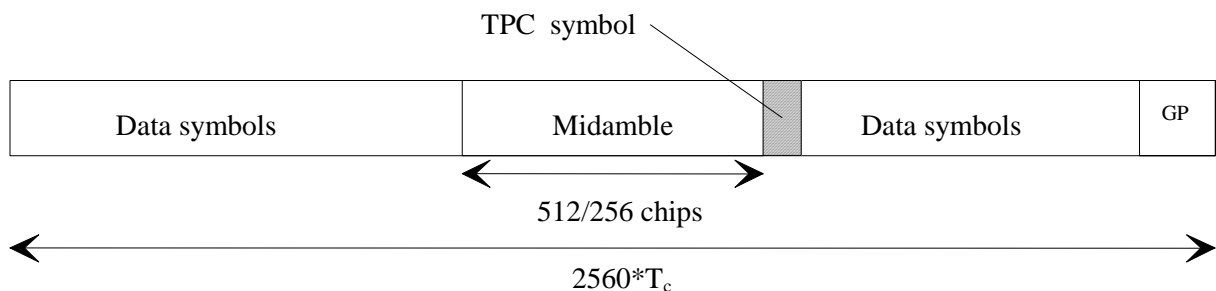


Figure 11: Position of TPC information in the traffic burst

The length of the TPC command is one symbol. The relationship between the TPC symbol and the TPC command is shown in table 4a.

Table 4a: TPC bit pattern

TPC Bits	TPC command	Meaning
00	'Down'	Decrease Tx Power
11	'Up'	Increase Tx Power

5.2.2.6 Timeslot formats

5.2.2.6.1 Downlink timeslot formats

The downlink timeslot format depends on the spreading factor, midamble length and on the number of the TFCI code word bits, as depicted in the table 5a.

Table 5a: Time slot formats for the Downlink

Slot Format #	Spreading Factor	Midamble length (chips)	$N_{\text{TFCI code word}}$ (bits)	Bits/slot	$N_{\text{Data/Slot}}$ (bits)	$N_{\text{data/data field}}$ (bits)
0	16	512	0	244	244	122
1	16	512	4	244	240	120
2	16	512	8	244	236	118
3	16	512	16	244	228	114
4	16	512	32	244	212	106
5	16	256	0	276	276	138
6	16	256	4	276	272	136
7	16	256	8	276	268	134
8	16	256	16	276	260	130
9	16	256	32	276	244	122
10	1	512	0	3904	3904	1952
11	1	512	4	3904	3900	1950
12	1	512	8	3904	3896	1948
13	1	512	16	3904	3888	1944
14	1	512	32	3904	3872	1936
15	1	256	0	4416	4416	2208
16	1	256	4	4416	4412	2206
17	1	256	8	4416	4408	2204
18	1	256	16	4416	4400	2200
19	1	256	32	4416	4384	2192

5.2.2.6.2 Uplink timeslot formats

The uplink timeslot format depends on the spreading factor, midamble length, guard period length and on the number of the TFCI code word bits. Due to TPC, different amount of bits are mapped to the two data fields. The timeslot formats are depicted in the table 5b.

Table 5b: Timeslot formats for the Uplink

Slot Format #	Spreading Factor	Midamble length (chips)	Guard Period (chips)	N _{TFCI} code word (bits)	N _{TPC} (bits)	Bits/slot	N _{Data/Slot} (bits)	N _{data/data field(1)} (bits)	N _{data/data field(2)} (bits)
0	16	512	96	0	0	244	244	122	122
1	16	512	96	0	2	244	242	122	120
2	16	512	96	4	2	244	238	120	118
3	16	512	96	8	2	244	234	118	116
4	16	512	96	16	2	244	226	114	112
5	16	512	96	32	2	244	210	106	104
6	16	256	96	0	0	276	276	138	138
7	16	256	96	0	2	276	274	138	136
8	16	256	96	4	2	276	270	136	134
9	16	256	96	8	2	276	266	134	132
10	16	256	96	16	2	276	258	130	128
11	16	256	96	32	2	276	242	122	120
12	8	512	96	0	0	488	488	244	244
13	8	512	96	0	2	486	484	244	240
14	8	512	96	4	2	482	476	240	236
15	8	512	96	8	2	478	468	236	232
16	8	512	96	16	2	470	452	228	224
17	8	512	96	32	2	454	420	212	208
18	8	256	96	0	0	552	552	276	276
19	8	256	96	0	2	550	548	276	272
20	8	256	96	4	2	546	540	272	268
21	8	256	96	8	2	542	532	268	264
22	8	256	96	16	2	534	516	260	256
23	8	256	96	32	2	518	484	244	240
24	4	512	96	0	0	976	976	488	488
25	4	512	96	0	2	970	968	488	480
26	4	512	96	4	2	958	952	480	472
27	4	512	96	8	2	946	936	472	464
28	4	512	96	16	2	922	904	456	448
29	4	512	96	32	2	874	840	424	416
30	4	256	96	0	0	1104	1104	552	552
31	4	256	96	0	2	1098	1096	552	544
32	4	256	96	4	2	1086	1080	544	536
33	4	256	96	8	2	1074	1064	536	528
34	4	256	96	16	2	1050	1032	520	512
35	4	256	96	32	2	1002	968	488	480
36	2	512	96	0	0	1952	1952	976	976
37	2	512	96	0	2	1938	1936	976	960
38	2	512	96	4	2	1910	1904	960	944
39	2	512	96	8	2	1882	1872	944	928
40	2	512	96	16	2	1826	1808	912	896
41	2	512	96	32	2	1714	1680	848	832
42	2	256	96	0	0	2208	2208	1104	1104
43	2	256	96	0	2	2194	2192	1104	1088
44	2	256	96	4	2	2166	2160	1088	1072
45	2	256	96	8	2	2138	2128	1072	1056
46	2	256	96	16	2	2082	2064	1040	1024
47	2	256	96	32	2	1970	1936	976	960

Slot Format #	Spreading Factor	Midamble length (chips)	Guard Period (chips)	N_{TFCI} code word (bits)	N_{TPC} (bits)	Bits/slot	$N_{\text{Data/Slot}}$ (bits)	$N_{\text{data/data field(1)}}$ (bits)	$N_{\text{data/data field(2)}}$ (bits)
48	1	512	96	0	0	3904	3904	1952	1952
49	1	512	96	0	2	3874	3872	1952	1920
50	1	512	96	4	2	3814	3808	1920	1888
51	1	512	96	8	2	3754	3744	1888	1856
52	1	512	96	16	2	3634	3616	1824	1792
53	1	512	96	32	2	3394	3360	1696	1664
54	1	256	96	0	0	4416	4416	2208	2208
55	1	256	96	0	2	4386	4384	2208	2176
56	1	256	96	4	2	4326	4320	2176	2144
57	1	256	96	8	2	4266	4256	2144	2112
58	1	256	96	16	2	4146	4128	2080	2048
59	1	256	96	32	2	3906	3872	1952	1920
60	16	512	192	0	0	232	232	122	110
61	16	512	192	0	2	232	230	122	108
62	16	512	192	4	2	232	226	120	106
63	16	512	192	8	2	232	222	118	104
64	16	512	192	16	2	232	214	114	100
65	16	512	192	32	2	232	198	106	92
66	8	512	192	0	0	464	464	244	220
67	8	512	192	0	2	462	460	244	216
68	8	512	192	4	2	458	452	240	212
69	8	512	192	8	2	454	444	236	208
70	8	512	192	16	2	446	428	228	200
71	8	512	192	32	2	430	396	212	184
72	4	512	192	0	0	928	928	488	440
73	4	512	192	0	2	922	920	488	432
74	4	512	192	4	2	910	904	480	424
75	4	512	192	8	2	898	888	472	416
76	4	512	192	16	2	874	856	456	400
77	4	512	192	32	2	826	792	424	368
78	2	512	192	0	0	1856	1856	976	880
79	2	512	192	0	2	1842	1840	976	864
80	2	512	192	4	2	1814	1808	960	848
81	2	512	192	8	2	1786	1776	944	832
82	2	512	192	16	2	1730	1712	912	800
83	2	512	192	32	2	1618	1584	848	736
84	1	512	192	0	0	3712	3712	1952	1760
85	1	512	192	0	2	3682	3680	1952	1728
86	1	512	192	4	2	3622	3616	1920	1696
87	1	512	192	8	2	3562	3552	1888	1664
88	1	512	192	16	2	3442	3424	1824	1600
89	1	512	192	32	2	3202	3168	1696	1472

5.2.3 Training sequences for spread bursts

In this subclause, the training sequences for usage as midambles in burst type 1, 2 and 3 (see subclause 5.2.2) are defined. The training sequences, i.e. midambles, of different users active in the same cell and same time slot are cyclically shifted versions of one cell-specific single basic midamble code. The applicable basic midamble codes are

given in Annex A.1 and A.2. As different basic midamble codes are required for different burst formats, the Annex A.1 shows the basic midamble codes \mathbf{m}_{pL} for burst type 1 and 3, and Annex and A.2 shows \mathbf{m}_{pS} for burst type 2. It should be noted that burst type 2 must not be mixed with burst type 1 or 3 in the same timeslot of one cell.

The basic midamble codes in Annex A.1 and A.2 are listed in hexadecimal notation. The binary form of the basic midamble code shall be derived according to table 6 below.

Table 6: Mapping of 4 binary elements m_i on a single hexadecimal digit

4 binary elements m_i	Mapped on hexadecimal digit
-1 -1 -1 -1	0
-1 -1 -1 1	1
-1 -1 1 -1	2
-1 -1 1 1	3
-1 1 -1 -1	4
-1 1 -1 1	5
-1 1 1 -1	6
-1 1 1 1	7
1 -1 -1 -1	8
1 -1 -1 1	9
1 -1 1 -1	A
1 -1 1 1	B
1 1 -1 -1	C
1 1 -1 1	D
1 1 1 -1	E
1 1 1 1	F

For each particular basic midamble code, its binary representation can be written as a vector \mathbf{m}_p :

$$\mathbf{m}_p = (m_1, m_2, \dots, m_p) \quad (1)$$

According to Annex A.1, the size of this vector \mathbf{m}_p is $P=456$ for burst type 1 and 3. Annex A.2 is setting $P=192$ for burst type 2. As QPSK modulation is used, the training sequences are transformed into a complex form, denoted as the complex vector $\underline{\mathbf{m}}_p$:

$$\underline{\mathbf{m}}_p = (\underline{m}_1, \underline{m}_2, \dots, \underline{m}_p) \quad (2)$$

The elements \underline{m}_i of $\underline{\mathbf{m}}_p$ are derived from elements m_i of \mathbf{m}_p using equation (3):

$$\underline{m}_i = (j)^i \cdot m_i \text{ for all } i = 1, \dots, P \quad (3)$$

Hence, the elements \underline{m}_i of the complex basic midamble code are alternating real and imaginary.

To derive the required training sequences (different shifts), this vector $\underline{\mathbf{m}}_p$ is periodically extended to the size:

$$i_{\max} = L_m + (K'-1)W + \lfloor P/K \rfloor \quad (4)$$

Notes on equation (4):

- L_m : Midamble length
- K' : Maximum number of different midamble shifts in a cell, when no intermediate shifts are used. This value depends on the midamble length.
- K : Maximum number of different midamble shifts in a cell, when intermediate shifts are used, $K=2K'$. This value depends on the midamble length.
- W : Shift between the midambles, when the number of midambles is K' .

- $\lfloor x \rfloor$ denotes the largest integer smaller or equal to x

Allowed values for L_m , K' and W are given in Annex A.1 and A.2.

So we obtain a new vector $\underline{\mathbf{m}}$ containing the periodic basic midamble sequence:

$$\underline{\mathbf{m}} = (m_1, m_2, \dots, m_{i_{\max}}) = (m_1, m_2, \dots, m_{L_m + (K'-1)W + \lfloor P/K \rfloor}) \quad (5)$$

The first P elements of this vector $\underline{\mathbf{m}}$ are the same ones as in vector $\underline{\mathbf{m}}_p$, the following elements repeat the beginning:

$$m_i = m_{i-P} \text{ for the subset } i = (P+1), \dots, i_{\max} \quad (6)$$

Using this periodic basic midamble sequence $\underline{\mathbf{m}}$ for each shift k a midamble $\underline{\mathbf{m}}^{(k)}$ of length L_m is derived, which can be written as a shift specific vector:

$$\underline{\mathbf{m}}^{(k)} = (m_1^{(k)}, m_2^{(k)}, \dots, m_{L_m}^{(k)}) \quad (7)$$

The L_m midamble elements $m_i^{(k)}$ are generated for each midamble of the first K' shifts ($k = 1, \dots, K'$) based on:

$$m_i^{(k)} = m_{i+(K'-k)W} \text{ with } i = 1, \dots, L_m \text{ and } k = 1, \dots, K' \quad (8)$$

The elements of midambles for the second K' shifts ($k = (K'+1), \dots, K = (K'+1), \dots, 2K'$) are generated based on a slight modification of this formula introducing intermediate shifts:

$$m_i^{(k)} = m_{i+(K-k-1)W + \lfloor P/K \rfloor} \text{ with } i = 1, \dots, L_m \text{ and } k = K'+1, \dots, K-1 \quad (9)$$

$$m_i^{(k)} = m_{i+(K'-1)W + \lfloor P/K \rfloor} \text{ with } i = 1, \dots, L_m \text{ and } k = K \quad (10)$$

The number K_{Cell} of midambles that is supported in each cell can be smaller than K , depending on the cell size and the possible delay spreads, see annex A. The number K_{Cell} is signalled by higher layers. The midamble sequences derived according to equations (7) to (10) have complex values and are not subject to channelisation or scrambling process, i.e. the elements $m_i^{(k)}$ represent complex chips for usage in the pulse shaping process at modulation.

The term 'a midamble code set' or 'a midamble code family' denotes K specific midamble codes $\underline{\mathbf{m}}^{(k)}$; $k=1, \dots, K$, based on a single basic midamble code $\underline{\mathbf{m}}_p$ according to (1).

5.2.4 Beamforming

When DL beamforming is used, at least that user to which beamforming is applied and which has a dedicated channel shall get one individual midamble according to subclause 5.2.3, even in DL.

5.3 Common physical channels

5.3.1 Primary common control physical channel (P-CCPCH)

The BCH as described in subclause 4.1.2 is mapped onto the Primary Common Control Physical Channel (P-CCPCH). The position (time slot / code) of the P-CCPCH is known from the Physical Synchronisation Channel (PSCH), see subclause 5.3.4.

5.3.1.1 P-CCPCH Spreading

The P-CCPCH uses fixed spreading with a spreading factor $SF = 16$ as described in subclause 5.2.1.1. The P-CCPCH always uses channelisation code $C_{Q=16}^{(k=1)}$.

5.3.1.2 P-CCPCH Burst Types

The burst type 1 as described in subclause 5.2.2 is used for the P-CCPCH. No TFCI is applied for the P-CCPCH.

5.3.1.3 P-CCPCH Training sequences

The training sequences, i.e. midambles, as described in subclause 5.2.3 are used for the P-CCPCH. For those timeslots in which the P-CCPCH is transmitted, the midambles $m^{(1)}$ and $m^{(2)}$ are reserved for P-CCPCH in order to support Space Code transmit Diversity (SCTD) and the beacon function, see 5.4 and 5.5. The use of midambles depends on whether SCTD is applied to the P-CCPCH:

- If no antenna diversity is applied to P-CCPCH, $m^{(1)}$ is used and $m^{(2)}$ is left unused. The maximum number K_{Cell} of midambles in a cell may be 4, 8 or 16.
- If SCTD antenna diversity is applied to P-CCPCH, $m^{(1)}$ is used for the first antenna and $m^{(2)}$ is used for the diversity antenna. The maximum number K_{Cell} of midambles in a cell may be 8 or 16. The case of 4 midambles is not allowed for SCTD.

5.3.2 Secondary common control physical channel (S-CCPCH)

PCH and FACH as described in subclause 4.1.2 are mapped onto one or more secondary common control physical channels (S-CCPCH). In this way the capacity of PCH and FACH can be adapted to the different requirements.

5.3.2.1 S-CCPCH Spreading

The S-CCPCH uses fixed spreading with a spreading factor $SF = 16$ as described in subclause 5.2.1.1.

5.3.2.2 S-CCPCH Burst Types

The burst types 1 or 2 as described in subclause 5.2.2 are used for the S-CCPCHs. TFCI may be applied for S-CCPCHs.

5.3.2.3 S-CCPCH Training sequences

The training sequences, i.e. midambles, as described in subclause 5.2.3 are used for the S-CCPCH.

5.3.3 The physical random access channel (PRACH)

The RACH as described in subclause 4.1.2 is mapped onto one uplink physical random access channel (PRACH).

5.3.3.1 PRACH Spreading

The uplink PRACH uses either spreading factor $SF=16$ or $SF=8$ as described in subclause 5.2.1.2. The set of admissible spreading codes for use on the PRACH and the associated spreading factors are broadcast on the BCH (within the RACH configuration parameters on the BCH).

5.3.3.2 PRACH Burst Type

The UEs send uplink access bursts of type 3 randomly in the PRACH. TFCI and TPC are not applied for the PRACH.

5.3.3.3 PRACH Training sequences

The training sequences, i.e. midambles, of different users active in the same time slot are time shifted versions of a single periodic basic code. The basic midamble codes for burst type 3 are shown in Annex A. The necessary time shifts are obtained by choosing either *all* $k=1,2,3,\dots,K'$ (for cells with small radius) or *uneven* $k=1,3,5,\dots\leq K'$ (for cells with large radius). Different cells use different periodic basic codes, i.e. different midamble sets.

For cells with large radius additional midambles may be derived from the time-inverted Basic Midamble Sequence. Thus, the second Basic Midamble Code m_2 is the time inverted version of Basic Midamble Code m_1 .

In this way, a joint channel estimation for the channel impulse responses of all active users within one time slot can be performed by a maximum of two cyclic correlations (in cells with small radius, a single cyclic correlator suffices). The different user specific channel impulse response estimates are obtained sequentially in time at the output of the cyclic correlators.

5.3.3.4 PRACH timeslot formats

For the PRACH the timeslot format is only spreading factor dependent. The timeslot formats 60 and 66 of table 5b are applicable for the PRACH.

5.3.3.5 Association between Training Sequences and Channelisation Codes

For the PRACH there exists a fixed association between the training sequence and the channelisation code. The generic rule to define this association is based on the order of the channelisation codes $c_Q^{(k)}$ given by k and the order of the midambles $m_j^{(k)}$ given by k , firstly, and j , secondly, with the constraint that the midamble for a spreading factor Q is the same as in the upper branch for the spreading factor $2Q$. The index $j=1$ or 2 indicates whether the original Basic Midamble Sequence ($j=1$) or the time-inverted Basic Midamble Sequence is used ($j=2$).

- For the case that all k are allowed and only one periodic basic code m_1 is available for the RACH, the association depicted in figure 12 is straightforward.
- For the case that only odd k are allowed the principle of the association is shown in figure 13. This association is applied for one and two basic periodic codes.

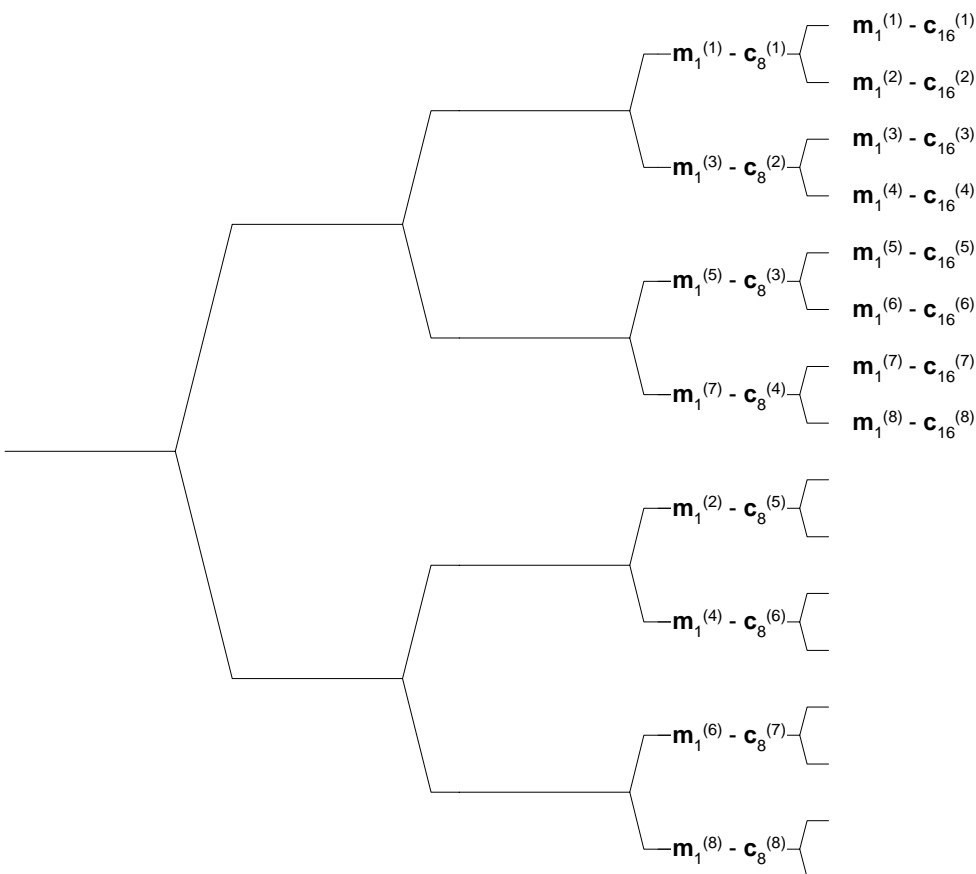


Figure 12: Association of Midambles to Channelisation Codes in the OVSF tree for all k

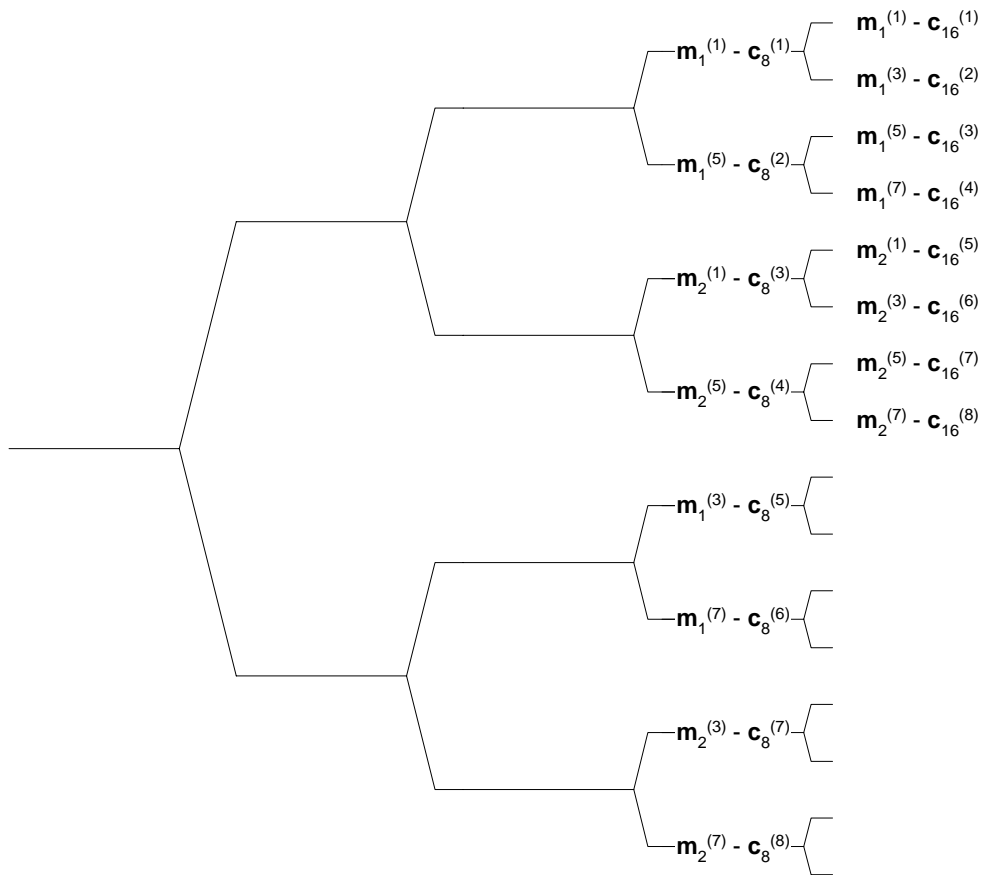


Figure 13: Association of Midambles to Channelisation Codes in the OVSF tree for odd k

5.3.4 The synchronisation channel (SCH)

In TDD mode code group of a cell can be derived from the synchronisation channel. In order not to limit the uplink/downlink asymmetry the SCH is mapped on one or two downlink slots per frame only.

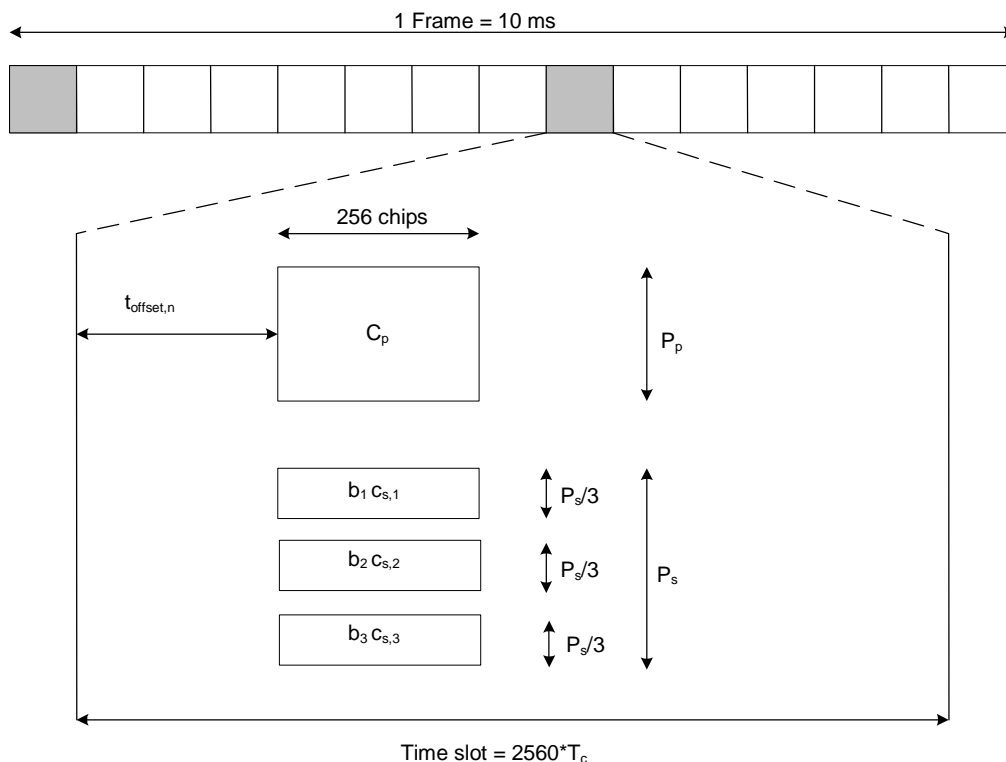
There are two cases of SCH and P-CCPCH allocation as follows:

- Case 1) SCH and P-CCPCH allocated in TS# k , $k=0\dots14$
- Case 2) SCH allocated in two TS: TS# k and TS# $k+8$, $k=0\dots6$; P-CCPCH allocated in TS# k .

The position of SCH (value of k) in frame can change on a long term basis in any case.

Due to this SCH scheme, the position of P-CCPCH is known from the SCH.

Figure 14 is an example for transmission of SCH, $k=0$, of Case 2.



$$b_i \in \{ \pm 1, \pm j \}, C_{s,i} \in \{ C_0, C_1, C_3, C_4, C_5, C_6, C_8, C_{10}, C_{12}, C_{13}, C_{14}, C_{15} \}, i=1,2,3; \text{ see [8]}$$

Figure 14: Scheme for Synchronisation channel SCH consisting of one primary sequence Cp and 3 parallel secondary sequences Cs,i in slot k and k+8 (example for k=0 in Case 2)

As depicted in figure 14, the SCH consists of a primary and three secondary code sequences each 256 chips long. The primary and secondary code sequences are defined in [8] clause 8 ‘Synchronisation codes for the 3.84 Mcps option’.

Due to mobile to mobile interference, it is mandatory for public TDD systems to keep synchronisation between base stations. As a consequence of this, a capture effect concerning SCH can arise. The time offset $t_{\text{offset},n}$ enables the system to overcome the capture effect.

The time offset $t_{\text{offset},n}$ is one of 32 values, depending on the code group of the cell, n, cf. ‘table 6 Mapping scheme for Cell Parameters, Code Groups, Scrambling Codes, Midambles and t_{offset} ’ in [8]. Note that the cell parameter will change from frame to frame, cf. ‘Table 7 Alignment of cell parameter cycling and system frame number’ in [8], but the cell will belong to only one code group and thus have one time offset $t_{\text{offset},n}$. The exact value for $t_{\text{offset},n}$, regarding column ‘Associated t_{offset} ’ in table 6 in [8] is given by:

$$t_{\text{offset},n} = \begin{cases} n \cdot 48 \cdot T_c & n < 16 \\ (720 + n \cdot 48) T_c & n \geq 16 \end{cases}; \quad n = 0, \dots, 31$$

5.3.5 Physical Uplink Shared Channel (PUSCH)

The USCH as described in subclause 4.1.2 is mapped onto one or more physical uplink shared channels (PUSCH). Timing advance, as described in [9], subclause 4.3, is applied to the PUSCH.

5.3.5.1 PUSCH Spreading

The spreading factors that can be applied to the PUSCH are SF = 1, 2, 4, 8, 16 as described in subclause 5.2.1.2.

5.3.5.2 PUSCH Burst Types

Burst types 1, 2 or 3 as described in subclause 5.2.2 can be used for PUSCH. TFCI and TPC can be transmitted on the PUSCH.

5.3.5.3 PUSCH Training Sequences

The training sequences as described in subclause 5.2.3 are used for the PUSCH.

5.3.5.4 UE Selection

The UE that shall transmit on the PUSCH is selected by higher layer signalling.

5.3.6 Physical Downlink Shared Channel (PDSCH)

The DSCH as described in subclause 4.1.2 is mapped onto one or more physical downlink shared channels (PDSCH).

5.3.6.1 PDSCH Spreading

The PDSCH uses either spreading factor $SF = 16$ or $SF = 1$ as described in subclause 5.2.1.1.

5.3.6.2 PDSCH Burst Types

Burst types 1 or 2 as described in subclause 5.2.2 can be used for PDSCH. TFCI can be transmitted on the PDSCH.

5.3.6.3 PDSCH Training Sequences

The training sequences as described in subclause 5.2.3 are used for the PDSCH.

5.3.6.4 UE Selection

To indicate to the UE that there is data to decode on the DSCH, three signalling methods are available:

- 1) using the TFCI field of the associated channel or PDSCH;
- 2) using on the DSCH user specific midamble derived from the set of midambles used for that cell;
- 3) using higher layer signalling.

When the midamble based method is used, the UE specific midamble allocation method shall be employed (see subclause 5.6), and the UE shall decode the PDSCH if the PDSCH was transmitted with the midamble assigned to the UE by UTRAN. For this method no other physical channels may use the same time slot as the PDSCH and only one UE may share the PDSCH time slot within one TTI.

Note: From the above mentioned signalling methods, only the higher layer signalling method is supported by higher layers in Release 4.

5.3.7 The Paging Indicator Channel (PICH)

The Paging Indicator Channel (PICH) is a physical channel used to carry the paging indicators.

5.3.7.1 Mapping of Paging Indicators to the PICH bits

Figure 15 depicts the structure of a PICH burst and the numbering of the bits within the burst. The same burst type is used for the PICH in every cell. N_{PIB} bits in a normal burst of type 1 or 2 are used to carry the paging indicators, where N_{PIB} depends on the burst type: $N_{PIB}=240$ for burst type 1 and $N_{PIB}=272$ for burst type 2. The bits $s_{N_{PIB}+1}, \dots, s_{N_{PIB}+4}$ adjacent to the midamble are reserved for possible future use.

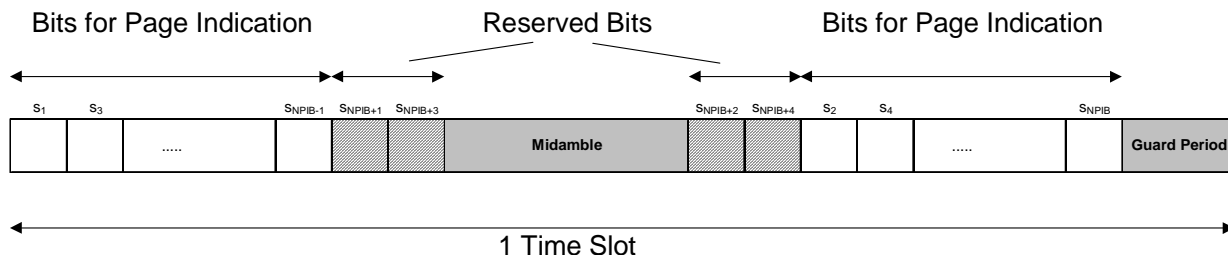


Figure 15: Transmission and numbering of paging indicator carrying bits in a PICH burst

Each paging indicator P_q in one time slot is mapped to the bits $\{s_{2L_{PI} \cdot q+1}, \dots, s_{2L_{PI} \cdot (q+1)}\}$ within this time slot. Thus, due to the interleaved transmission of the bits half of the symbols used for each paging indicator are transmitted in the first data part, and the other half of the symbols are transmitted in the second data part, as exemplary shown in figure 16 for a paging indicator length L_{PI} of 4 symbols.

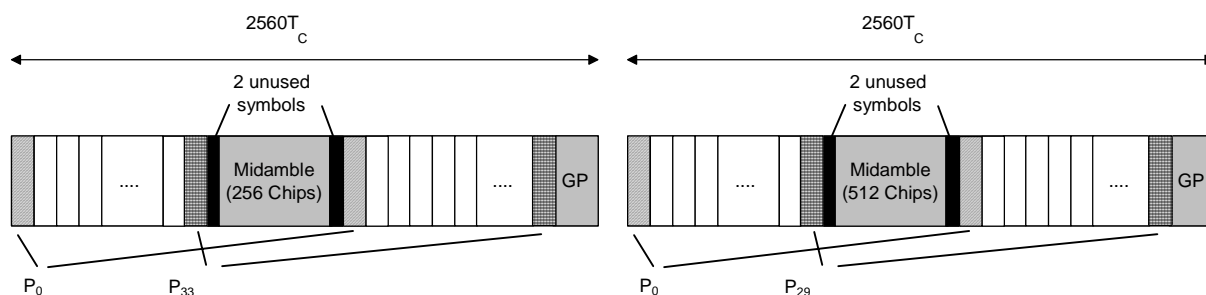


Figure 16: Example of mapping of paging indicators on PICH bits for $L_{PI}=4$

The setting of the paging indicators and the corresponding PICH bits (including the reserved ones) is described in [7].

In each radio frame, N_{PI} paging indicators are transmitted, using $L_{PI}=2$, $L_{PI}=4$ or $L_{PI}=8$ symbols. The number of paging indicators N_{PI} per radio frame is given by the paging indicator length and the burst type, which are both known by higher layer signalling. In table 7 this number is shown for the different possibilities of burst types and paging indicator lengths.

Table 7: Number N_{PI} of paging indicators per time slot for the different burst types and paging indicator lengths L_{PI}

	$L_{PI}=2$	$L_{PI}=4$	$L_{PI}=8$
Burst Type 1	$N_{PI}=60$	$N_{PI}=30$	$N_{PI}=15$
Burst Type 2	$N_{PI}=68$	$N_{PI}=34$	$N_{PI}=17$

5.3.7.2 Structure of the PICH over multiple radio frames

As shown in figure 17, the paging indicators of N_{PICH} consecutive frames form a PICH block, N_{PICH} is configured by higher layers. Thus, $N_P=N_{PICH} \cdot N_{PI}$ paging indicators are transmitted in each PICH block.

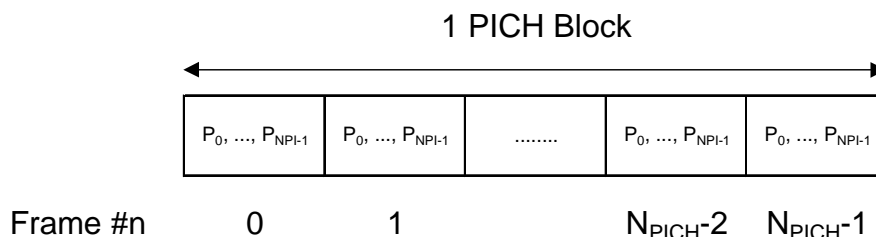


Figure 17: Structure of a PICH block

The value PI ($PI = 0, \dots, N_P - 1$) calculated by higher layers for use for a certain UE, see [15], is associated to the paging indicator P_q in the n th frame of one PICH block, where q is given by

$$q = PI \bmod N_{PI}$$

and n is given by

$$n = PI \operatorname{div} N_{PI}$$

The PI bitmap in the PCH data frames over I_{ub} contains indication values for all possible higher layer PI values, see [17]. Each bit in the bitmap indicates if the paging indicator P_q associated with that particular PI shall be set to 0 or 1. Hence, the calculation in the formulas above is to be performed in Node B to make the association between PI and P_q .

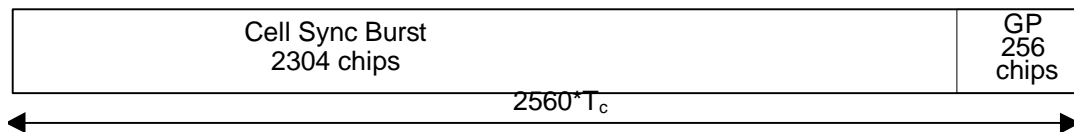
5.3.7.3 PICH Training sequences

The training sequences, i.e. midambles for the PICH, are generated as described in subclause 5.2.3. The allocation of midambles depends on whether SCTD is applied to the PICH.

- If no antenna diversity is applied to the PICH the midambles can be allocated as described in subclause 5.6.
- If SCTD antenna diversity is applied to the PICH the allocation of midambles shall be as described in [9].

5.3.8 The physical node B synchronisation channel (PNBSCH)

In case cell sync bursts are used for Node B synchronisation the PNBSCH shall be used for the transmission of the cell sync burst [8]. The PNBSCH shall be mapped on the same timeslot as the PRACH acc. to a higher layer schedule. The cell sync burst shall be transmitted at the beginning of a timeslot. In case of Node B synchronisation via the air interface the transmission of a RACH may be prohibited on higher layer command in specified frames and timeslots.



5.3.9 High Speed Physical Downlink Shared Channel (HS-PDSCH)

The HS-DSCH as described in subclause 4.1.2 is mapped onto one or more high speed physical downlink shared channels (HS-PDSCH).

5.3.9.1 HS-PDSCH Spreading

The HS-PDSCH shall use either spreading factor $SF = 16$ or $SF = 1$, as described in 5.2.1.1.

5.3.9.2 HS-PDSCH Burst Types

Burst types 1 or 2 as described in subclause 5.2.2 can be used for PDSCH. TFCI shall not be transmitted on the HS-PDSCH. The TF of the HS-DSCH is derived from the associated HS-SCCH.

5.3.9.3 HS-PDSCH Training Sequences

The training sequences as described in subclause 5.2.3 are used for the HS-PDSCH.

5.3.9.4 UE Selection

To indicate to the UE that there is data to decode on the HS-DSCH, the UE id on the associated HS-SCCH shall be used.

5.3.9.5 HS-PDSCH timeslot formats

An HS-PDSCH may use QPSK or 16QAM modulation symbols. The time slot formats are shown in table XX.

Table XX: Time slot formats for the HS-PDSCH

Slot Format #	Spreading Factor	Midamble length (chips)	N _{TFCI} code word (bits)	Bits/slot	N _{Data/Slot} (bits)	N _{data/data field} (bits)
0 (QPSK)	16	512	0	244	244	122
1 (16QAM)	16	512	0	488	488	244
2 (QPSK)	16	256	0	276	276	138
3 (16QAM)	16	256	0	552	552	276
4 (QPSK)	1	512	0	3904	3904	1952
5 (16QAM)	1	512	0	7808	7808	3904
6 (QPSK)	1	256	0	4416	4416	2208
7(16QAM)	1	256	0	8832	8832	4416

5.3.10 Shared Control Channel for HS-DSCH (HS-SCCH)

The HS-SCCH is a DL physical channel that carries higher layer control information for HS-DSCH. The physical layer will process this information according to [7] and will transmit the resulting bits on the HS-SCCH the structure of which is described below.

5.3.10.1 HS-SCCH Spreading

The HS-SCCH shall use spreading factor SF = 16, as described in 5.2.1.1.

5.3.10.2 HS-SCCH Burst Types

Burst type 1 as described in subclause 5.2.2 can be used for HS-SCCH. TFCI shall not be transmitted on the HS-SCCH.

5.3.10.3 HS-SCCH Training Sequences

The training sequences as described in subclause 5.2.3 are used for the HS-SCCH.

5.3.10.4 HS-SCCH timeslot formats

The HS-SCCH always uses time slot format #0 from table 5a, see section 5.2.2.6.1.

5.3.11 Shared Information Channel for HS-DSCH (HS-SICH)

The HS-SICH is a UL physical channel that carries higher layer control information and the Channel Quality Indicator CQI for HS-DSCH. The physical layer will process this information according to [7] and will transmit the resulting bits on the HS-SICH the structure of which is described below.

5.3.11.1 HS-SICH Spreading

The HS-SICH shall use spreading factor SF = 16, as described in 5.2.1.2.

5.3.11.2 HS-SICH Burst Types

Burst types 1 or 2 as described in subclause 5.2.2 can be used for HS-SICH. TFCI shall not be transmitted on the HS-SICH, however, the HS-SICH shall carry TPC information.

5.3.11.3 HS-SICH Training Sequences

The training sequences as described in subclause 5.2.3 are used for the HS-SICH.

5.3.11.4 HS-SICH timeslot formats

The HS-SICH may use time slot format #1 or #7 from table 5b, see section 5.2.2.6.2.

5.4 Transmit Diversity for DL Physical Channels

Table 8 summarizes the different transmit diversity schemes for different downlink physical channel types that are described in [9].

Table 8: Application of Tx diversity schemes on downlink physical channel types
"X" – can be applied, "-" – must not be applied

Physical channel type	Open loop TxDiversity		Closed loop TxDiversity
	TSTD	SCTD	
P-CCPCH	–	X	–
SCH	X	–	–
DPCH	–	–	X
PDSCH	–	–	X
PICH	–	X	–

5.5 Beacon characteristics of physical channels

For the purpose of measurements, physical channels at particular locations (time slot, code) shall have particular physical characteristics, called beacon characteristics. Physical channels with beacon characteristics are called beacon channels. The locations of the beacon channels are called beacon locations. The ensemble of beacon channels shall provide the beacon function, i.e. a reference power level at the beacon locations, regularly existing in each radio frame. Thus, beacon channels must be present in each radio frame, the only exception is when idle periods are used to support time difference measurements for location services [9]. Then it may be possible that the beacon channels occur in the same frame and time slot as the idle periods. In this case, the beacon channels will not be transmitted in that particular frame and time slot.

5.5.1 Location of beacon channels

The beacon locations are determined by the SCH and depend on the SCH allocation case, see subclause 5.3.4:

- Case 1) The beacon function shall be provided by the physical channels that are allocated to channelisation code $c_{Q=16}^{(k=1)}$ and to TS#k, k=0,...,14.
- Case 2) The beacon function shall be provided by the physical channels that are allocated to channelisation code $c_{Q=16}^{(k=1)}$ and to TS#k and TS#k+8, k=0,...,6.

Note that by this definition the P-CCPCH always has beacon characteristics.

5.5.2 Physical characteristics of beacon channels

The beacon channels shall have the following physical characteristics. They:

- are transmitted with reference power;
- are transmitted without beamforming;
- use burst type 1;
- use midamble $m^{(1)}$ and $m^{(2)}$ exclusively in this time slot; and
- midambles $m^{(9)}$ and $m^{(10)}$ are always left unused in this time slot, if 16 midambles are allowed in that cell.

Note that in the time slot where the P-CCPCH is transmitted only the midambles $m^{(1)}$ to $m^{(8)}$ shall be used, see 5.6.1. Thus, midambles $m^{(9)}$ and $m^{(10)}$ are always left unused in this time slot.

The reference power corresponds to the sum of the power allocated to both midambles $m^{(1)}$ and $m^{(2)}$. Two possibilities exist:

- If no SCTD antenna diversity is applied to the P-CCPCH and PICH all the reference power of any beacon channel is allocated to $m^{(1)}$.
- If SCTD antenna diversity is applied to the P-CCPCH and PICH for any beacon channel midambles $m^{(1)}$ and $m^{(2)}$ are each allocated half of the reference power. Midamble $m^{(1)}$ is used for the first antenna and $m^{(2)}$ is used for the diversity antenna. SCTD is applied to the P-CCPCH and PICH, see [9]; for all other beacon channels identical spread data sequences are transmitted on both antennas.

5.6 Midamble Allocation for Physical Channels

Midambles are part of the physical channel configuration which is performed by higher layers. Three different midamble allocation schemes exist:

- UE specific midamble allocation: A UE specific midamble for DL or UL is explicitly assigned by higher layers.
- Default midamble allocation: The midamble for DL or UL is allocated by layer 1 depending on the associated channelisation code.
- Common midamble allocation: The midamble for the DL is allocated by layer 1 depending on the number of channelisation codes currently being present in the DL time slot.

If a midamble is not explicitly assigned and the use of the common midamble allocation scheme is not signalled by higher layers, the midamble shall be allocated by layer 1, based on the default midamble allocation scheme. This default midamble allocation scheme is given by a fixed association between midambles and channelisation codes, see clause A.3, and shall be applied individually to all channelisation codes within one time slot. Different associations apply for different burst types and cell configurations with respect to the maximum number of midambles.

5.6.1 Midamble Allocation for DL Physical Channels

Beacon channels shall always use the reserved midambles $m^{(1)}$ and $m^{(2)}$, see 5.5. For DL physical channels that are located in the same time slot as the P-CCPCH, midambles shall be allocated based on the default midamble allocation scheme, using the association for burst type 1 and $K_{\text{Cell}}=8$ midambles. For all other DL physical channels, the midamble is explicitly assigned by higher layers or allocated by layer 1.

5.6.1.1 Midamble Allocation by signalling from higher layers

UE specific midambles may be signalled by higher layers to UE's as a part of the physical channel configuration, if:

- multiple UEs use the physical channels in one DL time slot; and
- beamforming is applied to all of these DL physical channels; and
- no closed loop TxDiversity is applied to any of these DL physical channels;

or

- PDSCH physical layer signalling based on the midamble is used.

5.6.1.2 Midamble Allocation by layer 1

5.6.1.2.1 Default midamble

If a midamble is not explicitly assigned and the use of the common midamble allocation scheme is not signalled by higher layers, the UE shall derive the midambles from the allocated channelisation codes and shall use an individual midamble for each channelisation code group containing one primary and a set of secondary channelisation codes. The association between midambles and channelisation code groups is given in annex A.3. All the secondary channelisation codes within a set use the same midamble as the primary channelisation code to which they are associated.

Higher layers shall allocate the channelisation codes in a particular order. Primary channelisation codes shall be allocated prior to associated secondary channelisation codes. If midambles are reserved for the beacon channels, all primary and secondary channelisation codes that are associated with the reserved midambles shall not be used.

Channelisation codes of one channelisation code group shall not be allocated to different UE's.

In the case that secondary channelisation codes are used, secondary channelisation codes of one set shall be allocated in ascending order, with respect to their numbering.

The UE shall assume different channel estimates for each of the individual midambles.

The default midamble allocation shall not apply for those downlink channels that are intended for a UE which will be the only UE assigned to a given time slot or slots for the duration of the assigned channel's existence (as in the case of high rate services).

5.6.1.2.2 Common Midamble

The use of the common midamble allocation scheme is signalled to the UE by higher layers as a part of the physical channel configuration. A common midamble may be assigned by layer 1 to all physical channels in one DL time slot, if:

- a single UE uses all physical channels in one DL time slot (as in the case of high rate service);

or

- multiple UEs use the physical channels in one DL time slot; and
- no beamforming is applied to any of these DL physical channels; and
- no closed loop TxDiversity is applied to any of these DL physical channels; and
- midambles are not used for PDSCH physical layer signalling.

The number of channelisation codes currently employed in the DL time slot is associated with the use of a particular common midamble. Different associations apply for different burst types and cell configurations with respect to the maximum number of midambles, see annex C.

5.6.2 Midamble Allocation for UL Physical Channels

If the midamble is explicitly assigned by higher layers, an individual midamble shall be assigned to all UE's in one UL time slot.

If no midamble is explicitly assigned by higher layers, the UE shall derive the midamble from the channelisation code that is used for the data part (except for TFCI/TPC) of the burst. The associations between midamble and channelisation code are the same as for DL physical channels.

5.7 Midamble Transmit Power

There shall be no offset between the sum of the powers allocated to all midambles in a timeslot and the sum of the powers allocated to the data symbol fields. The transmit power within a timeslot is hence constant.

The midamble transmit power of beacon channels is equal to the reference power. If SCTD is used for the P-CCPCH, the reference power is equally divided between the midambles $m^{(1)}$ and $m^{(2)}$.

The midamble transmit power of all other physical channels depends on the midamble allocation scheme used. The following rules apply

- In case of Default Midamble Allocation, every midamble is transmitted with the same power as the associated codes.
- In case of Common Midamble Allocation in the downlink, the transmit power of this common midamble is such that there is no power offset between the data parts and the midamble part of the overall transmit signal within one time slot.

- In case of UE Specific Midamble Allocation, the transmit power of the UE specific midamble is such that there is no power offset between the data parts and the midamble part of every user within one time slot.

The following figure 18 depicts the midamble powers for the different channel types and midamble allocation schemes.

Note 1: In figure 18, the codes $c(1)$ to $c(16)$ represent the set of usable codes and not the set of used codes.

Note 2: The common midamble allocation and the midamble allocation by higher layers are not applicable in those beacon time slots, in which the P-CCPCH is located, see section 5.6.1.

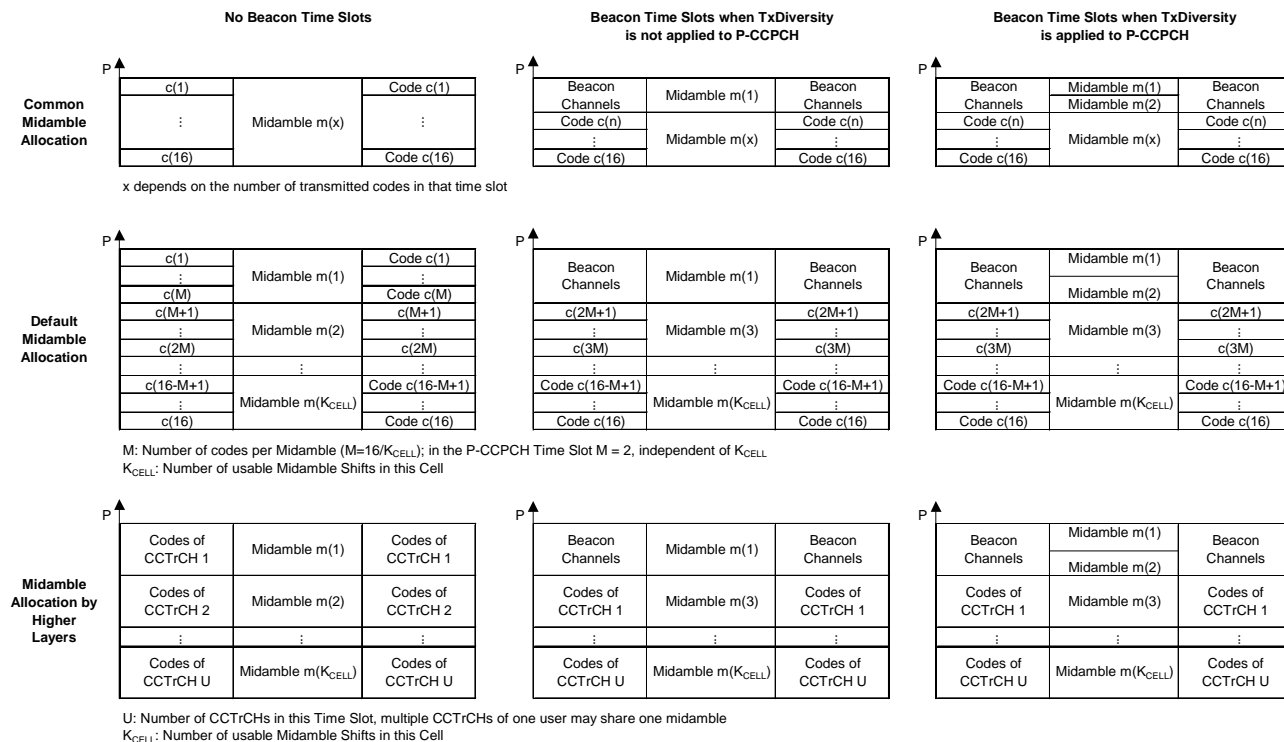


Figure 18: Midamble powers for the different midamble allocation schemes

6 Physical channels for the 1.28 Mcps option

All physical channels take three-layer structure with respect to timeslots, radio frames and system frame numbering (SFN), see [14]. Depending on the resource allocation, the configuration of radio frames or timeslots becomes different. All physical channels need guard symbols in every timeslot. The time slots are used in the sense of a TDMA component to separate different user signals in the time and the code domain. The physical channel signal format for 1.28Mcps TDD is presented in figure 19.

A physical channel in TDD is a burst, which is transmitted in a particular timeslot within allocated Radio Frames. The allocation can be continuous, i.e. the time slot in every frame is allocated to the physical channel or discontinuous, i.e. the time slot in a subset of all frames is allocated only. A burst is the combination of a data part, a midamble and a guard period. The duration of a burst is one time slot. Several bursts can be transmitted at the same time from one transmitter. In this case, the data part must use different OVFSF channelisation codes, but the same scrambling code. The midamble part has to use the same basic midamble code, but can use different midambles.

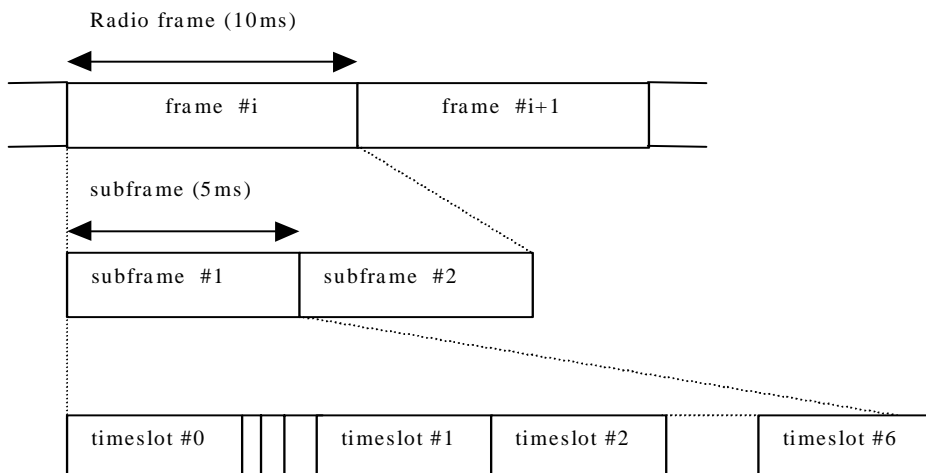


Figure 19: Physical channel signal format for 1.28Mcps TDD option

The data part of the burst is spread with a combination of channelisation code and scrambling code. The channelisation code is a OVSF code, that can have a spreading factor of 1, 2, 4, 8, or 16. The data rate of the physical channel is depending on the used spreading factor of the used OVSF code.

So a physical channel is defined by frequency, timeslot, channelisation code, burst type and Radio Frame allocation. The scrambling code and the basic midamble code are broadcast and may be constant within a cell. When a physical channel is established, a start frame is given. The physical channels can either be of infinite duration, or a duration for the allocation can be defined.

6.1 Frame structure

The TDMA frame has a duration of 10 ms and is divided into 2 sub-frames of 5ms. The frame structure for each sub-frame in the 10ms frame length is the same.

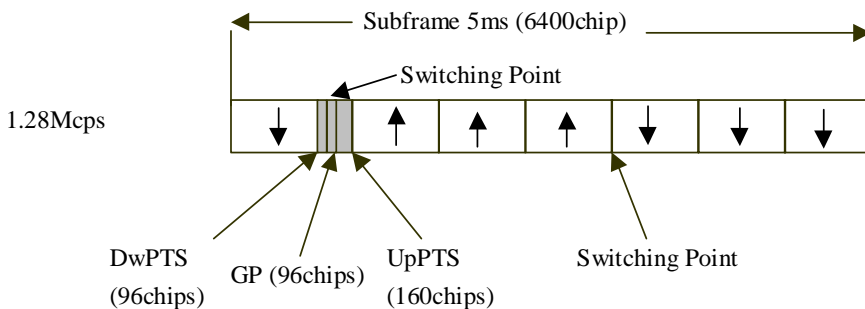


Figure 20: Structure of the sub-frame for 1.28Mcps TDD option

Time slot#n (n from 0 to 6): the nth traffic time slot, 864 chips duration;

DwPTS: downlink pilot time slot, 96 chips duration;

UpPTS: uplink pilot time slot, 160 chips duration;

GP: main guard period for TDD operation, 96 chips duration;

In Figure 20, the total number of traffic time slots for uplink and downlink is 7, and the length for each traffic time slot is 864 chips duration. Among the 7 traffic time slots, time slot#0 is always allocated as downlink while time slot#1 is always allocated as uplink. The time slots for the uplink and the downlink are separated by switching points. Between

the downlink time slots and uplink time slots, the special period is the switching point to separate the uplink and downlink. In each sub-frame of 5ms for 1.28Mcps option, there are two switching points (uplink to downlink and vice versa).

Using the above frame structure, the 1.28Mcps TDD option can operate on both symmetric and asymmetric mode by properly configuring the number of downlink and uplink time slots. In any configuration at least one time slot (time slot#0) has to be allocated for the downlink and at least one time slot has to be allocated for the uplink (time slot#1).

Examples for symmetric and asymmetric UL/DL allocations are given in figure 21.

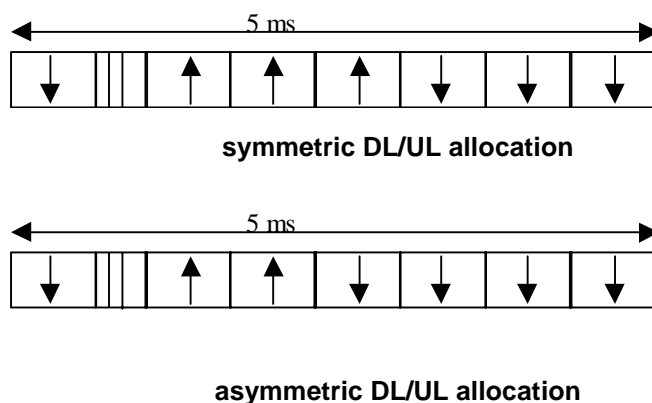


Figure 21: 1.28Mcps TDD sub-frame structure examples

6.2 Dedicated physical channel (DPCH)

The DCH as described in subclause 4.1 'Dedicated transport channels' is mapped onto the dedicated physical channel.

6.2.1 Spreading

The spreading of physical channels is the same as in 3.84 Mcps TDD (cf. 5.2.1 'Spreading').

6.2.2 Burst Format

A traffic burst consists of two data symbol fields, a midamble of 144 chips and a guard period. The data fields of the burst are 352 chips long. The corresponding number of symbols depends on the spreading factor, as indicated in table 9 below. The guard period is 16 chip periods long.

The burst format is shown in Figure 22. The contents of the traffic burst fields is described in table 10.

Table 9: number of symbols per data field in a traffic burst

Spreading factor (Q)	Number of symbols (N) per data field in Burst
1	352
2	176
4	88
8	44
16	22

Table 10: The contents of the traffic burst format fields

Chip number (CN)	Length of field in chips	Length of field in symbols	Contents of field
0-351	352	cf table 9	Data symbols
352-495	144	-	Midamble
496-847	352	cf table 9	Data symbols
848-863	16	-	Guard period

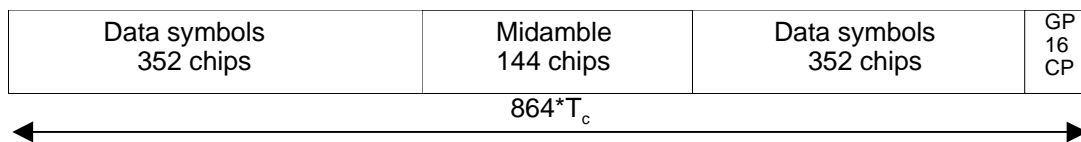


Figure 22: Burst structure of the traffic burst format (GP denotes the guard period and CP the chip periods)

6.2.2.1 Transmission of TFCI

The traffic burst format provides the possibility for transmission of TFCI in uplink and downlink.

The transmission of TFCI is configured by higher Layers. For each CCTrCH it is indicated by higher layer signalling, which TFCI format is applied. Additionally for each allocated timeslot it is signalled individually whether that timeslot carries the TFCI or not. If a time slot contains the TFCI, then it is always transmitted using the first allocated channelisation code in the timeslot, according to the order in the higher layer allocation message.

The transmission of TFCI is done in the data parts of the respective physical channel, this means that TFCI code word bits and data bits are subject to the same spreading procedure as depicted in [8]. Hence the midamble structure and length is not changed.

The TFCI code word bits are equally distributed between the two subframes and the respective data fields. The TFCI code word is to be transmitted possibly either directly adjacent to the midamble or after the SS and TPC symbols. Figure 23 shows the position of the TFCI code word in a traffic burst, if neither SS nor TPC are transmitted. Figure 24 shows the position of the TFCI code word in a traffic burst, if SS and TPC are transmitted.

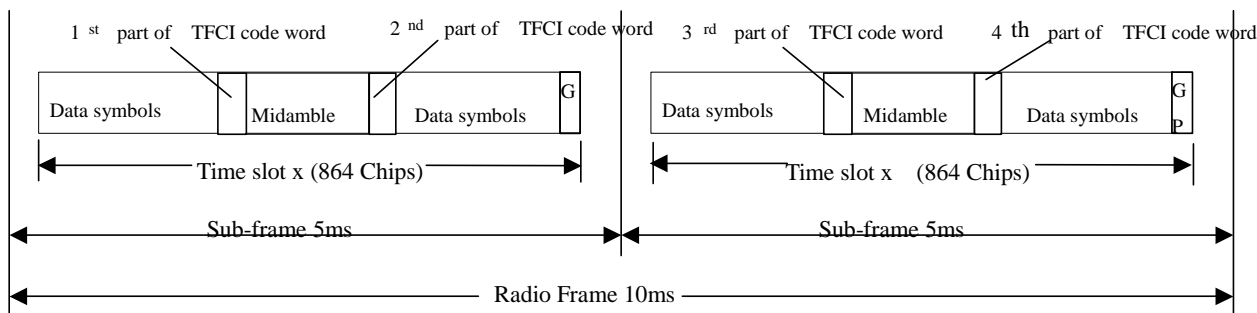


Figure 23: Position of the TFCI code word in the traffic burst in case of no TPC and SS in 1.28 Mcps TDD

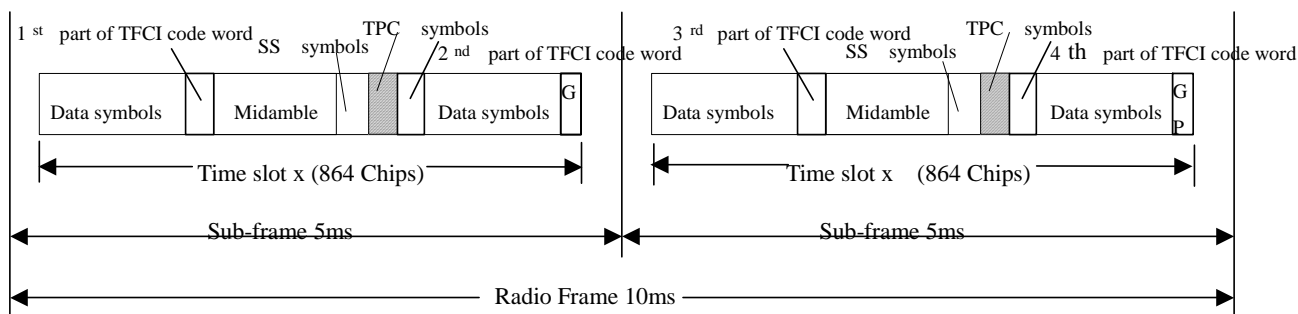


Figure 24: Position of the TFCI code word in the traffic burst in case of TPC and SS in 1.28 Mcps TDD

6.2.2.2 Transmission of TPC

The burst type for dedicated channels provides the possibility for transmission of TPC in uplink and downlink.

The transmission of TPC is done in the data parts of the traffic burst. Hence the midamble structure and length is not changed. The TPC information is to be transmitted directly after the SS information, which is transmitted after the midamble. Figure 25 shows the position of the TPC command in a traffic burst.

For every user the TPC information is to be transmitted at least once per 5ms sub-frame. If applied, transmission of TPC is done in the data parts of the traffic burst and it can be transmitted using the first allocated channelisation code and the first allocated timeslot (according to the order in the higher layer allocation message). Other allocations (more than one TPC transmission in one sub-frame) of TPC are also possible. The TPC is spread with the same spreading factor (SF) and spreading code as the data parts of the respective physical channel.

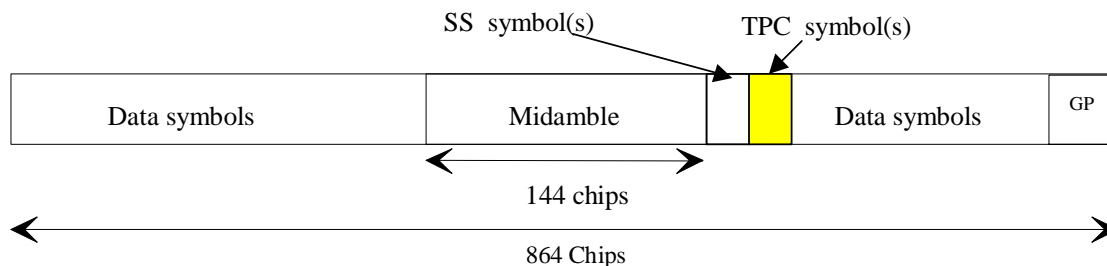


Figure 25: Position of TPC information in the traffic burst in downlink and uplink

For the number of layer 1 symbols per channelisation code there are 3 possibilities for each channelisation code, configured by higher layers:

- 1) one SS and one TPC symbol
- 2) no SS and no TPC symbols
- 3) 16/SF SS and 16/SF TPC symbols

So, in case 3), when SF=1, there are 16 TPC symbols which correspond to 32 bits (for QPSK) and 48 bits (for 8PSK).

In the following the uplink is described only. For the description of the downlink, downlink (DL) and uplink (UL) have to be interchanged.

Each of the TPC symbols for uplink power control in the DL will be associated with an UL time slot and an UL CCTrCH pair. This association varies with

- the number of allocated UL time slots and UL CCTrCHs on these time slots (time slot and CCTrCH pair) and
- the allocated TPC symbols in the DL.

In case a UE has

- more than one channelisation code

and/or

- channelisation codes being of lower spreading factor than 16 and using 16/SF SS and 16/SF TPC symbols,

the TPC commands for each ULtime slot CCTrCH pair (all channelisation codes on that time slot belonging to the same time slot and CCTrCH pair have the same TPC command) will be distributed to the following rules:

1. The ULtime slots and CCTrCH pairs the TPC commands are intended for will be numbered from the first to the last ULtime slot and CCTrCH pair allocated to the regarded UE (starting with 0). The number of a time slot and CCTrCH pair is smaller than the number of another time slot and CCTrCH pair within the same time slot if its spreading code with the lowest SC number according to the following table has a lower SC number than the spreading code with the lowest SC number of the other time slot and CCTrCH pair.
2. The commanding TPC symbols on all DL CCTrCHs allocated to one UE are numbered consecutively starting with zero according to the following rules:
 - a) The numbers of the TPC commands of a regarded DL time slot are lower than those of DL time slots being transmitted after that time slot
 - b) Within a DL time slot the numbers of the TPC commands of a regarded channelisation code are lower than those of channelisation codes having a higher spreading code number

The spreading code number is defined by the following table (see[8]):

SC number	SF (Q)	Walsh code number (k)
0	16	$\mathbf{c}_{Q=16}^{(k=1)}$
	...	
15	16	$\mathbf{c}_{Q=16}^{(k=16)}$
16	8	$\mathbf{c}_{Q=8}^{(k=1)}$
	...	
23	8	$\mathbf{c}_{Q=8}^{(k=8)}$
24	4	$\mathbf{c}_{Q=4}^{(k=1)}$
	...	
27	4	$\mathbf{c}_{Q=4}^{(k=4)}$
28	2	$\mathbf{c}_{Q=2}^{(k=1)}$
29	2	$\mathbf{c}_{Q=2}^{(k=2)}$
30	1	$\mathbf{c}_{Q=1}^{(k=1)}$

Note: Spreading factors 2-8 are not used in DL

- c) Within a channelisation code numbers of the TPC commands are lower than those of TPC commands being transmitted after that time

The following equation is used to determine the UL time slot which is controlled by the regarded TPC symbol in the DL:

$$UL_{pos} = (SFN' \cdot N_{UL_TPCsymbols} + TPC_{DLpos}) \bmod(N_{ULslot}),$$

where

UL_{pos} is the number of the controlled uplink time slot and CCTrCH pairs.

SFN' is the system frame number counting the sub-frames. The system frame number of the radio frames (SFN) can be derived from SFN' by

$SFN = SFN' \text{ div } 2$, where div is the remainder free division operation.

$N_{UL_PCsymbols}$ is the number of UL TPC symbols in a sub-frame.

TPC_{DLpos} is the number of the regarded UL TPC symbol in the DL within the sub-frame.

N_{ULslot} is the number of UL slots and CCTrCH pairs in a frame.

In Annex G two examples of the association of TPC commands to time slots and CCTrCH pairs are shown.

Coding of TPC:

The relationship between the TPC Bits and the transmitter power control command for QPSK is the same as in the 3.84Mcps TDD cf. [5.2.2.5 'Transmission of TPC'].

The relationship between the TPC Bits and the transmitter power control command for 8PSK is given in table 11

Table 11: TPC Bit Pattern for 8PSK

TPC Bits	TPC command	Meaning
000	'Down'	Decrease Tx Power
110	'Up'	Increase Tx Power

6.2.2.3 Transmission of SS

The burst type for dedicated channels provides the possibility for transmission of uplink synchronisation control (ULSC).

The transmission of ULSC is done in the data parts of the traffic burst. Hence the midamble structure and length is not changed. The ULSC information is to be transmitted directly after the midamble. Figure 26 shows the position of the SS command in a traffic burst.

For every user the ULSC information shall be transmitted at least once per transmitted sub-frame. By default the following rules apply:

1. If a TFCI is applied for a CCTrCH, the SS command(s) shall be transmitted using the same channelisation code and the same timeslots as the TFCI.
2. If no TFCI is applied for a CCTrCH, the SS command(s) shall be transmitted using the first allocated channelisation code and the first allocated timeslot, according to the order in the higher layer allocation message.

Apart from the default rules other allocations of SS commands are possible according higher layer signalling – e.g. the transmission of more than one SS command (on more than one time slot).

The SS command is spread with the same spreading factor (SF) and spreading code as the data parts of the respective physical channel.

The SS is utilised to command a timing adjustment by $(k/8) T_c$ each M sub-frames, where T_c is the chip period. The k and M values are signalled by the network. The SS, as one of L1 signals, is to be transmitted once per 5ms sub-frame.

