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Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project, Technical Specification Group Radio Access Network, Working Group 1 (3GPP TSG RAN WG1).

The contents of this TS may be subject to continuing work within the 3GPP and may change following formal TSG approval. Should the TSG modify the contents of this TS, it will be re-released with an identifying change of release date and an increase in version number as follows:

Version m.x.y

where:

m indicates [major version number]

x the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

y the third digit is incremented when editorial only changes have been incorporated into the specification.

1 Scope

This specification describes the documents being produced by the 3GPP TSG RAN WG1and first complete versions expected to be available by end of 1999. This specification describes the characteristics of the Layer 1 multiplexing and channel coding in the FDD mode of UTRA.

The S1 series specifies Um point for the 3G mobile system. This series 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>

[1] 3GPP RAN TS S1.02: "UE physical layer capabilities"

[2] 3GPP RAN TS S1.11: "Transport channels and physical channels (FDD)"

[3] 3GPP RAN TS S1.12: "Multiplexing and channel coding (FDD)"

[4] 3GPP RAN TS S1.13: "Spreading and modulation (FDD)"

[5] 3GPP RAN TS S1.14: "Physical layer procedures (FDD)"

[6] 3GPP RAN TS S1.21: "Transport channels and physical channels (TDD)"

[7] 3GPP RAN TS S1.22: "Multiplexing and channel coding (TDD)"

[8] 3GPP RAN TS S1.23: "Spreading and modulation (TDD)"

[9] 3GPP RAN TS S1.24: "Physical layer procedures (TDD)"

[10] 3GPP RAN TS S1.31: "Measurements"

[11] 3GPP RAN TS S2.01: "Radio Interface Protocol Architecture"

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:

<ACRONYM> <Explanation>

ARQ	Automatic Repeat Request
BCCH	Broadcast Control Channel
BER	Bit Error Rate
BLER	Block Error Rate
BS	Base Station
CCPCH	Common Control Physical Channel
DCH	Dedicated Channel
DL	Downlink (Forward link)
DPCH	Dedicated Physical Channel
DPCCH	Dedicated Physical Control Channel
DPDCH	Dedicated Physical Data Channel
DS-CDMA	Direct-Sequence Code Division Multiple Access
FACH	Forward Access Channel
FDD	Frequency Division Duplex
FER	Frame Error Rate
Mcps	Mega Chip Per Second
MS	Mobile Station
ODMA	Opportunity Driven Multiple Access
OVSF	Orthogonal Variable Spreading Factor (codes)
PCH	Paging Channel
PG	Processing Gain
PRACH	Physical Random Access Channel
PUF	Power Up Function
RACH	Random Access Channel
RX	Receive
SCH	Synchronisation Channel
SF	Spreading Factor
SIR	Signal-to-Interference Ratio
TDD	Time Division Duplex
TFCI	Transport Format Combination Indicator
TFI	Transport-Format Indicator
TPC	Transmit Power Control
TX	Transmit
UL	Uplink (Reverse link)
VA	Voice Activity

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 coding/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 {10 ms, 20 ms, 40 ms, 80 ms}.

Two or more services having different Quality of Service (QoS) requirements are multiplexed into one or more physical channels using a physical channel segmentation unit. Rate matching is used to adjust the channel symbol rates (i.e., symbol rate after physical channel segmentation) to an optimum level, where minimum QoS requirement of each service is fulfilled with the same channel symbol energy. The rate matching uses the algorithm described in section 4.2.4.

<Editor's note: According to the Ad Hoc4 result, ETSI scheme is used for uplink to achieve multiplexing of TrCHs with different transmission time interval. ARIB scheme is used for downlink to avoid the problem with the barancing of different TrCHs.>

The coding/multiplexing steps for uplink and for downlink are shown in Figure 4-1 and Figure 4-2 respectively.

The following coding/multiplexing steps can be identified:

- Add CRC to each transport block

<Editor's note: It should still be possible to code transport channels with same QoS separately. Combining several transport blocks from one or different transport channels before coding is a study item in Ad Hoc 5. Hence, a new name could perhaps be introduced for the block saying multiplexing of transport channels with the same QoS.>

- Possibility to multiplex transport channels with same QoS before coding.
- Channel coding
- Rate matching
- Insertion of discontinuous transmission (DTX) indication bits.
- Interleaving (two steps)
- Multiplexing of transport channels with different QoS
- Physical channel segmentation
- Mapping to physical channels

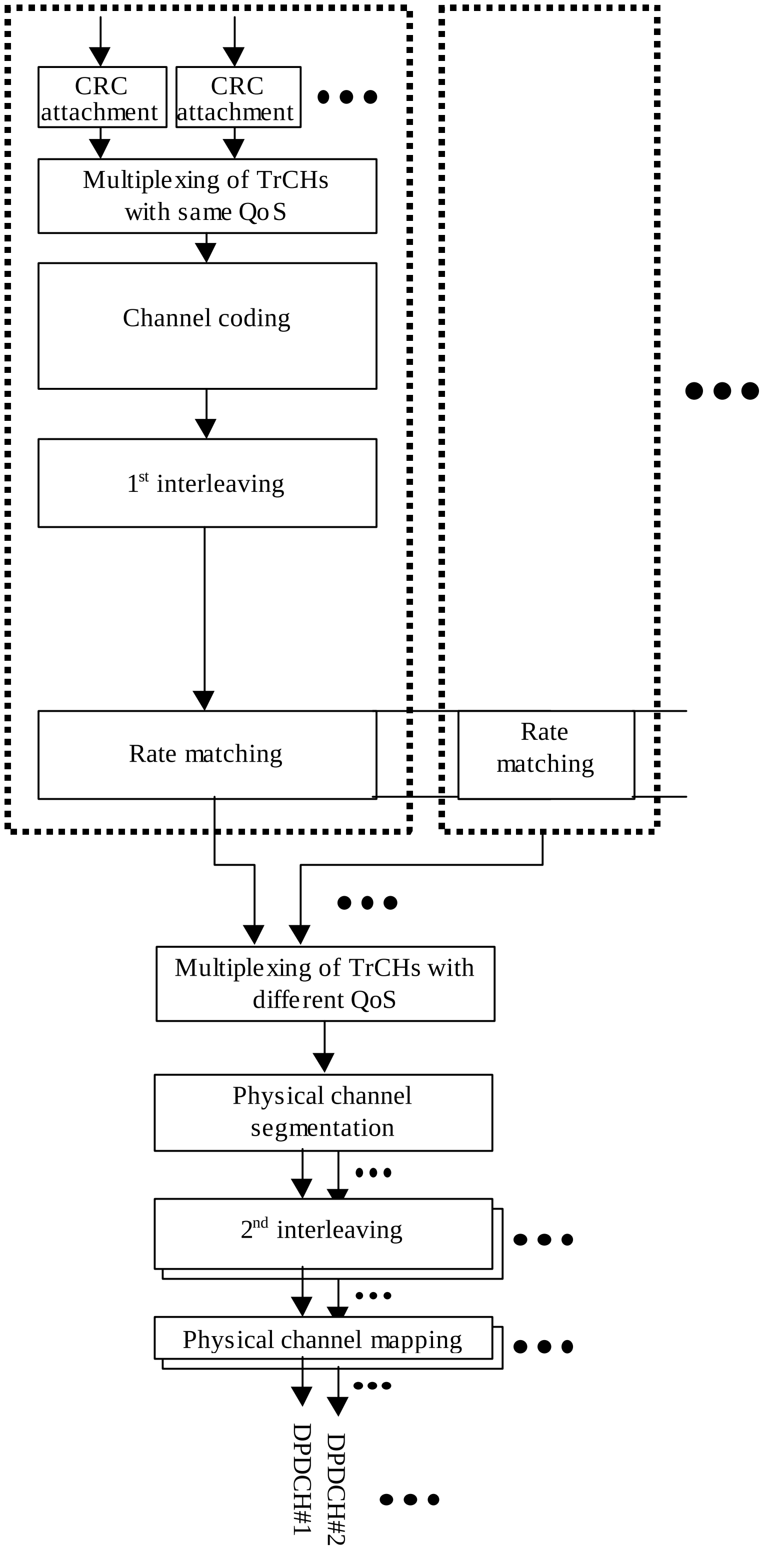


Figure 4-1. Transport channel multiplexing structure for uplink.

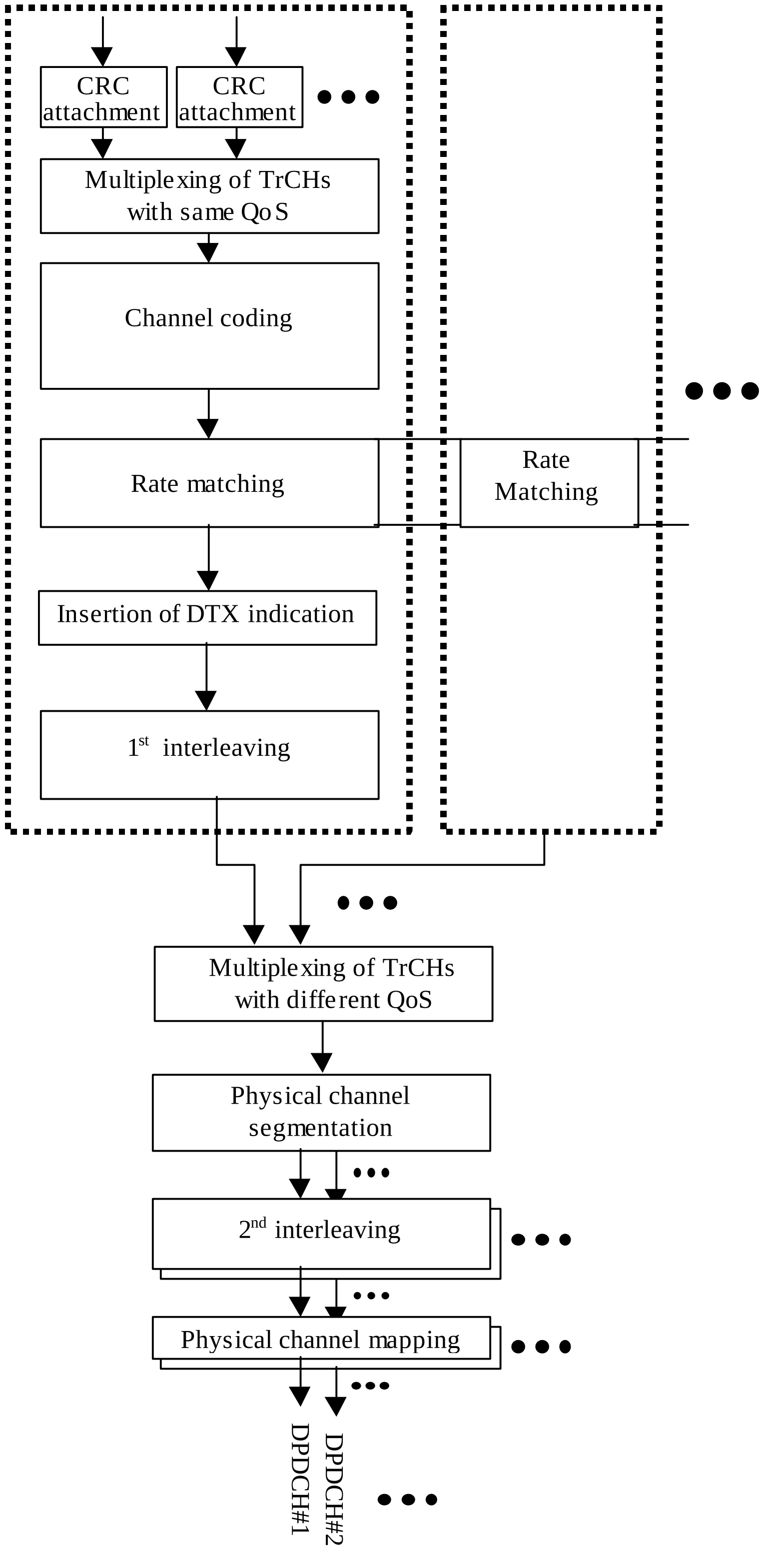


Figure 4-2. Transport channel multiplexing structure for downlink.

