ETSI TS 125 222 V6.3.0 (2009-03)

Technical Specification

Universal Mobile Telecommunications System (UMTS); Multiplexing and channel coding (TDD) (3GPP TS 25.222 version 6.3.0 Release 6)

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Contents

Foreword

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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)".

[14] ITU-T Recommendation X.691 (12/97) "Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

TrCH number: The transport channel number identifies a TrCH in the context of L1. The L3 transport channel identity (TrCH ID) maps onto the L1 transport channel number. The mapping between the transport channel number and the TrCH ID is as follows: TrCH 1 corresponds to the TrCH with the lowest TrCH ID, TrCH 2 corresponds to the TrCH with the next lowest TrCH ID and so on.

3.2   Symbols

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

$\lceil x \rceil$	round towards ∞, i.e. integer such that $x \le \lceil x \rceil < x+1$
$\lfloor x \rfloor$	round towards -∞, i.e. integer such that $x-1 < \lfloor x \rfloor \le x$
$/x/$	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.
$N_{TCFI\ code\ word}$	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
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
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
MICH	MBMS Indicator Channel
MS	Mobile Station
MT	Mobile Terminated
NRT	Non-Real Time
OVSF	Orthogonal Variable Spreading Factor
PC	Power Control
PCCC	Parallel Concatenated Convolutional Code
PICH	Paging Indicator Channel
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 Resouce Indicator
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 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[(*1)], 10 ms, 20 ms, 40 ms, 80 ms}.

Note: [(*1)] 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 4.2.11);

- 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 4.2.11A only for 1.28Mcps TDD)

- mapping to physical channels (see subclause 4.2.12).

The coding/multiplexing steps for uplink and downlink are shown in figures 1 and 1A.

$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$

CRC attachment

$b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$

TrBk concatenation / Code block segmentation

$o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$

Channel coding

$c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$

Radio frame equalisation

$t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$

1st interleaving

$d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$

Radio frame segmentation

$e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$

Rate matching

Rate matching

$\cdots$

$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$

$\cdots$

TrCH Multiplexing

$h_1, h_2, h_3, \ldots, h_S$

Bit Scrambling

$s_1, s_2, s_3, \ldots, s_S$

Physical channel segmentation

$u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU_p}$

$\cdots$

2nd interleaving

$\cdots$

$v_{t,1}, v_{t,2}, v_{t,3}, \ldots, v_{t,U_t}$

$\cdots$

Physical channel mapping

$\cdots$

$w_{p1}, w_{p2}, w_{p3}, \ldots, w_{pU_p}$

PhCH#1

PhCH#2

Figure 1: Transport channel multiplexing structure for uplink and downlink for 3.84Mcps TDD

$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$

CRC attachment

$b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$

TrBk concatenation / Code block segmentation

$o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$

Channel coding

$c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$

Radio frame equalisation

$t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$

1st interleaving

$d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$

Radio frame segmentation

$e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$

Rate matching

Rate matching

$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$

TrCH Multiplexing

$h_1, h_2, h_3, \ldots, h_S$

Bit Scrambling

$s_1, s_2, s_3, \ldots, s_S$

Physical channel segmentation

$u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU_p}$

2nd interleaving

$v_{t,1}, v_{t,2}, v_{t,3}, \ldots, v_{t,U_t}$

Subframe segmentation

$g_{p1}, g_{p2}, g_{p3}, \ldots, g_{pU_p}$

Physical channel mapping

$w_{p1}, w_{p2}, w_{p3}, \ldots, w_{pU_p}$

PhCH#1   PhCH#2

Figure 1A: 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 1A, 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:

$$g_{CRC24}(D) = D^{24} + D^{23} + D^6 + D^5 + D + 1$$

$$g_{CRC16}(D) = D^{16} + D^{12} + D^5 + 1$$

$$g_{CRC12}(D) = D^{12} + D^{11} + D^3 + D^2 + D + 1$$

$$g_{CRC8}(D) = D^8 + D^7 + D^4 + D^3 + D + 1$$

Denote the bits in a transport block delivered to layer 1 by $a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$, and the parity bits by

$p_{im1}, p_{im2}, p_{im3}, \ldots, p_{imL_i}$. 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:

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

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

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

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

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

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

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

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

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 $b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$, where $B_i = A_i + L_i$. The relation between a_{imk} and b_{imk} is:

$$b_{imk} = a_{imk} \qquad k = 1, 2, 3, \ldots, A_i$$

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

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 $b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$ 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 $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$, where i is the TrCH number and $X_i = M_i B_i$. They are defined by the following relations:

$$x_{ik} = b_{i1k} \qquad k = 1, 2, ..., B_i$$

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

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

…

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

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: $Z = unlimited$.

The bits output from code block segmentation, for $C_i \neq 0$, are denoted by $o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$, 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:

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

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

$$o_{i1k} = 0$$

end for

for $k = Y_i + 1$ to K_i

$$o_{i1k} = x_{i,(k-Y_i)}$$

end for

$r = 2$ -- Segmentation

while $r \leq C_i$

    for $k = 1$ to K_i

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

    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 $o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$, 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 $y_{ir1}, y_{ir2}, y_{ir3}, \ldots, y_{irY_i}$, 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 transport channels:

- convolutional coding;

- turbo coding;

- no coding.

Usage of coding scheme and coding rate for the different types of TrCH is shown in tables 1 and 1A. 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 for 3.84Mcps TDD

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

Table 1A: 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		1/3, 1/2
	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.
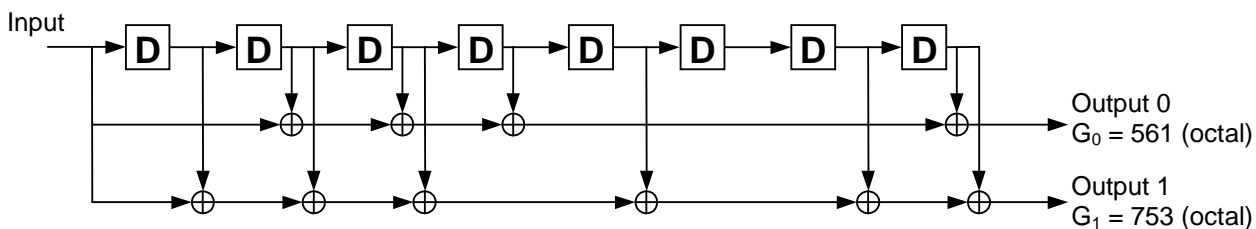
(a) Rate 1/2 convolutional coder
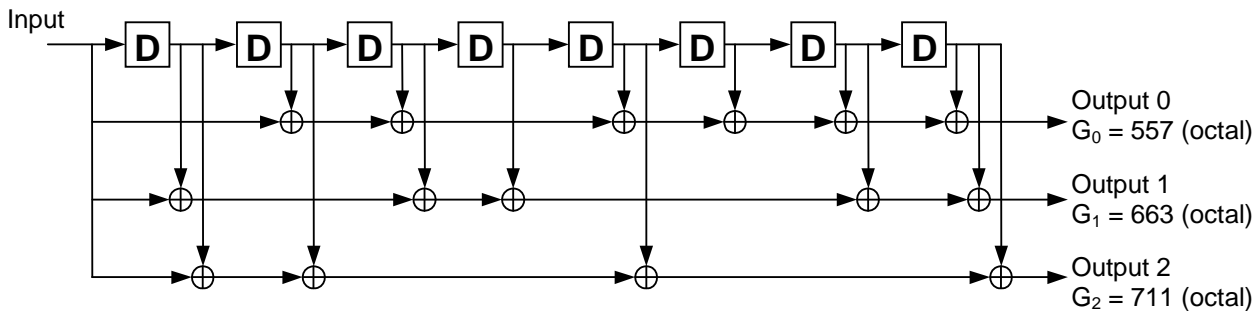
(b) Rate 1/3 convolutional coder

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:

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

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 , Y'(0), X(1), Y(1), Y'(1), etc:

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

where $x_1, x_2, \ldots, x_K$ 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 $z_1, z_2, \ldots, z_K$ and $z'_1, z'_2, \ldots, z'_K$ are the bits output from first and second 8-state constituent encoders, respectively.

The bits output from Turbo code internal interleaver are denoted by $x'_1, x'_2, \ldots, x'_K$, and these bits are to be input to the second 8-state constituent encoder.
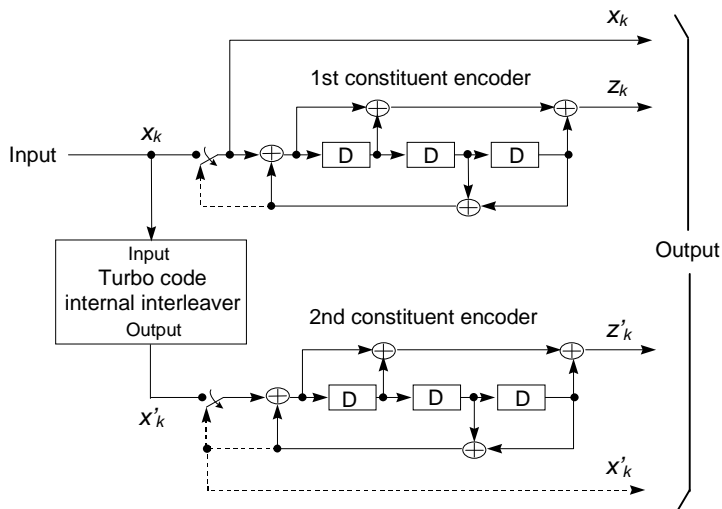
Figure 3: Structure of rate 1/3 Turbo coder (dotted lines apply for trellis termination only)

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 $x_1, x_2, x_3, \ldots, x_K$, 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

$\langle s(j) \rangle_{j \in \{0,1,\cdots,p-2\}}$ Base sequence for intra-row permutation

q_i Minimum prime integers

r_i Permuted prime integers

$\langle T(i) \rangle_{i \in \{0,1,\cdots,R-1\}}$ Inter-row permutation pattern

$\langle U_i(j) \rangle_{j \in \{0,1,\cdots,C-1\}}$ 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 $x_1, x_2, x_3, \ldots, x_K$ 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

$p = 53$ 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

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

end if

The columns of rectangular matrix are numbered 0, 1, …, 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 $x_1, x_2, x_3, \ldots, x_K$ into the $R \times C$ rectangular matrix row by row starting with bit y_1 in column 0 of row 0:

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

where $y_k = x_k$ for k = 1, 2, …, K and if $R \times C > K$, the dummy bits are padded such that $y_k = 0 \, or \, 1$ for $k = K + 1$, $K + 2$, …, $R \times C$. 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 $\langle s(j) \rangle_{j \in \{0,1,\cdots,p-2\}}$ for intra-row permutation as:

$s(j) = (v \times s(j-1)) \bmod p$, j = 1, 2,… (p - 2), and $s(0)$ = 1.

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

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

$r_{T(i)} = q_i$, i = 0, 1, …. , R - 1,

where $\langle T(i) \rangle_{i \in \{0,1,\cdots,R-1\}}$ 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 $<T(0), T(1), ..., T(R - 1)>$
$(40 \leq K \leq 159)$	5	<4, 3, 2, 1, 0>
$(160 \leq K \leq 200)$ or $(481 \leq K \leq 530)$	10	<9, 8, 7, 6, 5, 4, 3, 2, 1, 0>
$(2281 \leq K \leq 2480)$ 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 = 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 ($i = 0,1, ..., R$ - 1) intra-row permutation as:

if ($C = p$) then

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

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

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

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

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

end if

end if

if ($C = p$ - 1) then

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

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 $\langle T(i) \rangle_{i \in \{0,1,\cdots,R-1\}}$,

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 $x'_1, x'_2, \ldots, x'_K$, 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 $c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$, where i is the TrCH number and $E_i = C_i Y_i$. The output bits are defined by the following relations:

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

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

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

…

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

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

$t_{ik} = c_{ik,}$ for k = 1… E_i and

$t_{ik} = \{0 , 1\}$ for k= E_i +1… T_i, if $E_i < T_i$

where

$T_i = F_i * N_i$ and

$N_i = \left\lceil E_i / F_i \right\rceil$ is the number of bits per segment after size equalisation.

4.2.5 1st interleaving

The 1$^{\text{st}}$ interleaving is a block interleaver with inter-column permutations. The input bit sequence to the block interleaver is denoted by $x_{i,1}, x_{i,2}, x_{i,3}, \ldots, x_{i,X_i}$, 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 4 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 × 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 $\left\langle P1_{C1}(j) \right\rangle_{j \in \{0,1,\ldots,C1-1\}}$ 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 $y_{i,k}$:

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

5) Read the output bit sequence $y_{i,1}, y_{i,2}, y_{i,3}, \ldots, y_{i,(C1 \times R1)}$ of the block interleaver column by column from the inter-column permuted R1 × 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 <$P1_{C1}(0)$, $P1_{C1}(1)$, …, $P1_{C1}(C1-1)$>
5ms[(*1)], 10 ms	1	<0>
20 ms	2	<0,1>
40 ms	4	<0,2,1,3>
80 ms	8	<0,4,2,6,1,5,3,7>

[(*1)] 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 $t_{i,1}, t_{i,2}, t_{i,3}, \ldots, t_{i,T_i}$, 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 $d_{i,1}, d_{i,2}, d_{i,3}, \ldots, d_{i,T_i}$, 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 $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$ where i is the TrCH number and X_i is the number bits. The F_i output bit sequences per TTI are denoted by $y_{i,n_i1}, y_{i,n_i2}, y_{i,n_i3}, \ldots, y_{i,n_iY_i}$ 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:

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

where

$Y_i = (X_i / F_i)$ 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 $d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$, 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 $e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$, where i is the TrCH number and N_i is the number of bits. Hence, $e_{i,k} = y_{i,n_i k}$ and $N_i = Y_i$.