M (1-8) and k (1-8) can be adjusted during call setup or readjusted during the call.

Note: The smallest step for the SS signalled by the UTRAN is $1/8 T_c$. For the UE capabilities regarding the SS adjustment of the UE it is suggested to set the tolerance for the executed command to be $[1/9; 1/7] T_c$.

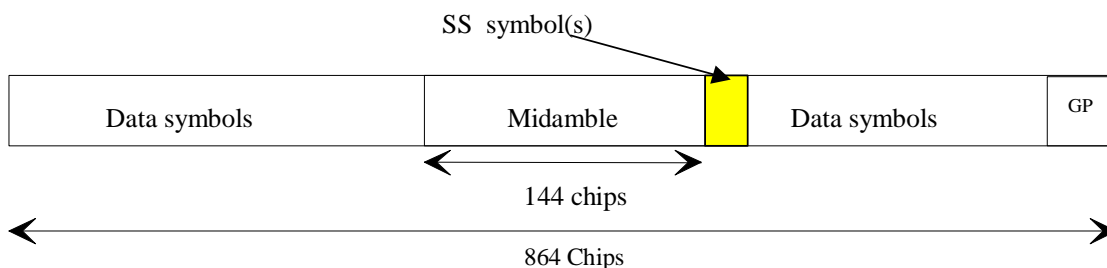


Figure 26: Position of ULSC information in the traffic burst (downlink and uplink)

Note that for the uplink where there is no SS symbol used, the SS symbol space is reserved for future use. This can keep UL and DL slots the same structure.

For the number of layer 1 symbols there are 3 possibilities configurable for each channelisation code during the call setup:

- one SS symbol
- no SS symbol
- $16/SF$ SS symbols

So, in case 3, when $SF=1$, there are 16 SS symbols which correspond to 32 bits (for QPSK) and 48 bits (for 8PSK).

Each of the SS symbols in the DL will be associated with an UL time slot depending on the allocated UL time slots and the allocated SS symbols in the DL.

Note: Even though the different time slots of the UE are controlled with independent SS commands, the UE is not in need to execute SS commands leading to a deviation of more than [3] chip with respect to the average timing advance applied by the UE.

The synchronisation shift commands for each UL time slot (all channelisation codes on that time slot have the same SS command) will be distributed to the following rules:

1. The UL time slots the SS commands are intended for will be numbered from the first to the last UL time slot occupied by the regarded UE (starting with 0) considering all CCTrCHs allocated to that UE.
2. The commanding SS symbols on all downlink CCTrCHs allocated to one UE are numbered consecutively starting with zero according to the following rules:
 - a) The numbers of the SS commands of a regarded DL time slot are lower than those of DL time slots being transmitted after that time slot
 - b) Within a DL time slot the numbers of the SS commands of a regarded channelisation code are lower than those of channelisation codes having a bigger spreading code number

The spreading code number is defined by the following table: (see TS 25.223)

Spreading code number	SF (Q)	Walsh code number (k)
0	16	$c_{Q=16}^{(k=1)}$
	...	
15	16	$c_{Q=16}^{(k=16)}$
	Spreading factors 2-8 are not used in DL	
30	1	$c_{Q=1}^{(k=1)}$

- c) Within a channelisation code numbers of the SS commands are lower than those of SS commands being transmitted after that time

The following equation is used to determine the UL time slot which is controlled by the regarded SS symbol:

$$UL_{pos} = (SFN' \cdot N_{SSymbols} + SS_{pos}) \bmod (N_{ULslot}),$$

where

UL_{pos} is the number of the controlled uplink time slot.

SFN' is the system frame number counting the sub-frames. The system frame number of the radio frames (SFN) can be derived from SFN' by

$SFN = SFN' \text{ div } 2$, where div is the remainder free division operation.

$N_{SSymbols}$ is the number of SS symbols in a frame.

SS_{pos} is the number of the regarded SS symbol within the sub-frame.

N_{ULslot} is the number of UL slots in a frame.

The relationship between the SS Bits and the SS command for QPSK is the given in table 12:

Table 12: Coding of the SS for QPSK

SS Bits	SS command	Meaning
00	'Down'	Decrease synchronisation shift by $k/8 T_c$
11	'Up'	Increase synchronisation shift by $k/8 T_c$
01	'Do nothing'	No change

The relationship between the SS Bits and the SS command for 8PSK is given in table 13:

Table 13: Coding of the SS for 8PSK

SS Bits	SS command	Meaning
000	'Down'	Decrease synchronisation shift by $k/8 T_c$
110	'Up'	Increase synchronisation shift by $k/8 T_c$
011	'Do nothing'	No change

6.2.2.4 Timeslot formats

The timeslot format depends on the spreading factor, the number of the TFCI code word bits, the number of SS and TPC symbols and the applied modulation scheme (QPSK/8PSK) as depicted in the following tables.

6.2.2.4.1 Timeslot formats for QPSK

6.2.2.4.1.1 Downlink timeslot formats

Table 14 : Time slot formats for the Downlink

Slot Format #	Spreading Factor	Midamble length (chips)	N _{TFCI} code word (bits)	N _{SS} & N _{TPC} (bits)	Bits/slot	N _{Data/Slot} (bits)	N _{data/data} field(1) (bits)	N _{data/data} field(2) (bits)
0	16	144	0	0 & 0	88	88	44	44
1	16	144	4	0 & 0	88	86	42	44
2	16	144	8	0 & 0	88	84	42	42
3	16	144	16	0 & 0	88	80	40	40
4	16	144	32	0 & 0	88	72	36	36
5	16	144	0	2 & 2	88	84	44	40
6	16	144	4	2 & 2	88	82	42	40
7	16	144	8	2 & 2	88	80	42	38
8	16	144	16	2 & 2	88	76	40	36
9	16	144	32	2 & 2	88	68	36	32
10	1	144	0	0 & 0	1408	1408	704	704
11	1	144	4	0 & 0	1408	1406	702	704
12	1	144	8	0 & 0	1408	1404	702	702
13	1	144	16	0 & 0	1408	1400	700	700
14	1	144	32	0 & 0	1408	1392	696	696
15	1	144	0	2 & 2	1408	1404	704	700
16	1	144	4	2 & 2	1408	1402	702	700
17	1	144	8	2 & 2	1408	1400	702	698
18	1	144	16	2 & 2	1408	1396	700	696
19	1	144	32	2 & 2	1408	1388	696	692
20	1	144	0	32 & 32	1408	1344	704	640
21	1	144	4	32 & 32	1408	1342	702	640
22	1	144	8	32 & 32	1408	1340	702	638
23	1	144	16	32 & 32	1408	1336	700	636
24	1	144	32	32 & 32	1408	1328	696	632

6.2.2.4.1.2

Uplink timeslot formats

Table 15 : Time slot formats for the Uplink

Slot Format #	Spreading Factor	Midamble length (chips)	N _{TFCI} code word (bits)	N _{SS} & N _{TPC} (bits)	Bits/slot	N _{Data/Slot} (bits)	N _{data/data} field(1) (bits)	N _{data/data} field(2) (bits)
0	16	144	0	0 & 0	88	88	44	44
1	16	144	4	0 & 0	88	86	42	44
2	16	144	8	0 & 0	88	84	42	42
3	16	144	16	0 & 0	88	80	40	40
4	16	144	32	0 & 0	88	72	36	36
5	16	144	0	2 & 2	88	84	44	40
6	16	144	4	2 & 2	88	82	42	40
7	16	144	8	2 & 2	88	80	42	38
8	16	144	16	2 & 2	88	76	40	36
9	16	144	32	2 & 2	88	68	36	32
10	8	144	0	0 & 0	176	176	88	88
11	8	144	4	0 & 0	176	174	86	88
12	8	144	8	0 & 0	176	172	86	86
13	8	144	16	0 & 0	176	168	84	84
14	8	144	32	0 & 0	176	160	80	80
15	8	144	0	2 & 2	176	172	88	84
16	8	144	4	2 & 2	176	170	86	84
17	8	144	8	2 & 2	176	168	86	82
18	8	144	16	2 & 2	176	164	84	80
19	8	144	32	2 & 2	176	156	80	76
20	8	144	0	4 & 4	176	168	88	80
21	8	144	4	4 & 4	176	166	86	80
22	8	144	8	4 & 4	176	164	86	78
23	8	144	16	4 & 4	176	160	84	76
24	8	144	32	4 & 4	176	152	80	72
25	4	144	0	0 & 0	352	352	176	176
26	4	144	4	0 & 0	352	350	174	176
27	4	144	8	0 & 0	352	348	174	174
28	4	144	16	0 & 0	352	344	172	172
29	4	144	32	0 & 0	352	336	168	168
30	4	144	0	2 & 2	352	348	176	172
31	4	144	4	2 & 2	352	346	174	172
32	4	144	8	2 & 2	352	344	174	170
33	4	144	16	2 & 2	352	340	172	168
34	4	144	32	2 & 2	352	332	168	164
35	4	144	0	8 & 8	352	336	176	160
36	4	144	4	8 & 8	352	334	174	160
37	4	144	8	8 & 8	352	332	174	158
38	4	144	16	8 & 8	352	328	172	156
39	4	144	32	8 & 8	352	320	168	152
40	2	144	0	0 & 0	704	704	352	352
41	2	144	4	0 & 0	704	702	350	352
42	2	144	8	0 & 0	704	700	350	350
43	2	144	16	0 & 0	704	696	348	348
44	2	144	32	0 & 0	704	688	344	344
45	2	144	0	2 & 2	704	700	352	348
46	2	144	4	2 & 2	704	698	350	348

Slot Format #	Spreading Factor	Midamble length (chips)	N _{TFCI} code word (bits)	N _{SS} & N _{TPC} (bits)	Bits/slot	N _{Data/Slot} (bits)	N _{data/data field(1)} (bits)	N _{data/data field(2)} (bits)
47	2	144	8	2 & 2	704	696	350	346
48	2	144	16	2 & 2	704	692	348	344
49	2	144	32	2 & 2	704	684	344	340
50	2	144	0	16 & 16	704	672	352	320
51	2	144	4	16 & 16	704	670	350	320
52	2	144	8	16 & 16	704	668	350	318
53	2	144	16	16 & 16	704	664	348	316
54	2	144	32	16 & 16	704	656	344	312
55	1	144	0	0 & 0	1408	1408	704	704
56	1	144	4	0 & 0	1408	1406	702	704
57	1	144	8	0 & 0	1408	1404	702	702
58	1	144	16	0 & 0	1408	1400	700	700
59	1	144	32	0 & 0	1408	1392	696	696
60	1	144	0	2 & 2	1408	1404	704	700
61	1	144	4	2 & 2	1408	1402	702	700
62	1	144	8	2 & 2	1408	1400	702	698
63	1	144	16	2 & 2	1408	1396	700	696
64	1	144	32	2 & 2	1408	1388	696	692
65	1	144	0	32 & 32	1408	1344	704	640
66	1	144	4	32 & 32	1408	1342	702	640
67	1	144	8	32 & 32	1408	1340	702	638
68	1	144	16	32 & 32	1408	1336	700	636
69	1	144	32	32 & 32	1408	1328	696	632

6.2.2.4.2 Time slot formats for 8PSK

The Downlink and the Uplink timeslot formats are described together in the following table.

Table 16: Timeslot formats for 8PSK modulation

Slot Format #	Spreading Factor	Midamble length (chips)	N _{TFCI} code word (bits)	N _{SS} & N _{TPC} (bits)	Bits/slot	N _{Data/Slot} (bits)	N _{data/data field(1)} (bits)	N _{data/data field(2)} (bits)
0	1	144	0	0 & 0	2112	2112	1056	1056
1	1	144	6	0 & 0	2112	2109	1053	1056
2	1	144	12	0 & 0	2112	2106	1053	1053
3	1	144	24	0 & 0	2112	2100	1050	1050
4	1	144	48	0 & 0	2112	2088	1044	1044
5	1	144	0	3 & 3	2112	2106	1056	1050
6	1	144	6	3 & 3	2112	2103	1053	1050
7	1	144	12	3 & 3	2112	2100	1053	1047
8	1	144	24	3 & 3	2112	2094	1050	1044
9	1	144	48	3 & 3	2112	2082	1044	1038
10	1	144	0	48 & 48	2112	2016	1056	960
11	1	144	6	48 & 48	2112	2013	1053	960
12	1	144	12	48 & 48	2112	2010	1053	957
13	1	144	24	48 & 48	2112	2004	1050	954
14	1	144	48	48 & 48	2112	1992	1044	948
15	16	144	0	0 & 0	132	132	66	66
16	16	144	6	0 & 0	132	129	63	66
17	16	144	12	0 & 0	132	126	63	63
18	16	144	24	0 & 0	132	120	60	60
19	16	144	48	0 & 0	132	108	54	54
20	16	144	0	3 & 3	132	126	66	60
21	16	144	6	3 & 3	132	123	63	60
22	16	144	12	3 & 3	132	120	63	57
23	16	144	24	3 & 3	132	114	60	54
24	16	144	48	3 & 3	132	102	54	48

6.2.3 Training sequences for spread bursts

In this subclause, the training sequences for usage as midambles are defined. The training sequences, i.e. midambles, of different users active in the same cell and same time slot are cyclically shifted versions of one single basic midamble code. The applicable basic midamble codes are given in Annex B.1.

The basic midamble codes in Annex B.1 are listed in hexadecimal notation. The binary form of the basic midamble code shall be derived according to table 17 below.

Table 17: Mapping of 4 binary elements m_i on a single hexadecimal digit:

4 binary elements m_i	Mapped on hexadecimal digit
-1 -1 -1 -1	0
-1 -1 -1 1	1
-1 -1 1 -1	2
-1 -1 1 1	3
-1 1 -1 -1	4
-1 1 -1 1	5
-1 1 1 -1	6
-1 1 1 1	7
1 -1 -1 -1	8
1 -1 -1 1	9
1 -1 1 -1	A
1 -1 1 1	B
1 1 -1 -1	C
1 1 -1 1	D
1 1 1 -1	E
1 1 1 1	F

For each particular basic midamble code, its binary representation can be written as a vector \mathbf{m}_p :

$$\mathbf{m}_p = (m_1, m_2, \dots, m_p) \quad (1)$$

According to Annex B.1, the size of this vector \mathbf{m}_p is $P=128$. As QPSK modulation is used, the training sequences are transformed into a complex form, denoted as the complex vector $\underline{\mathbf{m}}_p$:

$$\underline{\mathbf{m}}_p = (\underline{m}_1, \underline{m}_2, \dots, \underline{m}_p) \quad (2)$$

The elements \underline{m}_i of $\underline{\mathbf{m}}_p$ are derived from elements m_i of \mathbf{m}_p using equation (3):

$$\underline{m}_i = (j)^i \cdot m_i \text{ for all } i = 1, \dots, P \quad (3)$$

Hence, the elements \underline{m}_i of the complex basic midamble code are alternating real and imaginary.

To derive the required training sequences, this vector $\underline{\mathbf{m}}_p$ is periodically extended to the size:

$$i_{\max} = L_m + (K - 1)W \quad (4)$$

Notes on equation (4):

K and W are taken from Annex B.1

So we obtain a new vector $\underline{\mathbf{m}}$ containing the periodic basic midamble sequence:

$$\underline{\mathbf{m}} = (\underline{m}_1, \underline{m}_2, \dots, \underline{m}_{i_{\max}}) = (\underline{m}_1, \underline{m}_2, \dots, \underline{m}_{L_m + (K-1)W}) \quad (5)$$

The first P elements of this vector $\underline{\mathbf{m}}$ are the same ones as in vector $\underline{\mathbf{m}}_p$, the following elements repeat the beginning:

$$\underline{m}_i = \underline{m}_{i-P} \text{ for the subset } i = (P + 1), \dots, i_{\max} \quad (6)$$

Using this periodic basic midamble sequence $\underline{\mathbf{m}}$ for each user k a midamble $\underline{\mathbf{m}}^{(k)}$ of length L_m is derived, which can be written as a user specific vector:

$$\underline{\mathbf{m}}^{(k)} = (\underline{m}_1^{(k)}, \underline{m}_2^{(k)}, \dots, \underline{m}_{L_m}^{(k)}) \quad (7)$$

The L_m midamble elements $\underline{m}_i^{(k)}$ are generated for each midamble of the k users ($k = 1, \dots, K$) based on:

$$\underline{m}_i^{(k)} = \underline{m}_{i+(K-k)W} \text{ with } i = 1, \dots, L_m \text{ and } k = 1, \dots, K \quad (8)$$

The midamble sequences derived according to equations (7) to (8) have complex values and are not subject to channelisation or scrambling process, i.e. the elements $\underline{m}_i^{(k)}$ represent complex chips for usage in the pulse shaping process at modulation.

The term 'a midamble code set' or 'a midamble code family' denotes K specific midamble codes $\underline{\mathbf{m}}^{(k)}$; $k=1, \dots, K$, based on a single basic midamble code $\underline{\mathbf{m}}_p$ according to (1).

6.2.4 Beamforming

Beamforming is same as that of the 3.84Mcps TDD, cf. [5.2.4 Beamforming].

6.3 Common physical channels

6.3.1 Primary common control physical channel (P-CCPCH)

The BCH as described in section 4.1.2 'Common Transport Channels' is mapped onto the Primary Common Control Physical Channels (P-CCPCH1 and P-CCPCH2). The position (time slot / code) of the P-CCPCHs is fixed in the 1.28Mcps TDD. The P-CCPCHs are mapped onto the first two code channels of timeslot#0 with spreading factor of 16. The P-CCPCH is always transmitted with an antenna pattern configuration that provides whole cell coverage.

6.3.1.1 P-CCPCH Spreading

The P-CCPCH uses fixed spreading with a spreading factor $SF = 16$. The P-CCPCH1 and P-CCPCH2 always use channelisation code $c_{Q=16}^{(k=1)}$ and $c_{Q=16}^{(k=2)}$ respectively.

6.3.1.2 P-CCPCH Burst Format

The burst format as described in section 6.2.2 is used for the P-CCPCH. No TFCI is applied for the P-CCPCH.

6.3.1.3 P-CCPCH Training sequences

The training sequences, i.e. midambles, as described in subclause 6.2.3 are used for the P-CCPCH. For timeslots#0 in which the P-CCPCH is transmitted, the midambles $m^{(1)}$ and $m^{(2)}$ are reserved for P-CCPCH in order to support Space Code Transmit Diversity (SCTD) and the beacon function, see 6.4 and 6.5. The use of midambles depends on whether SCTD is applied to the P-CCPCH:

- If no antenna diversity is applied to P-CCPCH, $m^{(1)}$ is used and $m^{(2)}$ is left unused.
- If SCTD antenna diversity is applied to P-CCPCH, $m^{(1)}$ is used for the first antenna and $m^{(2)}$ is used for the diversity antenna.

6.3.2 Secondary common control physical channel (S-CCPCH)

PCH and FACH as described in subclause 4.1.2 are mapped onto one or more secondary common control physical channels (S-CCPCH). In this way the capacity of PCH and FACH can be adapted to the different requirements. The time slot and codes used for the S-CCPCH are broadcast on the BCH.

6.3.2.1 S-CCPCH Spreading

The S-CCPCH uses fixed spreading with a spreading factor $SF = 16$. The S-CCPCHs (S-CCPCH 1 and S-CCPCH 2) are always used in pairs, mapped onto two code channels with spreading factor 16. There can be more than one pair of S-CCPCHs in use in one cell.

6.3.2.2 S-CCPCH Burst Format

The burst format as described in section 6.2.2 is used for the S-CCPCH. TFCI may be applied for S-CCPCHs.

6.3.2.3 S-CCPCH Training sequences

The training sequences, i.e. midambles, as described in the subclause 6.2.3 are also used for the S-CCPCH.

6.3.3 Fast Physical Access CHannel (FPACH)

The Fast Physical Access CHannel (FPACH) is used by the Node B to carry, in a single burst, the acknowledgement of a detected signature with timing and power level adjustment indication to a user equipment. FPACH makes use of one code with spreading factor 16, so that its burst is composed by 44 symbols. The spreading code, training sequence and time slot position are configured by the network and signalled on the BCH.

6.3.3.1 FPACH burst

The FPACH burst contains 32 information bits. Table 18 reports the content description of the FPACH information bits and their priority order:

Table 18: FPACH information bits description

Information field	Length (in bits)
Signature Reference Number	3 (MSB)
Relative Sub-Frame Number	2
Received starting position of the UpPCH (UpPCH _{POS})	11
Transmit Power Level Command for RACH message	7
Reserved bits (default value: 0)	9 (LSB)

In the use and generation of the information fields is explained in [9].

6.3.3.1.1 Signature Reference Number

The reported number corresponds to the numbering principle for the cell signatures as described in [8].

The Signature Reference Number value range is 0 – 7 coded in 3 bits such that:

bit sequence(0 0 0) corresponds to the first signature of the cell; ...; bit sequence (1 1 1) corresponds to the 8th signature of the cell.

6.3.3.1.2 Relative Sub-Frame Number

The Relative Sub-Frame Number value range is 0 – 3 coded such that:

bit sequence (0 0) indicates one sub-frame difference; ...; bit sequence (1 1) indicates 4 sub-frame difference.

6.3.3.1.3 Received starting position of the UpPCH (UpPCH_{POS})

The received starting position of the UpPCH value range is 0 – 2047 coded such that:

bit sequence (0 0 ... 0 0 0) indicates the received starting position zero chip; ...; bit sequence (1 1 ... 1 1 1) indicates the received starting position 2047*1/8 chip.

6.3.3.1.4 Transmit Power Level Command for the RACH message

The transmit power level command is transmitted in 7 bits.

6.3.3.2 FPACH Spreading

The FPACH uses only spreading factor SF=16 as described in subclause 6.3.3. The set of admissible spreading codes for use on the FPACH is broadcast on the BCH.

6.3.3.2 FPACH Burst Format

The burst format as described in section 6.2.2 is used for the FPACH.

6.3.3.3 FPACH Training sequences

The training sequences, i.e. midambles, as described in subclause 6.2.3 are used for FPACH.

6.3.3.4 FPACH timeslot formats

The FPACH uses slot format #0 of the DL time slot formats given in subclause 6.2.2.4.1.1.

6.3.4 The physical random access channel (PRACH)

The RACH as described in subclause 4.1.2 is mapped onto one or more uplink physical random access channels (PRACH). In such a way the capacity of RACH can be flexibly scaled depending on the operators need.

6.3.4.1 PRACH Spreading

The uplink PRACH uses either spreading factor SF=16, SF=8 or SF=4 as described in subclause 6.2.1. The set of admissible spreading codes for use on the PRACH and the associated spreading factors are broadcast on the BCH (within the RACH configuration parameters on the BCH).

6.3.4.2 PRACH Burst Format

The burst format as described in section 6.2.2 is used for the PRACH.

6.3.4.3 PRACH Training sequences

The training sequences, i.e. midambles, of different users active in the same time slot are time shifted versions of a single periodic basic code. The basic midamble codes as described in subclause 6.2.3 are used for PRACH.

6.3.4.4 PRACH timeslot formats

The PRACH uses the following time slot formats taken from the uplink timeslot formats described in sub-clause 6.2.2.4.1.2:

Spreading Factor	Slot Format #
16	0
8	10
4	25

6.3.4.5 Association between Training Sequences and Channelisation Codes

The association between training sequences and channelisation codes of PRACH in the 1.28McpsTDD is same as that of the DPCH.

6.3.5 The synchronisation channels (DwPCH, UpPCH)

There are two dedicated physical synchronisation channels —DwPCH and UpPCH in each 5ms sub-frame of the 1.28Mcps TDD. The DwPCH is used for the down link synchronisation and the UpPCH is used for the uplink synchronisation.

The position and the contents of the DwPCH are equal to the DwPTS as described in the subclause 6.1., while the position and the contents of the UpPCH are equal to the UpPTS.

The DwPCH is transmitted at each sub-frame with an antenna pattern configuration which provides whole cell coverage. Furthermore it is transmitted with a constant power level which is signalled by higher layers.

The burst structure of the DwPCH (DwPTS) is described in the figure 27.

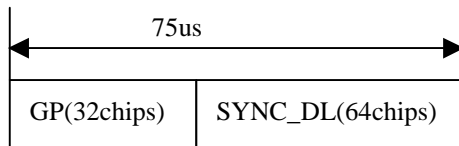


Figure 27: burst structure of the DwPCH (DwPTS)

Note: 'GP' for 'Guard Period'

The burst structure of the UpPCH (UpPTS) is described in the figure 28.

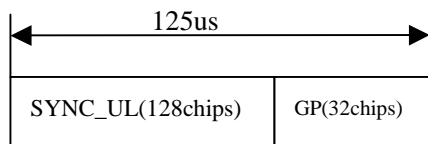


Figure 28: burst structure of the UpPCH (UpPTS)

The SYNC-DL code in DwPCH and the SYNC-UL code in UpPCH are not spreaded. The details about the SYNC-DL and SYNC-UL code are described in the corresponding subclause and annex in [8].

6.3.6 Physical Uplink Shared Channel (PUSCH)

For Physical Uplink Shared Channel (PUSCH) the burst structure of DPCH as described in subclause 6.2 shall be used. PUSCH provides the possibility for transmission of TFCI in uplink.

6.3.7 Physical Downlink Shared Channel (PDSCH)

For Physical Downlink Shared Channel (PDSCH) the burst structure of DPCH as described in subclause 6.2 shall be used. PDSCH provides the possibility for transmission of TFCI in downlink.

To indicate to the UE that there is data to decode on the DSCH, three signalling methods are available:

- 1) using the TFCI field of the associated channel or PDSCH;
- 2) using on the DSCH user specific midamble derived from the set of midambles used for that cell;
- 3) using higher layer signalling.

When the midamble based method is used, the UE shall decode the PDSCH if the PDSCH was transmitted with the midamble assigned to the UE by UTRAN, see 6.6.1.1.2 . For this method no other physical channels may use the same time slot as the PDSCH and only one UE may share the PDSCH time slot at the same time.

6.3.8 The Page Indicator Channel (PICH)

The Paging Indicator Channel (PICH) is a physical channel used to carry the paging indicators.

6.3.8.1 Mapping of Paging Indicators to the PICH bits

Figure 29 depicts the structure of a PICH transmission and the numbering of the bits within the bursts. The burst type as described in [6.2.2 ‘Burst Format’] is used for the PICH. N_{PIB} bits are used to carry the paging indicators, where $N_{PIB}=352$.

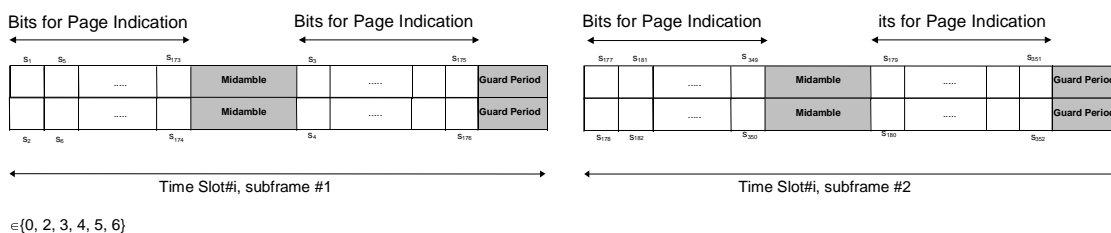


Figure 29: Transmission and numbering of paging indicator carrying bits in the PICH bursts

Each paging indicator P_q (where $P_q, q = 0, \dots, N_{PI}-1, P_q \in \{0, 1\}$) in one radio frame is mapped to the bits $\{s_{2L_{PI} \cdot q+1}, \dots, s_{2L_{PI} \cdot (q+1)}\}$ in subframe #1 or subframe #2.

The setting of the paging indicators and the corresponding PICH bits is described in [7].

In each radio frame, N_{PI} paging indicators are transmitted, using $L_{PI}=2, L_{PI}=4$ or $L_{PI}=8$ symbols. The number of paging indicators N_{PI} per radio frame is given by the paging indicator length, which signalled by higher layers. In table 19 this number is shown for the different possibilities of paging indicator lengths.

Table 19: Number N_{PI} of paging indicators per radio frame for different paging indicator lengths L_{PI}

	$L_{PI}=2$	$L_{PI}=4$	$L_{PI}=8$
N_{PI} per radio frame	88	44	22

6.3.8.2 Structure of the PICH over multiple radio frames

The structure of the PICH over multiple radio frames is common with 3.84 Mcps TDD, cf. [5.3.7.2 Structure of the PICH over multiple radio frames]

6.3.9 High Speed Physical Downlink Shared Channel (HS-PDSCH)

The HS-DSCH as described in subclause 4.1.2 is mapped onto one or more high speed physical downlink shared channels (HS-PDSCH).

6.3.9.1 HS-PDSCH Spreading

Spreading of the HS-PDSCH is common with 3.84 Mcps TDD, cf. [5.3.91HS-PDSCH Spreading]

6.3.9.2 HS-PDSCH Burst Types

The burst type as described in section 6.2.2 shall be used for the HS-PDSCH.

6.3.9.3 HS-PDSCH Training Sequences

The training sequences as described in subclause 6.2.3 are used for the HS-PDSCH.

6.3.9.4 UE Selection

UE selection is common with 3.84 Mcps TDD, cf. [5.3.9.4 UE selection].

6.3.9.5 HS-PDSCH timeslot formats

An HS-PDSCH may use QPSK or 16QAM modulation symbols. The time slot formats are shown in table XX.

Table XX: Time slot formats for the HS-PDSCH

Slot Format #	SF	Midamble length (chips)	N_{TFCI} code word (bits)	$N_{\text{SS}} & N_{\text{TPC}}$ (bits)	Bits/slot	$N_{\text{Data/Slot}}$ (bits)	$N_{\text{data/data field(1)}}$ (bits)	$N_{\text{data/data field(2)}}$ (bits)
0 (QPSK)	16	144	0	0 & 0	88	88	44	44
1 (16QAM)	16	144	0	0 & 0	176	176	88	88
2 (QPSK)	1	144	0	0 & 0	1408	1408	704	704
3 (16QAM)	1	144	0	0 & 0	2816	2816	1408	1408

6.3.10 Shared Control Channel for HS-DSCH (HS-SCCH)

The HS-SCCH is a DL physical channel that carries higher layer control information for HS-DSCH. The physical layer will process this information according to [7] and will transmit the resulting bits on the HS-SCCH the structure of which is described below.

The information on the HS-SCCH is carried by two separate physical channels (HS-SCCH1 and HS-SCCH2). The term HS-SCCH refers to the ensemble of these physical channels.

6.3.10.1 HS-SCCH Spreading

Spreading of the HS-SCCH is common with 3.84 Mcps TDD, cf. [5.3.10.1 HS-SCCH Spreading].

6.3.10.2 HS-SCCH Burst Types

The burst type as described in section 6.2.2 shall be used for the HS-SCCH.

6.3.10.3 HS-SCCH Training Sequences

The training sequences as described in subclause 6.2.3 are used for the HS-SCCH.

6.3.10.4 HS-SCCH timeslot formats

HS-SCCH1 shall use time slot format #5 and HS-SCCH2 shall use time slot format #0 from table 14, see section 6.2.2.4.1.1, i.e. HS-SCCH shall carry TPC and SS but no TFCI.

6.3.11 Shared Information Channel for HS-DSCH (HS-SICH)

The HS-SICH is a UL physical channel that carries higher layer control information and the Channel Quality Indicator CQI for HS-DSCH. The physical layer will process this information according to [7] and will transmit the resulting bits on the HS-SICH the structure of which is described below.

6.3.11.1 HS-SICH Spreading

Spreading of the HS-SICH is common with 3.84 Mcps TDD, cf. [5.3.11.1 HS-SICH Spreading].

6.3.11.2 HS-SICH Burst Types

The burst type as described in section 6.2.2 shall be used for the HS-SICH.

6.3.11.3 HS-SICH Training Sequences

The training sequences as described in subclause 6.2.3 are used for the HS-SCCH.

5.3.11.4 HS-SICH timeslot formats

The HS-SICH may use time slot format #5 from table 15, see section 6.2.2.4.1.2, i.e., it shall carry TPC and SS but no TFCI.

6.4 Transmit Diversity for DL Physical Channels

Table 20 summarizes the different transmit diversity schemes for different downlink physical channel types in 1.28Mcps TDD that are described in [9].

Table 20: Application of Tx diversity schemes on downlink physical channel types in 1.28Mcps TDD
"X" – can be applied, "-" – must not be applied

Physical channel type	Open loop TxDiversity		Closed loop TxDiversity
	TSTD	SCTD	
P-CCPCH	X	X	–
DwPCH	X	–	–
DPCH	X	–	X
PDSCH	X	–	X

6.5 Beacon characteristics of physical channels

For the purpose of measurements, physical channels at particular locations (time slot, code) shall have particular physical characteristics, called beacon characteristics. Physical channels with beacon characteristics are called beacon channels. The location of the beacon channels is called beacon location. The beacon channels shall provide the beacon function, i.e. a reference power level at the beacon location, regularly existing in each subframe. Thus, beacon channels must be present in each subframe.

6.5.1 Location of beacon channels

The beacon location is described as follows :

The beacon function shall be provided by the physical channels that are allocated to channelisation code $C_{Q=16}^{(k=1)}$ and $C_{Q=16}^{(k=2)}$ in Timeslot#0.

Note that by this definition the P-CCPCH always has beacon characteristics.

6.5.2 Physical characteristics of the beacon function

The beacon channels shall have the following physical characteristics.

They:

- are transmitted with reference power;
- are transmitted without beamforming;
- use midamble $m^{(1)}$ and $m^{(2)}$ exclusively in this time slot

The reference power corresponds to the sum of the power allocated to both midambles $m^{(1)}$ and $m^{(2)}$. Two possibilities exist:

- If no antenna diversity is applied to the P-CCPCH, all the reference power of any beacon channel is allocated to $m^{(1)}$.
- If SCTD antenna diversity is applied to the P-CCPCH, for any beacon channel midambles $m^{(1)}$ and $m^{(2)}$ are each allocated half of the reference power. Midamble $m^{(1)}$ is used for the first antenna and $m^{(2)}$ is used for the diversity antenna. SCTD is applied to the P-CCPCH, see [9]; for all other beacon channels identical spread data sequences are transmitted on both antennas.

6.6 Midamble Allocation for Physical Channels

The midamble allocation schemes for physical channels are the same as in the 3.84Mcps TDD option. The associations between channelisation codes and midambles for the default and common midamble allocation differ from the 3.84 Mcps TDD option. The associations are given in Annex B.2 [Association between Midambles and channelisation Codes] and D [Signalling of the number of channelisation codes for the DL common midamble case for 1.28Mcps TDD] respectively

6.6.1 Midamble Allocation for DL Physical Channels

Beacon channels shall always use the reserved midambles $m^{(1)}$ and $m^{(2)}$, see 6.5. For the other DL physical channels that are located in timeslot #0, midambles shall be allocated based on the default midamble allocation scheme, using the association for $K=8$ midambles. For all other DL physical channels, the midamble is explicitly assigned by higher layers or allocated by layer 1.

6.6.1.1 Midamble Allocation by signalling from higher layers

The midamble allocation by signalling is the same like in the 3.84 Mcps TDD cf. [5.6.1.1 Midamble allocation by signalling from higher layers]

6.6.1.2 Midamble Allocation by layer 1

6.6.1.2.1 Default midamble

The default midamble allocation by layer 1 is the same like in the 3.84 Mcps TDD cf. [5.6.1.2.1 Default midamble]. The associations between midambles and channelisation codes are given in Annex B.2 [Association between Midambles and channelisation Codes].

6.6.1.2.2 Common Midamble

The common midamble allocation by layer 1 is the same like in the 3.84 Mcps TDD cf. [5.6.1.2.2 Common midamble]. The respective associations are given in Annex D [Signalling of the number of channelisation codes for the DL common midamble case for 1.28 Mcps TDD].

6.6.2 Midamble Allocation for UL Physical Channels

The midamble allocation for UL Physical Channels is the same as in the 3.84 Mcps TDD cf. [5.6.2 Midamble allocation for UL Physical Channels]

6.7 Midamble Transmit Power

The setting of the midamble transmit power is done as in the 3.84 Mcps TDD option cf. 5.7 'Midamble Transmit Power'

7 Mapping of transport channels to physical channels for the 3.84 Mcps option

This clause describes the way in which transport channels are mapped onto physical resources, see figure 30.

Transport Channels	Physical Channels
DCH _____	Dedicated Physical Channel (DPCH)
BCH _____	Primary Common Control Physical Channel (P-CCPCH)
FACH _____	Secondary Common Control Physical Channel (S-CCPCH)
PCH _____	
RACH _____	Physical Random Access Channel (PRACH)
USCH _____	Physical Uplink Shared Channel (PUSCH)
DSCH _____	Physical Downlink Shared Channel (PDSCH)
	Paging Indicator Channel (PICH)
	Synchronisation Channel (SCH)
	Physical Node B Synchronisation Channel (PNBSCH)
HS-DSCH _____	High Speed Physical Downlink Shared Channel (HS-PDSCH)
	Shared Control Channel for HS-DSCH (HS-SCCH)
	Shared Information Channel for HS-DSCH (HS-SICH)

Figure 30: Transport channel to physical channel mapping

7.1 Dedicated Transport Channels

A dedicated transport channel is mapped onto one or more physical channels. An interleaving period is associated with each allocation. The frame is subdivided into slots that are available for uplink and downlink information transfer. The mapping of transport blocks on physical channels is described in TS 25.222 ("multiplexing and channel coding").

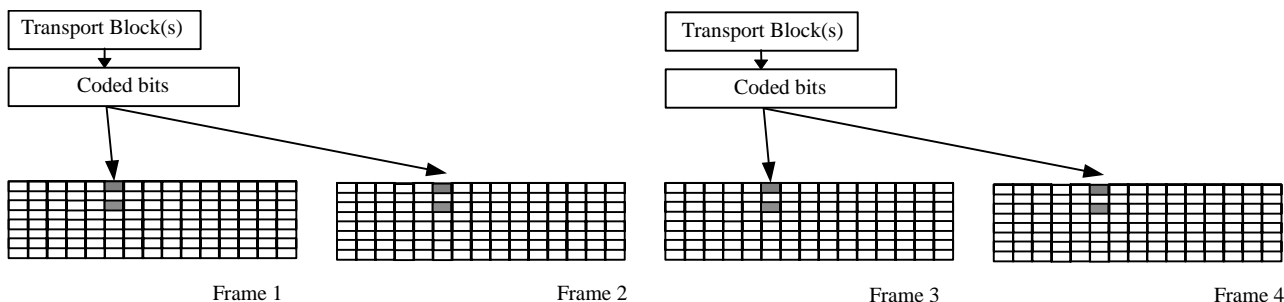


Figure 31: Mapping of Transport Blocks onto the physical bearer

For NRT packet data services, shared channels (USCH and DSCH) can be used to allow efficient allocations for a short period of time.

7.2 Common Transport Channels

7.2.1 The Broadcast Channel (BCH)

The BCH is mapped onto the P-CCPCH. The secondary SCH codes indicate in which timeslot a mobile can find the P-CCPCH containing BCH.

7.2.2 The Paging Channel (PCH)

The PCH is mapped onto one or several S-CCPCHs so that capacity can be matched to requirements. The location of the PCH is indicated on the BCH. It is always transmitted at a reference power level.

To allow an efficient DRX, the PCH is divided into PCH blocks, each of which comprising N_{PCH} paging sub-channels. N_{PCH} is configured by higher layers. Each paging sub-channel is mapped onto 2 consecutive PCH frames within one PCH block. Layer 3 information to a particular UE is transmitted only in the paging sub-channel, that is assigned to the UE by higher layers, see [15]. The assignment of UEs to paging sub-channels is independent of the assignment of UEs to page indicators.

7.2.2.1 PCH/PICH Association

As depicted in figure 32, a paging block consists of one PICH block and one PCH block. If a paging indicator in a certain PICH block is set to '1' it is an indication that UEs associated with this paging indicator shall read their corresponding paging sub-channel within the same paging block. The value $N_{GAP} > 0$ of frames between the end of the PICH block and the beginning of the PCH block is configured by higher layers.

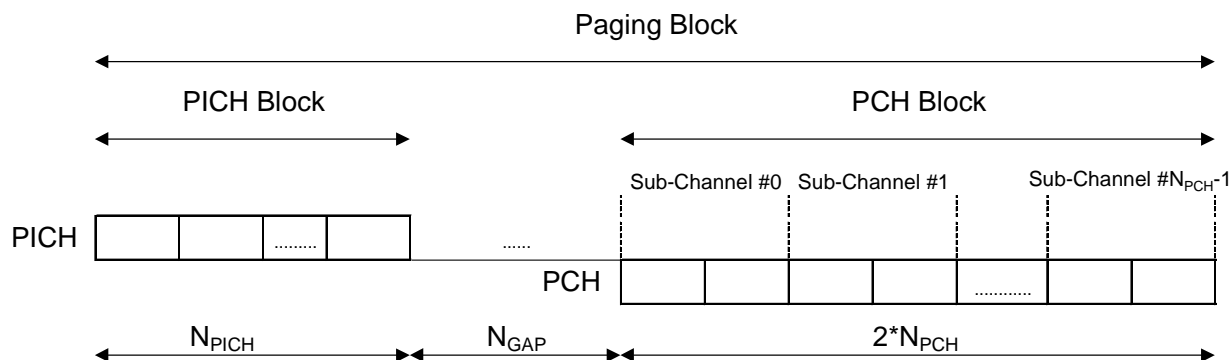


Figure 32: Paging Sub-Channels and Association of PICH and PCH blocks

7.2.3 The Forward Channel (FACH)

The FACH is mapped onto one or several S-CCPCHs. The location of the FACH is indicated on the BCH and both, capacity and location can be changed, if required. FACH may or may not be power controlled.

7.2.4 The Random Access Channel (RACH)

The RACH has intraslot interleaving only and is mapped onto PRACH. The same slot may be used for PRACH by more than one cell. Multiple transmissions using different spreading codes may be received in parallel. More than one slot per frame may be administered for the PRACH. The location of slots allocated to PRACH is broadcast on the BCH. The PRACH uses open loop power control. The details of the employed open loop power control algorithm may be different from the corresponding algorithm on other channels.

7.2.5 The Uplink Shared Channel (USCH)

The uplink shared channel is mapped on one or several PUSCH, see subclause 5.5.

7.2.6 The Downlink Shared Channel (DSCH)

The downlink shared channel is mapped on one or several PDSCH, see subclause 5.6.

7.2.7 The High Speed Downlink Shared Channel (HS-DSCH)

The high speed downlink shared channel is mapped on one or several HS-PDSCH, see subclause 5.3.9.

7.2.7.1 HS-DSCH/HS-SCCH Association and Timing

The HS-DSCH is always associated with one DL DPCH and a number of High Speed Shared Control Channels (HS-SCCH). The number of HS-SCCHs that are associated with an HS-DSCH for one UE can range from a minimum of one HS-SCCH ($M=1$) to a maximum of four HS-SCCH ($M=4$). All relevant Layer 1 control information is transmitted in the associated HS-SCCH i.e. the HS-PDSCH does not carry any Layer 1 control information.

The HS-DSCH related time slot information that is carried on the HS-SCCH refers to the next valid HS-PDSCH allocation, which is given by the following limitation: There shall be an offset of $n_{HS-SCCH} \geq 6$ time slots between the HS-SCCH carrying the HS-DSCH related information and the first indicated HS-PDSCH (in time) for a given UE. The HS-DSCH related time slot information shall not refer to two subsequent radio frames but shall always refer to either the same or the following radio frame, as illustrated in figure XX. Note that the figure only shows the HS-SCCH that carries the HS-DSCH related information for the given UE.

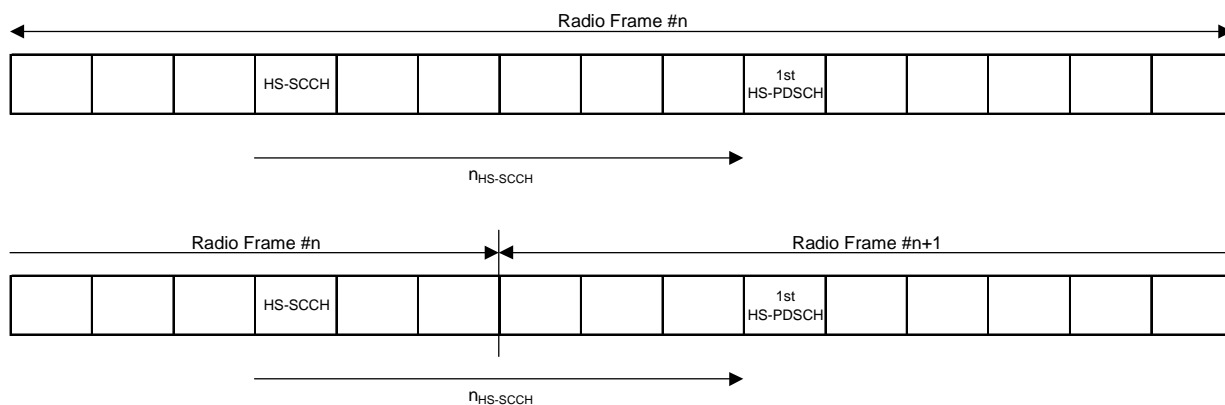


Figure XX: Timing for HS-SCCH and HS-DSCH for different radio frame configurations for a given UE

7.2.7.2 HS-SCCH/HS-DSCH/HS-SICH Association and Timing

The HS-SCCH is always associated with one HS-SICH. The association between the HS-SCCH in DL and HS-SICH in UL shall be pre-defined by higher layers and is common for all UEs.

The UE shall transmit HS-DSCH related information on the next available associated HS-SICH with the following limitation: There shall be an offset of $n_{HS-SICH} \geq 19$ time slots between the last allocated HS-PDSCH (in time) and the HS-SICH for the given UE. Hence, the HS-SICH transmission shall be made in the next or next but one radio frame, following the HS-DSCH transmission, as illustrated in figure XX. Note that the figure only shows the HS-SICH that carries the HS-DSCH related information for the given UE.

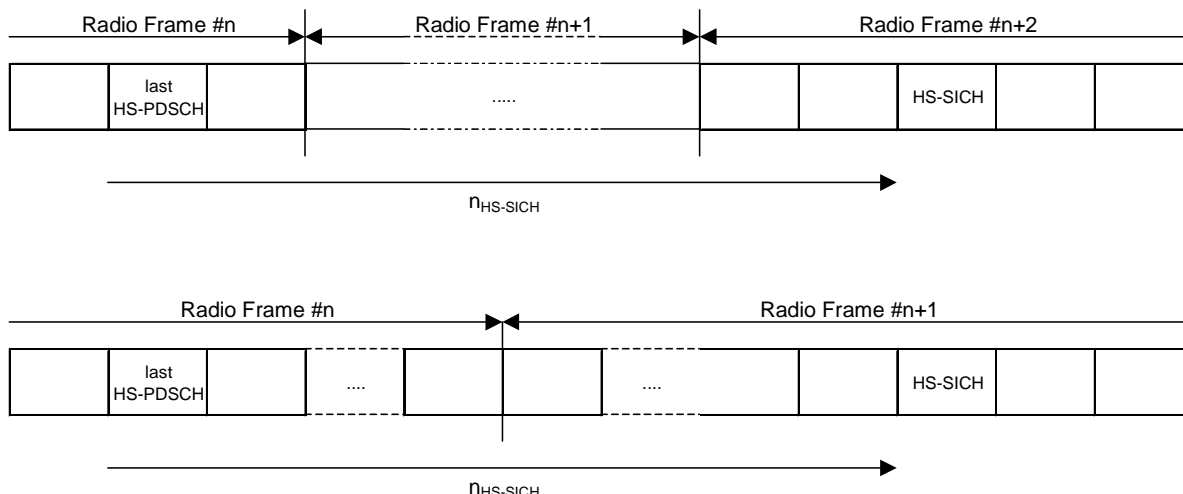


Figure XX: Timing for HS-DSCH and HS-SICH for different radio frame configurations for a given UE

8 Mapping of transport channels to physical channels for the 1.28 Mcps option

This clause describes the way in which the transport channels are mapped onto physical resources, see figure 33.

Transport channels	Physical channels
DCH	Dedicated Physical Channel (DPCH)
BCH	Primary Common Control Physical Channels (P-CCPCH)
PCH	Secondary Common Control Physical Channels(S-CCPCH)
FACH	Secondary Common Control Physical Channels(S-CCPCH)
	PICH
RACH	Physical Random Access Channel (PRACH)
USCH	Physical Uplink Shared Channel (PUSCH)
DSCH	Physical Downlink Shared Channel (PDSCH)
	Down link Pilot Channel (DwPCH)
	Up link Pilot Channel (UpPCH)
	FPACH
HS-DSCH	High Speed Physical Downlink Shared Channel (HS-PDSCH)
	Shared Control Channel for HS-DSCH (HS-SCCH)
	Shared Information Channel for HS-DSCH (HS-SICH)

Figure 33: Transport channel to physical channel mapping for 1.28Mcps TDD

8.1 Dedicated Transport Channels

The mapping of transport blocks to physical bearers is in principle the same as in 3.84 Mcps TDD but due to the subframe structure the coded bits are mapped onto each of the subframes within the given TTI.

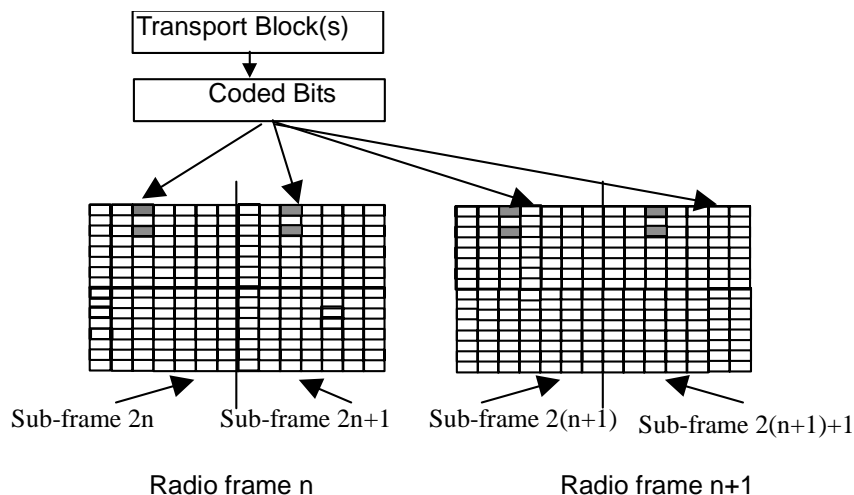


Figure 34 : Mapping of Transport Blocks onto the physical bearer (TTI= 20ms)

8.2 Common Transport Channels

8.2.1 The Broadcast Channel (BCH)

There are two P-CCPCHs, P-CCPCH 1 and P-CCPCH 2 which are mapped onto timeslot#0 using the channelisation codes $C_{Q=16}^{(k=1)}$ and $C_{Q=16}^{(k=2)}$ with spreading factor 16. The BCH is mapped onto the P-CCPCH1+P-CCPCH2.

The position of the P-CCPCHs is indicated by the relative phases of the bursts in the DwPTS with respect to the P-CCPCHs midamble sequences, see [8]. One special combination of the phase differences of the burst in the DwPTS with respect to the P-CCPCH midamble indicates the position of the P-CCPCH in the multi-frame and the start position of the interleaving period.

8.2.2 The Paging Channel (PCH)

The mapping of Paging Channels onto S-CCPCHs and the association between PCHs and Paging Indicator Channels is the same as in the 3.84 Mcps TDD option, cf. 7.2.2 'The paging Channel' and 7.2.2.1 'PCH/PICH Association' respectively.

8.2.3 The Forward Channel (FACH)

The FACH is mapped onto one or several S-CCPCHs. The location of the FACH is indicated on the BCH and both, capacity and location can be changed, if required. FACH may or may not be power controlled.

8.2.4 The Random Access Channel (RACH)

The RACH is mapped onto PRACH. More than one slot per frame may be administered for the PRACH. The location of slots allocated to PRACH is broadcast on the BCH. The uplink sync codes (SYNC-UL sequences) used by the UEs for UL synchronisation have a well known association with the P-RACHs, as broadcast on the BCH. On the PRACH, both power control and uplink synchronisation control are used.

8.2.5 The Uplink Shared Channel (USCH)

The uplink shared channel is mapped onto one or several PUSCH, see subclause 6.3.6 'Physical Uplink Shared Channel (PUSCH)'

8.2.6 The Downlink Shared Channel (DSCH)

The downlink shared channel is mapped onto one or several PDSCH, see subclause 6.3.7 ‘Physical Downlink Shared Channel (PDSCH)’

8.2.7 The High Speed Downlink Shared Channel (HS-DSCH)

The high speed downlink shared channel is mapped on one or several HS-PDSCH, see subclause 6.3.9.

8.2.7.1 HS-DSCH/HS-SCCH Association and Timing

The HS-DSCH is always associated with one DL DPCH and a number of High Speed Shared Control Channels (HS-SCCH). The number of HS-SCCHs that are associated with an HS-DSCH for one UE can range from a minimum of one HS-SCCH ($M=1$) to a maximum of four HS-SCCH ($M=4$). All relevant Layer 1 control information is transmitted in the associated HS-SCCH i.e. the HS-PDSCH does not carry any Layer 1 control information.

The HS-DSCH related time slot information that is carried on the HS-SCCH refers to the next valid HS-PDSCH allocation, which is given by the following limitation: There shall be an offset of $n_{HS-SCCH} \geq 3$ time slots between the HS-SCCH carrying the HS-DSCH related information and the first indicated HS-PDSCH (in time) for a given UE. DwPTS and UpPTS shall not be taken into account in this limitation. The HS-DSCH related time slot information shall not refer to two subsequent sub-frames but shall always refer to either the same or the following sub-frame, as illustrated in figure XX. Note that the figure only shows the HS-SCCH that carries the HS-DSCH related information for the given UE and that DwPTS and UpPTS are not considered in this figure.

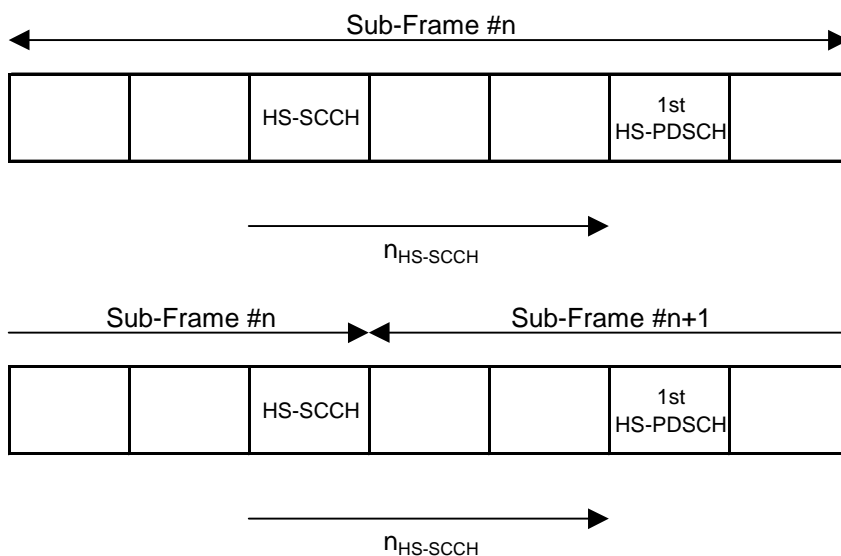


Figure XX: Timing for HS-SCCH and HS-DSCH for different radio frame configurations for a given UE

8.2.7.2 HS-SCCH/HS-DSCH/HS-SICH Association and Timing

The HS-SCCH is always associated with one HS-SICH, carrying the ACK/NACK and Channel Quality information (CQI). The association between the HS-SCCH in DL and HS-SICH in UL shall be pre-defined by higher layers and is common for all UEs.

The UE shall transmit HS-DSCH related information on the next available associated HS-SICH with the following limitation: There shall be an offset of $n_{HS-SICH} \geq 9$ time slots between the last allocated HS-PDSCH (in time) and the HS-SICH for the given UE. DwPTS and UpPTS shall not be taken into account in this limitation. Hence, the HS-SICH transmission shall always be made in the next but one sub-frame, following the HS-DSCH transmission, as illustrated in figure XX. Note that the figure only shows the HS-SICH that carries the HS-DSCH related information for the given UE and that DwPTS and UpPTS are not considered in this figure.

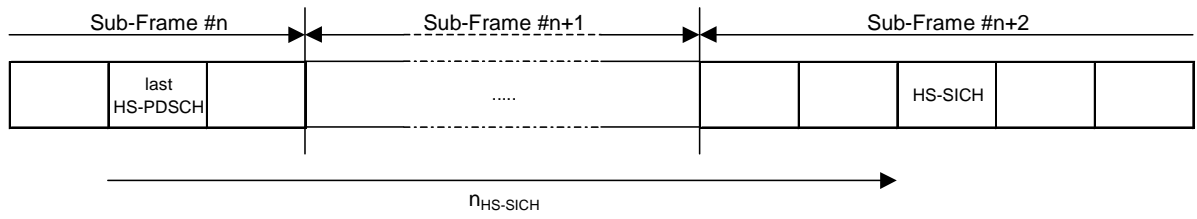


Figure XX: Timing for HS-DSCH and HS-SICH for different radio frame configurations for a given UE

Annex A (normative): Basic Midamble Codes for the 3.84 Mcps option

A.1 Basic Midamble Codes for Burst Type 1 and 3

In the case of burst type 1 or 3 (see subclause 5.2.2) the midamble has a length of $L_m=512$, which is corresponding to:

$K'=8$; $W=57$; $P=456$.

Depending on the possible delay spread cells are configured to use K_{Cell} midambles which are generated from the Basic Midamble Codes (see table A-1)

- for all $k=1,2,\dots,K$; $K=2K'$ or
- for $k=1,2,\dots,K'$, only, or
- for odd $k=1,3,5,\dots,\leq K'$, only.

Depending on the cell size midambles for PRACH are generated from the Basic Midamble Codes (see table A-1)

- for $k=1,2,\dots,K'$ or
- for odd $k=1,3,5,\dots,\leq K'$, only.

The cell configuration is broadcast on BCH.

The mapping of these Basic Midamble Codes to Cell Parameters is shown in TS 25.223.

Table A-1: Basic Midamble Codes m_p according to equation (5) from subclause 5.2.3 for case of burst type 1 and 3

Code ID	Basic Midamble Codes m_{PL} of length $P=456$
m_{PL0}	8DF65B01E4650910A4BF89992E48F43860B07FE55FA0028E454EDCD1F0A09A6F029668F55427253FB8A71E5EF2EF360E539C489584413C6DC4
m_{PL1}	4C63F9BC3FD7B655D5401653BE75E1018DC26D271AADA1CF13FD348386759506270F2F953E93A44468E0A76605EAE8526225903B1201077602
m_{PL2}	8522611FFCAEB55A5F07D966036C852E7B15B893B3ABA9672C327380283D168564B8E1200F0E2205AF1BB23A58679899785CFA2A6C131CFDC4
m_{PL3}	F58107E6B777C221999BDE9340E192DC6C31AB8AE85E70AA9BBEB39727435412A5A27C0EF73AB453ED0D28E5B032B94306EC1304736C91E922
m_{PL4}	89670985013DFD2223164B68A63BD58C7867E97316742D3ABD6CDBA4FC4E08C0B0CBE44451575C72F887507956BD1F27C466681800B4B016EE
m_{PL5}	FCDEF63500D6745CDB962594AF171740241E982E9210FC238C4DD85541F08C1A010F7B3161A7F4DF19BAD916FD308AB1CED2A32538C184E92C
m_{PL6}	DB04CE77A5BA7C0E09B6D3551072B11A7A43B6A355C1D6FDCF725D587874999895748DD09832ABC35CEC3008338249612E6FE5005E13B03103
m_{PL7}	D2F61A622D0BA9E448CD29587D398EF8CDC3B6582B6CDD50E9E20BF5FE2B3258041E14D60821DC6725132C22D787CD5D497780D4241E3B420D
m_{PL8}	7318524E62D806FA149ECC5435058A2B74111524B84727FE9A7923B4A1F0D8FCD89208F34BE55CADEB90130F9954BB30605A98C11045FF173D
m_{PL9}	8E832B4FA1A11E0BF318E84F54725C8052E0D099EF0AF54BC342BEE44976C9F38DE701623C7BF6474DF90D2E222A4915C8080E7CD3EC84DAC
m_{PL10}	CFA5BAC90780876C417933C43103B55699A8AD51164E590AF9DA6AF0C18804E1F74862F00CE7ECC899C85B6ABB0CAD5E50836AD7A39878FE2F
m_{PL11}	AD539094A19858A75458F1B98E286A4F7DC3A117083D04724CBE83F34102817C5531329CDB437FFF712241B644BDF0C1FEC8598A63C2F21BD7
m_{PL12}	BEB8483139529BDE23E42DA6AB8170DD0BFBB30CE28A4502FAF3C8EDA219B9A6D5B849D9C9E4451F74E2408EA046061201E0C1D69CF48F3A94
m_{PL13}	C482462CA7846266060D21688BA00B72E1EC84A3D5B7194C8DA39E21A3CE12BF512C8AAB6A7079F73C0D3E4F40AC555A4BCC453F1DFE3F6C82

Code ID	Basic Midamble Codes m_{PL} of length $P=456$
m_{PL14}	9663373935FD5C213AC58C0670206683D579D2526C05B0A81030DDF61A221D8A68EAD8D6F7AA0D662C07C6DCCD0115A54D39F03F7122B0675AC
m_{PL15}	387397AE5CD3F2B3912C26B8F87CE82CEFEC55507DB08FB0C4CF2FD6858896201ACA7264281D0298440DD3481E5E9DDB24C16F30EB7A22948A
m_{PL16}	AFE9266843C892571B6230D808788C63B9065EA3BDFF687B92B8734A8D7099559FEA22C9416576D0C087EB4503E87E356471B330182A24A3E6
m_{PL17}	6E6C550A4CB74010F6C3E0328651DF421C456D9A5E8AE9D3946C10189D72B579184552EE3E799970969C870FE8A37B6C4BA890992103486DC0
m_{PL18}	D803CA71B6F99CFB3105D40F4695D61EB0B62E803F79302EE3D2A6BF12EA70D304B181E8B38B3B74F5022B67EB8109808C62532688C563D4BE
m_{PL19}	E599ED48D01772055DBE9D343A4EA5EABE643DA38F06904FC7523B08C4101F021B199AF759A00D9AC298881D79413A77470992A75C771492D0
m_{PL20}	9F30AC4162CE5D185953705F3D45F026F38E9B5721AEFE07370214D526A2C4B344B508B57BF B2492320C05903C79CBEE08C6E7F218B57E14D6
m_{PL21}	B5971060DA84685B4D042ED0189FAF13C961B2EF61CC164E363B22AAB14AC8AF607906C1C6E04F2054C687AA6741A9E70639857DA02B6FFFFA
m_{PL22}	97135FC2226C4B4A5CBA5FCA3732763B87455F73A1148006F3DF214BD4C936D061E04045160E2CE33B9CD09D08FDE2A37F4E998322B4401D27
m_{PL23}	4D256D57C861B9791151A78D5299C56D116B6178B2A2D04BB95FB76540AF28341DC6EC4E7E D3BF9E508478D9C8F44914805DA82429E1CF320E
m_{PL24}	858EF5C84CE32D18D9ABA110EEA7474CF0CD70254D2928C3F4DFF6BB3A518587CADA19029078AC90A8336C8178203BE3289E601F07D089CB64
m_{PL25}	920A8796A511650AEF32F93DD3C39C624E07AE03CE8C96139973F54DCB9803C5164ADB502D4FF561564D607037FCD172921F1982B102C3312C
m_{PL26}	485C5DAE76B360A9C56E20B8422EA3E6ACF07CB093B5587CB0E6A5498A4714081EA98DBCD B0482B26E0D097C03444473D233BEF3C8E440DEBF
m_{PL27}	565A9D54EA789892B024F97E728E8EE112411942C48BD0C5BC8AA457D8DC9941F0F7424B38643FFFE6521CD306FBC56FE10F1428D4C245B5606
m_{PL28}	5AEF2C0C2C378179A1AC36242E6B3EDB72C42D3624437674F8D51260C0898C201837CBA14E9E23D1EF6451C4ACF27AB031F457A8A1BFD148AE
m_{PL29}	87D8FE685417822A23D925307E6C11081ADAC4702BCCD9BE448E78984D109B50DEF5B7C58B C71EA1F0A6826BA8AD1978843E7697F3E416AADA

Code ID	Basic Midamble Codes m_{PL} of length $P=456$
m _{PL30}	84802B72AF27B5BE724D1FB629E0E627BDB0D9061292562F98350C1D0C9D4B9D8E2BF71123C82EBB161003AE9829E07244D78F19926F8847A2
m _{PL31}	8CCB5128238BCB088E30972D62792AEF02B9BBDDCAD68C9916C00BF91CBE788B0F03851FAAF88605534FD73436C259D270B1013CB14226F658
m _{PL32}	62F4E6FAC2BF1979CE6854AA2D33534BFB2F946519101A6589131C3640707D40E67ED804AF8736AD213CAF5935741900061967E8285C27E34C
m _{PL33}	4095E5B4EEAFCDF68A34B267EEA28D8444FA533900F41499E260D2E65C256A52E1DD5861F5227C98E00687D107233F51A1167BCF72FB184654
m _{PL34}	5630E9A79FCAD303404D9E5A802299162657AAC734761C6E90DA8BCE4F61A763E0BB48D3FEB3F78468C828ABA4828DAD06E0F904CFD40421DC
m _{PL35}	CD12B24C0BCA8AAC1FCBF0500A3BC684A180E863D888F2506B48C68ECF17F76CB285991FBA18EB6397211FAD002F482D57A258CD45DE3FF1A6
m _{PL36}	AFCF2A50877286CD3405442730C45514F082D9EC296B367C0F64F04C4E0007DCA9E50BEED5C102126E319ACBC64F1729272F2F72C9397029FE
m _{PL37}	18F89EE8589D20882A72A44DCDF0050F0A3D88DBA6531614973D26905FDF41E3F779FF0648E8AF1540928511BCF4C25D9C64AF34AC31B8965
m _{PL38}	F890D550F33F032ECDA3A51FED427D634F64EB29AF1332A23CD961258E4BAED040E7B336918E250EC272A12816B9EBFFA1E0AE401185F08C10
m _{PL39}	ACE5DD61506047E80FB7D41BD3992DF4D7F18EB46CC145C0E9105428C2F8F299141F5D66691904A7DC2513A3B83994ACB1292246B32818FE9D
m _{PL40}	150680FF900C9B46E1E24D54BE2238CB950A934E5CCDE9BC3939EB51CB0AE202B7D339EEC2018B33A0AB9B63DA5D512D64FB58C0E51A1C82C2
m _{PL41}	51A579EED2663A002D32D10A0753173612F4D5BA167D1807C61F25C4D42C063682E8E9DD019F79D446A046EB3F75E50FEB228DC52F08E694B6
m _{PL42}	CDC644FE4C0C6897604F9D14D714123BF16FFF0E49F35F674908CA60653702FE27BCCA2A47098453AF8661055C8C549EB6A951A8396AD4B94D
m _{PL43}	750A10366C595373C5001CA3E4239764B1409D602CF6052B39BC6A3255A15FE06C782C4C5F847026A7E79838A2933A61C77BB6CBF5915B2DA5
m _{PL44}	B7490686D78E409082C4C48FE18D4C35429C20AADF96076B92FC4E85490664753DB0891A0B27FD849BB7FCA99E3B38F22F8C662852C0D35AA6
m _{PL45}	D86E1B575B47D23DA811806A54C231281F03317830E7BD305D3CAA7D6382A5233104CFD54D22DF9F34535E5B390D9040CF1375FEA44CEC29E2
m _{PL46}	828655960C026EC67B683480992AC2ED2C43ABC606F5220C2945F373470BE7ED5BCCF7C1AA0986BBCC84F11F1658AA568FAA0A60C5F0B5BFA
m _{PL47}	D76230E02C8533653AAB99B288AA2ADE25A1C1BF28516C04239240EAF1EFC0B98974B51F886861D8A1E9F5D62CFFEC309F071A9716B325101B
m _{PL48}	EA207662865B8A07D69648964DED818EE474A90B94473408871880E63EF0596B9FCFEC3C06B86EA6AD2B06C91672EFB33C70241A5450B59B8A
m _{PL49}	9CB5459549909835FAB22F0D99298C120ACF479F814CCE749079D40688F28101037762F125C776DA9C5FA1FCE0E76E452F8185354FDCDE94E2
m _{PL50}	227506304AEC1D6F93569B51FDC3405A0F38194F65BE17163A3CB9827A35AECEA757D020FE249377ECD561428A38FEED004EC859C272563185
m _{PL51}	96B9AEC9938910F0E533422A3977519B05CD4AD3909BC15A7502D48D49C124FA192A8E57027CFEB11DF542010603CE5C9FDF8E626D4FBF8CF4
m _{PL52}	A6AAD06E095A9BE0BD9F8A2ED40C3CBDBAE91C700CBB778C8696CC06F3A675C16BDB2918E5F2111005A8727206DC6A9684E05655185C398EEB
m _{PL53}	CD168D384A78DA172991AD333EE2A9880905AFE59E2A2A4AC4414C40F82874F98A3CBE7B44F4C7F4710B35FD88AFC0399FAEB070EB9CA4D30A
m _{PL54}	22016CA87AD1549174A8699DD65599697871091457E83E0912E7E77A06531C209394D283D18A38662B73681DD9C5BF330FED978BDA7D487CA8
m _{PL55}	B9401B0843AA6F7827A13BD66C922287E8886C31EB5B90B82B472CCD6DA3D8D4FBF78B8F8496DFA8252B06429D5DD17142F1C908ACCD70EAOC
m _{PL56}	E42B9EFDC5D09AC27B3C7DA28D02493A70521223B9D7A76A9D13E9C171017964D16A70C08EAD02C3DC948889C23E365AFCF01BF20B89B0BF5C
m _{PL57}	9DA0180168DB915E9F3597B59312198E1B5CC00D743C2ECB0DBAADA3E35A2465ED1EAA9D74734D49A313CE4DFF020D0760E3153DC485603943
m _{PL58}	B6C966619ECB98191D719C187C07BD503425650CAA3A2D1F2DF5212B1441D7A0C1D36A4C9C2550240AD17CA43BB3943DFFFBF1E283D81299CC
m _{PL59}	DB0E8C41F08A03D477C1AA548799274C4BF3EB68F2636166FDC8D4B1E7132539930297E228BA232BB5C279FA5ECA3AC10E24361AF050A453B8
m _{PL60}	89BCE2DE2974EEBA833CF32F224C85A2891484478527DB48FA6ECEA84C5E288CC3914CB54ADA0476278750187F68FBEA41017E1E58DF1A5A3D
m _{PL61}	70A457D1314A278625443EEB52520815EC92CEF17417B97440DCB531BC1CE83212F63270418D0FBDE71F6DB9E0EA88772E1E4535B6633E4425