<Editor's note: Code multiplexing is not used in uplink as a working assumption according to the results of Ad Hoc4. For downlink is FFS.>

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 code multiplexing, which corresponds to having several parallel multiplexing chains as in Figure 4-1, resulting in several data stream, each mapped to one or several physical channels. This code multiplexing is used only for downlink DSCHs. For the other transport channels including downlink DCHs, the code multiplexing shall not be used.

4.2.1 CRC calculation

Cyclic Redundancy Check is applied as an error detection scheme of transport blocks. A 16-bit CRC code is applied to each transport block of all transport channels. The entire transport block is used to calculate the CRC for each transport block. Generator Polynomial is as follows:

$G_{CRC16}(X)= X^{16}+X^{12}+X^{5}+1$

The initial value of the CRC arithmetic calculator shall be "all 0". Output to the convolutional coder or Turbo coder shall be done from the most significant bit .

4.2.2 Channel coding

The following options are available for the transport-channel specific coding, see also Figure 4-1:

- Convolutional coding
- Turbo coding
- Service-specific coding, e.g. unequal error protection for some types of speech codecs.

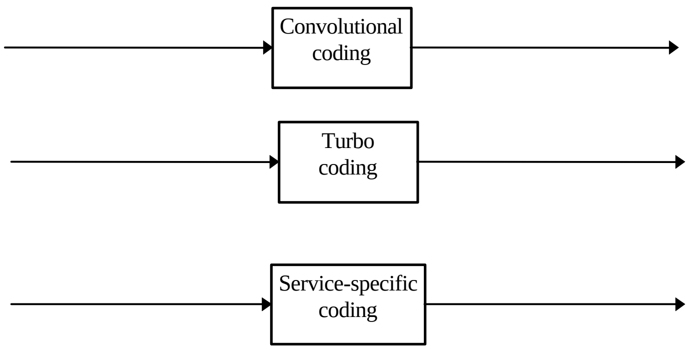


Figure 4-1. Channel coding.

<Editor's note: The following is a working assumption of Ad Hoc5.>

Turbo coding should be used for data rate above 32 kbps. Data rates equal to or less than 32 kbps are for further study.

<Editor's note: According to the discussion in WG1#2, Table 4-1 taken from ARIB document has been preserved for

the time being with some modifications so as to align with the Ad Hoc5 result.>

Table 4-1. Error Correction Coding Parameters

Transport channel type	Coding scheme (constraint length)	Coding rate
BCH	Convolutional code (K=9)	1/2
PCH		
FACH		
RACH		
DCH (equal or less than 32 kbps)		1/3 (1/2 in compressed mode using Method A*)
DCH (above 32 kbps)	Turbo code	

* See 4.4.2.1

[Editor’s note: Combined or segmented mode with Turbo coding is F.F.S.]

4.2.2.1 Convolutional coding

- The configuration of the convolutional coder is presented in Figure 4-1.
- The output from the convolutional coder shall be done in the order starting from output0, output1 and output2. (When coding rate is 1/2, output is done up to output 1).
- K-1 tail bits (value 0) shall be added to the end of the coding block.
- The initial value of the shift register of the coder shall be “all 0”.

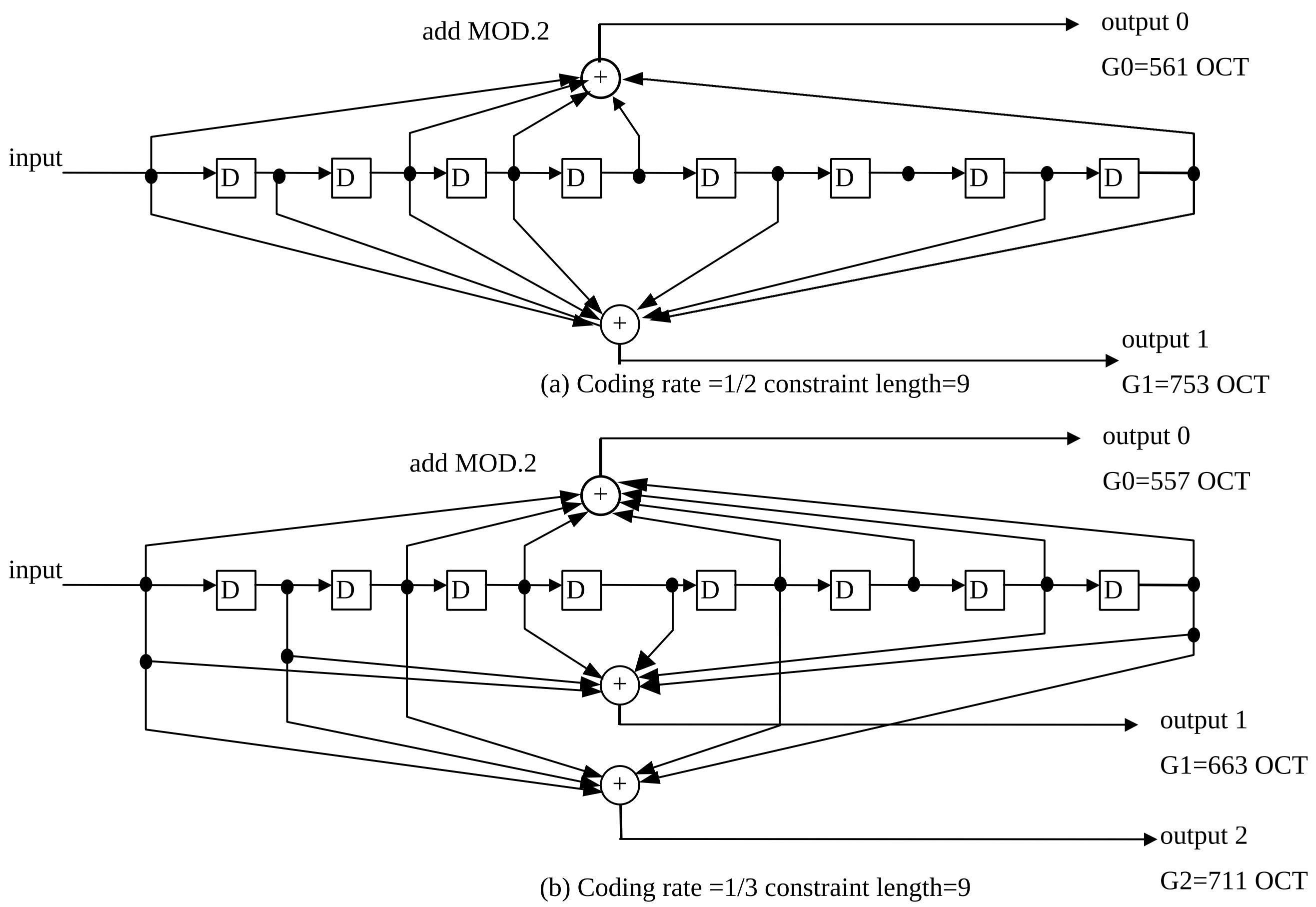


Figure 4-1. Convolutional Coder

4.2.2.2 Turbo coding

<Editor's note: The following is a working assumption of Ad Hoc5.>

<Editor's note: It needs to be clarified from TSG-SA what are the service specifications with respect to different quality of services.>

For data services requiring quality of service between 10^{-3} and 10^{-6} BER inclusive, parallel concatenated convolutional code (PCCC) with 8-state constituent encoders is used. If date services requiring quality of service bellow 10^{-6} BER are to be specified, the possibility of adopting serial concatenated convolutional code (SCCC) with 4-state constituent encoders for those services should be considered for further study.

The 8-state PCCC and the 4-state SCCC are described below.

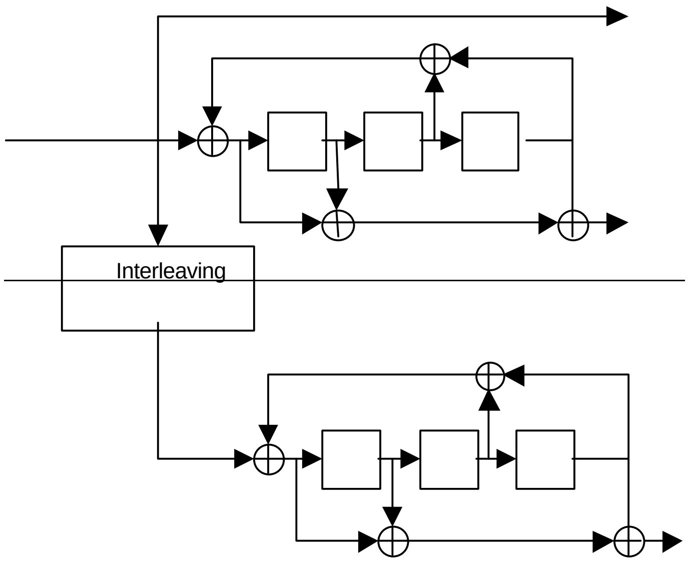
The transfer function of the 8-state constituent code for PCCC is

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

where,

$$d(D)=1+D^2+D^3$$

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



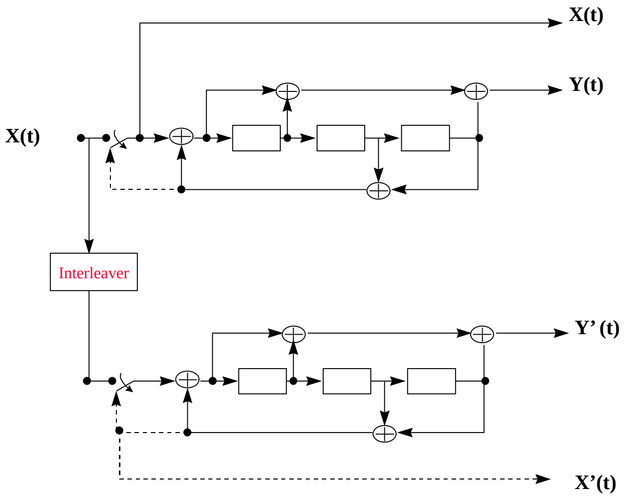


Figure 4-1. Structure of the 8 state PCCC encoder (dotted lines effective for trellis termination only)

The initial value of the shift registers of the PCCC encoder shall be all zeros.