4.2.7 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 combination j.

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...P during a radio frame.

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).

$P1_F(n_i)$: 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 (note that P1$_F$ self-inverse).

$S[n]$: The shift of the puncturing or repetition pattern for radio frame n_i when $n = P1_{F_i}(n_i)$.

$TF_i(j)$: 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.

Note: when the TTI is 5msec for 1.28Mcps, the above notation refers to a sub-frame rather than a radio frame. In this case, $F_i = 1$ and $n_i = 0$.

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:

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

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

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

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].

For each physical channel an individual minimum spreading factor Sp_{min} is transmitted by means of the higher layers. Denote the number of data bits in each physical channel by $U_{p,Sp}$, where p indicates the sequence number $1 \le p \le P_{max}$ and Sp indicates the spreading factor with the possible values {$16, 8, 4, 2, 1$} of this physical channel. The index p is described in section 4.2.12 with the following modifications: spreading factor (Q) is replaced by the minimum spreading factor Sp_{min} and k is replaced by the channelization code index at $Q= Sp_{min}$. Then, for N_{data} one of the following values in ascending order can be chosen:

$$\left\{ U_{1,S1_{min}}, U_{1,S1_{min}} + U_{2,S2_{min}}, U_{1,S1_{min}} + U_{2,S2_{min}} + ... + U_{P_{max},(SP_{max})_{min}} \right\}$$

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:

$$\left\{ U_{1,16}, ..., U_{1,S1_{min}}, U_{1,S1_{min}} + U_{2,16}, ..., U_{1,S1_{min}} + U_{2,S2_{min}}, ..., U_{1,S1_{min}} + U_{2,S2_{min}} + ... + U_{P_{max},16}, ..., U_{1,S1_{min}} + U_{2,S2_{min}} + ... + U_{P_{max},(SP_{max})_{min}} \right\}$$

$N_{data, j}$ for the transport format combination j is determined by executing the following algorithm:

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

$$\text{N}_{\text{data, j}} = \min \text{SET1}$$

The number of bits to be repeated or punctured, $\Delta N_{i,j}$, within one radio frame (one sub-frame when the TTI is 5msec) 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 (sub-frame). The number of physical channels corresponding to $\text{N}_{\text{data, j}}$, shall be denoted by P.

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

$a = 2$

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

$X_i = N_{i,j}$

$R = \Delta N_{i,j} \bmod N_{i,j}$ -- 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 mod 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 1: q is a signed quantity.

    If q is even

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

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

  end for

$e_{ini} = (a \times S[P1_{Fi}(n_i)] \times |\Delta N_i| + 1) \bmod (a \times N_{i,j})$

$e_{plus} = a \times X_i$

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

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 $b=3$

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

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.

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

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

$\text{if}(q \le 2)$

    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 $q' = q - gcd(q, F_i)/ F_i$ -- where 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 $F_i - 1$

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

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

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,

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

$e_{plus} = a \times X_i$

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

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.
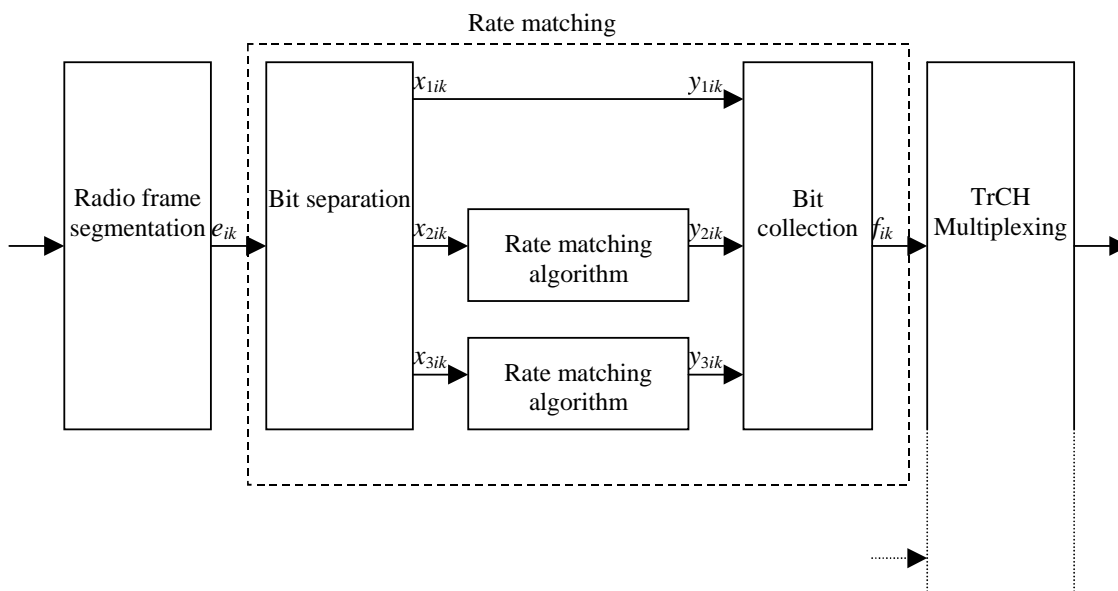
Figure 4: Puncturing of turbo encoded TrCHs
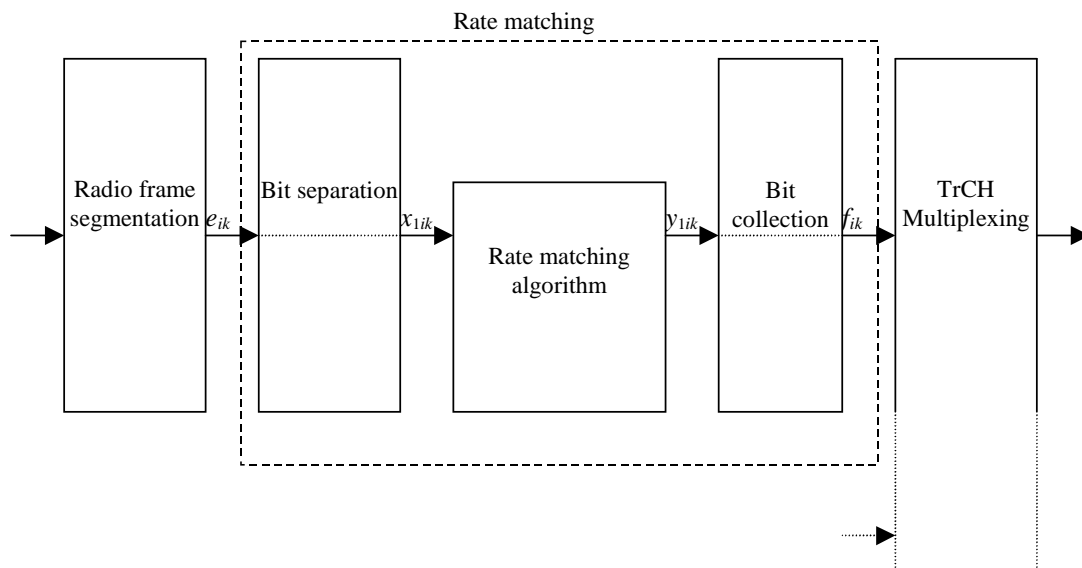
**Figure 5: Rate matching for uncoded TrCHs, convolutionally encoded TrCHs,
and for turbo encoded TrCHs with repetition**

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 5.

Table 5: TTI dependent offset needed for bit separation

TTI (ms)	α_1	α_2	α_3
5, 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
5, 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 $e_{i,1}, e_{i,2}, e_{i,3}, \ldots, e_{i,N_i}$, 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 $x_{b,i,1}, x_{b,i,2}, x_{b,i,3}, \ldots, x_{b,i,X_i}$. 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:

$$x_{1,i,k} = e_{i,3(k-1)+1+(\alpha_1+\beta_{n_i})\bmod 3} \qquad k = 1, 2, 3, \ldots, X_i \qquad X_i = \lfloor N_i/3 \rfloor$$

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

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

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

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

$$x_{1,i,k} = e_{i,k} \qquad k = 1, 2, 3, \ldots, X_i \qquad X_i = N_i$$

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 $y_{b,i,1}, y_{b,i,2}, y_{b,i,3}, \ldots, y_{b,i,Y_i}$.

Bit collection is the inverse function of the separation. The bits after collection are denoted by $z_{b,i,1}, z_{b,i,2}, z_{b,i,3}, \ldots, z_{b,i,Y_i}$. After bit collection, the bits indicated as punctured are removed and the bits are then denoted by $f_{i,1}, f_{i,2}, f_{i,3}, \ldots, f_{i,V_i}$, 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 ($Y_i=X_i$):

$$z_{i,3(k-1)+1+(\alpha_1+\beta_{n_i})\bmod 3} = y_{1,i,k} \qquad k = 1, 2, 3, \ldots, Y_I$$

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

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

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

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:

$$z_{i,k} = y_{1,i,k} \qquad k = 1, 2, 3, \ldots, Y_i$$

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 $x_{i,1}, x_{i,2}, x_{i,3}, \ldots, x_{i,X_i}$, 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

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

m = 1   -- index of current bit

do while m $<= X_i$

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

    if e $<= 0$ then   -- check if bit number m should be punctured

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

        $e = e + e_{plus}$ -- 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 $<= X_i$

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

        do while e $<= 0$ -- 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). If the TTI is smaller than 10ms, then no TrCH multiplexing is performed.

The bits input to the TrCH multiplexing are denoted by $f_{i,1}, f_{i,2}, f_{i,3}, \ldots, f_{i,V_i}$, 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 $h_1, h_2, h_3, \ldots, h_S$, where S is the number of bits, i.e. $S = \sum_i V_i$. The TrCH multiplexing is defined by the following relations:

$h_k = f_{1,k}$ $k = 1, 2, ..., V_1$

$h_k = f_{2,(k-V_1)}$ $k = V_1+1, V_1+2, ..., V_1+V_2$

$h_k = f_{3,(k-(V_1+V_2))}$ $k = (V_1+V_2)+1, (V_1+V_2)+2, ..., (V_1+V_2)+V_3$

$\ldots$

$$h_k = f_{I,(k-(V_1+V_2+...+V_{I-1}))} \qquad k = (V_1+V_2+...+V_{I-1})+1,\ (V_1+V_2+...+V_{I-1})+2,\ ...,\ (V_1+V_2+...+V_{I-1})+V_I$$

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 $h_1, h_2, h_3, ..., h_S$, 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 $s_1, s_2, s_3, ..., s_S$.

Bit scrambling is defined by the following relation:

$$s_k = h_k \oplus p_k \quad k = 1, 2..., S$$

and p_k results from the following operation:

$$p_k = \left(\sum_{i=1}^{16} g_i \cdot p_{k-i} \right) \bmod 2 ;\ p_k = 0; k < 1\ ;\ p_1 = 1\ ;\ g = \{0,0,0,0,0,0,0,0,0,0,1,0,1,1,0,1\}$$

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 $s_1, s_2, s_3, ..., s_S$, where S is the number of bits input to the physical channel segmentation block. The number of PhCHs after rate matching is denoted by P, as defined in subclause 4.2.7.1.

The bits after physical channel segmentation are denoted $u_{p,1}, u_{p,2}, u_{p,3}, ..., u_{p,U_p}$, 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:

$$u_{1,k} = s_k \qquad k = 1, 2, ..., U_1$$

Bits on second PhCH after physical channel segmentation:

$$u_{2,k} = s_{(k+U_1)} \qquad k = 1, 2, ..., U_2$$

…

Bits on the Pth PhCH after physical channel segmentation:

$$u_{P,k} = s_{(k+U_1+...+U_{P-1})} \qquad k = 1, 2, ..., U_P$$

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 $x_1, x_2, x_3, \ldots, x_U$, 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:

$$x_k = u_{1,k} \qquad\qquad k = 1, 2, \ldots, U_1$$

$$x_{(k+U_1)} = u_{2,k} \qquad\qquad k = 1, 2, \ldots, U_2$$

$$\ldots$$

$$x_{(k+U_1+\ldots+U_{P-1})} = u_{P,k} \qquad k = 1, 2, \ldots, U_P$$

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, …, C2 - 1 from left to right.

(2) Determine the number of rows of the matrix, R2, by finding minimum integer R2 such that:

$$U \le R2 \times C2.$$

The rows of rectangular matrix are numbered 0, 1, 2, …, R2 - 1 from top to bottom.

