3GPP TSG RAN WG1 Meeting #10
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CHANGE REQUEST

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25.222 CR 017 Current Version: V3.1.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to: TSG RAN#7 — for approval [X] — for information [ ] — strategic [ ] — non-strategic [ ] *(for SMG use only)*
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Form: CR cover sheet, version 2 for 3GPP and SMG The latest version of this form is available from: ftp://ftp.3gpp.org/Information/CR-Form-v2.doc

Proposed change affects: (U)SIM [ ] ME [X] UTRAN / Radio [X] Core Network [ ]
(at least one should be marked with an X)

Source: Siemens AG **Date:** 14.01.2000

Subject: Corrections to TS 25.222

Work item: TS 25.222

Category:
(only one category shall be marked with an X)

F	Correction	X
A	Corresponds to a correction in an earlier release	
B	Addition of feature	
C	Functional modification of feature	
D	Editorial modification	

Release:

Phase 2	
Release 96	
Release 97	
Release 98	
Release 99	X
Release 00	

Reason for change:
This CR includes the following corrections, mainly due to harmonisation reasons with FDD:
- Inclusion of flexible coding schemes for the FACH
- Modification of the chapter describing convolutional coding
- Clarification of the alignment of TrCHs with different TTI
- Handling of zero length transport blocks
- Clarification of the indices for timeslot related 2^{nd} interleaving

Furthermore, some minor editorial changes have been added.

Clauses affected:

Other specs affected:

Other 3G core specifications	[ ]	→ List of CRs:
Other GSM core specifications	[ ]	→ List of CRs:
MS test specifications	[ ]	→ List of CRs:
BSS test specifications	[ ]	→ List of CRs:
O&M specifications	[ ]	→ List of CRs:

Other comments:

<--------- double-click here for help and instructions on how to create a CR.

3.3 Abbreviations

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

<ACRONYM>	<Explanation>
ARQ	Automatic Repeat on Request
BCH	Broadcast Channel
BER	Bit Error Rate
BS	Base Station
BSS	Base Station Subsystem
CBR	Constant Bit Rate
CCCH	Common Control Channel
CCTrCH	Coded Composite Transport Channel
CDMA	Code Division Multiple Access
CFN	Connection Frame Number
CRC	Cyclic Redundancy Check
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
JD	Joint Detection
L1	Layer 1
L2	Layer 2
LLC	Logical Link Control
MA	Multiple Access
MAC	Medium Access Control
MS	Mobile Station
MT	Mobile Terminated
NRT	Non-Real Time
OVSF	Orthogonal Variable Spreading Factor
PC	Power Control
PCCC	Parallel Concatenated Convolutional Code
PCH	Paging Channel
PhCH	Physical Channel
PI	Paging Indicator
QoS	Quality of Service
QPSK	Quaternary Phase Shift Keying
RACH	Random Access Channel
RF	Radio Frequency
RLC	Radio Link Control
RRC	Radio Resource Control
RRM	Radio Resource Management
RSC	Recursive Systematic Convolutional Coder
RT	Real Time
RU	Resource Unit
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
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

4.2 Transport channel coding/multiplexing

Figure 4-1 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 {10 ms, 20 ms, 40 ms, 80 ms}.

The following coding/multiplexing steps can be identified:

- Add CRC to each transport block (see section 4.2.1)
- TrBk concatenation / Code block segmentation (see section 4.2.2)
- Channel coding (see section 4.2.3)
- Radio frame size equalization (see section 4.2.4)
- Interleaving (two steps, see sections 4.2.5 and 4.2.10)
- Radio frame segmentation (4.2.6)
- Rate matching (see section 4.2.7)
- Multiplexing of transport channels (see section 4.2.8)
- Physical channel segmentation (see section 4.2.9)
- Mapping to physical channels (see section 4.2.11)

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

Figure 4–1: Transport channel multiplexing structure for uplink and downlink

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 , and the parity bits by . A_i is the length of a transport block of TrCH i, m is the transport block number, and L_i is 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

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

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

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

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.

4.2.2.2 Code block segmentation

~~NOTE: It is assumed that filler bits are set to 0.~~

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 last 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 are denoted by , where i is the TrCH number, r is the code block number, and K_i is the number of bits.

Number of code blocks: $C_i = \lceil X_i / Z \rceil$

Number of bits in each code block: $K_i = \lceil X_i / C_i \rceil$

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

If $X_i \leq Z$, then $o_{i1k} = x_{ik}$, and $K_i = X_i$.