The output of the PCCC encoder is punctured to produce coded bits corresponding to the desired code rate 1/3 or 1/2. For rate 1/3, none of the systematic or parity bits are punctured, and the output sequence is X(0), Y(0), Y'(0), X(1), Y(1), Y'(1), etc. For rate 1/2, the parity bits produced by the constituent encoders are alternately punctured to produce the output sequence X(0), Y(0), X(1), Y'(1), X(2), Y(2), X(3), Y'(3), etc.

The SCCC is a rate 1/3 SCCC, The outer code of the SCCC is a rate 2/3 obtained by puncturing a rate ½ code with generating matrix

$$G^{(o)}(Z) = (1, (1+Z^2)/(1+Z+Z^2))$$

The rate 2/3 is obtained by puncturing every other parity-check bit.
The inner code is a rate ½ systematic recursive convolutional code with the same previous generating matrix

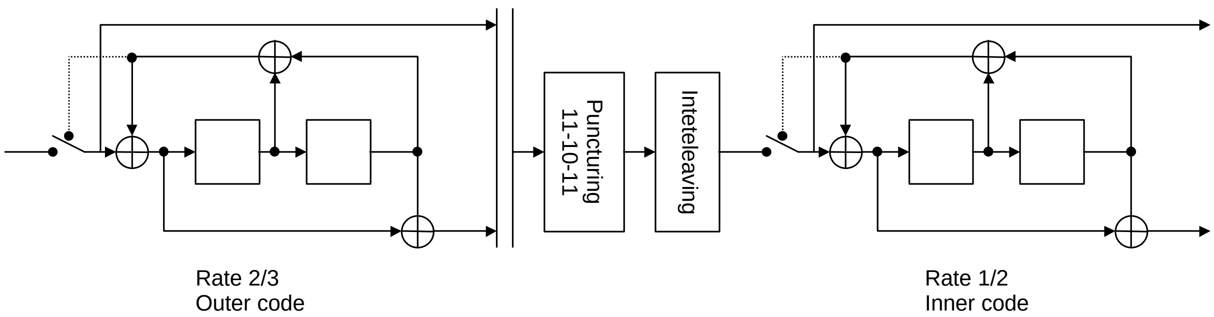


Figure 4-2. Structure of the 4 state SCCC encoder (dotted lines effective for trellis termination only)

4.2.2.2.1 Trellis termination for Turbo coding

<Editor's note: The following is a working assumption of Ad Hoc5.>

The conventional method of trellis termination is used in which the tail bits are taken from the shift register feedback after all information bits are encoded. Tail bits are added after the encoding of information bits.

Trellis termination for PCCC

The first three tail bits shall be used to terminate the first constituent encoder (upper switch of Figure 4-1 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 4-1 in lower position) while the first constituent encoder is disabled.

The transmitted bits for trellis termination shall then be

X(t) Y(t) X(t+1) Y(t+1) X(t+2) Y(t+2) X'(t) Y'(t) X'(t+1) Y'(t+1) X'(t+2) Y'(t+2).

Trellis termination for SCCC

The conventional method of trellis termination is used also for SCCC in which the tail bits are taken from the shift register feedback after all bits are encoded. The tailing bits of the outer encoder are included in the interleaver. The outer code is terminated first with two additional input bits taken from the shift register feedback (dotted line of Figure 4-2), the outer code thus, after puncturing, outputs three additional bit that are feeded into the interleaver. After that all bits have been encoded from the inner encoder (included the interleaved tail bit of the outer encoder), two additional input bits are taken from the shift register feedback of the inner encoder producing four tail bits (dotted line of Figure 4-2). Thus the total overhead due to the tailing bits is 3*2+4 =10 bits

4.2.2.2.2 Turbo code internal interleaver

<Editor's note: The following is a working assumption of Ad Hoc 5>

Figure 4-1 depicts the overall 8 State PCCC Turbo coding scheme including Turbo code internal interleaver. The Turbo code internal interleaver consists of mother interleaver generation and pruning. For arbitrary given block length K, one mother interleaver is selected from the 224 mother interleavers set. After the mother interleaver generation, *l*-bits are pruned in order to adjust the mother interleaver to the block length K. The definition of *l* is shown in Figure 4-1.

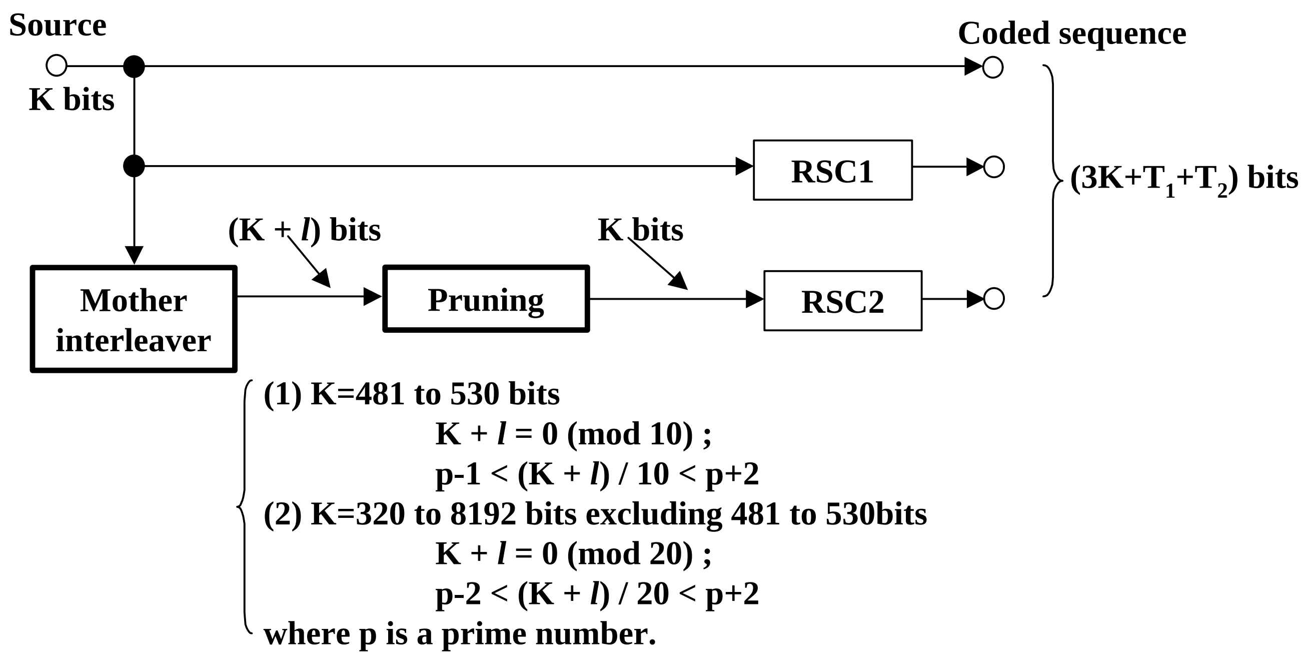


Figure 4-1. Overall 8 State PCCC Turbo Coding

4.2.2.2.2.1 Mother interleaver generation

<Editor's note: Block length of 8192 is FFS.>

The interleaving consists of three stages. In first stage, the input sequence is written into the rectangular matrix row by row. The second stage is intra-row permutation. The third stage is inter-row permutation. The three-stage permutations are described as follows, the input block length is assumed to be K (320 to 8192 bits).

First Stage:

(1) Determine a row number R such that
R=10 (K = 481 to 530 bits; Case-1)
R=20 (K = any other block length except 481 to 530 bits; Case-2)

(2) Determine a column number C such that
Case-1; C = 53
Csae-2;
(i) find minimum prime p such that,
0 < (p+1)-K/R
(ii) if 0 < p-K/R then go to (iii)
else C = p+1.
(iii) if 0 < p-1-K/R then C=p-1.
else C = p.

(3) The input sequence of the interleaver is written into the RxC rectangular matrix row by row.

Second Stage:

A. If C = p

(1) Select a primitive root g_0 from Table 4-yy.
(2) Perform the first (0-th) intra-row permutation as:
$c(i) = [g_0 \times c(i-1)] \bmod p$, i =1,2,…C-2., c(0) = 1, and c(C-1) = 0,

where c(i) is the input bit position of i-th output after the permutation.

(3) Select the minimum prime integer set {p_j } (j=1,2,…R-1) such that
g.c.d{p_j, p-1} =1
$p_j > 6$
$p_j > p_{(j-1)}$
where g.c.d. is greatest common divider
(4) Perform the j-th (j = 1, 2, …, C-1) intra-row permutation as:
$c_j(i) = c([i \times p_j] \bmod (p-1))$, i =1,2,…, (C-2)., $c_j(0) = 1$, and $c_j(C-1) = 0$,

where $c_j(i)$ is the input bit position of i-th output after the permutation of j-th row.

B. If C = p+1

(1) Same as case A.
(2) Perform the first (0-th) intra-row permutation as:
$c(i) = [g_0 \times c(i-1)] \bmod p$, i =1,2,…, (C-2)., c(0) = 1, c(C-1) = 0, and c(C) = p,

where c(i) is the input bit position of i-th output after the permutation.

(3) Same as case A.
(4) Perform the j-th (j = 1, 2, …, C-1) intra-row permutation as:
$c_j(i) = c([i \times p_j] \bmod (p-1))$, i =1,2,…, (C-2)., $c_j(0) = 1$, $c_j(C-1) = 0$, and $c_j(C) = p$,

where $c_j(i)$ is the input bit position of i-th output after the permutation of j-th row.

C. If C = p-1

(1) Same as case A.
(2) Perform the first (0-th) intra-row permutation as:
$c(i) = [g_0 \times c(i-1)] \bmod p$, i =1,2,…,(C-2)., and c(0) = 1,

where c(i) is the input bit position of i-th output after the permutation.

(3) Same as case A.
(4) Perform the j-th (j = 1, 2, …, C-1) intra-row permutation as:
$c_j(i) = c([i \times p_j] \bmod (p-1))$, i =1,2,…, (C-2)., and $c_j(0) = 1$,

where $c_j(i)$ is the input bit position of i-th output after the permutation of j-th row.