Code ID	Basic Midamble Codes m_{PL} of length $P=456$
m _{PL62}	C388460AD54B36C4452CF0433BD347100ACCC24C79C535AD3E1F23FE0425E93A044C553BFA116E09AA4BB32F13CFA76FBA1BC17520F45EFD44
m _{PL63}	0BAFCADCDF9AA2846681782CD3B90CA036A863C78EE1507620BC394D0C6804B4C97A15BC9C0D7B79E6892EA1BFF1A0DD9573A9213AB140D0D2
m _{PL64}	833B0226789A62882FCD27A30885E67872B1A1C2FA484AD498011599DD57E8E2A07A560B47167AA5F60EF47177DBB1632D5387A2896348640B
m _{PL65}	8F52820323ABA5E6C6B465821B621600B980E59F53A599DA5646BA103214336836CF17E3386CE4FB2BC5F25CCB30CF7F500546828EC8786B8E
m _{PL66}	E2E9A29C3C8207B9A4508FD2F667A159F068EEE8D00686F46EA904C3692C1D79DFF1B32E5103720D47B4B58AC35384A26087027E141B3126A8
m _{PL67}	70E7C39FD2D3AE1DCE341699A544D801A8688A6EE47C5CB3630022147DDC06241FC5337A348A462B2472DEC5E104DD520ADA5114DB065D4B0D
m _{PL68}	9E3483CAB164BD053C4971D4D87494CC689033D589EF80E5453376E4A8DCC02183B98C36B0FF7DDC0AD07FCE8B4D5164371BD03A2110AD1247
m _{PL69}	04DA1C649B0608938DAADD3FE920A4F681690C54505429DBDCDCF10067AB5714BCDDFE1F28692710F794765781C1D233344E119BEE8A8416DC
m _{PL70}	7A18D6D30BDF44410714C3DCA27D8F9EA8A542D87122205640B98313C91AD9A0B993A5A7BC3E035F93B88BBE6D4204BC82A9FA8D4C1A7618CF
m _{PL71}	EB9525E10265A48733C8E0E77E459310112A71DCA680F68AC044B64BC0A31D02EEA0F7ACAAAB7F1E574E94FEA2D1301CB14B03263DA8122B76
m _{PL72}	E706C6ED2D6F89153835079BE0C6D45310845EF2F9F6C6AE91B7419810508BA501C0148BF09955BAD90D6391BA8EBA5CEFB23221CC75143D7
m _{PL73}	DF071A10AC4120CD1431590BEDCFF9483CA7047B19590D035D309240BDB4264E9A3A2761402EC97FD8BC51B4AF32E37FBC47162A2357D18751
m _{PL74}	F0F952B2238139F46D8254D1A2C1C22A16BA71EC0C0C900ED1442452D7F44C798BC65FF40671B88074BA0B74C6510996EEAC495C5B49C37DEB
m _{PL75}	1C86BD82EDA81FD65418D3837B5552A853791456D93B06C62C650D86CFBEC269AFFD772763064062C03751B9428C6DA2E60383025F9E404B70
m _{PL76}	B390978DD2552C88AABA7838489A6F5A8E9C41E95FFA2215819BF8A5BFE39C8A706CC658E549E966611B843A1468406C41C09D1560BEDA4F1B
m _{PL77}	1A69EC9D053C7E84BAE7A48CCC71857D0C6B06D1065E3EA4633B133AA022B8104F6EE7C69B6184B746C8822958B0A16686F27C8A0E3B4FEAD
m _{PL78}	C95B2070816DC97C6D8DD2583263E73F9AAAFD13F0548D2EBD835824418F11E54111005FB713AB234BE412347358281C7DE331EDD21B8BEA52
m _{PL79}	56D6408399F23C2ED85EE0F68111D69A91A3AD9A732AC57CA08F86CC28B3CF4E4B02EBBA0BCE5CAE5BACC4D52004070797C04093A84BB18DBA
m _{PL80}	E662E7043867BE250764DA0596D34A582A619B408B505E6211DD6286E93A37F95B1EA680C0C5F3E777E3F71E8D75495D59043217FC0E222E16
m _{PL81}	27D5E681C222297AD478A079EF12F1A98F744B66335303322EF8880B931FEBF8322F4302944E80BED468A0A516D410B183D863795992DA7DDB
m _{PL82}	5100336C05F9E5BF35201906C1C588858E0DAF56130DF5554B9AB21CA15311A90290624CD63E03F5EDA49DB7A0C32AB5F1CA427A2D5635FDA5
m _{PL83}	C696DC993BFAEA9A61B781B9C5C3F5CFAA4C8339D8B03A9B0387883D0482A41AC78D6522425959846E561D26A30FF79A205C801A85889736B2
m _{PL84}	D562297561AFF42D3168296C1153E4E39BE7B2EB0348BC704625AA08391235075EE0DE0A79AB03222FEDB27218C56F96EAC2F91CC8FCE64B12
m _{PL85}	DD0B6768FC01CC0A551F8ACC36907129623E975AB8B3FF58037F1859E2FA8C62C2D9D1E8506916029A2C3F8CAD9A26AE2CC652F48800859F5C
m _{PL86}	923920696EB3AB413786C41854822282BB83F6900D33A232D470BE198BBF086067B72613300C593B74251E2F079857ADBBCD86583A9DCAA6DC
m _{PL87}	B8EF30C797D8D2C4EF11244F137D806E556A436626D0115A621C92C34D166A68BCEDFA0040DA8FD6F987B1CD5C2AA1C1B045E64475F0F8DABD
m _{PL88}	E1887001D414405ED6419E9EE1D1D346D924ED57ADF04B31B7948099976B2D1501A60DFFB287AD44C8783DF0C1EA5AA5D273D1389C8EA22DCC
m _{PL89}	8C2E379A58AA96748141CA84C35987905F984A49D3AD9BFF7807AC244C16C1DF74343C2E1F25514F5A0954CFBB3C92E25EF783136844998AC5
m _{PL90}	78F8A99E0A54E27F51C0726FE7A11EB26B1E29FE65F55AC8AC58011465900B958488A90F6DF614A58431DC8B6C6B9A6F032EE0E0B1306EC4B4
m _{PL91}	88F7A31B7B20E0F05CA26E729B4F8A1933962D7BD7BE3E1EB130B28C794C0B4D01CADE09006FF97E80117509733F3A9DC225413A0AE08CA662
m _{PL92}	BE4DFCEAC18905AC8D5DA27A794F88A4D3058D2EFA3B075A819DEAE688EAF8940A653ED7104E7B403D490F0A9030264E1F12B8922C75775E61
m _{PL93}	5BA4B79FC4550234D8922963BF3537485E3C8745A5DB90D3E2E454B30FF61112F508155B7C2B3C4C628AF846240C2021ACDE547E5A41F666B8

Code ID	Basic Midamble Codes m_{PL} of length $P=456$
m_{PL94}	00556D35649F7610AB24A43C4F16D6AC0571FD126F11880C5CD72100D730E4E4D6BB73C33F837FAF1072743B249ADA2E09598B1EB23F1180A7
m_{PL95}	7A0CC9F21BD69CF3023E944545C2176EF0D4F450B765C28359FB8A32137D043D0E5713E67B3F61320985D2C6106605081F87D2296321468A2F
m_{PL96}	DA669880995B0671201172BABFF141D5854A245E211879EF3038A7C84170DADBD368455F24653161E7886E15B253F93E3A3C568EFB17CDEB1A
m_{PL97}	4E294E53D1661C1F6F748302A7723DA951C00FDB8BEBBF67A68710BA0F1A255DFB1627059D41A23D3961726DE6FEB10E5D209CC4505B209812
m_{PL98}	73385DF701414E144768A67EF72924B1653479E962FB1554B7E54BC5284D9B3E41C0C133F878972230721918AA425501B920B204FECE0C7F8A
m_{PL99}	F4492160805F258CE592DF4D1200566F81D173458D78EA3ABED79A14AF88170DB1D4A9A5931D2B80C58C27FE17D806E3E6A66CDAAD09F118D4
m_{PL100}	44D562D9012D8B07B8F44596467C11A163982BB7EAEAC184078B6B8CE46B5D7E17C39CEF576A025491183017FA09931D070B307B86524B03FF
m_{PL101}	FCAEFFCC49A13B4FFA12C0CC6A2B90CF4F57D78B1E98294B04675C2F0991661FDC61A452A247F8C29E0284AA21026F368307375AA2C3F1E12C
m_{PL102}	C486DF0510DCAD5AB86E178A686D398E11A0ECFAC5A326C10129257E5456B22FB8E147E9190D9929A5DFFE44715FA47D62F04CFC9B1C201414
m_{PL103}	C10AF383DC708E257E15A8AB337BCE684A2F4AC7A22DC2C25C277F8E8D0858E79317CDDD9AA2EA6CBE604D24AC0945026103E7B4126FD361A4
m_{PL104}	A5C60A181148D9A931B2DDDB9D169648BA54F366B4EFAE88F6861909EE0F07C037EE349D0EC59A823286E366CA3943589EEA7F828C3728085F
m_{PL105}	96136AEBD5E28462B0421DF292BA899FFA660D80EA01620D2C7490E5347127884AA3C3D1FF44BCFE6C29EC589CDEF200C5742C5964F8B2B52
m_{PL106}	40F63C04ACAD986255D1E16B769A6D4C11A1D075E804BDC0AC61923E9A67F5D7417756328072455F6E22B1C64E06F367D1B0808295C2D90E22
m_{PL107}	F4B82D413578C4888C5F002CF6D0E03778134A860436551FD57537E4CED334B3C9CEBACE615238271717AA762448B86FA53D2074BCE35658A7
m_{PL108}	BCCC92D72C920E685530591FC351743D1E23DE044BF81D32650406113E23ECC757FDE4E386B6E2E7195EE4969717A7BD0812AC312B33A54308
m_{PL109}	6ED59DE0D44370A861CE2B42CF5E578E764A682AB5777905EE027D7160490EDC6C28989B23805AA697FCD215CB401BC5E4D430624C01B16192
m_{PL110}	DE80C0E273B92CC3C5034F7A20DB3914643C430B425C8B9249EAF73ACE8C3BCF17957242CF534D87A67D4DC0252275262E737F4095450CFA14
m_{PL111}	9505C4FEF2A397D5059F4729D013292A8321FFFA929ACB0A210D0A13E13061227C44A68FBD8CE6B66CE3D783363CD039AB35EE52603E09B758
m_{PL112}	E8BE90D7F954B14D8002A4CAC20765ABEED80634498C836D79B0F9338DBC17B28F05CF4E79136779E1C55AA30B6215F890882887B3B53C23E2
m_{PL113}	9F4B622C1358AE5468DC31E4B2CA320E5E20458C1DE5405BF4F9AD7D45A5BCAA39EC0626FFFC698C16A009CCCB7A18A64E85E70BA71731BA24
m_{PL114}	B91B2624843CF48299AFC2B1442570B41F28F578530D1E322E0B54282372131C71ACB924E70768A243EEC3200E7A5EBFA77111D9FB07FEA8AE
m_{PL115}	965F42DDA3A4650FE2F5103932B68F166FA424B9F0F7045311D962C2A9F66B9BC6C66FB480F9800354E0C54A72251071422CF1DFC44F94C00C
m_{PL116}	08ADCE48699FC30FA0788073BDAADB9177BBB4C1CED41F93085218364B8BAD8488561EF0FE1B0DDAA403C602494CB35697D62AA0A2B93A64CF
m_{PL117}	9A313BED80B1220D77C8ADA4B2E0B3D284A5120A94B741380923C78D3AD32BC3E71EC6EEA520E9D447D8727697598BB987F17506F482003ABD
m_{PL118}	24C9AD4C14EFEC002A3473FCAB04E492F2E269161A2960BA8AF09FD710B444A40C4E8B138418E62301E91FBA97AFDC58759A76D00F676736C7
m_{PL119}	6514C7733711CE4942CD2123AB37186EB7FECB7E78ABB28744864942FCF4C0F810054AF55B1042EB53064F0857C61D85B2CF0D2DC5826AF22F
m_{PL120}	B2C80CDC83E48C36BC6FDAB8661208EAD392F3A0571BE41DFAD765E744932ADEA50061E66C05498A5381B2A1F1B446587089DC4E4A2DF03D82
m_{PL121}	639368BA75CC709A3D9F28EDA237E32C2017A9BF1E382045B9426AEE0A4049DCB4E1D7EBE4647B855212824557497CFA039885A3BA42F98F63
m_{PL122}	6A70DDC17D0C8024B1C853F0C1948561EF32510151BE0C63BCA9171F20217891D1021EE72586CAFF557F8973336913A9A2A699B8740B054B8
m_{PL123}	2E32E3A35CCD001172CE310B63B4E406126045A0FA3795BE3E3D9B56F72405FC94FD89946818BAECD24A61BABBBE2D23052AB01EF73CA0CF4A
m_{PL124}	829395C35205A480AC1351C25E234BF52D384A3DE1C5138A650A6F82F739757D812D9C38231AB9FD81AA0648B11F6F6113F9312C57624FC746
m_{PL125}	D98FFE19C0AAAAB0571A9075ECD3E7373F5255DC669116A8C6913F0123E598F930934C5F6A601C37C529C371A0C391B59AC5A9E286D04011

Code ID	Basic Midamble Codes m_{PL} of length $P=456$
m_{PL126}	C1A108192BCE96C2430A63C189BB33856BE6B8B524703FCB205DAEF37EF544CD43CA09B6181B417398083FF2F781BA4AE89A5CA291DB928D71
m_{PL127}	42568DF9F61849BF9E7DEE750604BE2E0BC16CC464B1CDE15015E01D6498E9F3E6D6950E5824651F212BA0057CE9529B9CCAB88D8136B8545E

A.2 Basic Midamble Codes for Burst Type 2

In the case of burst type 2 (see subclause 5.2.2) the midamble has a length of $L_m=256$, which is corresponding to:

$K'=3$; $W=64$; $P=192$.

Depending on the possible delay spread cells are configured to use K_{Cell} midambles which are generated from the Basic Midamble Codes (see table A-2)

- for all $k=1,2,\dots,K$; $K=2K'$ or
- for $k=1,2,\dots,K'$, only.

The cell configuration is broadcast on BCH.

The mapping of these Basic Midamble Codes to Cell Parameters is shown in TS 25.223.

Table A-2: Basic Midamble Codes m_p according to equation (5) from subclause 6.2.3 for case of burst type 2

Code ID	Basic Midamble Codes m_{PS} of length $P=192$
m_{PS0}	5D253744435A24EF0ECC21F43AA5B8144FBDB348C746080C
m_{PS1}	9D7174187201B5CE0136B7A6D85D39A9DD8D4B00E23835E4
m_{PS2}	AE90B477C294E55D28467476C6011029CDE29B7325DF0683
m_{PS3}	BC8A44125F823E51E568641EC12A6C68EAFDFA2350E3233C
m_{PS4}	898B7317B830D207C9BC7B521D5715680824DC08347B2943
m_{PS5}	466C7482C8827655BC13F479C7C1417290679A9841297C4A
m_{PS6}	AC0734C27C7DC1B818A8492744290DFE866B0EBA62B0B56E
m_{PS7}	0A92106325B15A8C15FC3764724CE67A5056D50A77F9360E
m_{PS8}	AE69F62E23035083E6094B89493D33E06FDB6532D473A280
m_{PS9}	B485D4E3614C9C373EA1365FA6FA890E9844084EBA90EB0C
m_{PS10}	66182885E2D28360D2FEAB842C65304FFC956CE8DC8A90C7
m_{PS11}	CC30A9B0A742FCC1E9A408415368391F1299AEA3CB6509FE
m_{PS12}	673928915886947F464FDDAAD29A07D182328EBC5839089A
m_{PS13}	4418861C14D62B46EE6D70D4BF05A3ED801A01BD6CDC5235
m_{PS14}	DAD62DC88F52F2D140062C2330BE6540E6F86192322AFB04
m_{PS15}	A2122BAF24529CEA9855FB43CE40923E7CA7B30D92E40702
m_{PS16}	6C44AB41E11F54B0929DF65673BD231F92A380132D9F1712
m_{PS17}	1DC2742E756CDA6421340D0087DD087A615E4B8688CB2F75
m_{PS18}	2E0105328B56E9E07D9B5A62F38B08AF8D8C2817B54F3302
m_{PS19}	88315EC30A94CA4EDB2C77079D9BD810A2E280B50DABB213
m_{PS20}	440E0093D28CB2B2B0A95D18CEB4AB934C33FA45C1CFC7B0
m_{PS21}	CC9BF85D41A96A6EC314F9611D5E1C0672556C8850801BB4
m_{PS22}	1ABEA04C99BC26972715F01957C0B6B959CC71CD88120817
m_{PS23}	EC5A33DA0BA4470442C5CB324A8E47B0A9F7968FC8108EE8
m_{PS24}	F82086290271DB446B5B1DC15D9BE96414B19B3D5E0F540C
m_{PS25}	11A1A790D6958FD3A9157DF1E05D1378248CA201EBCC7592
m_{PS26}	AA8564882231907BCE78092DC6C9DD4F5A0E4A34AFCFB809
m_{PS27}	912EE2238212F87BC7CDA7F30441ED184A6AA954EC4D20C8
m_{PS28}	2D200D8B8891B804673E380A1AF5AB875986E29D37D3FDC9
m_{PS29}	75E086B6C818423491BF9D6365C52FD1C5E42A576E268170
m_{PS30}	50ADBF27DA2A3701470186B699118E16DDB0D10F705607B1
m_{PS31}	656C0692B4E22023590A906D2A74DFD471C883A7B1E0B3A2
m_{PS32}	C21FDACD09A3CDCE74C4794010A3E45769B142505C56A0E6
m_{PS33}	CD9392A87C2D4D7CE5801CDDA8A76339B6F900F008B290E2

Code ID	Basic Midamble Codes m_{PS} of length $P=192$
m_{PS34}	956426FEFD8B8D52073E87984E10C4D255064E1372C04A24
m_{PS35}	C4F4D6DF1B754AD6063FD10C331C1428ABB27B0700134B94
m_{PS36}	B65548082B34E9FAF43F33C4070F79099758CFD41B491A11
m_{PS37}	C8317EA111A82B04E78B88B864B1EF5D711BBE4A0527036
m_{PS38}	8FB7AD1188E8D1A5219845013672560FD38904E70537403B
m_{PS39}	B41A324E0D80AA0598A8D391C1D7FFC82B4A075218E98EC3
m_{PS40}	49A6350A62E208B011E86528B9A481A0E76D723F6675FF82
m_{PS41}	C344C8C23C42A7B7442E6022E95AE4B08A4BFA786F35F911
m_{PS42}	28F430CF67D69C9DF60E25656413BC5F932A022DB1406C44
m_{PS43}	2FA5D70CF0FED4213F32116051450391C2A627D9B670C428
m_{PS44}	959537D988FDD4F1360B4E84701AE5409229C30EDF8BC404
m_{PS45}	CDD2E0450F9EC12F81391AD4633CB29F315B4A0A890A9A22
m_{PS46}	158776A20B4B82C563EC08F086830EA66DBD2DCCB4DF6026
m_{PS47}	431FCACBE48208975950342709D11F19AD5FB047F3B440C9
m_{PS48}	86B141AC571BA6B42653B12FF04D4F0E6C81F3EB608660A2
m_{PS49}	86D297ABD34E8510F6CDB0EA617F1F1051C8799117B02211
m_{PS50}	80B2D9530B34E781311D95CFA3857F277CC07014D324AF5A
m_{PS51}	2B607B93FD8B45601C1E574E14CFC6912C22AEC1045ADC49
m_{PS52}	D234C5C45E105A837E6DD74BC4E534523A20317BA0625A29
m_{PS53}	768CCDB3E2A7A2B863128382590946B25472BE2BFFC40641
m_{PS54}	3DA38212E0A987EE1F665D4E13C2AA4446E00A76C948A073
m_{PS55}	09173135E4A2CFC8F2678750AB5257110906F013587BDE82
m_{PS56}	522E070B266F35E99C1F3C42D2017F8E415550492B72F086
m_{PS57}	D63E4BD805262A3DEF05C7D86C422E5048921E5531784132
m_{PS58}	564AF806E28131611E5F884229265D446A50E1E488EAFBBA
m_{PS59}	A2603E009D3D30147727B750C35C62299AF754D3E4A54E1C
m_{PS60}	938504B02599D33E28246E4271C375AE81A3BBE8D3F8A920
m_{PS61}	461516B2CAC6FC42A4B707CC6073BBE573C014892C811776
m_{PS62}	29186DE4CCAAB2CD0100BB19EA595879D63F0F0CFA881AA5
m_{PS63}	A064B449CB784A91B803369CDC5EF61A670AAAC044BA3E68
m_{PS64}	8719C454D88FF5149DB943CB6CADA01D0B9664B357A18203
m_{PS65}	A27EC68720F00A714AA2C45A7EF232286984D7B193F5C916
m_{PS66}	AC8361676AB424E48F0789082B0CD2EFB8D2E627D041DD66
m_{PS67}	ABA1BEB0064733A0620906BF2B29C95883F069D7E4C35D39
m_{PS68}	9E22EDED47D92CA1D0B7530EC6062287BD83A04874AE00C
m_{PS69}	0BADEF288B20F5686C5DE3A71219AC2172054326BE831696
m_{PS70}	953801EB2AF58C2F80E49A6CC46085CB554243E3B3BBEC8C
m_{PS71}	333A504C51C8FAC5025994565C3F600F154F64FAEF4EA484
m_{PS72}	A6583E19647662005474153A6F8DD88A473853E94B720CE7
m_{PS73}	90ACAF707D18AF34F5848C58166830AF620ACDC1B2DFDDA8
m_{PS74}	39C5C598A374EA82F3F83378258248DAD3808812DD0E74BB
m_{PS75}	F79525DE694629346D73F6256CC0F140F82603197AAA1844
m_{PS76}	B8C2A8F139097699A693022E78588D4058DB0A65FF52F813
m_{PS77}	449B50C2A52996FA5A828A907F30F9F460EE3D99930DF890
m_{PS78}	62CEC9574D30184BCB4F94EECF0CC23D2D2A8D0003F0AA33
m_{PS79}	B56D258889703F76A0738EE3A7D355994159A4851833E198
m_{PS80}	65894AA54C0F6C9A206521C9FC379A8AAF6E621C03CF849C
m_{PS81}	2D47F3414E30CC02C6835D95C9BA204488F0FFCB4852677D
m_{PS82}	12BE4DD8B906B584010F8A330AB67B278E8642FA33D51B68
m_{PS83}	BC928A90A4B10906CAEE638BF768E08542F48F1676006DF0
m_{PS84}	30C544E437C8ADA143566CD1BC4E9E7BA84139A08505C2F4
m_{PS85}	84FD5B05506192B753FBA2C719B584E0EDA01814999867D2
m_{PS86}	191F14DD00034E03AB5BB4342F1138B2CD33784E60CFD75A
m_{PS87}	B8ACE7990B6A98A80A61162C4D2D5F88F24E8F7DE4207590
m_{PS88}	EC1DBE72E8EED0C61054FC2695422AC0AD2D888265B21AB0
m_{PS89}	9A1B4CA467AB7E082AF4278E44D177EA78424508C23E8B08
m_{PS90}	999EE541C608164AC975214F3A37A677FC2CA03E2C2A4B20
m_{PS91}	1BDCC20265031432917A2EB828FB356A22DF9CB609C0F8F3
m_{PS92}	EB4A81859C93338B8A1B87C02C815AE09D765F6F2249B958
m_{PS93}	E6A5D1629F4CF09A1F280DE0C480D4C73B26ADE321A50AEE
m_{PS94}	BAAB7286DD24C80B15A7958039B904F1CA83C310C8C7AFF2
m_{PS95}	12220F72619E983717C68FFE1C4148F2354B7B1955B65620
m_{PS96}	A198706E24FAA08BD09EE392414816038E667BB34307D6B2

Code ID	Basic Midamble Codes m_{PS} of length $P=192$
m_{PS97}	30B3493B4C035881A7A722E4546527AAE787FA2C0893AC46
m_{PS98}	5A7318126522843DCB7F00A2D9F9BA8F88963E4152BC923C
m_{PS99}	844844B0CACAB702C332CE2692B4166F4B0C63E62BF151BF
m_{PS100}	B8297389526410313692F861DC60DA86A23607F7DDE24755
m_{PS101}	6C1144CF8BC01538D655D29ED62DE6E74A3180EC905BF1E0
m_{PS102}	E9DB3221FACFC5C88691A7013EF09672A130D52C3413AAE2
m_{PS103}	2FD0508615EC4CD4BF18ADD46D777078869130C8921A4F0E
m_{PS104}	40911B4E0525AC874228F6EF642E59154730CB187C7E417A
m_{PS105}	2034C6A027D4D850F5184AA64C3153231F4651B616BBFCF9
m_{PS106}	57833235451525A1DFA213FCE0B419B6494BC7B99F488410
m_{PS107}	6DC3D57F2E39158D036825F8804810D77CA1ECA610ECD894
m_{PS108}	F5C50DE43AA7B731CAB7683524021701F97650499A7070E4
m_{PS109}	F2184D2699785442E09FA22CC2D60A5A13FFF22AE660A470
m_{PS110}	EF0029DE0D79207205458CF4D7328E81A93518D93C9A74BD
m_{PS111}	9D6D8992482FB885AA5E878C3BA2045538B09886C23CDC2D
m_{PS112}	C0A5AB67D1CEA126F6476C75443F0A11CBE749412EF03104
m_{PS113}	1853A5C20CDF968C5A180D8EB5E72BF15517D06680D98412
m_{PS114}	8CEA1223227ADF37D0DAAB320906E1C79029F480D25181A7
m_{PS115}	5561038E96A658EF3EC665612FF92B064065D1ACC1F54812
m_{PS116}	C55A6263F08D664A1E53584560DFF5E611640D8281D9A843
m_{PS117}	4386A8EA59124D043F29056A4598735A4FC7BC11119B90C1
m_{PS118}	D6571B20668BED50BD7C80388C162632BCB069AA67C7FC22
m_{PS119}	4F9F09ABBC1391EC2CCA5359FB52250E533BF04324154106
m_{PS120}	662659F42188C9453F6E6DF00C579627045DA1461A3A0EA5
m_{PS121}	8DCC9274C0C2A9BA6096BF27FACA542CD01CA8653D60A80F
m_{PS122}	5C1210A1E50E505F6B73C90156C9D9F19AE2310BBD820DF0
m_{PS123}	B1E0A7CE26202E223D4FC06D5C9BBA4E5F6D98204D2D5286
m_{PS124}	DB506776958E34552F7E60E4B400D836153218F918E22FA6
m_{PS125}	ECAA60300439B2360B2AC3C43FB6241ACDE5055B295FA71C
m_{PS126}	BF1E6D9AA9CA4AC092BE60500C77D0DC7A6A236520F86722
m_{PS127}	051C5FA122845A30B4EC306B38016B45667C7754F92F13A0

A.3 Association between Midambles and Channelisation Codes

The following mapping schemes apply for the association between midambles and channelisation codes if no midamble is allocated by higher layers. Secondary channelisation codes are marked with a (*). These associations apply both for UL and DL.

A.3.1 Association for Burst Type 1/3 and $K_{Cell}=16$ Midambles

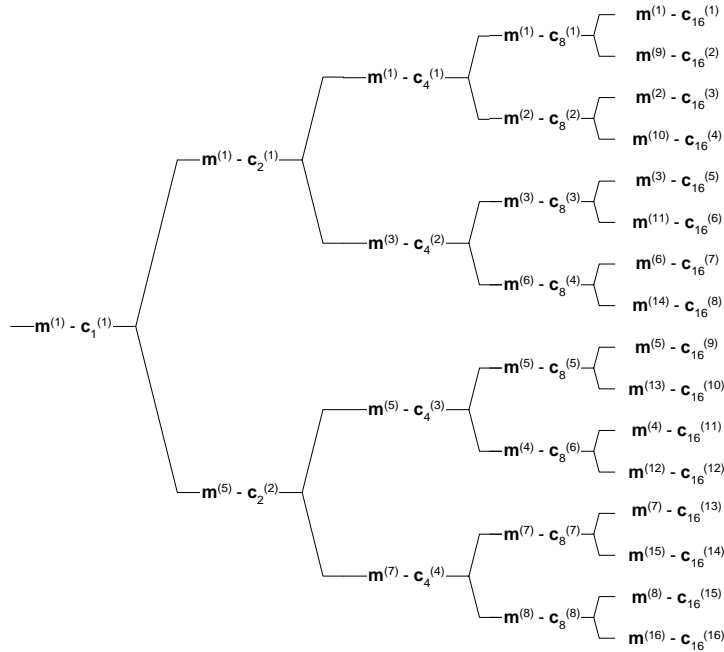


Figure A-1: Association of Midambles to Spreading Codes for Burst Type 1/3 and $K_{Cell}=16$

A.3.2 Association for Burst Type 1/3 and $K_{Cell}=8$ Midambles

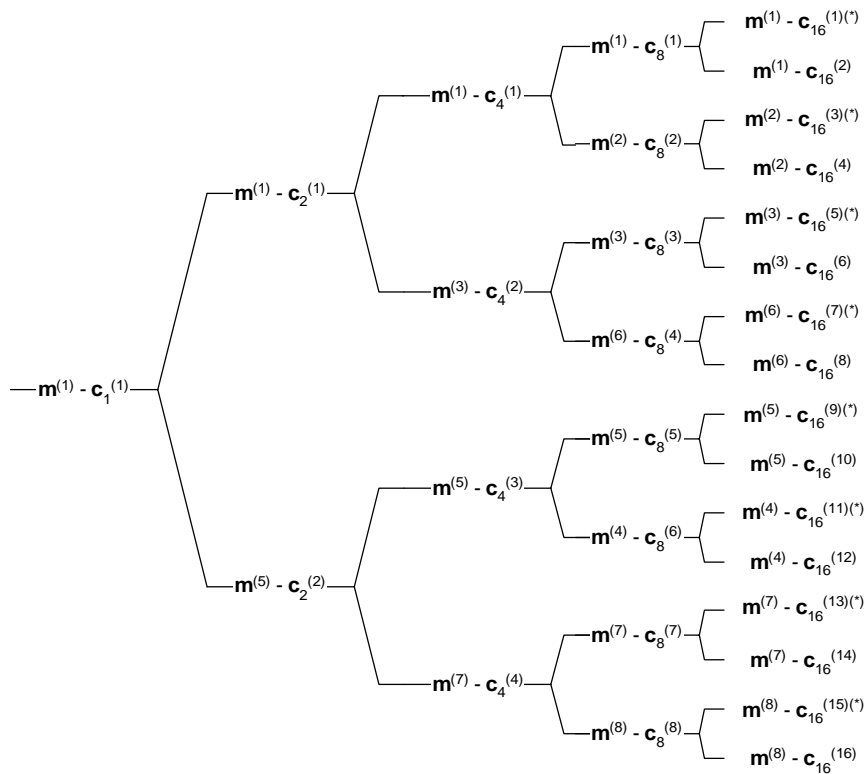


Figure A-2: Association of Midambles to Spreading Codes for Burst Type 1/3 and $K_{Cell}=8$

A.3.3 Association for Burst Type 1/3 and $K_{Cell}=4$ Midambles

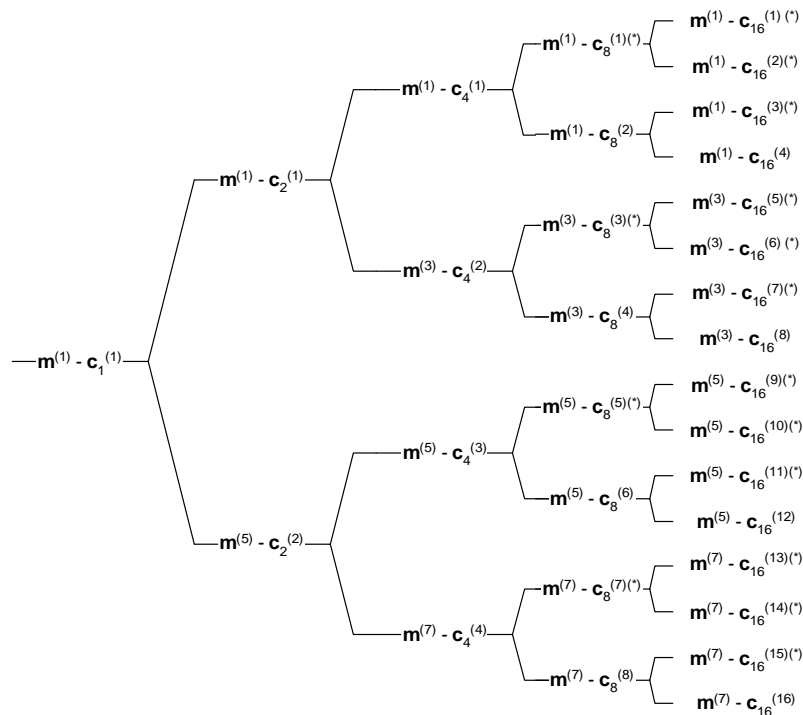


Figure A-3: Association of Midambles to Spreading Codes for Burst Type 1/3 and $K_{Cell}=4$

A.3.4 Association for Burst Type 2 and $K_{Cell}=6$ Midambles

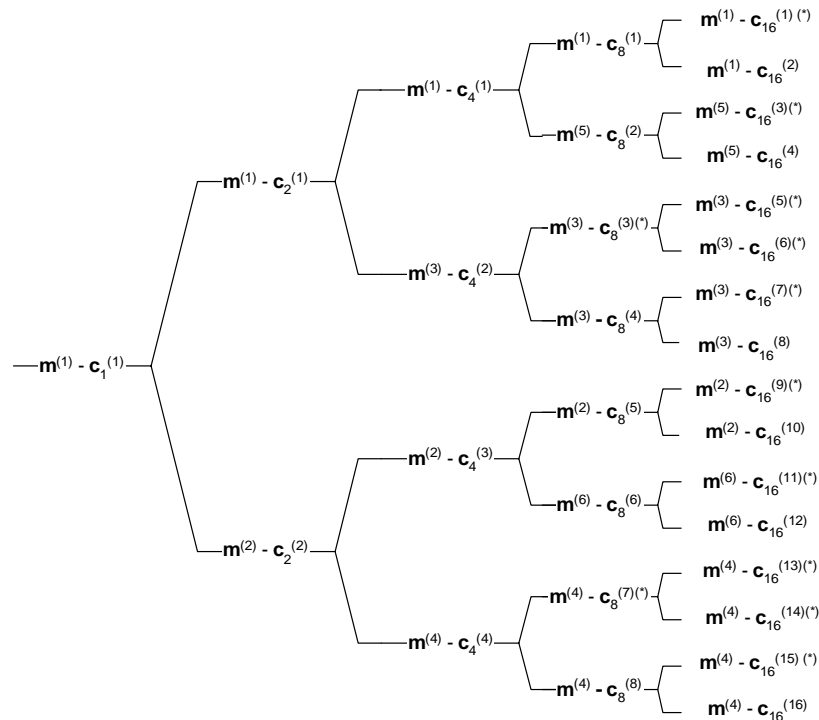


Figure A-4: Association of Midambles to Spreading Codes for Burst Type 2 and $K_{Cell}=6$

A.3.5 Association for Burst Type 2 and $K_{Cell}=3$ Midambles

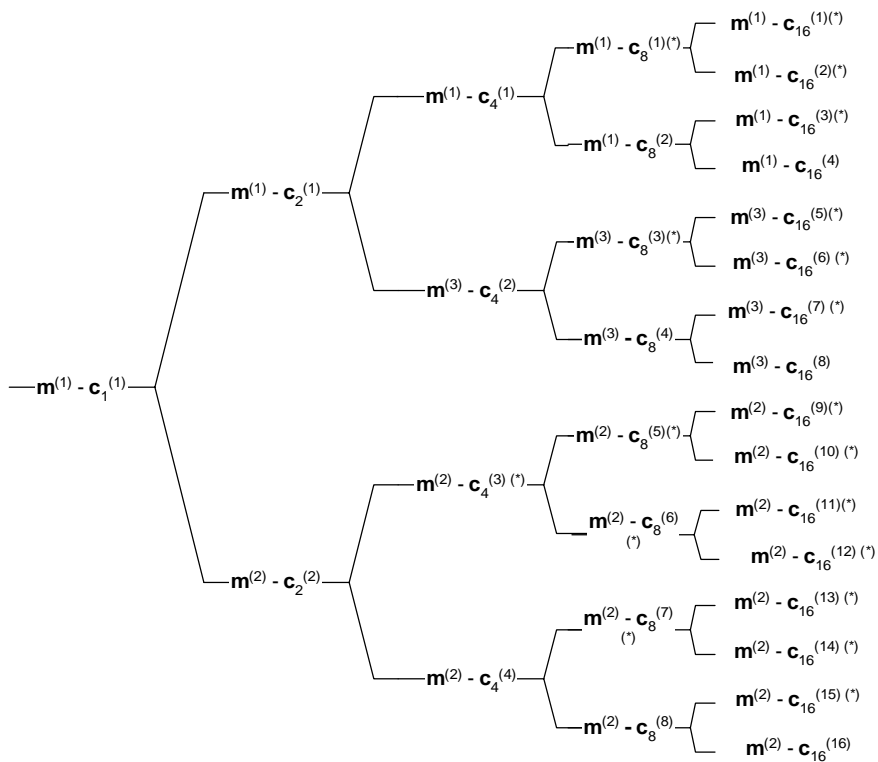


Figure A-5: Association of Midambles to Spreading Codes for Burst Type 2 and $K_{Cell}=3$

Note that the association for burst type 2 can be derived from the association for burst type 1 and 3, using the following table:

Burst Type 1/3	m(1)	m(2)	m(3)	m(4)	m(5)	m(6)	m(7)	m(8)
Burst Type 2	m(1)	m(5)	m(3)	m(6)	m(2)	m(4)	-	-

Annex B (normative): Basic Midamble Codes for the 1.28 Mcps option

B.1 Basic Midamble Codes

The midamble has a length of $L_m=144$, which is corresponding to:

$$K=2, 4, 6, 8, 10, 12, 14, 16, \quad W = \left\lfloor \frac{P}{K} \right\rfloor, P=128$$

Note: that $\lfloor x \rfloor$ denotes the largest integer number less or equal to x .

Depending on the possible delay spread cells are configured to use midambles which are generated from the Basic Midamble Codes (see table B.1). The cell configuration is broadcast on BCH.

The mapping of these Basic Midamble Codes to Cell Parameters is shown in [8].

Table B.1: Basic Midamble Codes m_p according to equation (5) from subclause 6.2.3

Code ID	Basic Midamble Codes m_p of length $P=128$
m_{P0}	B2AC420F7C8DEBFA69505981BCD028C3
m_{P1}	0C2E988E0DBA046643F57B0EA6A435E2
m_{P2}	D5CEC680C36A4454135F86DD37043962
m_{P3}	E150D08CAC2A00FF9B32592A631CF85B
m_{P4}	E0A9C3A8F6E40329B2F2943246003D44
m_{P5}	FE22658100A3A683EA759018739BD690
m_{P6}	B46062F89BB2A1139D76A1EF32450DA0
m_{P7}	EE63D75CC099092579400D956A90C3E0
m_{P8}	D9C0E040756D427A2611DAA35E6CD614
m_{P9}	EB56D03A498EC4FEC98AE220BC390450
m_{P10}	F598703DB0838112ED0BABB98642B665
m_{P11}	A0BC26A992D4558B9918986C14861EFF
m_{P12}	541350D109F1DD68099796637B824F88
m_{P13}	892D344A962314662F01F9455F7BC302
m_{P14}	49F270E29CCD742A40480DD4215E1632
m_{P15}	6A5C0410C6C39AA04E77423C355926DE
m_{P16}	7976615538203103D4DBCC219B16A9E1
m_{P17}	A6C3C3175845400BD2B738C43EE2645F
m_{P18}	A0FD56258D228642C6F641851C3751ED
m_{P19}	EFA48C3FC84AC625783C6C9510A2269A
m_{P20}	62A8EB1A420334B23396E8D76BC19740
m_{P21}	9E96235699D5D41C9816C921023BC741
m_{P22}	4362AE4CAE0DCC32D60A3FED1341A848
m_{P23}	454C068E6C4F190942E0904B95D61DFB
m_{P24}	607FEEA6E2E99206718A49C0D6A25034
m_{P25}	E1D1BCDA39A09095B5C81645103A077C
m_{P26}	994B445E558344DE211C8286DDD3D1A3
m_{P27}	C15233273581417638906ADB61FDCA3C
m_{P28}	8B79A274D542F096FB1388098230F8A1
m_{P29}	DF58AC1C5F44B2A40266385CE1DA5640
m_{P30}	B5949A1CC69962C464401D05FF5C1A7A
m_{P31}	85AC489841ED3EAA2D83BBB0039CC707
m_{P32}	AE371CC144BC95923CA8108D8B49FE82
m_{P33}	7F188484A649D1C22BDA1F09D49B5117
m_{P34}	ADAA3C657089DEF7C0284903A491C9B0
m_{P35}	C3F96893C7504DC3B51488604AF64F4C
m_{P36}	B4002F5AE0CE8623AC979D368E9148C1
m_{P37}	0EEBCC0C795C02A106C24ABB36D08C6E
m_{P38}	4B0F537E384A893F58971580D9894433
m_{P39}	08E0035AB29B7ECC53C15DAA0687CC8F
m_{P40}	8611ACBC4C82781D77654EE862506D60
m_{P41}	63315261A8F1CB02549802DBFD197C07
m_{P42}	9A2609A434F43E7DCADC0E22B2EF4012
m_{P43}	F4C9F0A127A88461209ABF8C69CE4D00
m_{P44}	C79124EE3FFC28C5C4524D2B01670D42
m_{P45}	C91985C4FED53D09361914354BA80E79
m_{P46}	82AA517260779ECFF26212C1A10BDC29
m_{P47}	561DE2040ACB458E0DBD354E43E111D9
m_{P48}	2E58C7202D17392BC1235782CEFABB09
m_{P49}	C4FAA121C698047650F6503126A577C1
m_{P50}	E7B75206A9B410E44346E0DAE842A23C
m_{P51}	3F8B1C32682B28D098D3805ED130EA7F
m_{P52}	8D5FC2C1C6715F824B401434C8D4BB82
m_{P53}	0B2A43453ACC028FE6EB6E1CB0740B59
m_{P54}	BC56948FC700BA4883262EE73E12D82A
m_{P55}	558D136710272912FA4F183D1189A7FD
m_{P56}	5709E7F82DC6500B7B12A3072D182645
m_{P57}	86D4F161C844AE5E20EE39FD5493B044
m_{P58}	8729B6EDC382B152185885F013DAE222
m_{P59}	154C45B50720F4C362C14C77FE8335A1
m_{P60}	C6A0962890351F4EB802DE43A7662C9E

mP61	D19D69D6B380B4B22457CB80033519F0
mP62	C7D89509FB0DAE9255998E0A00C2B262
mP63	DFD481C652C0C905D61D66F1732C4AA2
mP64	06C848619AF1D6C910A8EAC4B622FC06
mP65	0635E29D4E7AC8ABC189890241F45ECA
mP66	B272B020586AAD7B093AC2F459076638
mP67	B608ACE46E1A6BC96181EEDD88B54140
mP68	0A516092B3ED7849B168AFE223B8670E
mP69	D1A658C5009E04D0D7D5E9205EE663E8
mP70	AC316DC39B91EB60B1AABD8280740432
mP71	E3F06825476A026CD287625E514519FC
mP72	A56D092080DDE8994F387C175CC56833
mP73	15EA799DE587C506D0CD99A408217B05
mP74	A59C020BAB9AF6D3F813C391CA244CD2
mP75	74B0101EB9F3167434B94BABC8378882
mP76	CE752975C8DA9B0100386DB82A8C3D20
mP77	BBB38DCDB1E9118570AC147DC05241A4
mP78	944ABBF0866098101F6971731AB2E986
mP79	2BB147B2A30C68B4853F90481A166EB6
mP80	444840ACCF3F23C45B56D7704BF18283
mP81	87604F7450D1AD188C452981A5C7FC9B
mP82	8C3842EBC948A65BC4C8B387F11B7090
mP83	10B4767D071CF5DB2288E4029576135A
mP84	6F07AAB697CD0089572C6B062E2018E4
mP85	D3D65B442057E613A8655060C8D29E27
mP86	5EDA330514C604BF4E0894E09EC57A74
mP87	B0899CD094060724DED82AE85F18A43A
mP88	B2D999B86DF902BC25015CAE3A0823C4
mP89	C23CD40F04242B92D46EED82CD9A9A18
mP90	D22DDCC5CB82960125DD24655F3C8788
mP91	54987218FBD99AE4340FD4C9458E9850
mP92	BE4341822997A7B11EA1E8A1A2767005
mP93	255200FBA6EE48E6DE0A82B0461B8D0F
mP94	6FBD58A663932423503690CF9C171701
mP95	D215033A4AA87EC1C232BAC7EDA09370
mP96	CA0959B01AE48E80204F1E4A3F29CE55
mP97	582043413B9B825903E3A3545ED59463
mP98	5016541922971C703D16E284CBDF633B
mP99	7347EF160A1733CA98D43608A83A920B
mP100	908B22AD433CCA00B3FD47C691F1A290
mP101	BB22A272FC6923DF1B43BA4118806570
mP102	0FA75C87474836B47DC7624D61193802
mP103	A22EBA0658A4D0FF1E9CA5030A65CC06
mP104	6C9C51CA15F1F4981F4C46180A6A6697
mP105	4C847ACF8BC15359C405322851C9BDE2
mP106	C1D29499C0082C9DE473ED15B14D63E0
mP107	7E85ECC98AC761005076C5572869A431
mP108	D8F11121595B8F49F78A7039E44126A0
mP109	1A0BC814445FD71C8E5B1A9163ED2059
mP110	A7591F27F8B0C00C68CC41697954FA04
mP111	6CA2CE595E7406D79C4840183D41B9D0
mP112	C093D3CC701FC20E66F5AB22516C5460
mP113	D0E0CDE9B595546B96C4F8066B469020
mP114	E99F743A451431C8B427054A4E6F2007
mP115	C0D21A344A2C07DF2A6EBE6250C7B91E
mP116	F031223E282CF7A4D8EF174A908668AE
mP117	E4BD244AC16C55C7137FB068FD44280C
mP118	C44920DE2028F19FC2AAB36A0DCFDAD0
mP119	3FA7054E77135250699E6C8A11600742
mP120	D5740B4D8870C1C5B5A214C4266FC537
mP121	F0B7942D43BB6F38446442EB8126AB80
mP122	83DB9534EAD6238FA8968798CDF04848
mP123	EB9663CDDC2B291690703125BABC8B00
mP124	84D547225D4BBD20DEF1A583240C6E0F

m _{P125}	B51F6A771838BE934724AEA6A2669802
m _{P126}	D92AC05E10496794BBDC115233B1C068
m _{P127}	D3ACF0078EDA9856BBB0AF8651132103

B.2 Association between Midambles and Channelisation Codes

The following mapping schemes apply for the association between midambles and channelisation codes if no midamble is allocated by higher layers. Secondary channelisation codes are marked with (*). These associations apply for both UL and DL.

B.2.1 Association for K=16 Midambles

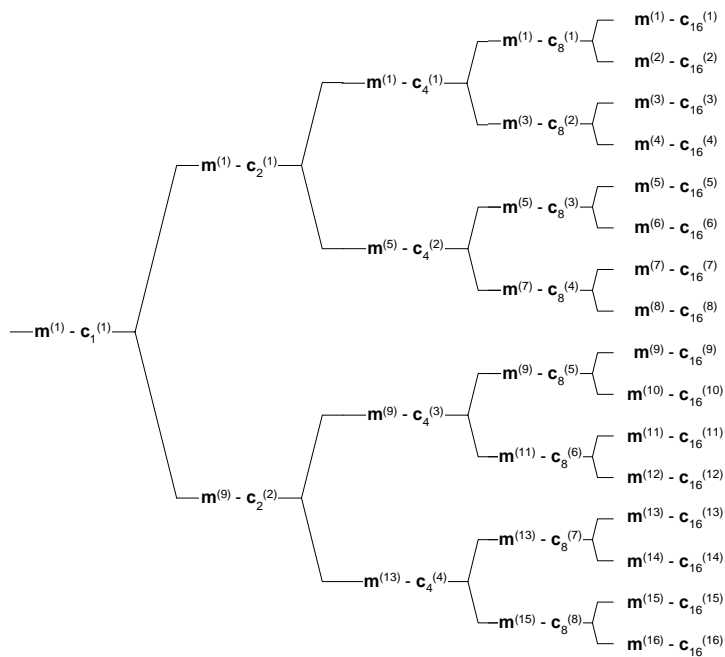


Figure B.2.1: Association of Midambles to Spreading Codes for K=16

B.2.2 Association for K=14 Midambles

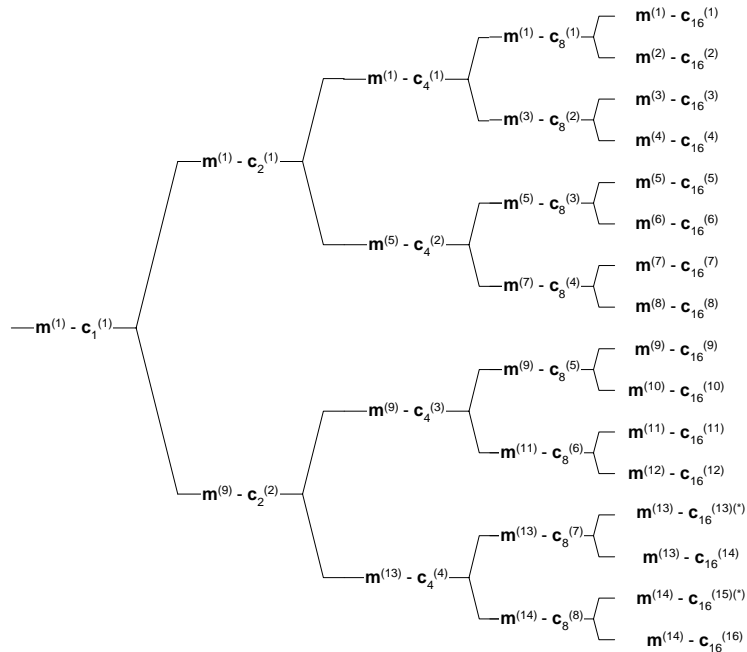


Figure B.2.2: Association of Midambles to Spreading Codes for K=14

B.2.3 Association for K=12 Midambles

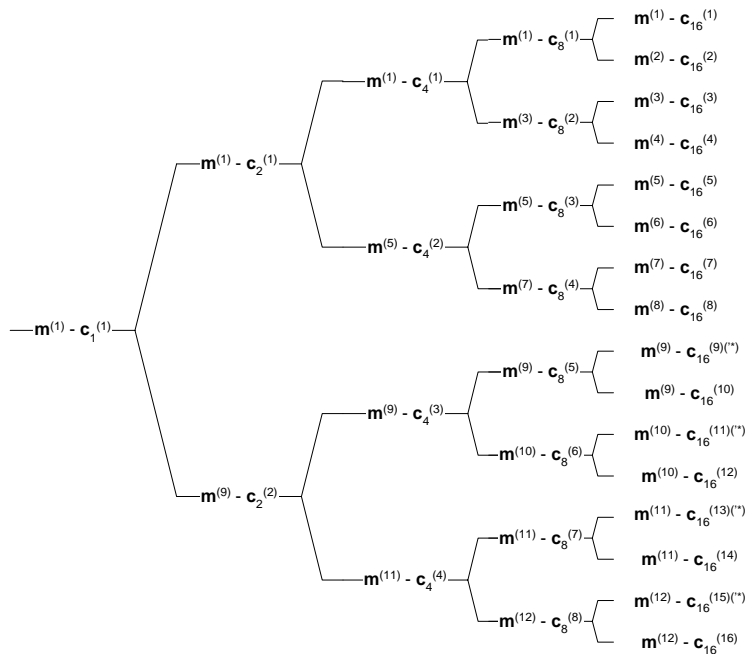


Figure B.2.3: Association of Midambles to Spreading Codes for K=12

B.2.4 Association for K=10 Midambles

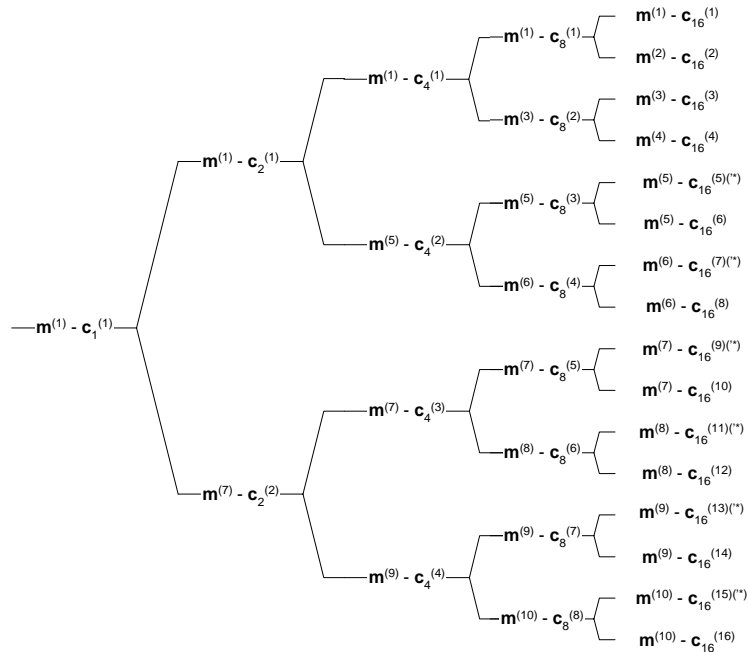


Figure B.2.4: Association of Midambles to Spreading Codes for K=10

B.2.5 Association for K=8 Midambles

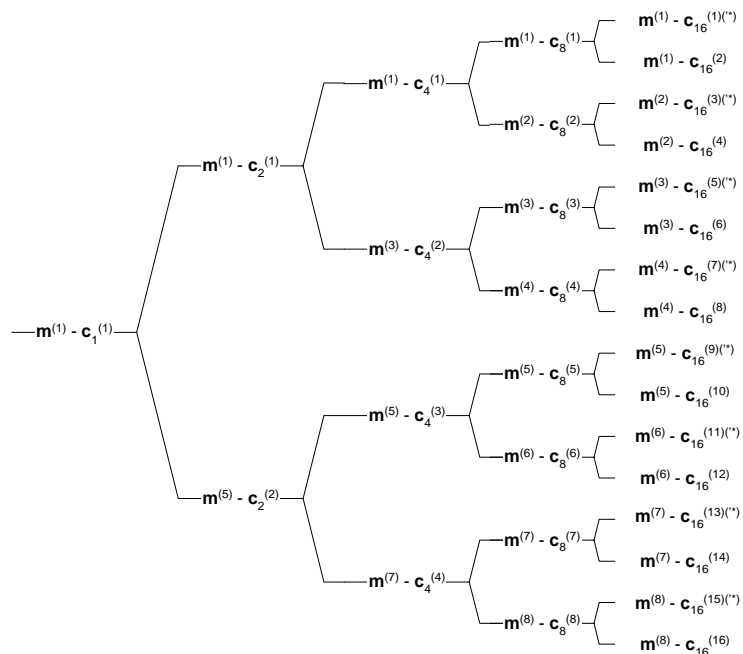


Figure B.2.5: Association of Midambles to Spreading Codes for K=8

B.2.6 Association for K=6 Midambles

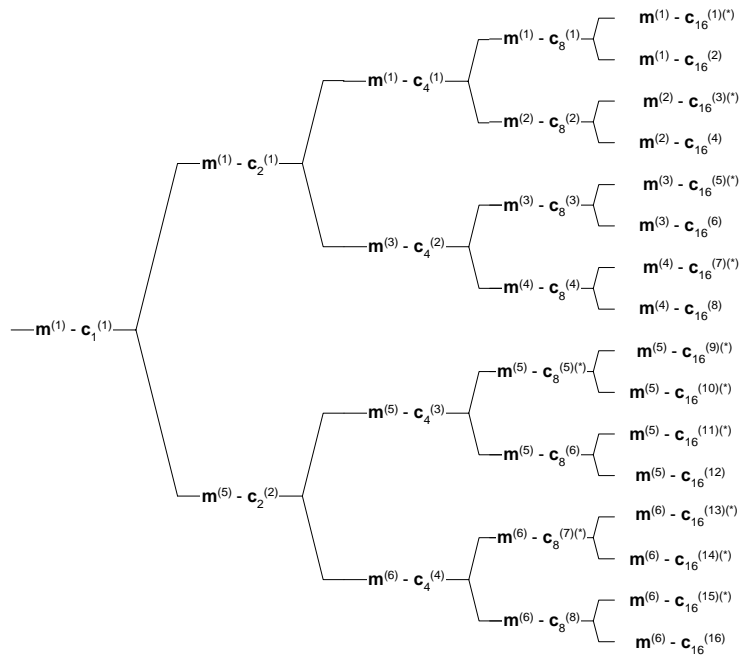


Figure B.2.6: Association of Midambles to Spreading Codes for K=6

B.2.7 Association for K=4 Midambles

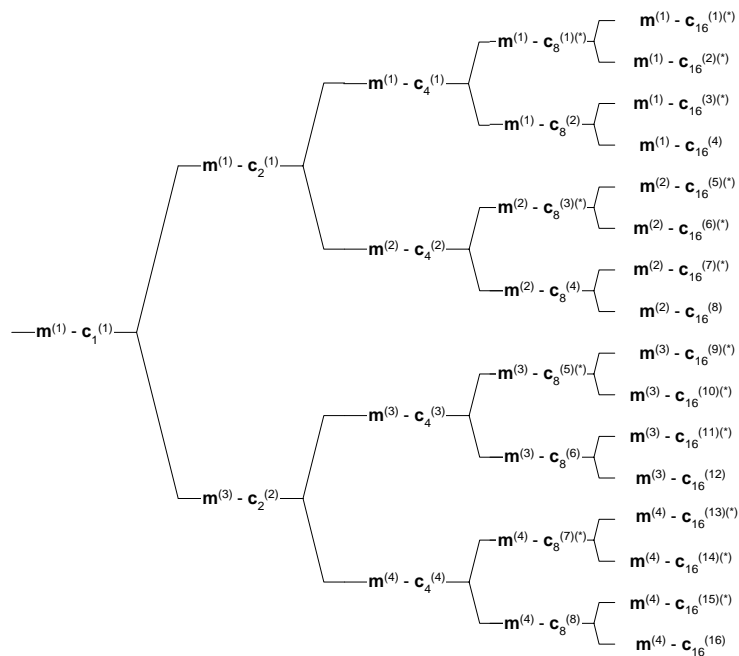


Figure B.2.7: Association of Midambles to Spreading Codes for K=4

B.2.8 Association for K=2 Midambles

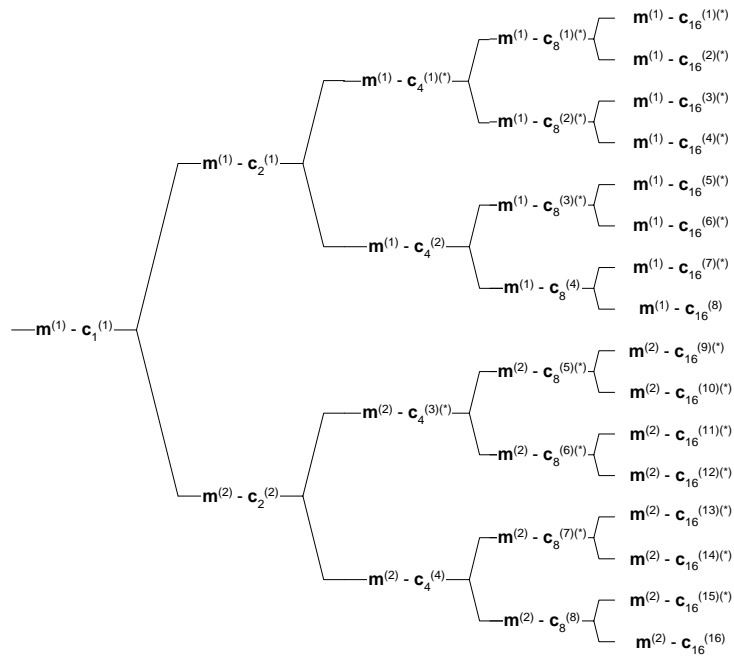


Figure B.2.8: Association of Midambles to Spreading Codes for K=2

Annex C (normative):

Signalling of the number of channelisation codes for the DL common midamble case for 3.84Mcps TDD

The following mapping schemes shall apply for the association between the number of channelisation codes employed in a timeslot and the use of a particular midamble shift in the DL common midamble case. In the following tables the presence of a particular midamble shift is indicated by '1'. Midamble shifts marked with '0' are left unused. Mapping schemes B.3 and B.4 are not applicable to beacon timeslots where a P-CCPCH is present, because the default midamble allocation scheme is applied to these timeslots. Note that in mapping schemes B.3 and B.4, the fixed and pre-allocated channelisation code for the beacon channel is included into the number of indicated channelisation codes.

C.1 Mapping scheme for Burst Type 1 and $K_{\text{Cell}}=16$ Midambles

m1	m2	m3	m4	m5	m6	m7	M8	m9	m10	m11	m12	m13	m14	m15	m16	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 code
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 codes
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3 codes
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4 codes
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5 codes
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	6 codes
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7 codes
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	8 codes
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	9 codes
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10 codes
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	11 codes
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	12 codes
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	13 codes
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	14 codes
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	15 codes
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	16 codes

C.2 Mapping scheme for Burst Type 1 and $K_{\text{Cell}}=8$ Midambles

M1	m2	m3	m4	m5	m6	m7	m8	
1	0	0	0	0	0	0	0	1 code or 9 codes
0	1	0	0	0	0	0	0	2 codes or 10 codes
0	0	1	0	0	0	0	0	3 codes or 11 codes
0	0	0	1	0	0	0	0	4 codes or 12 codes
0	0	0	0	1	0	0	0	5 codes or 13 codes
0	0	0	0	0	1	0	0	6 codes or 14 codes
0	0	0	0	0	0	1	0	7 codes or 15 codes
0	0	0	0	0	0	0	1	8 codes or 16 codes

C.3 Mapping scheme for Burst Type 1 and $K_{\text{Cell}}=4$ Midambles

m1	m3	m5	m7	
1	0	0	0	1 or 5 or 9 or 13 codes
0	1	0	0	2 or 6 or 10 or 14 codes
0	0	1	0	3 or 7 or 11 or 15 codes
0	0	0	1	4 or 8 or 12 or 16 codes

C.4 Mapping scheme for beacon timeslots and $K_{\text{Cell}}=16$ Midambles

m1	m2	m3	M4	m5	m6	m7	M8	m9	m10	m11	M12	m13	m14	m15	m16	
1	$x^{(*)}$	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1 codes or 13 codes
1	$x^{(*)}$	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2 codes or 14 codes
1	$x^{(*)}$	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3 codes or 15 codes
1	$x^{(*)}$	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4 codes or 16 codes
1	$x^{(*)}$	0	0	0	0	1	0	0	0	0	0	0	0	0	0	5 codes
1	$x^{(*)}$	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6 codes
1	$x^{(*)}$	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7 codes
1	$x^{(*)}$	0	0	0	0	0	0	0	0	0	1	0	0	0	0	8 codes
1	$x^{(*)}$	0	0	0	0	0	0	0	0	0	0	1	0	0	0	9 codes
1	$x^{(*)}$	0	0	0	0	0	0	0	0	0	0	0	1	0	0	10 codes
1	$x^{(*)}$	0	0	0	0	0	0	0	0	0	0	0	0	1	0	11 codes
1	$x^{(*)}$	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12 codes

(*) In case of Block-STTD encoding for the P-CCPCH, midamble shift 2 is used by the diversity antenna

C.5 Mapping scheme for beacon timeslots and $K_{\text{Cell}}=8$ Midambles

m1	m2	m3	m4	m5	m6	m7	M8	
1	$x^{(*)}$	1	0	0	0	0	0	1 or 7 or 13 codes
1	$x^{(*)}$	0	1	0	0	0	0	2 or 8 or 14 codes
1	$x^{(*)}$	0	0	1	0	0	0	3 or 9 or 15 codes
1	$x^{(*)}$	0	0	0	1	0	0	4 or 10 or 16 codes
1	$x^{(*)}$	0	0	0	0	1	0	5 codes or 11 codes
1	$x^{(*)}$	0	0	0	0	0	1	6 codes or 12 codes

(*) In case of Block-STTD encoding for the P-CCPCH, midamble shift 2 is used by the diversity antenna

C.6 Mapping scheme for beacon timeslots and $K_{\text{Cell}}=4$ Midambles

m1	m3	m5	m7	
1	1	0	0	1 or 4 or 7 or 10 or 13 or 16 codes
1	0	1	0	2 or 5 or 8 or 11 or 14 codes
1	0	0	1	3 or 6 or 9 or 12 or 15 codes

C.7 Mapping scheme for Burst Type 2 and $K_{\text{Cell}}=6$ Midambles

m1	m2	m3	m4	m5	m6	
1	0	0	0	0	0	1 or 7 or 13 codes
0	1	0	0	0	0	2 or 8 or 14 codes
0	0	1	0	0	0	3 or 9 or 15 codes
0	0	0	1	0	0	4 or 10 or 16 codes
0	0	0	0	1	0	5 or 11 codes
0	0	0	0	0	1	6 or 12 codes

C.8 Mapping scheme for Burst Type 2 and $K_{\text{Cell}}=3$ Midambles

m1	m2	m3	
1	0	0	1 or 4 or 7 or 10 or 13 or 16 codes
0	1	0	2 or 5 or 8 or 11 or 14 codes
0	0	1	3 or 6 or 9 or 12 or 15 codes

Annex D (normative):

Signalling of the number of channelisation codes for the DL common midamble case for 1.28Mcps TDD

The following mapping schemes shall apply for the association between the number of channelisation codes employed in a timeslot and the use of a particular midamble shift in the DL common midamble case. In the following tables the presence of a particular midamble shift is indicated by '1'. Midamble shifts marked with '0' are left unused.

D.1 Mapping scheme for K=16 Midambles

m1	m2	m3	m4	m5	m6	M7	M8	m9	m10	m11	m12	M13	m14	m15	m16	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 code
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 codes
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3 codes
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4 codes
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5 codes
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	6 codes
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7 codes
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	8 codes
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	9 codes
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10 codes
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	11 codes
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	12 codes
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	13 codes
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	14 codes
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	15 codes
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	16 codes

D.2 Mapping scheme for K=14 Midambles

m1	m2	m3	m4	m5	m6	M7	M8	m9	m10	m11	m12	M13	m14	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1 or 15 code(s)
0	1	0	0	0	0	0	0	0	0	0	0	0	0	2 or 16 codes
0	0	1	0	0	0	0	0	0	0	0	0	0	0	3 codes
0	0	0	1	0	0	0	0	0	0	0	0	0	0	4 codes
0	0	0	0	1	0	0	0	0	0	0	0	0	0	5 codes
0	0	0	0	0	1	0	0	0	0	0	0	0	0	6 codes
0	0	0	0	0	0	1	0	0	0	0	0	0	0	7 codes
0	0	0	0	0	0	0	1	0	0	0	0	0	0	8 codes
0	0	0	0	0	0	0	0	1	0	0	0	0	0	9 codes
0	0	0	0	0	0	0	0	0	1	0	0	0	0	10 codes
0	0	0	0	0	0	0	0	0	0	1	0	0	0	11 codes
0	0	0	0	0	0	0	0	0	0	0	1	0	0	12 codes
0	0	0	0	0	0	0	0	0	0	0	0	1	0	13 codes
0	0	0	0	0	0	0	0	0	0	0	0	0	1	14 codes

D.3 Mapping scheme for K=12 Midambles

m1	m2	m3	m4	m5	m6	M7	M8	m9	m10	m11	m12	
1	0	0	0	0	0	0	0	0	0	0	0	1 or 13 code(s)
0	1	0	0	0	0	0	0	0	0	0	0	2 or 14 codes
0	0	1	0	0	0	0	0	0	0	0	0	3 or 15 codes
0	0	0	1	0	0	0	0	0	0	0	0	4 or 16 codes
0	0	0	0	1	0	0	0	0	0	0	0	5 codes
0	0	0	0	0	1	0	0	0	0	0	0	6 codes
0	0	0	0	0	0	1	0	0	0	0	0	7 codes
0	0	0	0	0	0	0	1	0	0	0	0	8 codes
0	0	0	0	0	0	0	0	1	0	0	0	9 codes
0	0	0	0	0	0	0	0	0	1	0	0	10 codes
0	0	0	0	0	0	0	0	0	0	1	0	11 codes
0	0	0	0	0	0	0	0	0	0	0	1	12 codes

D.4 Mapping scheme for K=10 Midambles

m1	m2	m3	m4	m5	m6	M7	M8	m9	m10	
1	0	0	0	0	0	0	0	0	0	1 or 11 code(s)
0	1	0	0	0	0	0	0	0	0	2 or 12 codes
0	0	1	0	0	0	0	0	0	0	3 or 13codes
0	0	0	1	0	0	0	0	0	0	4 or 14 codes
0	0	0	0	1	0	0	0	0	0	5 or 15 codes
0	0	0	0	0	1	0	0	0	0	6 or 16 codes
0	0	0	0	0	0	1	0	0	0	7 codes
0	0	0	0	0	0	0	1	0	0	8 codes
0	0	0	0	0	0	0	0	1	0	9 codes
0	0	0	0	0	0	0	0	0	1	10 codes

D.5 Mapping scheme for K=8 Midambles

m1	m2	m3	m4	m5	m6	m7	m8	
1	0	0	0	0	0	0	0	1 or 9 code(s)
0	1	0	0	0	0	0	0	2 or 10 codes
0	0	1	0	0	0	0	0	3 or 11 codes
0	0	0	1	0	0	0	0	4 or 12 codes
0	0	0	0	1	0	0	0	5 or 13 codes
0	0	0	0	0	1	0	0	6 or 14 codes
0	0	0	0	0	0	1	0	7 or 15 codes
0	0	0	0	0	0	0	1	8 or 16 codes

D.6 Mapping scheme for K=6 Midambles

m1	m2	m3	m4	m5	m6	
1	0	0	0	0	0	1 or 7 or 13 code(s)
0	1	0	0	0	0	2 or 8 or 14 codes
0	0	1	0	0	0	3 or 9 or 15 codes
0	0	0	1	0	0	4 or 10 or 16 codes
0	0	0	0	1	0	5 or 11 codes
0	0	0	0	0	1	6 or 12 codes

D.7 Mapping scheme for K=4 Midambles

m1	m2	m3	m4	
1	0	0	0	1 or 5 or 9 or 13 code(s)
0	1	0	0	2 or 6 or 10 or 14 codes
0	0	1	0	3 or 7 or 11 or 15 codes
0	0	0	1	4 or 8 or 12 or 16 codes

D.8 Mapping scheme for K=2 Midambles

m1	m2	
1	0	1 or 3 or 5 or 7 or 9 or 11 or 13 or 15 code(s)
0	1	2 or 4 or 6 or 8 or 10 or 12 or 14 or 16 codes

Annex E (informative): CCPCH Multiframe Structure for the 3.84 Mcps option

In the following figures C.1 to C.3 some examples for Multiframe Structures on Primary and Secondary CCPCH are given. The figures show the placement of Common Transport Channels on the Common Control Physical Channels. Additional S-CCPCH capacity can be allocated on other codes and timeslots of course, e.g. FACH capacity is related to overall cell capacity and can be configured according to the actual needs. Channel capacities in the annex are derived using bursts with long midambles (Burst format 1). Every TrCH-box in the figures is assumed to be valid for two frames (see row 'Frame #'), i.e. the transport channels in CCPCHs have an interleaving time of 20msec.

The actual CCPCH Multiframe Scheme used in the cell is described and broadcast on BCH. Thus the system information structure has its roots in this particular transport channel and allocations of other Common Channels can be handled this way, i.e. by pointing from BCH.