If $X_i \geq Z$, then

$k = 1, 2, \ldots, K_i$

$k = 1, 2, \ldots, K_i$

$k = 1, 2, \ldots, K_i$

$k = 1, 2, \ldots, K_i - Y_i$

$k = (K_i - Y_i) + 1, (K_i - Y_i) + 2, \ldots, K_i$

4.2.3 Channel coding

Code blocks are delivered to the channel coding block. They are denoted by , 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 . The encoded blocks are serially multiplexed so that the block with lowest index r is output first from the channel coding block. The bits output are denoted by , where i is the TrCH number and $E_i = C_i Y_i$. The output bits are defined by the following relations:

$k = 1, 2, \ldots, Y_i$

$k = Y_i + 1, Y_i + 2, \ldots, 2Y_i$

$k = 2Y_i + 1, 2Y_i + 2, \ldots, 3Y_i$

$$k = (C_i - 1)Y_i + 1, (C_i - 1)Y_i + 2, \ldots, C_iY_i$$

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 channel coding

The values of Y_i in connection with each coding scheme:

- Convolutional coding, ½ rate: $Y_i = 2*K_i + 16$; 1/3 rate: $Y_i = 3*K_i + 24$
- Turbo coding, 1/3 rate: $Y_i = 3*K_i + 12$
- No channel coding, $Y_i = K_i$

Table 4.2.3-1: Error Correction Coding Parameters

Transport channel type	Coding scheme	Coding rate
BCH	Convolutional code	1/2
PCH		
RACH		
DCH, DSCH, USCH, FACH		1/3, 1/2
	Turbo code	1/3
	No coding	

~~**Table 4.2.3-1: Error Correction Coding Parameters**~~

~~Transport channel type~~	~~Coding scheme~~	~~Coding rate~~
~~BCH~~	~~Convolutional code~~	~~1/2~~
~~PCH~~		
~~FACH~~		
~~RACH~~		
~~DCH, DSCH, USCH~~		~~1/3, 1/2~~
	~~Turbo code~~	~~1/3~~
	~~No coding~~	

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

4.2.3.1 Convolutional Coding

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

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

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

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

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

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

- Constraint length K=9. Coding rates 1/2 and 1/3.
- The configuration of the convolutional coder is presented in figure 4-2.
- The output from the convolutional coder shall be done in the order output0, output1,output2, output0, output1,…, output2. (When coding rate is 1/2, output is done up to output 1).
- The initial value of the shift register of the coder shall be "all 0".
- K-1 tail bits (value 0) shall be added to the end of the code block before encoding.

Figure 4-2: Convolutional Coder

4.2.3.2 Turbo coding

4.2.3.2.1 Turbo coder

The turbo coding scheme is a parallel concatenated convolutional code (PCCC) with 8-state constituent encoders.

For data services requiring quality of service between 10^{-3} and 10^{-6} BER inclusive, parallel concatenated convolutional code (PCCC) with 8-state constituent encoders is used.

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

G(D)=

where,

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

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

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 section 4.2.7 and subsections:

N_{ij}: Number of bits in a radio frame before rate matching on TrCH *i* with transport format combination *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.

$N_{data,j}$: 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

I: Number of TrCHs in a CCTrCH.

Z_{mij}: 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* ($0 £ n_i < F_i$).

q: Average puncturing or repetition distance(normalised to only show the remaining rate matching on top of an integer number of repetitions).

$I_F(n_i)$: The inverse interleaving function of the 1st interleaver (note that the inverse interleaving function is identical to the interleaving function itself for the 1st interleaver).

$S(n_i)$: The shift of the puncturing or repetition pattern for radio frame 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 section 4.2.7.3.

e_{plus} Increment of variable *e* in the rate matching pattern determination algorithm of section 4.2.7.3.

e_{minus} Decrement of variable *e* in the rate matching pattern determination algorithm of section 4.2.7.3.

b: Indicates systematic and parity bits.

b=~~0~~1: Systematic bit. *X(t)* in 4.2.3.2.1.

~~Y:~~ b=~~1~~2: 1st parity bit (from the upper Turbo constituent encoder). *Y(t)* in section 4.2.3.2.1.

~~Y':~~ b=~~2~~3: 2nd parity bit (from the lower Turbo constituent encoder). *Y'(t)* in section 4.2.3.2.1.

4.2.7.1 Determination of rate matching parameters

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

for all i = 1 .. I

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 signalled from higher layers and denoted by PL. 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, usage of TPC and multiframe structure), which is given in [7].

Denote the number of data bits in each physical channel by ~~N~~$U_{p,Sp}$ (~~$N_{k,Sk}$~~), where ~~k~~p refers to the sequence number $1 \le p \le$ P_{max} of this physical channel in the allocation message, and the second index S~~k~~p indicates the spreading factor with the possible values {*16, 8, 4, 2, 1*}, respectively. For each physical channel an individual minimum spreading factor S~~k~~p_{min} is transmitted by means of the higher layer. Then, for N_{data} one of the following values in ascending order can be chosen: ~~{$N_{1,16}$, ..., $N_{1,S1min}$, $N_{1,S1min}+N_{2,16}$, ..., $N_{1,S1min}+N_{2,S2min}$, ..., $N_{1,S1min}+N_{2,S2min}+...+N_{P,16}$, ..., $N_{1,S1min}+N_{2,S2min}+...+N_{P,SPmin}$}.~~

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

SET1 = { N_{data} such that is non negative }

$N_{data, j}$ = min SET1

The number of bits to be repeated or punctured, ΔN_{ij}, within one radio frame for each TrCH i is calculated with the relations given at the beginning of this section for all possible transport format combinations j and selected every radio frame.