(3) Write the input bit sequence $x_1, x_2, x_3, \ldots, x_U$ into the R2 $\times$ C2 matrix row by row starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} y_1 & y_2 & y_3 & \cdots & y_{C2} \\ y_{(C2+1)} & y_{(C2+2)} & y_{(C2+3)} & \cdots & y_{(2\times C2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{((R2-1)\times C2+1)} & y_{((R2-1)\times C2+2)} & y_{((R2-1)\times C2+3)} & \cdots & y_{(R2\times C2)} \end{bmatrix}$$

where $y_k = x_k$ for $k = 1, 2, \ldots, U$ and if R2 $\times$ C2 > U, the dummy bits are padded such that $y_k = 0$ or 1 for $k = U + 1, U + 2, \ldots, R2 \times C2$. 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 $\langle P2(j) \rangle_{j \in \{0,1,\ldots,C2-1\}}$ that is shown in table 7, 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 .

$$\begin{bmatrix} y'_1 & y'_{(R2+1)} & y'_{(2\times R2+1)} & \cdots y'_{((C2-1)\times R2+1)} \\ y'_2 & y'_{(R2+2)} & y'_{(2\times R2+2)} & \cdots y'_{((C2-1)\times R2+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y'_{R2} & y'_{(2\times R2)} & y'_{(3\times R2)} & \cdots & y'_{(C2\times R2)} \end{bmatrix}$$

(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 at the output of the block interleaver are denoted by $z_1, z_2, \ldots, z_U$, where z_1

corresponds to the bit y'_k with smallest index k after pruning, z_2 to the bit y'_k with second smallest index k after pruning, and so on.

The bits $z_1, z_2, \ldots, z_U$ shall be segmented as follows:

$$u_{1,k} = z_k \qquad\qquad k = 1, 2, \ldots, U_1$$

$$u_{2,k} = z_{(k+U_1)} \qquad\qquad k = 1, 2, \ldots, U_2$$

…

$$u_{P,k} = z_{(k+U_1+\ldots+U_{P-1})} \qquad k = 1, 2, \ldots, U_P$$

The bits after frame related 2$^\text{nd}$ interleaving are denoted by $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$, where t refers to the timeslot sequence number and U_t is the number of bits transmitted in this timeslot during the respective radio frame.

Let T be the number of time slots in a CCTrCH during the respective radio frame (where for 1.28Mcps TDD, the respective radio frame includes subframes 1 and 2), and $t = 1, \ldots, T$. The physical layer shall assign the time slot sequence number t in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In time slot t, R_t refers to the number of physical channels within the respective time slot and $r = 1, \ldots, R_t$. The relation between r and t and the physical channel sequence number p as detailed in 4.2.12.1 is given by:

$$p = r \qquad\quad t = 1$$

$$p = R_1 + R_2, \ldots, R_{t-1} + r \qquad 1 < t \le T$$

Defining the relation $u_{t,r,k} = u_{p,k}$ and denoting U_{tr} as the number of bits for physical channel r in time slot t, the relation between $v_{t,k}$ and $u_{t,r,k}$ is given below:

$$v_{t,k} = u_{t,1,k} \qquad\qquad k = 1, 2, \ldots, U_{t1}$$

$$v_{t,(k+U_{t1})} = u_{t,2,k} \qquad\qquad k = 1, 2, \ldots, U_{t2}$$

…

$$v_{t,(k+U_{t1}+\ldots+U_{t(R_t-1)})} = u_{t,R_t,k} \qquad k = 1, 2, \ldots, U_{tR_t}$$

4.2.11.2 Timeslot related 2$^\text{nd}$ interleaving

In case of timeslot related 2$^\text{nd}$ interleaving, the bits input to the block interleaver are denoted by $x_{t,1}, x_{t,2}, x_{t,3}, \ldots, x_{t,U_t}$, where t is the timeslot sequence number, and U_t is the number of bits transmitted in this timeslot during the respective radio frame.

Let T be the number of time slots in a CCTrCH during the respective radio frame (where for 1.28Mcps TDD, the respective radio frame includes subframes 1 and 2), and $t = 1, \ldots, T$. The physical layer shall assign the time slot sequence number t in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In timeslot t, R_t refers to the number of physical channels within the respective timeslot and $r = 1, \ldots, R_t$. The relation between r and t and the physical channel sequence number p as detailed in 4.2.12.1 is given by:

$$p = r \qquad\quad t = 1$$

$$p = R_1 + R_2, \ldots, R_{t-1} + r \qquad 1 < t \le T$$

Defining the relation $u_{t,r,k} = u_{p,k}$ and denoting U_{tr} as the number of bits for physical channel r in time slot t, the relation between $x_{t,k}$ and $u_{t,r,k}$ is given below:

$$x_{t,k} = u_{t,1,k} \qquad\qquad k = 1, 2, \ldots, U_{t1}$$

$$x_{t,(k+U_{t1})} = u_{t,2,k} \qquad\qquad k = 1, 2, \ldots, U_{t2}$$

...

$$x_{t,(k+U_{t1}+\ldots+U_{t(R_t-1)})} = u_{t,R_t,k} \qquad k = 1, 2, \ldots, U_{tR_t}$$

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, ..., C2 - 1 from left to right.

(2) Determine the number of rows of the matrix, R2, by finding minimum integer R2 such that:

$U_t \le \text{R2} \times \text{C2}.$

The rows of rectangular matrix are numbered 0, 1, 2, ..., R2 - 1 from top to bottom.

(3) Write the input bit sequence $x_{t,1}, x_{t,2}, x_{t,3}, \ldots, x_{t,U_t}$ into the R2 $\times$ C2 matrix row by row starting with bit $y_{t,1}$ in column 0 of row 0:

$$\begin{bmatrix} y_{t,1} & y_{t,2} & y_{t,3} & \cdots & y_{t,\text{C2}} \\ y_{t,(\text{C2}+1)} & y_{t,(\text{C2}+2)} & y_{t,(\text{C2}+3)} & \cdots & y_{t,(2\times\text{C2})} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{t,((\text{R2}-1)\times\text{C2}+1)} & y_{t,((\text{R2}-1)\times\text{C2}+2)} & y_{t,((\text{R2}-1)\times\text{C2}+3)} & \cdots & y_{t,(\text{R2}\times\text{C2})} \end{bmatrix}$$

where $y_{t,k} = x_{t,k}$ for $k = 1, 2, \ldots, U_t$ and if R2 $\times$ C2 $> U_t$, the dummy bits are padded such that $y_{t,k} = 0$ or 1 for $k = U_t + 1, U_t + 2, \ldots,$ 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 $\langle P2(j) \rangle_{j \in \{0,1,\ldots,\text{C2}-1\}}$ 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 $y'_{t,k}$.

$$\begin{bmatrix} y'_{t,1} & y'_{t,(\text{R2}+1)} & y'_{t,(2\times\text{R2}+1)} & \cdots & y'_{t,((\text{C2}-1)\times\text{R2}+1)} \\ y'_{t,2} & y'_{t,(\text{R2}+2)} & y'_{t,(2\times\text{R2}+2)} & \cdots & y'_{t,((\text{C2}-1)\times\text{R2}+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y'_{t,\text{R2}} & y'_{t,(2\times\text{R2})} & y'_{t,(3\times\text{R2})} & \cdots & y'_{t,(\text{C2}\times\text{R2})} \end{bmatrix}$$

(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 $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$, 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 7 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>

4.2.11A 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 when the TTI of the CCTrCh is greater than 5msec. In this case, the operation of rate-matching guarantees that the size of bit streams is an even number and can be subdivided into 2 sub-frames. The transport channel multiplexing structure for uplink and downlink is shown in figure 1A.

The input to the sub-frame segmentation unit is segmented into timeslot chunks, where each timeslot chunk contains all of the bits that are to be transmitted in a given timeslot position in both of the sub-frames.

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$ where i is the timeslot number and X_i is the number of bits transmitted in timeslot i in a radio frame. The two output bit sequences per radio frame are denoted by $y_{i,n,1}, y_{i,n,2}, y_{i,n,3}, \ldots, y_{i,n,Yi}$ where n is the sub-frame number in current radio frame and Y_i is the number of bits per sub-frame for timeslot i. The output sequences are defined as follows:

$$y_{i,n,k} = x_{i,((n-1).Y_i)+k}, \text{ n = 1 or 2, k = 1}\ldots Y_i$$

where

$Y_i = (X_i / 2)$ is the number of bits in timeslot i per sub-frame,

x_{ik} is the kth bit of the input bit sequence and

$y_{i,n,k}$ is the kth bit of the output bit sequence corresponding to the nth sub-frame

4.2.12   Physical channel mapping

4.2.12.1   Physical channel mapping for the 3.84 Mcps option

The PhCH for both uplink and downlink is defined in [7]. The bits after physical channel mapping are denoted by $w_{p,1}, w_{p,2}, \ldots, w_{p,U_p}$, where p is the PhCH number corresponding to the sequence number $1 \le p \le P$ of this physical channel as detailed below, U_p is the number of bits in one radio frame for the respective PhCH, and $P \le P_{max}$. 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 layer shall assign the physical channel sequence number p to the physical channels of the CCTrCH in the respective radio frame, treating each allocated timeslot in ascending order. If within a timeslot there are multiple physical channels they shall first be ordered in ascending order of the spreading factor (Q) and subsequently by channelisation code index (k), as shown in [9].

The mapping of the bits $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ is performed like block interleaving, writing the bits into columns, but a PhCH with an odd number is filled in forward order, whereas 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 $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ are assigned to the bits of the physical channels

$w_{t,1,1\ldots U_{t1}}, w_{t,2,1\ldots U_{t2}}, \ldots, w_{t,P_t,1\ldots U_{tP_t}}$ in each timeslot.

In uplink there are at most two codes allocated (P≤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 $bs_1 = 1$; $bs_2 = SF1/SF2$;

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.

4.2.12.1.1 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 $SF1 >= SF2$ 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 mod P_t) + 1;

end do

if (p mod 2) == 0

pos = $U_{t,p}$ - fb_p -- reverse order

else

pos = $fb_p + 1$ -- forward order

endif

$w_{t,p,pos} = v_{t,k}$ -- assignment

$fb_p = fb_p + 1$ -- Increment number of already written bits

if (fb$_p$ mod bs$_p$) == 0   -- Conditional change to the next physical channel

    p = (p mod P$_t$) + 1;

  end if

end for

4.2.12.2   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 $w_{p1}, w_{p2}, \ldots, w_{pU_p}$, where p is the PhCH number and Up is the number of bits in one sub-frame for the respective PhCH. The bits wpk 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 y$_{t,n,1}$, y$_{t,n,2}$, y$_{t,n,3}$, ..., y$_{t,n,Ut}$ 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 subframe. Therefore, the bits y$_{t,n,1}$, y$_{t,n,2}$, y$_{t,n,3}$, ..., y$_{t,n,Ut}$ are assigned to the bits of the physical channels $w_{t1,1\ldots U_{t1}}, w_{t2,1\ldots U_{t2}}, \ldots, w_{tP_t,1\ldots U_{tP_t}}$ in each timeslot.

In uplink there are at most two codes allocated (P≤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 bsk the following rule is applied:

if

SF1 >= 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.

4.2.12.2.1   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 in the current sub-frame

U$_t$.:   total number of bits to be assigned for timeslot t in the current sub-frame

n = index of the current sub-frame (1 or 2)

bs$_p$:   number of consecutive bits to assign per code

for downlink all bs$_p$ = 1

for uplink   if SF1 >= 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 mod P_t) + 1 ;

end do

if (p mod 2) == 0

pos = $U_{t,p}$ - fb_p -- reverse order

else

pos = fb_p + 1   -- forward order

end if

$w_{tp,pos} = y_{t,n,k}$ -- assignment

$fb_p = fb_p + 1$ -- Increment number of already written bits

If (fb_p mod bs_p) == 0   -- Conditional change to the next physical channel

p = (p mod P_t) + 1 ;

end if

end for

4.2.13 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

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

CFN_i mod 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.

4.2.13.1   Allowed CCTrCH combinations for one UE

4.2.13.1.1   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.

4.2.13.1.2   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.

4.2.14   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.

4.2.14.1   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.

4.2.14.2   Explicit transport format detection based on TFCI

4.2.14.2.1   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.

TFCI (10 bits) $a_9...a_0$ → (32,10) sub-code of the second order Reed-Muller code → TFCI code word $b_0...b_{31}$

Figure 6: Channel coding of the TFCI bits

If the TFCI consists of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. 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 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 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 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 $i = 0,\ldots,31$. $N_{\text{TFCI code word}} = 32$.

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) a_0 (or a_0 and a_1 where a_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 radio frame.

In the case of $N_{\text{TFCI code word}} = 4$, the TFCI codeword $\{b_0, b_1, b_2, b_3\}$ is equal to the sequence $\{a_0, a_0, a_0, a_0\}$.

In the case of $N_{\text{TFCI code word}} = 8$, the TFCI codeword $\{b_0, b_1, \ldots , b_7\}$ is equal to the sequence $\{a_0, a_1, a_0, a_1, a_0, a_1, a_0, a_1\}$.

