

Agenda Item	: AH04 + AH08
Source	: Mitsubishi Electric (Trium-RD)
Title	: Minor corrections to 25.212 (Rate Matching, p-bit insertion, PhCH segmentation) 25.212 CR 72 rev 1
Document for	: Decision

Introduction

In this paper we propose several correction and editorial changes to 25.212 version 3.2.0.

Changes that have been done:

section	nature	description and motivation
1 st IL, p-bits insertion	correction	The P1 permutation is such that P1(x) is the original column position of column number x after permutation. So the p-bits insertion description works because P1 is self-inverse, but if it was not self-inverse it would be incorrect. We have corrected the section so that the description does no longer depends on this that P1 is self-inverse.
1 st IL operation	editorial	C_I , R_I and P_I replaced by C1, R1 and P1. C_I is already used as C_i , the code block number, for the last channel $i = I$. For the notation to be uniform through the section, the same type of change has been done to R_I and P_I .
1 st IL	editorial	the column permutation function is now noted P_{1F_i} whereas it used to be noted either P_1 (no index by the column number) or P_{F_i} (the name does not contain the 1 of P1 hinting that the permutation is for the 1 st IL).
1 st IL, p bit insertion	editorial	In the text, it is said that P1 is defined by the table 3 above. In fact Table 3 is in the following subsection.
RM, CM by puncturing	editorial	replaced TrCh and CCTrCh by TrCH and CCTrCH
RM, CM by puncturing	editorial	replaced "uncompressed radio frames" by "radio frames not overlapping with a transmission gap". Uncompressed is misleading, as a TTI overlapping with a transmission gap is compressed, and might well also contain a radio frame not overlapping with a transmission gap.
RM, CM by puncturing	editorial	improved readability by replacing the text editor like notation $Np_{i,l}^n$ and $Np_{i,l}^{TTI,m}$ and $\Delta N_{i,l}^{TTI,m}$ by formula editor formulas $Np_{i,l}^n$ $Np_{i,l}^{TTI,m}$. $\Delta N_{i,l}^{TTI,m}$
RM, CM by puncturing	correction	In formula $DN_{i,max}^{TTI,m} = \sum_{n=0}^{n=F_i} DN_{i,*}^n$ corrected so that the summation is carried out from n=0 to n= F_i -1, instead of up to F_i .

RM, fixed position 4.2.7.2.1	editorial	A sentence has been added to refer to the place where $\Delta N_{i,l}^{TTI}$ is computed from ΔN_{\max} and N_{\max}
Physical channel segmentation	editorial	The number of input bits has been renamed from Y to X . It looked unusual to us that the bits are named x_k and k is from 1 to Y instead from 1 to X
Physical channel segmentation	correction	There was a problem as sometimes the letter V was used instead of the letter U .
RM, UL, pattern determination e_{ini} setting, and S definition	correction	On the e-mail reflector it was clarified that the I_F function that is called "interleaving function" used in the column-wise pattern shifting 'S formula' is in fact the column permutation function $P1$. So we aligned this. Instead of using $P1$ where the S is written, we use it were S is read in order to be consistent with the definition of $P1$, this makes no functional difference as $P1$ is self-inverse. We also changed the definition of S to take into account that the index are permuted.
2 nd IL	editorial	For the same reason as for the 1 st IL, R_2 , C_2 and P_2 have been renamed $R2$, $C2$, and $P2$.
1 st and 2 nd IL	clarification	It has been clarified in the table giving the column permutation that the list given is $(P(0), P(1), \dots, P(C-1))$. Also curly brackets were replaced by round brackets.
In many places	editorial	Symbols not in italic were put in italic

Difference from revision 0

- Definition of the $S[\cdot]$ function used for the S formula
- All the V 's replaced by U 's in the PhCH segmentation
- Some TrCh had been forgotten and put as TrCH
- Some text editor formulas forgotten put to equation editor formulas
- CR header sheet now ticks "Correction+editorial change" instead of "functional+editorial change".
- Section "changes that should be done" just below has been rewritten in milder terms.

Changes that should be done

According to us all the first part of 4.2.7.2.1.2 up to "Calculations of $Np_{i,\max}^n$ and $Np_{i,\max}^{TTI,m}$ " exclusive is confusing and need to be reworked by the proponent. It is correct that one needs to take into account replacing $N_{data,*}$ by $N'_{data,*}$ for the radio frames that overlap with a transmission gap. However, the notation $N_{i,l}^{TTI,m}$ is confusing. $N_{i,l}^{TTI}$ is the amount of bit input to the rate matching function for TrCH i and TF l . This amount is entirely determined by i and l , so what is the meaning of the TTI number m ?