Third Stage:

Perform the inter-row permutation based on the following patterns.
A: {19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 10, 8, 13, 17, 3, 1, 16, 6, 15, 11} for R=20
B: {19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 16, 13, 17, 15, 3, 1, 6, 11, 8, 10} for R=20

C: {9, 8, 7, 6, 5, 4, 3, 2, 1, 0} for R=10

The usage of these patterns is as follows:

Block length K: Pattern
320 to 480-bit: A
481 to 530-bit: C
531 to 2280-bit: A
2281 to 2480-bit: B
2481 to 3160-bit: A
3161 to 3210-bit: B
3211 to 8192-bit: A

Table 4-1. Table of prime p and associated primitive root

p	g_o	*p*	g_o	*P*	g_o	*p*	g_o	*p*	g_o	*p*	g_o	*p*	g_o	*p*	g_o
17	3	59	2	103	5	157	5	211	2	269	2	331	3	389	2
19	2	61	2	107	2	163	2	223	3	271	6	337	10	397	5
23	5	67	2	109	6	167	5	227	2	277	5	347	2	401	3
29	2	71	7	113	3	173	2	229	6	281	3	349	2	409	21
31	3	73	5	127	3	179	2	233	3	283	3	353	3		
37	2	79	3	131	2	181	2	239	7	293	2	359	7		
41	6	83	2	137	3	191	19	241	7	307	5	367	6		
43	3	89	3	139	2	193	5	251	6	311	17	373	2		
47	5	97	5	149	2	197	2	257	3	313	10	379	2		
53	2	101	2	151	6	199	3	263	5	317	2	383	5		

4.2.2.2.3 Encoding blocks for Turbo code

<Editor's note: 8192 is FFS.>

Input data blocks for a turbo encoder consist of the user data and possible extra data being appended to the user data before turbo encoding. The encoding segments for a turbo encoder are defined in terms of systematic bits. The segment includes the user data, a possible error detection field (CRC), possible filler bits, and the termination. The maximum encoding segment length is 8192. The Algorithm for combining and segmentation is as follows:

Inputs:

R_{DATA} the user data rate (bits per second)

T_{DELAY} transmission time interval (seconds)

N_{EXTRA} extra data to be appended to the user data before encoding (CRC bits etc)

N_{TAIL} number of tail bits to be appended to the encoding segments (termination)

Outputs:

N_S number of segments

N_{TB} number of bits in the turbo encoder input segments

N_{FILL} number of filler (zero) bits in the last turbo encoder input segment

Do:

1. Let N_S = round_up($(R_{DATA} * T_{DELAY} + N_{EXTRA}) / (8192 - N_{TAIL})$)

2. Let N_{TB} = round_up ($(R_{DATA} * T_{DELAY} + N_{EXTRA}) / N_S$) + N_{TAIL};

3. Let N_{REM} = remainder of $(R_{DATA} * T_{DELAY} + N_{EXTRA}) / N_S$;

4. If N_{REM} not equal to 0 then insert $N_{FILL} = (N_S - N_{REM})$ zero bits to the end of the input data else $N_{FILL} = 0$.

5. End.

Here *round_up(x)* stands for an smallest interger number being larger or equal to *x*.

All turbo encoder input segments are of equal size and therefore the same turbo interleaver can be used for all turbo segments. A number of systematic bits over an entire channel interleaving block at output of the encoder is

$$N_S * (\text{round\_up}((R_{DATA} * T_{DELAY} + N_{EXTRA}) / N_S) + N_{TAIL}).$$

The N_{FILL} filler bits are padded to the end of the last encoding segment in order to make the last segment equal size to the precedent ones. The filler bits are encoded.

4.2.2.3 Service specific coding

In addition to standard channel coding options a service specific encoder can be used. In the simplest case it can mean that there is no channel coding at all. A more typical example is an optimized channel code for a specific speech codec.

4.2.3 1st interleaving

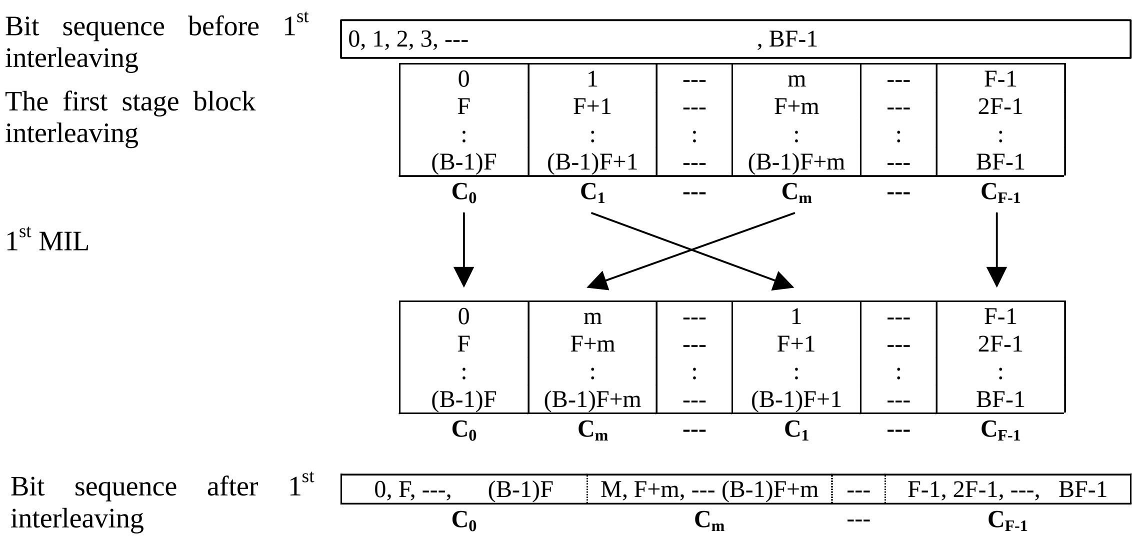
<Editor's note: In ETSI, the exact interleaver structure is for further study. However, ARIB MIL interleaver is the only channel interleaver proposal offered thus far in ETSI. So that, text from ARIB is taken.>

1st interleaving is carried out on a per-transport-channel basis. The span of the 1st interleaving is the same as the transmission time interval of the transport channel.

The channel interleaver has the interleaving pattern obtained by using Multi-stage Interleaving Method (MIL). The channel MIL consists of two-step interleaving process; 1st MIL and 2nd MIL. In the transmitter side, the 1st MIL is processed in advance of the 2nd MIL as shown in Figure 4-1 and Figure 4-2.

4.2.3.1 1st MIL

Overview of the 1st MIL is shown in Figure 4-1. Table 4-1 shows the 1st MIL pattern for all possible transmission time intervals.



F: the number of radio frames corresponding to the transmission time interval
B: the number of bits in a radio frame for the 1st interleaving unit

Figure 4-1. Overview of the inter-frame MIL

Table 4-1. 1st MIL pattern for each transmission time interval

Transmission time interval	Interleaving size [frames]	Interleaving pattern of the inter-frame MIL
10ms	1	$\mathbf{C_0}$
20ms	2	$\mathbf{C_0, C_1}$
40ms	4	$\mathbf{C_0, C_2, C_1, C_3}$
80ms	8	$\mathbf{C_0, C_4, C_2, C_6, C_1, C_5, C_3, C_7}$

4.2.4 Rate matching

The rate matching applies repetition and puncturing of the different transport channels.

For each combination of rates of the different transport channels, a puncturing/repetition factor is assigned to each transport channel. The set of puncturing/repetition factors is determined based on following criteria:

- desired transmission quality requirements of each transport channel is fulfilled and not significantly exceeded. This means that required transmission power to meet quality requirements for all transport channels is as low as possible.
- on the uplink, the total bit rate after transport channel multiplexing is identical to the total channel bit rate of the dedicated physical channels allocated
- on uplink and downlink, the total allocated code resource should be minimised
- the puncturing factors should not exceed a certain maximum puncturing factor, specific for each transport channel.

4.2.4.1 Rate matching algorithm

Let's denote:

$S_N = \{N_1, N_2, \ldots, N_L\}$ = ordered set (in ascending order from left to right) of allowed number of bits per block

N_C = number of bits per matching block

$S_0 = \{d_1, d_2, \ldots, d_{N_C}\}$ = set of N_C data bits

P = maximum amount of puncturing allowed

$$P = \begin{cases} 0.2\text{: for downlink} \\ 0.2\text{: for uplink} \end{cases}$$

The rate matching rule is as follows:

find N_i and N_{i+1} so that $N_i \le N_C < N_{i+1}$

$$if\ (\frac{N_i}{N_C} > 1 - P)$$

$y = N_C - N_i$

```
        e =  NC            -- initial error between current and desired puncturing ratio
                           -- this offset is flexible, e.g. e = 2Nc
        m = 1          -- index of current bit
        do while m <= NC
            e = e – 2 * y          -- update error
            if e <= 0 then         -- check if bit number m should be punctured
                puncture bit m from set S0
                e = e + 2*NC       -- update error
            end if
            m = m + 1              --  next bit
        end do
    else
        y = Ni+1-NC
        e = NC             -- initial error between current and desired puncturing ratio
                           -- this offset is flexible, e.g. e = 2Nc
        m = 1              -- index of current bit
        do while m <= NC
            e = e – 2 * y          -- update error
            do while e <= 0        -- check if bit number m should be repeated
                repeat bit m from set S0
                e = e +  2*NC      -- update error
            enddo
            m = m + 1              --  next bit
        end do
    end if
```

4.2.5 Insertion of discontinuous transmission (DTX) indication bits

In the downlink, both fix and flexible positions of the transport channels within the radio frame are possible. It is up to the UTRAN to decide whether fix and/or flexible positions are supported. When fix positions of the transport channels are used, DTX indicator bits are inserted as illustrated in Figure 4-2. These bits only indicate when the transmission should be turned off, they are not transmitted. When flexible positions are used, the DTX is placed in the end of each slot.

<Editor’s note: The exact DTX insertion point for the case with flexible positions of the transport channels is dependent on the choice of interleaving scheme. This should therefore be specified after the decision of interleaving scheme has been made. It is for further study if the DTX instead should be inserted in the end of each frame.>

4.2.6 Multiplexing of transport channels with different QoS

The coded transport channels are serially multiplexed within one radio frame. The output after the multiplexer (before physical channel segmentation) will thus be according to Figure 4-1.

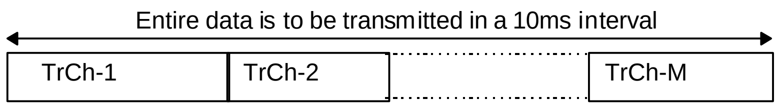


Figure 4-1. Transport channel multiplexing.

4.2.7 Physical channel segmentation

Data after multiplexing of transport channels with different QoS can get segmented into multiple physical channels which are transmitted in parallel during 10ms interval.

4.2.8 2^{nd} interleaving

<Editor’s note: In ETSI, the exact interleaver structure is for further study. However, ARIB MIL interleaver is the only channel interleaver proposal offered thus far in ETSI. So that, text from ARIB is taken.>

The 2^{nd} interleaving is carried out over one radio frame (10 ms) and is applied to the multiplexed set of transport channels.

2^{nd} MIL pattern corresponds to physical channel [symbol rate]. Table 4-1 shows the 2^{nd} MIL pattern for each interleaving size [frames].