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.
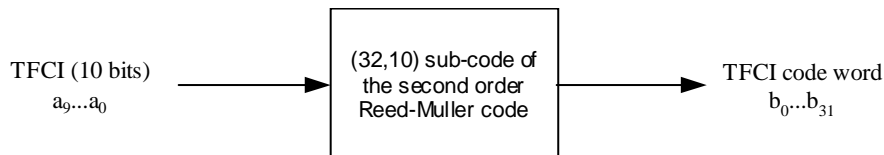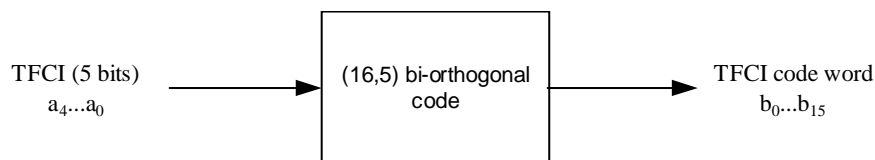

Figure 7: Channel coding of short length TFCI bits

If the TFCI consists of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero. 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 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 radio frame.

The output code word bits b_j are given by:

$$b_i = \sum_{n=0}^{4} (a_n \times M_{i,n}) \bmod 2$$

where $i = 0,…,15$. $N_{\text{TFCI code word}} = 16$.

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 $k=0…$ $N_{\text{TFCI code word}}$ -1.
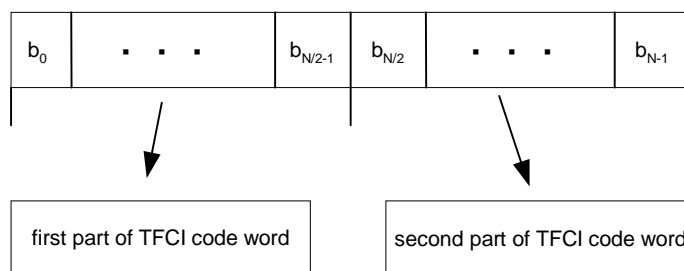
Figure 8: Mapping of TFCI code word bits to timeslot

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, $q = 0, ..., N_{PI}-1$, $P_q \in \{0, 1\}$ 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, $i = 1, ..., N_{PIB}$ is shown in table 10.

Table 10: Mapping of the paging indicator

P_q	Bits $\{e_{2Lpi*q+1}, e_{2Lpi*q+2}, ... ,e_{2Lpi*(q+1)}\}$	Meaning
0	{0, 0, ..., 0}	There is no necessity to receive the PCH
1	{1, 1, ..., 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 $e = \{e_1, e_2, ..., e_{NPIB}\}$ is extended by $S-N_{PIB}$ bits that are set to zero, resulting in a sequence $h = \{h_1, h_2, ..., h_S\}$:

$$h_k = e_k, \quad k = 1, ..., N_{PIB}$$
$$h_k = 0, \quad k = N_{PIB} +1, ..., S$$

The bits h_k, $k = 1, ..., S$ on the PICH then undergo bit scrambling as defined in section 4.2.9.

The bits s_k, $k = 1, ..., S$ output from the bit scrambler are then transmitted over the air as shown in [7].

4.3.3 Coding and Bit Scrambling of the MBMS Notification Indicator

The MBMS notification indicator N_q, $q = 0, ..., N_n-1$, $N_q \in \{0, 1\}$, is an identifier to instruct UEs whether there is an MBMS notification indication for the groups of MBMS services that are associated to the NI, calculated by higher layers, and the associated MBMS notification indicator N_q. The length L_{NI} of the MBMS notification indicator is $L_{NI}=2$, $L_{NI}=4$ or $L_{NI}=8$ symbols. $N_{NIB} = 2*N_n*L_{NI}$ bits are used for the MBMS notification indicator transmission in one MICH. The mapping of the MBMS notification indicators to the bits e_i, $i = 1, ..., N_{NIB}$ is shown in table 10A.

Table 10A: Mapping of the MBMS notification indicator

N_q	Bits $\{e_{2Lni*q+1}, e_{2Lni*q+2}, ... , e_{2Lni*(q+1)}\}$
0	$\{0, 0, ..., 0\}$
1	$\{1, 1, ..., 1\}$

If the number S of bits available for the MICH is bigger than the number N_{NIB} of bits used for the transmission of MBMS notification indicators, the sequence $e = \{e_1, e_2, ..., e_{NNIB}\}$ is extended by $S-N_{NIB}$ bits that are set to zero, resulting in a sequence $h = \{h_1, h_2, ..., h_S\}$:

$$h_k = e_k, \quad k = 1, ..., N_{NIB}$$
$$h_k = 0, \quad k = N_{NIB} +1, ..., S$$

The bits h_k, $k = 1, ..., S$ on the MICH then undergo bit scrambling as defined in section 4.2.9.

The bits s_k, $k = 1, ..., S$ 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 $N_{TFCI\ code\ word}$, and denote the TFCI code word bits by b_k, where k = 0, …, $N_{TFCI\ code\ word}$ -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:
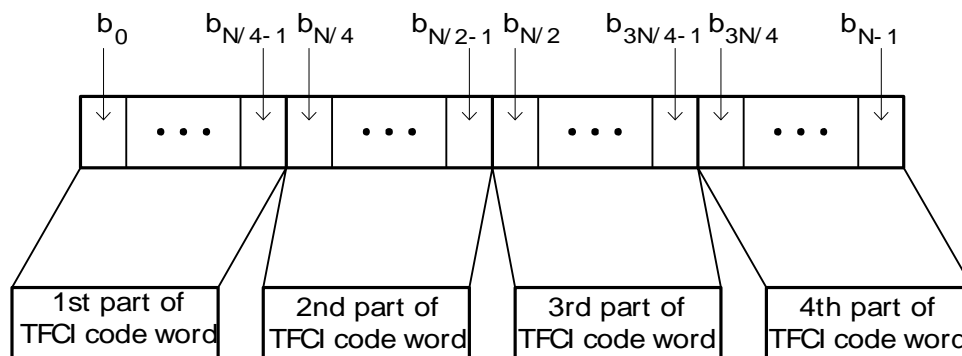
Figure 9: Mapping of TFCI code word bits to TFCI position in 1.28 Mcps TDD option, where N = N$_{TFCI\ code\ word}$.

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:
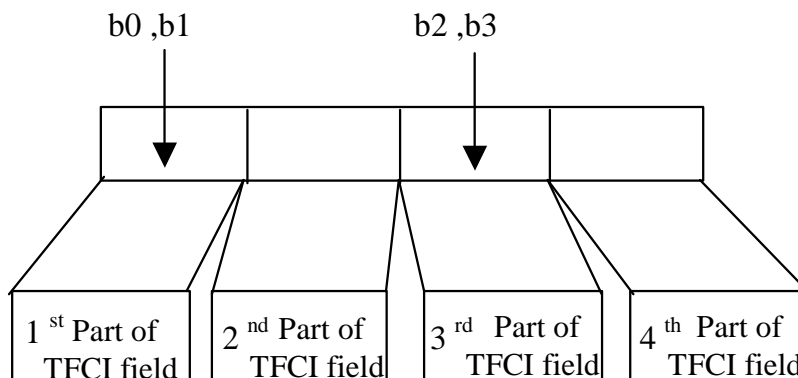
Figure 10: Mapping of TFCI code word bits to TFCI position in 1.28 Mcps TDD option, when $N_{\text{TFCI code word.}}$=4

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

If the TFCI consists of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. 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 11.

Table 11: 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 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…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. The TFCI bit(s) a_0 (or a_0 and a_1 where a_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 radio frame.

In the case of $N_{\text{TFCI code word}}$=6, the TFCI codeword $\{b_0, b_1, b_2, b_3, b_4, b_5\}$ is equal to the sequence $\{a_0, a_0, a_0, a_0, a_0, a_0\}$.

In the case of $N_{\text{TFCI code word}}$=12, the TFCI codeword $\{b_0, b_1, \ldots, b_{11}\}$ is equal to the sequence $\{a_0, a_1, a_0, a_1, a_0, a_1, a_0, a_1, a_0, a_1, a_0, a_1\}$.

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.
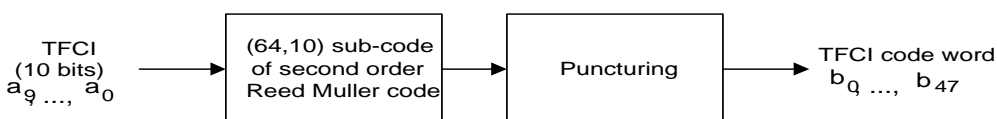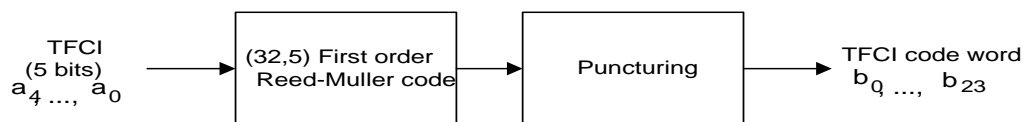

Figure 12: Channel coding of short TFCI bits for 8PSK

If the TFCI consists of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero. The code words of the punctured (32,5) first order Reed-Muller codes are linear combination of 5 basis sequences shown in Table 12.

Table 12: 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 radio frame.

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…23. $N_{TFCI\ code\ word} = 24$.

4.4.2.3 Mapping of TFCI code word

Denote the number of bits in the TFCI code word by $N_{TFCI\ code\ word}$, and denote the TFCI code word bits by b_k, where k = 0, …, $N_{TFCI\ code\ word} - 1$.

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.
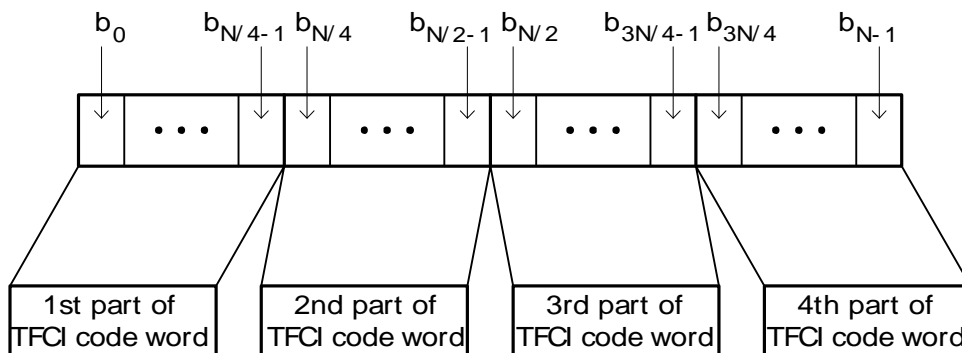
Figure 13: Mapping of TFCI code word bits to timeslot in 1.28 Mcps TDD option, where N = $N_{TFCI\ code\ word}$.

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.
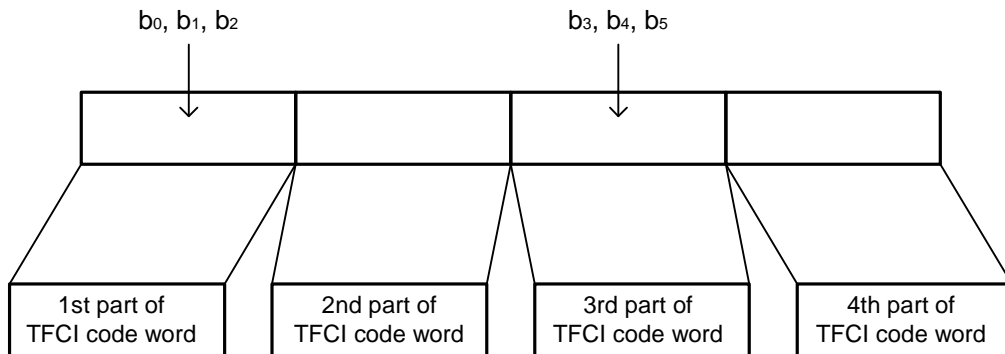
Figure 14: Mapping of TFCI code word bits to timeslot in 1.28 Mcps TDD option when N$_{\text{TFCI code word}}$ = 6

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, $q = 0, ..., N_{PI}-1$, $P_q \in \{0, 1\}$ 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, $i = 1, ..., N_{PIB}$ is shown in table 13.

Table 13: Mapping of the paging indicator

P$_q$	Bits {$e_{2L_{PI}*q+1}$, $e_{2L_{PI}*q+2}$, ... ,$e_{2L_{PI}*(q+1)}$}	Meaning
0	{0, 0, ..., 0}	There is no necessity to receive the PCH
1	{1, 1, ..., 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 $e = \{e_1, e_2, ..., e_{NPIB}\}$ is extended by $S-N_{PIB}$ bits that are set to zero, resulting in a sequence $h = \{h_1, h_2, ..., h_S\}$:

$$h_k = e_k, \quad k = 1, ..., N_{PIB}$$
$$h_k = 0, \quad k = N_{PIB}+1, ..., S$$

The bits h_k, $k = 1, ..., S$ on the PICH then undergo bit scrambling as defined in section 4.2.9.

The bits s_k, $k = 1, ..., S$ 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 ½ 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), …, 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.

$$\begin{bmatrix} x(0) & x(1) & x(2) & \ldots x(7) \\ x(8) & x(9) & x(10) & \ldots x(15) \\ \vdots & \vdots & \vdots & \ldots \vdots \\ x(80) & x(81) & x(82) & \ldots x(87) \end{bmatrix}$$

Hence, the interleaved sequence is denoted by y (i) and are given by:

y(0), y(1), …, y(87)=x(0), x(8), …,x(80),x(1), …, x(87).