These corrections, though clearly needed, have not been made in the document, in order to avoid blocking the CR by non obvious changes, and let the proponent of the concerned section sort it out.

Conclusion

We propose the CR enclosed hereinafter to be accepted.

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.212 CR 72r1

Current Version: **3.2.0**

GSM (AA.BB) or 3G (AA.BBB) specification number ↑

↑ CR number as allocated by MCC support team

For submission to: **RAN#8**
list expected approval meeting # here ↑

for approval
for information

strategic
non-strategic (for SMG use only)

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 UTRAN / Radio Core Network
(at least one should be marked with an X)

Source: Mitsubishi Electric **Date:** 12th April 2000

Subject: Minor corrections to 25.212 (Rate Matching, p-bit insertion, PhCH segmentation)

Work item: TS 25.212

Category: (only one category shall be marked with an X)	F Correction	<input checked="" type="checkbox"/>	Release:	Phase 2	<input type="checkbox"/>
	A Corresponds to a correction in an earlier release	<input type="checkbox"/>		Release 96	<input type="checkbox"/>
	B Addition of feature	<input type="checkbox"/>		Release 97	<input type="checkbox"/>
	C Functional modification of feature	<input type="checkbox"/>		Release 98	<input type="checkbox"/>
	D Editorial modification	<input checked="" type="checkbox"/>		Release 99	<input checked="" type="checkbox"/>
			Release 00	<input type="checkbox"/>	

Reason for change:

- P1 1st IL column permutation is not named clearly
- formula $DN^{TTL,m}_{i,max} = S_{n=0}^{n=Fi} DN^n_{i,*}$ should sum up to F_i-1
- PhCH segmentation uses sometimes symbol V instead of U

Clauses affected: 4.2.5. ; 4.2.7. ; 4.2.9.2. ; 4.2.10, 4.2.11

Other specs affected:	Other 3G core specifications	<input type="checkbox"/>	→ List of CRs:	
	Other GSM core specifications	<input type="checkbox"/>	→ List of CRs:	
	MS test specifications	<input type="checkbox"/>	→ List of CRs:	
	BSS test specifications	<input type="checkbox"/>	→ List of CRs:	
	O&M specifications	<input type="checkbox"/>	→ List of CRs:	

Other comments: **Important comment to secretary : because of an MS Word problem some formulas could not appear as underlined by the revision mark tool, so they have been put between two ¶ characters. The MS word experts of the secretary are kindly requested to remove these characters and this comment for this CR to be more presentable for RAN #8.**

endif

n = n + 1

end do

4.2.5.2 1st interleaver operation

The 1st interleaving is a block interleaver with inter-column permutations. The input bit sequence to the 1st interleaver is denoted by $x_{i1}, x_{i2}, x_{i3}, \dots, x_{iX_i}$, where i is TrCH number and X_i the number of bits (at this stage X_i is assumed and guaranteed to be an integer multiple of TTI). The output bit sequence is derived as follows:

(1) Select the number of columns C_1C_i from table 3.

(2) Determine the number of rows R_1R_i defined as:

$$R_1R_i = X_i / C_1C_i$$

(3) Write the input bit sequence into the $R_1R_i \times C_1C_i$ rectangular matrix row by row starting with bit x_{i1} in the first column of the first row and ending with bit $x_{i,(R_1C_1)}$ in column C_1C_i of row R_1R_i :

$$\begin{bmatrix} x_{i1} & x_{i2} & x_{i3} & \dots & x_{iC_1} \\ x_{i,(C_1+1)} & x_{i,(C_1+2)} & x_{i,(C_1+3)} & \dots & x_{i,(2C_1)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ x_{i,((R_1-1)C_1+1)} & x_{i,((R_1-1)C_1+2)} & x_{i,((R_1-1)C_1+3)} & \dots & x_{i,(R_1C_1)} \end{bmatrix}$$

$$\begin{bmatrix} x_{i1} & x_{i2} & x_{i3} & \dots & x_{iC_i} \\ x_{i,(C_i+1)} & x_{i,(C_i+2)} & x_{i,(C_i+3)} & \dots & x_{i,(2C_i)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ x_{i,((R_i-1)C_i+1)} & x_{i,((R_i-1)C_i+2)} & x_{i,((R_i-1)C_i+3)} & \dots & x_{i,(R_iC_i)} \end{bmatrix}$$