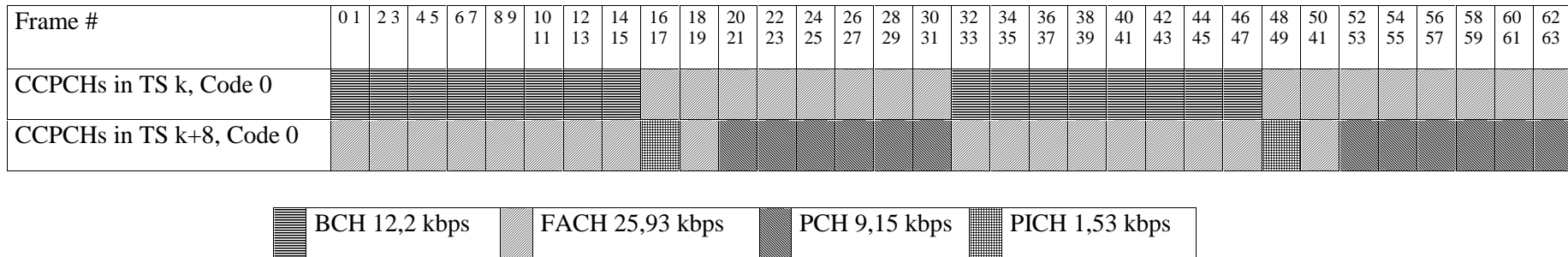


Figure C.1: Example for a multiframe structure for CCPCHs and PICH that is repeated every 64th frame

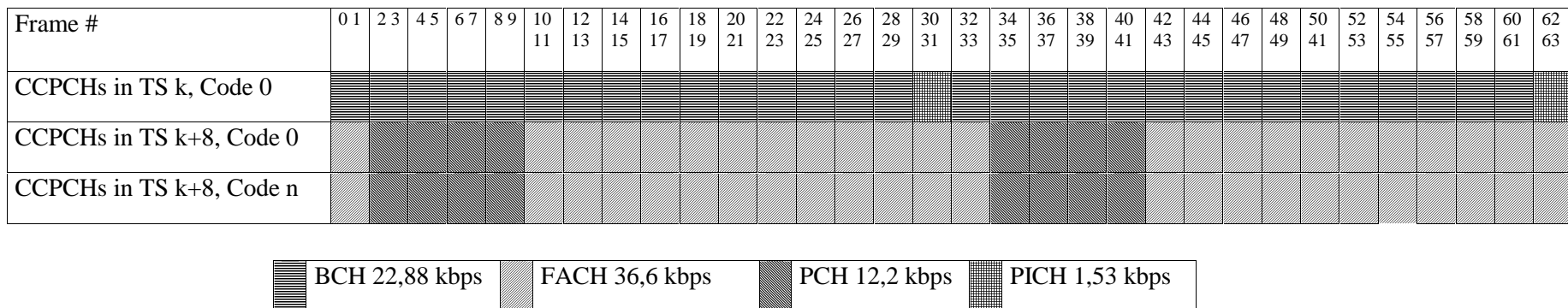


Figure C.2: Example for a multiframe structure for CCPCHs and PICH that is repeated every 64th frame, n=1...7

Annex F (informative): CCPCH Multiframe Structure for the 1.28 Mcps option

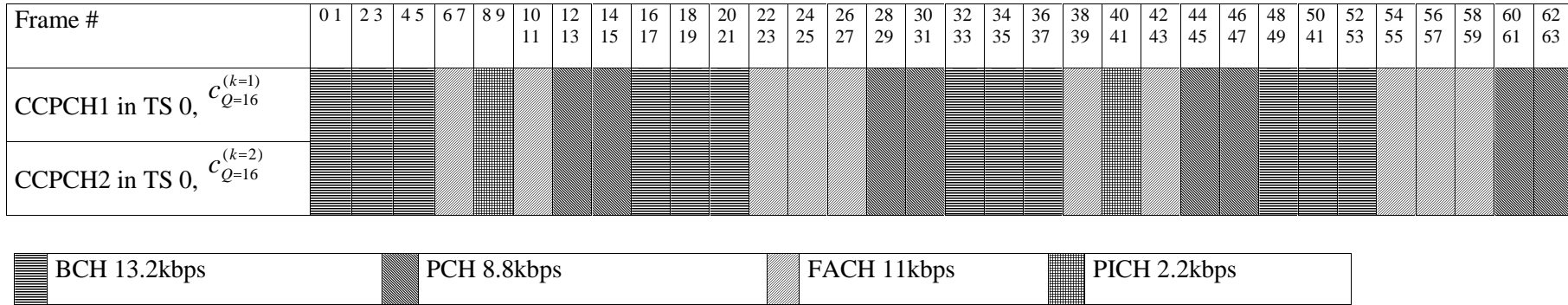


Figure F.1: Example for a multiframe structure for CCPCHs and PICH that is repeated every 64th frame (128 sub-frame)

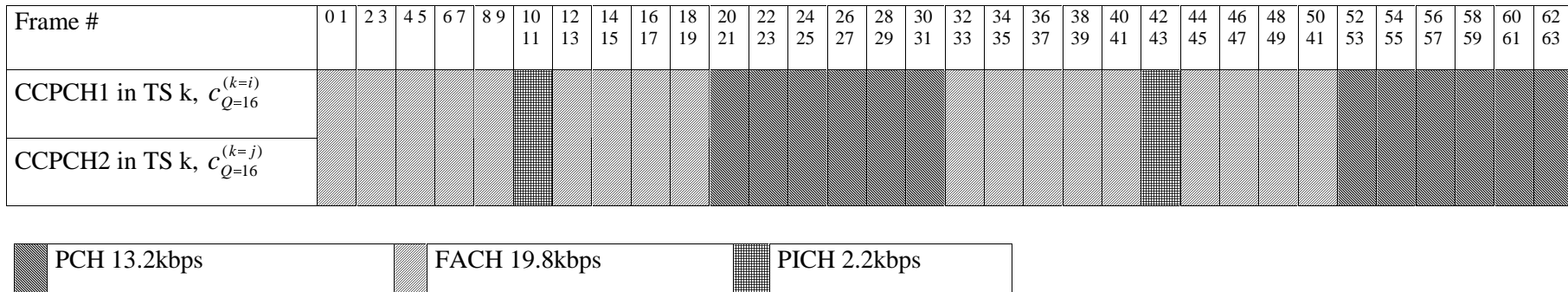


Figure F.2: Example for a multiframe structure for S-CCPCHs and PICH that is repeated every 64th frame, $i,j=1...16 (i \neq j), k \neq 0, 1, (128 \text{ sub-frame})$

Annex G (informative): Examples of the association of DL TPC commands to UL uplink time slots for 1.28 Mcps TDD

In the following two examples of the association of UL TPC commands to UL time slots and CCTrCHs are shown (see 6.2.2.2):

Table G.1 Two examples of the association of DL TPC commands to UL uplink time slots with NULslot=3

Case 1: $N_{UL_TPCsymbols}=2$; Case 2: $N_{UL_TPCsymbols}=4$

Sub-Frame Number	Case 1 (2 UL TPC symbols)		The order of the served UL time slot and CCTrCH pairs (UL time slot and CCTrCH number)	Case 2 (4 UL TPC symbols)	
	The order of UL TPC symbols			The order of UL TPC symbols	
SFN'=0	(1 st UL _{pos} =0)	0	0 (TS3)	0	(1 st UL _{pos} =0)
		1	1 (TS4)	1	
			2 (TS5)	2	
			0 (TS3)	3	
SFN'=1	(1 st UL _{pos} =2)	0	0 (TS3)	0	(1 st UL _{pos} =1)
		1	1 (TS4)	1	
			2 (TS5)	2	
			0 (TS3)	3	
			1 (TS4)		
SFN'=2	(1 st UL _{pos} =1)	0	0 (TS3)	0	(1 st UL _{pos} =2)
		1	1 (TS4)	1	
			2 (TS5)	2	
			0 (TS3)	3	
			1 (TS4)		
			2 (TS5)		
.
.
.

Annex H (informative): Examples of the association of DL SS commands to UL uplink time slots

In the following two examples of the association of DL SS commands to UL uplink time slots are shown (see 6.2.2.3):

Table H.1 Two examples of the association of DL SS commands to UL uplink time slots with $N_{ULslot}=3$

Case 1: $N_{SSsymbols}=2$; Case 2: $N_{SSsymbols}=4$

Sub-Frame Number	Case 1 (2 DL SS symbols)		The order of the served UL time slot (UL time slot number)	Case 2 (4 DL SS symbols)	
	The order of DL SS symbols			The order of DL SS symbols	
SFN'=0	(1 st $UL_{pos}=0$)	0	0 (TS3)	0	(1 st $UL_{pos}=0$)
		1	1 (TS4)	1	
			2 (TS5)	2	
			0 (TS3)	3	
SFN'=1	(1 st $UL_{pos}=2$)	0	0 (TS3)	0	(1 st $UL_{pos}=1$)
		1	1 (TS4)	1	
			2 (TS5)	2	
			0 (TS3)	3	
			1 (TS4)		
SFN'=2	(1 st $UL_{pos}=1$)	0	0 (TS3)	0	(1 st $UL_{pos}=2$)
		1	1 (TS4)	1	
			2 (TS5)	2	
			0 (TS3)	3	
			1 (TS4)		
			2 (TS5)		
.
.
.

Annex I (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
14/01/00	RAN_05	RP-99591	-	-	Approved at TSG RAN #5 and placed under Change Control	-	3.0.0
14/01/00	RAN_06	RP-99691	001	02	Primary and Secondary CCPCH in TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99691	002	02	Removal of Superframe for TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99691	006	-	Corrections to TS25.221	3.0.0	3.1.0
14/01/00	RAN_06	RP-99691	007	1	Clarifications for Spreading in UTRA TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99691	008	-	Transmission of TFCI bits for TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99691	009	-	Midamble Allocation in UTRA TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99690	010	-	Introduction of the timeslot formats to the TDD specifications	3.0.0	3.1.0
14/01/00	-	-	-	-	Change history was added by the editor	3.1.0	3.1.1
31/03/00	RAN_07	RP-000067	003	2	Cycling of cell parameters	3.1.1	3.2.0
31/03/00	RAN_07	RP-000067	011	-	Correction of Midamble Definition for TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000067	012	-	Introduction of the timeslot formats for RACH to the TDD specifications	3.1.1	3.2.0
31/03/00	RAN_07	RP-000067	013	-	Paging Indicator Channel reference power	3.1.1	3.2.0
31/03/00	RAN_07	RP-000067	014	1	Removal of Synchronisation Case 3 in TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000067	015	1	Signal Point Constellation	3.1.1	3.2.0
31/03/00	RAN_07	RP-000067	016	-	Association between Midambles and Channelisation Codes	3.1.1	3.2.0
31/03/00	RAN_07	RP-000067	017	-	Removal of ODMA from the TDD specifications	3.1.1	3.2.0
26/06/00	RAN_08	RP-000271	018	1	Removal of the reference to ODMA	3.2.0	3.3.0
26/06/00	RAN_08	RP-000271	019	-	Editorial changes in transport channels section	3.2.0	3.3.0
26/06/00	RAN_08	RP-000271	020	1	TPC transmission for TDD	3.2.0	3.3.0
26/06/00	RAN_08	RP-000271	021	-	Editorial modification of 25.221	3.2.0	3.3.0
26/06/00	RAN_08	RP-000271	023	-	Clarifications on TxDiversity for UTRA TDD	3.2.0	3.3.0
26/06/00	RAN_08	RP-000271	024	-	Clarifications on PCH and PICH in UTRA TDD	3.2.0	3.3.0
23/0900	RAN_09	RP-000344	022	1	Correction to midamble generation in UTRA TDD	3.3.0	3.4.0
23/0900	RAN_09	RP-000344	026	2	Some corrections for TS25.221	3.3.0	3.4.0
23/0900	RAN_09	RP-000344	028	-	Terminology regarding the beacon function	3.3.0	3.4.0
23/0900	RAN_09	RP-000344	030	1	TDD Access Bursts for HOV	3.3.0	3.4.0
23/0900	RAN_09	RP-000344	031	1	Number of codes signalling for the DL common midamble case	3.3.0	3.4.0
15/12/00	RAN_10	RP-000542	034	-	Correction on TFCI & TPC Transmission	3.4.0	3.5.0
15/12/00	RAN_10	RP-000542	035	1	Clarifications on Midamble Associations	3.4.0	3.5.0
15/12/00	RAN_10	RP-000542	036	-	Clarification on PICH power setting	3.4.0	3.5.0
16/03/01	RAN_11	-	-	-	Approved as Release 4 specification (v4.0.0) at TSG RAN #11	3.5.0	4.0.0
16/03/01	RAN_11	RP-010062	033	2	Correction to SCH section	3.5.0	4.0.0
16/03/01	RAN_11	RP-010062	037	1	Bit Scrambling for TDD	3.5.0	4.0.0
16/03/01	RAN_11	RP-010062	039	1	Corrections of PUSCH and PDSCH	3.5.0	4.0.0
16/03/01	RAN_11	RP-010062	040	-	Alteration of SCH offsets to avoid overlapping Midamble	3.5.0	4.0.0
16/03/01	RAN_11	RP-010062	041	-	Clarifications & Corrections for TS25.221	3.5.0	4.0.0
16/03/01	RAN_11	RP-010062	045	1	Corrections on the PRACH and clarifications on the midamble generation and the behaviour in case of an invalid TFI combination on the DCHs	3.5.0	4.0.0
16/03/01	RAN_11	RP-010062	046	-	Clarification of TFCI transmission	3.5.0	4.0.0
16/03/01	RAN_11	RP-010062	048	-	Corrections to Table 5.b "Timeslot formats for the Uplink"	3.5.0	4.0.0
16/03/01	RAN_11	RP-010073	042	2	Introduction of the Physical Node B Synchronization Channel	3.5.0	4.0.0
16/03/01	RAN_11	RP-010071	043	1	Inclusion of 1.28Mcps TDD in TS 25.221	3.5.0	4.0.0
16/03/01	RAN_11	RP-010072	044	-	Correction of beacon characteristics due to IPDLs	3.5.0	4.0.0
15/06/01	RAN_12	RP-010336	051	-	Clarification of Midamble Usage in TS25.221	4.0.0	4.1.0
15/06/01	RAN_12	RP-010336	053	-	Addition to the abbreviation list, correction of references to tables and figures	4.0.0	4.1.0
15/06/01	RAN_12	RP-010342	049	-	Correction of spelling in definition of beacon characteristics	4.0.0	4.1.0
15/06/01	RAN_12	RP-010342	055	-	Correction of Note for PDSCH signalling methods	4.0.0	4.1.0
21/09/01	RAN_13	RP-010522	057	-	TFCI Terminology	4.1.0	4.2.0
21/09/01	RAN_13	RP-010522	063	-	Clarification of notations in TS25.221 and TS25.223	4.1.0	4.2.0
21/09/01	RAN_13	RP-010522	062	-	Addition and correction of the reference	4.1.0	4.2.0
21/09/01	RAN_13	RP-010528	058	1	Corrections for TS 25.221	4.1.0	4.2.0
14/12/01	RAN_14	RP-010741	065	1	Transmit Diversity for P-CCPCH and PICH	4.2.0	4.3.0
14/12/01	RAN_14	RP-010741	067	-	Clarification of midamble transmit power in TS25.221	4.2.0	4.3.0
14/12/01	RAN_14	RP-010746	059	-	Bit Scrambling for 1.28 Mcps TDD	4.2.0	4.3.0
14/12/01	RAN_14	RP-010746	068	-	Transmit Diversity for P-CCPCH and PICH	4.2.0	4.3.0
14/12/01	RAN_14	RP-010746	069	-	Corrections of reference numbers in TS 25.221	4.2.0	4.3.0

CHANGE REQUEST

⌘ **25.222 CR 066** ⌘ rev **2** ⌘ Current version: **4.2.0** ⌘

For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.

Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ Inclusion of HSDPA in 25.222		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ 05, Feb, 2002
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories:		Use <u>one</u> of the following releases:
	F (correction)		2 (GSM Phase 2)
	A (corresponds to a correction in an earlier release)		R96 (Release 1996)
	B (addition of feature),		R97 (Release 1997)
	C (functional modification of feature)		R98 (Release 1998)
	D (editorial modification)		R99 (Release 1999)
	Detailed explanations of the above categories can be found in 3GPP TR 21.900.		REL-4 (Release 4)
			REL-5 (Release 5)

Reason for change:	⌘ Addition of HSDPA functionality.		
Summary of change:	⌘ Adds channel coding and multiplexing chain for HS-DSCH, HS-SCCH and HS-SICH.		
Consequences if not approved:	⌘ - HSDPA will not be a part of REL-5.		

Clauses affected:	⌘ 2,3,4		
Other specs affected:	<input type="checkbox"/> Other core specifications <input type="checkbox"/> Test specifications <input type="checkbox"/> O&M Specifications	⌘	REL-4 25.201, 25.221, 25.223, 25.224
Other comments:	⌘		

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- 3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

3GPP TS 25.222 V4.2.0 (2001-12)

Technical Specification

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Multiplexing and channel coding (TDD) (Release 4)



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Keywords

UMTS, radio, mux

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Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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- x the first digit:
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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document describes multiplexing, channel coding and interleaving for UTRA Physical Layer TDD mode.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TS 25.202: "UE capabilities".
 - [2] 3GPP TS 25.211: "Transport channels and physical channels (FDD)".
 - [3] 3GPP TS 25.212: "Multiplexing and channel coding (FDD)".
 - [4] 3GPP TS 25.213: "Spreading and modulation (FDD)".
 - [5] 3GPP TS 25.214: "Physical layer procedures (FDD)".
 - [6] 3GPP TS 25.215: "Physical layer – Measurements (FDD)".
 - [7] 3GPP TS 25.221: "Transport channels and physical channels (TDD)".
 - [9] 3GPP TS 25.223: "Spreading and modulation (TDD)".
 - [10] 3GPP TS 25.224: "Physical layer procedures (TDD)".
 - [11] 3GPP TS 25.225: "Measurements".
 - [12] 3GPP TS 25.331: "RRC Protocol Specification".
 - [13] 3GPP TS 25.308: "High Speed Downlink Packet Access (HSDPA): Overall description (stage 2)".
-

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

TrCH number: transport channel number represents a TrCH ID assigned to L1 by L2. Transport channels are multiplexed to the CCTrCH in the ascending order of these IDs.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

$\lceil x \rceil$	round towards ∞ , i.e. integer such that $x \leq \lceil x \rceil < x+1$
$\lfloor x \rfloor$	round towards $-\infty$, i.e. integer such that $x-1 < \lfloor x \rfloor \leq x$
$ x $	absolute value of x

Unless otherwise is explicitly stated when the symbol is used, the meaning of the following symbols are:

i	TrCH number
j	TFC number
k	Bit number
l	TF number
m	Transport block number
n	Radio frame number
p	PhCH number
r	Code block number
I	Number of TrCHs in a CCTrCH.
C_i	Number of code blocks in one TTI of TrCH i .
F_i	Number of radio frames in one TTI of TrCH i .
M_i	Number of transport blocks in one TTI of TrCH i .
$N_{TFCI \text{ code word}}$	Number of TFCI code word bits after TFCI encoding
P	Number of PhCHs used for one CCTrCH.
PL	Puncturing Limit. Signalled from higher layers
RM_i	Rate Matching attribute for TrCH i . Signalled from higher layers.

Temporary variables, i.e. variables used in several (sub)clauses with different meaning.

x, X
 y, Y
 z, Z

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

<ACRONYM>	<Explanation>
ARQ	Automatic Repeat on Request
BCH	Broadcast Channel
BER	Bit Error Rate
BS	Base Station
BSS	Base Station Subsystem
CBR	Constant Bit Rate
CCCH	Common Control Channel
CCTrCH	Coded Composite Transport Channel
CDMA	Code Division Multiple Access
CFN	Connection Frame Number
CRC	Cyclic Redundancy Check
CQI	Channel Quality Indicator
DCA	Dynamic Channel Allocation
DCCH	Dedicated Control Channel
DCH	Dedicated Channel
DL	Downlink
DRX	Discontinuous Reception
DSCH	Downlink Shared Channel
DTX	Discontinuous Transmission
FACH	Forward Access Channel
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FEC	Forward Error Control
FER	Frame Error Rate
GF	Galois Field
HARQ	Hybrid Automatic Repeat reQuest
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	Shared Control Channel for HS-DSCH
HS-SICH	Shared Information Channel for HS-DSCH
JD	Joint Detection
L1	Layer 1

L2	Layer 2
LLC	Logical Link Control
MA	Multiple Access
MAC	Medium Access Control
MS	Mobile Station
MT	Mobile Terminated
NRT	Non-Real Time
OVSF	Orthogonal Variable Spreading Factor
PC	Power Control
PCCC	Parallel Concatenated Convolutional Code
PCH	Paging Channel
PhCH	Physical Channel
PI	Paging Indicator (value calculated by higher layers)
P_q	Paging Indicator (indicator set by physical layer)
QoS	Quality of Service
QPSK	Quaternary Phase Shift Keying
RACH	Random Access Channel
RF	Radio Frequency
RLC	Radio Link Control
RMF	Recommended Modulation Format
RRC	Radio Resource Control
RRM	Radio Resource Management
RSC	Recursive Systematic Convolutional Coder
RT	Real Time
RTBS	Recommended Transport Block Size
RU	Resource Unit
RV	Redundancy Version
SCCC	Serial Concatenated Convolutional Code
SCH	Synchronization Channel
SNR	Signal to Noise Ratio
TCH	Traffic channel
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TFRI	Transport Format Resource Indicator
TFRC	Transport Format Resource Combination
TPC	Transmit Power Control
TrBk	Transport Block
TrCH	Transport Channel
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
USCH	Uplink Shared Channel
UTRA	UMTS Terrestrial Radio Access
VBR	Variable Bit Rate

4 Multiplexing, channel coding and interleaving

4.1 General

Data stream from/to MAC and higher layers (Transport block / Transport block set) is encoded/decoded to offer transport services over the radio transmission link. Channel coding scheme is a combination of error detection, error correcting (including rate matching), and interleaving and transport channels mapping onto/splitting from physical channels.

In the UTRA-TDD mode, the total number of basic physical channels (a certain time slot one spreading code on a certain carrier frequency) per frame is given by the maximum number of time slots and the maximum number of CDMA codes per time slot.

4.2 General Transport channel coding/multiplexing of TrCHs

This section only applies to the transport channels: DCH, RACH, DSCH, USCH, BCH, FACH and PCH. Other transport channels which do not use the general method are described separately below.

Figure 1 illustrates the overall concept of transport-channel coding and multiplexing. Data arrives to the coding/multiplexing unit in form of transport block sets, once every transmission time interval. The transmission time interval is transport-channel specific from the set {5 ms^(*), 10 ms, 20 ms, 40 ms, 80 ms}.

Note: ^(*) may be applied for PRACH for 1.28 Mcps TDD

The following coding/multiplexing steps can be identified:

- add CRC to each transport block (see subclause 4.2.1);
- TrBk concatenation / Code block segmentation (see subclause 4.2.2);
- channel coding (see subclause 4.2.3);
- radio frame size equalization (see subclause 4.2.4);
- interleaving (two steps, see subclauses 4.2.5 and 4.2.10);
- radio frame segmentation (see subclause 4.2.6);
- rate matching (see subclause 4.2.7);
- multiplexing of transport channels (see subclause 4.2.8);
- bit scrambling (see subclause 4.2.9);
- physical channel segmentation (see subclause 4.2.10);
- sub-frame segmentation(see subclause 4.2.12 only for 1.28Mcps TDD)
- mapping to physical channels (see subclause 4.2.13).

The coding/multiplexing steps for uplink and downlink are shown in figures 1 and 2.

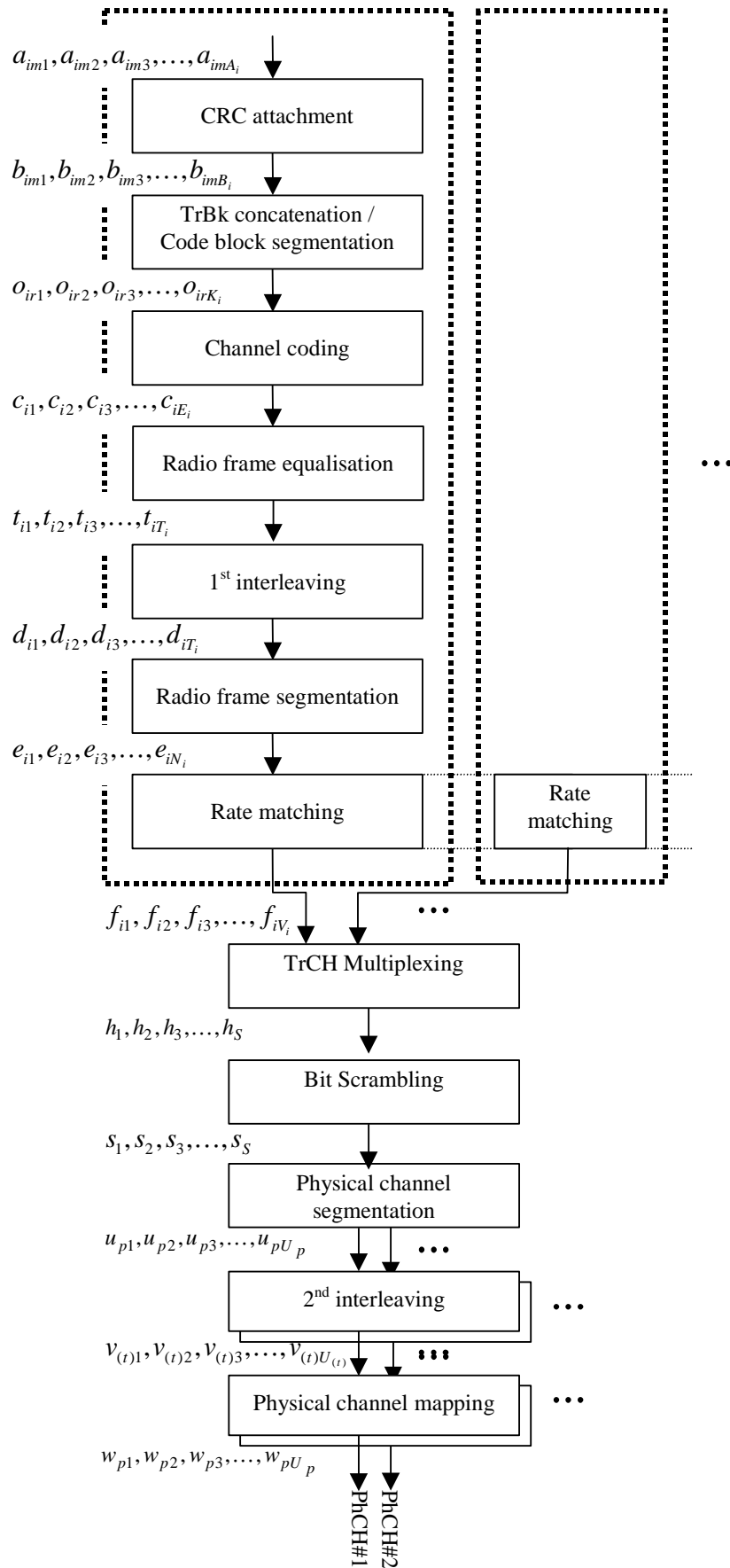


Figure 1: Transport channel multiplexing structure for uplink and downlink for 3.84Mcps TDD

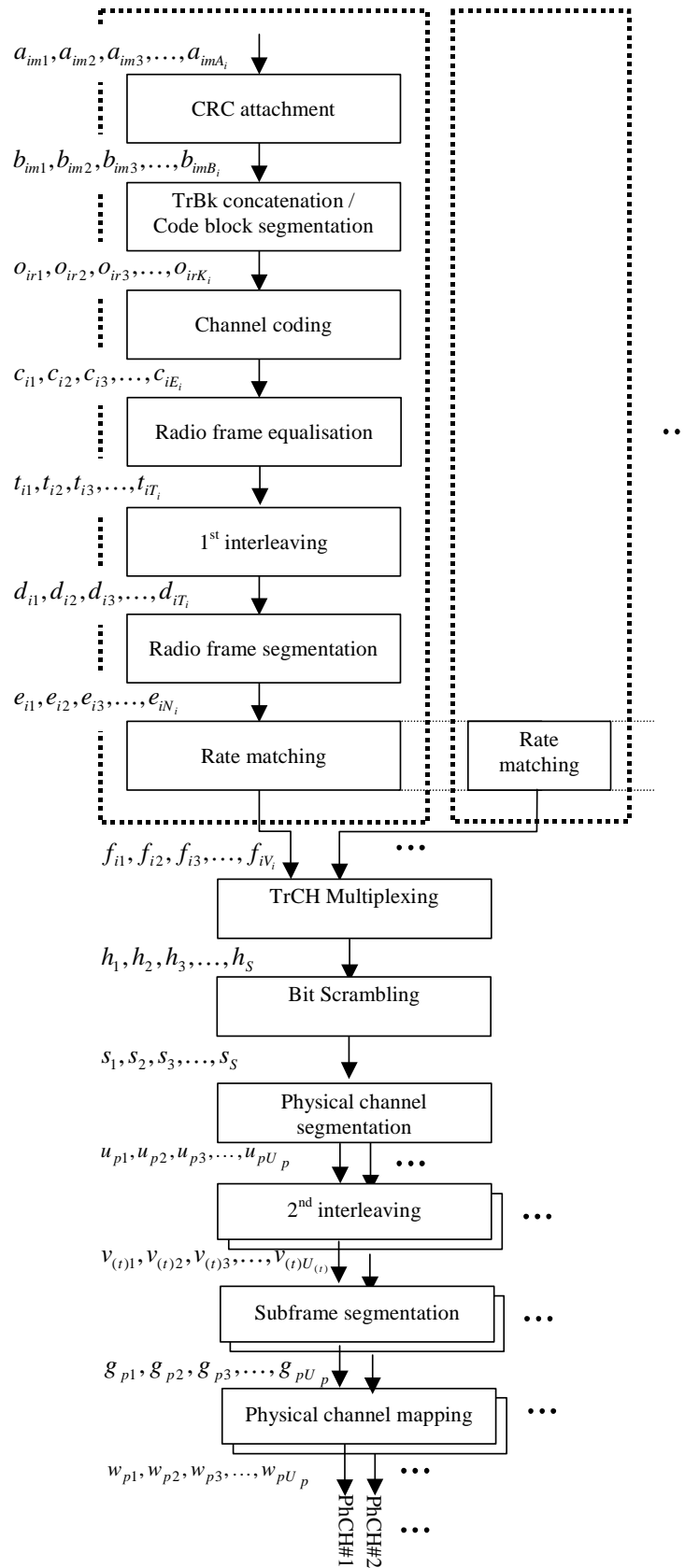


Figure 2: Transport channel multiplexing structure for uplink and downlink of 1.28Mcps TDD

Primarily, transport channels are multiplexed as described above, i.e. into one data stream mapped on one or several physical channels. However, an alternative way of multiplexing services is to use multiple CCTrCHs (Coded Composite Transport Channels), which corresponds to having several parallel multiplexing chains as in figures 1 and 2, resulting in several data streams, each mapped to one or several physical channels.

4.2.1 CRC attachment

Error detection is provided on transport blocks through a Cyclic Redundancy Check (CRC). The size of the CRC is 24, 16, 12, 8 or 0 bits and it is signalled from higher layers what CRC size that should be used for each transport channel.

4.2.1.1 CRC calculation

The entire transport block is used to calculate the CRC parity bits for each transport block. The parity bits are generated by one of the following cyclic generator polynomials:

$$g_{\text{CRC24}}(D) = D^{24} + D^{23} + D^6 + D^5 + D + 1$$

$$g_{\text{CRC16}}(D) = D^{16} + D^{12} + D^5 + 1$$

$$g_{\text{CRC12}}(D) = D^{12} + D^{11} + D^3 + D^2 + D + 1$$

$$g_{\text{CRC8}}(D) = D^8 + D^7 + D^4 + D^3 + D + 1$$

Denote the bits in a transport block delivered to layer 1 by $a_{im1}, a_{im2}, a_{im3}, \dots, a_{imA_i}$, and the parity bits by

$P_{im1}, P_{im2}, P_{im3}, \dots, P_{imL_i}$. A_i is the size of a transport block of TrCH i , m is the transport block number, and L_i is the number of parity bits. L_i can take the values 24, 16, 12, 8, or 0 depending on what is signalled from higher layers.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial:

$$a_{im1}D^{A_i+23} + a_{im2}D^{A_i+22} + \dots + a_{imA_i}D^{24} + p_{im1}D^{23} + p_{im2}D^{22} + \dots + p_{im23}D^1 + p_{im24}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC24}}(D)$, polynomial:

$$a_{im1}D^{A_i+15} + a_{im2}D^{A_i+14} + \dots + a_{imA_i}D^{16} + p_{im1}D^{15} + p_{im2}D^{14} + \dots + p_{im15}D^1 + p_{im16}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC16}}(D)$, polynomial:

$$a_{im1}D^{A_i+11} + a_{im2}D^{A_i+10} + \dots + a_{imA_i}D^{12} + p_{im1}D^{11} + p_{im2}D^{10} + \dots + p_{im11}D^1 + p_{im12}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC12}}(D)$ and the polynomial:

$$a_{im1}D^{A_i+7} + a_{im2}D^{A_i+6} + \dots + a_{imA_i}D^8 + p_{im1}D^7 + p_{im2}D^6 + \dots + p_{im7}D^1 + p_{im8}$$

yields a remainder equal to 0 when divided by $g_{\text{CRC8}}(D)$.

If no transport blocks are input to the CRC calculation ($M_i = 0$), no CRC attachment shall be done. If transport blocks are input to the CRC calculation ($M_i \neq 0$) and the size of a transport block is zero ($A_i = 0$), CRC shall be attached, i.e. all parity bits equal to zero.

4.2.1.2 Relation between input and output of the CRC attachment block

The bits after CRC attachment are denoted by $b_{im1}, b_{im2}, b_{im3}, \dots, b_{imB_i}$, where $B_i = A_i + L_i$. The relation between a_{imk} and b_{imk} is:

$$b_{imk} = a_{imk} \quad k = 1, 2, 3, \dots, A_i$$

$$b_{imk} = p_{im(L_i+1-(k-A_i))} \quad k = A_i + 1, A_i + 2, A_i + 3, \dots, A_i + L_i$$

4.2.2 Transport block concatenation and code block segmentation

All transport blocks in a TTI are serially concatenated. If the number of bits in a TTI is larger than the maximum size of a code block, then code block segmentation is performed after the concatenation of the transport blocks. The maximum size of the code blocks depends on whether convolutional, turbo coding or no coding is used for the TrCH.

4.2.2.1 Concatenation of transport blocks

The bits input to the transport block concatenation are denoted by $b_{im1}, b_{im2}, b_{im3}, \dots, b_{imB_i}$ where i is the TrCH number, m is the transport block number, and B_i is the number of bits in each block (including CRC). The number of transport blocks on TrCH i is denoted by M_i . The bits after concatenation are denoted by $x_{i1}, x_{i2}, x_{i3}, \dots, x_{iX_i}$, where i is the TrCH number and $X_i = M_i B_i$. They are defined by the following relations:

$$x_{ik} = b_{i1k} \quad k = 1, 2, \dots, B_i$$

$$x_{ik} = b_{i,2,(k-B_i)} \quad k = B_i + 1, B_i + 2, \dots, 2B_i$$

$$x_{ik} = b_{i,3,(k-2B_i)} \quad k = 2B_i + 1, 2B_i + 2, \dots, 3B_i$$

...

$$x_{ik} = b_{i,M_i,(k-(M_i-1)B_i)} \quad k = (M_i - 1)B_i + 1, (M_i - 1)B_i + 2, \dots, M_i B_i$$

4.2.2.2 Code block segmentation

Segmentation of the bit sequence from transport block concatenation is performed if $X_i > Z$. The code blocks after segmentation are of the same size. The number of code blocks on TrCH i is denoted by C_i . If the number of bits input to the segmentation, X_i , is not a multiple of C_i , filler bits are added to the beginning of the first block. If turbo coding is selected and $X_i < 40$, filler bits are added to the beginning of the code block. The filler bits are transmitted and they are always set to 0. The maximum code block sizes are:

- convolutional coding: $Z = 504$;
- turbo coding: $Z = 5114$;
- no channel coding: $Z = \text{unlimited}$.

The bits output from code block segmentation, for $C_i \neq 0$, are denoted by $o_{ir1}, o_{ir2}, o_{ir3}, \dots, o_{irK_i}$, where i is the TrCH number, r is the code block number, and K_i is the number of bits per code block.

Number of code blocks:

$$C_i = \begin{cases} \lceil X_i / Z \rceil & \text{when } Z \neq \text{unlimited} \\ 0 & \text{when } Z = \text{unlimited} \text{ and } X_i = 0 \\ 1 & \text{when } Z = \text{unlimited} \text{ and } X_i \neq 0 \end{cases}$$

Number of bits in each code block (applicable for $C_i \neq 0$ only):

if $X_i < 40$ and Turbo coding is used, then

$$K_i = 40$$

else

$$K_i = \lceil X_i / C_i \rceil$$

end if

Number of filler bits: $Y_i = C_i K_i - X_i$

for $k = 1$ to Y_i -- Insertion of filler bits

$$o_{ilk} = 0$$

end for

Table 1: Usage of channel coding scheme and coding rate for 3.84Mcps TDD

Type of TrCH	Coding scheme	Coding rate
BCH	Convolutional coding	1/2
PCH		
RACH		
DCH, DSCH, FACH, USCH	Turbo coding	1/3, 1/2
		1/3
	No coding	

Table 2: Usage of channel coding scheme and coding rate for 1.28Mcps TDD

Type of TrCH	Coding scheme	Coding rate
BCH	Convolutional coding	1/3
PCH		1/3, 1/2
RACH		1/2
DCH, DSCH, FACH, USCH		Turbo coding
	1/3	
	No coding	

4.2.3.1 Convolutional coding

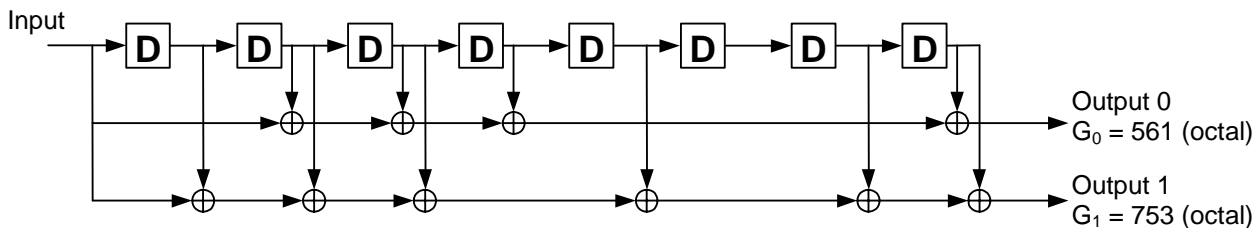
Convolutional codes with constraint length 9 and coding rates 1/3 and 1/2 are defined.

The configuration of the convolutional coder is presented in figure 2.

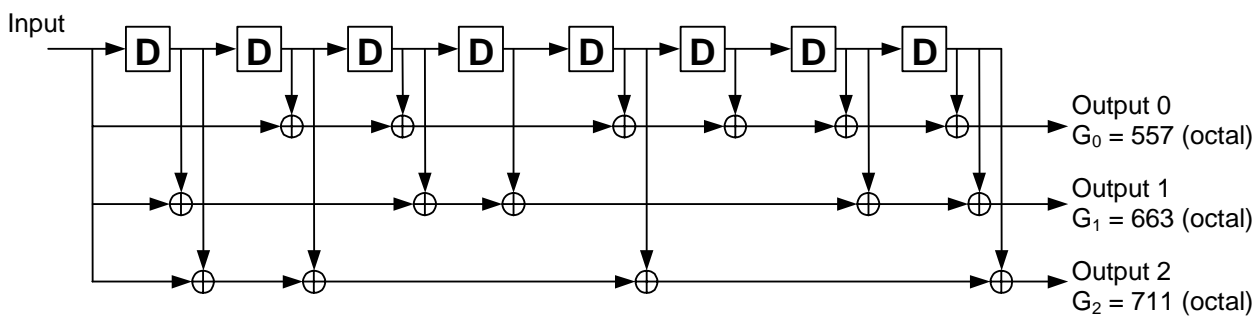
Output from the rate 1/3 convolutional coder shall be done in the order output 0, output 1, output 2, output 0, output 1, output 2, output 0, ..., output 2. Output from the rate 1/2 convolutional coder shall be done in the order output 0, output 1, output 0, output 1, output 0, ..., output 1.

8 tail bits with binary value 0 shall be added to the end of the code block before encoding.

The initial value of the shift register of the coder shall be "all 0" when starting to encode the input bits.



(a) Rate 1/2 convolutional coder



(b) Rate 1/3 convolutional coder

Figure 2: Rate 1/2 and rate 1/3 convolutional coders

4.2.3.2 Turbo coding

4.2.3.2.1 Turbo coder

The scheme of Turbo coder is a Parallel Concatenated Convolutional Code (PCCC) with two 8-state constituent encoders and one Turbo code internal interleaver. The coding rate of Turbo coder is 1/3. The structure of Turbo coder is illustrated in figure 3.

The transfer function of the 8-state constituent code for PCCC is:

$$G(D) = \begin{bmatrix} 1, & g_1(D) \\ & g_0(D) \end{bmatrix},$$

where

$$g_0(D) = 1 + D^2 + D^3,$$

$$g_1(D) = 1 + D + D^3.$$

The initial value of the shift registers of the 8-state constituent encoders shall be all zeros when starting to encode the input bits.

Output from the Turbo coder is , Y(0), X(1), Y(1), Y'(1), etc:

$$x_1, z_1, z'_1, x_2, z_2, z'_2, \dots, x_K, z_K, z'_K,$$

where x_1, x_2, \dots, x_K are the bits input to the Turbo coder i.e. both first 8-state constituent encoder and Turbo code internal interleaver, and K is the number of bits, and z_1, z_2, \dots, z_K and z'_1, z'_2, \dots, z'_K are the bits output from first and second 8-state constituent encoders, respectively.

The bits output from Turbo code internal interleaver are denoted by x'_1, x'_2, \dots, x'_K , and these bits are to be input to the second 8-state constituent encoder.

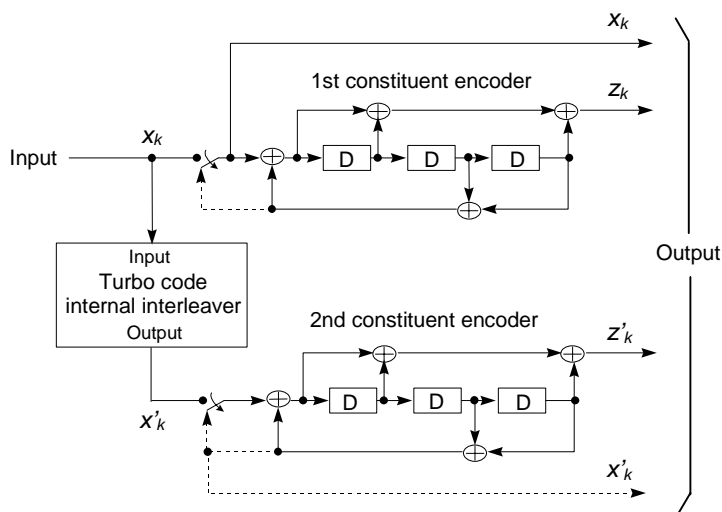


Figure 3: Structure of rate 1/3 Turbo coder (dotted lines apply for trellis termination only)

4.2.3.2.2 Trellis termination for Turbo coder

Trellis termination is performed by taking the tail bits from the shift register feedback after all information bits are encoded. Tail bits are padded after the encoding of information bits.

The first three tail bits shall be used to terminate the first constituent encoder (upper switch of figure 3 in lower position) while the second constituent encoder is disabled. The last three tail bits shall be used to terminate the second constituent encoder (lower switch of figure 3 in lower position) while the first constituent encoder is disabled.

The transmitted bits for trellis termination shall then be:

$$x_{K+1}, z_{K+1}, x_{K+2}, z_{K+2}, x_{K+3}, z_{K+3}, x'_{K+1}, z'_{K+1}, x'_{K+2}, z'_{K+2}, x'_{K+3}, z'_{K+3}.$$

4.2.3.2.3 Turbo code internal interleaver

The Turbo code internal interleaver consists of bits-input to a rectangular matrix with padding, intra-row and inter-row permutations of the rectangular matrix, and bits-output from the rectangular matrix with pruning. The bits input to the Turbo code internal interleaver are denoted by $x_1, x_2, x_3, \dots, x_K$, where K is the integer number of the bits and takes one value of $40 \leq K \leq 5114$. The relation between the bits input to the Turbo code internal interleaver and the bits input to the channel coding is defined by $x_k = o_{irk}$ and $K = K_i$.

The following subclause specific symbols are used in subclauses 4.2.3.2.3.1 to 4.2.3.4.3.3:

K Number of bits input to Turbo code internal interleaver

R Number of rows of rectangular matrix

C Number of columns of rectangular matrix

p Prime number

v Primitive root

$\langle s(j) \rangle_{j \in \{0,1,\dots,p-2\}}$ Base sequence for intra-row permutation

q_i Minimum prime integers

r_i Permuted prime integers

$\langle T(i) \rangle_{i \in \{0,1,\dots,R-1\}}$ Inter-row permutation pattern

$\langle U_i(j) \rangle_{j \in \{0,1,\dots,C-1\}}$ Intra-row permutation pattern of i -th row

i Index of row number of rectangular matrix

j Index of column number of rectangular matrix

k Index of bit sequence

4.2.3.2.3.1 Bits-input to rectangular matrix with padding

The bit sequence $x_1, x_2, x_3, \dots, x_K$ input to the Turbo code internal interleaver is written into the rectangular matrix as follows.

(1) Determine the number of rows of the rectangular matrix, R , such that:

$$R = \begin{cases} 5, & \text{if } (40 \leq K \leq 159) \\ 10, & \text{if } ((160 \leq K \leq 200) \text{ or } (481 \leq K \leq 530)) \\ 20, & \text{if } (K = \text{any other value}) \end{cases}.$$

The rows of rectangular matrix are numbered 0, 1, ..., $R - 1$ from top to bottom.

(2) Determine the prime number to be used in the intra-permutation, p , and the number of columns of rectangular matrix, C , such that:

if ($481 \leq K \leq 530$) then

$$p = 53 \text{ and } C = p.$$

else

Find minimum prime number p from table 3 such that

$$K \leq R \times (p + 1),$$

and determine C such that

$$C = \begin{cases} p - 1 & \text{if } K \leq R \times (p - 1) \\ p & \text{if } R \times (p - 1) < K \leq R \times p. \\ p + 1 & \text{if } R \times p < K \end{cases}$$

end if

The columns of rectangular matrix are numbered $0, 1, \dots, C - 1$ from left to right.

Table 3: List of prime number p and associated primitive root v

p	v	p	v	p	v	p	v	p	v
7	3	47	5	101	2	157	5	223	3
11	2	53	2	103	5	163	2	227	2
13	2	59	2	107	2	167	5	229	6
17	3	61	2	109	6	173	2	233	3
19	2	67	2	113	3	179	2	239	7
23	5	71	7	127	3	181	2	241	7
29	2	73	5	131	2	191	19	251	6
31	3	79	3	137	3	193	5	257	3
37	2	83	2	139	2	197	2		
41	6	89	3	149	2	199	3		
43	3	97	5	151	6	211	2		

- (3) Write the input bit sequence $x_1, x_2, x_3, \dots, x_K$ into the $R \times C$ rectangular matrix row by row starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} y_1 & y_2 & y_3 & \dots & y_C \\ y_{(C+1)} & y_{(C+2)} & y_{(C+3)} & \dots & y_{2C} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{((R-1)C+1)} & y_{((R-1)C+2)} & y_{((R-1)C+3)} & \dots & y_{R \times C} \end{bmatrix}.$$

where $y_k = x_k$ for $k = 1, 2, \dots, K$ and if $R \times C > K$, the dummy bits are padded such that $y_k = 0$ or 1 for $k = K + 1, K + 2, \dots, R \times C$. These dummy bits are pruned away from the output of the rectangular matrix after intra-row and inter-row permutations.

4.2.3.2.3.2 Intra-row and inter-row permutations

After the bits-input to the $R \times C$ rectangular matrix, the intra-row and inter-row permutations for the $R \times C$ rectangular matrix are performed stepwise by using the following algorithm with steps (1) – (6).

- (1) Select a primitive root v from table 3 in section 4.2.3.2.3.1, which is indicated on the right side of the prime number p .
- (2) Construct the base sequence $\langle s(j) \rangle_{j \in \{0, 1, \dots, p-2\}}$ for intra-row permutation as:

$$s(j) = (v \times s(j-1)) \bmod p, \quad j = 1, 2, \dots, (p-2), \text{ and } s(0) = 1.$$

(3) Assign $q_0 = 1$ to be the first prime integer in the sequence $\langle q_i \rangle_{i \in \{0,1,\dots,R-1\}}$, and determine the prime integer q_i in the sequence $\langle q_i \rangle_{i \in \{0,1,\dots,R-1\}}$ to be a least prime integer such that $\text{g.c.d}(q_i, p - 1) = 1$, $q_i > 6$, and $q_i > q_{(i-1)}$ for each $i = 1, 2, \dots, R - 1$. Here g.c.d. is greatest common divisor.

(4) Permute the sequence $\langle q_i \rangle_{i \in \{0,1,\dots,R-1\}}$ to make the sequence $\langle r_i \rangle_{i \in \{0,1,\dots,R-1\}}$ such that

$$r_{T(i)} = q_i, \quad i = 0, 1, \dots, R - 1,$$

where $\langle T(i) \rangle_{i \in \{0,1,\dots,R-1\}}$ is the inter-row permutation pattern defined as the one of the four kind of patterns, which are shown in table 4, depending on the number of input bits K .

Table 4: Inter-row permutation patterns for Turbo code internal interleaver

Number of input bits K	Number of rows R	Inter-row permutation patterns $\langle T(0), T(1), \dots, T(R-1) \rangle$
$(40 \leq K \leq 159)$	5	$\langle 4, 3, 2, 1, 0 \rangle$
$(160 \leq K \leq 200)$ or $(481 \leq K \leq 530)$	10	$\langle 9, 8, 7, 6, 5, 4, 3, 2, 1, 0 \rangle$
$(2281 \leq K \leq 2480)$ or $(3161 \leq K \leq 3210)$	20	$\langle 19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 16, 13, 17, 15, 3, 1, 6, 11, 8, 10 \rangle$
$K = \text{any other value}$	20	$\langle 19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 10, 8, 13, 17, 3, 1, 16, 6, 15, 11 \rangle$

(5) Perform the i -th ($i = 0, 1, \dots, R - 1$) intra-row permutation as:

if ($C = p$) then

$$U_i(j) = s((j \times r_i) \bmod (p - 1)), \quad j = 0, 1, \dots, (p - 2), \text{ and } U_i(p - 1) = 0,$$

where $U_i(j)$ is the original bit position of j -th permuted bit of i -th row.

end if

if ($C = p + 1$) then

$$U_i(j) = s((j \times r_i) \bmod (p - 1)), \quad j = 0, 1, \dots, (p - 2). \quad U_i(p - 1) = 0, \text{ and } U_i(p) = p,$$

where $U_i(j)$ is the original bit position of j -th permuted bit of i -th row, and

if ($K = R \times C$) then

Exchange $U_{R-1}(p)$ with $U_{R-1}(0)$.

end if

end if

if ($C = p - 1$) then

$$U_i(j) = s((j \times r_i) \bmod (p - 1)) - 1, \quad j = 0, 1, \dots, (p - 2),$$

where $U_i(j)$ is the original bit position of j -th permuted bit of i -th row.

end if

(6) Perform the inter-row permutation for the rectangular matrix based on the pattern $\langle T(i) \rangle_{i \in \{0,1,\dots,R-1\}}$,

where $T(i)$ is the original row position of the i -th permuted row.

4.2.3.2.3.3 Bits-output from rectangular matrix with pruning

After intra-row and inter-row permutations, the bits of the permuted rectangular matrix are denoted by y'_k :

$$\begin{bmatrix} y'_1 & y'_{(R+1)} & y'_{(2R+1)} & \cdots & y'_{((C-1)R+1)} \\ y'_2 & y'_{(R+2)} & y'_{(2R+2)} & \cdots & y'_{((C-1)R+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y'_R & y'_{2R} & y'_{3R} & \cdots & y'_{C \times R} \end{bmatrix}$$

The output of the Turbo code internal interleaver is the bit sequence read out column by column from the intra-row and inter-row permuted $R \times C$ rectangular matrix starting with bit y'_1 in row 0 of column 0 and ending with bit y'_{CR} in row $R - 1$ of column $C - 1$. The output is pruned by deleting dummy bits that were padded to the input of the rectangular matrix before intra-row and inter row permutations, i.e. bits y'_k that corresponds to bits y_k with $k > K$ are removed from the output. The bits output from Turbo code internal interleaver are denoted by x'_1, x'_2, \dots, x'_K , where x'_1 corresponds to the bit y'_k with smallest index k after pruning, x'_2 to the bit y'_k with second smallest index k after pruning, and so on. The number of bits output from Turbo code internal interleaver is K and the total number of pruned bits is:

$$R \times C - K.$$

4.2.3.3 Concatenation of encoded blocks

After the channel coding for each code block, if C_i is greater than 1, the encoded blocks are serially concatenated so that the block with lowest index r is output first from the channel coding block, otherwise the encoded block is output from channel coding block as it is. The bits output are denoted by $c_{i1}, c_{i2}, c_{i3}, \dots, c_{iE_i}$, where i is the TrCH number and $E_i = C_i Y_i$. The output bits are defined by the following relations:

$$c_{ik} = y_{i1k} \quad k = 1, 2, \dots, Y_i$$

$$c_{ik} = y_{i,2,(k-Y_i)} \quad k = Y_i + 1, Y_i + 2, \dots, 2Y_i$$

$$c_{ik} = y_{i,3,(k-2Y_i)} \quad k = 2Y_i + 1, 2Y_i + 2, \dots, 3Y_i$$

...

$$c_{ik} = y_{i,C_i,(k-(C_i-1)Y_i)} \quad k = (C_i - 1)Y_i + 1, (C_i - 1)Y_i + 2, \dots, C_i Y_i$$

If no code blocks are input to the channel coding ($C_i = 0$), no bits shall be output from the channel coding, i.e. $E_i = 0$.

4.2.4 Radio frame size equalisation

Radio frame size equalisation is padding the input bit sequence in order to ensure that the output can be segmented in F_i data segments of same size as described in the subclause 4.2.6.

The input bit sequence to the radio frame size equalisation is denoted by $c_{i1}, c_{i2}, c_{i3}, \dots, c_{iE_i}$, where i is TrCH number and E_i the number of bits. The output bit sequence is denoted by $t_{i1}, t_{i2}, t_{i3}, \dots, t_{iT_i}$, where T_i is the number of bits. The output bit sequence is derived as follows:

$$t_{ik} = c_{ik}, \text{ for } k = 1 \dots E_i \text{ and}$$

$$t_{ik} = \{0, 1\} \text{ for } k = E_i + 1 \dots T_i, \text{ if } E_i < T_i$$

where

$$T_i = F_i * N_i \text{ and}$$

$$N_i = \lceil E_i / F_i \rceil \text{ is the number of bits per segment after size equalisation.}$$

4.2.5 1st interleaving

The 1st interleaving is a block interleaver with inter-column permutations. The input bit sequence to the block interleaver is denoted by $x_{i,1}, x_{i,2}, x_{i,3}, \dots, x_{i,X_i}$, where i is TrCH number and X_i the number of bits. Here X_i is guaranteed to be an integer multiple of the number of radio frames in the TTI. The output bit sequence from the block interleaver is derived as follows:

- 1) select the number of columns $C1$ from table 5 depending on the TTI. The columns are numbered 0, 1, ..., $C1 - 1$ from left to right.
- 2) determine the number of rows of the matrix, $R1$ defined as

$$R1 = X_i / C1.$$

The rows of the matrix are numbered 0, 1, ..., $R1 - 1$ from top to bottom.

- 3) write the input bit sequence into the $R1 \times C1$ matrix row by row starting with bit $x_{i,1}$ in column 0 of row 0 and ending with bit $x_{i,(R1 \times C1)}$ in column $C1 - 1$ of row $R1 - 1$:

$$\begin{bmatrix} x_{i,1} & x_{i,2} & x_{i,3} & \dots & x_{i,C1} \\ x_{i,(C1+1)} & x_{i,(C1+2)} & x_{i,(C1+3)} & \dots & x_{i,(2 \times C1)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ x_{i,((R1-1) \times C1+1)} & x_{i,((R1-1) \times C1+2)} & x_{i,((R1-1) \times C1+3)} & \dots & x_{i,(R1 \times C1)} \end{bmatrix}$$

- 4) Perform the inter-column permutation for the matrix based on the pattern $\langle P1_{C1}(j) \rangle_{j \in \{0,1,\dots,C1-1\}}$ shown in table 5, where $P1_{C1}(j)$ is the original column position of the j -th permuted column. After permutation of the columns, the bits are denoted by $y_{i,k}$:

$$\begin{bmatrix} y_{i,1} & y_{i,(R1+1)} & y_{i,(2 \times R1+1)} & \dots & y_{i,((C1-1) \times R1+1)} \\ y_{i,2} & y_{i,(R1+2)} & y_{i,(2 \times R1+2)} & \dots & y_{i,((C1-1) \times R1+2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{i,R1} & y_{i,(2 \times R1)} & y_{i,(3 \times R1)} & \dots & y_{i,(C1 \times R1)} \end{bmatrix}$$

- 5) Read the output bit sequence $y_{i,1}, y_{i,2}, y_{i,3}, \dots, y_{i,(C1 \times R1)}$ of the block interleaver column by column from the inter-column permuted $R1 \times C1$ matrix. Bit $y_{i,1}$ corresponds to row 0 of column 0 and bit $y_{i,(R1 \times C1)}$ corresponds to row $R1 - 1$ of column $C1 - 1$.

Table 5 Inter-column permutation patterns for 1st interleaving

TTI	Number of columns C1	Inter-column permutation patterns $\langle P1_{C1}(0), P1_{C1}(1), \dots, P1_{C1}(C1-1) \rangle$
5ms ^(*) , 10 ms	1	$\langle 0 \rangle$
20 ms	2	$\langle 0, 1 \rangle$
40 ms	4	$\langle 0, 2, 1, 3 \rangle$
80 ms	8	$\langle 0, 4, 2, 6, 1, 5, 3, 7 \rangle$

^(*) can be used for PRACH for 1.28 Mcps TDD

4.2.5.1 Relation between input and output of 1st interleaving

The bits input to the 1st interleaving are denoted by $t_{i,1}, t_{i,2}, t_{i,3}, \dots, t_{i,T_i}$, where i is the TrCH number and T_i the number of bits. Hence, $x_{i,k} = t_{i,k}$ and $X_i = T_i$.

The bits output from the 1st interleaving are denoted by $d_{i,1}, d_{i,2}, d_{i,3}, \dots, d_{i,T_i}$, and $d_{i,k} = y_{i,k}$.

4.2.6 Radio frame segmentation

When the transmission time interval is longer than 10 ms, the input bit sequence is segmented and mapped onto consecutive F_i radio frames. Following radio frame size equalisation the input bit sequence length is guaranteed to be an integer multiple of F_i .

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \dots, x_{iX_i}$ where i is the TrCH number and X_i is the number bits. The F_i output bit sequences per TTI are denoted by $y_{i,n_1}, y_{i,n_2}, y_{i,n_3}, \dots, y_{i,n_{Y_i}}$ where n_i is the radio frame number in current TTI and Y_i is the number of bits per radio frame for TrCH i . The output sequences are defined as follows:

$$y_{i,n,k} = x_{i,((n-1)Y_i)+k}, n_i = 1 \dots F_i, k = 1 \dots Y_i$$

where

$$Y_i = (X_i / F_i) \text{ is the number of bits per segment.}$$

The n_i -th segment is mapped to the n_i -th radio frame of the transmission time interval.

The input bit sequence to the radio frame segmentation is denoted by $d_{i1}, d_{i2}, d_{i3}, \dots, d_{iT_i}$, where i is the TrCH number and T_i the number of bits. Hence, $x_{ik} = d_{ik}$ and $X_i = T_i$.

The output bit sequence corresponding to radio frame n_i is denoted by $e_{i1}, e_{i2}, e_{i3}, \dots, e_{iN_i}$, where i is the TrCH number and N_i is the number of bits. Hence, $e_{i,k} = y_{i,n,k}$ and $N_i = Y_i$.

4.2.7 Rate matching

Rate matching means that bits on a TrCH are repeated or punctured. Higher layers assign a rate-matching attribute for each TrCH. This attribute is semi-static and can only be changed through higher layer signalling. The rate-matching attribute is used when the number of bits to be repeated or punctured is calculated.

The number of bits on a TrCH can vary between different transmission time intervals. When the number of bits between different transmission time intervals is changed, bits are repeated to ensure that the total bit rate after TrCH multiplexing is identical to the total channel bit rate of the allocated physical channels.

If no bits are input to the rate matching for all TrCHs within a CCTrCH, the rate matching shall output no bits for all TrCHs within the CCTrCH.

Notation used in subclause 4.2.7 and subclauses:

N_{ij} : Number of bits in a radio frame before rate matching on TrCH i with transport format combination j .

$\Delta N_{i,j}$: If positive – number of bits to be repeated in each radio frame on TrCH i with transport format

If negative – number of bits to be punctured in each radio frame on TrCH i with transport format combination j .

RM_i : Semi-static rate matching attribute for TrCH i . Signalled from higher layers.

PL : Puncturing limit. This value limits the amount of puncturing that can be applied in order to minimise the number of physical channels. Signalled from higher layers. The allowed puncturing in % is actually equal to $(1-PL)*100$.

$N_{data,j}$: Total number of bits that are available for a CCTrCH in a radio frame with transport format combination j .

P : number of physical channels used in the current frame.

P_{max} : maximum number of physical channels allocated for a CCTrCH.

U_p : Number of data bits in the physical channel p with $p = 1 \dots P$.

- I : Number of TrCHs in a CCTrCH.
- Z_{ij} : Intermediate calculation variable.
- F_i : Number of radio frames in the transmission time interval of TrCH i .
- n_i : Radio frame number in the transmission time interval of TrCH i ($0 \leq n_i < F_i$).
- q : Average puncturing or repetition distance (normalised to only show the remaining rate matching on top of an integer number of repetitions).
- $PI_F(n_i)$: The column permutation function of the 1st interleaver, $PI_F(x)$ is the original position of column with number x after permutation. PI is defined on table 5 of section 4.2.5 (note that PI_F self-inverse).
- $S[n]$: The shift of the puncturing or repetition pattern for radio frame n_i when $n = PI_{F_i}(n_i)$.
- $TF_i(j)$: Transport format of TrCH i for the transport format combination j .
- $TFS(i)$: The set of transport format indexes l for TrCH i .
- e_{ini} : Initial value of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.
- e_{plus} : Increment of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.
- e_{minus} : Decrement of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.
- b : Indicates systematic and parity bits.
- $b=1$: Systematic bit. $X(t)$ in subclause 4.2.3.2.1.
- $b=2$: 1st parity bit (from the upper Turbo constituent encoder). $Y(t)$ in subclause 4.2.3.2.1.
- $b=3$: 2nd parity bit (from the lower Turbo constituent encoder). $Y(t)$ in subclause 4.2.3.2.1.

4.2.7.1 Determination of rate matching parameters

The following relations, defined for all TFC j , are used when calculating the rate matching pattern:

$$Z_{0,j} = 0$$

$$Z_{i,j} = \left\lfloor \frac{\left(\left(\sum_{m=1}^i RM_m \times N_{m,j} \right) \times N_{data,j} \right)}{\sum_{m=1}^I RM_m \times N_{m,j}} \right\rfloor \quad \text{for all } i = 1 \dots I(1)$$

$$\Delta N_{i,j} = Z_{i,j} - Z_{i-1,j} - N_{i,j} \quad \text{for all } i = 1 \dots I$$

Puncturing can be used to minimise the required transmission capacity. The maximum amount of puncturing that can be applied is 1-PL, PL is signalled from higher layers. The possible values for N_{data} depend on the number of physical channels P_{max} , allocated to the respective CCTrCH, and on their characteristics (spreading factor, length of midamble and TFCI code word, usage of TPC and multiframe structure), which is given in [7].

Denote the number of data bits in each physical channel by $U_{p,Sp}$, where p refers to the sequence number $1 \leq p \leq P_{max}$ of this physical channel as detailed in section 4.2.11, and the second index Sp indicates the spreading factor with the possible values $\{16, 8, 4, 2, 1\}$, respectively. For each physical channel an individual minimum spreading factor Sp_{min} is transmitted by means of the higher layers. Then, for N_{data} one of the following values in ascending order can be chosen:

$$\left\{ U_{1,Sp_{min}}, U_{1,Sp_{min}} + U_{2,Sp_{min}}, U_{1,Sp_{min}} + U_{2,Sp_{min}} + \dots + U_{P_{max},(Sp_{max})_{min}} \right\}$$

Optionally, if indicated by higher layers for the UL the UE shall vary the spreading factor autonomously, so that N_{data} is one of the following values in ascending order:

$$\{U_{1,16}, \dots, U_{1,S1_{\min}}, U_{1,S1_{\min}} + U_{2,16}, \dots, U_{1,S1_{\min}} + U_{2,S2_{\min}}, \dots, U_{1,S1_{\min}} + U_{2,S2_{\min}} + \dots + U_{P_{\max},16}, \dots, U_{1,S1_{\min}} + U_{2,S2_{\min}} + \dots + U_{P_{\max}(SP_{\max})_{\min}}\}$$

$N_{data,j}$ for the transport format combination j is determined by executing the following algorithm:

$$SET1 = \{ N_{data} \text{ such that } \left(\min_{1 \leq y \leq I} \{RM_y\} \right) \times N_{data} - PL \times \sum_{x=1}^I RM_x \times N_{x,j} \text{ is non negative} \}$$

$$N_{data,j} = \min SET1$$

The number of bits to be repeated or punctured, $\Delta N_{i,j}$, within one radio frame for each TrCH i is calculated with the relations given at the beginning of this subclause for all possible transport format combinations j and selected every radio frame.

If $\Delta N_{i,j} = 0$ then the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.3 does not need to be executed.

Otherwise, the rate matching pattern is calculated with the algorithm described in subclause 4.2.7.3. For this algorithm the parameters e_{ini} , e_{plus} , e_{minus} , and X_i are needed, which are calculated according to the equations in subclauses 4.2.7.1.1 and 4.2.7.1.2.

4.2.7.1.1 Uncoded and convolutionally encoded TrCHs

$$a = 2$$

$$\Delta N_i = \Delta N_{i,j}$$

$$X_i = N_{i,j}$$

$$R = \Delta N_{i,j} \bmod N_{i,j} \text{ -- note: in this context } \Delta N_{i,j} \bmod N_{i,j} \text{ is in the range of } 0 \text{ to } N_{i,j}-1 \text{ i.e. } -1 \bmod 10 = 9.$$

if $R \neq 0$ and $2 \times R \leq N_{i,j}$

$$\text{then } q = \lceil N_{i,j} / R \rceil$$

else

$$q = \lceil N_{i,j} / (R - N_{i,j}) \rceil$$

endif

NOTE 1: q is a signed quantity.

If q is even

$$\text{then } q' = q + \gcd(|q|, F_i) / F_i \text{ -- where } \gcd(|q|, F_i) \text{ means greatest common divisor of } |q| \text{ and } F_i$$

NOTE 2: q' is not an integer, but a multiple of 1/8.

else

$$q' = q$$

endif

for $x = 0$ to F_i-1

$$S[\lfloor x \times q' \rfloor \bmod F_i] = (\lfloor x \times q' \rfloor \div F_i)$$

end for

$$e_{ini} = (a \times S[P1_{F_i}(n_i)] \times |\Delta N_i| + 1) \bmod (a \times N_{i,j})$$

$$e_{plus} = a \times X_i$$

$$e_{minus} = a \times |\Delta N_i|$$

puncturing for $\Delta N_i < 0$, repetition otherwise.

4.2.7.1.2 Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{i,j} > 0$, the parameters in subclause 4.2.7.1.1 are used.

If puncturing is to be performed, the parameters below shall be used. Index b is used to indicate systematic ($b=1$), 1st parity ($b=2$), and 2nd parity bit ($b=3$).

$a = 2$ when $b=2$

$a = 1$ when $b=3$

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{i,j} / 2 \rfloor, & b = 2 \\ \lfloor \Delta N_{i,j} / 2 \rfloor, & b = 3 \end{cases}$$

If ΔN_i is calculated as 0 for $b=2$ or $b=3$, then the following procedure and the rate matching algorithm of subclause 4.2.7.3 don't need to be performed for the corresponding parity bit stream.

$$X_i = \lfloor N_{i,j} / 3 \rfloor,$$

$$q = \lfloor X_i / |\Delta N_i| \rfloor$$

if ($q \leq 2$)

for $r=0$ to F_i-1

$$S[(3 \times r + b - 1) \bmod F_i] = r \bmod 2;$$

end for

else

if q is even

then $q' = q - \text{gcd}(q, F_i) / F_i$ -- where $\text{gcd}(q, F_i)$ means greatest common divisor of q and F_i

NOTE: q' is not an integer, but a multiple of 1/8.

else $q' = q$

endif

for $x=0$ to F_i-1

$$r = \lceil x \times q' \rceil \bmod F_i;$$

$$S[(3 \times r + b - 1) \bmod F_i] = \lceil x \times q' \rceil \text{div } F_i;$$

endfor

endif

For each radio frame, the rate-matching pattern is calculated with the algorithm in subclause 4.2.7.3, where:

X_i is as above,

$$e_{mi} = (a \times S[P1 \ F_i(n_i)] \times |\Delta N_i| + X_i) \bmod (a \times X_i), \text{ if } e_{mi} = 0 \text{ then } e_{mi} = a \times X_i$$

$$e_{plus} = a \times X_i$$

$$e_{minus} = a \times |\Delta N_i|$$

4.2.7.2 Bit separation and collection for rate matching

The systematic bits of turbo encoded TrCHs shall not be punctured, the other bits may be punctured. The systematic bits, first parity bits, and second parity bits in the bit sequence input to the rate matching block are therefore separated into three sequences.

The first sequence contains:

- All of the systematic bits that are from turbo encoded TrCHs.
- From 0 to 2 first and/or second parity bits that are from turbo encoded TrCHs. These bits come into the first sequence when the total number of bits in a block after radio frame segmentation is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The second sequence contains:

- All of the first parity bits that are from turbo encoded TrCHs, except those that go into the first sequence when the total number of bits is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The third sequence contains:

- All of the second parity bits that are from turbo encoded TrCHs, except those that go into the first sequence when the total number of bits is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The second and third sequences shall be of equal length, whereas the first sequence can contain from 0 to 2 more bits. Puncturing is applied only to the second and third sequences.

The bit separation function is transparent for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition. The bit separation and bit collection are illustrated in figures 4 and 5.

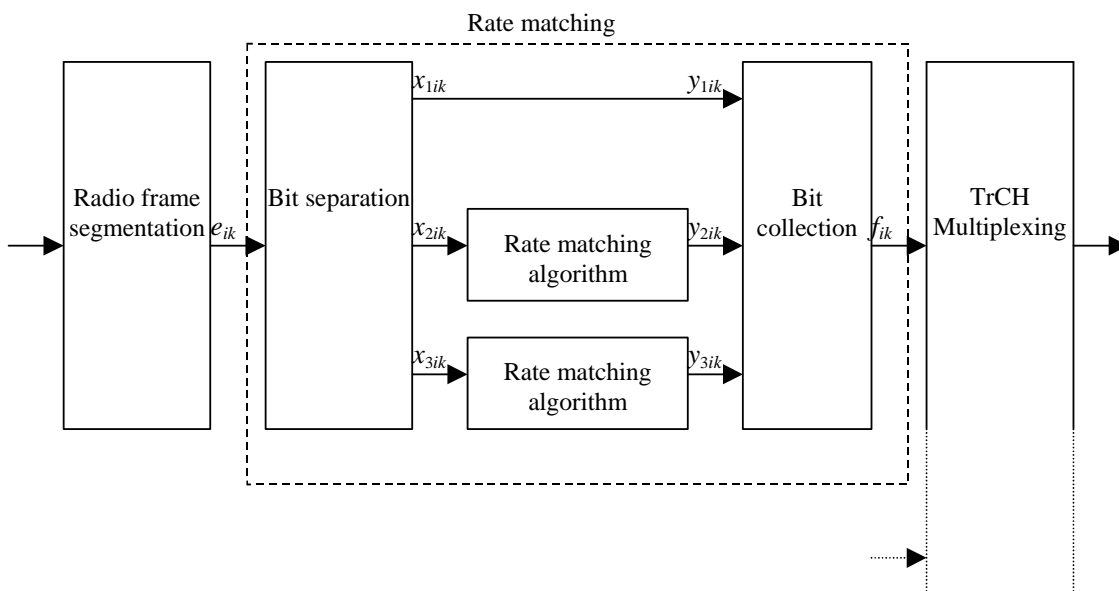


Figure 4: Puncturing of turbo encoded TrCHs

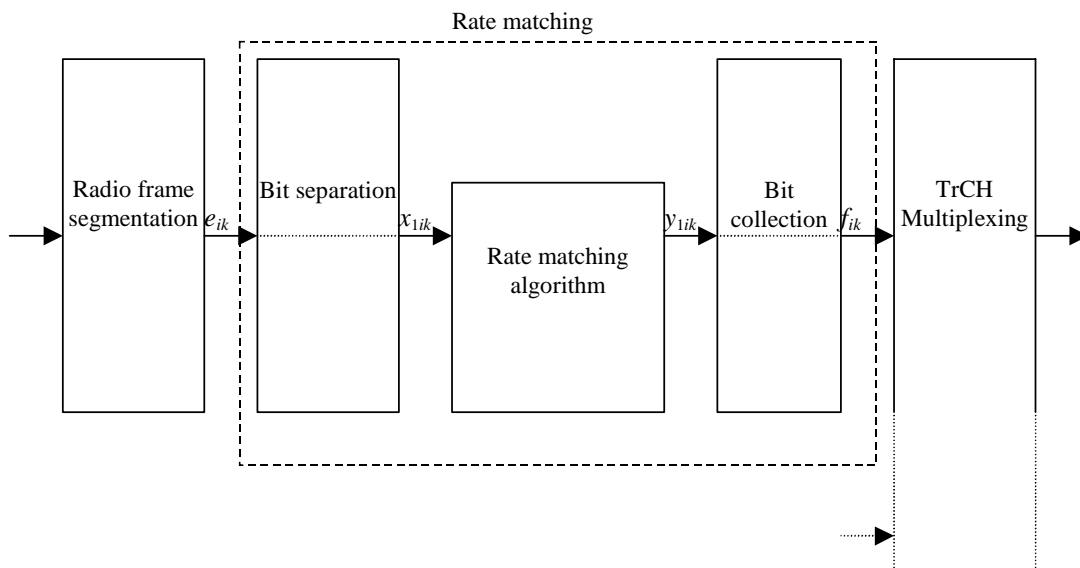


Figure 5: Rate matching for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition

The bit separation is dependent on the 1st interleaving and offsets are used to define the separation for different TTIs. b indicates the three sequences defined in this section, with $b=1$ indicating the first sequence, $b = 2$ the second one, and $b = 3$ the third one.

