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Technical Specification

3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) Radio Access Network (RAN); Working Group 1 (WG1); Physical layer - General description

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Contents

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Foreword

This Technical Specification has been produced by the 3GPP.

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where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 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 specification;

1 Scope

This specification gives a general description of the physical layer of the UTRA radio interface. This specification also describes the document structure of the 3GPP physical layer specifications, i.e. TS 25.200 series. The TS 25.200 series specifies the Uu point for the 3G mobile system, and defines the minimum level of specifications required for basic connections in terms of mutual connectivity and compatibility.

2 References

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

<Editor's Note: Relevant references should be discussed>

<Editor's Note: This is 3GPP TS 25.201: "Physical layer – General description" >

[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 25.214: "Physical layer procedures (FDD)"

[5] 3GPP TS 25.221: "Physical channels and mapping of transport channels onto physical channels (TDD)"

[6] 3GPP TS 25.222: "Multiplexing and channel coding (TDD)"

[7] 3GPP TS 25.223: "Spreading and modulation (TDD)"

[8] 3GPP TS 25.224: "Physical layer procedures (TDD)"

[9] 3GPP TS 25.231: "Physical layer - Measurements"

[10] 3GPP TR R1.02: "User Equipment physical layer capabilities"

[11] 3GPP TS 25.301: "Radio Interface Protocol Architecture"

[12] 3GPP TS 25.302: "Services provided by the physical layer"

[13] 3GPP TS 25.101: "UE Radio transmission and reception (FDD)"

[14] 3GPP TS 25.102: "UE Radio transmission and reception (TDD)"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

<defined term>: <definition>.

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

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

<symbol> <Explanation>

3.3 Abbreviations

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

BER	Bit Error Rate
CCTrCH	Coded Composite Transport Channel
DCA	Dynamic channel allocation
DCH	Dedicated Channel
DS-CDMA	Direct-Sequence Code Division Multiple Access
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FER	Frame Error Rate
GSM	Global System for Mobile Communication
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
PCS	Personal Communications System
PHS	Persona Handyphone System
QPSK	Quaternary Phase Shift Keying
RACH	Random Access Channel
RF	Radio Frequency
RLC	Radio Link Control
RRC	Radio Resource Control
SAP	Service Access Point
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
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 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.

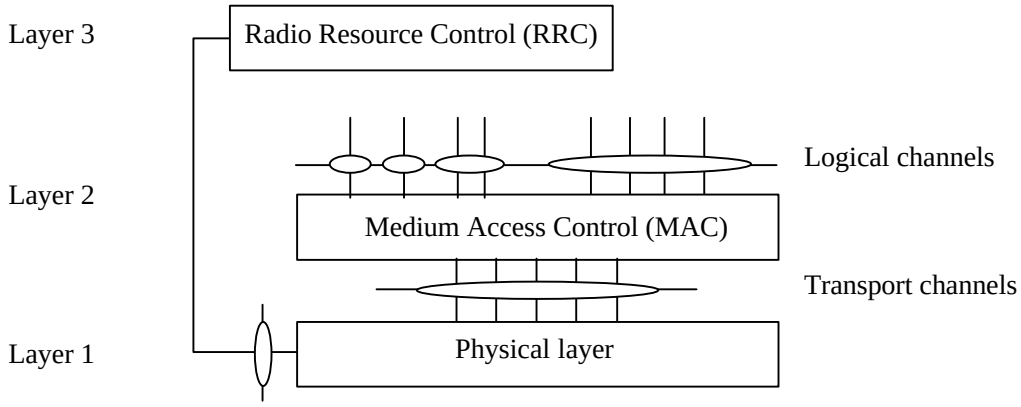

Fig. 5-1 Radio interface protocol architecture around the physical layer

Figure 4-1 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 upper layer

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
- Rate matching (data multiplexed on DCH)

- 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
- Closed-loop power control
- RF processing <Note: RF processing is defined in TS 25.100 series>

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 spread over approximately 5 MHz bandwidth, thus also often denoted as Wideband CDMA (WCDMA) due that nature.

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.

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 both UTRA modes use 72-frame multiframe structure. The resulting longer frame duration is under discussion (hyperframe etc.) <Editor's note: Some discussion on the terminology between multiframe/superframe etc. needed >

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.

Furthermore, relaying between nodes can be used by means of Opportunity Driven Multiple Access (ODMA) in TDD mode.

4.2.2 Coding and interleaving

For the channel coding in UTRA two options are supported:

- Convolutional coding, either 1/2 rate or 1/3 rate for packet data and services requiring quality level 10^{-3} or lower over the physical layer with forward error correction (FEC).
- Turbo coding, for the services requiring higher than 10^{-3} quality level.

< Editor's note: FEC coding selection is indicated by upper layers >

4.2.3 Modulation and spreading

The UTRA modulation scheme is QPSK. 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 Transmission and reception~~

~~UTRA uses paired/unpaired frequency bands. The detail frequency bands are described in TS 25.101 and 25.102. Several power classes are being defined currently.~~

4.2.~~5~~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 fast closed loop and slow quality loop for FDD mode and for TDD mode open loop power control together with slow closed loop; <Editor's Note: TDD fast power control is FFS >

~~2)~~~~Handover measurements for handover within UTRA. Specific features being determined in addition to the relative strength of the base station, for the FDD mode the timing relation between for the base stations for support of asynchronous soft handover;~~

~~3)~~~~The measurement procedures for preparation for handover to GSM900/GSM1800; <Editor's Note: How about other systems in Japan or USA? >~~

~~4)~~~~The measurements procedures for UE before random access process;~~

~~5)~~2) Dynamic Channel Allocation (DCA) with TDD mode operation;

~~6)~~3) ODMA specific procedures such as probing.