4.4.5   Coding and Bit Scrambling of the MBMS Notification Indicator

The MBMS notification indicator N_q, $q = 0, ..., N_n-1$, $N_q \in \{0, 1\}$ is an identifier to instruct the UE whether there is an MBMS notification indication for the groups of MBMS services that are associated to the NI, calculated by higher layers, and the associated MBMS notification indicator N_q. The length L_{NI} of the MBMS notification indicator is $L_{NI}=2$, $L_{NI}=4$ or $L_{NI}=8$ symbols. $N_{NIB} = 2*N_n*L_{NI}$ bits are used for the MBMS notification indicator transmission in one MICH. The mapping of the MBMS notification indicators to the bits e_i, $i = 1, ..., N_{NIB}$ is shown in table 13A.

Table 13A: Mapping of the MBMS notification indicator

N_q	Bits $\{e_{2L_{NI}*q+1}, e_{2L_{NI}*q+2}, … ,e_{2L_{NI}*(q+1)}\}$
0	{0, 0, ..., 0}
1	{1, 1, ..., 1}

If the number S of bits available for the MICH is bigger than the number N_{NIB} of bits used for the transmission of MBMS notification indicators, the sequence $e = \{e_1, e_2, ..., e_{NNIB}\}$ is extended by $S-N_{NIB}$ bits that are set to zero, resulting in a sequence $h = \{h_1, h_2, ..., h_S\}$:

$$h_k = e_k, \quad k = 1, ..., N_{NIB}$$
$$h_k = 0, \quad k = N_{NIB}+1, ..., S$$

The bits h_k, $k = 1, ..., S$ on the MICH then undergo bit scrambling as defined in section 4.2.9.

The bits s_k, $k = 1, ..., S$ output from the bit scrambler are then transmitted over the air as shown in [7].

4.5   Coding for HS-DSCH

Figure 15 illustrates the overall concept of transport-channel coding for HS-DSCH. Data arrives at the coding unit in the form of one transport block once every TTI. The TTI is 5 ms for 1.28 Mcps TDD and 10 ms for 3.84 Mcps TDD.

The following coding steps for HS-DSCH 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);

- bit scrambling (see subclause 4.5.5);

- interleaving for HS-DSCH (see subclause 4.5.6);

- constellation re-arrangement for 16QAM (see subclause 4.5.7);

- mapping to physical channels (see subclause 4.5.8).

The coding steps for HS-DSCH are shown in figure 15.

$a_{im1}, a_{im2}, a_{im3}, \ldots a_{imA}$

```
┌─────────────────────────┐
│      CRC attachment      │
└─────────────────────────┘
```

$b_{im1}, b_{im2}, b_{im3}, \ldots b_{imB}$

```
┌─────────────────────────┐
│  Code block segmentation │
└─────────────────────────┘
```

$O_{ir1}, O_{ir2}, O_{ir3}, \ldots O_{irK}$

```
┌─────────────────────────┐
│      Channel Coding      │
└─────────────────────────┘
```

$c_{i1}, c_{i2}, c_{i3}, \ldots c_{iE}$

```
┌─────────────────────────┐
│ Physical Layer Hybrid-ARQ│
│      functionality       │
└─────────────────────────┘
```

$w_1, w_2, w_3, \ldots w_R$

```
┌─────────────────────────┐
│      Bit Scrambling      │
└─────────────────────────┘
```

$s_1, s_2, s_3, \ldots s_R$

```
┌─────────────────────────┐
│        HS-DSCH           │
│      Interleaving        │
└─────────────────────────┘
```

$v_1, v_2, v_3, \ldots v_R$

```
┌─────────────────────────┐
│      Constellation       │
│     re-arrangement       │
│       for 16 QAM         │
└─────────────────────────┘
```

$r_1, r_2, r_3, \ldots r_R$

```
┌─────────────────────────┐
│ Physical channel mapping │
└─────────────────────────┘
```

$w_{t,p,1}, w_{t,p,2}, \ldots w_{t,p,Up}$

PhCH#1   PhCH#P
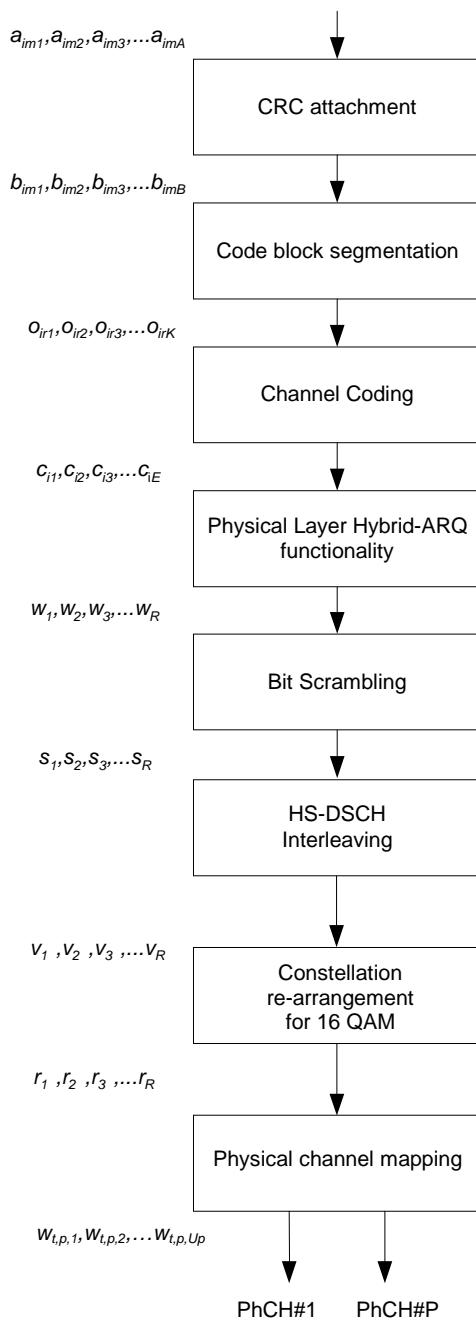
Figure 15. Coding chain for HS-DSCH

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: $i = 1$, $L_I = 24$ 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}, $b_{im3}, \ldots b_{imB}$ input to the block are mapped to the bits x_{i1}, x_{i2}, $x_{i3}, \ldots x_{iX1}$ 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 output bits from the code block segmentation function are o_{ir1}, o_{ir2}, $o_{ir3}, \ldots o_{irK}$.

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 virtual 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.
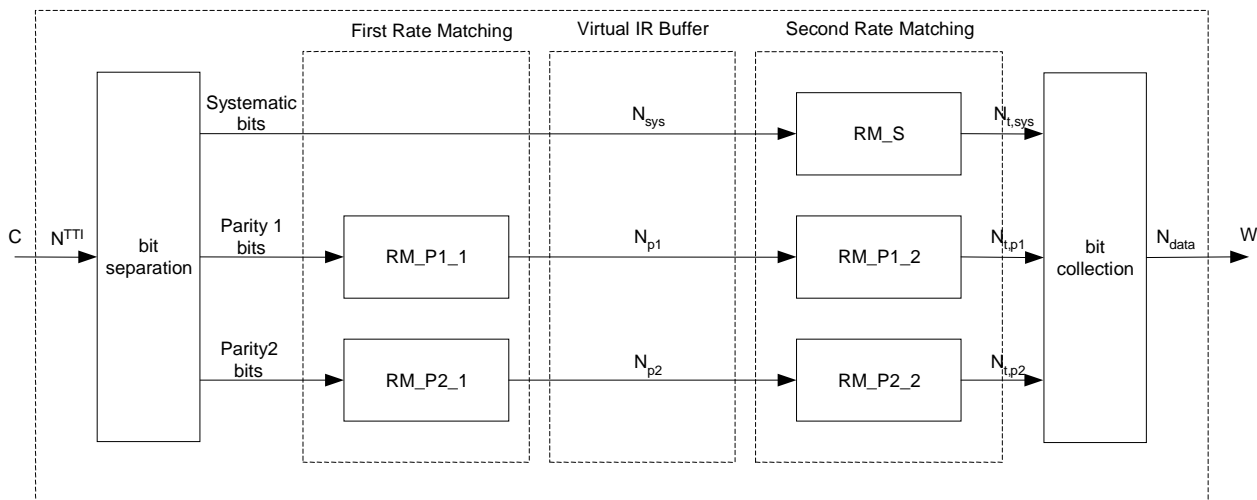
Figure 16: HS-DSCH hybrid ARQ functionality

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 channel 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. Bits selected for puncturing which appear as δ in the algorithm in 4.2.7.3 above shall be discarded and are not counted in the streams towards the bit collection.

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 between transmissions that prioritise systematic bits (s = 1) and non systematic bits (s = 0). The parameter r (range 0 to $r_{max}-1$) 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_i, e_{plus} and e_{minus} are calculated as per table 14below.

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. For the HS-DSCH, denote the number of timeslots used as T, the number of codes per timeslot as C and the number of bits available in timeslot t as U_t, where $U_t = C \times N_{Data/Slot}$ and $N_{Data/Slot}$ is as defined in

[7] for timeslot t. N_{data} is the number of bits available to the HS-DSCH in one TTI and is defined as $N_{data} = \sum_{t=1}^{T} U_t$.

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 transmission is $N_{t,sys} = \min\{N_{sys}, N_{data}\}$ for a transmission that prioritises systematic bits and $N_{t,sys} = \max\{N_{data} - (N_{p1} + N_{p2}), 0\}$ for a transmission that prioritises non systematic bits.

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 $N_{t,sys} = \left\lfloor N_{sys} \cdot \dfrac{N_{data}}{N_{sys} + 2N_{p1}} \right\rfloor$.

The number of parity bits in a transmission is: $N_{t,p1} = \left\lfloor \dfrac{N_{data} - N_{t,sys}}{2} \right\rfloor$ and $N_{t,p2} = \left\lceil \dfrac{N_{data} - N_{t,sys}}{2} \right\rceil$ for the parity 1 and parity 2 bits, respectively.

Table 14 below summarizes the resulting parameter choice for the second rate matching stage.

Table 14: Parameters for HARQ second rate matching

	X_i	e_{plus}	e_{minus}
Systematic RM S	N_{sys}	N_{sys}	$\left| N_{sys} - N_{t,sys} \right|$
Parity 1 RM P1_2	N_{p1}	$2 \cdot N_{p1}$	$2 \cdot \left| N_{p1} - N_{t,p1} \right|$
Parity 2 RM P2_2	N_{p2}	N_{p2}	$\left| N_{p2} - N_{t,p2} \right|$

The rate matching parameter e_{ini} is calculated for each bit stream according to the RV parameters r and s using

$$e_{ini}(r) = \left\{ \left(X_i - \lfloor r \cdot e_{plus} / r_{max} \rfloor - 1 \right) \bmod e_{plus} \right\} + 1 \text{ in the case of puncturing, i.e., } N_{data} \leq N_{sys} + N_{p1} + N_{p2},$$

and

$$e_{ini}(r) = \left\{ \left(X_i - \lfloor (s + 2 \cdot r) \cdot e_{plus} / (2 \cdot r_{max}) \rfloor - 1 \right) \bmod e_{plus} \right\} + 1 \text{ for repetition, i.e., } N_{data} > N_{sys} + N_{p1} + N_{p2}.$$

Where $r \in \{0, 1, \cdots, r_{max} - 1\}$ and r_{max} is the total number of redundancy versions allowed by varying r as defined in 4.6.1.4. Note that r_{max} varies depending on the modulation mode, i.e. for 16QAM $r_{max} = 2$ and for QPSK $r_{max} = 4$.

Note: For the modulo operation the following clarification is used: the value of (x mod y) is strictly in the range of 0 to y-1 (i.e. -1 mod 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:

$$N_{row} = 4 \text{ for 16QAM and } N_{row} = 2 \text{ for QPSK}$$

$$N_{col} = N_{data} / N_{row}$$

where N_{data} is used as defined in 4.5.4.3 above.

Data is written into the interleaver column by column, and read out of the interleaver column by column, starting from the first column.

$N_{t,sys}$ is the number of transmitted systematic bits. Intermediate values N_r and N_c are calculated using:

$$N_r = \left\lfloor \frac{N_{t,sys}}{N_{col}} \right\rfloor \text{ and } N_c = N_{t,sys} - N_r \cdot N_{col}.$$

If $N_c = 0$ and $N_r > 0$, the systematic bits are written into rows $1 \ldots N_r$.

Otherwise systematic bits are written into rows $1 \ldots N_r + 1$ in the first N_c columns and, if $N_r > 0$, also into rows $1 \ldots N_r$ in the remaining $N_{col} - N_c$ 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, starting with a parity 2 bit in the first available column with the lowest index number.

In the case of 16QAM for each column the bits are read out of the interleaver in the order row 1, row 2, row 3, 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 Interleaving for HS-DSCH

The interleaving for TDD is done over all bits in the TTI, as shown in figure 17 when QPSK modulation is being used for the HS-DSCH, and figure 18 when 16-QAM modulation is being used. The bits input to the block interleaver are denoted by $s_1, s_2, s_3, \ldots, s_R$, where R is the number of bits in one TTI.
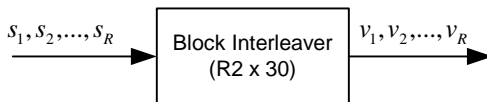
Figure 17: Interleaver structure for HS-DSCH with QPSK modulation

For QPSK, the interleaver 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 output bit sequence from the block interleaver is derived as follows:

(1) The number of columns of the matrix is 30. The columns of the matrix are numbered 0, 1, 2, …, 29 from left to right.