The offsets α_b for these sequences are listed in table 6.

Table 6: TTI dependent offset needed for bit separation

TTI (ms)	α_1	α_2	α_3
10, 40	0	1	2
20, 80	0	2	1

The bit separation is different for different radio frames in the TTI. A second offset is therefore needed. The radio frame number for TrCH i is denoted by n_i , and the offset by β_{n_i} .

Table 7: Radio frame dependent offset needed for bit separation

TTI (ms)	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7
10	0	NA	NA	NA	NA	NA	NA	NA
20	0	1	NA	NA	NA	NA	NA	NA
40	0	1	2	0	NA	NA	NA	NA
80	0	1	2	0	1	2	0	1

4.2.7.2.1 Bit separation

The bits input to the rate matching are denoted by $e_{i,1}, e_{i,2}, e_{i,3}, \dots, e_{i,N_i}$, where i is the TrCH number and N_i is the number of bits input to the rate matching block. Note that the transport format combination number j for simplicity has been left out in the bit numbering, i.e. $N_i=N_{ij}$. The bits after separation are denoted by $x_{b,i,1}, x_{b,i,2}, x_{b,i,3}, \dots, x_{b,i,X_i}$. For turbo encoded TrCHs with puncturing, b indicates the three sequences defined in section 4.2.7.2, with $b=1$ indicating the first sequence, and so forth. For all other cases b is defined to be 1. X_i is the number of bits in each separated bit sequence. The relation between $e_{i,k}$ and $x_{b,i,k}$ is given below.

For turbo encoded TrCHs with puncturing:

$$x_{1,i,k} = e_{i,3(k-1)+1+(\alpha_1+\beta_{n_i}) \bmod 3} \quad k = 1, 2, 3, \dots, X_i \quad X_i = \lfloor N_i / 3 \rfloor$$

$$x_{1,i,\lfloor N_i/3 \rfloor+k} = e_{i,3\lfloor N_i/3 \rfloor+k} \quad k = 1, \dots, N_i \bmod 3 \quad \text{Note: When } (N_i \bmod 3) = 0 \text{ this row is not needed.}$$

$$x_{2,i,k} = e_{i,3(k-1)+1+(\alpha_2+\beta_{n_i}) \bmod 3} \quad k = 1, 2, 3, \dots, X_i \quad X_i = \lfloor N_i/3 \rfloor$$

$$x_{3,i,k} = e_{i,3(k-1)+1+(\alpha_3+\beta_{n_i}) \bmod 3} \quad k = 1, 2, 3, \dots, X_i \quad X_i = \lfloor N_i/3 \rfloor$$

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$$x_{1,i,k} = e_{i,k} \quad k = 1, 2, 3, \dots, X_i \quad X_i = N_i$$

4.2.7.2.2 Bit collection

The bits $x_{b,i,k}$ are input to the rate matching algorithm described in subclause 4.2.7.3. The bits output from the rate matching algorithm are denoted $y_{b,i,1}, y_{b,i,2}, y_{b,i,3}, \dots, y_{b,i,Y_i}$.

Bit collection is the inverse function of the separation. The bits after collection are denoted by

$z_{b,i,1}, z_{b,i,2}, z_{b,i,3}, \dots, z_{b,i,Y_i}$. After bit collection, the bits indicated as punctured are removed and the bits are then denoted by $f_{i,1}, f_{i,2}, f_{i,3}, \dots, f_{i,V_i}$, where i is the TrCH number and $V_i = N_{i,j} + \Delta N_{i,j}$. The relations between $y_{b,i,k}$, $z_{b,i,k}$, and $f_{i,k}$ are given below.

For turbo encoded TrCHs with puncturing ($Y_i = X_i$):

$$z_{i,3(k-1)+1+(\alpha_1+\beta_{n_i}) \bmod 3} = y_{1,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

$$z_{i,3\lfloor N_i/3 \rfloor+k} = y_{1,i,\lfloor N_i/3 \rfloor+k} \quad k = 1, \dots, N_i \bmod 3 \quad \text{Note: When } (N_i \bmod 3) = 0 \text{ this row is not needed.}$$

$$z_{i,3(k-1)+1+(\alpha_2+\beta_{n_i}) \bmod 3} = y_{2,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

$$z_{i,3(k-1)+1+(\alpha_3+\beta_{n_i}) \bmod 3} = y_{3,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

After the bit collection, bits $z_{i,k}$ with value δ , where $\delta \notin \{0, 1\}$, are removed from the bit sequence. Bit $f_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $f_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$$z_{i,k} = y_{1,i,k} \quad k = 1, 2, 3, \dots, Y_i$$

When repetition is used, $f_{i,k} = z_{i,k}$ and $Y_i = V_i$.

When puncturing is used, $Y_i = X_i$ and bits $z_{i,k}$ with value δ , where $\delta \notin \{0, 1\}$, are removed from the bit sequence. Bit $f_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $f_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

4.2.7.3 Rate matching pattern determination

The bits input to the rate matching are denoted by $x_{i,1}, x_{i,2}, x_{i,3}, \dots, x_{i,X_i}$, where i is the TrCH and X_i is the parameter given in subclauses 4.2.7.1.1 and 4.2.7.1.2.

NOTE: The transport format combination number j for simplicity has been left out in the bit numbering.

The rate matching rule is as follows:

if puncturing is to be performed

```

e = eini    -- initial error between current and desired puncturing ratio
m = 1        -- index of current bit
do while m <= Xi
    e = e - eminus    -- update error
    if e <= 0 then    -- check if bit number m should be punctured
        set bit xi,m to  $\delta$  where  $\delta \notin \{0, 1\}$ 
        e = e + eplus    -- update error
    end if
    m = m + 1    -- next bit
end do
else
e = eini    -- initial error between current and desired puncturing ratio
m = 1        -- index of current bit
do while m <= Xi
    e = e - eminus    -- update error
    do while e <= 0    -- check if bit number m should be repeated
        repeat bit xi,m
        e = e + eplus    -- update error
    end do
    m = m + 1    -- next bit
end do
end if

```

A repeated bit is placed directly after the original one.

4.2.8 TrCH multiplexing

Every 10 ms, one radio frame from each TrCH is delivered to the TrCH multiplexing. These radio frames are serially multiplexed into a coded composite transport channel (CCTrCH). If the TTI is smaller than 10ms, then no TrCH multiplexing is performed.

The bits input to the TrCH multiplexing are denoted by $f_{i,1}, f_{i,2}, f_{i,3}, \dots, f_{i,V_i}$, where i is the TrCH id number and V_i is the number of bits in the radio frame of TrCH i . The number of TrCHs is denoted by I . The bits output from TrCH multiplexing are denoted by $h_1, h_2, h_3, \dots, h_S$, where S is the number of bits, i.e. $S = \sum_i V_i$. The TrCH multiplexing is defined by the following relations:

$$h_k = f_{1,k} \quad k = 1, 2, \dots, V_1$$

$$h_k = f_{2,(k-V_1)} \quad k = V_1+1, V_1+2, \dots, V_1+V_2$$

$$h_k = f_{3,(k-(V_1+V_2))} \quad k = (V_1+V_2)+1, (V_1+V_2)+2, \dots, (V_1+V_2)+V_3$$

...

$$h_k = f_{I,(k-(V_1+V_2+\dots+V_{I-1}))} \quad k = (V_1+V_2+\dots+V_{I-1})+1, (V_1+V_2+\dots+V_{I-1})+2, \dots, (V_1+V_2+\dots+V_{I-1})+V_I$$

4.2.9 Bit Scrambling

The bits output from the TrCH multiplexer are scrambled in the bit scrambler. The bits input to the bit scrambler are denoted by $h_1, h_2, h_3, \dots, h_S$, where S is the number of bits input to the bit scrambling block equal to the total number of bits on the CCTrCH. The bits after bit scrambling are denoted $s_1, s_2, s_3, \dots, s_S$.

Bit scrambling is defined by the following relation:

$$s_k = h_k \oplus p_k \quad k = 1, 2, \dots, S$$

and p_k results from the following operation:

$$p_k = \left(\sum_{i=1}^{16} g_i \cdot p_{k-i} \right) \bmod 2; \quad p_k = 0; k < 1; \quad p_1 = 1; \quad g = \{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1\}$$

4.2.10 Physical channel segmentation

When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $s_1, s_2, s_3, \dots, s_S$, where S is the number of bits input to the physical channel segmentation block. The number of PhCHs is denoted by P .

The bits after physical channel segmentation are denoted $u_{p,1}, u_{p,2}, u_{p,3}, \dots, u_{p,U_p}$, where p is PhCH number and U_p is the in general variable number of bits in the respective radio frame for each PhCH. The relation between s_k and $u_{p,k}$ is given below.

Bits on first PhCH after physical channel segmentation:

$$u_{1,k} = s_k \quad k = 1, 2, \dots, U_1$$

Bits on second PhCH after physical channel segmentation:

$$u_{2,k} = s_{(k+U_1)} \quad k = 1, 2, \dots, U_2$$

...

Bits on the P^{th} PhCH after physical channel segmentation:

$$u_{P,k} = s_{(k+U_1+\dots+U_{P-1})} \quad k = 1, 2, \dots, U_P$$

4.2.11 2nd interleaving

The 2nd interleaving is a block interleaver and consists of bits input to a matrix with padding, the inter-column permutation for the matrix and bits output from the matrix with pruning. The 2nd interleaving can be applied jointly to all data bits transmitted during one frame, or separately within each timeslot, on which the CCTrCH is mapped. The selection of the 2nd interleaving scheme is controlled by higher layer.

4.2.11.1 Frame related 2nd interleaving

In case of frame related 2nd interleaving, the bits input to the block interleaver are denoted by $x_1, x_2, x_3, \dots, x_U$, where U is the total number of bits after TrCH multiplexing transmitted during the respective radio frame with

$$S = U = \sum_p U_p$$

The relation between x_k and the bits $u_{p,k}$ in the respective physical channels is given below:

$$x_k = u_{1,k} \quad k = 1, 2, \dots, U_1$$

$$x_{(k+U_1)} = u_{2,k} \quad k = 1, 2, \dots, U_2$$

...

$$x_{(k+U_1+\dots+U_{p-1})} = u_{p,k} \quad k = 1, 2, \dots, U_p$$

The following steps have to be performed once for each CCTrCH:

- (1) Assign $C2 = 30$ to be the number of columns of the matrix. The columns of the matrix are numbered $0, 1, 2, \dots, C2 - 1$ from left to right.
- (2) Determine the number of rows of the matrix, $R2$, by finding minimum integer $R2$ such that:

$$U \leq R2 \times C2.$$

The rows of rectangular matrix are numbered $0, 1, 2, \dots, R2 - 1$ from top to bottom.

- (3) Write the input bit sequence $x_1, x_2, x_3, \dots, x_U$ into the $R2 \times C2$ matrix row by row starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} y_1 & y_2 & y_3 & \dots & y_{C2} \\ y_{(C2+1)} & y_{(C2+2)} & y_{(C2+3)} & \dots & y_{(2 \times C2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{((R2-1) \times C2+1)} & y_{((R2-1) \times C2+2)} & y_{((R2-1) \times C2+3)} & \dots & y_{(R2 \times C2)} \end{bmatrix}$$

where $y_k = x_k$ for $k = 1, 2, \dots, U$ and if $R2 \times C2 > U$, the dummy bits are padded such that $y_k = 0$ or 1 for $k = U + 1, U + 2, \dots, R2 \times C2$. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

- (4) Perform the inter-column permutation for the matrix based on the pattern $\langle P_2(j) \rangle_{j \in \{0,1,\dots,C2-1\}}$ that is shown in table 8, where $P_2(j)$ is the original column position of the j -th permuted column. After permutation of the columns, the bits are denoted by y'_k .

$$\begin{bmatrix} y'_1 & y'_{(R2+1)} & y'_{(2 \times R2+1)} & \dots & y'_{((C2-1) \times R2+1)} \\ y'_2 & y'_{(R2+2)} & y'_{(2 \times R2+2)} & \dots & y'_{((C2-1) \times R2+2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y'_{R2} & y'_{(2 \times R2)} & y'_{(3 \times R2)} & \dots & y'_{(C2 \times R2)} \end{bmatrix}$$

- (5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted $R2 \times C2$ matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits y'_k that corresponds to bits y_k with $k > U$ are removed from the output. The bits after frame related 2nd interleaving are denoted by v_1, v_2, \dots, v_U , where v_1 corresponds to the bit y'_k with smallest index k after pruning, v_2 to the bit y'_k with second smallest index k after pruning, and so on.

4.2.11.2 Timeslot related 2nd interleaving

In case of timeslot related 2nd interleaving, the bits input to the block interleaver are denoted by $x_{t,1}, x_{t,2}, x_{t,3}, \dots, x_{t,U_t}$, where t refers to a certain timeslot, and U_t is the number of bits transmitted in this timeslot during the respective radio frame.

In each timeslot t the relation between $x_{t,k}$ and $u_{t,p,k}$ is given below with P_t referring to the number of physical channels within the respective timeslot:

$$x_{t,k} = u_{t,1,k} \quad k = 1, 2, \dots, U_{t1}$$

$$x_{t,(k+U_{t1})} = u_{t,2,k} \quad k = 1, 2, \dots, U_{t2}$$

...

$$x_{t,(k+U_{t1}+\dots+U_{t(P_t-1)})} = u_{t,P_t,k} \quad k = 1, 2, \dots, U_{tP_t}$$

The following steps have to be performed for each timeslot t , on which the respective CCTrCH is mapped:

- (1) Assign $C2 = 30$ to be the number of columns of the matrix. The columns of the matrix are numbered $0, 1, 2, \dots, C2 - 1$ from left to right.

- (2) Determine the number of rows of the matrix, $R2$, by finding minimum integer $R2$ such that:

$$U_t \leq R2 \times C2.$$

The rows of rectangular matrix are numbered $0, 1, 2, \dots, R2 - 1$ from top to bottom.

- (3) Write the input bit sequence $x_{t,1}, x_{t,2}, x_{t,3}, \dots, x_{t,U_t}$ into the $R2 \times C2$ matrix row by row starting with bit $y_{t,1}$ in column 0 of row 0:

$$\begin{bmatrix} y_{t,1} & y_{t,2} & y_{t,3} & \dots & y_{t,C2} \\ y_{t,(C2+1)} & y_{t,(C2+2)} & y_{t,(C2+3)} & \dots & y_{t,(2 \times C2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{t,((R2-1) \times C2+1)} & y_{t,((R2-1) \times C2+2)} & y_{t,((R2-1) \times C2+3)} & \dots & y_{t,(R2 \times C2)} \end{bmatrix}$$

where $y_{t,k} = x_{t,k}$ for $k = 1, 2, \dots, U_t$ and if $R2 \times C2 > U_t$, the dummy bits are padded such that $y_{t,k} = 0$ or 1 for $k = U_t + 1, U_t + 2, \dots, R2 \times C2$. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

- (4) Perform the inter-column permutation for the matrix based on the pattern $\langle P2(j) \rangle_{j \in \{0,1,\dots,C2-1\}}$ that is shown in table 8, where $P2(j)$ is the original column position of the j -th permuted column. After permutation of the columns, the bits are denoted by $y'_{t,k}$.

$$\begin{bmatrix} y'_{t,1} & y'_{t,(R2+1)} & y'_{t,(2 \times R2+1)} & \dots & y'_{t,((C2-1) \times R2+1)} \\ y'_{t,2} & y'_{t,(R2+2)} & y'_{t,(2 \times R2+2)} & \dots & y'_{t,((C2-1) \times R2+2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y'_{t,R2} & y'_{t,(2 \times R2)} & y'_{t,(3 \times R2)} & \dots & y'_{t,(C2 \times R2)} \end{bmatrix}$$

- (5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted $R2 \times C2$ matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits $y'_{t,k}$ that corresponds to bits $y_{t,k}$ with $k > U_t$ are removed from the output. The bits after time slot 2nd interleaving are denoted by $v_{t,1}, v_{t,2}, \dots, v_{t,U_t}$, where $v_{t,1}$

corresponds to the bit $y'_{t,k}$ with smallest index k after pruning, $v_{t,2}$ to the bit $y'_{t,k}$ with second smallest index k after pruning, and so on.

Table 8 Inter-column permutation pattern for 2nd interleaving

Number of Columns C2	Inter-column permutation pattern < P2(0), P2(1), ..., P2(C2-1) >
30	<0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17>

4.2.12 Sub-frame segmentation for the 1.28 Mcps option

In the 1.28Mcps TDD, it is needed to add a sub-frame segmentation unit between 2nd interleaving unit and physical channel mapping unit. The operation of rate-matching guarantees that the bit streams is a even number and can be subdivided into 2 sub-frames. The transport channel multiplexing structure for uplink and downlink is shown in figure 2.

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \dots, x_{iX_i}$ where i is the TrCH number and X_i is the number bits. The two output bit sequences per radio frame are denoted by $y_{i,n_1}, y_{i,n_2}, y_{i,n_3}, \dots, y_{i,n_i}$ where n_i is the sub-frame number in current radio frame and Y_i is the number of bits per radio frame for TrCH i . The output sequences are defined as follows:

$$y_{i,n,k} = x_{i,((n_i-1)Y_i)+k}, \quad n_i = 1 \text{ or } 2, \quad k = 1 \dots Y_i$$

where

$Y_i = (X_i / 2)$ is the number of bits per sub-frame,

x_{ik} is the k^{th} bit of the input bit sequence and

$y_{i,n,k}$ is the k^{th} bit of the output bit sequence corresponding to the n^{th} sub-frame

The input bit sequence to the sub-frame segmentation is denoted by $v_{(t)1}, v_{(t)2}, \dots, v_{(t)U_{(t)}}$, $x_{ik} = v_{(t)k}$ and $X_i = U_{(t)}$.

The output bit sequence corresponding to subframe n_i is denoted by $g_{p1}, g_{p2}, \dots, g_{pU_p}$, where p is the PhCH number and U_p is the number of bits in one subframe for the respective PhCH. Hence, $g_{pk} = y_{i,n,k}$ and $U_p = Y_i$.

4.2.13 Physical channel mapping

4.2.13.1 Physical channel mapping for the 3.84 Mcps option

The PhCH for both uplink and downlink is defined in [6]. The bits after physical channel mapping are denoted by $w_{p,1}, w_{p,2}, \dots, w_{p,U_p}$, where p is the PhCH number corresponding to the sequence number $1 \leq p \leq P_{max}$ of this physical channel as detailed below, and U_p is the number of bits in one radio frame for the respective PhCH. The bits $w_{p,k}$ are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k .

The physical channel sequence number p are to be allocated by the physical layer in ascending order of the timeslots in which they appear. If more than one physical channel appears in a timeslot, they shall be allocated the sequence number in order of the timeslot first and then of their channelisation codes. The channelisation codes shall be ordered in ascending order of the spreading Factor (Q) and then channelisation index (k), as shown in [9].

The mapping of the bits $v_{(t)1}, v_{(t)2}, \dots, v_{(t)U_{(t)}}$ is performed like block interleaving, writing the bits into columns, but a PhCH with an odd number is filled in forward order, were as a PhCH with an even number is filled in reverse order.

The mapping scheme, as described in the following subclause, shall be applied individually for each timeslot t used in the current frame. Therefore, the bits $v_{t,1}, v_{t,2}, \dots, v_{t,U_t}$ are assigned to the bits of the physical channels

$w_{t,1,1\dots U_{t1}}, w_{t,2,1\dots U_{t2}}, \dots, w_{t,P_t,1\dots U_{tP_t}}$ in each timeslot.

In uplink there are at most two codes allocated ($P \leq 2$). If there is only one code, the same mapping as for downlink is applied. Denote SF1 and SF2 the spreading factors used for code 1 and 2, respectively. For the number of consecutive bits to assign per code bs_k the following rule is applied:

if

SF1 \geq SF2 then $bs_1 = 1$; $bs_2 = SF1/SF2$;

else

SF2 $>$ SF1 then $bs_1 = SF2/SF1$; $bs_2 = 1$;

end if

In the downlink case bs_p is 1 for all physical channels.

4.2.13.1.1 Mapping scheme

Notation used in this subclause:

P_t : number of physical channels for timeslot t , $P_t = 1..2$ for uplink ; $P_t = 1..16$ for downlink

$U_{t,p}$: capacity in bits for the physical channel p in timeslot t

U_t : total number of bits to be assigned for timeslot t

bs_p : number of consecutive bits to assign per code

for downlink all $bs_p = 1$

for uplink if SF1 \geq SF2 then $bs_1 = 1$; $bs_2 = SF1/SF2$;

if SF2 $>$ SF1 then $bs_1 = SF2/SF1$; $bs_2 = 1$;

fb_p : number of already written bits for each code

pos: intermediate calculation variable

for $p=1$ to P_t -- reset number of already written bits for every physical channel

$fb_p = 0$

end for

$p = 1$ -- start with PhCH #1

for $k=1$ to U_t

do while ($fb_p == U_{t,p}$) -- physical channel filled up already ?

$p = (p \bmod P_t) + 1$;

end do

if ($p \bmod 2 == 0$)

$pos = U_{t,p} - fb_p$ -- reverse order

else

$pos = fb_p + 1$ -- forward order

```

endif
 $w_{t,p, \text{pos}} = v_{t,k}$            -- assignment
 $\text{fb}_p = \text{fb}_p + 1$            -- Increment number of already written bits
if ( $\text{fb}_p \bmod \text{bs}_p$ ) == 0      -- Conditional change to the next physical channel
     $p = (p \bmod P_t) + 1$ ;
end if
end for

```

4.2.13.2 Physical channel mapping for the 1.28 Mcps option

The bit streams from the sub-frame segmentation unit are mapped onto code channels of time slots in sub-frames.

The bits after physical channel mapping are denoted by $w_{p1}, w_{p2}, \dots, w_{pU_p}$, where p is the PhCH number and U_p is the number of bits in one sub-frame for the respective PhCH. The bits w_{pk} are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k .

The mapping of the bits $g_{p1}, g_{p2}, \dots, g_{pU_p}$ is performed like block interleaving, writing the bits into columns, but a PhCH with an odd number is filled in forward order, where as a PhCH with an even number is filled in reverse order.

The mapping scheme, as described in the following subclause, shall be applied individually for each timeslot t used in the current subframe. Therefore, the bits $g_{p1}, g_{p2}, \dots, g_{pU_p}$ are assigned to the bits of the physical channels $w_{t1,1\dots U_{t1}}, w_{t2,1\dots U_{t2}}, \dots, w_{tP_t,1\dots U_{tP_t}}$ in each timeslot.

In uplink there are at most two codes allocated ($P \leq 2$). If there is only one code, the same mapping as for downlink is applied. Denote SF1 and SF2 the spreading factors used for code 1 and 2, respectively. For the number of consecutive bits to assign per code bs_k the following rule is applied:

```

if
SF1 >= SF2 then  $\text{bs}_1 = 1$  ;  $\text{bs}_2 = \text{SF1}/\text{SF2}$  ;
else
SF2 > SF1 then  $\text{bs}_1 = \text{SF2}/\text{SF1}$ ;  $\text{bs}_2 = 1$  ;
end if

```

In the downlink case bs_p is 1 for all physical channels.

4.2.13.2.1 Mapping scheme

Notation used in this subclause:

P_t : number of physical channels for timeslot t , $P_t = 1..2$ for uplink ; $P_t = 1..16$ for downlink

U_{tp} : capacity in bits for the physical channel p in timeslot t

U_t : total number of bits to be assigned for timeslot t

bs_p : number of consecutive bits to assign per code

for downlink all $\text{bs}_p = 1$

for uplink if SF1 >= SF2 then $\text{bs}_1 = 1$; $\text{bs}_2 = \text{SF1}/\text{SF2}$;

if SF2 > SF1 then $\text{bs}_1 = \text{SF2}/\text{SF1}$; $\text{bs}_2 = 1$;

```

fbp:   number of already written bits for each code
pos:    intermediate calculation variable
for p=1 to Pt           -- reset number of already written bits for every physical channel
fbp = 0
end for
p = 1                   -- start with PhCH #1
for k=1 to Ut
do while (fbp == Ut,p) -- physical channel filled up already ?
p = (p mod Pt) + 1 ;
end do
if (p mod 2) == 0
pos = Ut,p - fbp      -- reverse order
else
pos = fbp + 1         -- forward order
end if
wtp,pos = gt,k       -- assignment
fbp = fbp + 1       -- Increment number of already written bits
If (fbp mod bsp) == 0 -- Conditional change to the next physical channel
p = (p mod Pt) + 1 ;
end if
end for

```

4.2.14 Multiplexing of different transport channels onto one CCTrCH, and mapping of one CCTrCH onto physical channels

Different transport channels can be encoded and multiplexed together into one Coded Composite Transport Channel (CCTrCH). The following rules shall apply to the different transport channels which are part of the same CCTrCH:

- 1) Transport channels multiplexed into one CCTrCh shall have co-ordinated timings. When the TFCS of a CCTrCH is changed because one or more transport channels are added to the CCTrCH or reconfigured within the CCTrCH, or removed from the CCTrCH, the change may only be made at the start of a radio frame with CFN fulfilling the relation

$$\text{CFN} \bmod F_{\max} = 0,$$

where F_{\max} denotes the maximum number of radio frames within the transmission time intervals of all transport channels which are multiplexed into the same CCTrCH, including any transport channels i which are added reconfigured or have been removed, and CFN denotes the connection frame number of the first radio frame of the changed CCTrCH.

After addition or reconfiguration of a transport channel i within a CCTrCH, the TTI of transport channel i may only start in radio frames with CFN fulfilling the relation

$$\text{CFN}_i \bmod F_i = 0.$$

- 2) Different CCTrCHs cannot be mapped onto the same physical channel.

- 3) One CCTrCH shall be mapped onto one or several physical channels.
- 4) Dedicated Transport channels and common transport channels cannot be multiplexed into the same CCTrCH.
- 5) For the common transport channels, only the FACH and PCH may belong to the same CCTrCH.
- 6) Each CCTrCH carrying a BCH shall carry only one BCH and shall not carry any other Transport Channel.
- 7) Each CCTrCH carrying a RACH shall carry only one RACH and shall not carry any other Transport Channel.

Hence, there are two types of CCTrCH.

CCTrCH of dedicated type, corresponding to the result of coding and multiplexing of one or several DCH.

CCTrCH of common type, corresponding to the result of the coding and multiplexing of a common channel, i.e. RACH and USCH in the uplink and DSCH, BCH, FACH or PCH in the downlink, respectively.

Transmission of TFCI is possible for CCTrCH containing Transport Channels of:

- dedicated type;
- USCH type;
- DSCH type;
- FACH and/or PCH type.

4.2.14.1 Allowed CCTrCH combinations for one UE

4.2.14.1.1 Allowed CCTrCH combinations on the uplink

The following CCTrCH combinations for one UE are allowed, also simultaneously:

- 1) several CCTrCH of dedicated type;
- 2) several CCTrCH of common type.

4.2.14.1.2 Allowed CCTrCH combinations on the downlink

The following CCTrCH combinations for one UE are allowed, also simultaneously:

- 3) several CCTrCH of dedicated type;
- 4) several CCTrCH of common type.

4.2.15 Transport format detection

Transport format detection can be performed both with and without Transport Format Combination Indicator (TFCI). If a TFCI is transmitted, the receiver detects the transport format combination from the TFCI. When no TFCI is transmitted, so called blind transport format detection may be used, i.e. the receiver side uses the possible transport format combinations as a priori information.

4.2.15.1 Blind transport format detection

Blind Transport Format Detection is optional both in the UE and the UTRAN. Therefore, for all CCTrCH a TFCI shall be transmitted, including the possibility of a TFCI code word length zero, if only one TFC is defined.

4.2.15.2 Explicit transport format detection based on TFCI

4.2.15.2.1 Transport Format Combination Indicator (TFCI)

The Transport Format Combination Indicator (TFCI) informs the receiver of the transport format combination of the CCTrCHs. As soon as the TFCI is detected, the transport format combination, and hence the individual transport channels' transport formats are known, and decoding of the transport channels can be performed.

4.3 Coding for layer 1 control for the 3.84 Mcps option

4.3.1 Coding of transport format combination indicator (TFCI)

Encoding of the TFCI depends on its length. If there are 6-10 bits of TFCI the channel encoding is done as described in subclause 4.3.1.1. Also specific coding of less than 6 bits is possible as explained in subclause 4.3.1.2.

4.3.1.1 Coding of long TFCI lengths

The TFCI is encoded using a (32, 10) sub-code of the second order Reed-Muller code. The coding procedure is as shown in figure 6.

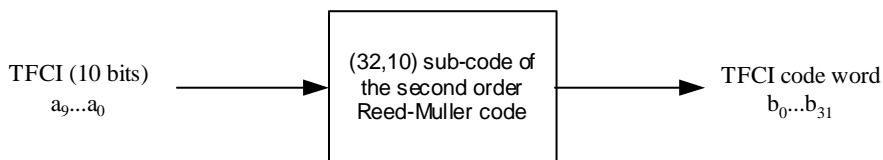


Figure 6: Channel coding of the TFCI bits

TFCI is encoded by the (32,10) sub-code of second order Reed-Muller code. The code words of the (32,10) sub-code of second order Reed-Muller code are linear combination of some among 10 basis sequences. The basis sequences are as follows in table 9.

Table 9: Basis sequences for (32,10) TFCI code

I	M _{i,0}	M _{i,1}	M _{i,2}	M _{i,3}	M _{i,4}	M _{i,5}	M _{i,6}	M _{i,7}	M _{i,8}	M _{i,9}
0	1	0	0	0	0	1	0	0	0	0
1	0	1	0	0	0	1	1	0	0	0
2	1	1	0	0	0	1	0	0	0	1
3	0	0	1	0	0	1	1	0	1	1
4	1	0	1	0	0	1	0	0	0	1
5	0	1	1	0	0	1	0	0	1	0
6	1	1	1	0	0	1	0	1	0	0
7	0	0	0	1	0	1	0	1	1	0
8	1	0	0	1	0	1	1	1	1	0
9	0	1	0	1	0	1	1	0	1	1
10	1	1	0	1	0	1	0	0	1	1
11	0	0	1	1	0	1	0	1	1	0
12	1	0	1	1	0	1	0	1	0	1
13	0	1	1	1	0	1	1	0	0	1
14	1	1	1	1	0	1	1	1	1	1
15	1	0	0	0	1	1	1	1	0	0
16	0	1	0	0	1	1	1	1	0	1
17	1	1	0	0	1	1	1	0	1	0
18	0	0	1	0	1	1	0	1	1	1
19	1	0	1	0	1	1	0	1	0	1
20	0	1	1	0	1	1	0	0	1	1
21	1	1	1	0	1	1	0	1	1	1
22	0	0	0	1	1	1	0	1	0	0
23	1	0	0	1	1	1	1	1	0	1
24	0	1	0	1	1	1	1	0	1	0
25	1	1	0	1	1	1	1	0	0	1
26	0	0	1	1	1	1	0	0	1	0
27	1	0	1	1	1	1	1	1	0	0
28	0	1	1	1	1	1	1	1	1	0
29	1	1	1	1	1	1	1	1	1	1
30	0	0	0	0	0	1	0	0	0	0
31	0	0	0	0	1	1	1	0	0	0

The TFCI bits $a_0, a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9$ (where a_0 is LSB and a_9 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output TFCI code word bits b_i are given by:

$$b_i = \sum_{n=0}^9 (a_n \times M_{i,n}) \bmod 2$$

where $i = 0, \dots, 31$. $N_{\text{TFCI code word}} = 32$.

4.3.1.2 Coding of short TFCI lengths

4.3.1.2.1 Coding very short TFCIs by repetition

If the number of TFCI bits is 1 or 2, then repetition will be used for coding. In this case each bit is repeated to a total of 4 times giving 4-bit transmission ($N_{\text{TFCI code word}}=4$) for a single TFCI bit and 8-bit transmission ($N_{\text{TFCI code word}}=8$) for 2 TFCI bits. The TFCI bit(s) b_0 (or b_0 and b_1 where b_0 is the LSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame. In the case of two TFCI bits denoted b_0 and b_1 the TFCI code word shall be $\{ b_0, b_1, b_0, b_1, b_0, b_1, b_0, b_1 \}$.

4.3.1.2.2 Coding short TFCIs using bi-orthogonal codes

If the number of TFCI bits is in the range 3 to 5 the TFCI is encoded using a (16, 5) bi-orthogonal (or first order Reed-Muller) code. The coding procedure is as shown in figure 7.

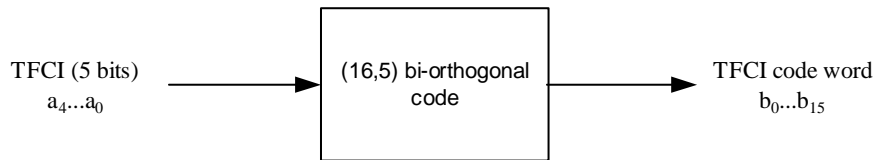


Figure 7: Channel coding of short length TFCI bits

The code words of the (16,5) bi-orthogonal code are linear combinations of 5 basis sequences as defined in table 10.

Table 10: Basis sequences for (16,5) TFCI code

i	M _{i,0}	M _{i,1}	M _{i,2}	M _{i,3}	M _{i,4}
0	1	0	0	0	1
1	0	1	0	0	1
2	1	1	0	0	1
3	0	0	1	0	1
4	1	0	1	0	1
5	0	1	1	0	1
6	1	1	1	0	1
7	0	0	0	1	1
8	1	0	0	1	1
9	0	1	0	1	1
10	1	1	0	1	1
11	0	0	1	1	1
12	1	0	1	1	1
13	0	1	1	1	1
14	1	1	1	1	1
15	0	0	0	0	1

The TFCI bits a_0, a_1, a_2, a_3, a_4 (where a_0 is LSB and a_4 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output code word bits b_j are given by:

$$b_i = \sum_{n=0}^4 (a_n \times M_{i,n}) \text{ mod } 2$$

where $i = 0, \dots, 15$. $N_{\text{TFCI code word}} = 16$.

4.3.1.3 Mapping of TFCI code word

The mapping of the TFCI code word to the TFCI bit positions in a timeslot shall be as follows.

Denote the number of bits in the TFCI code word by $N_{\text{TFCI code word}}$, denote the TFCI code word bits by b_k where $k=0 \dots N_{\text{TFCI code word}}-1$.

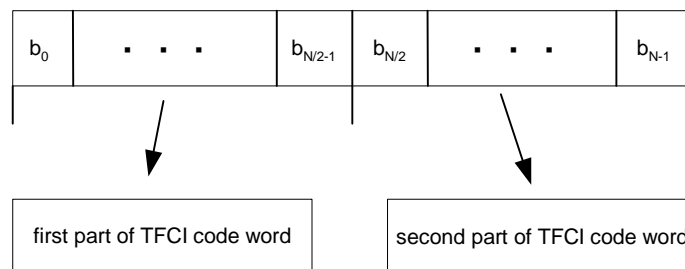


Figure 8: Mapping of TFCI code word bits to timeslot

The locations of the first and second parts of the TFCI code word in the timeslot is defined in [7].

If the shortest transmission time interval of any constituent TrCH is at least 20 ms the successive TFCI code words in the frames in the TTI shall be identical. If TFCI is transmitted on multiple timeslots in a frame each timeslot shall have the same TFCI code word.

4.3.2 Coding and Bit Scrambling of the Paging Indicator

The paging indicator P_q , $q = 0, \dots, N_{PI}-1$, $P_q \in \{0, 1\}$ is an identifier to instruct the UE whether there is a paging message for the groups of mobiles that are associated to the PI, calculated by higher layers, and the associated paging indicator P_q . The length L_{PI} of the paging indicator is $L_{PI}=2$, $L_{PI}=4$ or $L_{PI}=8$ symbols. $N_{PIB} = 2 * N_{PI} * L_{PI}$ bits are used for the paging indicator transmission in one radio frame. The mapping of the paging indicators to the bits e_i , $i = 1, \dots, N_{PIB}$ is shown in table 11.

Table 11: Mapping of the paging indicator

P_q	Bits $\{e_{2L_{PI}q+1}, e_{2L_{PI}q+2}, \dots, e_{2L_{PI}(q+1)}\}$	Meaning
0	$\{0, 0, \dots, 0\}$	There is no necessity to receive the PCH
1	$\{1, 1, \dots, 1\}$	There is the necessity to receive the PCH

If the number S of bits in one radio frame available for the PICH is bigger than the number N_{PIB} of bits used for the transmission of paging indicators, the sequence $e = \{e_1, e_2, \dots, e_{N_{PIB}}\}$ is extended by $S - N_{PIB}$ bits that are set to zero, resulting in a sequence $h = \{h_1, h_2, \dots, h_S\}$:

$$h_k = e_k, \quad k = 1, \dots, N_{PIB}$$

$$h_k = 0, \quad k = N_{PIB} + 1, \dots, S$$

The bits h_k , $k = 1, \dots, S$ on the PICH then undergo bit scrambling as defined in section 4.2.9.

The bits s_k , $k = 1, \dots, S$ output from the bit scrambler are then transmitted over the air as shown in [7].

4.4 Coding for layer 1 control for the 1.28 Mcps option

4.4.1 Coding of transport format combination indicator (TFCI) for QPSK

The coding of TFCI for 1.28Mcps TDD is same as that of 3.84Mcps TDD.cf.[4.3.1 'Coding of transport format combination indicator'].

4.4.1.1 Mapping of TFCI code word

Denote the number of bits in the TFCI code word by $N_{TFCI \text{ code word}}$ and denote the TFCI code word bits by b_k , where $k = 0, \dots, N_{TFCI \text{ code word}} - 1$

When the number of bits in the TFCI code word is 8, 16, 32, the mapping of the TFCI code word to the TFCI bit positions shall be as follows:

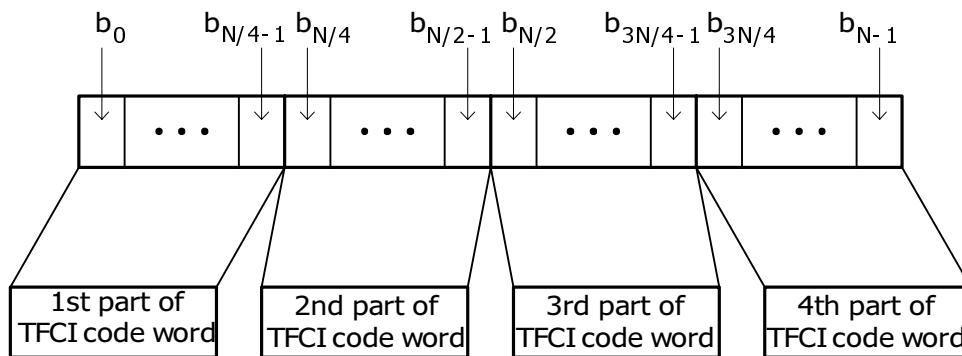


Figure 9: Mapping of TFCI code word bits to TFCI position in 1.28 Mcps TDD option, where $N = N_{\text{TFCI code word}}$

When the number of bits of the TFCI code word is 4, then the TFCI code word is equally divided into two parts for the consecutive two subframe and mapped onto the end of the first data field in each of the consecutive subframes. The mapping for $N_{\text{TFCI code word}} = 4$ is shown in figure 10:

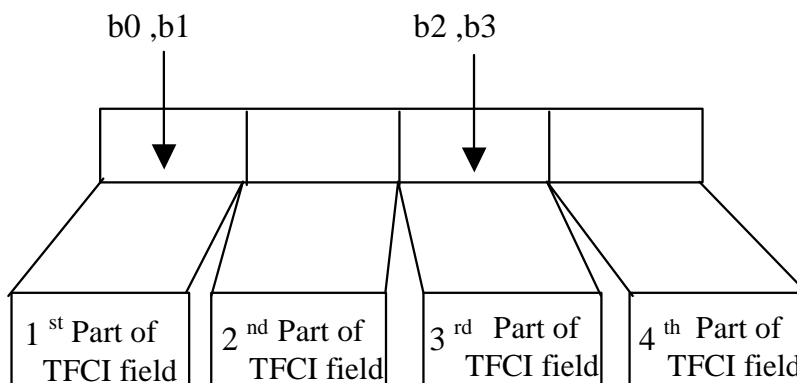


Figure 10: Mapping of TFCI code word bits to TFCI position in 1.28 Mcps TDD option, when $N_{\text{TFCI code word}} = 4$

The location of the 1st to 4th parts of the TFCI code word in the timeslot is defined in [7].

If the shortest transmission time interval of any constituent TrCH is at least 20 ms, then successive TFCI code words in the frames within the TTI shall be identical. If a TFCI is transmitted on multiple timeslots in a frame each timeslot shall have the same TFCI code word.

4.4.2 Coding of transport format combination indicator (TFCI) for 8PSK

Encoding of TFCI bits depends on the number of them and the modulation in use. When 2 Mcps service is transmitted, 8PSK modulation is applied in 1.28 Mcps TDD option. The encoding scheme for TFCI when the number of bits are 6 – 10, and less than 6 bits is described in section 4.4.2.1 and 4.4.2.2, respectively.

4.4.2.1 Coding of long TFCI lengths

When the number of TFCI bits is 6 – 10, the TFCI bits are encoded by using a (64,10) sub-code of the second order Reed-Muller code, then 16 bits out of 64 bits are punctured (Puncturing positions are 0, 4, 8, 13, 16, 20, 27, 31, 34, 38, 41, 44, 50, 54, 57, 61st bits). The coding procedure is shown in Figure 11.

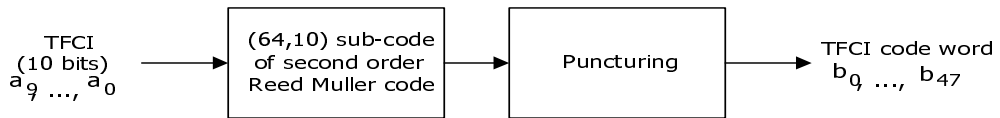


Figure 11: Channel coding of long TFCI bits for 8PSK

The code words of the punctured (48,10) sub-code of the second order Reed-Muller codes are linear combination of 10 basis sequences. The basis sequences are shown in Table 12.

Table 12: Basis sequences for (48,10) TFCI code

I	M _{i,0}	M _{i,1}	M _{i,2}	M _{i,3}	M _{i,4}	M _{i,5}	M _{i,6}	M _{i,7}	M _{i,8}	M _{i,9}
0	1	0	0	0	0	0	1	0	1	0
1	0	1	0	0	0	0	1	1	0	0
2	1	1	0	0	0	0	1	1	0	1
3	1	0	1	0	0	0	1	1	1	0
4	0	1	1	0	0	0	1	0	1	0
5	1	1	1	0	0	0	1	1	1	0
6	1	0	0	1	0	0	1	1	1	1
7	0	1	0	1	0	0	1	1	0	1
8	1	1	0	1	0	0	1	0	1	0
9	0	0	1	1	0	0	1	1	0	0
10	0	1	1	1	0	0	1	1	0	1
11	1	1	1	1	0	0	1	1	1	1
12	1	0	0	0	1	0	1	0	1	1
13	0	1	0	0	1	0	1	1	1	0
14	1	1	0	0	1	0	1	0	0	1
15	1	0	1	0	1	0	1	0	1	1
16	0	1	1	0	1	0	1	1	0	0
17	1	1	1	0	1	0	1	1	1	0
18	0	0	0	1	1	0	1	0	0	1
19	1	0	0	1	1	0	1	0	1	1
20	0	1	0	1	1	0	1	0	1	0
21	0	0	1	1	1	0	1	0	1	0
22	1	0	1	1	1	0	1	1	0	1
23	0	1	1	1	1	0	1	1	1	0
24	0	0	0	0	0	1	1	1	0	1
25	1	0	0	0	0	1	1	1	1	0
26	1	1	0	0	0	1	1	1	1	1
27	0	0	1	0	0	1	1	0	1	1
28	1	0	1	0	0	1	1	1	0	1
29	1	1	1	0	0	1	1	0	1	1
30	0	0	0	1	0	1	1	0	0	1
31	0	1	0	1	0	1	1	0	0	1
32	1	1	0	1	0	1	1	1	1	1
33	1	0	1	1	0	1	1	0	0	1
34	0	1	1	1	0	1	1	1	1	0
35	1	1	1	1	0	1	1	1	0	1
36	0	0	0	0	1	1	1	1	1	0
37	1	0	0	0	1	1	1	0	1	1
38	1	1	0	0	1	1	1	1	1	1
39	0	0	1	0	1	1	1	1	0	0
40	1	0	1	0	1	1	1	1	0	0
41	1	1	1	0	1	1	1	1	1	1
42	0	0	0	1	1	1	1	1	1	1
43	0	1	0	1	1	1	1	0	1	0
44	1	1	0	1	1	1	1	0	1	0
45	0	0	1	1	1	1	1	0	1	1
46	0	1	1	1	1	1	1	0	0	1
47	1	1	1	1	1	1	1	1	0	0

Let's define the TFCI bits as $a_0, a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9$, where a_0 is the LSB and a_9 is the MSB. The TFCI bits shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output TFCI code word bits b_i are given by:

$$b_i = \sum_{n=0}^9 (a_n \times M_{i,n}) \text{ mod } 2$$

where $i=0 \dots 47$. $N_{\text{TFCI code word}}=48$.

4.4.2.2 Coding of short TFCI lengths

4.4.2.2.1 Coding very short TFCIs by repetition

When the number of TFCI bits is 1 or 2, then repetition will be used for the coding. In this case, each bit is repeated to a total of 6 times giving 6-bit transmission ($N_{\text{TFCI code word}} = 6$) for a single TFCI bit and 12-bit transmission ($N_{\text{TFCI code word}} = 12$) for 2 TFCI bits. For a single TFCI bit b_0 , the TFCI code word shall be $\{b_0, b_0, b_0, b_0, b_0, b_0\}$. For two TFCI bits b_0 and b_1 , the TFCI code word shall be $\{b_0, b_1, b_0, b_1, b_0, b_1, b_0, b_1, b_0, b_1, b_0, b_1\}$.

4.4.2.2.2 Coding short TFCIs using bi-orthogonal codes

If the number of TFCI bits is in the range of 3 to 5, the TFCI bits are encoded using a (32,5) first order Reed-Muller code, then 8 bits out of 32 bits are punctured (Puncturing positions are 0, 1, 2, 3, 4, 5, 6, 7th bits). The coding procedure is shown in Figure 12.

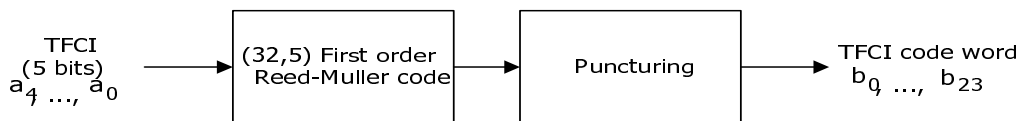


Figure 12: Channel coding of short TFCI bits for 8PSK

The code words of the punctured (32,5) first order Reed-Muller codes are linear combination of 5 basis sequences shown in Table 13.

Table 13: Basis sequences for (24,5) TFCI code

i	M_{i,0}	M_{i,1}	M_{i,2}	M_{i,3}	M_{i,4}
0	0	0	0	1	0
1	1	0	0	1	0
2	0	1	0	1	0
3	1	1	0	1	0
4	0	0	1	1	0
5	1	0	1	1	0
6	0	1	1	1	0
7	1	1	1	1	0
8	0	0	0	0	1
9	1	0	0	0	1
10	0	1	0	0	1
11	1	1	0	0	1
12	0	0	1	0	1
13	1	0	1	0	1
14	0	1	1	0	1
15	1	1	1	0	1
16	0	0	0	1	1
17	1	0	0	1	1
18	0	1	0	1	1
19	1	1	0	1	1
20	0	0	1	1	1
21	1	0	1	1	1
22	0	1	1	1	1
23	1	1	1	1	1

Let's define the TFCI bits as a_0, a_1, a_2, a_3, a_4 , where a_0 is the LSB and a_4 is the MSB. The TFCI bits shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output code word bits b_i are given by:

$$b_i = \sum_{n=0}^4 (a_n \times M_{i,n}) \text{ mod } 2$$

where $i=0 \dots 23$. $N_{\text{TFCI code word}} = 24$.

4.4.2.3 Mapping of TFCI code word

Denote the number of bits in the TFCI code word by $N_{\text{TFCI code word}}$, and denote the TFCI code word bits by b_k , where $k = 0, \dots, N_{\text{TFCI code word}} - 1$.

When the number of bits in the TFCI code word is 12, 24 or 48, the mapping of the TFCI code word to the TFCI bit positions in a time slot shall be as follows.

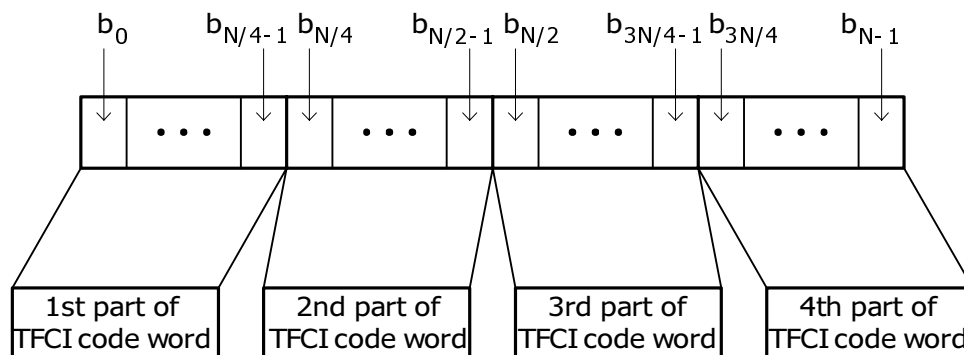


Figure 13: Mapping of TFCI code word bits to timeslot in 1.28 Mcps TDD option, where $N = N_{\text{TFCI code word}}$

When the number of bits in the TFCI code word is 6, the TFCI code word is equally divided into two parts for the consecutive two sub-frames and mapped onto the first data field in each of the consecutive sub-frames. The mapping of the TFCI code word to the TFCI bit positions in a time slot shall be as shown in figure 14.

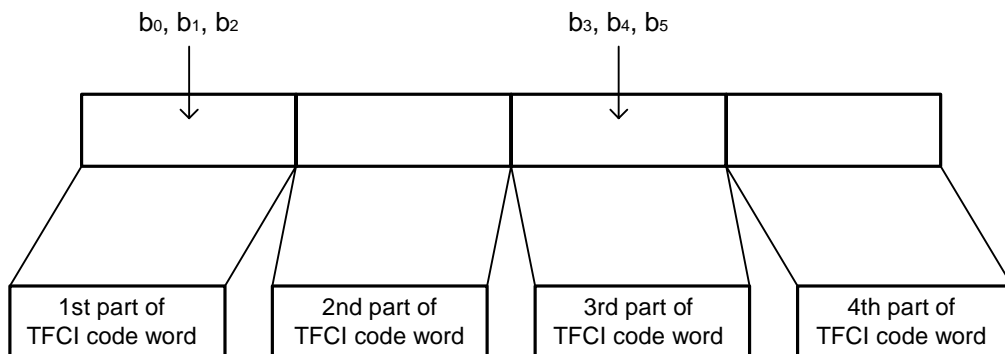


Figure 14: Mapping of TFCI code word bits to timeslot in 1.28 Mcps TDD option when $N_{\text{TFCI code word}} = 6$

The location of the 1st to 4th parts of the TFCI code word in the timeslot is defined in [7].

4.4.3 Coding and Bit Scrambling of the Paging Indicator

The paging indicator $P_q, q = 0, \dots, N_{PI}-1, P_q \in \{0, 1\}$ is an identifier to instruct the UE whether there is a paging message for the groups of mobiles that are associated to the PI, calculated by higher layers, and the associated paging indicator P_q . The length L_{PI} of the paging indicator is $L_{PI}=2, L_{PI}=4$ or $L_{PI}=8$ symbols. $N_{PIB} = 2 * N_{PI} * L_{PI}$ bits are used for the paging indicator transmission in one radio frame. The mapping of the paging indicators to the bits $e_i, i = 1, \dots, N_{PIB}$ is shown in table 14.

Table 14: Mapping of the paging indicator

P_q	Bits $\{e_{2L_{PI} * q + 1}, e_{2L_{PI} * q + 2}, \dots, e_{2L_{PI} * (q+1)}\}$	Meaning
0	$\{0, 0, \dots, 0\}$	There is no necessity to receive the PCH
1	$\{1, 1, \dots, 1\}$	There is the necessity to receive the PCH

If the number S of bits in one radio frame available for the PICH is bigger than the number N_{PIB} of bits used for the transmission of paging indicators, the sequence $e = \{e_1, e_2, \dots, e_{N_{PIB}}\}$ is extended by $S - N_{PIB}$ bits that are set to zero, resulting in a sequence $h = \{h_1, h_2, \dots, h_S\}$:

$$h_k = e_k, \quad k = 1, \dots, N_{PIB}$$

$$h_k = 0, \quad k = N_{PIB} + 1, \dots, S$$

The bits $h_k, k = 1, \dots, S$ on the PICH then undergo bit scrambling as defined in section 4.2.9.

The bits $s_k, k = 1, \dots, S$ output from the bit scrambler are then transmitted over the air as shown in [7].

4.4.4 Coding of the Fast Physical Access Channel (FPACH) information bits

The FPACH burst is composed by 32 information bits which are block coded and convolutional coded, and then delivered in one sub-frame as follows:

1. The 32 information bits are protected by 8 parity bits for error detection as described in sub-clause 4.2.1.1.
2. Convolutional code with constraint length 9 and coding rate $\frac{1}{2}$ is applied as described in sub-clause 4.2.3.1. The size of data block $c(k)$ after convolutional encoder is 96 bits.
3. To adjust the size of the data block $c(k)$ to the size of the FPACH burst, 8 bits are punctured as described in sub-clause 4.2.7 with the following clarifications:

- $N_{i,j}=96$ is the number of bits in a radio sub-frame before rate matching
- $\Delta N_{i,j} = -8$ is the number of bits to punctured in a radio sub-frame
- $e_{ini} = a \times N_{ij}$

The 88 bits after rate matching are then delivered to the intra-frame interleaving.

4. The bits in input to the interleaving unit are denoted as $\{x(0), \dots, x(87)\}$. The coded bits are block rectangular interleaved according to the following rule: the input is written row by row, the output is read column by column.

$$\begin{bmatrix} x(0) & x(1) & x(2) & \dots & x(7) \\ x(8) & x(9) & x(10) & \dots & x(15) \\ \vdots & \vdots & \vdots & \dots & \vdots \\ x(80) & x(81) & x(82) & \dots & x(87) \end{bmatrix}$$

Hence, the interleaved sequence is denoted by $y(i)$ and are given by:

$$y(0), y(1), \dots, y(87) = x(0), x(8), \dots, x(80), x(1), \dots, x(87).$$

4.5 Coding for HS-DSCH

Figure 15 illustrates the overall concept of transport-channel coding and multiplexing for HS-DSCH. Data arrives to the coding/multiplexing unit in form of one transport block once every transmission time interval. The transmission time interval is 5 ms for 1.28 Mcps TDD and 10ms for 3.84 Mcps TDD.

The following coding/multiplexing steps for HS-DSCH can be identified:

- add CRC to each transmission time interval (see subclause 4.5.1);
- code block segmentation (see subclause 4.5.2);
- channel coding (see subclause 4.5.3);
- hybrid ARQ (see subclause 4.5.4);
- bit scrambling (see subclause 4.5.5);
- physical channel segmentation (see subclause 4.5.6);
- interleaving for HS-DSCH (see subclauses 4.5.7);
- —mapping to physical channels (see subclause 4.5.8).
- constellation re-arrangement for 16QAM (see subclause 4.5.9).

The coding steps for HS-DSCH are shown in figure 15.

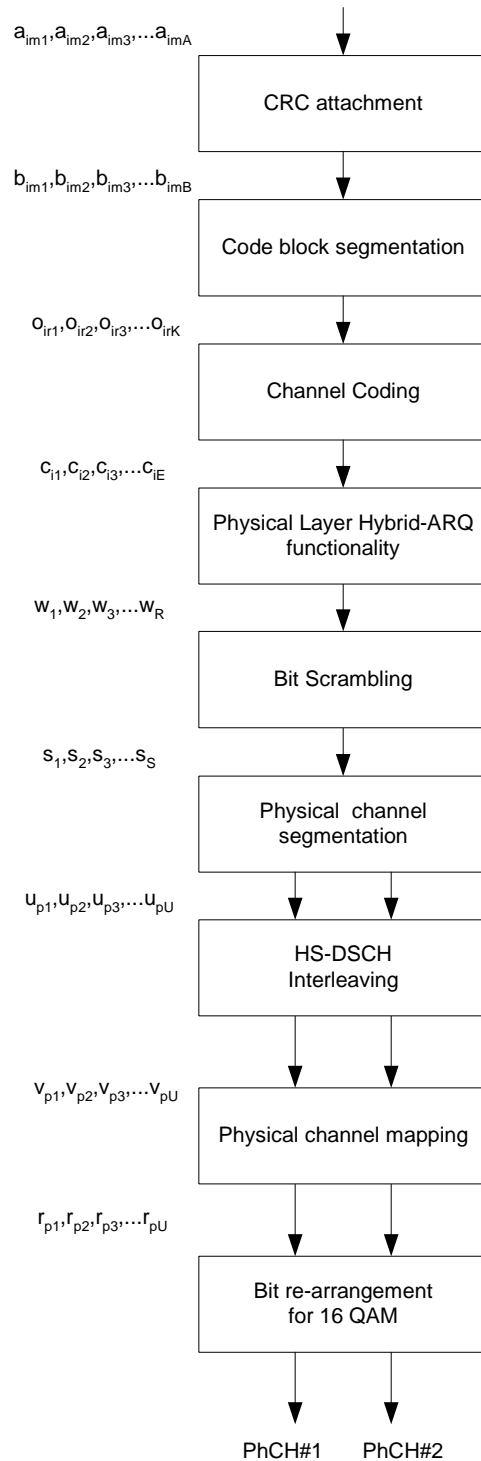


Figure 15. Transport channel multiplexing structure for HS-DSCH

In the following the number of transport blocks is always one. When referencing non HS-DSCH formulae which are used in correspondence with HS-DSCH formulae the convention is used that transport block subscripts may be omitted (e.g. X_i when i is always 1 may be written X).

4.5.1 CRC attachment for HS-DSCH

A CRC of size 24 bits is calculated and added per HS-DSCH TTI. The CRC polynomial is defined in 4.2.1.1 with the following specific parameters: $i=1$, $L_1 = 24$ bits.

4.5.2 Code block segmentation for HS-DSCH

Code block segmentation for the HS-DSCH transport channel shall be done with the general method described in 4.2.2.2 above with the following specific parameters.

There will only be one transport block, $i=1$. The bits $b_{im1}, b_{im2}, b_{im3}, \dots, b_{imB}$ input to the block are mapped to the bits $x_{i1}, x_{i2}, x_{i3}, \dots, x_{iXi}$ directly. It follows that $X_1 = B$. Note that the bits x referenced here refer only to the internals of the code block segmentation function.

The value of $Z = 5114$ for turbo coding shall be used.

4.5.3 Channel coding for HS-DSCH

Channel coding for the HS-DSCH transport channel shall be done with the general method described in 4.2.3.2 above with the following specific parameters.

There will be a maximum of one transport block, $i=1$. The rate 1/3 turbo coding shall be used.

4.5.4 Hybrid ARQ for HS-DSCH

The hybrid ARQ functionality matches the number of bits at the output of the channel coder to the total number of bits of the HS-PDSCH set to which the HS-DSCH is mapped. The hybrid ARQ functionality is controlled by the redundancy version (RV) parameters. The exact set of bits at the output of the hybrid ARQ functionality depends on the number of input bits, the number of output bits, and the RV parameters.

The hybrid ARQ functionality consists of two rate-matching stages and a buffer as shown in the figure below.

The first rate matching stage matches the number of input bits to the virtual IR buffer, information about which is provided by higher layers. Note that, if the number of input bits does not exceed the virtual IR buffering capability, the first rate-matching stage is transparent.

The second rate matching stage matches the number of bits after first rate matching stage to the number of physical channel bits available in the HS-PDSCH set in the TTI.

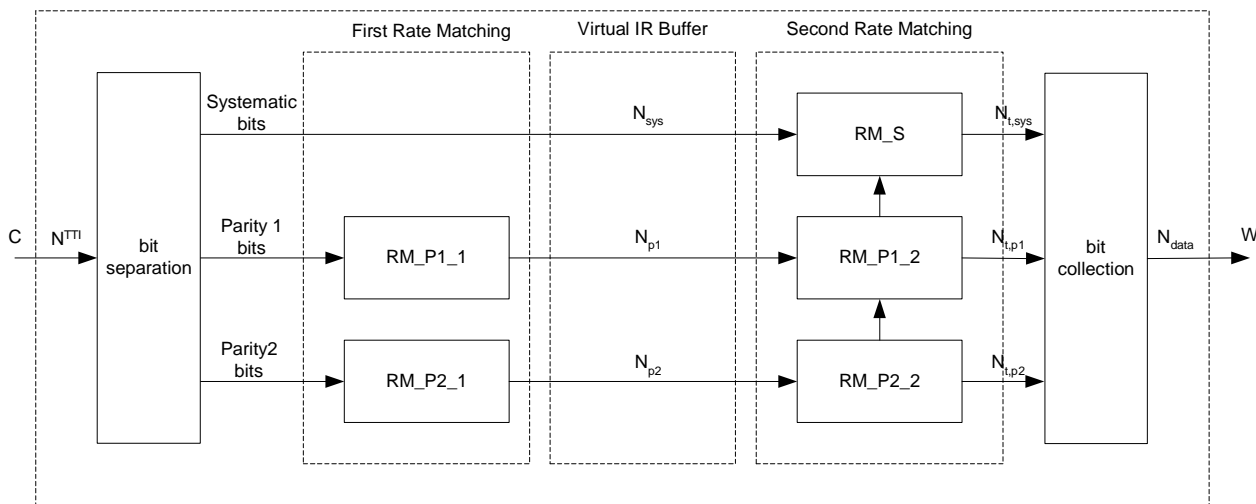


Figure 17 - HS-DSCH hybrid ARQ functionality

4.5.4.1 HARQ bit separation

The HARQ bit separation function shall be performed in the same way as bit separation for turbo encoded TrCHs in 4.2.7.2 above.

4.5.4.2 HARQ First Rate Matching Stage

HARQ first stage rate matching for the HS-DSCH transport channel shall be done with the general method described in 4.2.7.1.2 above with the following specific parameters.

The maximum number of soft bits available in the virtual IR buffer is N_{IR} which is signalled from higher layers for each HARQ process. The number of coded bits in a TTI before rate matching is N^{TTI} this is deduced from information signalled from higher layers and parameters signalled on the HS-SCCH for each TTI. Note that HARQ processing and physical layer storage occurs independently for each HARQ process currently active.

If N_{IR} is greater than or equal to N^{TTI} (i.e. all coded bits of the corresponding TTI can be stored) the first rate matching stage shall be transparent. This can, for example, be achieved by setting $e_{minus} = 0$. Note that no repetition is performed.

If N_{IR} is smaller than N^{TTI} the parity bit streams are punctured as in 4.2.7.1.2 above by setting the rate matching parameter $\Delta N_{il}^{TTI} = N_{IR} - N^{TTI}$ where the subscripts i and l refer to transport channel and transport format in the referenced sub-clause. Note the negative value is expected when the rate matching implements puncturing. Bits selected for puncturing which appear as δ in the algorithm in 4.2.7 above shall be discarded and not counted in the totals for the streams through the virtual IR buffer.

4.5.4.3 HARQ Second Rate Matching Stage

HARQ second stage rate matching for the HS-DSCH transport channel shall be done with the general method described in 4.2.7.3 above with the following specific parameters.

The parameters of the second rate matching stage depend on the value of the RV parameters s and r . The parameter s can take the value 0 or 1 to distinguish self-decodable ($s = 1$) and non self-decodable ($s = 0$) transmissions. The parameter r (range 0 to r_{max}) changes the initial error variable e_{ini} in the case of puncturing. In case of repetition both parameters r and s change the initial error variable e_{ini} . The parameters X , e_{plus} and e_{minus} are calculated as per table 10 below.

Denote the number of bits before second rate matching as N_{sys} for the systematic bits, N_{p1} for the parity 1 bits, and N_{p2} for the parity 2 bits, respectively. Denote the number of physical channels used for the CCTrCH by P . N_{data} is the number of bits available to the CCTrCH in one radio frame and defined as $N_{data} = P \times 3 \times N_{data1}$, where N_{data1} is defined in [2]. The rate matching parameters are determined as follows.

For $N_{data} \leq N_{sys} + N_{p1} + N_{p2}$, puncturing is performed in the second rate matching stage. The number of transmitted systematic bits in a retransmission is $N_{t,sys} = \min\{N_{sys}, N_{data}\}$ for a transmission of self-decodable type and $N_{t,sys} = \max\{N_{data} - (N_{p1} + N_{p2}), 0\}$ in the non self-decodable case.

For $N_{data} > N_{sys} + N_{p1} + N_{p2}$ repetition is performed in the second rate matching stage. A similar repetition rate in

all bit streams is achieved by setting the number of transmitted systematic bits to $N_{t,sys} = \left\lfloor N_{sys} \cdot \frac{N_{data}}{N_{sys} + 2N_{p2}} \right\rfloor$.

The number of parity bits in a transmission is: $N_{t,p1} = \left\lfloor \frac{N_{data} - N_{t,sys}}{2} \right\rfloor$ and $N_{t,p2} = \left\lfloor \frac{N_{data} - N_{t,sys}}{2} \right\rfloor$ for the parity 1 and parity 2 bits, respectively.

Table 10 below summarizes the resulting parameter choice for the second rate matching stage. The parameter a in the table is chosen using $a = 2$ for parity 1 and $a = 1$ for parity 2.

Table 10 - Parameters for HARQ second rate matching

	X_i	e_{plus}	e_{minus}
Systematic RM S	N_{sys}	N_{sys}	$ N_{sys} - N_{t,sys} $
Parity 1 RM P1_2	N_{p1}	$a \cdot N_{p1}$	$a \cdot N_{p1} - N_{t,p1} $
Parity 2 RM P2_2	N_{p2}	$a \cdot N_{p2}$	$a \cdot N_{p2} - N_{t,p2} $

The rate matching parameter e_{ini} is calculated for each bit stream according to the RV parameters r and s using

$$e_{ini}(r) = \left\{ \left[X_i - \left(r \cdot e_{plus} / r_{max} \right) - 1 \right] \bmod e_{plus} \right\} + 1 \text{ in the case of puncturing, i.e., } N_{data} \leq N_{sys} + N_{p1} + N_{p2},$$

and

$$e_{ini}(r) = \left\{ \left[X_i - \left((s + 2 \cdot r) \cdot e_{plus} / (2 \cdot r_{max}) \right) - 1 \right] \bmod e_{plus} \right\} + 1 \text{ for repetition, i.e., } N_{data} > N_{sys} + N_{p1} + N_{p2}.$$

Where $r \in \{0, 1, \dots, r_{max} - 1\}$ and r_{max} is the total number of redundancy versions allowed by varying r . Note that r_{max} varies depending on the modulation mode.

Note: For the modulo operation the following clarification is used: the value of $(x \bmod y)$ is strictly in the range of 0 to $y-1$ (i.e. $-1 \bmod 10 = 9$).

4.5.4.4 HARQ bit collection

The HARQ bit collection is achieved using a rectangular interleaver of size $N_{row} \times N_{col}$.

The number of rows and columns are determined from:

$$N_{row} = \log_2(M)$$

$$N_{col} = F / N_{row}$$

where M is the modulation size and F is the number of coded and rate-matched bits to be transmitted.

Data is written into the interleaver column by column, and read out of the interleaver column by column.

$N_{t,sys}$ is the number of transmitted systematic bits. Intermediate values N_r and N_c are calculated using:

$$N_r = \left\lfloor \frac{N_{t,sys}}{N_{col}} \right\rfloor \text{ and } N_c = \left(\frac{N_{t,sys}}{N_{col}} - N_r \right) \cdot N_{col}.$$

If $N_c=0$, the systematic bits are written into rows $1 \dots N_r$.

Otherwise systematic bits are written into rows $1 \dots N_r + 1$ in the first N_c columns and rows $1 \dots N_r$ in the remaining N_c columns. The remaining space is filled with parity bits. The parity bits are written column wise into the remaining rows of the respective columns. Parity 1 and 2 bits are written in alternating order.

In the case of 16QAM for each column the bits are read out of the interleaver in the order row 1, row 3, row 2, row 4. In the case of QPSK for each column the bits are read out of the interleaver in the order row1, row2.

4.5.5 Bit scrambling

The bit scrambling for HS-DSCH shall be done with the general method described in subclause 4.2.9.

4.5.6 Physical channel segmentation for HS-DSCH

When more than one HS-PDSCH is used, physical channel segmentation divides the bits among the different physical channels. The bits input to the physical channel segmentation are denoted by $w_1, w_2, w_3, \dots, w_R$, where R is the number of bits input to the physical channel segmentation block. The number of PhCHs is denoted by P .

The bits after physical channel segmentation are denoted $u_{p1}, u_{p2}, u_{p3}, \dots, u_{pU}$, where p is PhCH number and U is the

number of bits in one TTI for each HS-PDSCH, i.e. $U = \frac{R}{P}$. The relation between w_k and u_{pk} is given below.

For all modes, some bits of the input flow are mapped to each code until the number of bits on the code is U .

Bits on first PhCH after physical channel segmentation:

$$u_{1,k} = w_k \quad k = 1, 2, \dots, U$$

Bits on second PhCH after physical channel segmentation:

$$u_{2,k} = w_{k+U} \quad k = 1, 2, \dots, U$$

...