Table 4-1. Intra-frame MIL pattern for each physical channel [symbol rate]

Physical channel	Link	Symbol rate [ksps]	TFCI bits in a frame [bits]	DATA bits in a frame [bits]	Interleaving pattern of the intra-frame MIL
Perch CH	Forward	16	0	160	160[10[5[3x2]x2]x16[4[2x2]x4[2x2]]]
CCPCH	FACH	64	0	1152	1152[72[9[3x3]x8[4[2x2]x2]]x16[4[2x2]x4[2x2]]]
	PCH	64	0	272	272[17[4[2x2,4x1,4x1,4x1,4x1]x5[3x2]]x16[4[2x2]x4[2x2]]]
	Reverse	32	0	320	320[20[4[2x2]x5[3x2]]x16[4[2x2]x4[2x2]]]
		128	0	1280	1280[80[10[5[3x2]x2]x8[4[2x2]x2]]x16[4[2x2]x4[2x2]]]
DPCH	Forward	8	0	64	64[4[2x2]x16[4[2x2]x4[2x2]]]
			32	32	32[2x16[4[2x2]x4[2x2]]]
		16	0	160	160[10[5[3x2]x2]x16[4[2x2]x4[2x2]]]
			32	128	128[8[4[2x2]x2]x16[4[2x2]x4[2x2]]]
		32	0	480	480[30[6[3x2]x5[2x3]]x16[4[2x2]x4[2x2]]]
			32	448	448[28[7[3x3[2x2]]x4[2x2]]x16[4[2x2]x4[2x2]]]
		64	0	1120	1120[70[10[5[3x2]x2]x7[3x3[2x2]]]x16[4[2x2]x4[2x2]]]
			128	992	992[62[9[3x3]x7[3x3[2x2]]]x16[4[2x2]x4[2x2]]]
		128	0	2400	2400[150[15[5[2x3]x3]x10[5[3x2]x2]]x16[4[2x2]x4[2x2]]]
			128	2272	2272[142[13[2x7[3x3[2x2],3[3x1,2xR{2},2xR{2}]x3[R{3}x1,R{3}x1,3x1]]]x11[3x5[3x2]]]x16[4[2x2]x4[2x2]]]
		256	0	4832	4832[302[19[5[2x3]x4[2x2]]x16[4[2x2]x4[2x2]]]x16[4[2x2]x4[2x2]]]
			128	4704	4704[294[19[5[2x3]x4[2x2]]x16[4[2x2]x4[2x2]]]x16[4[2x2]x4[2x2]]]
		512	0	9952	9952[622[32[8[4[2x2]x2]x4[2x2]]x20[4[2x2]x5[3x2]]]x16[4[2x2]x4[2x2]]]
			128	9824	9824[614[31[7[3x3[2x2]]x5[2x3]]x20[4[2x2]x5[3x2]]] x16[4[2x2]x4[2x2]]]
		1024	0	20192	20192[1262[40[8[4[2x2]x2]x5[2x3]]x32[8[4[2x2]x2]x4[2x2]]]x16[4[2x2]x4[2x2]]]
			128	20064	20064[1254[40[8[4[2x2]x2]x5[2x3]]x32[8[4[2x2]x2]x4[2x2]]] x16[4[2x2]x4[2x2]]]
		2048	0	40416	40416[2526[79[10[5[3x2]x2]x8[4[2x2]x2]]x32[8[4[2x2]x2]x4[2x2]]]x16[4[2x2]x4[2x2]]]
			128	40288	40288[2518[79[10[5[3x2]x2]x8[4[2x2]x2]]x32[8[4[2x2]x2]x4[2x2]]] x16[4[2x2]x4[2x2]]]
		4096	0	81376	81376[5086[80[10[5[3x2]x2]x8[4[2x2]x2]]x64[8[4[2x2]x2]x8[4[2x2]x2]]]x16[4[2x2]x4[2x2]]]
			128	81248	81248[5078[80[10[5[3x2]x2]x8[4[2x2]x2]]x64[8[4[2x2]x2]x8[4[2x2]x2]]]x16[4[2x2]x4[2x2]]]

Table 4-1. Intra-frame MIL pattern for each physical channel [symbol rate] (Cont')

Physical channel	Link	Symbol rate [ksps]	TFCI bits [bits]	DATA bits in a frame [bits]	Interleaving pattern of the intra-frame MI
DPCH	Reverse	16	0, 32	160	160[10[5[3x2]x2]x16[4[2x2]x4[2x2]]]
		32	0, 32	320	320[20[4[2x2]x5[3x2]]x16[4[2x2]x4[2x2]]]
		64	0, 32	640	640[40[8[4[2x2]x2]x5[2x3]]x16[4[2x2]x4[2x2]]]
		128	0, 32	1280	1280[80[10[5[3x2]x2]x8[4[2x2]x2]]x16[4[2x2]x4[2x2]]]
		256	0, 32	2560	2560[160[16[4[2x2]x4[2x2]]x10[5[3x2]x2]]x16[4[2x2]x4[2x2]]]
		512	0, 32	5120	5120[320[20[4[2x2]x5[3x2]]x16[4[2x2]x4[2x2]]]x16[4[2x2]x4[2x2]]]
		1024	0, 32	10240	10240[640[32[8[4[2x2]x2]x4[2x2]]x20[4[2x2]x5[3x2]]]x16[4[2x2]x4[2x2]]]
		2048	0, 32	20480	20480[1280[40[8[4[2x2]x2]x5[2x3]]x32[8[4[2x2]x2]x4[2x2]]]x16[4[2x2]x4[2x2]]]
		4096	0, 32	40960	40960[2560[80[10[5[3x2]x2]x8[4[2x2]x2]]x32[8[4[2x2]x2]x4[2x2]]]x16[4[2x2]x4[2x2]]]

Definition: L[NxM] ... NxM block interleaver as shown the following figure:

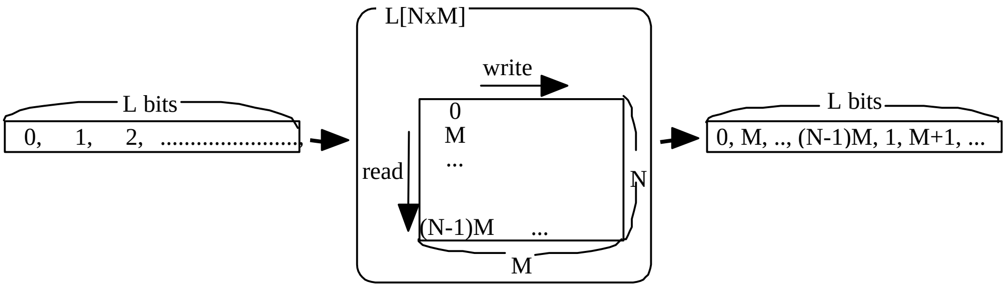


Figure 4-1. Channel Interleaving

4.2.9 Physical channel mapping

4.2.9.1 Uplink

On the uplink, transport data after 2nd interleaving is mapped onto one or several DPDCHs. Continuous transmission is applied for uplink DPDCH at all times.

4.2.9.2 Downlink

<Editor's note:. Ad Hoc4 conclusions are included with regard to the mapping position of transport channels.>

On the downlink, transport data after 2nd interleaving is mapped onto data fields in one or several DPDCHs, which are defined in S1.11. If the total bit rate after transport channel multiplexing is not identical to the total channel bit rate of the allocated dedicated physical channels, discontinuous transmission is used.

- If transport data is less than the number of DPDCH bits in a radio frame, the DPDCH transmission can be turn off for data absent.
- The transmission of the DPDCH symbols shall be ON, only if there is data to transmit. If there is no data, the transmission shall be OFF.

- For transport channels not relying on TFCI for rate detection (blind rate detection), the positions of the transport channels within the frame should be fixed.
- For transport channels relying on TFCI for rate detection, the UTRAN decides whether the positions of the transport channels should be fixed or flexible.
- Pilot and TPC symbols are always transmitted regardless of the data existence.

<Editor’s note: Following bullet is unclear.>

- The information to notify whether voice and/or control information exist or not shall not be transmitted.

4.2.10 DSCH transmission when associated with DCH

<Editor’s note: Following is taken from text proposal in the Ad Hoc 14 report Tdoc.240. >

- The data stream on DSCH shall be transmitted continuously over the 10 ms allocation period with no DTX on slot period.
- The spreading factor is indicated with the TFCI or with higher layer signaling on DCH.
- Rate matching is implemented as in uplink, when there is data to transmit the 10 ms frame is fully filled with no DTX. The rates for the data as well as rate matching parameters are pre-negotiated at higher layers and are all part of the TFCI indication for particular data rate with particular spreading code.

4.2.11 Multicode Transmission

4.2.11.1 Downlink

- When 1 Radio Link consists of multiple dedicated physical channels (spreading codes), transmission shall be performed as described below, and pilot aided coherent detection and transmitter power control, etc. shall be performed comprehensively for all the dedicated physical channels in 1 Radio Link. When multiple Radio Links were allocated for one MS, pilot aided coherent detection and transmitter power control shall be performed independently for each Radio Link.
- The frame timing and scrambling code phase shall be matched at all dedicated physical channels in one Radio Link. Also, the symbol rate of the multiple physical channels designated within one Radio Link shall all be the same.
- In all of the dedicated physical channels within one Radio Link, the spreading codes used at one particular dedicated physical channel shall be used only for the pilot symbol and the TPC symbol part. (See Figure 4-1)
- Transmission power of pilot symbols and TPC symbols in 1 Radio Link might be transmitted at a different transmission power from that multiplied by the number of dedicated physical channels in 1 Radio Link for the transmission power by symbols other than the pilot symbols and TPC symbols. (See Figure 4-2)
- Generally, δ shall be settled around the value which sets the power of DPCCH part to be one-N th of the DPDCH part, where N is the number of dedicated physical channels in a radio link. But basically, there is no regulation about the difference δ of transmission power.
- Mobile Station should reflect the difference δ in target received SIR for downlink closed-loop transmission power control.

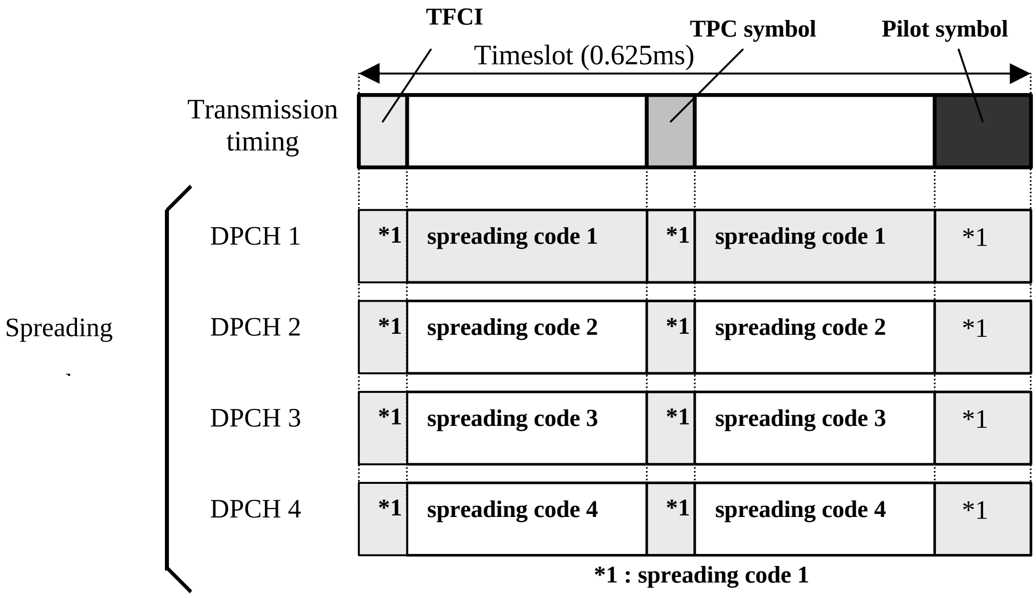


Figure 4-1. Spreading code in multi-code transmission

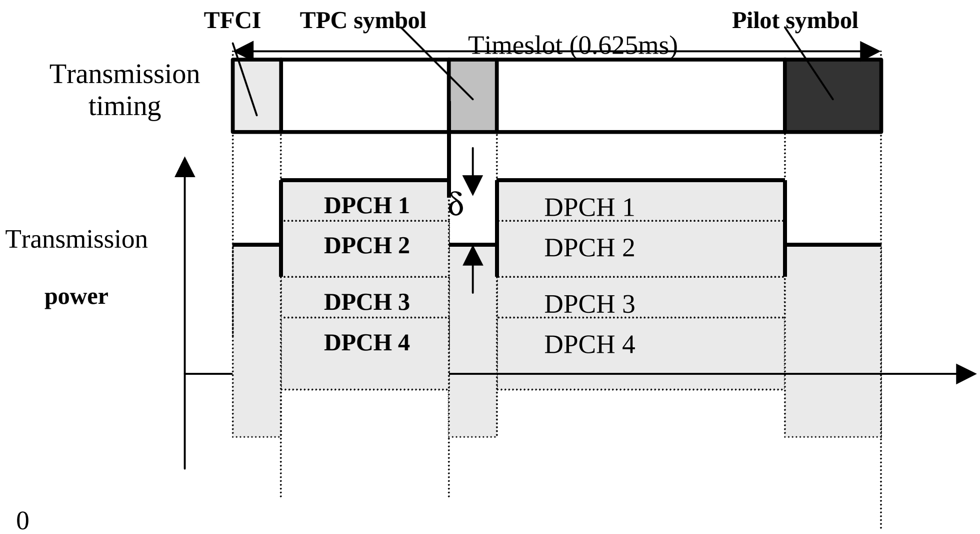


Figure 4-2. Transmission power in multi-code transmission

4.2.11.2 Uplink

For multi-code transmission in one uplink radio link, each additional uplink DPDCH may be transmitted on either the I or the Q branch, sharing a single common DPCCH. Each DPDCH branch shall use its own spreading code, multiple DPDCHs on different branches may share a common scrambling code. When multiple radio links are allocated for one MS, pilot aided coherent detection and transmit power control shall be performed independently for each radio link.