(2) Determine the number of rows of the matrix, *R2*, by finding minimum integer *R2* such that $R \le 30 \times R2$. The rows of rectangular matrix are numbered 0, 1, 2, …, *R2* – 1 from top to bottom.

(3) Write the input bit sequence s_1, s_2, s_3, ..., s_R into the $R2 \times 30$ matrix row by row starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} y_1 & y_2 & y_3 & \cdots & y_{30} \\ y_{31} & y_{32} & y_{33} & \cdots & y_{60} \\ \vdots & \vdots & \vdots & & \vdots \\ y_{30 \cdot (R2-1)+1} & y_{30 \cdot (R2-1)+2} & y_{30 \cdot (R2-1)+3} & \cdots & y_{30 \cdot R2} \end{bmatrix}$$

where $y_k = s_k$ for k = 1, 2, …, R and, if $R < 30 \times R2$, dummy bits are inserted for k = R+1, R+2, …, 30×R2. 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 $\left\langle P2(j) \right\rangle_{j \in \{0,1,...,29\}}$ 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''_k.

$$\begin{bmatrix} y'_1 & y'_{R2+1} & y'_{2 \cdot R2+1} & \cdots & y'_{29 \cdot R2+1} \\ y'_2 & y'_{R2+2} & y'_{2 \cdot R2+2} & \cdots & y'_{29 \cdot R2+2} \\ \vdots & \vdots & \vdots & & \vdots \\ y'_{R2} & y'_{2 \cdot R2} & y'_{3 \cdot R2} & \cdots & y'_{30 \cdot R2} \end{bmatrix}$$

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted *R2*×30 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 > R are removed from the output. The bits after interleaving are denoted by v_1, v_2, v_3, ..., v_R, 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.
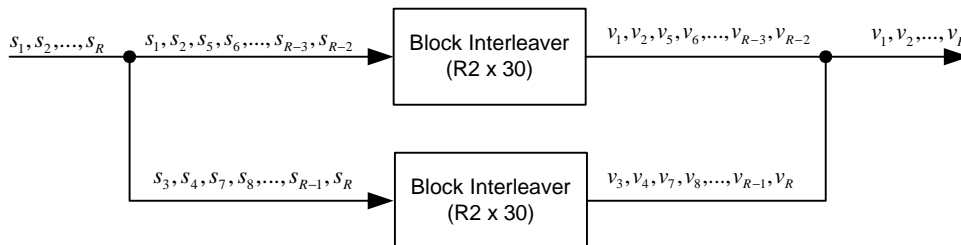
Figure 18: Interleaver structure for HS-DSCH with 16-QAM modulation

For 16QAM, a second identical interleaver operates in parallel to the first. For both interleavers, *R2* is chosen to be the minimum integer that satisfies $R \le 60 \times R2$. The output bits from the bit scrambling operation are divided pairwise between the interleavers: bits s_k and s_{k+1} go to the first interleaver and bits s_{k+2} and s_{k+3} go to the second interleaver,

where $k \bmod 4 = 1$. Bits are collected pairwise from the interleavers: bits v_k and v_{k+1} are obtained from the first interleaver and bits v_{k+2} and v_{k+3} are obtained from the second interleaver, where again $k \bmod 4 = 1$.

4.5.7 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 15 describes the operations that produce the different rearrangements.

The bits of the input sequence are mapped in groups of 4 so that v_k, v_{k+1}, v_{k+2}, v_{k+3} are used, where $k \bmod 4 = 1$.

Table 15: Constellation re-arrangement for 16 QAM

Constellation version parameter *b*	Output bit sequence	Operation
0	$v_k \, v_{k+1} \, v_{k+2} \, v_{k+3}$	None
1	$v_{k+2} \, v_{k+3} \, v_k \, v_{k+1}$	Swapping MSBs with LSBs
2	$v_k \, v_{k+1} \, \overline{v_{k+2} \, v_{k+3}}$	Inversion of the logical values of LSBs
3	$v_{k+2} \, v_{k+3} \, \overline{v_k \, v_{k+1}}$	Swapping MSBs with LSBs, and inversion of the logical values of LSBs

The output bit sequences from the table above map to the output bits in groups of 4, i.e. r_k, r_{k+1}, r_{k+2}, r_{k+3}, where $k \bmod 4 = 1$.

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 r_1, r_2, ..., r_R, where R is the number of physical channel bits in the allocation for the current TTI. These bits are mapped to the physical channel bits, $\{w_{t,p,j} : t = 1, 2, ..., T; p = 1, 2, ..., C; j = 1, 2, ..., U_t\}$, where t is the timeslot index, T is the number of timeslots in the allocation message, p is the physical channel index, C is the number of codes per timeslot in the allocation message, j is the physical channel bit index and U_t is the number of bits per physical channel in timeslot t. The timeslot index, t, increases with increasing timeslot number; the physical channel index, p, increases with increasing channelisation code index, and the physical channel bit index, j, increases with increasing physical channel bit position in time.

The bits r_k shall be mapped to the PhCHs according to the following rule :

Define $\{y_{t,k} : k = 1, 2, ..., C \cdot U_t\}$ to be the set of bits to be transmitted in timeslot t as follows :

$$y_{1,k} = r_k \qquad \text{for } k = 1, 2, ..., C \cdot U_1$$

$$y_{2,k} = r_{k+C \cdot U_1} \qquad \text{for } k = 1, 2, ..., C \cdot U_2$$

…

$$y_{T,k} = r_{k+C \sum_{t=1}^{T-1} U_t} \qquad \text{for } k = 1, 2, ..., C \cdot U_T$$

When the modulation level applied to the physical channels is 16- QAM :

The physical channel p used to transmit the kth bit in the sequence $y_{t,k}$ is :

$$p = \left\lfloor \frac{k-1}{4} \right\rfloor \bmod C + 1$$

If p is odd then :

$$w_{t,p,j} = y_{t,k} \text{ where } j = 4 \cdot \left\lfloor \frac{k-1}{4 \cdot C} \right\rfloor + (k-1) \bmod 4 + 1$$

If p is even then :

$$w_{t,p,j} = y_{t,k} \text{ where } j = U_t - 4 \cdot \left\lfloor \frac{k-1}{4 \cdot C} \right\rfloor - 3 + (k-1) \bmod 4$$

Otherwise, when the modulation level applied to the physical channels is QPSK :

The physical channel p used to transmit the kth bit in the sequence $y_{t,k}$ is :

$$p = (k-1) \bmod C + 1$$

If p is odd then :

$$w_{t,p,j} = y_{t,k} \text{ where } j = \left\lfloor \frac{k-1}{C} \right\rfloor + 1$$

If p is even then :

$$w_{t,p,j} = y_{t,k} \text{ where } j = U_t - \left\lfloor \frac{k-1}{C} \right\rfloor$$

4.6 Coding/Multiplexing for HS-SCCH

The following information, provided by higher layers, is transmitted by means of the HS-SCCH physical channel.

- Channelisation-code-set information (8 bits): $x_{ccs,1}, x_{ccs,2}, \ldots, x_{ccs,8}$

- Time slot information (n bits where $n = 5$ for 1.28 Mcps TDD and $n = 13$ for 3.84 Mcps TDD): $x_{ts,1}, x_{ts,2}, \ldots, x_{ts,n}$

- 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): $x_{tbs,1}, x_{tbs,2}, \ldots, x_{tbs,m}$

- 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): $x_{nd,1}$

- HS-SCCH cyclic sequence number (3 bits): $x_{hcsn,1}, x_{hcsn,2}, x_{hcsn,3}$

- UE identity (16 bits): $x_{ue,1}, x_{ue,2}, \ldots, x_{ue,16}$

The following coding/multiplexing steps can be identified:

- multiplexing of HS-SCCH information (see subclause 4.6.2)

- CRC attachment (see subclause 4.6.3);

- channel coding (see subclause 4.6.4);

- rate matching (see subclause 4.6.5);

- interleaving for HS-SCCH (see subclause 4.6.6);

- mapping to physical channels (see subclauses 4.6.7 and 4.6.8).

The general coding/multiplexing flow is shown in Figure 19.
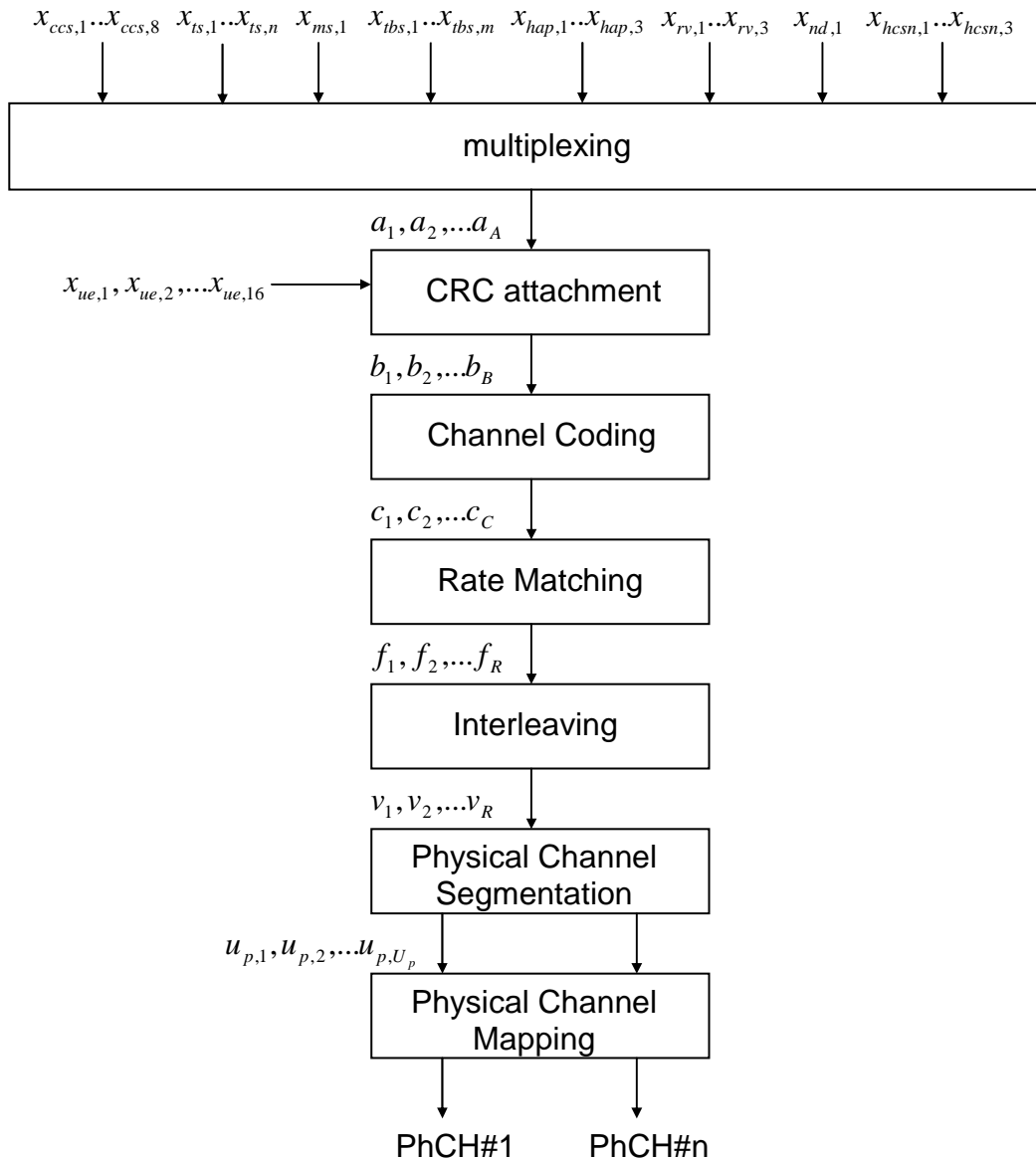
Figure 19 Coding and Multiplexing for HS-SCCH

4.6.1 HS-SCCH information field mapping

4.6.1.1 Channelisation code set information mapping

HS-PDSCH channelisation codes are allocated contiguously from a signalled start code to a signalled stop code, and the allocation includes both the start and stop code. The start code k_{start} is signalled by the bits $x_{ccs,1}$, $x_{ccs,2}$, $x_{ccs,3}$, $x_{ccs,4}$ and the stop code k_{stop} by the bits $x_{ccs,5}$, $x_{ccs,6}$, $x_{ccs,7}$, $x_{ccs,8}$. The mapping in Table 16 below applies.