Bits on the P^{th} PhCH after physical channel segmentation:

$$u_{p,k} = w_{k+(P-1) \times U} \quad k = 1, 2, \dots, U$$

4.5.7 Interleaving for HS-DSCH

The interleaving for TDD is done as shown in figure 18 below, separately for each physical channel. The bits input to the block interleaver are denoted by $u_1, u_2, u_3, \dots, u_U$, where U is the number of bits in one TTI. For QPSK the interleaver is the same as Rel99 2nd interleaver described in Section 4.2.11.1. The interleaver is of fixed size: R2=32 rows and C2=30 columns.

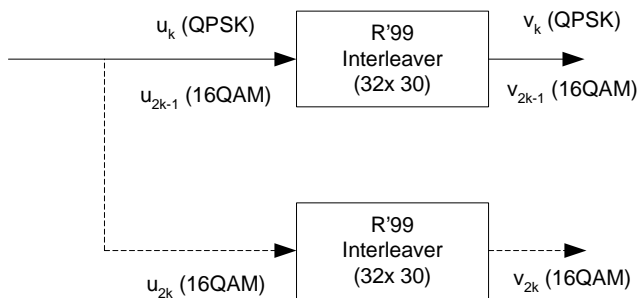


Figure 18 - Interleaver structure for HSDPA

For 16QAM, there are two identical interleavers of the same fixed size $R2 \times C2 = 32 \times 30$. The output bits from the physical channel segmentation are divided between the interleavers: all odd numbered bits to interleaver one and all even numbered bits to interleaver two.

Note: the outputs of the interleavers will result in mapping to 16QAM symbols such that the output of first interleaver is mapped to the more reliable positions (i_1 and q_1) whereas the output of the second interleaver is mapped to the less reliable positions (i_2 and q_2).

4.5.8 Physical channel mapping for HS-DSCH

The HS-PDSCH is defined in [7]. The bits input to the physical channel mapping are denoted by $v_{p1}, v_{p2}, \dots, v_{pU}$, where p is the physical channel number and U is the number of bits in one TTI for one HS-PDSCH. The bits v_{pk} are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k .

4.5.9 Constellation re-arrangement for 16 QAM

This function only applies to 16 QAM modulated bits. In case of QPSK it is transparent.

The following table describes the operations that produce the different rearrangements.

The bits of the input sequence are mapped in groups of 4 so that $v_{pk}, v_{pk+1}, v_{pk+2}, v_{pk+3}$ map to $i_a i_b q_a q_b$, where $k \bmod 4 = 0$.

Table XX – Constellation re-arrangement for 16 QAM

Constellation version parameter b	Output bit sequence	Operation
0	$i_a q_a i_b q_b$	None
1	$i_b q_b i_a q_a$	Swapping i_a with i_b and q_a with q_b
2	$i_a q_a \overline{i_b q_b}$	XOR with 0011 (equivalent to inversion of the logical values of i_b and q_b)
3	$i_b q_b \overline{i_a q_a}$	Swapping i_a with i_b and q_a with q_b and XOR with 0011

The output bit sequences from the table above map to the output bits in groups of 4, i.e. $r_{pk}, r_{pk+1}, r_{pk+2}, r_{pk+3}$, where $k \bmod 4 = 0$.

4.6 Coding/Multiplexing for HS-SCCH

The following information, provided by higher layers, is transmitted by means of the HS-SCCH physical channel.

- Channelization-code-set information (8 bits): $x_{ccs,1}, x_{ccs,2}, \dots, x_{ccs,8}$

- Time slot information (n bits where $n = 5$ for 1.28 Mcps TDD and $n = 13$ for 3.84 Mcps TDD):

$$x_{ts,1}, x_{ts,2}, \dots, x_{ts,n}$$

- Modulation scheme information (1 bit): $x_{ms,1}$

- Transport-block size information (m bits where $m = 6$ for 1.28 Mcps TDD and $m = 9$ for 3.84 Mcps TDD):

$$x_{tbs,1}, x_{tbs,2}, \dots, x_{tbs,m}$$

- Hybrid-ARQ process information (3 bits): $x_{hap,1}, x_{hap,2}, x_{hap,3}$

- Redundancy version information (3 bits): $x_{rv,1}, x_{rv,2}, x_{rv,3}$

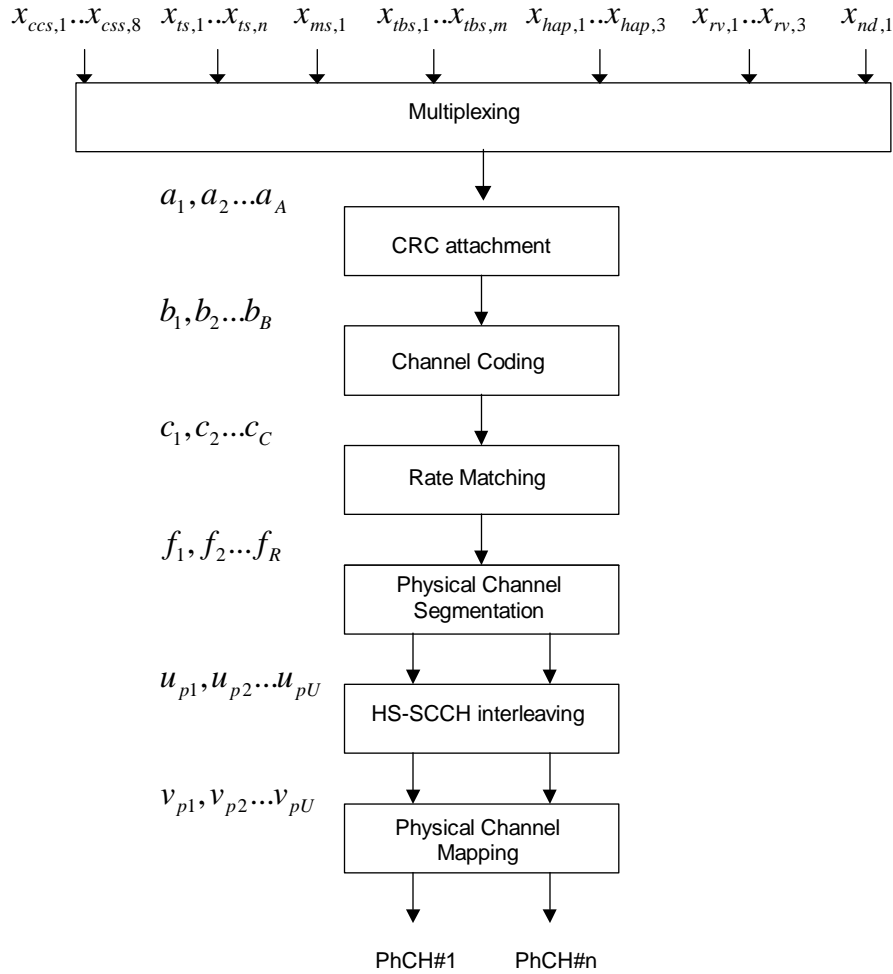
- New data indicator (1 bit): $x_{nd,1}$

- UE identity (10 bits) $x_{ue,1}, x_{ue,2}, \dots, x_{ue,10}$

The following coding/multiplexing steps can be identified:

- multiplexing of HS-SCCH information (see subclause 4.6.1)
- CRC attachment (see subclause 4.6.2);
- channel coding (see subclause 4.6.3);
- rate matching (see subclause 4.6.4);
- interleaving for HS-SCCH (see subclause 4.6.5);
- mapping to physical channels (see subclause 4.6.6).

The general coding/multiplexing flow is shown in the figure below.



4.6.1 Multiplexing of HS-SCCH information

The information carried on the HS-SCCH is multiplexed onto the bits a_1, a_2, \dots, a_A according to the following rule :

$$a_1, a_2 \dots a_8 = x_{css,1}, x_{css,2} \dots x_{css,8}$$

$$a_9, a_{10} \dots a_{9+n-1} = x_{ts,1}, x_{ts,2} \dots x_{ts,n}$$

$$a_{9+n} = x_{ms,1}$$

$$a_{9+n+1}, a_{9+n+2} \dots a_{9+n+m} = x_{tbs,1}, x_{tbs,2} \dots x_{tbs,m}$$

$$a_{10+n+m}, a_{11+n+m}, a_{12+n+m} = x_{hap,1}, x_{hap,2}, x_{hap,3}$$

$$a_{13+n+m}, a_{14+n+m}, a_{15+n+m} = x_{rv,1}, x_{rv,2}, x_{rv,3}$$

$$a_{16+n+m} = x_{nd,1}$$

4.6.2 CRC attachment for HS-SCCH

The bits b_1, \dots, b_B are generated by adding the computed CRC of length 16 as described in the general section 4.2.1.1, and then scrambling the computed CRC by the modulo 2 addition of an extended UE identifier. The MSBs of the UE identifier shall be extended to 16 bits by zero padding.

4.6.3 Channel coding for HS-SCCH

Channel coding for the HS-SCCH shall be done with the general method described in 4.2.3 with the following specific parameters:

The rate 1/3 convolutional coding shall be used for HS-SCCH.

4.6.4 Rate matching for HS-SCCH

Rate matching for HS-SCCH shall be done with the general method described in 4.2.7.

4.6.5 Physical Channel Segmentation for HS-SCCH

Physical Channel Segmentation for HS-SCCH shall be done with the general method described in 4.2.10. For 1.28 Mcps TDD, the HS-SCCH consists of two physical channels HS-SCCH1 and HS-SCCH2; for 3.84 Mcps TDD the HS-SCCH only uses one physical channel, see [7].

4.6.6 Interleaving for HS-SCCH

Interleaving for HS-SCCH shall be done with the general method described in 4.2.11.1.

4.6.7 Physical channel mapping for HS-SCCH

Physical channel mapping for the HS-SCCH shall be done with the general method described in subclause 4.2.13.

4.7 Coding for HS-SICH

The following information, provided by higher layers, is transmitted by means of the HS-SICH physical channel.

- Recommended Modulation Format (RMF) (1 bit): $x_{rmf,1}$
- Recommended Transport-block size (RTBS) (n bits where n = 6 for 1.28 Mcps TDD and n = 9 for 3.84 Mcps TDD):
 $x_{tbs,1}, x_{tbs,2}, \dots, x_{tbs,n}$
- Hybrid-ARQ information ACK/NACK (1 bit): $x_{an,1}$

The following coding/multiplexing steps can be identified:

- separate coding of RMF, RTBS and ACK/NACK (see subclause 4.7.1);
- multiplexing of HS-SICH information (4.7.2)
- interleaving for HS-SICH (see subclause 4.7.3);
- mapping to physical channels (see subclause 4.7.4).

The general coding/multiplexing flow is shown in the figure 18.

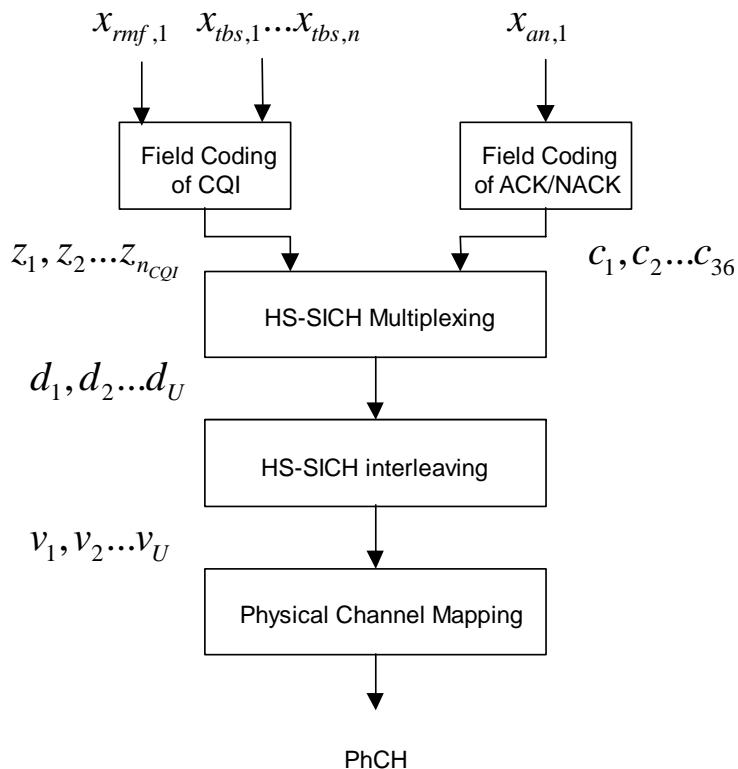


Figure 18 - Coding and multiplexing for HS-SICH

4.7.1 Coding for HS-SICH

4.7.1.1 Field Coding of ACK/NACK

The ACK/NACK field of the HS-SICH is repetition coded to 36 bits. The coded bits are defined as $c_1 \dots c_{36}$

4.7.1.2 Field Coding of CQI

4.7.1.2.1 Field Coding of CQI for 1.28 Mcps TDD

The quality information consists of Recommended Transport Block Size (RTBS) and Recommended Modulation Format (RMF) fields. The 6 bits of the RTBS field are coded to 32 bits using a (32, 6) 1st order Reed-Muller code. The coding procedure is as shown in figure 19.

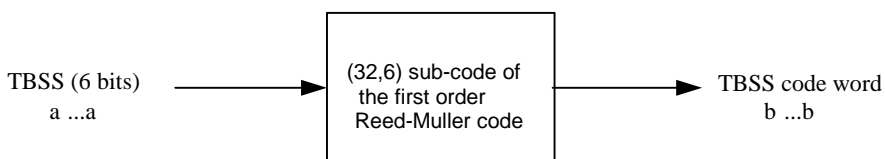


Figure 19 Field coding of RTBS information bits

The coding uses a subset basis sequences as the TFCI coder as described in subclause 4.3.1.1. The basis sequences that are used for RTBS coding are as follows in table 16.

Table 16: Basis sequences for (32,6) RTBS code

I	M _{i,0}	M _{i,1}	M _{i,2}	M _{i,3}	M _{i,4}	M _{i,5}
0	1	0	0	0	0	1
1	0	1	0	0	0	1
2	1	1	0	0	0	1
3	0	0	1	0	0	1
4	1	0	1	0	0	1
5	0	1	1	0	0	1
6	1	1	1	0	0	1
7	0	0	0	1	0	1
8	1	0	0	1	0	1
9	0	1	0	1	0	1
10	1	1	0	1	0	1
11	0	0	1	1	0	1
12	1	0	1	1	0	1
13	0	1	1	1	0	1
14	1	1	1	1	0	1
15	1	0	0	0	1	1
16	0	1	0	0	1	1
17	1	1	0	0	1	1
18	0	0	1	0	1	1
19	1	0	1	0	1	1
20	0	1	1	0	1	1
21	1	1	1	0	1	1
22	0	0	0	1	1	1
23	1	0	0	1	1	1
24	0	1	0	1	1	1
25	1	1	0	1	1	1
26	0	0	1	1	1	1
27	1	0	1	1	1	1
28	0	1	1	1	1	1
29	1	1	1	1	1	1
30	0	0	0	0	0	1
31	0	0	0	0	1	1

The output RTBS code word bits b_i are given by:

$$b_i = \sum_{j=0}^5 (a_j \times M_{i,j}) \text{ mod } 2$$

where $i = 0, \dots, 31$. $N_{\text{RTBS code word}} = 32$.

The 1 bit of the RMF is repetition coded to 16 bits to produce the bits $b_{32}, b_{33} \dots b_{47}$.

The CQI is composed of the bits $z_1, z_2 \dots z_{n_{\text{CQI}}}$ where :

$$z_1, z_2 \dots z_{n_{\text{CQI}}} = b_0, b_1 \dots b_{47}$$

4.7.1.2.2 Field Coding of CQI for 3.84 Mcps TDD

RTBS and RMF bits are multiplexed onto the bits $y_1, y_2 \dots y_{10}$ according to the following rule :

$$y_1 = x_{\text{rmf},1}$$

$$y_2, y_3 \dots y_{10} = x_{\text{tbs},1}, x_{\text{tbs},2} \dots x_{\text{tbs},9}$$

The bits $y_1, y_2 \dots y_{10}$ are coded to produce the CQI bits $z_1, z_2 \dots z_{n_{CQI}}$ using a (32,10) sub-code of the second order Reed-Muller code as defined in subclause 4.3.1.1, where $n_{CQI} = 32$.

4.7.2 Multiplexing of HS-SICH information fields

The CQI bits $z_1, z_2 \dots z_{n_{CQI}}$ are multiplexed with the repetition coded ACK/NACK bits $c_1 \dots c_{36}$ to produce the bits $d_1, d_2 \dots d_U$ where U is the number of physical channel bits carried by HS-SICH, according to the following rule:

$$d_1, d_2 \dots d_{n_{CQI}} = z_1, z_2 \dots z_{n_{CQI}}$$

$$d_{n_{CQI}+1}, d_{n_{CQI}+2} \dots d_{n_{CQI}+36} = c_1, c_2 \dots c_{36}$$

$$d_{n_{CQI}+37}, d_{n_{CQI}+38} \dots d_U = 0, 0 \dots 0$$

5.1.4.1.3.2 Interleaver for HS-SICH

Interleaver for HS-SICH shall be done with the general method described in 4.2.11.1.

5.4.1.3.3 Physical channel mapping for HS-SICH

Physical channel mapping for HS-SICH shall be done with the general method described in 4.2.13.

Annex A (informative):
Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
14/01/00	RAN_05	RAN_05	-		Approved at TSG RAN #5 and placed under Change Control	-	3.0.0
14/01/00	RAN_06	RP-99694	001	3	Correction of rate matching parameters for repetition after 1st Interleaving in 25.222	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	002	1	Clarification of bit separation and collection	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	003	-	Changing the initial offset value for convolutional code rate matching	3.0.0	3.1.0
14/01/00	RAN_06	RP-99693	004	1	Editorial corrections to TS 25.222	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	007	-	Update of rate matching rule for TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	009	1	Modified physical channel mapping scheme	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	013	-	Introduction of TFCI for S-CCPCH in TDD mode	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	015	-	TFCI coding and mapping in TDD	3.0.0	3.1.0
14/01/00	-	-	-	-	Change history was added by the editor	3.1.0	3.1.1
31/03/00	RAN_07	RP-000068	017	-	Corrections to TS 25.222	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	018	-	Refinements of Physical Channel Mapping	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	019	1	TFCI coding specification in TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	021	-	Modification of Turbo code internal interleaver	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	023	-	Update of TS 25.222 - clarification of BTFD for TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	025	-	Change of TFCI basis for TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	026	-	Padding Function for Turbo coding of small blocks	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	027	-	Editorial modification of shifting parameter calculation for turbo code puncturing	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	029	1	Editorial changes of channel coding section	3.1.1	3.2.0
26/06/00	RAN_08	RP-000272	030	-	Parity bit attachment to 0 size transport block	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	031	-	Correction of the mapping formula	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	034	-	Alignment of Multiplexing for TDD	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	036	2	Bit separation of the Turbo encoded data	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	038	2	Revision of code block segmentation description	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	039	-	Editorial corrections in channel coding section	3.2.0	3.3.0
23/09/00	RAN_09	RP-000345	040	1	Update of TS 25.222	3.3.0	3.4.0
23/09/00	RAN_09	RP-000345	041	1	Editorial corrections in Turbo code internal interleaver section	3.3.0	3.4.0
23/09/00	RAN_09	RP-000345	042	-	Paging Indicator Terminology	3.3.0	3.4.0
23/09/00	RAN_09	RP-000345	043	1	Bit separation and collection for rate matching	3.3.0	3.4.0
23/09/00	RAN_09	RP-000345	048	-	Puncturing Limit definition in WG1 specification	3.3.0	3.4.0
15/12/00	RAN_10	RP-000543	049	-	Clarification on the Ci formula	3.4.0	3.5.0
15/12/00	RAN_10	RP-000543	050	-	Correction on TFCI & TPC Transmission	3.4.0	3.5.0
15/12/00	RAN_10	RP-000543	053	1	Editorial corrections in TS 25.222	3.4.0	3.5.0
16/03/01	RAN_11	-	-	-	Approved as Release 4 specification (v4.0.0) at TSG RAN #11	3.5.0	4.0.0
16/03/01	RAN_11	RP-010063	051	1	Bit Scrambling for TDD	3.5.0	4.0.0
16/03/01	RAN_11	RP-010063	054	1	Corrections & Clarifications for TS25.222	3.5.0	4.0.0
16/03/01	RAN_11	RP-010071	055	1	Inclusion of 1.28Mcps TDD in TS 25.222	3.5.0	4.0.0
21/09/01	RAN_13	RP-010523	057	-	TFCI Terminology	4.0.0	4.1.0
21/09/01	RAN_13	RP-010529	058	-	5ms TTI for PRACH for 1.28 Mcps TDD	4.0.0	4.1.0
21/09/01	RAN_13	RP-010529	060	-	A correction on the meaning of FPACH in TS 25.222	4.0.0	4.1.0
14/12/01	RAN_14	RP-010747	059	-	Bit Scrambling for TDD	4.1.0	4.2.0
14/12/01	RAN_14	RP-010747	061	-	Corrections in clause 4.1 and 4.2 of TS 25.222	4.1.0	4.2.0

CHANGE REQUEST

⌘ **25.223 CR 026** ⌘ rev **1** ⌘ Current version: **4.3.0** ⌘
Spec Title: Spreading and modulation (TDD) ⌘

For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.

Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ CR to include HSDPA in TS25.223		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ HSDPA-Phys	Date:	⌘ 22-01-2002
Category:	⌘ B	Release:	⌘ REL-5
	<i>Use one of the following categories:</i> F (correction) A (corresponds to a correction in an earlier release) B (addition of feature), C (functional modification of feature) D (editorial modification) Detailed explanations of the above categories can be found in 3GPP TR 21.900.		<i>Use one of the following releases:</i> 2 (GSM Phase 2) R96 (Release 1996) R97 (Release 1997) R98 (Release 1998) R99 (Release 1999) REL-4 (Release 4) REL-5 (Release 5)

Reason for change:	⌘ To add the HSDPA functionality in the specification		
Summary of change:	⌘ <ol style="list-style-type: none"> 1. Acromym list is updated. 2. Add the new 16QAM mapping for 3.84Mcps TDD. 3. Add the new 16QAM mapping for 1.28Mcps TDD. 		
Consequences if not approved:	⌘ HSDPA will not be part of REL-5		

Clauses affected:	⌘ 3.2,4,5.2.1,5.2.2,6.2.3.		
Other specs affected:	⌘ <input checked="" type="checkbox"/> Other core specifications <input type="checkbox"/> Test specifications <input type="checkbox"/> O&M Specifications	⌘ TS25.224	
Other comments:	⌘		

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3GPP TS 25.223 V4.3.05.0.0 (20042-123)

Technical Specification

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Spreading and modulation (TDD) (Release 45)



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Keywords

UMTS, radio, modulation

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Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

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1 Scope

The present document describes spreading and modulation for UTRA Physical Layer TDD mode.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- | | |
|------|---|
| [1] | 3GPP TS 25.201: "Physical layer - general description". |
| [2] | 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)". |
| [3] | 3GPP TS 25.212: "Multiplexing and channel coding (FDD)". |
| [4] | 3GPP TS 25.213: "Spreading and modulation (FDD)". |
| [5] | 3GPP TS 25.214: "Physical layer procedures (FDD)". |
| [6] | 3GPP TS 25.215: "Physical layer – Measurements (FDD)". |
| [7] | 3GPP TS 25.221: "Physical channels and mapping of transport channels onto physical channels (TDD)". |
| [8] | 3GPP TS 25.222: "Multiplexing and channel coding (TDD)". |
| [9] | 3GPP TS 25.102: "UTRA (UE) TDD; Radio Transmission and Reception". |
| [10] | 3GPP TS 25.105: "UTRA (BS) TDD; Radio Transmission and Reception". |
| [11] | 3GPP TS25.308: High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2 |
-

3 Symbols and abbreviations

3.1 Symbols

For the purposes of the present document, the following symbols apply:

C_p :	PSC
C_i :	i :th secondary SCH code
$C_{CSC, m}^{(k)}$:	CSC derived as k :th offset version from m :th applicable constituent Golay complementary pair

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

16QAM	16 Quadrature Amplitude Modulation
CCTrCH	Coded Composite Transport Channel

DPCH	Dedicated Physical Channel
CDMA	Code Division Multiple Access
CSC	Cell Synchronisation Code
FDD	Frequency Division Duplex
MIB	Master Information Block
OVSF	Orthogonal Variable Spreading Factor
P-CCPCH	Primary Common Control Physical Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
PN	Pseudo Noise
PRACH	Physical Random Access Channel
PSC	Primary Synchronisation Code
QPSK	Quadrature Phase Shift Keying
RACH	Random Access Channel
SCH	Synchronisation Channel
SF	Spreading Factor
SFN	System Frame Number
TDD	Time Division Duplex
TFC	Transport Format Combination
UE	User Equipment
UL	Uplink

4 General

In the following, a separation between the data modulation and the spreading modulation has been made. The data modulation for 3.84Mcps TDD is defined in clause 5 'Data modulation for the 3.84 Mcps option', the data modulation for 1.28Mcps TDD is defined in clause 6 'Data modulation for the 1.28 Mcps option' and the spreading modulation in clause 7 'Spreading modulation'.

Table 1: Basic modulation parameters

Chip rate	same as FDD basic chiprate: 3.84 Mchip/s	Low chiprate: 1.28 Mchip/s
Data modulation	QPSK,16QAM (HS-PDSCH only)	QPSK, 8PSK,16QAM (HS-PDSCH only)
Spreading characteristics	Orthogonal Q chips/symbol, where $Q = 2^p$, $0 \leq p \leq 4$	Orthogonal Q chips/symbol, where $Q = 2^p$, $0 \leq p \leq 4$

5 Data modulation for the 3.84 Mcps option

5.1 Symbol rate

The symbol duration T_s depends on the spreading factor Q and the chip duration T_c : $T_s = Q \times T_c$, where $T_c = \frac{1}{\text{chiprate}}$.

5.2 Mapping of bits onto signal point constellation

5.2.1 QPSK modulation

5.2.1.1 Mapping for burst type 1 and 2

~~5.2.1 Mapping for burst type 1 and 2~~

The data modulation is performed to the bits from the output of the physical channel mapping procedure in [8] and combines always 2 consecutive binary bits to a complex valued data symbol. Each user burst has two data carrying parts, termed data blocks:

$$\underline{\mathbf{d}}^{(k,i)} = \left(\underline{d}_1^{(k,i)}, \underline{d}_2^{(k,i)}, \dots, \underline{d}_{N_k}^{(k,i)} \right)^T, \quad i = 1, 2; k = 1, \dots, K_{Code} \quad (1)$$

K_{Code} is the number of used codes in a time slot, $\max K_{Code} = 16$. N_k is the number of symbols per data field for the code k . This number is linked to the spreading factor Q_k as described in table 1 of [7].

Data block $\underline{\mathbf{d}}^{(k,1)}$ is transmitted before the midamble and data block $\underline{\mathbf{d}}^{(k,2)}$ after the midamble. Each of the N_k data symbols $\underline{d}_n^{(k,i)}$; $i=1, 2$; $k=1, \dots, K_{Code}$; $n=1, \dots, N_k$; of equation 1 has the symbol duration $T_s^{(k)} = Q_k \cdot T_c$ as already given.

The data modulation is QPSK, thus the data symbols $\underline{d}_n^{(k,i)}$ are generated from two consecutive data bits from the output of the physical channel mapping procedure in [8]:

$$b_{l,n}^{(k,i)} \in \{0,1\}, \quad l = 1, 2; k = 1, \dots, K_{Code}; n = 1, \dots, N_k; i = 1, 2 \quad (2)$$

using the following mapping to complex symbols:

consecutive binary bit pattern	complex symbol
$\begin{matrix} (k,i) & (k,i) \\ l,n & 2n \end{matrix}$	$\underline{d}_n^{(k,i)}$
00	+j
01	+1
10	-1
11	-j

The mapping corresponds to a QPSK modulation of the interleaved and encoded data bits $b_{l,n}^{(k,i)}$ of equation 2.

5.2.1.2 Mapping for burst type 3

~~5.2.2 Mapping for burst type 3~~

In case of burst type 3, the definitions in subclause 5.2.1 apply with a modified number of symbols in the second data block. For the burst type 3, the number of symbols in the second data block $\underline{\mathbf{d}}^{(k,2)}$ is decreased by $\frac{96}{Q_k}$ symbols.

5.2.2 16QAM modulation

5.2.2.1 Mapping for burst type 1 and 2

The data modulation is performed to the bits from the output of the physical channel mapping procedure. In case of 16QAM, modulation 4 consecutive binary bits are represented by one complex valued data symbol. Each user burst has two data carrying parts, termed data blocks:

$$\underline{\mathbf{d}}^{(k,i)} = (d_1^{(k,i)}, d_2^{(k,i)}, \dots, d_{N_k}^{(k,i)})^T \quad i = 1, 2; k = 1, \dots, K. \quad (1)$$

N_k is the number of symbols per data field for the user k . This number is linked to the spreading factor Q_k .

Data block $\underline{\mathbf{d}}^{(k,1)}$ is transmitted before the midamble and data block $\underline{\mathbf{d}}^{(k,2)}$ after the midamble. Each of the N_k data symbols $d_n^{(k,i)}$; $i=1, 2$; $k=1, \dots, K$; $n=1, \dots, N_k$; of equation 3 has the symbol duration $T_s^{(k)} = Q_k T_c$ as already given.

The data modulation is 16QAM, thus the data symbols $d_n^{(k,i)}$ are generated from 4 consecutive data bits from the output of the physical channel mapping procedure in [8]:

using the following mapping to complex symbols:

Consecutive binary bit pattern $\begin{matrix} (k,i) & (k,i) & (k,i) & (k,i) \\ l,n & 2,n & 3,n & 4,n \end{matrix}$	complex symbol $d_n^{(k,i)} \cdot e^{j\pi/4}$
0000	$\sqrt{1/10} + j\sqrt{1/10}$
0001	$\sqrt{1/10} + j\sqrt{9/10}$
0010	$\sqrt{9/10} + j\sqrt{1/10}$
0011	$\sqrt{9/10} + j\sqrt{9/10}$
0100	$\sqrt{1/10} - j\sqrt{1/10}$
0101	$\sqrt{1/10} - j\sqrt{9/10}$
0110	$\sqrt{9/10} - j\sqrt{1/10}$
0111	$\sqrt{9/10} - j\sqrt{9/10}$
1000	$-\sqrt{1/10} + j\sqrt{1/10}$
1001	$-\sqrt{1/10} + j\sqrt{9/10}$
1010	$-\sqrt{9/10} + j\sqrt{1/10}$
1011	$-\sqrt{9/10} + j\sqrt{9/10}$
1100	$-\sqrt{1/10} - j\sqrt{1/10}$
1101	$-\sqrt{1/10} - j\sqrt{9/10}$
1110	$-\sqrt{9/10} - j\sqrt{1/10}$
1111	$-\sqrt{9/10} - j\sqrt{9/10}$

The mapping corresponds to a 16QAM modulation of the interleaved and encoded data bits $b_{l,n}^{(k,i)}$ of the table above and $d_n^{(k,i)}$ of equation 3.

6 Data modulation for the 1.28 Mcps option

6.1 Symbol rate

The symbol duration T_s depends on the spreading factor Q and the chip duration T_c : $T_s = Q \times T_c$, where $T_c = \frac{1}{\text{chiprate}}$.

6.2 Mapping of bits onto signal point constellation

6.2.1 QPSK modulation

The mapping of bits onto the signal point constellation for QPSK modulation is the same as in the 3.84Mcps TDD cf. [5.2.1 Mapping for burst type 1 and 2].

6.2.2 8PSK modulation

The data modulation is performed to the bits from the output of the physical channel mapping procedure. In case of 8PSK modulation 3 consecutive binary bits are represented by one complex valued data symbol. Each user burst has two data carrying parts, termed data blocks:

$$\underline{\mathbf{d}}^{(k,i)} = \left(\underline{d}_1^{(k,i)}, \underline{d}_2^{(k,i)}, \dots, \underline{d}_{N_k}^{(k,i)} \right)^T, \quad i = 1, 2; k = 1, \dots, K_{Code} \quad (1a)$$

N_k is the number of symbols per data field for the code k . This number is linked to the spreading factor Q_k .

Data block $\underline{\mathbf{d}}^{(k,1)}$ is transmitted before the midamble and data block $\underline{\mathbf{d}}^{(k,2)}$ after the midamble. Each of the N_k data symbols $\underline{d}_n^{(k,i)}$; $i = 1, 2$; $k = 1, \dots, K_{Code}$; $n = 1, \dots, N_k$; of equation 1 has the symbol duration $T_s^{(k)} = Q_k \cdot T_c$ as already given.

The data modulation is 8PSK, thus the data symbols $\underline{d}_n^{(k,i)}$ are generated from 3 consecutive data bits from the output of the physical channel mapping procedure in [8]:

$$b_{l,n}^{(k,i)} \in \{0,1\} \quad l = 1, 2, 3; k = 1, \dots, K_{Code}; n = 1, \dots, N_k; i = 1, 2 \quad (2a)$$

using the following mapping to complex symbols:

Consecutive binary bit pattern			complex symbol
$b_{1n}^{(k,i)}$	$b_{2n}^{(k,i)}$	$b_{3n}^{(k,i)}$	$\underline{d}_n^{(k,i)}$
0	0	0	$\cos(11\pi/8) + j\sin(11\pi/8)$
0	0	1	$\cos(9\pi/8) + j\sin(9\pi/8)$
0	1	0	$\cos(5\pi/8) + j\sin(5\pi/8)$
0	1	1	$\cos(7\pi/8) + j\sin(7\pi/8)$
1	0	0	$\cos(13\pi/8) + j\sin(13\pi/8)$
1	0	1	$\cos(15\pi/8) + j\sin(15\pi/8)$
1	1	0	$\cos(3\pi/8) + j\sin(3\pi/8)$
1	1	1	$\cos(\pi/8) + j\sin(\pi/8)$

The mapping corresponds to a 8PSK modulation of the interleaved and encoded data bits $b_{l,n}^{(k,i)}$ of the table above and $\underline{d}_n^{(k,i)}$ of equation 1a.

6.2.3 16QAM modulation

The mapping of bits onto the signal point constellation for 16QAM modulation is the same as in the 3.84Mcps TDD cf. [5.2.2.1 16QAM modulation].

7 Spreading modulation

7.1 Basic spreading parameters

Spreading of data consists of two operations: Channelisation and Scrambling. Firstly, each complex valued data symbol $d_n^{(k,i)}$ of equation 1 is spread with a real valued channelisation code $c^{(k)}$ of length $Q_k \in \{1, 2, 4, 8, 16\}$. The resulting sequence is then scrambled by a complex sequence \underline{v} of length 16.

7.2 Channelisation codes

The elements $c_q^{(k)}$; $k=1, \dots, K_{Code}$; $q=1, \dots, Q_k$; of the real valued channelisation codes

$$c^{(k)} = (c_1^{(k)}, c_2^{(k)}, \dots, c_{Q_k}^{(k)}) ; k=1, \dots, K_{Code};$$

shall be taken from the set

$$V_c = \{1, -1\} \tag{3}$$

The $c_{Q_k}^{(k)}$ are Orthogonal Variable Spreading Factor (OVSF) codes, allowing to mix in the same timeslot channels with different spreading factors while preserving the orthogonality. The OVSF codes can be defined using the code tree of figure 1.

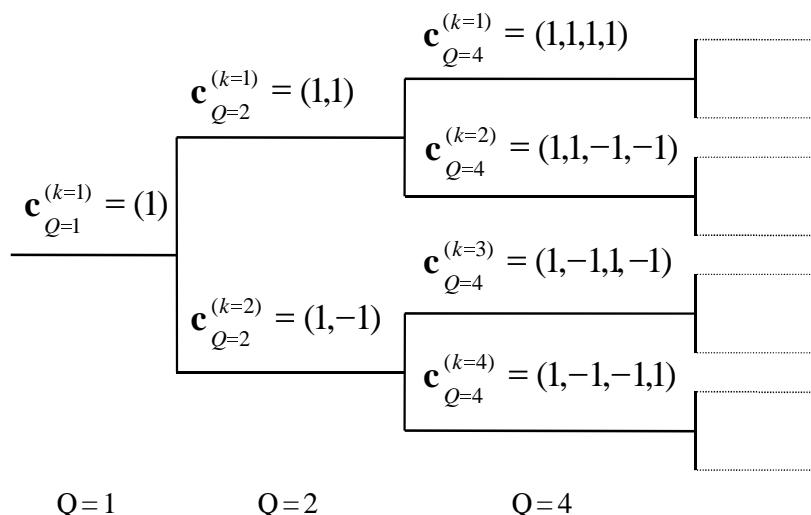


Figure 1: Code-tree for generation of Orthogonal Variable Spreading Factor (OVSF) codes for Channelisation Operation

Each level in the code tree defines a spreading factor indicated by the value of Q in the figure. All codes within the code tree cannot be used simultaneously in a given timeslot. A code can be used in a timeslot if and only if no other code on the path from the specific code to the root of the tree or in the sub-tree below the specific code is used in this timeslot. This means that the number of available codes in a slot is not fixed but depends on the rate and spreading factor of each physical channel.

The spreading factor goes up to $Q_{MAX}=16$.

7.3 Channelisation Code Specific Multiplier

Associated with each channelisation code is a multiplier $w_{Q_k}^{(k)}$ taking values from the set $\{e^{j\pi/2 \cdot p_k}\}$, where p_k is a permutation of the integer set $\{0, \dots, Q_k - 1\}$ and Q_k denotes the spreading factor. The multiplier is applied to the data sequence modulating each channelisation code. The values of the multiplier for each channelisation code are given in the table below:

k	$w_{Q=1}^{(k)}$	$w_{Q=2}^{(k)}$	$w_{Q=4}^{(k)}$	$w_{Q=8}^{(k)}$	$w_{Q=16}^{(k)}$
1	1	1	-j	1	-1
2		+j	1	+j	-j
3			+j	+j	1
4			-1	-1	1
5				-j	+j
6				-1	-1
7				-j	-1
8				1	1
9					-j
10					+j
11					1
12					+j
13					-j
14					-j
15					+j
16					-1

7.4 Scrambling codes

The spreading of data by a real valued channelisation code $\mathbf{c}^{(k)}$ of length Q_k is followed by a cell specific complex scrambling sequence $\underline{\mathbf{v}} = (\underline{v}_1, \underline{v}_2, \dots, \underline{v}_{16})$. The elements $\underline{v}_i; i = 1, \dots, 16$ of the complex valued scrambling codes shall be taken from the complex set

$$\underline{\mathbf{v}} = \{1, j, -1, -j\} \quad (4)$$

In equation 4 the letter j denotes the imaginary unit. A complex scrambling code $\underline{\mathbf{v}}$ is generated from the binary

scrambling codes $\mathbf{v} = (v_1, v_2, \dots, v_{16})$ of length 16 shown in Annex A. The relation between the elements $\underline{\mathbf{v}}$ and \mathbf{v} is given by:

$$\underline{v}_i = (j)^i \cdot v_i \quad v_i \in \{1, -1\} \quad i = 1, \dots, 16 \quad (5)$$

Hence, the elements \underline{v}_i of the complex scrambling code $\underline{\mathbf{v}}$ are alternating real and imaginary.

The length matching is obtained by concatenating Q_{MAX}/Q_k spread words before the scrambling. The scheme is illustrated in figure 2 and is described in more detail in subclause 6.4.

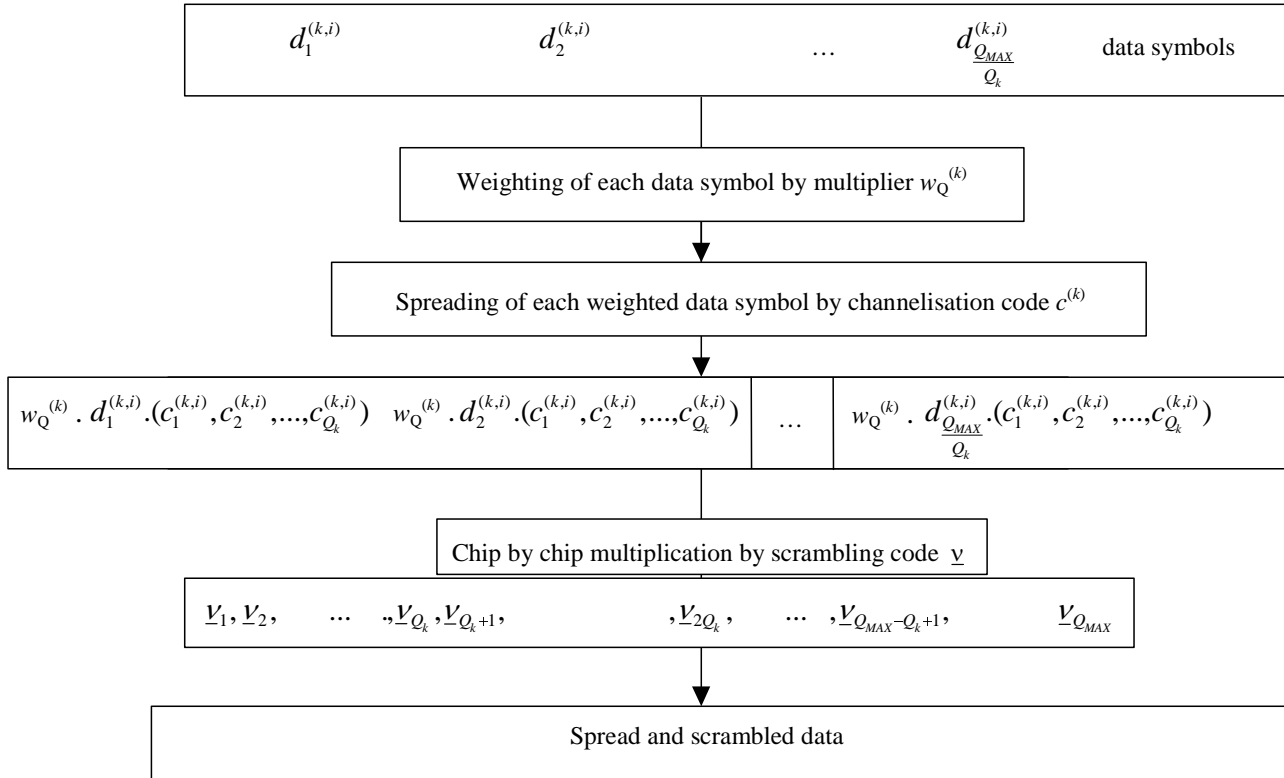


Figure 2: Spreading of data symbols

7.5 Spread signal of data symbols and data blocks

The combination of the user specific channelisation and cell specific scrambling codes can be seen as a user and cell specific spreading code $\mathbf{s}^{(k)} = (s_p^{(k)})$ with

$$s_p^{(k)} = c_{1 + [(p-1) \bmod Q_k]}^{(k)} \cdot v_{1 + [(p-1) \bmod Q_{MAX}]}, \quad k=1, \dots, K_{Code}, p=1, \dots, N_k Q_k.$$

With the root raised cosine chip impulse filter $Cr_0(t)$ the transmitted signal belonging to the data block $\underline{\mathbf{d}}^{(k,1)}$ of equation 1 transmitted before the midamble is

$$d^{(k,1)}(t) = \sum_{n=1}^{N_k} d_n^{(k,1)} w_{Q_k}^{(k)} \sum_{q=1}^{Q_k} s_{(n-1)Q_k+q}^{(k)} \cdot Cr_0(t - (q-1)T_c - (n-1)Q_k T_c) \quad (6)$$

and for the data block $\underline{\mathbf{d}}^{(k,2)}$ of equation 1 transmitted after the midamble

$$d^{(k,2)}(t) = \sum_{n=1}^{N_k} d_n^{(k,2)} w_{Q_k}^{(k)} \sum_{q=1}^{Q_k} s_{(n-1)Q_k+q}^{(k)} \cdot Cr_0(t - (q-1)T_c - (n-1)Q_k T_c - N_k Q_k T_c - L_m T_c) \quad (7)$$

where L_m is the number of midamble chips.

7.6 Modulation for the 3.84 Mcps option

The complex-valued chip sequence is QPSK modulated as shown in figure 3.

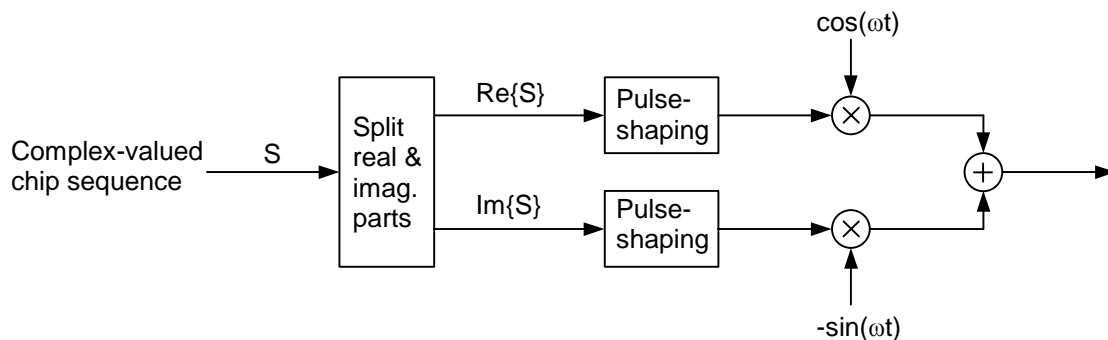


Figure 3: Modulation of complex valued chip sequences

The pulse-shaping characteristics are described in [9] and [10].

7.6.1 Combination of physical channels in uplink

Figure 4 illustrates the principle of combination of two different physical uplink channels within one timeslot. The DPCHs to be combined belong to same CCTrCH, did undergo spreading as described in sections before and are thus represented by complex-valued sequences. First, the amplitude of all DPCHs is adjusted according to UL open loop power control as described in [10]. Each DPCH is then separately weighted by a weight factor γ_i and combined using complex addition. After combination of Physical Channels the gain factor β_j is applied, depending on the actual TFC as described in [10].

In case of different CCTrCH, principle shown in Figure 4 applies to each CCTrCH separately.

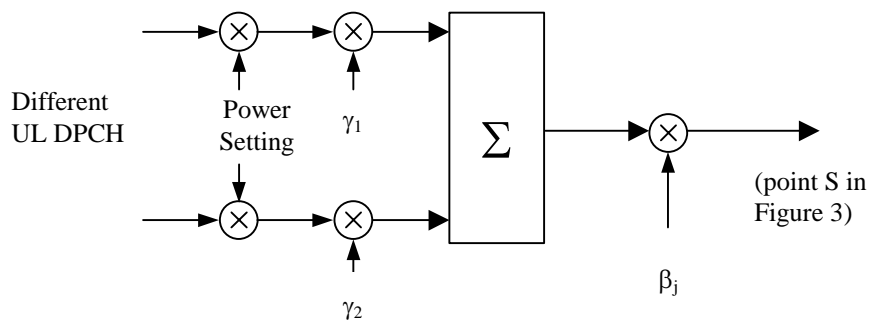


Figure 4: Combination of different physical channels in uplink

The values of weight factors γ_i are depending on the spreading factor SF of the corresponding DPCH:

SF of DPCH _i	γ_i
16	1
8	$\sqrt{2}$
4	2
2	$2\sqrt{2}$
1	4

The possible values for gain factors β_j (corresponding to j -th TFC) are listed in table below:

Signalling value for β_j	Quantized value β_j
15	16/8
14	15/8
13	14/8
12	13/8
11	12/8
10	11/8
9	10/8
8	9/8
7	8/8
6	7/8
5	6/8
4	5/8
3	4/8
2	3/8
1	2/8
0	1/8

7.6.2 Combination of physical channels in downlink

Figure 5 illustrates how different physical downlink channels are combined within one timeslot. Each complex-valued spread channel is separately weighted by a weight factor G_i . If a timeslot contains the SCH, the complex-valued SCH, as described in [7] is separately weighted by a weight factor G_{SCH} . All downlink physical channels are then combined using complex addition.

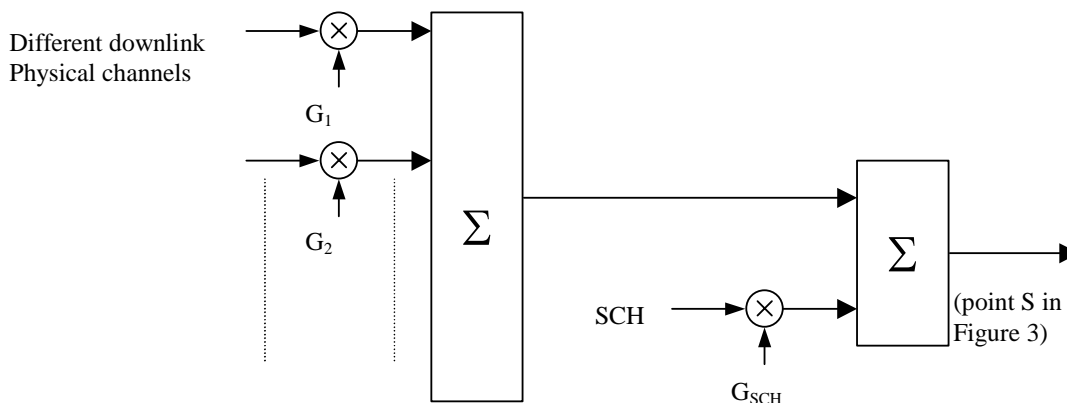


Figure 5: Combination of different physical channels in downlink in case of SCH timeslot

7.7 Modulation for the 1.28 Mcps option

The complex-valued chip sequence is modulated as shown in figure 6.

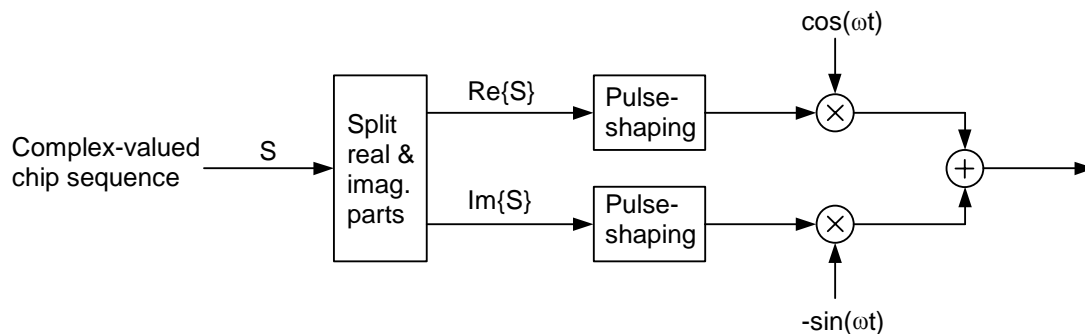


Figure 6: Modulation of complex valued chip sequences

The pulse-shaping characteristics are described in [9] and [10].

7.7.1 Combination of physical channels in uplink

The combination of physical channels in uplink is the same as in the 3.84 Mcps TDD cf. [7.5.1 Combination of physical channels in uplink]

7.7.2 Combination of physical channels in downlink

Figure 7 illustrates how different physical downlink channels are combined within one timeslot. Each spread channel is separately weighted by a weight factor G_i . All downlink physical channels are then combined using complex addition.

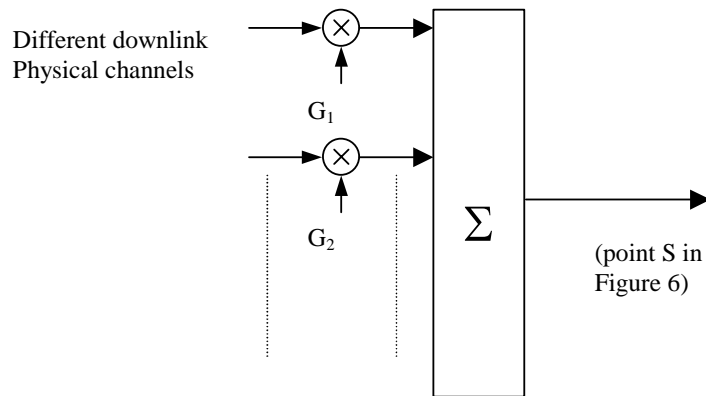


Figure 7: Combination of different physical channels in downlink

8 Synchronisation codes for the 3.84 Mcps option

8.1 Code Generation

The primary synchronisation code (PSC), C_p , is constructed as a so-called generalised hierarchical Golay sequence. The PSC is furthermore chosen to have good aperiodic auto correlation properties.

Define $a = \langle x_1, x_2, x_3, \dots, x_{16} \rangle = \langle 1, 1, 1, 1, 1, 1, -1, -1, 1, -1, 1, -1, 1, -1, -1, 1 \rangle$

The PSC is generated by repeating the sequence 'a' modulated by a Golay complementary sequence and creating a complex-valued sequence with identical real and imaginary components.

The PSC, C_p , is defined as $C_p = \langle y(0), y(1), y(2), \dots, y(255) \rangle$

where $y = (1 + j) \times \langle a, a, a, -a, -a, a, -a, -a, a, a, a, -a, a, -a, a, a \rangle$

and the left most index corresponds to the chip transmitted first in time.

The 12 secondary synchronization codes, $\{C_0, C_1, C_3, C_4, C_5, C_6, C_8, C_{10}, C_{12}, C_{13}, C_{14}, C_{15}\}$ are complex valued with identical real and imaginary components, and are constructed from the position wise multiplication of a Hadamard sequence and a sequence z , defined as

$$z = \langle b, b, b, -b, b, b, -b, -b, b, -b, b, -b, -b, -b, -b \rangle, \text{ where}$$

$$b = \langle x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, -x_9, -x_{10}, -x_{11}, -x_{12}, -x_{13}, -x_{14}, -x_{15}, -x_{16} \rangle$$

and $x_1, x_2, x_3, \dots, x_{16}$ are the same as in the definition of the sequence 'a' above.

The Hadamard sequences are obtained as the rows in a matrix H_8 constructed recursively by:

$$H_0 = (1)$$

$$H_k = \begin{pmatrix} H_{k-1} & H_{k-1} \\ H_{k-1} & -H_{k-1} \end{pmatrix}, \quad k \geq 1$$

The rows are numbered from the top starting with row 0 (the all ones sequence).

Denote the n :th Hadamard sequence h_n as a row of H_8 numbered from the top, $n = 0, 1, 2, \dots, 255$, in the sequel.

Furthermore, let $h_m(l)$ and $z(l)$ denote the l th symbol of the sequence h_m and z , respectively where $l = 0, 1, 2, \dots, 255$ and $l = 0$ corresponds to the leftmost symbol.

The i :th secondary SCH code word, C_i , $i = 0, 1, 3, 4, 5, 6, 8, 10, 12, 13, 14, 15$ is then defined as

$$C_i = (1 + j) \times \langle h_m(0) \times z(0), h_m(1) \times z(1), h_m(2) \times z(2), \dots, h_m(255) \times z(255) \rangle,$$

where $m = (16 \times i)$ and the leftmost chip in the sequence corresponds to the chip transmitted first in time.

8.2 Code Allocation

Three secondary SCH codes are QPSK modulated and transmitted in parallel with the primary synchronization code. The QPSK modulation carries the following information:

- the code group that the base station belongs to (32 code groups:5 bits; Cases 1, 2);
- the position of the frame within an interleaving period of 20 msec (2 frames:1 bit, Cases 1, 2);
- the position of the SCH slot(s) within the frame (2 SCH slots:1 bit, Case 2).

The modulated secondary SCH codes are also constructed such that their cyclic-shifts are unique, i.e. a non-zero cyclic shift less than 2 (Case 1) and 4 (Case 2) of any of the sequences is not equivalent to some cyclic shift of any other of the sequences. Also, a non-zero cyclic shift less than 2 (Case 1) and 4 (Case 2) of any of the sequences is not equivalent to itself with any other cyclic shift less than 8. The secondary synchronization codes are partitioned into two code sets for Case 1 and four code sets for Case 2. The set is used to provide the following information:

Case 1:

Table 2: Code Set Allocation for Case 1

Code Set	Code Group
1	0-15
2	16-31

The code group and frame position information is provided by modulating the secondary codes in the code set.

Case 2:

Table 3: Code Set Allocation for Case 2

Code Set	Code Group
1	0-7
2	8-15
3	16-23
4	24-31

The slot timing and frame position information is provided by the comma free property of the code word and the Code group is provided by modulating some of the secondary codes in the code set.

The following SCH codes are allocated for each code set:

Case 1

Code set 1: C_1, C_3, C_5 .

Code set 2: C_{10}, C_{13}, C_{14} .

Case 2

Code set 1: C_1, C_3, C_5 .

Code set 2: C_{10}, C_{13}, C_{14} .

Code set 3: C_0, C_6, C_{12} .

Code set 4: C_4, C_8, C_{15} .

The following subclauses 7.2.1 to 7.2.2 refer to the two cases of SCH/P-CCPCH usage as described in [7].

Note that in the tables 4 and 5 corresponding to Cases 1 and 2, respectively, Frame 1 implies the frame with an odd SFN and Frame 2 implies the frame with an even SFN.

8.2.1 Code allocation for Case 1

Table 4: Code Allocation for Case 1

Code Group	Code Set	Frame 1			Frame 2			Associated t_{offset}
0	1	C_1	C_3	C_5	C_1	C_3	$-C_5$	t_0
1	1	C_1	$-C_3$	C_5	C_1	$-C_3$	$-C_5$	t_1
2	1	$-C_1$	C_3	C_5	$-C_1$	C_3	$-C_5$	t_2
3	1	$-C_1$	$-C_3$	C_5	$-C_1$	$-C_3$	$-C_5$	t_3
4	1	jC_1	jC_3	C_5	jC_1	jC_3	$-C_5$	t_4
5	1	jC_1	$-jC_3$	C_5	jC_1	$-jC_3$	$-C_5$	t_5
6	1	$-jC_1$	jC_3	C_5	$-jC_1$	jC_3	$-C_5$	t_6
7	1	$-jC_1$	$-jC_3$	C_5	$-jC_1$	$-jC_3$	$-C_5$	t_7
8	1	jC_1	jC_5	C_3	jC_1	jC_5	$-C_3$	t_8
9	1	jC_1	$-jC_5$	C_3	jC_1	$-jC_5$	$-C_3$	t_9
10	1	$-jC_1$	jC_5	C_3	$-jC_1$	jC_5	$-C_3$	t_{10}
11	1	$-jC_1$	$-jC_5$	C_3	$-jC_1$	$-jC_5$	$-C_3$	t_{11}
12	1	jC_3	jC_5	C_1	jC_3	jC_5	$-C_1$	t_{12}
13	1	jC_3	$-jC_5$	C_1	jC_3	$-jC_5$	$-C_1$	t_{13}
14	1	$-jC_3$	jC_5	C_1	$-jC_3$	jC_5	$-C_1$	t_{14}
15	1	$-jC_3$	$-jC_5$	C_1	$-jC_3$	$-jC_5$	$-C_1$	t_{15}
16	2	C_{10}	C_{13}	C_{14}	C_{10}	C_{13}	$-C_{14}$	t_{16}
17	2	C_{10}	$-C_{13}$	C_{14}	C_{10}	$-C_{13}$	$-C_{14}$	t_{17}
...
20	2	jC_{10}	jC_{13}	C_{14}	jC_{10}	jC_{13}	$-C_{14}$	t_{20}
...
24	2	jC_{10}	jC_{14}	C_{13}	jC_{10}	jC_{14}	$-C_{13}$	t_{24}
...
31	2	$-jC_{13}$	$-jC_{14}$	C_{10}	$-jC_{13}$	$-jC_{14}$	$-C_{10}$	t_{31}

NOTE: The code construction for code groups 0 to 15 using only the SCH codes from code set 1 is shown. The construction for code groups 16 to 31 using the SCH codes from code set 2 is done in the same way.

8.2.2 Code allocation for Case 2

Table 5: Code Allocation for Case 2

Code Group	Code Set	Frame 1						Frame 2						Associated t_{offset}
		Slot k			Slot k+8			Slot k			Slot k+8			
0	1	C_1	C_3	C_5	C_1	C_3	$-C_5$	$-C_1$	$-C_3$	C_5	$-C_1$	$-C_3$	$-C_5$	t_0
1	1	C_1	$-C_3$	C_5	C_1	$-C_3$	$-C_5$	$-C_1$	C_3	C_5	$-C_1$	C_3	$-C_5$	t_1
2	1	jC_1	jC_3	C_5	jC_1	jC_3	$-C_5$	$-jC_1$	$-jC_3$	C_5	$-jC_1$	$-jC_3$	$-C_5$	t_2
3	1	jC_1	$-jC_3$	C_5	jC_1	$-jC_3$	$-C_5$	$-jC_1$	jC_3	C_5	$-jC_1$	jC_3	$-C_5$	t_3
4	1	jC_1	jC_5	C_3	jC_1	jC_5	$-C_3$	$-jC_1$	$-jC_5$	C_3	$-jC_1$	$-jC_5$	$-C_3$	t_4
5	1	jC_1	$-jC_5$	C_3	jC_1	$-jC_5$	$-C_3$	$-jC_1$	jC_5	C_3	$-jC_1$	jC_5	$-C_3$	t_5
6	1	jC_3	jC_5	C_1	jC_3	jC_5	$-C_1$	$-jC_3$	$-jC_5$	C_1	$-jC_3$	$-jC_5$	$-C_1$	t_6
7	1	jC_3	$-jC_5$	C_1	jC_3	$-jC_5$	$-C_1$	$-jC_3$	jC_5	C_1	$-jC_3$	jC_5	$-C_1$	t_7
8	2	C_{10}	C_{13}	C_{14}	C_{10}	C_{13}	$-C_{14}$	$-C_{10}$	$-C_{13}$	C_{14}	$-C_{10}$	$-C_{13}$	$-C_{14}$	t_8
9	2	C_{10}	$-C_{13}$	C_{14}	C_{10}	$-C_{13}$	$-C_{14}$	$-C_{10}$	C_{13}	C_{14}	$-C_{10}$	C_{13}	$-C_{14}$	t_9
10	2	jC_{10}	jC_{13}	C_{14}	jC_{10}	jC_{13}	$-C_{14}$	$-jC_{10}$	$-jC_{13}$	C_{14}	$-jC_{10}$	$-jC_{13}$	$-C_{14}$	t_{10}
11	2	jC_{10}	$-jC_{13}$	C_{14}	jC_{10}	$-jC_{13}$	$-C_{14}$	$-jC_{10}$	jC_{13}	C_{14}	$-jC_{10}$	jC_{13}	$-C_{14}$	t_{11}
12	2	jC_{10}	jC_{14}	C_{13}	jC_{10}	jC_{14}	$-C_{13}$	$-jC_{10}$	$-jC_{14}$	C_{13}	$-jC_{10}$	$-jC_{14}$	$-C_{13}$	t_{12}
13	2	jC_{10}	$-jC_{14}$	C_{13}	jC_{10}	$-jC_{14}$	$-C_{13}$	$-jC_{10}$	jC_{14}	C_{13}	$-jC_{10}$	jC_{14}	$-C_{13}$	t_{13}
14	2	jC_{13}	jC_{14}	C_{10}	jC_{13}	jC_{14}	$-C_{10}$	$-jC_{13}$	$-jC_{14}$	C_{10}	$-jC_{13}$	$-jC_{14}$	$-C_{10}$	t_{14}
15	2	jC_{13}	$-jC_{14}$	C_{10}	jC_{13}	$-jC_{14}$	$-C_{10}$	$-jC_{13}$	jC_{14}	C_{10}	$-jC_{13}$	jC_{14}	$-C_{10}$	t_{15}
16	3	C_0	C_6	C_{12}	C_0	C_6	$-C_{12}$	$-C_0$	$-C_6$	C_{12}	$-C_0$	$-C_6$	$-C_{12}$	t_{16}
...
23	3	jC_6	$-jC_{12}$	C_0	jC_6	$-jC_{12}$	$-C_0$	$-jC_6$	jC_{12}	C_0	$-jC_6$	jC_{12}	$-C_0$	t_{20}
24	4	C_4	C_8	C_{15}	C_4	C_8	$-C_{15}$	$-C_4$	$-C_8$	C_{15}	$-C_4$	$-C_8$	$-C_{15}$	t_{24}
...
31	4	jC_8	$-jC_{15}$	C_4	jC_8	$-jC_{15}$	$-C_4$	$-jC_8$	jC_{15}	C_4	$-jC_8$	jC_{15}	$-C_4$	t_{31}

NOTE: The code construction for code groups 0 to 15 using the SCH codes from code sets 1 and 2 is shown. The construction for code groups 16 to 31 using the SCH codes from code sets 3 and 4 is done in the same way.

8.3 Evaluation of synchronisation codes

The evaluation of information transmitted in SCH on code group and frame timing is shown in table 6, where the 32 code groups are listed. Each code group is containing 4 specific scrambling codes (cf. subclause 6.3), each scrambling code associated with a specific short and long basic midamble code.

Each code group is additionally linked to a specific t_{Offset} , thus to a specific frame timing. By using this scheme, the UE can derive the position of the frame border due to the position of the SCH sequence and the knowledge of t_{Offset} . The complete mapping of Code Group to Scrambling Code, Midamble Codes and t_{Offset} is depicted in table 6.

Table 6: Mapping scheme for Cell Parameters, Code Groups, Scrambling Codes, Midambles and t_{Offset}

CELL PARAMETER	Code Group	Associated Codes			Associated t_{Offset}
		Scrambling Code	Long Basic Midamble Code	Short Basic Midamble Code	
0	Group 0	Code 0	m_{PL0}	m_{SL0}	t_0
1		Code 1	m_{PL1}	m_{SL1}	
2		Code 2	m_{PL2}	m_{SL2}	
3		Code 3	m_{PL3}	m_{SL3}	
4	Group 1	Code 4	m_{PL4}	m_{SL4}	t_1
5		Code 5	m_{PL5}	m_{SL5}	
6		Code 6	m_{PL6}	m_{SL6}	
7		Code 7	m_{PL7}	m_{SL7}	
⋮					
124	Group 31	Code 124	m_{PL124}	m_{SL124}	t_{31}
125		Code 125	m_{PL125}	m_{SL125}	
126		Code 126	m_{PL126}	m_{SL126}	
127		Code 127	m_{PL127}	m_{SL127}	

For basic midamble codes m_p cf. [7], annex A 'Basic Midamble Codes'.

Each cell shall cycle through two sets of cell parameters in a code group with the cell parameters changing each frame. Table 7 shows how the cell parameters are cycled according to the SFN.

Table 7: Alignment of cell parameter cycling and SFN

Initial Cell Parameter Assignment	Code Group	Cell Parameter used when SFN mod 2 = 0	Cell Parameter used when SFN mod 2 = 1
0	Group 0	0	1
1		1	0
2		2	3
3		3	2
4	Group 1	4	5
5		5	4
6		6	7
7		7	6
⋮			
124	Group 31	124	125
125		125	124
126		126	127
127		127	126

9 Synchronisation codes for the 1.28 Mcps option

9.1 The downlink pilot timeslot (DwPTS)

The contents of DwPTS is composed of 64 chips of a SYNC-DL sequence, cf. [B.1 Basic SYNC-DL sequence] and 32 chips of guard period (GP). The SYNC-DL code is not scrambled

There should be 32 different basic SYNC-DL codes for the whole system.

For the generation of the complex valued SYNC-DL codes of length 64, the basic binary SYNC-DL codes

$= (s_1, s_2, \dots, s_{64})$ of length 64 shown in Table 9 are used. The relation between the elements \underline{s} and \mathbf{S} is given by:

$$\underline{s}_i = (j)^i \cdot s_i \quad s_i \in \{1, -1\} \quad i=1, \dots, 64 \quad (1)$$

Hence, the elements \underline{s}_i of the complex SYNC-DL code \mathbf{S} are alternating real and imaginary.

The SYNC-DL is QPSK modulated and the phase of the SYNC-DL is used to signal the presence of the P-CCPCH in the multi-frame of the resource units of code $C_{Q=16}^{(k=1)}$ and $C_{Q=16}^{(k=2)}$ in time slot #0.

9.1.1 Modulation of the SYNC-DL

The SYNC-DL sequences are modulated with respect to the midamble ($m^{(1)}$) in time slot #0.

Four consecutive phases (phase quadruple) of the SYNC-DL are used to indicate the presence of the P-CCPCH in the following 4 sub-frames. In case the presence of a P-CCPCH is indicated, the next following sub-frame is the first sub-frame of the interleaving period. As QPSK is used for the modulation of the SYNC-DL, the phases 45, 135, 225, and 315° are used.

The total number of different phase quadruples is 2 (S1 and S2). A quadruple always starts with an even system frame number ((SFN mod 2) = 0). Table 8 is showing the quadruples and their meaning.

Table 8: Sequences for the phase modulation for the SYNC-DL

Name	Phase quadruple	Meaning
S1	135, 45, 225, 135	There is a P-CCPCH in the next 4 sub-frames
S2	315, 225, 315, 45	There is no P-CCPCH in the next 4 sub-frames

9.2 The uplink pilot timeslot (UpPTS)

The contents in UpPTS is composed of 128 chips of a SYNC-UL sequence, cf. [B.2 Basic SYNC-UL sequence] and 32 chips of guard period (GP). The SYNC-UL code is not scrambled.

There should be 256 different basic SYNC-UL codes (see Table 10) for the whole system.

For the generation of the complex valued SYNC-UL codes of length 128, the basic binary SYNC-UL codes

$= (s_1, s_2, \dots, s_{128})$ of length 128 shown in Table 10 are used. The relation between the elements \underline{s} and \mathbf{S} is given by:

$$\underline{s}_i = (j)^i \cdot s_i \quad s_i \in \{1, -1\} \quad i=1, \dots, 128 \quad (2)$$

Hence, the elements \underline{s}_i of the complex SYNC-UL code \mathbf{S} are alternating real and imaginary.

9.3 Code Allocation

Relationship between the SYNC-DL and SYNC-UL sequences, the scrambling codes and the midamble codes

Code Group	Associated Codes			
	SYNC-DL ID	SYNC-UL ID	Scrambling Code ID	Basic Midamble Code ID
Group 1	0	0...7	0	0
			1	1
			2	2
			3	3
Group 2	1	8...15	4	4
			5	5
			6	6
			7	7
⋮				
Group 32	31	248...255	124	124
			125	125
			126	126
			127	127

10 Cell synchronisation codes

The cell synchronisation codes (CSCs) are constructed as so-called CEC sequences, i.e. concatenated and periodically extended complementary sequences. They are complex-valued sequences that are derived as cyclically offset versions from a set of possible constituent Golay complementary pairs.

The CSCs are chosen to have good aperiodic auto correlation properties. The aperiodic auto correlations of the applicable constituent Golay complementary pairs and every pair of their derived cyclically offset versions are complementary. Furthermore, orthogonality is preserved for all CSCs which are derived from the same constituent Golay complementary pair due to this complementary property.

The delay and weight matrices for the set of $M = 8$ possible constituent Golay complementary pairs are listed in the table below:

Code ID m	Delay matrices D_m and weight matrices W_m of constituent Golay complementary pairs
0	$D_0 = \langle 512, 64, 128, 1, 16, 4, 256, 32, 8, 2 \rangle$, $W_0 = \langle 1, 1, 1, 1, -1, -1, 1, 1, 1, 1 \rangle$
1	$D_1 = \langle 2, 16, 32, 256, 1, 8, 128, 4, 512, 64 \rangle$, $W_1 = \langle 1, -1, 1, -1, 1, -1, -1, 1, -1, -1 \rangle$
2	$D_2 = \langle 16, 512, 32, 256, 4, 1, 64, 8, 2, 128 \rangle$, $W_2 = \langle -1, 1, 1, -1, -1, 1, -1, 1, -1, -1 \rangle$
3	$D_3 = \langle 512, 16, 8, 4, 2, 256, 128, 64, 32, 1 \rangle$, $W_3 = \langle -1, -1, -1, -1, -1, 1, -1, 1, 1, 1 \rangle$
4	$D_4 = \langle 512, 128, 256, 32, 2, 4, 64, 1, 16, 8 \rangle$, $W_4 = \langle 1, -1, 1, -1, -1, -1, -1, -1, -1, 1 \rangle$
5	$D_5 = \langle 1, 2, 4, 64, 512, 16, 32, 256, 128, 8 \rangle$, $W_5 = \langle -1, 1, 1, 1, 1, -1, -1, 1, -1, 1 \rangle$
6	$D_6 = \langle 8, 16, 128, 2, 32, 1, 256, 512, 4, 64 \rangle$, $W_6 = \langle -1, -1, 1, 1, 1, 1, -1, -1, -1, 1 \rangle$
7	$D_7 = \langle 1, 2, 128, 16, 256, 32, 8, 512, 64, 4 \rangle$, $W_7 = \langle 1, 1, -1, -1, -1, -1, 1, -1, -1, -1 \rangle$

A constituent Golay complementary pair of length $N = 1024$, defined as:

$$s_m = \langle s_m(0), s_m(1), s_m(2), \dots, s_m(1023) \rangle \text{ and } g_m = \langle g_m(0), g_m(1), g_m(2), \dots, g_m(1023) \rangle$$

shall be derived from the selected delay and weight matrices:

$$D_m = \langle D_m(0), D_m(1), D_m(2), \dots, D_m(9) \rangle \text{ and } W_m = \langle W_m(0), W_m(1), W_m(2), \dots, W_m(9) \rangle$$

as follows.