4.2.12 Rate detection

Two kinds of rate detection can be employed; explicit rate detection and blind rate detection. In the explicit rate detection, transmitter side transmits Transport Format Combination Indicator (TFCI), and receiver side detects transport format combination using TFCI. In the blind rate detection, transmitter side does not transmit TFCI, and receiver side detect transport format combination using some information, e.g. received power ratio of DPDCH to DPCCH, CRC check results.

For uplink, the blind rate detection is an operator option. For downlink, the blind rate detection can be applied with convolutional coding, the maximum number of different transport formats and maximum data rates allowed shall be specified.

4.2.12.1 Blind Rate Detection

Two kinds of blind rate detection are employed. Examples of these methods are given in Annex A.

4.2.12.2 Explicit Rate Detection

4.2.12.2.1 Transport Format Combination Indicator

Transport Format Combination Indicator (TFCI) informs the receiver of the number of bits in each frame of each of the services currently in use. As soon as a certain bit-rate is known, the number of code channels, the spreading factor and the puncturing/repetition rate is immediately known from the rules described in section 7.2.4.

This document therefore only explains the mapping from TFCI bits to TFCI service rate combinations.

A connection may in general include the variable-rate services S_1, S_2, …, S_K. Each service S_i has a set of possible transport format combination indicators $TF_{i,1}$,$TF_{i,2}$,…$TF_{i,Li}$:

S_1: $TF_{1,1}$, … , $TF_{1,L1}$

S_2: $TF_{2,1}$, … , $TF_{2,L2}$

…

S_K: $TF_{K,1}$, … , $TF_{K,LK}$

This gives L=L1xL2x…xLK service rate combinations, and thus it is required that L is less than or equal to 64 with the default TFCI word or 1024 with the extended TFCI word.

These service rate combinations shall be mapped to a certain service rate combination number, *m*, in the following way:

For j=K:-1:1,

SRC[j]= m MOD L[j];

m = m DIV L[j];

End;

From this pseudo-code, given a service rate combination number, i.e. a certain combination of TFCI bits, *m*, SRC contains the rates of each of the K services. The integer values used for *m* shall be consecutive, starting from 0. Note that this code gives the mapping rule from *m* to SRC, i.e. the rule used in the receiving side. The mapping rule from SRC to *m*, i.e. the transmitting side rule, is [TBD].

4.2.13 Coding Procedure

4.2.13.1 SFN(System Frame Number)

- SFN indicates super frame synchronisation. It is broadcasted in BCH. (See S1.11)

4.2.13.2 PI part

- Applied to: PCH
- An identifier to instruct whether there is termination information to the MS, and the necessity to receive BCH. When there arises the need to make the MS receives BCH, the necessity of reception shall be notified to the MS by PI1 and PI2.
- The bit configuration is presented in Table 4-1.

Table 4-1. PI part bit configuration

Bit	identified content
All 0	There is no termination information and not necessary to receive BCH
All 1	There is termination information or necessary to receive BCH

4.2.14 Bit transmission Sequence

- DCH shall be transmitted in the order it was input. Other various information shall be transmitted from the MSB side.
- CRC bits shall be transmitted most significant bit first .

<Editor's note: It is proposed to delete the ARQ section for the time being from here, since there is no contents defined.>

4.3 Coding for layer 1 control

4.3.1 Coding of Transport-format-combination indicator (TFCI)

<Editor's note: Only wording is changed, not technical contents, except that TFCI bit repetition is mentioned to be done only in downlink, since in uplink it it not needed.>

The number of TFCI bits is variable and is set at the beginning of the call via higher layer signalling. Encoding of the TFCI bits depends on the number of them. If there are at most 6 bits of TFCI, the channel encoding is done as described in section 0. Correspondingly, if the TFCI word is extended to 7-10 bits the channel encoding is done as explained in the section 4.3.1.2. For improved TFCI detection reliability, in downlink, repetition is used by increasing the number of TFCI bits within a slot.

4.3.1.1 Coding of default TFCI word

If the number of TFCI bits is up to 6, the TFCI bits are encoded using biorthogonal (32, 6) block code. The coding procedure is as shown in Figure 4-1.

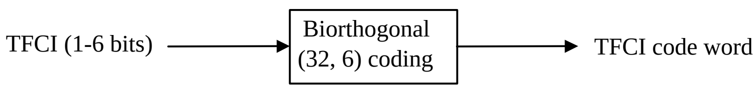


Figure 4-1. Channel coding of TFCI bits.

If the TFCI consist of less than 6 bits, it is padded with zeros to 6 bits, by setting the most significant bits to zero. The receiver can use the information that not all 6 bits are used for the TFCI, thereby reducing the error rate in the TFCI decoder. The length of the TFCI code word is 32 bits. Thus there are 2 bits of (encoded) TFCI in every slot of the radio frame. The code words of the biorthogonal block code are from the level 32 of the code three of OVSF codes defined in document S1.13. The code words, $C_{32,I}$, $I = 1,\ldots,32$, form an orthogonal set, $S_{C_{32}} = \{C_{32,1}, C_{32,2}, ..., C_{32,32}\}$, of 32 code words of length 32 bits. By taking the binary complements of the code words of $S_{C_{32}}$, another set, $\bar{S}_{C_{32}} = \{\bar{C}_{32,1}, \bar{C}_{32,2}, ..., \bar{C}_{32,32}\}$ is formed. These two sets are mutually biorthogonal yielding total of 64 different code words.

Mapping of the TFCI bits to the code words is done as shown in the Figure 4-2.

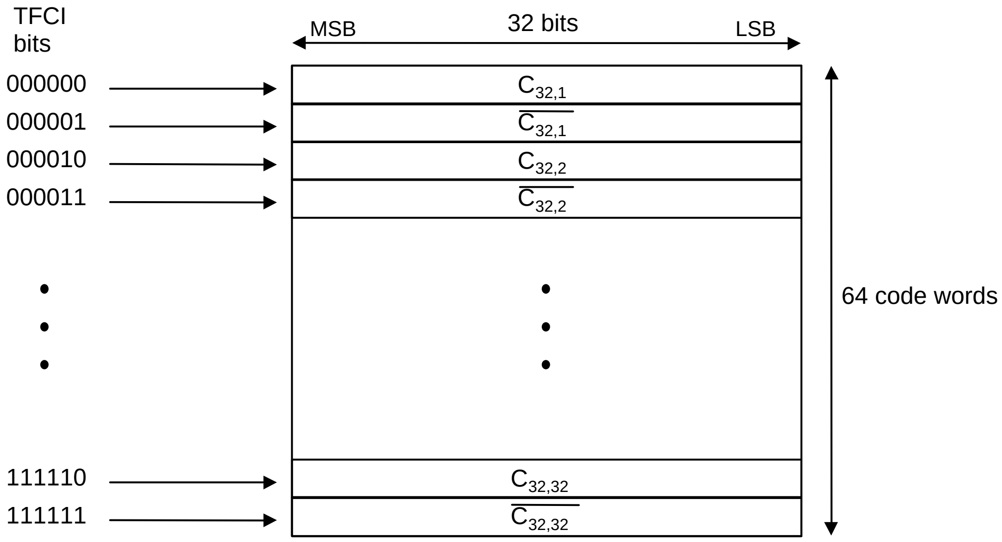


Figure 4-2. Mapping of TFCI bits to biorthogonal code words.

4.3.1.2 Coding of extended TFCI word

If the number of TFCI bits is 7-10 the TFCI information field is split into two words of length 5 bits as shown in the following formula: .

$n := \lfloor \sqrt{TFCI} \rfloor$; n is the largest integer being smaller than or equal to the square root of the transmitted TFCI value.

if $TFCI < n^2 + n$

then $Word1 := n$; $Word2 := TFCI - n^2$

else $Word2 := n$; $Word1 := n^2 + 2n - TFCI$

Both of the words are encoded using biorthogonal (16, 5) block code. The code words of the biorthogonal (16, 5) code are from two mutually biorthogonal sets, $S_{C_{16}} = \{C_{16,1}, C_{16,2}, ..., C_{16,16}\}$ and its binary complement, $\bar{S}_{C_{16}} = \{\bar{C}_{16,1}, \bar{C}_{16,2}, ..., \bar{C}_{16,16}\}$. Words of set $S_{C_{16}}$ are from the level 16 of the code three of OVSF codes defined in document S1.13. The mapping of information bits to code words is shown in the Table 4-1.

Table 4-1. Mapping of information bits to code words for biorthogonal (16, 5) code.

Information bits	Code word
00000	$C_{16,1}$
00001	$\overline{C}_{16,1}$
00010	$C_{16,2}$
...	...
11101	$\overline{C}_{16,15}$
11110	$C_{16,16}$
11111	$\overline{C}_{16,16}$

4.3.2 Interleaving of TFCI words

4.3.2.1 Interleaving of default TFCI word

As only one code word for TFCI of maximum length of 6 bits is needed no channel interleaving for the encoded bits are done. Instead, the bits of the code word are directly mapped to the slots of the radio frame as depicted in the Figure 4-1. Within a slot the more significant bit is transmitted before the less significant bit.

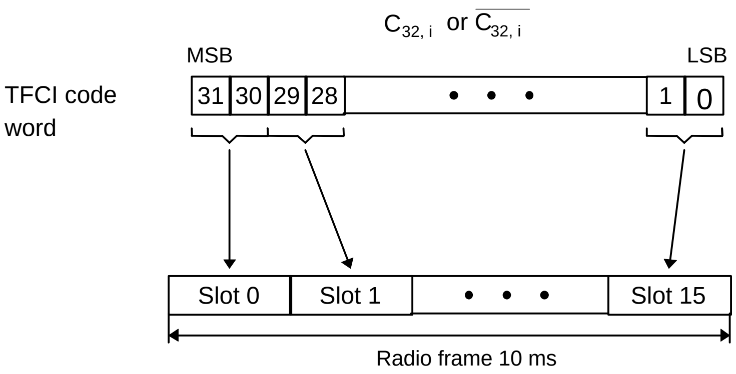


Figure 4-1. Time multiplexing of code words of (32, 6) code to the slots of the radio frame.