Table 16: Channelisation code set information mapping

k_{start}	$x_{ccs,1}$	$x_{ccs,2}$	$x_{ccs,3}$	$x_{ccs,4}$	k_{stop}	$x_{ccs,5}$	$x_{ccs,6}$	$x_{ccs,7}$	$x_{ccs,8}$
1	0	0	0	0	1	0	0	0	0
2	0	0	0	1	2	0	0	0	1
3	0	0	1	0	3	0	0	1	0
4	0	0	1	1	4	0	0	1	1
5	0	1	0	0	5	0	1	0	0
6	0	1	0	1	6	0	1	0	1
7	0	1	1	0	7	0	1	1	0
8	0	1	1	1	8	0	1	1	1
9	1	0	0	0	9	1	0	0	0
10	1	0	0	1	10	1	0	0	1
11	1	0	1	0	11	1	0	1	0
12	1	0	1	1	12	1	0	1	1
13	1	1	0	0	13	1	1	0	0
14	1	1	0	1	14	1	1	0	1
15	1	1	1	0	15	1	1	1	0
16	1	1	1	1	16	1	1	1	1

If a value of $k_{start} = 16$ and $k_{stop} = 1$ is signalled, a spreading factor of SF=1 shall be used for the HS-PDSCH resources. Other than this case, $k_{start} > k_{stop}$ shall be treated as an error by the UE.

4.6.1.2   Timeslot information mapping

4.6.1.2.1   1.28 Mcps TDD

For 1.28 Mcps, the timeslots to be used for HS-PDSCH resources are signalled by the bits $x_{ts,1}$, $x_{ts,2}$, …, $x_{ts,5}$, where bit $x_{ts,n}$ carries the information for timeslot n+1. Timeslots 0 and 1 cannot be used for HS-DSCH resources. If the signalling bit is set (i.e. equal to 1), then the corresponding timeslot shall be used for HS-PDSCH resources. Otherwise, the timeslot shall not be used. All used timeslots shall use the same channelisation code set, as signalled by the channelisation code set information bits.

4.6.1.2.2   3.84 Mcps TDD

For 3.84 Mcps, the timeslots to be used for HS-PDSCH resources are signalled by the bits $x_{ts,1}$, $x_{ts,2}$, …, $x_{ts,13}$, where bit $x_{ts,n}$ carries the information for the nth available timeslot for HS-PDSCH resources, where the order of the timeslots available for HS-PDSCH resources shall be the same as the order of the 15 time slots within each frame with the following two slots removed:

- The slot containing the P-CCPCH

- The first slot in a frame containing the PRACH

If the P-CCPCH and/or PRACH are assigned to some, but not all frames, then the corresponding time slots shall remain unavailable for these frames as well..

If the bit is set (i.e. equal to 1), then the corresponding timeslot shall be used for HS-PDSCH resources. Otherwise, the timeslot shall not be used. All used timeslots shall use the same channelisation code set, as signalled by the channelisation code set information bits.

4.6.1.3   Modulation scheme information mapping

The modulation scheme to be used by the HS-PDSCH resources shall be signalled by bit $x_{ms,1}$. The mapping scheme in Table 17 shall apply.

Table 17: Modulation scheme information mapping

$x_{ms,1}$	Modulation Scheme
0	QPSK
1	16-QAM

4.6.1.4 Redundancy and constellation version information mapping

The redundancy version (RV) parameters *r*, *s* and constellation version parameter *b* are mapped 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 18: RV mapping 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 19: RV mapping 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

4.6.1.5 HS-SCCH cyclic sequence number

The HS-SCCH cyclic sequence number is mapped such that $x_{hcsn,1}$ corresponds to the MSB and $x_{hcsn,3}$ to the LSB.

4.6.1.6 UE identity

The UE identity is the HS-DSCH Radio Network Identifier (H-RNTI) defined in [12]. This is mapped such that $x_{ue,1}$ corresponds to the MSB and $x_{ue,16}$ to the LSB, cf. [14].

4.6.1.7 HARQ process identifier mapping

The hybrid-ARQ process information $x_{hap,1}$, $x_{hap,2}$, $x_{hap,3}$ is unsigned binary representation of the HARQ process identifier where $x_{hap,1}$ is MSB.

4.6.1.8 Transport block size index mapping

The transport-block size information $x_{tbs,1}$, $x_{tbs,2}$, …, $x_{tbs,m}$ is unsigned binary representation of the transport block size index where $x_{tbs,1}$ is MSB.

4.6.2 Multiplexing of HS-SCCH information

The information carried on the HS-SCCH is multiplexed onto the bits $a_1, a_2, ... a_A$ according to the following rule :

$$a_1, a_2 ... a_8 = x_{ccs,1}, x_{ccs,2} ... x_{ccs,8}$$

$$a_9, a_{10} ... a_{9+n-1} = x_{ts,1}, x_{ts,2} ... x_{ts,n}$$

$$a_{9+n} = x_{ms,1}$$

$$a_{9+n+1}, a_{9+n+2} \ldots a_{9+n+m} = x_{tbs,1}, x_{tbs,2} \ldots x_{tbs,m}$$

$$a_{10+n+m}, a_{11+n+m}, a_{12+n+m} = x_{hap,1}, x_{hap,2}, x_{hap,3}$$

$$a_{13+n+m}, a_{14+n+m}, a_{15+n+m} = x_{rv,1}, x_{rv,2}, x_{rv,3}$$

$$a_{16+n+m} = x_{nd,1}$$

$$a_{17+n+m}, a_{18+n+m}, a_{19+n+m} = x_{hcsn,1}, x_{hcsn,2}, x_{hcsn,3}$$

4.6.3 CRC attachment for HS-SCCH

From the sequence of bits $a_1, a_2, \ldots a_A$ a 16 bit CRC is calculated according to Section 4.2.1.1. This gives a sequence of bits $y_1, y_2, \ldots y_{16}$ where

$$y_k = p_{im(17-k)} \qquad \text{k} = 1,2,\ldots 16$$

This latter sequence of bits is then masked with the UE identity and appended to the sequence of bits $a_1, a_2, \ldots a_A$. The bits at the output of the CRC attachment block is the sequence of bits $b_1, b_2, \ldots b_B$, where

$$b_i = a_i \qquad\qquad i=1,2,\ldots,A$$

$$b_i = \left(y_{i-A} + x_{ue,i-A} \right) \bmod 2 \qquad i=A+1\ldots B$$

4.6.4 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.

4.6.5 Rate matching for HS-SCCH

Rate matching for HS-SCCH shall be done with the general method described in 4.2.7.

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 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].

4.6.8 Physical channel mapping for HS-SCCH

Physical channel mapping for the HS-SCCH shall be done with the general method described in subclause 4.2.12.

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): $x_{tbs,1}, x_{tbs,2}, \ldots, x_{tbs,n}$

- 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 4.7.2);

- multiplexing of HS-SICH information (4.7.3);

- interleaving for HS-SICH (see subclause 4.7.4);

- mapping to physical channels (see subclause 4.7.5).

The general coding/multiplexing flow is shown in the figure 20.
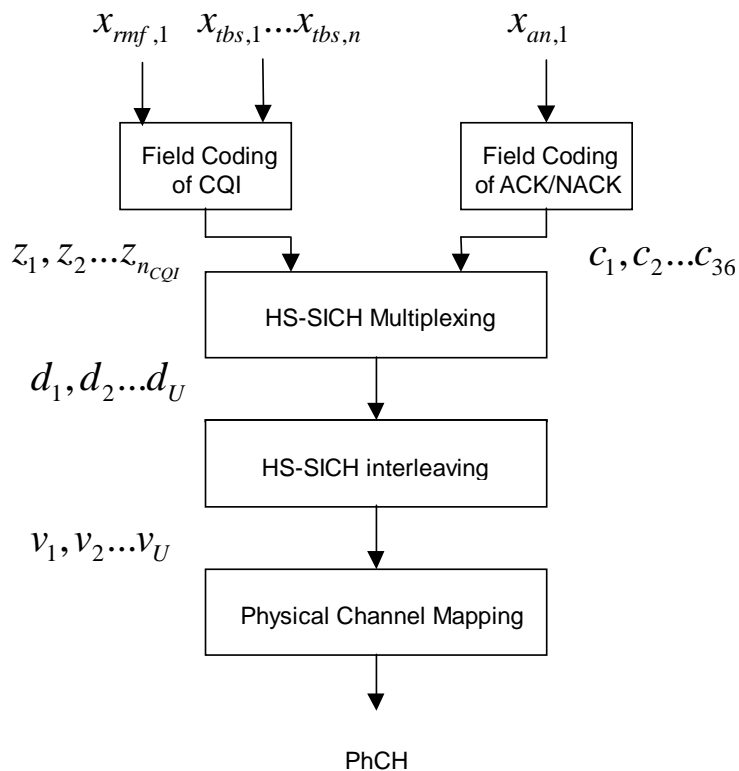
Figure 20Coding and multiplexing for HS-SICH

4.7.1   HS-SICH information field mapping

4.7.1.1   RMF information mapping

The RMF information bit, $x_{rmf,1}$, shall be mapped according to the mapping specified in subclause 4.6.1.3.

4.7.1.2 RTBS information mapping

The RTBS information bits, $x_{tbs,1}$, $x_{tbs,2}$, …, $x_{tbs,n}$, shall be mapped according to the same mapping as is used for the transport block size information bits in subclause 4.6. This mapping is defined by higher layers [12].

4.7.1.3 ACK/NACK information mapping

The ACK/NACK information bit $x_{an,1}$ shall be mapped according to the mapping given in Table 20 below.

Table 20: ACK/NACK information mapping

ACK/NACK	$x_{an,1}$
ACK	1
NACK	0

4.7.2 Coding for HS-SICH

4.7.2.1 Field Coding of ACK/NACK

The ACK/NACK bit $x_{an,1}$ shall be repetition coded to 36 bits. The coded bits are defined as $c_1 … c_{36}$

4.7.2.2 Field Coding of CQI

4.7.2.2.1 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 21.

$$x_{tbs,1}, x_{tbs,2},…, x_{tbs,6} \longrightarrow \boxed{\begin{array}{c}(32,6)\ \text{1st order} \\ \text{Reed-Muller} \\ \text{Code}\end{array}} \longrightarrow z_1, z_2,…, z_{32}$$
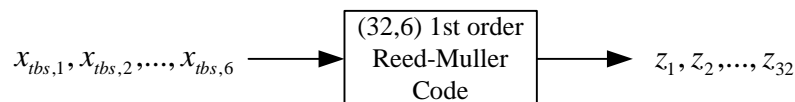
Figure 21: Field coding of RTBS information bits

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 21.

Table 21: 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 $\{z_i : i = 1, \ldots, 32\}$ are given by:

$$z_i = \left(\sum_{n=1}^{6} x_{tbs,n} \cdot M_{i-1,n-1} \right) \bmod 2$$

The RMF bit $x_{rmf,1}$ is repetition coded to 16 bits to produce the bits . $z_{33}, z_{34}, \ldots, z_{n_{CQI}}$ where $n_{CQI} = 48$.

4.7.2.2.2 Field Coding of CQI for 3.84 Mcps TDD

RTBS and RMF bits are multiplexed onto the bits $y_1, y_2 \ldots y_{10}$ according to the following rule :

$$y_1 = x_{rmf,1}$$

$$y_2, y_3 \ldots y_{10} = x_{tbs,1}, x_{tbs,2} \ldots x_{tbs,9}$$

The bits $y_1, y_2 \ldots y_{10}$ are coded to produce the bits $w_1, w_2, \ldots w_{32}$ using a (32,10) sub-code of the second order Reed-Muller code as defined in subclause 4.3.1.1..

The bits $w_1, w_2, \ldots w_{32}$ are used to produce the CQI bits $z_1, z_2 \ldots z_{n_{CQI}}$ using a (4,1) repetition code, where $n_{CQI} = 128$, such that:

$z_n, z_{n+32}, z_{n+64}, z_{n+96} = w_n \quad n=1\dots32$

4.7.3 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.:

$$d_1, d_2 \dots d_{n_{CQI}} = z_{1,} z_2 \dots z_{n_{CQI}}$$

$$d_{n_{CQI}+1}, d_{n_{CQI}+2} \dots d_{n_{CQI}+36} = c_{1,} c_2 \dots c_{36}$$

$$d_{n_{CQI}+37}, d_{n_{CQI}+38} \dots d_U = 0,0\dots.0$$

4.7.4 Interleaver for HS-SICH

Interleaver for HS-SICH shall be done with the general method described in 4.2.11.1.

4.7.5 Physical channel mapping for HS-SICH

Physical channel mapping for HS-SICH shall be done with the general method described in 4.2.12.