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 UTRAN. Specific features being determined in addition to the relative strength of cells, 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; <Editor's Note: How about other systems in Japan or USA? >

3) The measurements procedures for UE before random access process;

5 Document structure of physical layer specification

5.1 Overview

The physical layer specification consists of a general documents (TS 25.201), four FDD mode documents (TS 25.211 through 25.214), four TDD mode documents (TS 25.221 through 25.224), and one special issue document (TS 25.231). In addition, there is a technical report (TR R1.02).

5.2 TS 25.201: Physical layer – General description

The scope is to describe:

- the contents of the Layer 1documents (25.200 series);
- where to find information;
- a general description of Layer 1.

5.3 TS 25.211: Physical channels and mapping of transport channels onto physical channels (FDD)

The scope is to establish the characteristics of the Layer-1 transport channels and physical channels in the FDD mode, and to specify:

- the different transport channels that exist;
- which physical channels exist;
- what is the structure of each physical channel, slot format etc.;
- relative timing between different physical channels in the same link, and relative timing between uplink and downlink;
- mapping of data onto the physical channels.

5.4 TS 25.212: Multiplexing and channel coding (FDD)

The scope is to describe multiplexing, channel coding and interleaving in the FDD mode, and to specify:

- coding and multiplexing of transport channels into CCTrCHs;
- channel coding alternatives;
- coding for Layer 1 control information, such as TFCI;
- the different interleavers;
- how is rate matching done;
- multiplexing.

5.5 TS 25.213: Spreading and modulation (FDD)

The scope is to establish the characteristics of the spreading and modulation in the FDD mode, and to specify:

- the spreading (channelization plus scrambling);
- generation of channelization and scrambling codes;
- generation of RACH preamble codes;
- generation of SCH synchronisation codes;
- modulation.

(RF channel arrangements and Pulse shaping are specified in TS 25.101)

5.6 TS 25.214: Physical layer procedures (FDD)

The scope is to establish the characteristics of the physical layer procedures in the FDD mode, and to specify:

- power control procedures;
- random access procedure;
- paging procedure.

5.7 TS 25.221: Physical channels and mapping of transport channels onto physical channels (TDD)

The scope is to establish the characteristics of the Layer-1 transport channels and physical channels in the TDD mode, and to define:

- transport channels;
- physical channels, structure and contents;
- timing relationship between physical channels;
- mapping of data to the physical channels.

5.8 TS 25.222: Multiplexing and channel coding (TDD)

The scope is to describe multiplexing, channel coding and interleaving in the TDD mode, and to specify:

- channel coding;

- interleaving;
- rate matching;
- multiplexing.

5.9 TS 25.223: Spreading and modulation (TDD)

The scope is to establish the characteristics of the spreading and modulation in the TDD mode, and to specify:

- data modulation;
- spreading;
- generation of codes.

(RF channel arrangements and Pulse shaping are specified in TS 25.102)

5.10 TS 25.224: Physical layer procedures (TDD)

The scope is to establish the characteristics of the physical layer procedures in the TDD mode, and to specify:

- Cell synchronisation;
- Dynamic channel allocation (DCA);
- timing advance;
- power control procedures;
- idle mode tasks.

5.11 TS 25.231: Physical layer - Measurements

The scope is to specify:

- the measurements that Layer 1 is to perform;
- reporting of measurements to higher layers and network;
- handover measurements, idle-mode measurements etc.

5.12 TR R1.02: User Equipment physical layer capabilities

The scope is to describe:

- the physical layer capabilities of UEs.

History

Document history		
V0.0.1	1999-02-12	New document merged from ETSI & ARIB, produced jointly by the editors. To be updated after the conclusions from Ad Hocs. Forwarded to TSG/RAN/WG1 for agreement.
V1.0.0	1999-03-05	Agreed by 3GPP TSG.
V1.0.1	1999-03-17	Update References and Section 6 “Document structure”. Remove Section 7.3 “Elements for layer-to-layer communication”.
V1.1.0	1999-03-24	Approved by 3GPP/TSG/RAN/WG1. Update the document titles of S1.11, S1.21, and S1.31.
V1.1.1	1999-04-20	Add sentences proposed in R1-99255 into Section 7.1.2. Reflect Turbo coding working assumptions. Approved by 3GPP RAN WG1.
TS 25.201 V2.0.0	1999-04-23	Endorsed by 3GPP TSG RAN as TS 25.201 v2.0.0.
V2.0.1	1999-06-04	Remove Pulse shaping and Frequency band descriptions; Correct Specification numbers; Revise the protocol architecture description. Renumber Chapters 6 and 7.
V2.1.0	1999-06-04	Approved by 3GPP TSG RAN WG1.
V2.1.0	1999-06-22	Endorsed by TSG-RAN
V2.1.1	1999-07-29	Revisions according to chip-rate and slot-structure change. Rename “S1.02” “TR R1.02”.
V2.2.0	1999-08-30	Approved by 3GPP TSG RAN WG1 #7

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