4.3.2.2 Interleaving of extended TFCI word

After channel encoding of the two 5 bit TFCI words there are two code words of length 16 bits. They are interleaved and mapped to DPCCH as shown in the Figure 4-1. Note that $b_{1,i}$ and $b_{2,i}$ denote the bit *i* of code word 1 and code word 2, respectively.

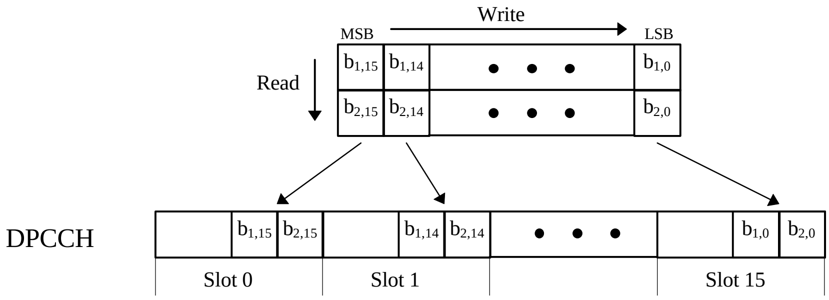


Figure 4-1. Interleaving of TFCI code words.

4.4 Coding of compressed mode

To support interfrequency measurements downlink transmission may, on network command, enter compressed mode. Uplink transmission may also enter compressed mode, on network command, if measurements will be made at frequencies close to FDD uplink band.

In compressed mode, slots N_{first} to N_{last} are not used for transmission of data. As illustrated in Figure 4-1, which shows the example of fixed idle length position with single frame method (see section 4.4.3), 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 section 4.4.2).What frames are compressed, are decided by the network. When in compressed mode, compressed frames can occur periodically, as illustrated in Figure 4-1, or requested on demand. The rate of and type of compressed frames is variable and depends on the environment and the measurement requirements.

<Editor's note: The following is a working assumption of Ad Hoc8.>.

For uplink compressed mode, smaller transmission gap lengths could be used for single receivers. Uplink compressed mode could be used regardless of downlink for duel receivers.

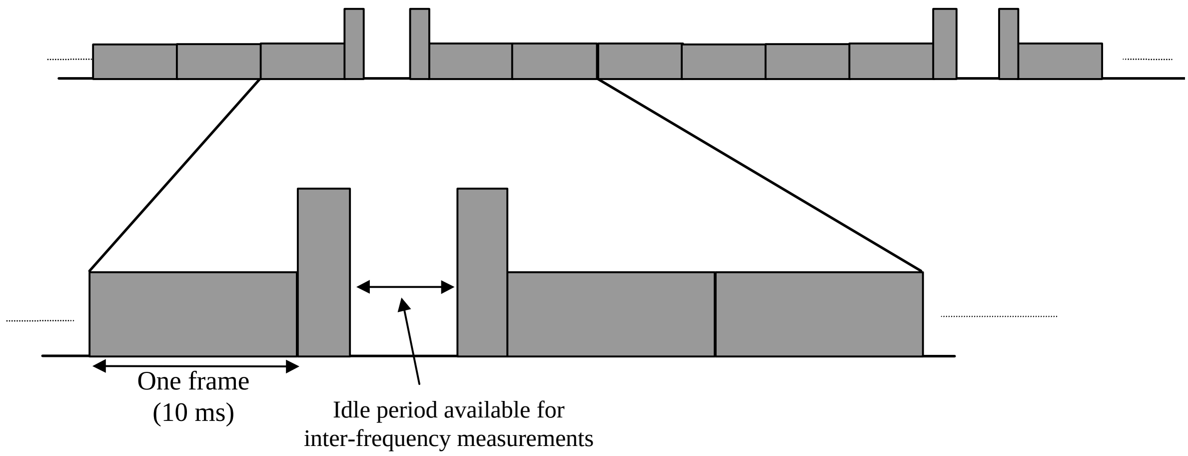
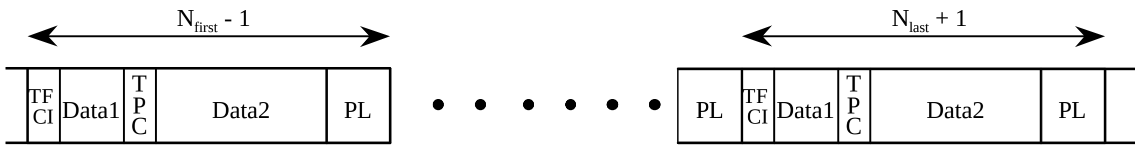


Figure 4-1. Compressed mode transmission.

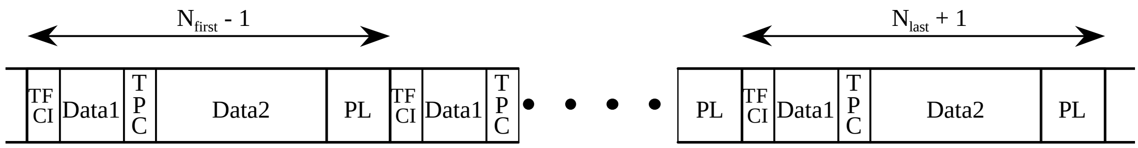
4.4.1 Frame structure types in downlink

There are two different types of frame structures defined for downlink compressed transmission. Type A is the basic case, which maximises the transmission gap length. Type B, which is more optimised for power control, can be used if the requirement of the transmission gap length allows that. Slot structure for uplink compressed mode is for further study.

- With frame structure of type A, BTS transmission is off from the beginning of TFCI field in slot Nfirst, until the end of Data2 field in slot Nlast (Figure 4-1(a)).
- With frame structure of type B, BTS transmission is off from the beginning of Data2 field in slot Nfirst, until the end of Data2 field in slot Nlast (Figure 4-1(b)) Dummy bits are transmitted in the TFCI and Data1 fields of slot Nfirst, and BTS and MS do not use the dummy bits. Thus BTS and MS utilize only the TPC field of Nfirst.



(a) Frame structure type A



(b) Frame structure type B

Figure 4-1. Frame structure types in downlink compressed transmission

4.4.2 Transmission Time Reduction Method

When in compressed mode, the information normally transmitted during a 10 ms frame is compressed in time. The mechanism provided for achieving this is either changing the code rate, which means puncturing in practice, or the reduction of the spreading factor by a factor of two.-The maximum idle length is defined to be 5 ms per one 10 ms frame.

4.4.2.1 Method A1: by Puncturing, basic case

During compressed mode, rate matching (puncturing) is applied for making short transmission gap length in one frame. Algorithm of rate matching (puncturing) described in 4.2.4 is used. The maximum transmission gap length allowed to be achieved with this method is the case where the code rate is increased from 1/3 to 1/2 by puncturing, which corresponds to 2 - 5 time slots per 10 ms frame, depending on the rate matching conditions that would be used in the non-compressed frame case. The explanation of the rate matching conditions are given below:

Example 1: If rate matching conditions in the non-compressed frame case would be such that maximum puncturing =0.2 would be used, then during compressed mode further puncturing of 1-(2/(3*(1-0.2))) =0.17 is allowed which corresponds to 0.17*16=2.7 => 2 time slots.

Example 2: If rate matching conditions in the non-compressed frame case would be such that no puncturing would be used, then during compressed mode puncturing of 1-(2/3)=0.33 is allowed which corresponds to 0.33*16=5.3 => 5 time slots.

4.4.2.2 Method A2: By puncturing, for services that allow larger delay

Other methods of supporting compressed mode may be considered as options. For example, with services that allows for a larger delay, e.g. data services with interleaving over several frames, multiple frames might be compressed together in order to create a short measurement slot. As an example, for a 2 Mbps service, with interleaving of 5 frames (50 ms), a 5 ms idle slot can be created by puncturing only 10% of 5 frames, as illustrated in Figure 4-1.

Figure 4-1. Multi-frame compressed mode for long-delay services.

4.4.2.3 Method B: by Reducing the Spreading Factor by 2

<Editor's note: The second scrambling code possibility was defined only in ETSI, and not in ARIB.. The second scrambling code possibility was suggested by Ad Hoc8.>

During compressed mode, the spreading factor (SF) can be reduced by 2 to enable the transmission of the information bits in the remaining time slots of a compressed frame. This can accommodate up to 50% idle slots per frame which is the maximum compression factor required. Additional rate matching is required if there are less than 50% idle slots. Reducing the spreading factor will normally be used if rate matching alone is not sufficient to transmit all information bits in compressed mode. Decrease of the spreading factor could involve change of the scrambling code, but when such an option could be used is for further study. Use of this method for uplink compressed mode is for further study.

4.4.3 Transmission gap lengths position

Transmission gap lengths can be placed at both fixed position and adjustable position for each purpose such as interfrequency power measurement, acquisition of control channel of other system/carrier, and actual handover operation.

4.4.3.1 Fixed transmission gap lengths position

Transmission gap lengths can be placed on fixed positions. The fixed transmission gap lengths positions are located on the center of a frame or on the center of two connected frames as shown in Figure 4-1. Table 4-1 shows the parameters for the fixed transmission gap lengths position case.

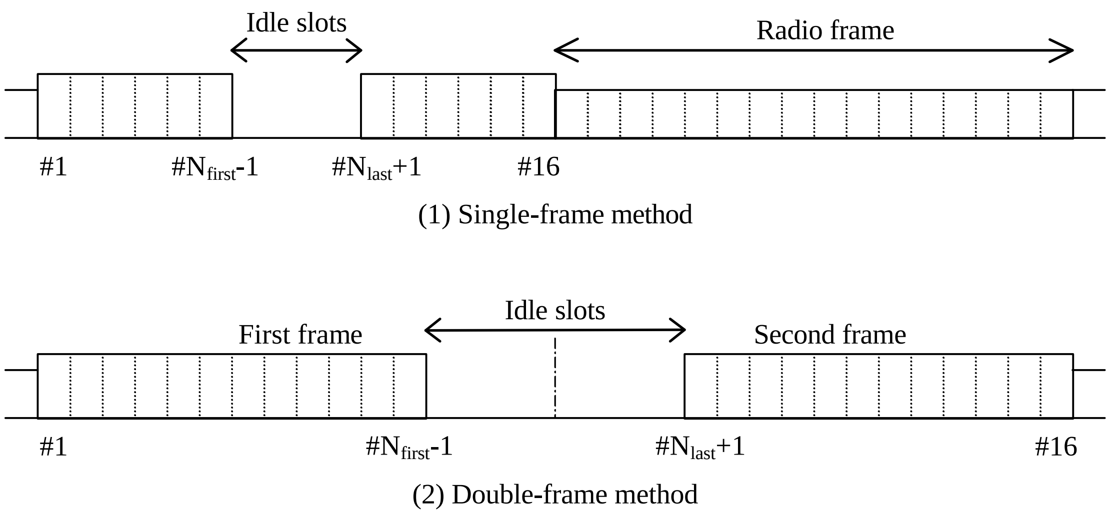


Figure 4-1. Fixedtransmission gap lengths position

Table 4-1. Parameters for fixed transmission gap lengths position

	Single-frame method		Double-frame method	
Transmission gap length (slot)	N_{first}	N_{last}	N_{first}	N_{last}
2	8	9	16 in first frame	1 in second frame
3	8	10	16 in first frame	2 in second frame
4	7	10	15 in first frame	2 in second frame
5	7	11	15 in first frame	3 in second frame
6	6	11	14 in first frame	3 in second frame
8	5	12	13 in first frame	4 in second frame
10	N.A.	N.A.	12 in first frame	5 in second frame
16	N.A.	N.A.	9 in first frame	8 in second frame

4.4.3.2 Adjustable transmission gap lengths position

Position of transmission gap lengths can be adjustable/relocatable for some purpose e.g. data acquisition on certain position as shown in Figure 4-1. Parameters of the adjustable transmission gap lengths positions are calculated as follows:

N_{idle} is the number of consecutive idle slots during compressed mode, as shown in Table 4-1,

N_{idle} = 2,3,4,5,6,8,10,16.