Annex A (informative):
Change history

<table>
<tr><th colspan="8">Change history</th></tr>
<tr><th>Date</th><th>TSG #</th><th>TSG Doc.</th><th>CR</th><th>Rev</th><th>Subject/Comment</th><th>Old</th><th>New</th></tr>
<tr><td>14/01/00</td><td>RAN_05</td><td>RAN_05</td><td>-</td><td></td><td>Approved at TSG RAN #5 and placed under Change Control</td><td>-</td><td>3.0.0</td></tr>
<tr><td>14/01/00</td><td>RAN_06</td><td>RP-99694</td><td>001</td><td>3</td><td>Correction of rate matching parameters for repetition after 1st Interleaving in 25.222</td><td>3.0.0</td><td>3.1.0</td></tr>
<tr><td>14/01/00</td><td>RAN_06</td><td>RP-99694</td><td>002</td><td>1</td><td>Clarification of bit separation and collection</td><td>3.0.0</td><td>3.1.0</td></tr>
<tr><td>14/01/00</td><td>RAN_06</td><td>RP-99694</td><td>003</td><td>-</td><td>Changing the initial offset value for convolutional code rate matching</td><td>3.0.0</td><td>3.1.0</td></tr>
<tr><td>14/01/00</td><td>RAN_06</td><td>RP-99693</td><td>004</td><td>1</td><td>Editorial corrections to TS 25.222</td><td>3.0.0</td><td>3.1.0</td></tr>
<tr><td>14/01/00</td><td>RAN_06</td><td>RP-99694</td><td>007</td><td>-</td><td>Update of rate matching rule for TDD</td><td>3.0.0</td><td>3.1.0</td></tr>
<tr><td>14/01/00</td><td>RAN_06</td><td>RP-99694</td><td>009</td><td>1</td><td>Modified physical channel mapping scheme</td><td>3.0.0</td><td>3.1.0</td></tr>
<tr><td>14/01/00</td><td>RAN_06</td><td>RP-99694</td><td>013</td><td>-</td><td>Introduction of TFCI for S-CCPCH in TDD mode</td><td>3.0.0</td><td>3.1.0</td></tr>
<tr><td>14/01/00</td><td>RAN_06</td><td>RP-99694</td><td>015</td><td>-</td><td>TFCI coding and mapping in TDD</td><td>3.0.0</td><td>3.1.0</td></tr>
<tr><td>14/01/00</td><td>-</td><td>-</td><td>-</td><td></td><td>Change history was added by the editor</td><td>3.1.0</td><td>3.1.1</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>017</td><td>-</td><td>Corrections to TS 25.222</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>018</td><td>-</td><td>Refinements of Physical Channel Mapping</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>019</td><td>1</td><td>TFCI coding specification in TDD</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>021</td><td>-</td><td>Modification of Turbo code internal interleaver</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>023</td><td>-</td><td>Update of TS 25.222 - clarification of BTFD for TDD</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>025</td><td>-</td><td>Change of TFCI basis for TDD</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>026</td><td>-</td><td>Padding Function for Turbo coding of small blocks</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>027</td><td>-</td><td>Editorial modification of shifting parameter calculation for turbo code puncturing</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>31/03/00</td><td>RAN_07</td><td>RP-000068</td><td>029</td><td>1</td><td>Editorial changes of channel coding section</td><td>3.1.1</td><td>3.2.0</td></tr>
<tr><td>26/06/00</td><td>RAN_08</td><td>RP-000272</td><td>030</td><td>-</td><td>Parity bit attachment to 0 size transport block</td><td>3.2.0</td><td>3.3.0</td></tr>
<tr><td>26/06/00</td><td>RAN_08</td><td>RP-000272</td><td>031</td><td>-</td><td>Correction of the mapping formula</td><td>3.2.0</td><td>3.3.0</td></tr>
<tr><td>26/06/00</td><td>RAN_08</td><td>RP-000272</td><td>034</td><td>-</td><td>Alignment of Multiplexing for TDD</td><td>3.2.0</td><td>3.3.0</td></tr>
<tr><td>26/06/00</td><td>RAN_08</td><td>RP-000272</td><td>036</td><td>2</td><td>Bit separation of the Turbo encoded data</td><td>3.2.0</td><td>3.3.0</td></tr>
<tr><td>26/06/00</td><td>RAN_08</td><td>RP-000272</td><td>038</td><td>2</td><td>Revision of code block segmentation description</td><td>3.2.0</td><td>3.3.0</td></tr>
<tr><td>26/06/00</td><td>RAN_08</td><td>RP-000272</td><td>039</td><td>-</td><td>Editorial corrections in channel coding section</td><td>3.2.0</td><td>3.3.0</td></tr>
<tr><td>23/09/00</td><td>RAN_09</td><td>RP-000345</td><td>040</td><td>1</td><td>Update of TS 25.222</td><td>3.3.0</td><td>3.4.0</td></tr>
<tr><td>23/09/00</td><td>RAN_09</td><td>RP-000345</td><td>041</td><td>1</td><td>Editorial corrections in Turbo code internal interleaver section</td><td>3.3.0</td><td>3.4.0</td></tr>
<tr><td>23/09/00</td><td>RAN_09</td><td>RP-000345</td><td>042</td><td>-</td><td>Paging Indicator Terminology</td><td>3.3.0</td><td>3.4.0</td></tr>
<tr><td>23/09/00</td><td>RAN_09</td><td>RP-000345</td><td>043</td><td>1</td><td>Bit separation and collection for rate matching</td><td>3.3.0</td><td>3.4.0</td></tr>
<tr><td>23/09/00</td><td>RAN_09</td><td>RP-000345</td><td>048</td><td>-</td><td>Puncturing Limit definition in WG1 specification</td><td>3.3.0</td><td>3.4.0</td></tr>
<tr><td>15/12/00</td><td>RAN_10</td><td>RP-000543</td><td>049</td><td>-</td><td>Clarification on the Ci formula</td><td>3.4.0</td><td>3.5.0</td></tr>
<tr><td>15/12/00</td><td>RAN_10</td><td>RP-000543</td><td>050</td><td>-</td><td>Correction on TFCI & TPC Transmission</td><td>3.4.0</td><td>3.5.0</td></tr>
<tr><td>15/12/00</td><td>RAN_10</td><td>RP-000543</td><td>053</td><td>1</td><td>Editorial corrections in TS 25.222</td><td>3.4.0</td><td>3.5.0</td></tr>
<tr><td>16/03/01</td><td>RAN_11</td><td>-</td><td>-</td><td>-</td><td>Approved as Release 4 specification (v4.0.0) at TSG RAN #11</td><td>3.5.0</td><td>4.0.0</td></tr>
<tr><td>16/03/01</td><td>RAN_11</td><td>RP-010063</td><td>051</td><td>1</td><td>Bit Scrambling for TDD</td><td>3.5.0</td><td>4.0.0</td></tr>
<tr><td>16/03/01</td><td>RAN_11</td><td>RP-010063</td><td>054</td><td>1</td><td>Corrections & Clarifications for TS25.222</td><td>3.5.0</td><td>4.0.0</td></tr>
<tr><td>16/03/01</td><td>RAN_11</td><td>RP-010071</td><td>055</td><td>1</td><td>Inclusion of 1.28Mcps TDD in TS 25.222</td><td>3.5.0</td><td>4.0.0</td></tr>
<tr><td>21/09/01</td><td>RAN_13</td><td>RP-010523</td><td>057</td><td>-</td><td>TFCI Terminology</td><td>4.0.0</td><td>4.1.0</td></tr>
<tr><td>21/09/01</td><td>RAN_13</td><td>RP-010529</td><td>058</td><td>1</td><td>5ms TTI for PRACH for 1.28 Mcps TDD</td><td>4.0.0</td><td>4.1.0</td></tr>
<tr><td>21/09/01</td><td>RAN_13</td><td>RP-010529</td><td>060</td><td>-</td><td>A correction on the meaning of FPACH in TS 25.222</td><td>4.0.0</td><td>4.1.0</td></tr>
<tr><td>14/12/01</td><td>RAN_14</td><td>RP-010747</td><td>059</td><td>-</td><td>Bit Scrambling for TDD</td><td>4.1.0</td><td>4.2.0</td></tr>
<tr><td>14/12/01</td><td>RAN_14</td><td>RP-010747</td><td>061</td><td>-</td><td>Corrections in clause 4.1 and 4.2 of TS 25.222</td><td>4.1.0</td><td>4.2.0</td></tr>
<tr><td>08/03/02</td><td>RAN_15</td><td>RP-020050</td><td>063</td><td>1</td><td>Correction to addition of padding zeros to PICH in TDD</td><td>4.2.0</td><td>4.3.0</td></tr>
<tr><td>08/03/02</td><td>RAN_15</td><td>RP-020050</td><td>065</td><td>3</td><td>Clarification of the requirement for the determination of the rate matching parameters and editorial corrections to 25.222</td><td>4.2.0</td><td>4.3.0</td></tr>
<tr><td>08/03/02</td><td>RAN_15</td><td>RP-020058</td><td>066</td><td>2</td><td>Inclusion of HSDPA in 25.222</td><td>4.2.0</td><td>5.0.0</td></tr>
<tr><td>07/06/02</td><td>RAN_16</td><td>RP-020311</td><td>077</td><td>-</td><td>Second Stage Interleaving and Physical Channel Mapping</td><td>5.0.0</td><td>5.1.0</td></tr>
<tr><td>07/06/02</td><td>RAN_16</td><td>RP-020311</td><td>076</td><td>1</td><td>Zero padding for TFCI (3.84Mcps TDD)</td><td>5.0.0</td><td>5.1.0</td></tr>
<tr><td>07/06/02</td><td>RAN_16</td><td>RP-020314</td><td>073</td><td>-</td><td>Correction to addition of padding zeros to PICH in 1.28 Mcps TDD</td><td>5.0.0</td><td>5.1.0</td></tr>
<tr><td>07/06/02</td><td>RAN_16</td><td>RP-020314</td><td>086</td><td>-</td><td>Zero padding for TFCI (1.28Mcps TDD)</td><td>5.0.0</td><td>5.1.0</td></tr>
<tr><td>07/06/02</td><td>RAN_16</td><td>RP-020317</td><td>078</td><td>2</td><td>Removal of inconsistencies and ambiguities in the HARQ description</td><td>5.0.0</td><td>5.1.0</td></tr>
<tr><td>07/06/02</td><td>RAN_16</td><td>RP-020317</td><td>079</td><td>4</td><td>Corrections to HS-DSCH coding</td><td>5.0.0</td><td>5.1.0</td></tr>
<tr><td>07/06/02</td><td>RAN_16</td><td>RP-020317</td><td>082</td><td>1</td><td>Corrections to HSDPA Multiplexing and Coding</td><td>5.0.0</td><td>5.1.0</td></tr>
<tr><td>07/06/02</td><td>RAN_16</td><td>RP-020317</td><td>084</td><td>-</td><td>Introduction of HS-SCCH Cyclic Sequence Counter for TDD</td><td>5.0.0</td><td>5.1.0</td></tr>
<tr><td>19/09/02</td><td>RAN_17</td><td>RP-020570</td><td>097</td><td>-</td><td>Clarification of the definition of layer 1 transport channel numbers</td><td>5.1.0</td><td>5.2.0</td></tr>
<tr><td>19/09/02</td><td>RAN_17</td><td>RP-020585</td><td>093</td><td>-</td><td>HS-DSCH Interleaving for TDD</td><td>5.1.0</td><td>5.2.0</td></tr>
<tr><td>19/09/02</td><td>RAN_17</td><td>RP-020585</td><td>091</td><td>1</td><td>HS-SCCH corrections for TDD</td><td>5.1.0</td><td>5.2.0</td></tr>
<tr><td>19/09/02</td><td>RAN_17</td><td>RP-020585</td><td>089</td><td>1</td><td>Clarification of TFRI bits for 3.84Mcps HSDPA TDD</td><td>5.1.0</td><td>5.2.0</td></tr>
<tr><td>15/10/02</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Moving of misplaced sections 4.6.1.5 and 4.6.1.6</td><td>5.2.0</td><td>5.2.1</td></tr>
</table>

22/12/02	RAN_18	RP-020843	100	-	Corrections to TFCI encoding of very short TFCI lengths	5.2.1	5.3.0
22/12/02	RAN_18	RP-020843	102	-	Corrections to TFCI encoding of very short TFCI lengths	5.2.1	5.3.0
22/12/02	RAN_18	RP-020849	103	-	Correction of editorial Error	5.2.1	5.3.0
22/12/02	RAN_18	RP-020849	104	-	Miscellaneous Minor HSDPA Corrections	5.2.1	5.3.0
22/12/02	RAN_18	RP-020852	107	-	Editorial modification to the section numberings	5.2.1	5.3.0
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25/03/03	RAN_19	RP-030139	109	3	Miscellaneous Corrections	5.3.0	5.4.0
24/06/03	RAN_20	RP-030276	111	-	Corrections to field coding of CQI for HS-SICH (3.84Mcps TDD)	5.4.0	5.5.0
24/06/03	RAN_20	RP-030276	112	-	Correction to definition of number of bits available to HS-DSCH in one TTI.	5.4.0	5.5.0
06/01/04	RAN_22	RP-030646	118	1	Correction of subframe segmentation, physical channel mapping & rate matching for 1.28Mcps TDD	5.5.0	5.6.0
06/01/04	RAN_22	RP-030650	119	-	Clarification of the CRC attachment procedure for HS-SCCH (TDD)	5.5.0	5.6.0
06/01/04	RAN_22	RP-030660	120		HARQ process identifier mapping	5.5.0	5.6.0
06/01/04	RAN_22	RP-030712	121		Alignment of "Soft channel bits" terminology with 25.306	5.5.0	5.6.0
13/01/04	RAN_22	-	-	-	Created for M.1457 update	5.6.0	6.0.0
07/09/04	RAN_25	RP-040315	124	1	Correction of symbol Xi defined in sub-frame segmentation step	6.0.0	6.1.0
13/12/04	RAN_26	RP-040451	125	-	Introduction of MICH	6.1.0	6.2.0
03/03/09	RAN_43	RP-090231	171	-	Editorial correction for 1.28Mcps TDD	6.2.0	6.3.0

History

Document history		
V6.0.0	December 2003	Publication
V6.1.0	September 2004	Publication
V6.2.0	December 2004	Publication
V6.3.0	March 2009	Publication