If ΔN_{ij} = 0 then the output data of the rate matching is the same as the input data and the rate matching algorithm of section 4.2.7.3 does not need to be executed.

Otherwise, the rate matching pattern is calculated with the algorithm described in section 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 section 4.2.7.1.1 and 4.2.7.1.2

4.2.7.3 Rate matching pattern determination

The bits input to the rate matching are denoted by , where *i* is the TrCH and X_i is the parameter given in section 4.2.7.1.1 and 4.2.7.1.2.~~The bits output from the rate matching are denoted by , where *i* is the TrCH number and $V_i = N + DN$.~~

Note that 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 *d* where *d* Ï {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.

4.2.10 2nd interleaving

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.

4.2.10.1 Frame related 2nd interleaving

In case of frame related interleaving, the bits input to the 2^{nd} interleaver are denoted , where U is the total number of bits after TrCH multiplexing transmitted during the respective radio frame with .

The relation between x_k and the bits u_{pk} in the respective physical channels is given below:

$k = 1, 2, \ldots, U_1$

$k = 1, 2, \ldots, U_2$

…

$k = 1, 2, \ldots, U_P$

The following steps have to be performed once for each CCTrCH:

(1) Set the number of columns $C_2 = 30$. The columns are numbered 0, 1, 2, …, C_2-1 from left to right.

(2) Determine the number of rows R_2 by finding minimum integer R_2 such that $U \le R_2 C_2$.

(3) The bits input to the 2^{nd} interleaving are written into the R_2 C_2 rectangular matrix row by row.

(4) Perform the inter-column permutation based on the pattern $\{P_2(j)\}$ ($j = 0, 1, \ldots, C_2-1$) that is shown in table 4.2.9-1, 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.

(5) The output of the 2^{nd} interleaving is the bit sequence read out column by column from the inter-column permuted R_2 C_2 matrix. The output is pruned by deleting bits that were not present in the input bit sequence, i.e. bits y_k that corresponds to bits x_k with $k>U$ are removed from the output. The bits after 2^{nd} interleaving are denoted by , where v_1 corresponds to the bit y_k with smallest index k after pruning, v_2 to the bit y_k with second smallest index k after pruning, and so on.

4.2.10.2 Timeslot related 2nd interleaving

In case of timeslot related 2nd interleaving, the bits input to the 2nd interleaver are denoted , where t refers to a certain timeslot, and U_t is the number of bits transmitted in this timeslot during the respective radio frame

In each timeslot t the relation between x_{tk} and u_{tpk} is given below with P_t refering to the number of physical channels within the respective timeslot:

~~$k = 1, 2, \ldots,$~~

$k = 1, 2, \ldots,$

~~$k = 1, 2, \ldots,$~~

$k = 1, 2, \ldots,$

…

~~$k = 1, 2, \ldots,$~~

$k = 1, 2, \ldots,$

The following steps have to be performed for each timeslot t, on which the respective CCTrCH is mapped:

(1) Set the number of columns $C_2 = 30$. The columns are numbered 0, 1, 2, …, C_2-1 from left to right.

(2) Determine the number of rows R_2 by finding minimum integer R_2 such that
U_t £ R_2C_2.

(3) The bits input to the 2nd interleaving are written into the R_2 C_2 rectangular matrix row by row.

(4) Perform the inter-column permutation based on the pattern $\{P_2(j)\}$ $(j = 0, 1, \ldots, C_2-1)$ that is shown in table 4.2.9-1, 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_{tk}.

(5) The output of the 2nd interleaving is the bit sequence read out column by column from the inter-column permuted R_2 C_2 matrix. The output is pruned by deleting bits that were not present in the input bit sequence, i.e. bits y_{tk} that corresponds to bits x_{tk} with $k>U_t$ are removed from the output. The bits after 2nd interleaving are denoted by

4.2.12 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 sh~~ould~~all have co-ordinated timings~~ in the sense that transport blocks arriving from higher layers on different transport channels of potentially different transmission time intervals shall have aligned transmission time instants as shown in figure 4-6~~. When the TFCS of a CCTrCH is changed because a transport channel *i* is added to the CCTrCH or reconfigured within the CCTrCH, the TTI of transport channel *i* may only start in radio frames with CFN fulfilling the relation

   $CFN_i \bmod F_{max} = 0$,

   where F_{max} denotes the maximum number of radio frames within the transmission time intervals of all transport channels which are multiplexed into the same CCTrCH, including transport channel *i* which is added or reconfigured, and CFN_i denotes the connection frame number of the first radio frame within the transmission time interval of transport channel *i*.

   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

   $CFN_i \bmod F_i = 0$.

2) Different CCTrCHs cannot be mapped onto the same physical channel.

3) One CCTrCH shall be mapped onto one or several physical channels.

~~**Figure 4-6: Possible transmission time instants regarding CCTrCH**~~

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