Define:

$$\mathbf{a}^{(0)} = \langle a^{(0)}(0), a^{(0)}(1), a^{(0)}(2), \dots, a^{(0)}(1023) \rangle = \langle 1, 0, 0, \dots, 0 \rangle \text{ and}$$

$$\mathbf{b}^{(0)} = \langle b^{(0)}(0), b^{(0)}(1), b^{(0)}(2), \dots, b^{(0)}(1023) \rangle = \langle 1, 0, 0, \dots, 0 \rangle.$$

Then, the elements of the set of auxiliary sequences:

$$\mathbf{a}^{(n)} = \langle a^{(n)}(0), a^{(n)}(1), a^{(n)}(2), \dots, a^{(n)}(1023) \rangle \text{ and } \mathbf{b}^{(n)} = \langle b^{(n)}(0), b^{(n)}(1), b^{(n)}(2), \dots, b^{(n)}(1023) \rangle$$

are given by the recursive relations:

$$a^{(n+1)}(i) = a^{(n)}(i) + W_m(n) \times b^{(n)}(i - D_m(n)) \text{ and}$$

$$b^{(n+1)}(i) = a^{(n)}(i) - W_m(n) \times b^{(n)}(i - D_m(n))$$

with element index $i = 0, 1, 2, \dots, 1023$ and iteration index $n = 0, 1, 2, \dots, 9$. Operations on the element index shall be performed modulo 1024.

The elements of the constituent Golay complementary pairs s_m and g_m are then obtained from the output of the last iteration step using:

$$s_m(i) = a^{(10)}(i) \text{ and } g_m(i) = b^{(10)}(i) \text{ for } i = 0, 1, 2, \dots, 1023$$

From each applicable constituent Golay complementary pair s_m and g_m , up to $K = 8$ different cyclically offset pairs $s_m^{(k)}$ and $g_m^{(k)}$, with offset index $k = 0, 1, 2, \dots, K-1$, of length 1152 chips can be derived. The complementary property of the respective aperiodic auto correlation is preserved for each particular pair of sequences $s_m^{(k)}$ and $g_m^{(k)}$. The generation of the K cyclically offset pairs from s_m and g_m is done in a similar way as the generation of the user midambles from a periodic basic midamble sequence as described in [7].

With $N = 1024$, $K = 8$, $W = 128$, the elements of a cyclically offset pair:

$$s_m^{(k)} = \langle s_m^{(k)}(0), s_m^{(k)}(1), s_m^{(k)}(2), \dots, s_m^{(k)}(1151) \rangle \text{ and } g_m^{(k)} = \langle g_m^{(k)}(0), g_m^{(k)}(1), g_m^{(k)}(2), \dots, g_m^{(k)}(1151) \rangle$$

for a particular offset k , with $k = 0, 1, 2, \dots, K-1$, shall be derived from the elements of the constituent Golay complementary pairs s_m and g_m using:

$$s_m^{(k)}(i) = (j)^i \times s_m(i + k \times W) \text{ and } g_m^{(k)}(i) = (j)^i \times g_m(i + k \times W) \text{ for } i = 0, 1, 2, \dots, N - k \times W - 1,$$

$$s_m^{(k)}(i) = (j)^i \times s_m(i - N + k \times W) \text{ and } g_m^{(k)}(i) = (j)^i \times g_m(i - N + k \times W) \text{ for } i = N - k \times W, N - k \times W + 1, \dots, 1151.$$

Hence, the elements of $s_m^{(k)}$ and $g_m^{(k)}$ are alternating real and imaginary.

Note that both $s_m^{(0)}$ and $g_m^{(0)}$ simply correspond to s_m and g_m respectively, followed by its first W elements as post extension and that both $s_m^{(7)}$ and $g_m^{(7)}$ simply correspond to the last W elements of s_m and g_m in form of a pre extension, followed by s_m and g_m respectively.

Finally, the CSC $C_{CSC, m}^{(k)}$ derived from the m :th applicable constituent Golay complementary pair s_m and g_m , and for the k :th offset is then defined as a concatenation of $s_m^{(k)}$ and $g_m^{(k)}$ by:

$$C_{CSC, m}^{(k)} = \langle s_m^{(k)}(0), s_m^{(k)}(1), s_m^{(k)}(2), \dots, s_m^{(k)}(1151), g_m^{(k)}(0), g_m^{(k)}(1), g_m^{(k)}(2), \dots, g_m^{(k)}(1151) \rangle$$

where the leftmost element $s_m^{(k)}(0)$ in the sequence corresponds to the chip to be first transmitted in time. An CSC has therefore length 2304 chips.

Note that due to this construction method, the auto correlations for all CSCs derived from one particular constituent Golay complementary pair s_m and g_m can be obtained simultaneously and in sequential order from the sum of partial correlations with s_m and g_m , these CSCs remaining orthogonal.

CSCs derived according to above have complex values and shall not be subject to the channelisation or scrambling process, i.e. its elements represent complex chips for usage in the pulse shaping process at modulation.

Annex A (normative): Scrambling Codes

The applicable scrambling codes are listed below. Code numbers are referring to table 6 'Mapping scheme for Cell Parameters, Code Groups, Scrambling Codes, Midambles and t_{offset} ' in subclause 7.3 'Evaluation of synchronisation codes'.

Scrambling Code	v ₁	v ₂	v ₃	v ₄	v ₅	v ₆	v ₇	v ₈	v ₉	v ₁₀	v ₁₁	v ₁₂	v ₁₃	v ₁₄	v ₁₅	v ₁₆
Code 0	-1	1	-1	-1	-1	1	-1	-1	1	-1	1	1	-1	1	-1	-1
Code 1	1	1	1	1	1	-1	1	-1	1	-1	-1	1	1	1	-1	-1
Code 2	1	-1	1	1	1	-1	1	1	-1	1	1	1	1	-1	-1	-1
Code 3	1	1	1	-1	-1	-1	-1	1	-1	-1	1	-1	-1	-1	1	-1
Code 4	1	1	1	-1	-1	-1	-1	1	1	1	1	-1	1	1	1	-1
Code 5	-1	1	1	-1	-1	-1	1	1	1	1	1	1	1	-1	1	-1
Code 6	-1	1	-1	-1	-1	1	-1	-1	-1	1	1	1	1	-1	-1	-1
Code 7	1	-1	1	-1	-1	-1	-1	-1	1	1	-1	-1	-1	1	1	-1
Code 8	1	1	1	-1	-1	-1	1	-1	1	1	-1	1	1	1	1	-1
Code 9	1	1	-1	1	1	1	1	-1	1	1	1	-1	-1	-1	1	-1
Code 10	1	-1	1	-1	1	1	1	1	-1	-1	1	1	-1	1	1	-1
Code 11	-1	1	1	1	1	-1	-1	-1	-1	1	-1	-1	-1	1	-1	-1
Code 12	-1	-1	1	-1	-1	-1	1	-1	-1	-1	-1	1	1	1	1	-1
Code 13	1	-1	1	1	1	-1	-1	-1	1	-1	-1	-1	-1	1	-1	-1
Code 14	1	-1	-1	-1	-1	1	-1	-1	1	-1	1	1	1	-1	-1	-1
Code 15	1	1	-1	-1	-1	1	1	-1	1	-1	1	-1	-1	-1	-1	-1
Code 16	1	-1	-1	1	-1	1	-1	1	-1	-1	-1	-1	1	1	-1	-1
Code 17	1	1	1	-1	1	1	1	-1	1	1	-1	1	-1	-1	1	-1
Code 18	-1	1	1	1	-1	1	-1	-1	-1	1	-1	-1	1	-1	-1	-1
Code 19	-1	1	-1	-1	1	-1	-1	-1	-1	1	1	1	-1	1	-1	-1
Code 20	-1	-1	-1	-1	1	-1	1	-1	-1	1	1	-1	1	1	-1	-1
Code 21	1	1	1	1	-1	-1	1	1	-1	1	1	-1	1	-1	1	-1
Code 22	1	-1	-1	-1	-1	1	1	1	-1	1	-1	-1	-1	1	-1	-1
Code 23	-1	1	1	1	-1	1	1	1	1	-1	1	1	-1	1	-1	-1
Code 24	-1	-1	1	-1	1	1	1	-1	-1	-1	-1	1	-1	-1	1	-1
Code 25	1	-1	1	1	1	-1	1	1	1	-1	1	1	-1	1	-1	-1
Code 26	1	-1	-1	-1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1
Code 27	-1	1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1	1	-1	-1
Code 28	-1	-1	-1	1	-1	-1	-1	1	-1	-1	-1	1	1	1	1	-1
Code 29	1	-1	1	1	-1	1	-1	-1	-1	1	-1	-1	-1	1	-1	-1
Code 30	-1	-1	-1	-1	-1	-1	1	1	1	-1	-1	1	1	-1	1	-1
Code 31	1	1	-1	-1	1	1	1	1	-1	1	-1	1	-1	1	1	-1
Code 32	1	-1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	-1	-1
Code 33	-1	-1	-1	1	1	1	1	-1	1	1	1	-1	1	1	1	-1
Code 34	1	-1	-1	-1	1	-1	-1	-1	1	-1	1	1	-1	1	-1	-1
Code 35	1	-1	1	1	-1	1	-1	-1	1	-1	-1	-1	1	-1	-1	-1
Code 36	1	1	-1	1	1	1	-1	1	-1	-1	-1	1	1	1	1	-1
Code 37	-1	-1	-1	1	-1	-1	1	-1	-1	-1	1	-1	1	1	1	-1
Code 38	-1	1	-1	-1	1	-1	1	1	1	-1	-1	-1	1	-1	-1	-1
Code 39	-1	1	1	1	1	-1	-1	-1	1	-1	-1	-1	1	-1	-1	-1
Code 40	-1	1	-1	1	-1	-1	-1	-1	-1	-1	1	1	-1	1	1	-1
Code 41	1	1	-1	1	-1	-1	1	-1	-1	-1	1	-1	-1	-1	1	-1
Code 42	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	1	-1	-1	-1
Code 43	-1	-1	1	1	-1	-1	-1	-1	-1	1	-1	1	-1	1	1	-1
Code 44	-1	-1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	1	-1
Code 45	-1	-1	1	-1	1	1	-1	1	1	1	1	-1	1	1	1	-1

Scrambling Code	v ₁	v ₂	v ₃	v ₄	v ₅	v ₆	v ₇	v ₈	v ₉	v ₁₀	v ₁₁	v ₁₂	v ₁₃	v ₁₄	v ₁₅	v ₁₆
Code 46	-1	1	1	-1	1	1	-1	-1	-1	-1	-1	-1	1	-1	1	-1
Code 47	1	-1	-1	1	1	1	-1	-1	1	1	1	1	1	-1	1	-1
Code 48	1	1	-1	1	1	1	-1	1	1	1	-1	1	-1	-1	1	-1
Code 49	-1	-1	1	1	-1	1	1	-1	-1	1	-1	1	-1	-1	-1	-1
Code 50	1	1	-1	1	-1	-1	1	-1	1	1	1	-1	1	1	1	-1
Code 51	1	-1	-1	1	1	1	-1	-1	1	-1	1	-1	-1	-1	-1	-1
Code 52	1	1	1	-1	1	1	1	-1	-1	-1	-1	1	1	1	1	-1
Code 53	-1	1	1	1	-1	-1	-1	1	-1	1	1	1	1	1	1	-1
Code 54	-1	-1	1	-1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1
Code 55	-1	1	1	-1	-1	-1	-1	-1	1	-1	1	-1	1	1	-1	-1
Code 56	-1	1	1	1	-1	1	1	1	-1	1	1	1	1	-1	-1	-1
Code 57	-1	1	1	-1	-1	-1	1	1	-1	1	-1	1	-1	-1	-1	-1
Code 58	-1	1	-1	1	-1	-1	-1	-1	-1	1	1	-1	1	1	-1	-1
Code 59	1	1	-1	-1	-1	-1	-1	-1	1	-1	1	-1	-1	1	1	-1
Code 60	-1	1	1	-1	1	1	1	1	-1	1	-1	1	1	1	-1	-1
Code 61	-1	-1	1	1	1	-1	-1	1	1	-1	1	-1	-1	-1	-1	-1
Code 62	-1	1	-1	-1	1	1	1	-1	1	-1	-1	-1	-1	-1	1	-1
Code 63	-1	1	-1	1	-1	-1	1	1	1	-1	-1	1	-1	-1	-1	-1
Code 64	1	-1	-1	1	-1	-1	1	1	-1	-1	-1	-1	1	-1	1	-1
Code 65	-1	-1	-1	1	1	1	1	-1	-1	-1	1	-1	-1	-1	1	-1
Code 66	-1	-1	-1	-1	1	-1	-1	1	1	1	-1	-1	1	-1	1	-1
Code 67	-1	-1	-1	1	1	1	-1	1	1	1	-1	1	1	1	1	-1
Code 68	1	-1	1	1	-1	-1	-1	1	1	-1	-1	-1	-1	-1	1	-1
Code 69	-1	-1	1	-1	1	-1	-1	-1	1	1	1	-1	-1	1	-1	-1
Code 70	1	1	-1	1	-1	-1	-1	1	-1	-1	-1	1	-1	-1	1	-1
Code 71	1	-1	-1	1	-1	-1	-1	-1	-1	1	-1	1	1	1	-1	-1
Code 72	1	1	1	1	-1	1	1	-1	1	1	-1	-1	1	-1	1	-1
Code 73	-1	1	1	1	-1	-1	-1	1	-1	1	-1	-1	-1	-1	1	-1
Code 74	1	1	-1	1	-1	1	-1	-1	-1	-1	-1	1	1	-1	-1	-1
Code 75	1	1	-1	-1	1	-1	-1	1	-1	1	-1	1	-1	-1	-1	-1
Code 76	-1	1	-1	-1	-1	-1	-1	1	-1	1	1	1	-1	-1	1	-1
Code 77	-1	1	-1	1	1	1	1	1	-1	1	1	-1	1	1	-1	-1
Code 78	-1	1	-1	1	-1	1	1	-1	-1	-1	1	1	-1	-1	-1	-1
Code 79	-1	1	-1	1	1	1	-1	-1	-1	1	1	-1	-1	-1	-1	-1
Code 80	1	1	-1	1	-1	1	-1	-1	-1	-1	1	-1	-1	1	-1	-1
Code 81	1	1	1	1	1	-1	1	-1	-1	-1	1	1	-1	1	1	-1
Code 82	-1	1	-1	1	1	1	1	1	1	1	-1	-1	-1	1	1	-1
Code 83	1	1	-1	-1	1	-1	1	-1	-1	-1	-1	-1	-1	1	1	-1
Code 84	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	-1	-1	1	-1
Code 85	-1	1	1	-1	-1	1	-1	1	1	1	1	1	1	1	-1	-1
Code 86	-1	-1	-1	1	-1	-1	-1	1	1	1	-1	1	-1	-1	1	-1
Code 87	1	1	-1	-1	-1	1	-1	1	1	1	1	1	-1	1	1	-1
Code 88	-1	1	1	-1	1	1	-1	-1	1	-1	1	-1	-1	-1	-1	-1
Code 89	-1	1	-1	-1	1	-1	1	1	-1	1	-1	-1	-1	1	-1	-1
Code 90	1	-1	-1	-1	-1	-1	-1	1	1	-1	1	1	-1	-1	1	-1
Code 91	-1	1	-1	-1	-1	-1	1	-1	1	-1	1	1	-1	-1	1	-1
Code 92	-1	1	1	-1	1	-1	1	-1	-1	-1	-1	-1	1	1	-1	-1
Code 93	-1	-1	-1	-1	-1	1	1	-1	-1	-1	1	1	1	-1	1	-1
Code 94	1	-1	1	-1	-1	1	1	-1	1	1	-1	-1	-1	-1	-1	-1
Code 95	1	1	1	1	1	-1	-1	1	-1	-1	1	1	1	-1	1	-1
Code 96	1	1	-1	-1	-1	1	1	-1	-1	-1	-1	-1	1	-1	1	-1
Code 97	1	1	-1	-1	1	-1	-1	1	1	1	1	1	1	-1	1	-1
Code 98	1	1	-1	1	1	-1	1	1	1	1	1	-1	1	-1	-1	-1

Scrambling Code	v ₁	v ₂	v ₃	v ₄	v ₅	v ₆	v ₇	v ₈	v ₉	v ₁₀	v ₁₁	v ₁₂	v ₁₃	v ₁₄	v ₁₅	v ₁₆
Code 99	1	-1	1	-1	1	-1	-1	1	-1	-1	1	1	-1	-1	-1	-1
Code 100	1	-1	1	1	-1	-1	1	-1	-1	1	-1	-1	-1	-1	1	-1
Code 101	1	1	1	1	-1	1	-1	1	1	1	-1	-1	-1	1	1	-1
Code 102	1	-1	1	-1	1	1	1	1	-1	1	1	-1	1	1	-1	-1
Code 103	-1	-1	1	-1	-1	1	-1	-1	1	1	1	-1	1	-1	-1	-1
Code 104	1	-1	1	1	-1	1	1	1	-1	1	1	1	-1	1	-1	-1
Code 105	1	1	1	1	1	1	-1	-1	1	-1	-1	1	1	-1	1	-1
Code 106	1	1	-1	-1	-1	1	-1	1	-1	-1	-1	-1	-1	1	1	-1
Code 107	-1	-1	-1	-1	1	1	-1	-1	-1	1	1	-1	1	-1	1	-1
Code 108	-1	-1	-1	1	-1	1	-1	-1	1	1	-1	1	1	-1	-1	-1
Code 109	-1	1	-1	1	1	-1	-1	1	1	1	-1	-1	-1	-1	-1	-1
Code 110	-1	-1	1	1	-1	1	-1	1	1	1	1	1	-1	1	1	-1
Code 111	1	1	1	-1	-1	1	1	1	1	1	-1	1	-1	1	-1	-1
Code 112	-1	-1	1	1	1	-1	1	-1	1	1	1	1	-1	1	1	-1
Code 113	1	1	-1	-1	1	-1	1	-1	1	1	1	1	-1	1	1	-1
Code 114	-1	-1	-1	1	1	-1	-1	-1	1	1	-1	1	-1	1	-1	-1
Code 115	1	-1	-1	1	1	1	1	1	1	-1	1	-1	1	1	-1	-1
Code 116	-1	1	1	1	1	-1	1	1	1	-1	1	1	1	-1	-1	-1
Code 117	1	1	1	-1	1	1	-1	1	-1	-1	1	-1	1	1	1	-1
Code 118	-1	-1	-1	-1	-1	1	-1	1	1	-1	-1	1	1	1	-1	-1
Code 119	-1	-1	-1	1	-1	1	1	1	-1	-1	1	-1	-1	1	-1	-1
Code 120	-1	-1	1	-1	1	-1	1	1	-1	-1	1	-1	-1	1	-1	-1
Code 121	-1	1	1	1	1	1	1	-1	1	-1	1	1	-1	-1	1	-1
Code 122	-1	-1	-1	1	1	-1	1	1	-1	-1	1	-1	1	-1	-1	-1
Code 123	1	-1	1	-1	1	1	-1	-1	1	-1	-1	1	-1	-1	-1	-1
Code 124	-1	-1	1	1	1	1	1	1	1	-1	1	-1	-1	1	1	-1
Code 125	1	-1	-1	1	1	-1	1	-1	1	1	1	1	1	1	-1	-1
Code 126	1	1	1	1	-1	1	-1	1	-1	1	1	-1	1	1	-1	-1
Code 127	1	-1	1	-1	-1	-1	-1	-1	1	-1	-1	1	1	1	-1	-1

Annex B (normative): Synchronisation sequence

B.1 Basic SYNC-DL sequence

Table 9: Basic SYNC-DL Codes

Code ID	SYNC-DL Codes of length 64
0	B3A7CC05A98688E4
1	9D559BD290606791
2	2CE7BA12A017C3A2
3	34511D20672F4712
4	9A772841474603F2
5	9109B1A5CE01F228
6	8FD429B3594501C0
7	25251354AA3F8C19
8	C9A3B8E0C043EA56
9	BA04B888E5BC1802
10	A735354299370207
11	74C3C8DA4415AE51
12	F4FD0458A0124663
13	A011D4E16C3D6064
14	BDA0661B0CAA8C68
15	8E31123F28928698
16	F095C1632E2906AB
17	B60B4A8A664071CF
18	AA094DCCE91E041A
19	C0C31CDA8A256807
20	D516964FB18C1890
21	30DE01834F4AACCE
22	8F700323BA5CAD34
23	1B50F4DEE0C1380C
24	443382164F56F2D1
25	E1E4005D49B846B4
26	040A97165330BFAA
27	C48E26881693AD78
28	D4354B2FE02361CC
29	5383AB6C8A10CE84
30	D417A730F2F12244
31	ABF0A0D905A939C4

B.2 Basic SYNC-UL Codes

Table 10: Basic SYNC-UL Codes

Code ID	SYNC-UL Codes of length 128
0	C11C20F0D1807DB8859175B798EC094A
1	91278068081EC8E74543DBC1C9AD4235
2	38F5AEE2E513DB12A663BA04160103E5
3	7AA8A0A210F12A1E4332F2EDD33011FC
4	C180EA3B9BA1774EB9611BD249C4A508
5	B072A2C839489D496B98CE9D0132FBC9
6	B2723EAC6EB01667F2B33961C8074234
7	C4144AD060F0EC095E227B92CF7C8280
8	653036A10D3054146FCF815986C63A14
9	F899CA61435D64DC07FDF04C4A0C053A
10	B56F2D6893A8051407F4C341D88DC7DC
11	DC0BE838242142EDE6413A72C88D74AA
12	22A2FD86E4086C70A4860B13C76E579F
13	A3CBC21322C97D2A02728E7875F39588
14	D4EC4F694A082CB38E3B1558A0FCC89F
15	CC891141C4E216D235C15CF5D3F9B002
16	A1993114C50B77CB0C0725D1E22FD016
17	24F73A979DE52F82E8800CCB93842A59
18	8F878FA04659842E294D8DEAB20BA2FD
19	AC90B0442D70662B028CF76A6BECDF09
20	D94A284DF64D7B0102F0E084C29C88C8
21	8603200C7596F24E865FD3815693358D
22	B466B12CF433642BD8B08F1F452E0550
23	86A3A1772C1C99FCA7DBBA0C312E34A0
24	622A1889F72A9A2C042D46F08EFEE1AC
25	BF220A362BC0D3B0D7CE400954C6CFAE
26	D28D73C52E89CF57905C502244F63616
27	AD4E1C2103697D64D8B9D4C035D90548
28	8F081A9BA12B6C6BD024531AA984D21C
29	E4092429BE82988E1E3585BF6A6AE550
30	08BD36E0A9C061782CB38B35B335CA56
31	1CDFF3CC2685D1C44F4A1059AB03F40A
32	506ED4E88FB1CECE3243F2A27A0221A4
33	846CF58A7AB613C83A24130B5778C0E2
34	A2711A99E26A0C75AC026F4CFAECE893
35	D846EEEBA2432AC05A01043C62579DCF
36	6B16B4E851CAF2121FC4CF88820C89E7
37	AA4889A78207674A74E10C6F2BE11D48
38	8534CF8145BC991052814ED5C72709EE
39	01AEF15D2290A84A607425746D9963C7

40	999188F758245D5164FE16D852942C71
41	CF71C008599287E446E30745BD56E2D2
42	248414BA0DF8CDC4711FE7C8707ED0AD
43	EB2E263EC016191C81AB714BFE4D2B30
44	862082A7482FAC1C499793A0D8CED670
45	DE2C22B2783AB75A7342608DE413840A
46	E31AA60B727F2CA2A78DAAC10665011D
47	CEF6CD06509870AC9E0177ACD550921D
48	E52C84D499FFCDC287581691471540F2
49	B33BF6551A4322504BEE0930BCA1EC68
50	555BE6886D0FC43D72315E6C6D384148
51	8444F67451EE23CE1240C90F0B52A492
52	5C290D28E84060E69D09788A261B10FF
53	337E0C35E83CD38CCC5D45804241F952
54	A7879F0D31A8982A01EE6AC4952984DC
55	A37F506508928C70A83D69A2373781B9
56	42F55208EE12909803A7CBEB19B5419E
57	57E5E268A328FCC9ED04B9E5420AC702
58	EB033AD1222F84D8642C4E3FAAD28206
59	98EE1415F026AC0E862C520451697DD0
60	6A0528AEA4B7CD6702660D81F8821E19
61	763D626A87C603BCB09E1A4C800A378F
62	EEA61897879289340C23F669D6A03762
63	A6571B3CC2D0E04F017ACC808B92DCE7
64	DDF88B52EA1831D293A803CF23C8C471
65	6CA4D333A2684140475DAB491F61C17A
66	A7D2AD23043989A13289F7C3E135580A
67	B1C752FA66B41C81904EDE27EA000E2E
68	8694BE3CC1CB36BE2A095F89CC619080
69	9C20334E1BBC596B25E151180BF99940
70	484256214F81070DD9C49A2B05A43DCE
71	401A20BCBE29B7438A7AEE44635A9E23
72	8858585C3239CBF628033FA0DF189378
73	EFA36404C1BA5118CC5F9052FD28D9C3
74	155609873D8A042D496E6477B747C4F8
75	8446077883A6D7D2549CC9742E3FD023
76	E630142B189AA209371A6F0FFDBC30A7
77	C46060535AC6DBB2095F1D7826D0CD5C
78	E00D19E48797148B28DEDA9D429362E2
79	645DE447E938485489416CAFCC1C571F
80	DA10AFBF2AE61C593A1D88584DE30598
81	BB248AEA5FD3FE210CD48FC401E1A686
82	A89F146BD9191F445301C081CB6F5625
83	15BBF04F247C59150208949EB6B9CC58

84	08F48BFA7804B5B2CC2E96510232E062
85	9AA2BE74005A3679C626B209580B8D03
86	9D40664A2C808F2F293E255398B37E6A
87	6869C98A8AAD81CAE41A23C83FF9EEA0
88	576E8948E61BD0927C4140C3C04C4CF3
89	0F942C67A1137B6EAA058C2A74872C73
90	9D058E27ED546C10632684BBC84E5BC1
91	79D4B840E20148B134F90B51164BCBD0
92	0E35E1D8D1214C05FAC790B69B239150
93	FFA1BB0232CD71480BE5CA1C2A269F89
94	B2956F5F4E270446F9211584792628DB
95	F56CCA23421C8EC8F8A41F7DA4A41EA2
96	0B5ECA04F1789A7148C80C39D57D05F6
97	A10B538E8A8CFC8F8925C485F2A88660
98	9925C2C715001D9FC78ACCC51DA1AF34
99	0DAC9CFDEA40429A8B12C7D320D60F70
100	377FC9A097017958440914E83118E39D
101	8421096FA8B47E4E943B6473671955CC
102	574086183477C4F68540CB7E858263B1
103	895B6A8980C6703C779F49F40C5CFC19
104	D0D253E157BC19262150CEA668679E71
105	B8889C60EBA812BD7F0B6498823296D2
106	A13FB9F3A08528E44B13C12CF0D461AA
107	8D4DCFBE43D6E2024B1F8470224AA330
108	536D159E119E0893838657B12A074E64
109	DCFD49C504AD3A2F049A0CB70238EC8A
110	D363DB4C46C11757FA8FB18139789102
111	424A1E8A1D4DA256E4CA3BC8C2201BE3
112	417B619ED30FEB0A847CC3A191A20398
113	843FBBC95453C61786D1332612B45B4D
114	F26CACC0732CF8ED0C5BC1462B1620B4
115	88E0FE440C70E9249A92A7AF94638880
116	99A52B7D8C950308057E0661D7459960
117	A5C28218BF5D16E63E42698A0A6B0896
118	B2763BEEC784A12E8C50778536921806
119	987B2B6A3A77A059B30A082457AB84E0
120	820DB500F1B206358D7A7F210AB85AA8
121	97760A5CFC5E03EB439C914590045938
122	896A720E8857C8708A59F8C94DE0841E
123	2D101F0CF95263843412577340DEBB11
124	E8E5214B4DCF5D11A245B0149D49C87C
125	51224EAA10099ACDE384834A5ADF03D8
126	64E51253554A230C186FDE4E8781BC09
127	A499E391E69ED08890AC1A82A6115BEC

128	EE54C6E1834210D3EC1B07A456B92AA8
129	949DB5CA82420B54C1E0BCC111E704D9
130	9439EE9A9E4C447D1AA350926495047F
131	AD095CC0E7438AECE38D60980B3F2D00
132	83089C254C5EE9788072BC3D9282F798
133	A27DC1A457BC5A56563D8A9B11203615
134	713053A9C0B1B08B14705FF5A7244DB4
135	D36D4B9F4007354E0EC1B0CA8C8C7124
136	82E7C990612114F1CCE1BD9509FD4386
137	C8D83FF0B48B14830D2015D53F8C0672
138	08AF223C869A36B169148FDDABB7D120
139	B6C284C600AD0A99F86C449F8F4C53A6
140	DC741B320C07682AF92AC4DBDE0C28C2
141	89B8D84FA902265850C0FA6FF0EB2C4F
142	A69445B3A52201DB984BC03D1956D7F3
143	0FE0F7224B7AD72E4D4530D0223F590C
144	1B8C06F051434048EB925133AD3BD3F9
145	E133D4C3C942726A351300C37E55D0DF
146	9E09481D1881A66F562D8B453BC83AB2
147	2397B04B60A3C5700907BDBBA4E818C8
148	8F81F7A08CC6C8DA3D692AD34F50C012
149	9AB325352981BCCFA072F8FDE3009221
150	4FA88B7F1F8A620C31B0D486C52AC2F6
151	097AF0ADD16D7D39851049F0130EE444
152	A5027732DACFF11C388D5820A4A9BA49
153	1CD981EA2EDB46218A407C7E20D4BE84
154	D0FD94279FA67EC61A3904C0AD8ACA04
155	EA73A9415EC2004D49E9D0F645961C75
156	005AF0614A7552041194DEECBF8DD016
157	B514481533DA0A731705B93CF634E40D
158	983054521841A6E4FF34B2C07B5684FE
159	C46D927D0FD2B2F509550025677C6871
160	2AD85C08127487C87ECE014D65169102
161	0F617852FA3930AA7EE74B400B2CC831
162	AE9D395004C6E27540C378625D36E0D6
163	DC4FA55750F10B0636248F12C212FFE4
164	D3602B8D6CBF1809C88B827185631ECF
165	A94825850708E7723EA8F22C44BF78B2
166	A62D231C16AEFE0B0026B306662945A
167	9C7BE810A86465A50551F89125D93B12
168	9712D9338B9CC60485C10172F50F121F
169	A3902CE0E0B9912591FF28C695728257
170	4167057891AB29473A9E0F67F3658921
171	B3368B91EC12A284BC414C8F0D7F8D20

172	EE21888101ABF06C1175828CB58B598D
173	E43923A00ECC32CCC2D162A4A44BD7F4
174	CC9E30B8538AD51703EEB6F70801AB22
175	B908AD2F1501DA1C156811736CD798CD
176	2B46302ACCC2F808797FC648A614326D
177	8A54494F1BE27235B8764023AA0FBCFA
178	BC1041E6F636421E89277DC154439103
179	275B39A63029B974E3561AE0A8FC8032
180	9283F6FE819B80492A22B85CE5CE5DC4
181	4CCB52C0CE058A78022C22DF5788CBCC
182	B0DF9608DE549A6F6C581516919A81E6
183	2CA185163CC36060D1E85BB0A7FBB988
184	66101D2846155CAC986FC790D2124EFC
185	8016E3904644D2093579B83BD7AB5071
186	531CAB7085BEC14257439658023647CF
187	DF2910165AA5051E41F6EB198E4D491C
188	BA32052042B0FB2188DE7857DA1B6788
189	9E6D075AFF0EA4153615E140BF380666
190	9ACC5A037902534642A3BE391AA40F9B
191	4D741A3B4499843010D7E5FA8988DC80
192	FA1421C96EDC6092726154560B1C2FC8
193	882946076223CAE0B0BFE3EDA59826D5
194	CEBB288C28B7472A0D3917012276C034
195	BD35A6E00C9528DB38289CF823C34F30
196	E2C93618B6B2800D51171A5F85746A55
197	B43EF39A1A64F0E220AF740F9494291B
198	AC537817C2612744A58132A8AFBC44A3
199	98A321249A821DDBF81C38235A371A14
200	AE1D46069090D81BB6B08FED9E687285
201	7EAE2415DC2CD60AE083249A33B56E05
202	3D942AAA9BC9F27289421CE0B301FB98
203	1548BA6D08530727AC6D059C005C6C42
204	FF47C21142C65B502DA70647BAE831D1
205	C83AA7FEAC5E51A08091E10DB0C233D9
206	E86EDD2EC2DAA3104229EDC43471A16A
207	22FAFB9C184B78B56EE91B6602C03244
208	E45631DC509B1290C08D2C1A1F15DBFE
209	D203C51207092B56568FDAD9E2D44473
210	2AA87F31A7D1AB1C90024F936006C4A5
211	913136153593DEABC7305BF0C5A62180
212	D8DA5FE401F2758642A082C53A6A5CB8
213	23C2295213147F324DE8EC1C103BAE88
214	883AF097FCDE82B366A1844245E0D727
215	79E5E9F8C933159ACADC22A06F900A70

216	FE40502B44A9E44B2C336250D47538CC
217	670452E19172C843176F1278FE41D584
218	B7EAA436078E6886A3024F593AD57580
219	1044D4CDD7230E7B1953AD1232DF07E2
220	4D821ECAC3D845A2E1011695624576FF
221	96622ED2FBD44D1B859D70601999F438
222	CCC31C3D6D5B41B8D82FF4522A4C0146
223	4A84F7CD62E0C712980E6A0C89BF394F
224	10E56751F000927284DBE174E68ECC4C
225	A3DE70921356F026E084CFE302A210A9
226	B12DA0621B343A8C3FE941A32EA5D571
227	D653135DE825A74B743E275C19020C71
228	5CAD301BF846B2EE921D33A3D4BB1220
229	1292445ACBB548C668FC3853578474E6
230	B94B4B89C0654688C9E007D9061DF5FE
231	75A2C91E76061A8680884E8BFD14A64A
232	83726F3070B47ECE21504A5065D74A36
233	964A471444A270840919F7FE07382D14
234	A582701EBFCA899B8497088C3560F300
235	64FCB63E21CAC63002D1E09FD1543274
236	B1E1C83F689ADF422C865F98D288838A
237	A06A0D822165D3F3416B47419ECCB547
238	1D2068039A32B7EF728914ECE07CB416
239	64C0CF81F78E8823ECC8661A5295422A
240	902A7243F593F2180E5A306A8438E6A9
241	A4CCED356D56BF1B41C28E1504301FE8
242	82AE90E2F76B3055A2E3A966025CC01A
243	8B90D5A62364E18574145C5895CEFF60
244	43F7EA1AB0D19032551AD9DE21307353
245	DD5D8424AC60360B1C14E65815C9B15E
246	C632A67382ECB2681DFB8525140E2878
247	3A6ACF212B6F8B9C53FF224C2E00C16C
248	86A90C267B1171093F362FE5CB14E3A0
249	EA262EC36E6589C3BB005426AF2590F4
250	200F03126C5B0D7B901128E7757C5F70
251	68FC090C2221AA98BF0D24E85066EFC2
252	9E26CEC67832FC42A87E92FA1015212E
253	ACD889634F79506F2582EA03240F2A07
254	AA65407E1F4A33BF9A62860A3D6A4CC0
255	B1B950AC76A608AA32D04B03C7FF24D3

Annex C (informative): Generalised Hierarchical Golay Sequences

C.1 Alternative generation

The generalised hierarchical Golay sequences for the PSC described in 7.1 may be also viewed as generated (in real valued representation) by the following methods:

Method 1.

The sequence y is constructed from two constituent sequences x_1 and x_2 of length n_1 and n_2 respectively using the following formula:

$$- y(i) = x_2(i \bmod n_2) * x_1(i \operatorname{div} n_2), i = 0 \dots (n_1 * n_2) - 1.$$

The constituent sequences x_1 and x_2 are chosen to be the following length 16 (i.e. $n_1 = n_2 = 16$) sequences:

- x_1 is defined to be the length 16 ($N^{(1)}=4$) Golay complementary sequence obtained by the delay matrix $D^{(1)} = [8, 4, 1, 2]$ and weight matrix $W^{(1)} = [1, -1, 1, 1]$.
- x_2 is a generalised hierarchical sequence using the following formula, selecting $s=2$ and using the two Golay complementary sequences x_3 and x_4 as constituent sequences. The length of the sequence x_3 and x_4 is called n_3 respectively n_4 .
- $x_2(i) = x_4(i \bmod s + s*(i \operatorname{div} sn_3)) * x_3((i \operatorname{div} s) \bmod n_3), i = 0 \dots (n_3 * n_4) - 1.$
- x_3 and x_4 are defined to be identical and the length 4 ($N^{(3)}=N^{(4)}=2$) Golay complementary sequence obtained by the delay matrix $D^{(3)} = D^{(4)} = [1, 2]$ and weight matrix $W^{(3)} = W^{(4)} = [1, 1]$.

The Golay complementary sequences x_1, x_3 and x_4 are defined using the following recursive relation:

$$a_0(k) = \delta(k) \text{ and } b_0(k) = \delta(k);$$

$$a_n(k) = a_{n-1}(k) + W_n^{(j)} \cdot b_{n-1}(k - D_n^{(j)});$$

$$b_n(k) = a_{n-1}(k) - W_n^{(j)} \cdot b_{n-1}(k - D_n^{(j)});$$

$$k = 0, 1, 2, \dots, 2^{*}N^{(j)} - 1;$$

$$n = 1, 2, \dots, N^{(j)}.$$

The wanted Golay complementary sequence x_j is defined by a_n assuming $n=N^{(j)}$. The Kronecker delta function is described by δ, k, j and n are integers.

Method 2

The sequence y can be viewed as a pruned Golay complementary sequence and generated using the following parameters which apply to the generator equations for a and b above:

$$(a) \text{ Let } j = 0, N^{(0)} = 8.$$

$$(b) [D_1^0, D_2^0, D_3^0, D_4^0, D_5^0, D_6^0, D_7^0, D_8^0] = [128, 64, 16, 32, 8, 1, 4, 2].$$

$$(c) [W_1^0, W_2^0, W_3^0, W_4^0, W_5^0, W_6^0, W_7^0, W_8^0] = [1, -1, 1, 1, 1, 1, 1, 1].$$

$$(d) \text{ For } n = 4, 6, \text{ set } b_4(k) = a_4(k), b_6(k) = a_6(k).$$

CHANGE REQUEST

⌘ **25.224** **CR 081** ⌘ rev **1** ⌘ Current version: **4.3.0** ⌘

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Proposed change affects: ⌘ (U)SIM ME/UE Radio Access Network Core Network

Title:	⌘ Power Control and Procedures for HSDPA		
Source:	⌘ TSG RAN WG1		
Work item code:	⌘ AH32 HSDPA	Date:	⌘ February 15, 2002
Category:	⌘ B	Release:	⌘ REL-5
	Use <u>one</u> of the following categories: F (correction) A (corresponds to a correction in an earlier release) B (addition of feature), C (functional modification of feature) D (editorial modification) Detailed explanations of the above categories can be found in 3GPP TR 21.900.		Use <u>one</u> of the following releases: 2 (GSM Phase 2) R96 (Release 1996) R97 (Release 1997) R98 (Release 1998) R99 (Release 1999) REL-4 (Release 4) REL-5 (Release 5)

Reason for change:	⌘ The requirements for implementation of HSDPA were not in the specifications. .		
Summary of change:	⌘ <ol style="list-style-type: none"> 1. Acronym list is updated. 2. Sections for power control setting for HS-SICH, HS-PSDCH and HS-SCCH are added. 3. Sections describing the HS-DSCH procedure and measurement feedback procedures are added. 4. HS-PDSCH and HS-SICH are added as possible candidates for TxD. 		
Consequences if not approved:	⌘ HSDPA will not be part of REL-5		

Clauses affected:	⌘ 3, 4.2.2.4 (new), 4.2.3.6 (new), 4.2.3.7(new), 4.6.1, 4.11(new), 4.11.1 (new) 5.1.1.5 (new), 5.1.2.5 (new), 5.1.2.6 (new), 5.5.1, 5.7, (new), 5.7.1(new)		
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Keywords

UMTS, radio, layer 1

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Foreword

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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
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1 Scope

The present document describes the Physical Layer Procedures in the TDD mode of UTRA.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TS 25.201: "Physical layer - general description".
- [2] 3GPP TS 25.102: "UE physical layer capabilities".
- [3] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".
- [4] 3GPP TS 25.212: "Multiplexing and channel coding (FDD)".
- [5] 3GPP TS 25.213: "Spreading and modulation (FDD)".
- [6] 3GPP TS 25.214: "Physical layer procedures (FDD)".
- [7] 3GPP TS 25.215: "Physical Layer - Measurements (FDD)".
- [8] 3GPP TS 25.221: "Physical channels and mapping of transport channels onto physical channels (TDD)".
- [9] 3GPP TS 25.222: "Multiplexing and channel coding (TDD)".
- [10] 3GPP TS 25.223: "Spreading and modulation (TDD)".
- [11] 3GPP TS 25.225: "Physical Layer - Measurements (TDD)".
- [12] 3GPP TS 25.301: "Radio Interface Protocol Architecture".
- [13] 3GPP TS 25.302: "Services Provided by the Physical Layer".
- [14] 3GPP TS 25.401: "UTRAN Overall Description".
- [15] 3GPP TS 25.331: "RRC Protocol Specification"
- [16] 3GPP TS 25.433: "UTRAN Iub Interface NBAP Signalling"
- [17] 3GPP TS 25.105: "UTRA (BS) TDD; Radio transmission and Reception"
- [18] 3GPP TS 25.321: "MAC protocol specification"
- [19] 3GPP TS 25.303: "Interlayer Procedures in Connected Mode"
- [20] 3GPP TS 25.402: "Synchronisation in UTRAN Stage 2"

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACK	Acknowledgement
ASC	Access Service Class
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
CCTrCH	Coded Composite Transport Channel
CDMA	Code Division Multiple Access
CQI	Channel Quality Information
CRC	Cyclic Redundancy Check
DCA	Dynamic Channel Allocation
DL	Downlink
DPCH	Dedicated Physical Channel
DTX	Discontinuous Transmission
FACH	Forward Access Channel
FDD	Frequency Division Duplex
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	Shared Control Channel for HS-DSCH
HS-SICH	Shared Information Channel for HS-DSCH
ISCP	Interference Signal Code Power
MAC	Medium Access Control
NACK	Negative Acknowledgement
NRT	Non-Real Time
P-CCPCH	Primary Common Control Physical Channel
PC	Power Control
PDSCH	Physical Downlink Shared Channel
PRACH	Physical Random Access Channel
PUSCH	Physical Uplink Shared Channel
RACH	Random Access Channel
RL	Radio Link
RRC	Radio Resource Control
RSCP	Received Signal Code Power
RT	Real Time
RU	Resource Unit
SBGP	Special Burst Generation Gap
SBP	Special Burst Period
SBSP	Special Burst Scheduling Period
S-CCPCH	Secondary Common Control Physical Channel
SCH	Synchronisation Channel
SCTD	Space Code Transmit Diversity
SFN	System Frame Number
SIR	Signal-to-Interference Ratio
SSCH	Secondary Synchronisation Channel
STD	Selective Transmit Diversity
TA	Timing Advance
TDD	Time Division Duplex
TF	Transport Format
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TFCS	Transport Format Combination Set
TFRC	Transport Format Resource Combination
TFRI	Transport Format Resource Indicator
TPC	Transmit Power Control
TSTD	Time Switched Transmit Diversity
TTI	Transmission Time Interval
TxAA	Transmit Adaptive Antennas
UE	User Equipment
UL	Uplink

UMTS	Universal Mobile Telecommunications System
UTRAN	UMTS Radio Access Network
VBR	Variable Bit Rate

4 Physical layer procedures for the 3,84 Mcps option

4.1 General

4.2 Transmitter Power Control

4.2.1 General Parameters

Power control is applied for the TDD mode to limit the interference level within the system thus reducing the intercell interference level and to reduce the power consumption in the UE.

All codes within one timeslot allocated to the same CCTrCH use the same transmission power, in case they have the same spreading factor.

Table 1: Transmit Power Control characteristics

	Uplink	Downlink
Power control rate	Variable 1-7 slots delay (2 slot SCH) 1-14 slots delay (1 slot SCH)	Variable, with rate depending on the slot allocation.
TPC Step size	--	1dB or 2 dB or 3 dB
Remarks	All figures are without processing and measurement times	

4.2.2 Uplink Control

4.2.2.1 General Limits

During the operation of the uplink power control procedure the UE transmit power shall not exceed a maximum allowed value which is the lower out of the maximum output power of the terminal power class and a value which may be set by higher layer signalling.

Uplink power control shall be performed while the total UE transmit power is below the maximum allowed output power. In some cases the total UE transmit power in a timeslot after uplink power control calculation might exceed the maximum allowed output power. In these cases the calculated transmit power of all uplink physical channels in this timeslot shall be scaled by the same amount in dB before transmission. The total UE transmission power used shall be the maximum allowed output power.

The UTRAN may not expect the UE to be capable of reducing its total transmit power below the minimum level specified in [2].

4.2.2.2 PRACH

The transmit power for the PRACH is set by higher layers based on open loop power control as described in [15].

4.2.2.3 DPCH, PUSCH and HS-SICH

The transmit power for DPCH, and PUSCH and HS-SICH is set by higher layers based on open loop power control as described in [15].

In the case that a NAK is being transmitted on the HS-SICH, the UE shall apply a power offset to the transmit power of the entire HS-SICH. This power offset shall be signalled by higher layers.

4.2.2.3.1 Gain Factors

Two or more transport channels may be multiplexed onto a CCTrCH as described in [9]. These transport channels undergo rate matching which involves repetition or puncturing. This rate matching affects the transmit power required to obtain a particular E_b/N_0 . Thus, the transmission power of the CCTrCH shall be weighted by a gain factor β .

There are two ways of controlling the gain factors for different TFC's within a CCTrCH transmitted in a radio frame:

- β is signalled for the TFC, or
- β is computed for the TFC, based upon the signalled settings for a reference TFC.

Combinations of the two above methods may be used to associate β values to all TFC's in the TFCS for a CCTrCH. The two methods are described in sections 4.2.2.3.1.1 and 4.2.2.3.1.2 respectively. Several reference TFC's for several different CCTrCH's may be signalled from higher layers.

The weight and gain factors may vary on a radio frame basis depending upon the current SF and TFC used. The setting of weight and gain factors is independent of any other form of power control. That means that the transmit power P_{UL} is calculated according to the formula given in [15] and then the weight and gain factors are applied on top of that, cf. [10].

4.2.2.3.1.1 Signalled Gain Factors

When the gain factor β_j is signalled by higher layers for a certain TFC, the signalled values are used directly for weighting DPCH or PUSCH within a CCTrCH. Exact values are given in [10].

4.2.2.3.1.2 Computed Gain Factors

The gain factor β_j may also be computed for certain TFCs, based on the signalled settings for a reference TFC:

Let β_{ref} denote the signalled gain factor for the reference TFC. Further, let β_j denote the gain factor used for the j -th TFC.

Define the variable:
$$K_{ref} = \sum_i RM_i \cdot N_i$$

where RM_i is the semi-static rate matching attribute for transport channel i , N_i is the number of bits output from the radio frame segmentation block for transport channel i and the sum is taken over all the transport channels i in the reference TFC.

Similarly, define the variable
$$K_j = \sum_i RM_i \cdot N_i$$

where the sum is taken over all the transport channels i in the j -th TFC.

Moreover, define the variable
$$L_{ref} = \sum_i \frac{1}{SF_i}$$

where SF_i is the spreading factor of DPCH or PUSCH i and the sum is taken over all DPCH or PUSCH i used in the reference TFC.

Similarly, define the variable
$$L_j = \sum_i \frac{1}{SF_i}$$

where the sum is taken over all DPCH or PUSCH i used in the j -th TFC.

Then the variable A_j , called the nominal power relation for TFC j , is computed as:

$$A_j = \sqrt{\frac{L_j}{L_{ref}}} \times \sqrt{\frac{K_{ref}}{K_j}}$$

The gain factors β_j for the j -th TFC are then computed as follows:

- If $A_j > 1$, then β_j is the largest quantized β -value, for which the condition $\beta_j \leq 1 / A_j$ holds.
- If $A_j \leq 1$, then β_j is the smallest quantized β -value, for which the condition $\beta_j \geq 1 / A_j$ holds.

The quantized β -values are given in [10].

4.2.2.3.2 Out of synchronisation handling

As stated in 4.2.3.3, the association between TPC commands sent on uplink DPCH and PUSCH, with the power controlled downlink DPCH and PDSCH is signaled by higher layers. In the case of multiple DL CCTrCHs it is possible that an UL CCTrCH will provide TPC commands to more than one DL CCTrCH.

In the second phase of synchronisation evaluation, as defined in 4.4.2.1.2, the UE shall shut off the transmission of an UL CCTrCH if the following criteria are fulfilled for any one of the DL CCTrCHs commanded by its TPC:

- The UE estimates the received dedicated channel burst quality over the last 160 ms period to be worse than a threshold Q_{out} , and in addition, no special burst, as defined in 4.5, is detected with quality above a threshold, Q_{sbout} . Q_{out} and Q_{sbout} are defined implicitly by the relevant tests in [2]. If the UE detects the beacon channel reception level [10 dB] above the handover triggering level, then the UE shall use a 320 ms estimation period for the burst quality evaluation and for the Special Burst detection window.

UE shall subsequently resume the uplink transmission of the CCTrCH if the following criteria are fulfilled:

- The UE estimates the received dedicated CCTrCH burst reception quality over the last 160 ms period to be better than a threshold Q_{in} or the UE detects a burst with quality above threshold Q_{sbin} and TFCI decoded to be that of the Special Burst. Q_{in} and Q_{sbin} are defined implicitly by the relevant tests in [2]. If the UE detects the beacon channel reception level [10 dB] above the handover triggering level, then the UE shall use a 320 ms estimation period for the burst quality evaluation and for the Special Burst detection window.

4.2.3 Downlink Control

4.2.3.1 P-CCPCH

The Primary CCPCH transmit power is set by higher layer signalling and can be changed based on network conditions on a slow basis. The reference transmit power of the P-CCPCH is broadcast on BCH or individually signalled to each UE.

4.2.3.2 S-CCPCH, PICH

The relative transmit power of the Secondary CCPCH and the PICH compared to the P-CCPCH transmit power are set by higher layer signalling. The PICH power offset relative to the P-CCPCH reference power is signalled on the BCH.

4.2.3.3 SCH

The SCH transmit power is set by higher layer signalling [16]. The value is given relative to the power of the P-CCPCH.

4.2.3.4 PNBSCH

The PNBSCH transmit power is set by higher layer signalling [16]. The value given is relative to the power of the P-CCPCH

4.2.3.5 DPCH, PDSCH

The initial transmission power of the downlink DPCH and the PDSCH shall be set by the network. If associated uplink CCTrCHs for TPC commands are signalled to the UE by higher layers (mandatory for a DPCH), the network shall transit into inner loop power control after the initial transmission. The UE shall then generate TPC commands to control the network transmit power and send them in the TPC field of the associated uplink CCTrCHs. An example on how to derive the TPC commands and the definition of the inner loop power control are given in Annex A.1. A TPC command sent in an uplink CCTrCH controls all downlink DPCHs or PDSCHs to which the associated downlink CCTrCH is mapped to.

In the case that no associated downlink data is scheduled within 15 timeslots before the transmission of a TPC command then this is regarded as a transmission pause. The TPC commands in this case shall be derived from measurements on the P-CCPCH. An example solution for the generation of the TPC command for this case is given in Annex A 1.

Each TPC command shall always be based on all associated downlink transmissions received since the previous related TPC command. Related TPC commands are defined as TPC commands associated with the same downlink CCTrCHs. If there are no associated downlink transmissions between two or more uplink transmissions carrying related TPC commands, then these TPC commands shall be identical and they shall be regarded by the UTRAN as a single TPC command. This rule applies both to the case where the TPC commands are based on measurements on the associated CCTrCH or, in the case of a transmission pause, on the P-CCPCH.

As a response to the received TPC command, UTRAN may adjust the transmit power. When the TPC command is judged as "down", the transmission power may be reduced by the TPC step size, whereas if judged as "up", the transmission power may be raised by the TPC step size.

The UTRAN may apply an individual offset to the transmission power in each timeslot according to the downlink interference level at the UE.

The transmission power of one DPCH or PDSCH shall not exceed the limits set by higher layer signalling by means of Maximum_DL_Power (dB) and Minimum_DL_Power (dB). The transmission power is defined as the average power over one timeslot of the complex QPSK symbols of a single DPCH or PDSCH before spreading relative to the power of the P-CCPCH.

During a downlink transmission pause, both UE and Node B shall use the same TPC step size which is signalled by higher layers. The UTRAN may accumulate the TPC commands received during the pause. TPC commands that shall be regarded as identical may only be counted once. The initial UTRAN transmission power for the first data transmission after the pause may then be set to the sum of transmission power before the pause and a power offset according to the accumulated TPC commands. Additionally this sum may include a constant set by the operator and a correction term due to uncertainties in the reception of the TPC bits. The total downlink transmission power at the Node B within one timeslot shall not exceed Maximum Transmission Power set by higher layer signalling. If the total transmit power of all channels in a timeslot exceeds this limit, then the transmission power of all downlink DPCHs and PDSCHs shall be reduced by the same amount in dB. The value for this power reduction is determined, so that the total transmit power of all channels in this timeslot is equal to the maximum transmission power.

4.2.3.5.1 Out of synchronisation handling

When the dedicated physical channel out of sync criteria based on the received burst quality is as given in the subclause 4.4.2 then the UE shall set the uplink TPC command = "up". The CRC based criteria shall not be taken into account in TPC bit value setting.

4.2.3.6 HS-PDSCH

The HS-PDSCH power control is under the control of the NodeB.

4.2.3.7 HS-SCCH

Higher layers shall indicate the initial transmit power of the HS-SCCH. How exactly this information is taken into account in the power setting should be left to NodeB.

Following the initial transmission, the NodeB may optionally power control the HS-SCCH. This may be done using TPC commands sent by the UE in the HS-SICH. The following procedure shall be used in the UE to generate these TPC bits :

1. The UE shall be signalled a BLER target for the HS-SCCH by higher layers. The initial SIR target value shall be set autonomously by the UE.
2. The UE shall not adapt its SIR target until it has detected an HS-SCCH transmission intended for it. Errors in HS-SCCH transmissions received before this first detected transmission shall not count towards the BLER target.
3. Once the UE has detected this first HS-SCCH transmission, it may start to adapt its SIR target in order to meet the specified BLER target. For the purposes of BLER estimation, the UE shall assume that an HS-SCCH message is scheduled for it in every TTI following the first detected HS-SCCH transmission.
4. If, following the detection of the first HS-SCCH transmission intended for the UE, a period of 8 TTIs elapses during which the UE does not detect any HS-SCCH transmissions intended for it, the UE shall reset its SIR target to the initial value and shall not start adapting it again until it has detected a subsequent HS-SCCH transmission intended for it. Errors in HS-SCCH transmissions received during this period (i.e. after the last detected HS-SCCH transmission intended for the UE but before the subsequent detected HS-SCCH transmission intended for the UE) shall not count towards the BLER target.

4.3 Timing Advance

UTRAN may adjust the UE transmission timing with timing advance. The initial value for timing advance (TA_{phys}) will be determined in the UTRAN by measurement of the timing of the PRACH. The required timing advance will be represented as an 6 bit number (0-63) 'UL Timing Advance' TA_{ul} , being the multiplier of 4 chips which is nearest to the required timing advance (i.e. $TA_{phys} = TA_{ul} \times 4$ chips).

When Timing Advance is used the UTRAN will continuously measure the timing of a transmission from the UE and send the necessary timing advance value. On receipt of this value the UE shall adjust the timing of its transmissions accordingly in steps of ± 4 chips. The transmission of TA values is done by means of higher layer messages. Upon receiving the TA command the UE shall adjust its transmission timing according to the timing advance command at the frame number specified by higher layer signaling. The UE is signaled the TA value in advance of the specified frame activation time to allow for local processing of the command and application of the TA adjustment on the specified frame. Node-B is also signaled the TA value and radio frame number that the TA adjustment is expected to take place.

If TA is enabled by higher layers, after handover the UE shall transmit in the new cell with timing advance TA adjusted by the relative timing difference Δt between the new and the old cell:

$$TA_{new} = TA_{old} + 2\Delta t.$$

4.4 Synchronisation procedures

4.4.1 Cell Search

During the cell search, the UE searches for a cell and determines the downlink scrambling code, basic midamble code and frame synchronisation of that cell. How cell search is typically done is described in Annex C.

4.4.2 Dedicated channel synchronisation

4.4.2.1 Synchronisation primitives

4.4.2.1.1 General

For the dedicated channels, synchronisation primitives are used to indicate the synchronisation status of radio links, both in uplink and downlink. The definition of the primitives is given in the following subclauses.

4.4.2.1.2 Downlink synchronisation primitives

Layer 1 in the UE shall check the synchronization status of each DL CCTrCH individually in every radio frame. All bursts and transport channels of a CCTrCH shall be taken into account. Synchronisation status is indicated to higher layers, using the CPHY-Sync-IND or CPHY-Out-of-Sync-IND primitives. For dedicated physical channels configured with Repetition Periods [15] only the configured active periods shall be taken into account in the estimation. The status check shall also include detection of the Special Bursts defined in 4.5 for DTX.

The criteria for reporting synchronization status are defined in two different phases.

The first phase lasts until 160 ms after the downlink CCTrCH is considered to be established by higher layers. During this time, Out-of-sync shall not be reported. In-sync shall be reported using the CPHY-Sync-IND primitive if any one of the following three criteria is fulfilled.

- a) The UE estimates the burst reception quality over the previous 40 ms period to be better than a threshold Q_{in} . This criterion shall be assumed not to be fulfilled before 40 ms of burst reception quality measurement have been collected.
- b) At least one transport block with a CRC attached is received in a TTI ending in the current frame with correct CRC.
- c) The UE detects at least one Special Burst. Special Burst detection shall be successful if the burst is detected with quality above a threshold, Q_{sbin} , and the TFCI is decoded to be that of the Special Burst.

The second phase starts 160 ms after the downlink dedicated channel is considered established by higher layers. During this phase both Out-of-Sync and In-Sync are reported as follows.

Out-of-sync shall be reported using the CPHY-Out-of-Sync-IND primitive if all three of the following criteria are fulfilled:

- the UE estimates the received dedicated channel burst quality over the last 160 ms period to be worse than a threshold Q_{out} . The value, Q_{out} is defined implicitly by the relevant tests in [2];
- no Special Burst is detected with quality above a threshold Q_{sbout} within the last 160 ms period. The value Q_{sbout} is defined implicitly by the relevant tests in [2];
- over the previous 160 ms, no transport block has been received with a correct CRC

If the UE detects the beacon channel reception level [10 dB] above the handover triggering level, the UE shall use 320 ms estimation period for the burst quality evaluation and for the Special Burst and CRC detection window.

In-sync shall be reported using the CPHY-Sync-IND primitive if any of the following criteria is fulfilled:

- the UE estimates the received burst reception quality over the last 160 ms period to be better than a threshold Q_{in} . The value, Q_{in} is defined implicitly by the relevant tests in [2].
- the UE detects at least one Special Burst with quality above a threshold Q_{sbin} within the last 160 ms period. The value, Q_{sbin} , is defined implicitly by the relevant tests in [2].
- at least one transport block with a CRC attached is received in a TTI ending in the current frame with correct CRC.

If the UE detects the beacon channel reception level [10 dB] above the handover triggering level, the UE uses 320 ms estimation period for the burst quality evaluation and for the Special Burst detection window.

If no data are provided by higher layers for transmission during the second phase on the downlink dedicated channel then DTX shall be applied as defined in section 4.5.

How the primitives are used by higher layers is described in [15]. The above definitions may lead to radio frames where neither the In-Sync or Out-of-Sync primitives are reported.

4.4.2.1.3 Uplink synchronisation primitives

Layer 1 in the Node B shall every radio frame check synchronisation status, individually for each UL CCTrCH of the radio link. Synchronisation status is indicated to the RL Failure/Restored triggering function using either the CPHY-Sync-IND or CPHY-Out-of-Sync-IND primitive.

The exact criteria for indicating in-sync/out-of-sync is not subject to specification, but could e.g. be based on received burst quality or CRC checks. One example would be to have the same criteria as for the downlink synchronisation status primitives.

4.4.2.2 Radio link monitoring

4.4.2.2.1 Downlink radio link failure

The downlink CCTrCHs are monitored by the UE, to trigger radio link failure procedures. The downlink CCTrCH failure status is specified in [15], and is based on the synchronisation status primitives CPHY-Sync-IND and CPHY-Out-of-Sync-IND, indicating in-sync and out-of-sync respectively. These primitives shall provide status for each DL CCTrCH separately.

4.4.2.2.2 Uplink radio link failure/restore

The uplink CCTrCHs are monitored by the Node B in order to trigger CCTrCH failure/restore procedures. The uplink CCTrCH failure/restore status is reported using the synchronisation status primitives CPHY-Sync-IND and CPHY-Out-of-Sync-IND, indicating in-sync and out-of-sync respectively.

When the CCTrCH is in the in-sync state, Node B shall start timer T_RLFAILURE after receiving N_OUTSYNC_IND consecutive out-of-sync indications. Node B shall stop and reset timer T_RLFAILURE upon receiving successive N_INSYNC_IND in-sync indications. If T_RLFAILURE expires, Node B shall indicate to higher layers which CCTrCHs are out-of-sync using the synchronization status primitives. Furthermore, the CCTrCH state shall be changed to the out-of-sync state.

When a CCTrCH is in the out-of-sync state, after receiving N_INSYNC_IND successive in-sync indications Node B shall indicate that the CCTrCH has re-established synchronisation and the CCTrCH's state shall be changed to the in-sync-state. The specific parameter settings (values of T_RLFAILURE, N_OUTSYNC_IND, and N_INSYNC_IND) are configurable, see [16].

4.5 Discontinuous transmission (DTX) of Radio Frames

DTX is applied to CCTrCHs mapped to dedicated and shared physical channels (PUSCH, PDSCH, UL DPCH and DL DPCH), if the total bit rate of the CCTrCH differs from the total channel bit rate of the physical channels allocated to this CCTrCH.

Rate matching is used in order to fill resource units completely, that are only partially filled with data. In the case that after rate matching and multiplexing no data at all is to be transmitted in a resource unit the complete resource unit is discarded from transmission. This applies also to the case where only one resource unit is allocated and no data has to be transmitted.

4.5.1 Use of Special Bursts for DTX

In case there are no transport blocks provided for transmission by higher layers for any given CCTrCH after link establishment, then a Special Burst shall be transmitted in the first allocated frame of the transmission pause. If, including the first frame, there is a consecutive period of Special Burst Period (SBP) frames without transport blocks provided by higher layers, then another special burst shall be generated and transmitted at the next possible frame. This pattern shall be continued until transport blocks are provided for the CCTrCH by the higher layers. SBP shall be provided by higher layers. The value of SBP shall be independently specified for uplink and for downlink and shall be designated as

SBGP (special burst generation period) for uplink transmissions

SBSP (special burst scheduling parameter) for downlink transmissions

The default value for both SBGP and SBSP shall be 8.

This special burst shall have the same slot format as the burst used for data provided by higher layers. The special burst is filled with an arbitrary bit pattern, contains a TFCI and TPC bits if inner loop PC is applied and is transmitted for each CCTrCH individually on the physical channel which is defined to carry the TFCI. The TFCI of the special burst is filled with "0" bits. The transmission power of the special burst shall be the same as that of the substituted physical channel of the CCTrCH carrying the TFCI.

4.5.2 Use of Special Bursts for Initial Establishment / Reconfiguration

Upon initial establishment or reconfiguration for either 160 ms following detection of in-sync, or until the first transport block is received from higher layers, both the UE and the Node B shall transmit the special burst for each CCTrCH for each assigned resource which was scheduled to include a TFCI.

4.6 Downlink Transmit Diversity

Downlink transmit diversity for PDSCH, DPCH, P-CCPCH, and SCH is optional in UTRAN. Its support is mandatory at the UE.

4.6.1 Transmit Diversity for PDSCH and DPCH

The transmitter structure to support transmit diversity for PDSCH and DPCH transmission is shown in figure 1. Channel coding, interleaving and spreading are done as in non-diversity mode. The spread complex valued signal is fed to both TX antenna branches, and weighted with antenna specific weight factors w_1 and w_2 . The weight factors are complex valued signals (i.e., $w_i = a_i + jb_i$), in general. These weight factors are calculated on a per slot and per user basis.

The weight factors are determined by the UTRAN. Examples of transmit diversity schemes are given in annex B.

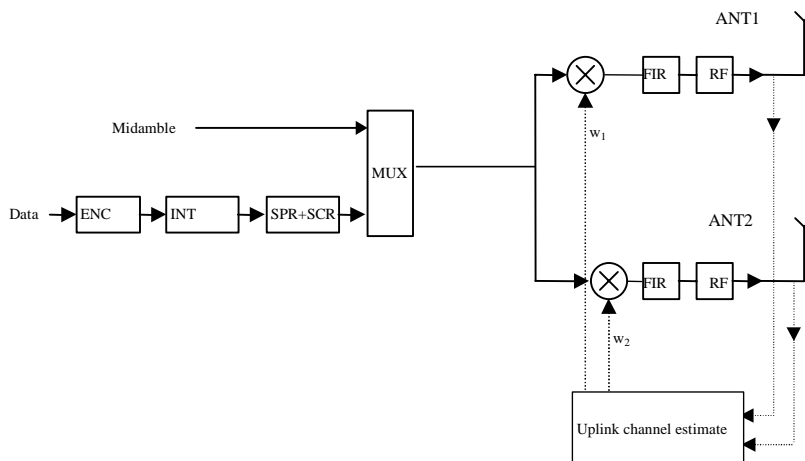


Figure 1: Downlink transmitter structure to support Transmit Diversity for PDSCH and DPCH transmission (UTRAN Access Point)

4.6.2 Transmit Diversity for SCH

Time Switched Transmit Diversity (TSTD) can be employed as transmit diversity scheme for the synchronisation channel.

4.6.2.1 SCH Transmission Scheme

The transmitter structure to support transmit diversity for SCH transmission is shown in figure 2. P-SCH and S-SCH are transmitted from antenna 1 and antenna 2 alternatively. An example for the antenna switching pattern is shown in figure 3.

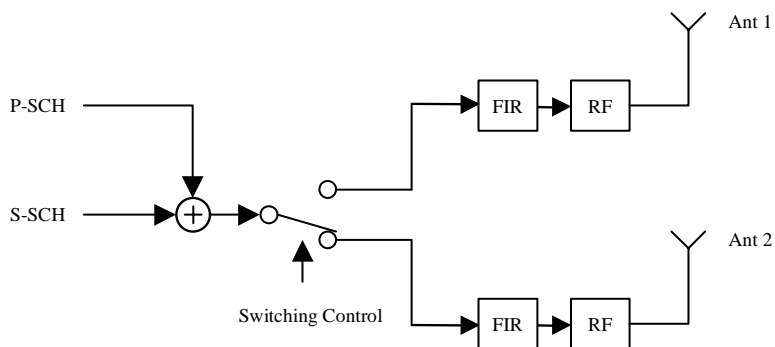


Figure 2: Downlink transmitter structure to support Transmit Diversity for SCH transmission (UTRAN Access Point)

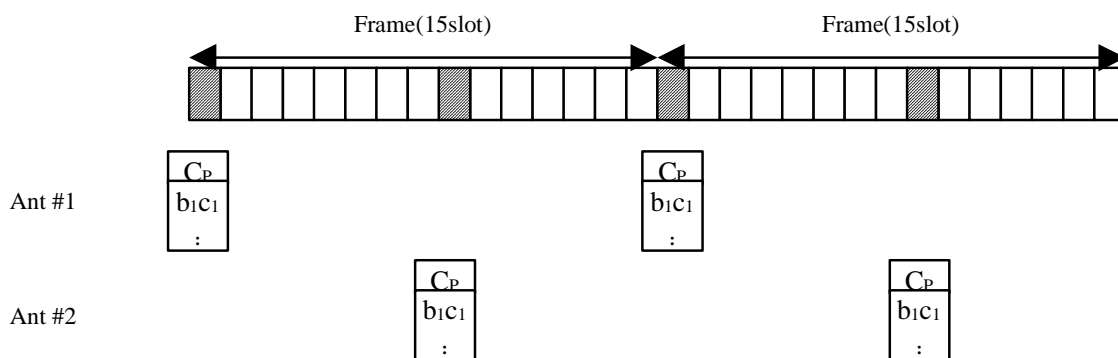


Figure 3: Antenna Switching Pattern (Case 2)

4.6.3 Transmit Diversity for P-CCPCH and PICH

Space Code Transmit Diversity (SCTD) for the P-CCPCH and PICH may be employed optionally in the UTRAN. The support is mandatory in the UE. The use of SCTD for the P-CCPCH and PICH will be indicated by higher layers. If SCTD is applied to the P-CCPCH then it is also applied to the PICH. Otherwise it is not applied to either.

4.6.3.1 P-CCPCH Transmission Scheme

The open loop downlink transmit diversity scheme for the P-CCPCH is shown in figure 4. Channel coding, rate matching, interleaving and bit-to-symbol mapping are performed as in the non-diversity mode. In Space Code Transmit Diversity mode the data sequence is spread with the channelisation codes $c_{16}^{(k=1)}$ and $c_{16}^{(k=2)}$ and scrambled with the cell specific scrambling code. The spread sequence on code $c_{16}^{(k=2)}$ is then transmitted on the diversity antenna. The power applied to each antenna shall be equal.

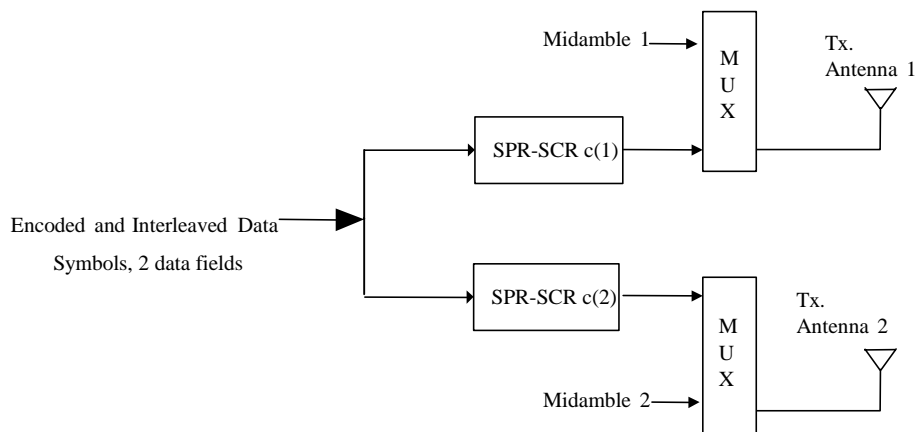


Figure 4: Block Diagram of the transmitter SCTD

4.6.3.2 PICH Transmission Scheme

The transmission scheme for the PICH shall be identical to that of the P-CCPCH, but the channelisation code and midamble assignment depends on whether the PICH is a beacon channel:

- If the PICH is a beacon channel, then the channelisation codes and midambles are identical to that of the P-CCPCH.
- If the PICH is not a beacon channel, then the channelisation codes are assigned by higher layers and the midambles that are associated with these codes by default shall be used, see [8]. The higher layers assign only the code for the first antenna, the code for the second antenna is $m+1$, where m is a code assigned for the first antenna.