N_{first} specifies the starting slot of the consecutive idle slots,

N_{first} = 1,2,3,…,16.

N_{last} shows the number of the final idle slot and is calculated as follows;

If $N_{first} + N_{idle} <= 17$, then $N_{last} = N_{first} + N_{idle} - 1$ (in the same frame),

If $N_{first} + N_{idle} > 17$, then $N_{last} = N_{first} + N_{idle} - 17$ (in the next frame).

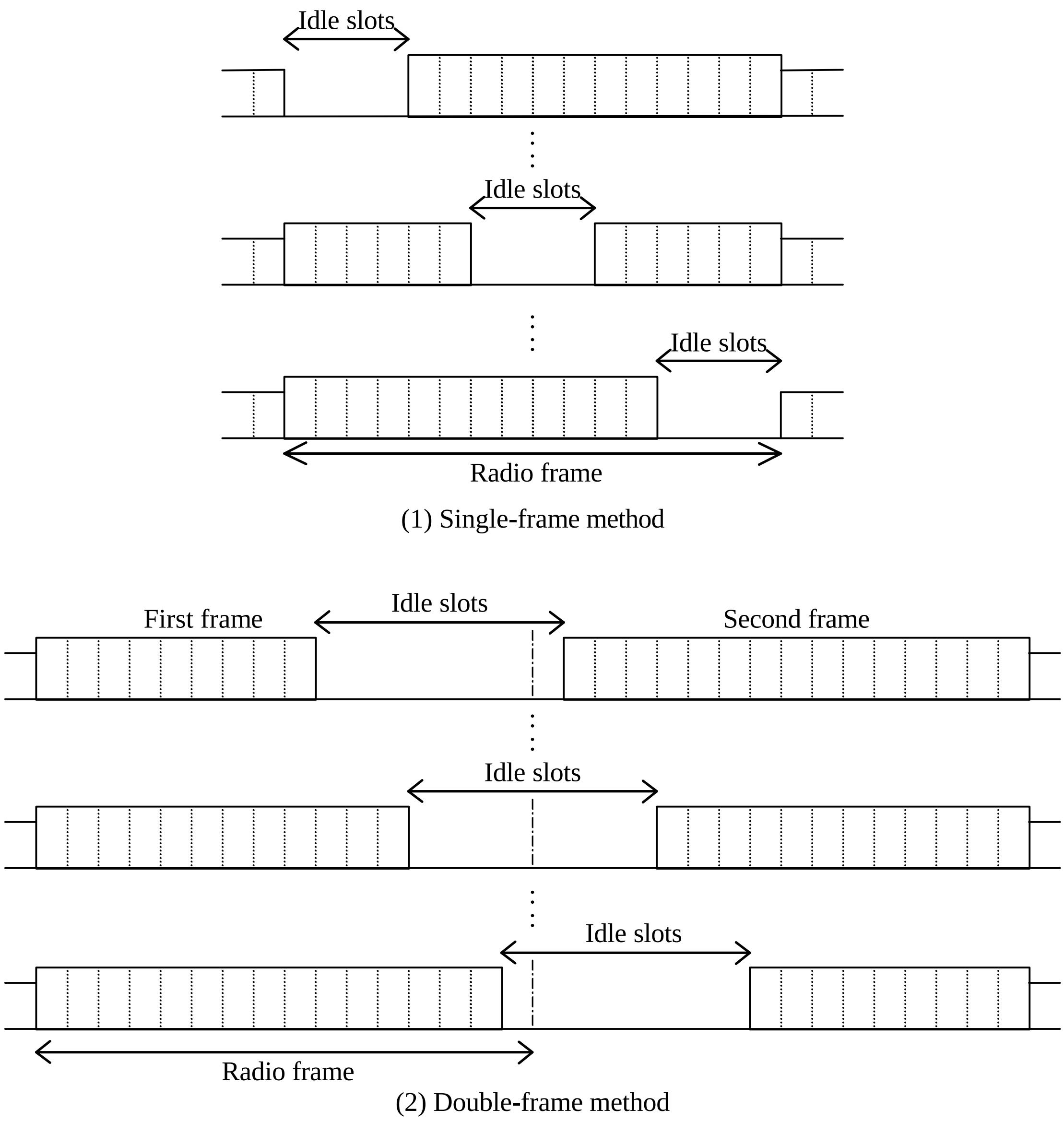


Figure 4-1. Concept of adjustable transmission gap lengths position

4.4.3.3 Parameters for Compressed Mode

< Editor's note: Ad Hoc8 suggestion is that there is need for further clarifications in Table 4-1 (e.g. rationales between change of coding rate/puncturing/change of spreading factor and idle time size, spreading factor range for different modes, etc.).>

Table 4-1 shows the detailed parameters for each number of idle slots. This is an example for the 10ms interleaving depth. Application of compressed mode for interleaving depths other than 10ms are for further study. Each number of idle slots are classified for three cases:

Case 1 - Power measurement : Number of idle slots = 3, 4, 5, 6.

Case 2 - Acquisition of control channels : Number of idle slots = 3, 4, 5, 6, 8, 10.

Case 3 - Actual handover operation : Number of idle slots = 10, 16.

Table 4-1. Parameters for compressed *mode*

Number of idle slots	Mode	Spreading Factor	Idle length [ms]	Transmission time reduction method	Idle frame combining
3	A	512 - 256	1.63 - 1.63	Puncturing	(S)/(D)
	B	128 - 1	1.63 - 1.75		
4	A	512 - 256	2.25 - 2.25	Puncturing (D) Coding rate reduction:R=1/3->1/2 (S)	
	B	128 - 1	2.25 - 2.37		
5	A	512 - 256	2.87 - 2.87		
	B	128 - 1	2.87 – 2.99		
6	A	512 - 256	3.50 - 3.50	Puncturing (D)Spreading factor reduction by 2 (S)	
	B	128 - 2/1	3.50 - 3.62		
8	A	512 - 256	4.75 - 4.75	R=1/3->1/2(D) Spreading factor reduction by 2 (S)	
	B	128 - 2/1	4.75 - 4.87		
10	A	512 - 256	6.00 - 6.00	Coding rate reduction: R=1/3->1/2	(D)
	B	128 - 1	6.00 - 6.12		
16	A	512 - 256	9.75 - 9.75	Spreading factor reduction by 2	
	B	128 - 2	9.75 - 9.87		

(S): Single-frame method as shown in Figure 4-1 (1).

(D): Double-frame method as shown in Figure 4-1 (2).

SF=“2/1”: “2” is for (S) and “1” is for (D).]

Annex A (informative): Blind rate detection

A.1 Blind Rate Detection using Received Power Ratio

- This method is used for dual transport format case (the possible data rates, 0 and full rate, and only transmitting CRC for full rate).
- The rate detection is done using average received power ratio of DPDCH to DPCCH.
  Pc: Received Power per bit of DPCCH calculated from all pilot and TPC bits per slot over 10ms frame.
  Pd: Received Power per bit of DPDCH calculated from *X* bits per slot over 10ms 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 rate detection.

If *Pd/Pc >T* then

"TX_ON"

else

"TX_OFF"

A.2 Blind Rate Detection using CRC

- This method is used for multiple transport format case (the possible data rates: 0, …, (full rate)/r, …, full rate, and always transmitting CRC for all transport formats).
- At the transmitter, the variable-rate DCH data to be transmitted is block-encoded using a cyclic redundancy check (CRC) and then convolutionally encoded. It is necessary that the CRC parity bits are mapped on the head position (or certain position) in a frame as shown in Figure A-1.
- The receiver knows only the possible transport formats (or the possible end bit position $\{n_{end}\}$ by Layer-3 negotiation (See Figure A-1). 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.
- Blind rate detection method by 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. Each recovered data sequence is then error-detected by CRC and if there is no error, the recovered sequence is declared to be correct.
- The following variable is defined:

$$s(n_{end}) = -10 \log \left((a_0(n_{end}) - a_{min}(n_{end})) / (a_{max}(n_{end}) - a_{min}(n_{end})) \right) \text{ [dB]} \qquad \text{(Eq. 1)}$$

  where $a_{max}(n_{end})$ and $a_{min}(n_{end})$ are, respectively, the maximum and minimum path-metric valuse among all survivors at end bit position n_{end}, and $a_0(n_{end})$ 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. 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

$$s(n_{end}) =< D \qquad \text{(Eq. 2)}$$

  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 are 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 rate detection using CRC.

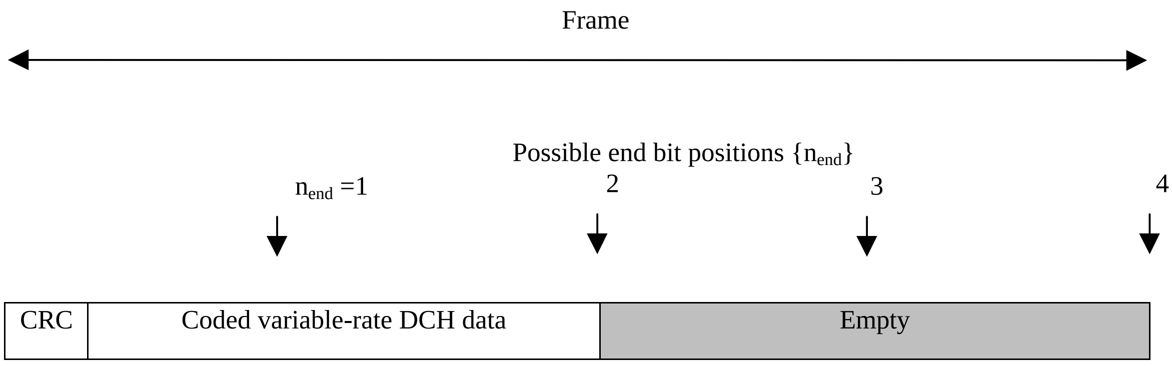


Figure A-1. An example of variable rate data format

(Number of possible transport formats = 4, transmitted end bit position n_{end} = 2)

Figure A-2.Basic processing flow of blind rate detection

5 History

Document history		
V0.0.1	1999-02-12	First version created by the editor on the basis of XX.04 and the Volume 3 of the ARIB specification.
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