4.7 Random access procedure

The physical random access procedure described below is invoked whenever a higher layer requests transmission of a message on the RACH. The physical random access procedure is controlled by primitives from RRC and MAC. Retransmission on the RACH in case of failed transmission (e.g. due to a collision) is controlled by higher layers. Thus, the backoff algorithm and associated handling of timers is not described here. The definition of the RACH in terms of PRACH sub-channels and associated Access Service Classes is broadcast on the BCH in each cell. Parameters for common physical channel uplink outer loop power control are also broadcast on the BCH in each cell. The UE needs to decode this information prior to transmission on the RACH. Higher layer signalling may indicate, that in some frames a timeslot shall be blocked for RACH uplink transmission.

4.7.1 PRACH sub-channels

A PRACH is defined by a timeslot and a channelization code, which is randomly selected from the PRACH Channelisation Code List [15] signaled by higher layers. In order to separate different ASCs each PRACH has N sub-channels associated with it (numbered from 0 to $N-1$). N may be assigned the value 1,2,4, or 8 by higher layer signaling. Sub-channel i for a PRACH defined in timeslot k is defined as the k :th slot in the frames where $\text{SFN} \bmod N = i$. Therefore follows the definition:

- Sub-channel i associated to a PRACH defined in timeslot k is defined as the k :th timeslot in the frames where $\text{SFN} \bmod N = i$.

Figure 5 illustrates the eight possible subchannels for the case, $N=8$. For illustration, the figure assumes that the PRACH is assigned timeslot 3.

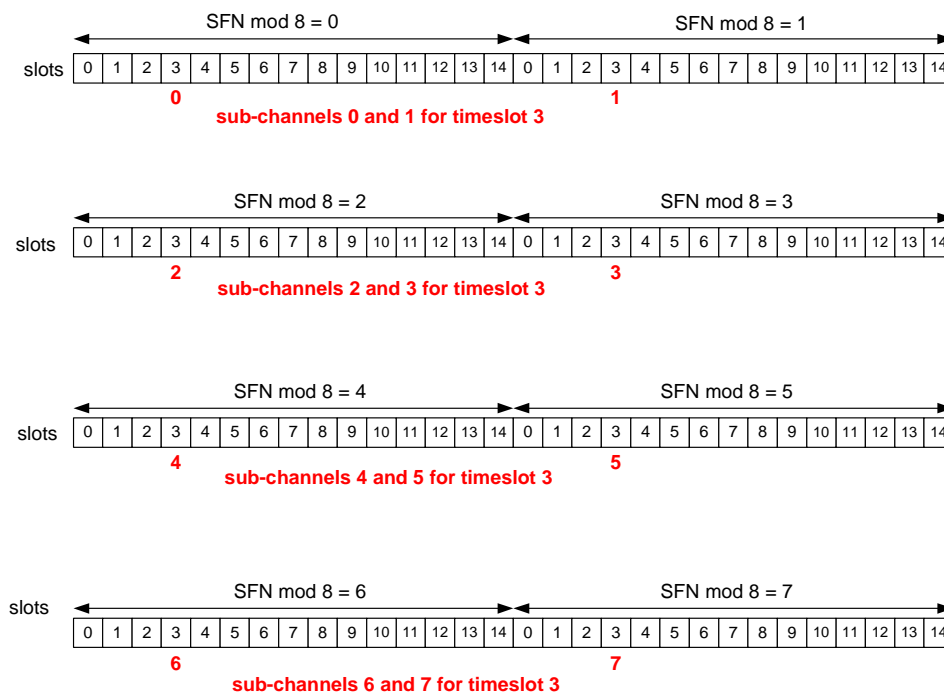


Figure 5: Eight sub-channels for timeslot 3

4.7.2 Physical random access procedure

The physical random access procedure described in this subclause is initiated upon request from the MAC sublayer (see [18] and [19]).

Note: The selection of a PRACH is done by the RRC Layer.

Before the physical random-access procedure can be initiated, Layer 1 shall receive the following information from the RRC layer using the primitives CPHY-TrCH-Config-REQ and CPHY-RL-Setup/Modify-REQ.

- the available PRACH sub-channels and channelization codes (There is a 1-1 mapping between the channelization code and the midamble shift as defined by RRC) for each Access Service Class (ASC) of the selected PRACH (the selection of a PRACH is done by the RRC). CPHY-RL-Setup/Modify-REQ);
- the timeslot, spreading factor, and midamble type(direct or inverted) for the selected PRACH (CPHY-RL-Setup/Modify-REQ);
- the RACH Transport Format (CPHY-TrCH-Config-REQ);
- the RACH transport channel identity (CPHY-TrCH-Config-REQ)
- the set of parameters for common physical channel uplink outer loop power control(CPHY-RL-Setup/Modify-REQ).

NOTE: The above parameters may be updated from higher layers before each physical random access procedure is initiated.

At each initiation of the physical random access procedure, Layer 1 shall receive the following information from the MAC:

- the ASC of the PRACH transmission;
- the data to be transmitted (Transport Block Set).

In addition, Layer 1 may receive information from higher layers, that a timeslot in certain frames shall be blocked for PRACH uplink transmission.

The physical random-access procedure shall be performed as follows:

- 1 Randomly select one channelization code from the set of designated codes for the selected ASC. The random function shall be such that each code is chosen with equal probability.
- 2 Determine the midamble shift to use, based on the selected channelization code.
- 3 Randomly select a sub-channel from the set of available sub-channels. The random function shall be such that each of the allowed selections is chosen with equal probability.
- 4 Set the PRACH message transmission power level according to the specification for common physical channels in uplink (see subclause 4.2.2.2).
- 5 Transmit the RACH Transport Block Set (the random access message) with no timing advance in the selected sub-channel using the selected channelization code.

4.8 DSCH procedure

The physical downlink shared channel procedure described below shall be applied by the UE when the physical layer signalling either with the midamble based signalling or TFCI based signalling is used to indicate for the UE the need for PDSCH detection. There is also a third alternative to indicate to the UE the need for the PDSCH detection and this is done by means of higher layer signalling, already described in [8].

4.8.1 DSCH procedure with TFCI indication

When the UE has been allocated by higher layers to receive data on DSCH using the TFCI, the UE shall decode the PDSCH in the following cases:

- In case of a standalone PDSCH the TFCI is located on the PDSCH itself, then the UE shall decode the TFCI and based on which data rate was indicated by the TFCI, the decoding shall be performed. The UE shall decode PDSCH only if the TFCI word decode corresponds to the TFC part of the TFCS given to the UE by higher layers.
- In case that the TFCI is located on the DCH, the UE shall decode the PDSCH frame or frames if the TFCI on the DCH indicates the need for PDSCH reception. Upon reception of the DCH time slot or time slots, the PDSCH slot (or first PDSCH slot) shall start $SFN\ n+2$ after the DCH frame containing the TFCI, where n indicates the SFN on which the DCH is received. In the case that the TFCI is repeated over several frames, the PDSCH slot shall start $SFN\ n+2$ after the frame having the DCH slot which contains the last part of the repeated TFCI.

4.8.2 DSCH procedure with midamble indication

When the UE has been allocated by higher layers to receive PDSCH based on the midamble used on the PDSCH (midamble based signalling described in [8]), the UE shall operate as follows:

- The UE shall test the midamble it received and if the midamble received was the same as indicated by higher layers to correspond to PDSCH reception, the UE shall detect the PDSCH data according to the TF given by the higher layers for the UE.
- In case of multiple time slot allocation for the DSCH indicated to be part of the TF for the UE, the UE shall receive all timeslots if the midamble of the first timeslot of PDSCH was the midamble indicated to the UE by higher layers.
- In case the standalone PDSCH (no associated DCH) contains the TFCI the UE shall detect the TF indicated by the TFCI on PDSCH.

4.9 Node B Synchronisation Procedure over the Air

An option exists to use cell sync bursts to achieve and maintain Node B synchronisation [20]. This optional procedure is based on transmissions of cell synchronisation bursts [10] in predetermined timeslots normally assigned to contain PRACH, according to an RNC schedule. Such soundings between neighbouring cells facilitate timing offset measurements by the cells. The timing offset measurements are reported back to the RNC for processing. The RNC generates cell timing updates that are transmitted to the Node Bs and cells for implementation.

When Cell Sync Bursts are used to achieve and maintain intercell Synchronisation there are three distinct phases, with a potential additional sub-phase involving late entrant cells.

4.9.1 Frequency Acquisition Phase

The frequency acquisition phase is used to bring cells of an RNS area to within frequency limits prior to initial synchronisation. No traffic is supported during this phase. In this phase cell(s) identified as master time reference shall transmit cell sync bursts [10] specified by higher layers continuously, i. e. one in every timeslot. All other cells shall listen for transmissions and shall perform frequency locking to the transmissions received. They shall signal completion of frequency acquisition to the RNC and begin continuous transmission of cell sync bursts specified by higher layers.

4.9.2 Initial Synchronisation

For Initial Phase, where no traffic is supported, the following procedure for initial synchronisation may be used to bring cells of an RNS area into synchronisation at network start up. In this phase each cell shall transmit cell sync bursts [10] according to the higher layer command. All cells use the same cell sync burst code and code offset. Each cell shall listen for transmissions from other cells. Each cell shall report the timing and received SIR of successfully detected cell sync bursts to the RNC. The RNC uses these measurements to adjust the timing of each cell to achieve the required synchronisation accuracy.

4.9.3 Steady-State Phase

The steady-state phase is used to maintain the required synchronisation accuracy. With the start of the steady-state phase, traffic is supported in a cell. A procedure that may be used for the steady-state phase involves cell sync bursts [10] that are transmitted and received without effect on existing traffic. Higher layers signal the transmit parameters, i. e. when to transmit which code and code offset, and which transmit power to use. The higher layers also signal to appropriate cells the receive parameters i. e. which codes and code offsets to measure in a certain timeslot. Upon determination of errors in timing, the RNC may adjust the timing of a cell or cells.

4.9.4 Late entrant cells

A procedure that may be used for introducing new cells into an already synchronised RNS involves the one time transmission of a single cell sync burst [10] (scheduled by higher layers) by all neighbour cells of the late entrant cell. and received by the late entrant cell. The RNC may use this information to adjust the late entrant cell sufficiently to allow the cell to enter steady state phase.

4.10 Idle periods for IPDL location method

4.10.1 General

To support time difference measurements for location services, idle periods can be created in the downlink (hence the name IPDL) during which time transmission of all channels from a Node B is temporarily ceased, except for the SCH transmission. During these idle periods the visibility of neighbour cells from the UE is improved.

The idle periods are arranged in a determined pattern according to higher layer parameters. An idle period has a duration of one time slot. During idle periods only the SCH is transmitted. No attempt is made to prevent data loss.

In general there are two modes for these idle periods:

- Continuous mode, and

- Burst mode.

In continuous mode the idle periods are active all the time. In burst mode the idle periods are arranged in bursts where each burst contains enough idle periods to allow a UE to make sufficient measurements for its location to be calculated. The bursts are separated by a period where no idle periods occur.

The time difference measurements can be performed on any channel. If the P-CCPCH falls in an idle slot, UTRAN may decide not to transmit the P-CCPCH in two consecutive frames, the first of these two frames containing the idle slot. This option is signalled by higher layers.

4.10.2 Parameters of IPDL

The following parameters are signalled to the UE via higher layers:

- IP_Status:** This is a logic value that indicates if the idle periods are arranged in continuous or burst mode.
- IP_Spacing:** The number of 10 ms radio frames between the start of a radio frame that contains an idle period and the next radio frame that contains the next idle period. Note that there is at most one idle period in a radio frame.
- IP_Start:** The number of the first frame with idle periods. In case of continuous mode IP_Start is the SFN of the first frame with idle periods and in case of burst mode IP_Start defines the number of frames after Burst_Start with the first frame with idle periods.
- IP_Slot:** The number of the slot that has to be idle [0..14].
- IP_PCCPCH:** This logic value indicates, if the P-CCPCH is switched off in two consecutive frames. The first of these two frames contains the idle period.

Additionally in the case of burst mode operation the following parameters are also communicated to the UE.

- Burst_Start:** Specifies the start of the first burst of idle periods. $256 \times \text{Burst_Start}$ is the SFN where the first burst of idle periods starts.
- Burst_Length:** The number of idle periods in a burst of idle periods.
- Burst_Freq:** Specifies the time between the start of a burst and the start of the next burst. $256 \times \text{Burst_Freq}$ is the number of radio frames between the start of a burst and the start of the next burst.

4.10.3 Calculation of idle period position

In burst mode, burst #0 starts in the radio frame with $\text{SFN} = 256 \times \text{Burst_Start}$. Burst #n starts in the radio frame with $\text{SFN} = 256 \times \text{Burst_Start} + n \times 256 \times \text{Burst_Freq}$ ($n = 0, 1, 2, \dots$). The sequence of bursts according to this formula continues up to and including the radio frame with $\text{SFN} = 4095$. At the start of the radio frame with $\text{SFN} = 0$, the burst sequence is terminated (no idle periods are generated) and at $\text{SFN} = 256 \times \text{Burst_Start}$ the burst sequence is restarted with burst #0 followed by burst #1 etc., as described above.

Continuous mode is equivalent to burst mode, with only one burst spanning the whole SFN cycle of 4096 radio frames, this burst starts in the radio frame with $\text{SFN} = 0$. In case of continuous mode the parameter IP_Start defines the first frame with idle periods.

The position of an idle period is defined by two values: IP_Frame(x) and IP_Slot. IP_Frame(x) defines the x^{th} frame within a burst that contains the idle period. IP_Slot defines the slot in that frame during which no transmission takes place except for the SCH.

The actual frame with idle periods within a burst is calculated as follows:

$$\text{IP_Frame}(x) = \text{IP_Start} + (x-1) \times \text{IP_Spacing} \text{ with } x = 1, 2, 3, \dots$$

If the parameter IP_PCCPCH is set to 1, then the P-CCPCH will not be transmitted in the frame IP_Frame(x) + 1 within a burst.

Figure 6 below illustrates the idle periods for the burst mode case, if the IP_P-CCPCH parameter is set to 0.

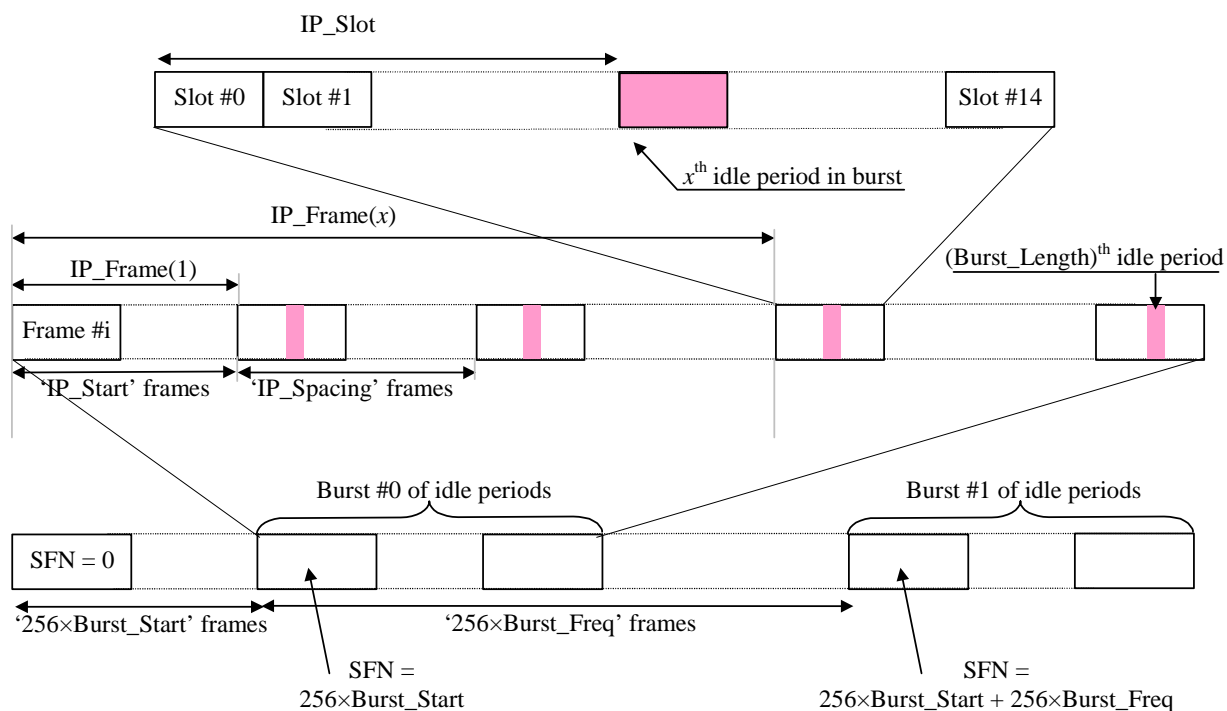


Figure 6: Idle Period placement in the case of burst mode operation with IP_P-CCPCH parameter set to 0

4.11 HS-DSCH Procedure

4.11.1 Link Adaptation Procedure

For HS-DSCH, the modulation scheme and effective code rate, may be selected by higher layers located within the Node B. This may be achieved by appropriate selection of an HS-DSCH transport format by higher layers. Selection of the transport format may be based on channel-quality feedback reported by the UE.

The overall HSDPA procedure consists of *two parts*:

Node B procedure:

- 1) The Node B shall transmit HS-SCCH carrying a UE identity identifying the UE for which HS-DSCH TTI allocation has been given. In case of HS-DSCH transmissions in consecutive TTIs to the same UE, the same HS-SCCH shall be used for associated signaling.
- 2) The Node B transmits HS-DSCH to the UE using the resources indicated in the HS-SCCH.
- 3) Upon receiving the HS-SICH from the respective UE the status report (ACK/NACK and CQI) shall be passed to higher layers.

UE procedure:

- 1) When indicated by higher layers the UE shall start monitoring all HS-SCCHs that are allocated to it. The information carried on the HS-SCCH is described in [8].
- 2) In case HS-SCCH is identified to be correct the UE shall read the HS-PDSCHs indicated by the HS-SCCH. In case HS-SCCH is identified to be incorrect the UE shall discard the data on the HS-SCCH and returns to monitoring.

- 3) After reading the HS-PDSCHs the UE shall generate an ACK/NACK message and CQI and transmits those to the NodeB in the associated HS-SICH.

4.11.2. HS-DSCH Channel Quality Indication Procedure

The quality indicator sent by the UE on the HS-SICH is a recommended Transport Format Resource Combination, TFRC. The recommended TFRC shall be based on the HS-PDSCH resources most recently received by the UE and refers to the possible transport formats and modulation schemes as configured by higher layers. Hence the channel quality indicator (CQI) consists only of the Transport Block Size and Modulation Format fields of the TFRI. The UE adopts the same mapping table for these fields as does the NodeB.

The reporting procedure is as follows:

1. The UE receives a message on an HS-SCCH telling it which resources have been allocated to it for the next associated HS-DSCH transmission.
2. The UE reads the HS-DSCH transmission, and makes the necessary measurements to derive a CQI that it estimates would give it the highest throughput for the allocated resources whilst still meeting a specified threshold BLER, $BLER_{threshold}$. The $BLER_{threshold}$ is signalled by higher layers.
3. The UE reports the most recently derived CQI to the NodeB in the next available HS_SICH.

5 Physical layer procedures for the 1,28 Mcps option

5.1 Transmitter Power Control

The basic purpose of power control is to limit the interference level within the system thus reducing the intercell interference level and to reduce the power consumption in the UE.

The main characteristics of power control are summarized in the following table.

Table 2: Transmit Power Control characteristics

	Uplink	Downlink
Power control rate	Variable Closed loop: 0-200 cycles/sec. Open loop: (about 200us – 3575us delay)	Variable Closed loop: 0-200 cycles/sec.
Step size	1,2,3 dB (closed loop)	1,2,3 dB (closed loop)
Remarks	All figures are without processing and measurement times	

Note: All codes within one timeslot allocated to the same CCTrCH use the same transmission power in case they have the same Spreading Factor.

5.1.1 Uplink Control

5.1.1.1 General limits

By means of higher layer signalling, the Maximum_Allowed_UL_TX_ power for uplink may be set to a value lower than what the terminal power class is capable of. The total transmit power shall not exceed the allowed maximum. If this would be the case, then the transmit power of all uplink physical channels in a timeslot is reduced by the same amount in dB.

5.1.1.2 UpPTS

Open loop power control is used for UpPTS.

The transmit power level by a UE on the UpPTS shall be calculated based on the following equation:

$$P_{\text{UpPTS}} = L_{\text{P-CCPCH}} + \text{PRX}_{\text{UpPTS,des}}$$

where, P_{UpPTS} : transmit power level in dBm,

$L_{\text{P-CCPCH}}$: measured path loss in dB (P-CCPCH reference transmit power level is broadcast on BCH),

$\text{PRX}_{\text{UpPTS,des}}$: desired RX power level at cell's receiver in dBm, which is an average value and is broadcast on BCH.

5.1.1.3 PRACH

In 1,28 Mcps TDD, the F-PACH is the response of a node B to the SYNC-UL burst of the UE. The response, a one burst long message, shall bring besides the acknowledgement to the received SYNC-UL burst, the timing and power level indications to prepare the transmission of the RACH burst.

The transmit power level on the PRACH is calculated by the following equation:

$$P_{\text{PRACH}} = L_{\text{P-CCPCH}} + \text{PRX}_{\text{PRACH,des}}$$

Where, P_{PRACH} is the UE transmit power level on the PRACH;

$\text{PRX}_{\text{PRACH,des}}$ is the desired receive power level on the PRACH, which is signalled by the higher layer signalling on the F-PACH.

5.1.1.4 DPCH and PUSCH

The closed loop power control makes use of layer 1 symbol in the DPCH. The power control step can take the values 1,2,3 dB within the overall dynamic range 80dB. The initial transmission power of the uplink Dedicated Physical Channel is signalled by higher layers.

Closed-loop TPC is based on SIR and the TPC processing procedures are described in this section.

The node B should estimate signal-to-interference ratio SIR_{est} of the received uplink DPCH. The node B should then generate TPC commands and transmit the commands according to the following rule: if $\text{SIR}_{\text{est}} > \text{SIR}_{\text{target}}$ then the TPC command to transmit is "down", while if $\text{SIR}_{\text{est}} < \text{SIR}_{\text{target}}$ then the TPC command to transmit is "up".

At the UE, soft decision on the TPC bits is performed, and when it is judged as 'down', the mobile transmit power shall be reduced by one power control step, whereas if it is judged as 'up', the mobile transmit power shall be raised by one power control step. A higher layer outer loop adjusts the target SIR. This scheme allows quality based power control.

The closed loop power control procedure for UL DPCH is not affected by the use of TSTD.

An example of UL power control procedure for DPCH is given in Annex A.3.

5.1.1.4.1 Out of synchronization handling

Same as that of 3,84 Mcps TDD, cf.[4.2.2.3.3 Out of synchronisation handling].

5.1.1.5 HS-SICH

The transmit power of the HS-SICH shall be set by the UE according to the procedures described below. In the case that a NAK is being transmitted on the HS-SICH, the UE shall apply a power offset to the transmit power of the entire HS-SICH. This power offset shall be signalled by higher layers.

On receipt of a TPC command in the HS-SCCH, the UE shall adjust the HS-SICH transmit power according to the power control step size specified by higher layers. However, for the first HS-SICH transmission following the first detected HS-SCCH transmission, or the first HS-SICH transmission following a gap of one or more detected HS-SCCH transmissions to the UE, the UE shall use open loop power control to set the HS-SICH transmit power for that

transmission. In this case, the transmit power of the HS-SICH, $P_{\text{HS-SICH}}$, shall be calculated using the following equation:

$$P_{\text{HS-SICH}} = L_{\text{P-CCPCH}} + \text{PRX}_{\text{HS-SICH,des}}$$

where $L_{\text{P-CCPCH}}$ is the measured pathloss from the NodeB (based on the P-CCPCH received power level) and $\text{PRX}_{\text{HS-SICH,des}}$ is the desired receive power level on the HS-SICH when an ACK is being transmitted, which shall be signalled to the UE by higher layers.

5.1.2 Downlink Control

5.1.2.1 P-CCPCH

Same as that of 3,84 Mcps TDD, cf.[4.2.3.1 P-CCPCH].

5.1.2.2 The power of the F-PACH

The transmit power for the F-PACH is set by the higher layer signalling.

5.1.2.3 S-CCPCH, PICH

Same as that of 3,84 Mcps TDD, cf.[4.2.3.2 S-CCPCH, PICH].

5.1.2.4 DPCH, PDSCH

The initial transmission power of the downlink Dedicated Physical Channel is set by the higher layer signalling until the first UL DPCH arrives. After the initial transmission, the node B transits into SIR-based closed-loop TPC.

The UE should estimate signal-to-interference ratio SIR_{est} of the received downlink DPCH. The UE should then generate TPC commands and transmit the commands according to the following rule: if $\text{SIR}_{\text{est}} > \text{SIR}_{\text{target}}$ then the TPC command to transmit is "down", while if $\text{SIR}_{\text{est}} < \text{SIR}_{\text{target}}$ then the TPC command to transmit is "up".

At the Node B, soft decision on the TPC bits is performed, and when it is judged as 'down', the transmission power may be reduced by one power control step, whereas if judged as 'up', the transmission power shall be raised by one power control step.

When TSTD is applied, the UE can use two consecutive measurements of the received SIR in two consecutive sub-frames to generate the power control command. An example implementation of DL power control procedure for 1,28 Mcps TDD when TSTD is applied is given in Annex A.3.

The transmission power of one DPCH or PDSCH shall not exceed the limits set by higher layer signalling by means of Maximum_DL_Power (dB) and Minimum_DL_Power (dB). The transmission power is defined as the average power over one timeslot of the complex QPSK (or 8PSK respectively) symbols of a single DPCH or PDSCH before spreading relative to the power of the P-CCPCH.

During a downlink transmission pause, both UE and Node B shall use the same TPC step size, which is signalled by higher layers. The UTRAN may accumulate the TPC commands received during the pause. TPC commands that shall be regarded as identical may only be counted once. The initial UTRAN transmission power for the first data transmission after the pause may then be set to the sum of transmission power before the pause and a power offset according to the accumulated TPC commands. Additionally this sum may include a constant set by the operator and a correction term due to uncertainties in the reception of the TPC bits. The total downlink transmission power at the Node B within one timeslot shall not exceed Maximum Transmission Power set by higher layer signalling. If the total transmit power of all channels in a timeslot exceeds this limit, then the transmission power of all downlink DPCHs and PDSCHs shall be reduced by the same amount in dB. The value for this power reduction is determined, so that the total transmit power of all channels in this timeslot is equal to the maximum transmission power.

5.1.2.4.1 Out of synchronisation handling

Same as that of 3,84 Mcps TDD, cf.[4.2.3.5.1 Out of synchronisation handling].

5.1.2.5 HS-PDSCH

The power control for HS-PDSCH for 1.28 Mcps TDD is the same as for 3.84 Mcps, see section 4.2.3.6

5.1.2.6 HS-SCCH

The power control for HS-SCCH for 1.28 Mcps TDD is the same as for 3.84 Mcps, see section 4.2.3.7

5.2 UL Synchronisation

5.2.1 General Description

Support of UL synchronization is mandatory for the UE.

5.2.1.1 Preparation of uplink synchronization (downlink synchronization)

When a UE is powered on, it first needs to establish the downlink synchronisation with the cell. Only after the UE has established the downlink synchronisation, it shall start the uplink synchronisation procedure.

5.2.1.2 Establishment of uplink synchronization

The establishment of uplink synchronization is done during the random access procedure and involves the UpPCH and the PRACH.

Although the UE can receive the downlink signal from the Node B, the distance to Node B is still uncertain. This would lead to unsynchronised uplink transmission. Therefore, the first transmission in the uplink direction is performed in a special time-slot UpPTS to reduce interference in the traffic time-slots.

The timing used for the UpPCH is set e.g. according to the received power level of DwPCH and/or P-CCPCH.

After the detection of the SYNC-UL sequence in the searching window, the Node B will evaluate the timing, and reply by sending the adjustment information to the UE to modify its timing for next transmission. This is done with the FPACH within the following 4 sub-frames. After sending the PRACH the uplink synchronization is established. The uplink synchronisation procedure shall also be used for the re-establishment of the uplink synchronisation when uplink is out of synchronisation.

5.2.1.3 Maintenance of uplink synchronisation

Uplink synchronization is maintained in 1,28 Mcps TDD by sending the uplink advanced in time with respect to the timing of the received downlink.

For the maintenance of the uplink synchronization, the midamble field of each uplink burst can be used.

In each uplink time slot the midamble for each UE is different. The Node B may estimate the timing by evaluating the channel impulse response of each UE in the same time slot. Then, in the next available downlink time slot, the Node B will signal Synchronisation Shift (SS) commands to enable the UE to properly adjust its Tx timing.

5.2.2 UpPCH

Open loop uplink synchronisation control is used for UpPCH.

The UE may estimate the propagation delay Δt_p based upon the path loss using the received P-CCPCH and/or DwPCH power.

The UpPCH is sent to the Node B advanced in time according to the timing of the received DwPCH. The time of the beginning of the UpPCH $T_{TX-UpPCH}$ is given by:

$$T_{TX-UpPCH} = T_{RX-DwPCH} - 2\Delta t_p + 12 \cdot 16 T_C$$

in multiple of 1/8 chips, where

$T_{TX-UpPCH}$ is the beginning time of UpPCH transmission with the UE's timing,

$T_{RX-DwPCH}$ is the received beginning time of DwPCH with the UE's timing,

$2\Delta t_p$ is the timing advance of the UpPCH ($UpPCH_{ADV}$).

5.2.3 PRACH

The Node B shall measure the received SYNC-UL timing deviation $UpPCH_{POS}$. $UpPCH_{POS}$ is sent in the FPACH and is represented as an 11 bit number (0-2047) being the multiple of 1/8 chips which is nearest to received position of the UpPCH.

Time of the beginning of the PRACH $T_{TX-PRACH}$ is given by:

$$T_{TX-PRACH} = T_{RX-PRACH} - (UpPCH_{ADV} + UpPCH_{POS} - 8 * 16 T_C)$$

in multiple of 1/8 chips, where

$T_{TX-PRACH}$ is the beginning time of PRACH transmission with the UE's timing,

$T_{RX-PRACH}$ is the beginning time of PRACH reception with the UE's timing if the PRACH was a DL channel.

5.2.4 DPCH and PUSCH

The closed loop uplink synchronisation control uses layer 1 symbols (SS commands) for DPCH and PUSCH. After establishment of the uplink synchronisation, NodeB and UE start to use the closed loop UL synchronisation control procedure. This procedure is continuous during connected mode.

The Node B will continuously measure the timing of the UE and send the necessary synchronisation shift commands in each sub-frame. On receipt of these synchronisation shift commands the UE shall adjust the timing of its transmissions accordingly, in steps of $\pm k/8$ chips or do nothing, each M sub-frames.

The default value of M (1-8) and k (1-8) is configured by higher layers.

During a 1,28 Mcps TDD to 1,28 Mcps TDD hand-over the UE shall transmit in the new cell with timing advance TA adjusted by the relative timing difference Δt between the new and the old cell if indicated by higher layers:

$$TA_{new} = TA_{old} + 2\Delta t.$$

5.2.4.1 Out of synchronization handling

Same as that of 3,84 Mcps TDD, cf.[4.2.2.3.3 Out of synchronisation handling.]

5.2.5 HS-SICH

The initial transmit timing for the HS-SICH shall be taken from that of the associated uplink DPCH. The UE shall then adjust the timing of the HS-SICH according to SS commands transmitted to it on the HS-SCCH. The step size for these commands shall be signalled to the UE by higher layers. In the case that there is a gap of one or more subframes during which no HS-SCCH transmissions, and thus no SS commands, are received by the UE, the UE shall adjust the timing of the HS-SICH according to SS commands received on the associated downlink DPCH until such time as another HS-SCCH transmission is received.

5.3 Synchronisation procedures

5.3.1 Cell search

During the initial cell search, the UE searches for a cell. It then determines the DwPTS synchronisation, scrambling code and basic midamble code, control multi-frame synchronisation and then reads the BCH. How cell search is typically done is described in Annex D.

5.3.2 DCH synchronization

The DPCH synchronisation is the same as that of 3,84 Mcps TDD, cf. [4.4.2 Dedicated channel synchronisation].

5.4 Discontinuous transmission (DTX) of Radio Frames

DTX is the same as in the 3,84 Mcps TDD option, cf. [4.5 Discontinuous transmission (DTX) of Radio Frames]. The special burst is transmitted in both consecutive subframes (subframe#1 and #2).

5.5 Downlink Transmit Diversity

Downlink transmit diversity for DPCH, P-CCPCH, and DwPTS is optional in UTRAN. Its support is mandatory at the UE.

5.5.1 Transmit Diversity for DPCH

Closed loop Transmit Diversity or Time Switched Transmit Diversity (TSTD) may be employed as transmit diversity scheme for downlink DPCH.

5.5.1.1 TSTD for DPCH

TSTD can be employed as transmit diversity scheme for downlink DPCH. An example for the transmitter structure of the TSTD transmitter is shown in figure 7. Channel coding, rate matching, interleaving, bit-to-symbol mapping, spreading, and scrambling are performed as in the non-diversity mode. Then the data is time multiplexed with the midamble sequence. Then, after pulse shaping, modulation and amplification, DPCH is transmitted from antenna 1 and antenna 2 alternately every sub-frame. Not all DPCH in the sub-frame need to be transmitted on the same antenna and not all DPCH within a sub-frame have to use TSTD. Figure 8 shows an example for the antenna switching pattern for the transmission of DPCH for the case that all physical channels are transmitted with TSTD and are using the same antenna in the sub-frame.

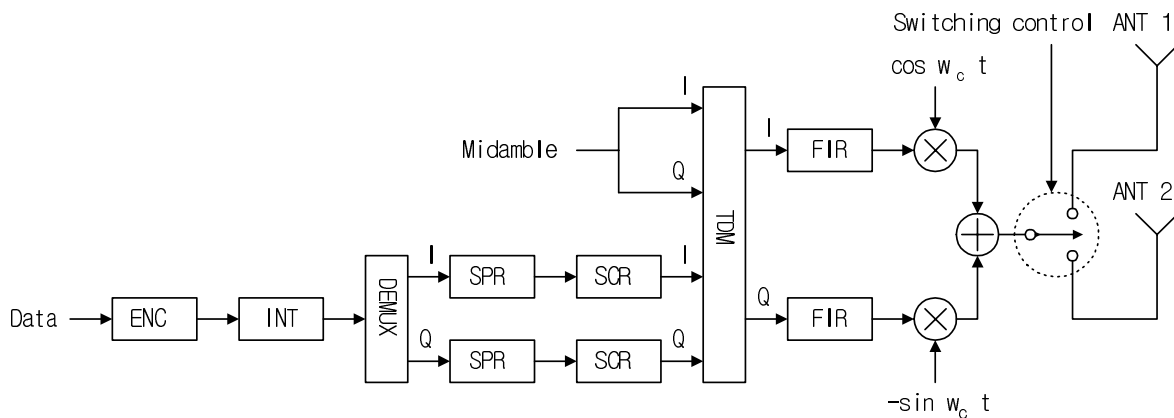


Figure 7: Example for TSTD Transmitter structure for DPCH and P-CCPCH.

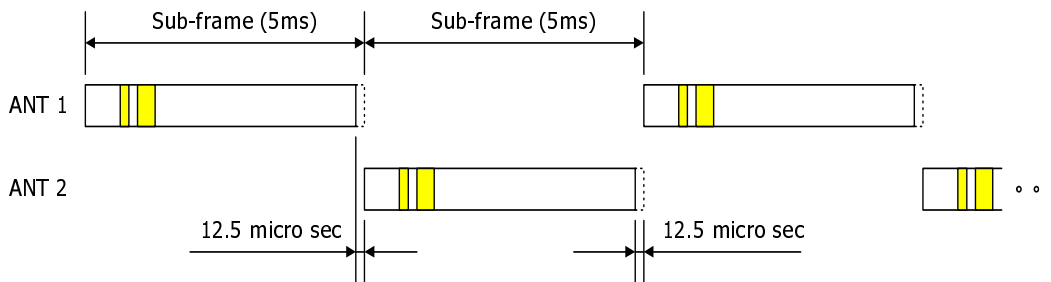


Figure 8: Example for the antenna switching pattern for TSTD transmission of DPCH and P-CCPCH: all physical channels are transmitted with TSTD and are using the same antenna in the sub-frame.

5.5.1.2 Closed Loop Tx Diversity for DPCH

The transmitter structure to support transmit diversity for DPCH transmission is shown in figure 9. Channel coding, interleaving and spreading are done as in non-diversity mode. The spread complex valued signal is fed to both TX antenna branches, and weighted with antenna specific weight factors w_1 and w_2 . The weight factors are complex valued signals (i.e., $w_i = a_i + jb_i$), in general. These weight factors are calculated on a per slot and per user basis.

The weight factors are determined by the UTRAN.

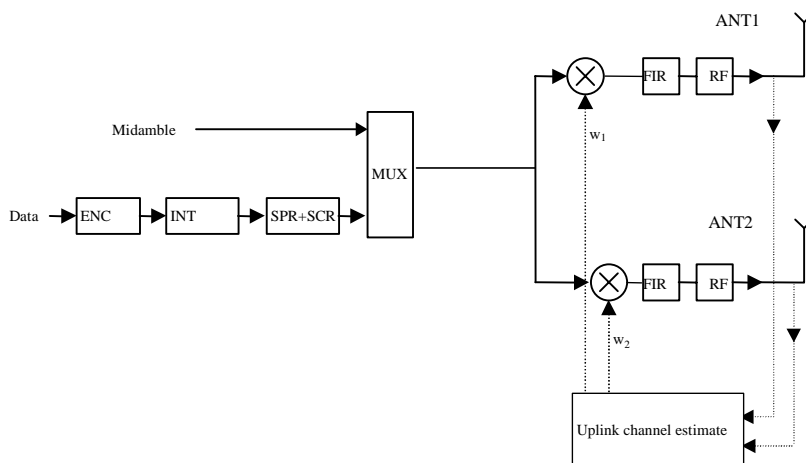


Figure 9: Downlink transmitter structure to support Transmit Diversity for DPCH transmission (UTRAN Access Point) in 1,28 Mcps TDD

5.5.2 Transmit Diversity for DwPTS

The transmitter structure to support transmit diversity for DwPCH transmission is shown in figure 10. DwPCH is transmitted from antenna 1 and antenna 2 alternatively.

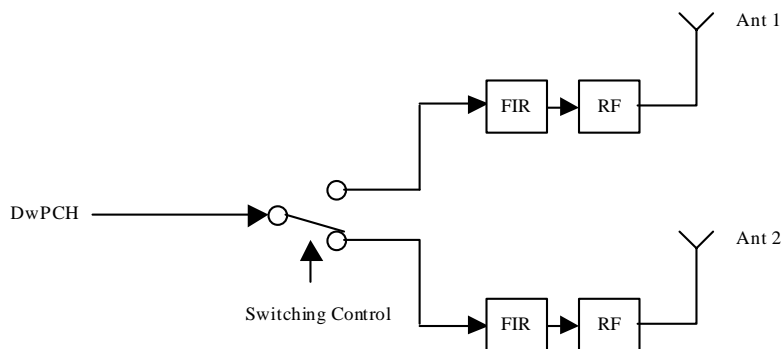


Figure 10: Downlink transmitter structure to support Transmit Diversity for DwPCH transmission (UTRAN Access Point) in 1,28 Mcps TDD

5.5.3 Transmit Diversity for P-CCPCH

TSTD or Space Code Transmit Diversity (SCTD) can be employed as transmit diversity scheme for the Primary Common Control Physical Channel (P-CCPCH)

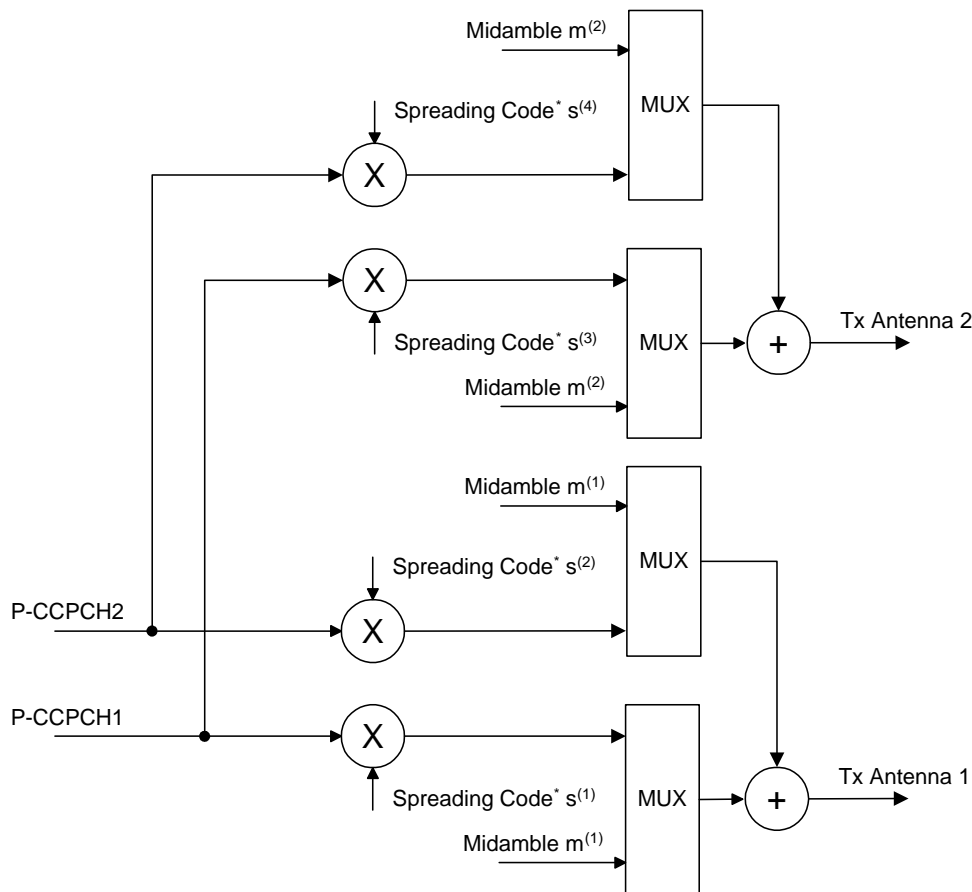
5.5.3.1 TSTD Transmission Scheme for P-CCPCH

A block diagram of an example of a TSTD transmitter is shown in figure 7. Channel coding, rate matching, interleaving, bit-to-symbol mapping, spreading, and scrambling are performed as in the non-diversity mode. Then the data is time multiplexed with the midamble sequence. Then, after pulse shaping and modulation and amplification, P-CCPCH is transmitted from antenna 1 and antenna 2 alternately every sub-frame. If there is a DPCH that uses TSTD, TSTD is also applied to P-CCPCH. An example of the antenna-switching pattern is shown in figure 8.

5.5.3.2 SCTD Transmission Scheme for P-CCPCH

The open loop downlink transmit diversity scheme for the P-CCPCH is shown in figure 11. Channel coding, rate matching, interleaving and bit-to-symbol mapping are performed as in the non-diversity mode. In TxDiversity mode the data sequence on P-CCPCH1 is spread with the channelisation codes $c_{16}^{(k=1)}$ and $c_{16}^{(k=3)}$ and scrambled with the cell specific scrambling code. The data sequence on P-CCPCH2 is spread with the channelisation codes $c_{16}^{(k=2)}$ and $c_{16}^{(k=4)}$ and scrambled with the cell specific scrambling code. The spread sequences on code $c_{16}^{(k=3)}$ and code $c_{16}^{(k=4)}$ are then transmitted on the diversity antenna. The power applied to each antenna shall be equal.

The use of SCTD will be indicated by higher layers.



* Spreading by $s^{(k)}$ means channelisation by $c^{(k)}$ and cell specific scrambling

Figure 11: Block Diagram of the transmitter (SCTD) in 1,28 Mcps TDD

5.6 Random Access Procedure

The physical random access procedure described below is invoked whenever a higher layer requests transmission of a message on the RACH. The physical random access procedure is controlled by primitives from RRC and MAC.

5.6.1 Definitions

$FPACH_i$: FPACH number i

L_i : Length of RACH transport blocks associated to $FPACH_i$ in sub-frames

N_{RACH_i} : The number of PRACHs associated to the i^{th} FPACH

n_{RACH_i} : The number of a PRACH associated to the i^{th} FPACH ranging from 0 to $N_{RACH_i}-1$

M : Maximum number transmissions in the UpPCH

WT : Maximum number of sub-frames to wait for the network acknowledgement to a sent signature

SFN' : The sub-frame number counting the sub-frames. At the beginning of the frame with the system frame number $SFN=0$ the sub-frame number is set to zero.

5.6.2 Preparation of random access

When the UE is in Idle mode, it will keep the downlink synchronisation and read the system information. From the used SYNC-DL code in DwPCH, the UE will get the code set of 8 SYNC-UL codes (signatures) assigned to UpPCH for random access.

The description (codes, spreading factor, midambles, time slots) of the P-RACH, FPACH, and S-CCPCH (carrying the FACH transport channel) channel is broadcast on the BCH.

Thus, when sending a SYNC-UL sequence, the UE knows which FPACH resources, P-RACH resources and CCPCH resources will be used for the access.

The physical random access procedure described in this sub-clause is initiated upon request from the MAC sub-layer (see [18] and [19]).

Before the physical random-access procedure can be initiated, Layer 1 shall receive the following information by a CPHY-TrCH-Config-REQ from the RRC layer:

- The association between which signatures and which FPACHs; which FPACHs and which PRACHs; which PRACHs and which CCPCHs; including the parameter values for each listed physical channel.
- The length L_i of a RACH message associated to $FPACH_i$ can be configured to be either 1 or 2 or 4 sub-frames corresponding to a length in time of either 5 ms or 10 ms or 20 ms.

NOTE 1: N_{RACH_i} PRACHs can be associated with to $FPACH_i$. The maximum allowed

$$N_{RACH_i} \text{ is } L_i.$$

- The available UpPCH sub-channels for each Access Service Class (ASC);

NOTE 2: An UpPCH sub-channel is defined by a (sub-set of) signature(s) and sub-frame numbers.

- The set of Transport Format parameters for the PRACH message;
- The "M" maximum number transmissions in the UpPCH;
- The "WT" maximum number of sub-frames to wait for the network acknowledgement to a sent signature; (1..4) the maximum value supported by Layer 1 is 4 sub-frames.
- The initial signature power "Signature_Initial_Power";
- The power-ramping factor Power Ramp Step [Integer];

The above parameters may be updated from higher layers before each physical random access procedure is initiated.

At each initiation of the physical random access procedure, Layer 1 shall receive the following information from the higher layers (MAC):

- The Transport Format to be used for the specific PRACH message;
- The ASC for the specific Random Access procedure with the timing and power level indication;
- The data to be transmitted (Transport Block Set).

5.6.3 Random access procedure

The physical random-access procedure shall be performed as follows:

UE side:

- 1 Set the Signature Re-Transmission Counter to M.
- 2 Set the Signature transmission power to Signature_Initial_Power.
- 3 Randomly select the UpPCH sub-channel from the available ones for the given ASC. The random function shall be such that each of the allowed selections is chosen with equal probability.
- 4 Transmit a signature using the selected UpPCH sub-channel at the signature transmission power. In the case that the Commanded Signature transmission Power exceeds the maximum allowed value, set the Signature transmission Power to the maximum allowed power.

- 5 After sending a signature, listen to the relevant FPACH for the next WT sub-frames to get the network acknowledgement. The UE will read the FPACH_i associated to the transmitted UpPCH only in the sub-frames fulfilling the following relation:

$$(\text{SFN}' \bmod L_i) = n_{\text{RACH}i}; n_{\text{RACH}i} = 0, \dots, N_{\text{RACH}i} - 1,$$

- 6 In case no valid answer is detected in the due time: Increase the Signature transmission power by $\Delta P_0 = \text{Power Ramp Step [dB]}$, decrease the Signature Re-transmission counter by one and if it is still greater than 0, then repeat from step 3; else report a random access failure to the MAC sub-layer.
- 7 In case a valid answer is detected in the due time
- set the timing and power level values according to the indication received by the network in the FPACH_i
 - send at the sub-frame coming 2 sub-frames after the one carrying the signature acknowledgement, the RACH message on the relevant PRACH. In case L_i is bigger than one and the sub-frame number of the acknowledgement is odd the UE will wait one more sub-frame. The relevant PRACH is the $n_{\text{RACH}i}^{\text{th}}$ PRACH associated to the FPACH_i if the following equation is fulfilled:

$$(\text{SFN}' \bmod L) = n_{\text{RACH}i};$$

Here SFN' is the sub-frame number of the arrival of the acknowledgement.

Both on the UpPCH and on the PRACH, the transmit power level shall never exceed the indicated value signalled by the network.

Network side:

- The node B will transmit the FPACH_i associated to the transmitted UpPCH only in the sub-frames fulfilling the following relation:

$$(\text{SFN}' \bmod L) = n_{\text{RACH}i}; n_{\text{RACH}i} = 0, \dots, N_{\text{RACH}i} - 1,$$

- The Node B will not acknowledge UpPCHs transmitted more than WT sub-frames ago

At the reception of a valid signature:

- Measure the timing deviation with respect to the reference time T_{ref} of the received first path in time from the UpPCH and acknowledge the detected signature sending the FPACH burst on the relevant FPACH.

For examples on the random access procedure refer to Annex E.

5.6.3.1 The use and generation of the information fields transmitted in the FPACH

The Fast Physical Access CHannel (FPACH) is used by the Node B to carry, in a single burst, the acknowledgement of a detected signature with timing and power level adjustment indication to a user equipment.

The length and coding of the information fields is explained in TS25.221 sub-clause 6.3.3.1.

5.6.3.1.1 Signature Reference Number

The Signature Reference Number field contains the number of the acknowledged signature. The user equipment shall use this information to verify whether it is the recipient of the FPACH message.

5.6.3.1.2 Relative Sub-Frame Number

The Relative Sub-Frame Number field indicates the current sub-frame number with respect to the sub-frame at which the acknowledged signature has been detected.

The user equipment shall use this information to verify whether it is the recipient of the FPACH message.

5.6.3.1.3 Received starting position of the UpPCH ($UpPCH_{POS}$)

The *received starting position of the UpPCH ($UpPCH_{POS}$)* field indirectly indicates to the user equipment the timing adjustment it has to implement for the following transmission to the network. The node B computes the proper value for this parameter according to the following rules: $UpPCH_{POS} = UpPTS_{Rxpath} - UpPTS_{TS}$

where

$UpPTS_{Rxpath}$: time of the reception in the Node B of the SYNC-UL to be used in the uplink synchronization process

$UpPTS_{TS}$: time instance two symbols prior to the end of the DwPCH according to the Node B internal timing

This information shall be used by the UE to adjust its timing when accessing the network, as described in section [5.2 'Uplink Synchronisation'] .

5.6.3.1.4 Transmit Power Level Command for the RACH message

This field indicates to the user equipment the power level to use for the RACH message transmission on the FPACH associated P-RACH.

The network may set this value based on the measured interference level (I) (in dBm) on the specific PRACH and on the desired signal to interference ratio (SIR) (in dB) on this channel as follows:

Transmit Power Level Command for the PRACH($PRX_{PRACH,des}$)

$PRX_{PRACH,des}$ is the desired receive power level on the PRACH.

The UE shall add to this value the estimated path-loss to compute the power level to transmit for the PRACH.

5.6.4 Random access collision

When a collision is very likely or in bad propagation environment, the Node B does not transmit the FPACH or cannot receive the SYNC-UL. In this case, the UE will not get any response from the Node B. Thus the UE will have to adjust its Tx time and Tx power level based on a new measurement and send a SYNC-UL again after a random delay.

Note that at each (re-)transmission, the SYNC-UL sequence will be randomly selected again by the UE.

Note: Due to the two-step approach a collision most likely happens on the UpPCH. The resources allocated to PRACH are virtually collision free. This two-step approach will guarantee that the RACH resources can be handled with conventional traffic on the same UL time slots.

5.7 HS-DSCH Procedure

The HS-DSCH procedure is the same as that of 3,84 Mcps TDD, cf. 4.11 HS-DSCH Procedure.

Annex A (informative): Power Control

A.1 Example Implementation of Downlink Power Control in the UE

The power control may be realized by two cascaded control loops. The outer loop controls the transmission quality, whose reference value is set by higher layers [15], by providing the reference value for the inner loop. This reference value should be the SIR at the UE [15]. The inner loop controls the physical quantity for which the outer loop produces the reference value (e. g. the SIR) by generating TPC commands. This may be done by comparing the measured SIR to its reference value. When the measured value is higher than the target SIR value, TPC command = "down". When this is lower than or equal to the target SIR value, TPC command = "up".

In case of a downlink transmission pause on the DPCH or PDSCH, the receive power (RSCP) of the data can no longer be used for inner loop SIR calculations in the UE. In this case the UE should trace the fluctuations of the pathloss based on the P-CCPCH and use these values instead for generating the TPC commands. This pathloss together with the timeslot ISCP measurement in the data timeslot, which is ongoing, should be used to calculate a virtual SIR value:

$$SIR_{virt}(i) = RSCP_{virt}(i) - ISCP(i),$$

$$RSCP_{virt}(i) = RSCP_0 + L_0 - L(i) + \sum_{k=1}^{i-1} TPC(k),$$

RSCP:	Received signal code power in dBm
ISCP:	Interference signal code power in the DPCH / PDSCH timeslot in dBm
L:	pathloss in dB measured on the P-CCPCH. The same weighting of the long- and short-term pathloss should be used as for uplink open loop power control, see Annex A.1
i:	index for the frames during a transmission pause, $1 \leq i \leq$ number of frames in the pause
L_0 :	weighted pathloss in the last frame before the transmission pause in dB
$RSCP_0$:	RSCP of the data that was used in the SIR calculation of the last frame before the pause in dBm
TPC (k):	\pm power control stepsize in dB according to the TPC bit generated and transmitted in frame k, TPC bit "up" = +stepsize, TPC bit "down" = -stepsize

A.2 Example Implementation of Closed Loop Uplink Power Control in Node B for 1,28 Mcps TDD

The measurement of received SIR shall be carried out periodically at Node B. When the measured value is higher than the target SIR value, TPC command = "down". When the measurement is lower than or equal to the target SIR, TPC command = "up".

In case of an uplink transmission pause on DPCH, the initial uplink transmission power of DPCH after the pause can be determined by an open loop power control. After the initial transmission after the pause, a closed loop uplink power control procedure can resume.

A.3 Example Implementation of Downlink Power Control in UE for 1,28 Mcps TDD when TSTD is used

When TSTD is applied, the UE can use the consecutive measurements of SIR to calculate SIR_{AVG} :

$$SIR_{AVG}(i) = w_1 SIR(i-1) + w_2 SIR(i),$$

where, $w_1 + w_2 = 1$, $w_1 \geq 0$, $w_2 \geq 0$, and $SIR(i)$ is the measurement of SIR in sub-frame i and $SIR_{AVG}(i)$ is the measurement of SIR_{AVG} in sub-frame i . If SIR_{AVG} is greater than the target SIR value, TPC command = "down". If the SIR_{AVG} is smaller than the target SIR value, TPC command = "up".

In case of a downlink transmission pause on the DPCH, the example in Annex A.1 can be used for DL power control with $RSCP_{virt}(i)$ and $ISCP(i)$ replaced by $RSCP_{AVG}(i)$ and $ISCP_{AVG}(i)$, where

$$RSCP_{AVG}(i) = w_1 RSCP_{virt}(i-1) + w_2 RSCP_{virt}(i),$$

$$ISCP_{AVG}(i) = w_1 ISCP(i-1) + w_2 ISCP(i).$$

A.4 Example Implementation of open Loop Power Control for access procedure for 1,28 Mcps TDD

The higher layer signals (on BCH) a power increment that is applied only for the access procedure. At each new transmission of a SYNC-UL burst during the access procedure, the transmit power level can be increased by this power increment.

Annex B (informative): Determination of Weight Information

Selective Transmit Diversity (STD) and Transmit Adaptive Antennas (TxAA) are examples of transmit diversity schemes for dedicated physical channels.

B.1 STD Weights

The weight vector will take only two values depending on the signal strength received by each antenna in the uplink slot. For each user, the antenna receiving the highest power will be selected (i.e. the corresponding weight will be set to 1).

Table 3: STD weights for two TX antennas

	W_1	W_2
Antenna 1 receiving highest power	1	0
Antenna 2 receiving highest power	0	1

B.2 TxAA Weights

In a generic sense, the weight vector to be applied at the transmitter is the \underline{w} that maximises:

$$P = \underline{w}^H \mathbf{H}^H \mathbf{H} \underline{w} \quad (1)$$

where

$$\mathbf{H} = [\underline{h}_1 \quad \underline{h}_2] \text{ and } \underline{w} = [w_1, w_2]^T$$

and where the column vector \underline{h}_i represents the estimated uplink channel impulse response for the i 'th transmission antenna, of length equal to the length of the channel impulse response.

Annex C (informative): Cell search procedure for 3,84 Mcps TDD

During the cell search, the UE searches for a cell and determines the downlink scrambling code, basic midamble code and frame synchronisation of that cell. The cell search is typically carried out in three steps:

Step 1: Primary synchronisation code acquisition

During the first step of the cell search procedure, the UE uses the SCH's primary synchronisation code to find a cell. This is typically done with a single matched filter (or any similar device) matched to the primary synchronisation code which is common to all cells. A cell can be found by detecting peaks in the matched filter output.

Note that for a cell of SCH slot configuration case 1, the SCH can be received periodically every 15 slots. In case of a cell of SCH slot configuration case 2, the following SCH slot can be received at offsets of either 7 or 8 slots from the previous SCH slot.

Step 2: Code group identification and slot synchronisation

During the second step of the cell search procedure, the UE uses the SCH's secondary synchronisation codes to identify 1 out of 32 code groups for the cell found in the first step. This is typically done by correlating the received signal with the secondary synchronisation codes at the detected peak positions of the first step. The primary synchronisation code provides the phase reference for coherent detection of the secondary synchronisation codes. The code group can then uniquely be identified by detection of the maximum correlation values.

Each code group indicates a different t_{offset} parameter and 4 specific cell parameters. Each of the cell parameters is associated with one particular downlink scrambling code and one particular long and short basic midamble code. When the UE has determined the code group, it can unambiguously derive the slot timing of the found cell from the detected peak position in the first step and the t_{offset} parameter of the found code group in the second step.

Note that the modulation of the secondary synchronisation codes also indicates the position of the SCH slot within a 2 frames period, e.g. a frame with even or odd SFN. Additionally, in the case of SCH slot configuration following case 2, the SCH slot position within one frame, e.g. first or last SCH slot, can be derived from the modulation of the secondary synchronisation codes.

Step 3: Downlink scrambling code, basic midamble code identification and frame synchronisation

During the third and last step of the cell search procedure, the UE determines the exact downlink scrambling code, basic midamble code and frame timing used by the found cell. The long basic midamble code can be identified by correlation over the P-CCPCH (or any other beacon channel) with the 4 possible long basic midamble codes of the code group found in the second step. A P-CCPCH (or any other beacon channel) always uses the midamble $m^{(1)}$ (and in case of SCTD also midamble $m^{(2)}$) derived from the long basic midamble code and always uses a fixed and pre-assigned channelisation code.

When the long basic midamble code has been identified, downlink scrambling code and cell parameter are also known. The UE can read system and cell specific BCH information and acquire frame synchronisation.

Note that even for an initial cell parameter assignment, a cell cycles through a set composed of 2 different cell parameters according to the SFN of a frame, e.g. the downlink scrambling code and the basic midamble code of a cell alternate for frames with even and odd SFN. Cell parameter cycling leaves the code group of a cell unchanged.

If the UE has received information about which cell parameters or SCH configurations to search for, cell search can be simplified.

Annex D (informative): Cell search procedure for 1,28 Mcps TDD

During the initial cell search, the UE searches for a cell. It then determines the DwPTS synchronization, scrambling and basic midamble code identification, control multi-frame synchronisation and then reads the contents in BCH. This initial cell search is carried out in 4 steps:

Step 1: Search for DwPTS

During the first step of the initial cell search procedure, the UE uses the SYNC-DL (in DwPTS) to acquire DwPTS synchronization to a cell. This is typically done with one or more matched filters (or any similar device) matched to the received SYNC-DL which is chosen from PN sequences set. A single or more matched filter (or any similar device) is used for this purpose. During this procedure, the UE needs to identify which of the 32 possible SYNC-DL sequences is used.

Step 2: Scrambling and basic midamble code identification

During the second step of the initial cell search procedure, the UE receives the midamble of the P-CCPCH. The P-CCPCH is followed by the DwPTS. In the 1,28 Mcps TDD each DwPTS code corresponds to a group of 4 different basic midamble code. Therefore there are total 128 midamble codes and these codes are not overlapping with each other. Basic midamble code number divided by 4 gives the SYNC-DL code number. Since the SYNC-DL and the group of basic midamble codes of the P-CCPCH are related one by one (i.e., once the SYNC-DL is detected, the 4 midamble codes can be determined), the UE knows which 4 basic midamble codes are used. Then the UE can determine the used basic midamble code using a try and error technique. The same basic midamble code will be used throughout the frame. As each basic midamble code is associated with a scrambling code, the scrambling code is also known by that time. According to the result of the search for the right midamble code, UE may go to next step or go back to step 1.

Step 3: Control multi-frame synchronisation

During the third step of the initial cell search procedure, the UE searches for the MIB(Master Indication Block) of multi-frame of the BCH in the P-CCPCH indicated by QPSK phase modulation of the DwPTS with respect to the P-CCPCH midamble. The control multi-frame is positioned by a sequence of QPSK symbols modulated on the DwPTS. [n] consecutive DwPTS are sufficient for detecting the current position in the control multi-frame. According to the result of the control multi-frame synchronisation for the right midamble code, UE may go to next step or go back to step 2.

Step 4: Read the BCH

The (complete) broadcast information of the found cell in one or several BCHs is read. According to the result the UE may move back to previous steps or the initial cell search is finished.

Annex E (informative): Examples random access procedure for 1,28 Mcps TDD

Table E-1: One PRACH, TTI=5ms, WT=4, L =1, SF4 PRACH

Sub-frame Number	0	1	2	3	4	5	6	7	8	9	10
Users sending on UpPCH	1	3	5	7							
	2	4	6	8							
Acknowledged user on FPACH		1	2	3	4	5	6	7			
User sending on PRACH 0				1	2	3	4	5	6	7	

User 8 is not granted because more than 5 sub-frames would have passed since the UpPCH.

Table E-2: Two PRACHs, TTI=10ms, WT=4, L =2, SF8 PRACH

Sub-frame Number	0	1	2	3	4	5	6	7	8	9	10	11
Users sending on UpPCH	1	3	5	7								
	2	4	6	8								
Acknowledged user on FPACH		1	2	3	4	5	6	7				
User sending on PRACH 0					2	2	4	4	6	6		
User sending on PRACH 1					1	1	3	3	5	5	7	7

User 8 is not granted because more than 5 sub-frames would have passed since the UpPCH.

Table E-3: Four PRACHs, TTI=20ms, WT=4, L =4, SF16 PRACH

Sub-frame Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Users sending on UpPCH	1	3	5	7										
	2	4	6	8										
Acknowledged user on FPACH		1	2	3	4	5	6	7						
User sending on PRACH 0							4	4	4	4				
User sending on PRACH 1					1	1	1	1	5	5	5	5		
User sending on PRACH 2					2	2	2	2	6	6	6	6		
User sending on PRACH 3							3	3	3	3	7	7	7	7

User 8 is not granted because more than 5 sub-frames would have passed since the UpPCH.

Table E-4: Two PRACHs, TTI=20ms, WT=4, L =4, SF16 PRACH

Sub-frame Number	0	1	2	3	4	5	6	7	8	9	10	11	12
Users sending on UpPCH	1	3	5	7									
	2	4	6	8									
Acknowledged user on FPACH	X	1			2	3			X	X			
User sending on PRACH 0							2	2	2	2			
User sending on PRACH 1					1	1	1	1	3	3	3	3	

The FPACH is used ONLY in sub-frames 0, 1, 4, 5, 8, 9,... because they correspond to the used RACH resources.

The FPACH in sub-frame 0 is not used because no UpPCH is preceding.

The FPACH in sub-frames 8,9 is not used because no UpPCH is preceding in the last 4 sub-frames.

In contrast to the previous examples users 4,5,6,7 are not granted because they would no lead to a RACH anyway. In this example their grand would come too late.

User 8 is not granted because more than 4 sub-frames would have passed since the UpPCH.

Annex F (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
14/01/00	RAN_05	RP-99594	-		Approved at TSG RAN #5 and placed under Change Control	-	3.0.0
14/01/00	RAN_06	RP-99698	001	01	Primary and Secondary CCPCCH in TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99698	002	-	Measurement procedure of received reference power for OL-TPC in TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99699	004	1	STTD capability for P-CCPCCH, TDD component	3.0.0	3.1.0
14/01/00	RAN_06	RP-99697	005	1	Alignment of Terminology Regarding Spreading for TDD Mode	3.0.0	3.1.0
14/01/00	-	-	-		Change history was added by the editor	3.1.0	3.1.1
31/03/00	RAN_07	RP-000070	003	2	Cycling of cell parameters	3.1.1	3.2.0
31/03/00	RAN_07	RP-000070	007	2	Clarifications on the UL synchronisation and Timing advance	3.1.1	3.2.0
31/03/00	RAN_07	RP-000070	008	-	Modification of SIR threshold on setting TPC	3.1.1	3.2.0
31/03/00	RAN_07	RP-000070	009	1	New section describing the random access procedure	3.1.1	3.2.0
31/03/00	RAN_07	RP-000070	011	-	Removal of Synchronisation Case 3 in TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000070	012	1	Clarifications on power control procedures	3.1.1	3.2.0
31/03/00	RAN_07	RP-000070	013	-	Signal Point Constellation	3.1.1	3.2.0
31/03/00	RAN_07	RP-000070	014	2	Out-of-sync handling for UTRA TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000070	015	-	Removal of ODMA from the TDD specifications	3.1.1	3.2.0
26/06/00	RAN_08	RP-000274	016	-	Editorial correction for the power control section in 25.224	3.2.0	3.3.0
26/06/00	RAN_08	RP-000274	017	-	Power control for TDD during DTX	3.2.0	3.3.0
26/06/00	RAN_08	RP-000274	018	1	Power Control for PDSCH	3.2.0	3.3.0
26/06/00	RAN_08	RP-000274	020	1	Editorial modification of 25.224	3.2.0	3.3.0
26/06/00	RAN_08	RP-000274	021	-	Clarifications on Tx Diversity for UTRA TDD	3.2.0	3.3.0
26/06/00	RAN_08	RP-000274	022	1	Introduction of the TDD DSCH detection procedure in TS 25.224	3.2.0	3.3.0
26/06/00	RAN_08	RP-000274	023	-	Downlink power control on timeslot basis	3.2.0	3.3.0
23/09/00	RAN_09	RP-000347	019	1	Gain Factors for TDD Mode	3.3.0	3.4.0
23/09/00	RAN_09	RP-000347	025	-	Terminology regarding the beacon function	3.3.0	3.4.0
23/09/00	RAN_09	RP-000347	026	1	Synchronisation of timing advance adjustment and timing deviation measurement	3.3.0	3.4.0
23/09/00	RAN_09	RP-000347	027	1	CCTrCH UL/DL pairing for DL inner loop power control	3.3.0	3.4.0
23/09/00	RAN_09	RP-000347	028	1	RACH timing in TDD mode	3.3.0	3.4.0
23/09/00	RAN_09	RP-000347	030	1	TDD Access Bursts for HOV	3.3.0	3.4.0
23/09/00	RAN_09	RP-000347	032	-	Removal of ODMA related abbreviations and correction of references	3.3.0	3.4.0
23/09/00	RAN_09	RP-000347	033	-	Clarifications on the Out-of-sync handling for UTRA TDD	3.3.0	3.4.0
15/12/00	RAN_10	RP-000544	035	1	Radio Link establishment and sync status reporting	3.4.0	3.5.0
15/12/00	RAN_10	RP-000544	040	-	Clarification on PICH power setting	3.4.0	3.5.0
15/12/00	RAN_10	RP-000544	042	-	Correction to TDD timing advance description	3.4.0	3.5.0
15/12/00	RAN_10	RP-000544	043	-	Limit on maximum value of alpha used for open loop power control	3.4.0	3.5.0
16/03/01	RAN_11	-	-	-	Approved as Release 4 specification (v4.0.0) at TSG RAN #11	3.5.0	4.0.0
16/03/01	RAN_11	RP-010065	036	-	DTX and Special Burst Scheduling	3.5.0	4.0.0
16/03/01	RAN_11	RP-010065	037	1	RACH random access procedure	3.5.0	4.0.0
16/03/01	RAN_11	RP-010065	045	-	Introduction of closed-loop Tx diversity for the PDSCH and DTX for the PUSCH/PDSCH	3.5.0	4.0.0
16/03/01	RAN_11	RP-010065	046	2	Corrections of TDD power control sections	3.5.0	4.0.0
16/03/01	RAN_11	RP-010065	050	-	Use of a special burst in reconfiguration	3.5.0	4.0.0
16/03/01	RAN_11	RP-010065	053	-	Known TFCI for the TDD special burst	3.5.0	4.0.0
16/03/01	RAN_11	RP-010073	044	2	Layer 1 procedure for Node B synchronisation	3.5.0	4.0.0
16/03/01	RAN_11	RP-010071	047	1	Inclusion of 1,28 Mcps TDD in TS 25.224	3.5.0	4.0.0
16/03/01	RAN_11	RP-010072	048	1	Idle periods for IPDL location method	3.5.0	4.0.0
15/06/01	RAN_12	RP-010338	057	-	Correction of Timing Advance section for 3.84 Mcps TDD	4.0.0	4.1.0
15/06/01	RAN_12	RP-010338	059	-	Addition to the abbreviation list	4.0.0	4.1.0
15/06/01	RAN_12	RP-010343	049	-	Clarification of IP_Frame(x) definition	4.0.0	4.1.0
15/06/01	RAN_12	RP-010343	055	1	Correction of IPDL burst parameters	4.0.0	4.1.0
21/09/01	RAN_13	RP-010525	064	1	Correction of criteria for OOS indication	4.1.0	4.2.0
21/09/01	RAN_13	RP-010531	060	-	Corrections for TS 25.224	4.1.0	4.2.0
21/09/01	RAN_13	RP-010531	062	1	Corrections of Annex E in 25.224	4.1.0	4.2.0
21/09/01	RAN_13	RP-010531	061	-	Corrections and Clarifications for calculation of idle period position in subclause 4.10.3 in 25.224	4.1.0	4.2.0
14/12/01	RAN_14	RP-010742	066	-	Removal of the remark on power control	4.2.0	4.3.0
14/12/01	RAN_14	RP-010742	068	1	Transmit Diversity for P-CCPCCH and PICH	4.2.0	4.3.0
14/12/01	RAN_14	RP-010742	070	1	Correction to random access procedure (Primitive from MAC)	4.2.0	4.3.0
14/12/01	RAN_14	RP-010749	073	1	Random access procedure for 1.28Mcps TDD	4.2.0	4.3.0
14/12/01	RAN_14	RP-010749	074	-	Transmit diversity for P-CCPCCH and PICH	4.2.0	4.3.0
14/12/01	RAN_14	RP-010749	075	-	Correction of Annex A.3 in 25.224	4.2.0	4.3.0
14/12/01	RAN_14	RP-010749	076	-	Removal of the remark on power control	4.2.0	4.3.0