(4) Perform the inter-column permutation based on the pattern $\{P_{1C_1P_+}(j)\}$ ($j=0,1, \dots, C_1C_i-1$) shown in table 3, where $P_{1C_1P_+}(j)$ is the original column position of the j -th permuted column. After permutation of the columns, the bits are denoted by y_{ik} :

$$\begin{bmatrix} y_{i,1} & y_{i,(R_1+1)} & y_{i,(2R_1+1)} & \dots & y_{i,((C_1-1)R_1+1)} \\ y_{i,2} & y_{i,(R_1+2)} & y_{i,(2R_1+2)} & \dots & y_{i,((C_1-1)R_1+2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{i,R_1} & y_{i,(2R_1)} & y_{i,(3R_1)} & \dots & y_{i,(C_1R_1)} \end{bmatrix} \begin{bmatrix} y_{i1} & y_{i,(R_i+1)} & y_{i,(2R_i+1)} & \dots & y_{i,((C_i-1)R_i+1)} \\ y_{i2} & y_{i,(R_i+2)} & y_{i,(2R_i+2)} & \dots & y_{i,((C_i-1)R_i+2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{iR_i} & y_{i,(2R_i)} & y_{i,(3R_i)} & \dots & y_{i,(C_iR_i)} \end{bmatrix}$$

(5) Read the output bit sequence $y_{i1}, y_{i2}, y_{i3}, \dots, y_{i,(C_1R_1)}$ of the 1st interleaving column by column from the inter-column permuted $R_1R_i \times C_1C_i$ matrix. Bit y_{i1} corresponds to the first row of the first column and bit $y_{i,(R_1C_1)}$ corresponds to row R_1R_i of column C_1C_i .

Table 3

TTI	Number of columns C_1C_i	Inter-column permutation patterns $(P_{1C_1(0)}, \dots, P_{1C_1(C_1-1)})$
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)}

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

The bits input to the 1st interleaving are denoted by $t_{i1}, t_{i2}, t_{i3}, \dots, t_{iT_i}$, where i is the TrCH number and T_i the number of bits. Hence, $z_{ik} = t_{ik}$ and $X_i = T_i$.

The bits output from the 1st interleaving are denoted by $d_{i1}, d_{i2}, d_{i3}, \dots, d_{iT_i}$, and $d_{ik} = y_{ik}$.

4.2.7 Rate matching

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

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

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

Notation used in subclause 4.2.7 and subclauses:

- N_{ij} : For uplink: Number of bits in a radio frame before rate matching on TrCH i with transport format combination j .
- For downlink: An intermediate calculation variable (not an integer but a multiple of 1/8).
- N_{il}^{TTI} : Number of bits in a transmission time interval before rate matching on TrCH i with transport format l .
Used in downlink only.
- ΔN_{ij} : For uplink: If positive - number of bits that should be repeated in each radio frame on TrCH i with transport format combination j .
- If negative - number of bits that should be punctured in each radio frame on TrCH i with transport format combination j .
- For downlink: An intermediate calculation variable (not an integer but a multiple of 1/8).
- ΔN_{il}^{TTI} : If positive - number of bits to be repeated in each transmission time interval on TrCH i with transport format l .
- If negative - number of bits to be punctured in each transmission time interval on TrCH i with transport format l .
- Used in downlink only.
- $N_{p,i,l}^{TTI,m}$ $N_{p,i,l}^{TTI,m}$ $m=0$ to $(F_{max}/F_i) - 1$: Positive or null: number of bits to be removed in TTI number m within the largest TTI, to create the required gaps in the compressed radio frames of this TTI, in case of compressed mode by puncturing, for TrCH i with transport format l . In case of fixed positions and compressed mode by puncturing, this value is noted $N_{p,i,max}^{TTI,m}$ $N_{p,i,max}^{TTI,m}$ since it is calculated for all TrCHs with their maximum number of bits; thus it is the same for all TFCs
- Used in downlink only.
- $N_{p,i,l}^n$ $N_{p,i,l}^n$ $n=0$ to $F_{max} - 1$: Positive or null: number of bits, in radio frame number n within the largest TTI, corresponding to the gap for compressed mode in this radio frame, for TrCH i with transport format l . The value will be null for the ~~un-compressed~~ radio frames not overlapping with a transmission gap. In case of fixed positions and compressed mode by puncturing, this value is noted $N_{p,i,max}^n$ $N_{p,i,max}^n$ since it is calculated for all TrCHs with their maximum number of bits; thus it is the same for all TFCs
- Used in downlink only.
- $N_{TGL}[k]$, $k=0$ to $F_i - 1$: Positive or null: number of bits in each radio frame corresponding to the gap for compressed mode for the CCTrCH.
- RM_i : Semi-static rate matching attribute for transport channel i . Signalled from higher layers.

PL: Puncturing limit for uplink. This value limits the amount of puncturing that can be applied in order to avoid multicode or to enable the use of a higher spreading factor. Signalled from higher layers.

$N_{data,j}$: Total number of bits that are available for the CCTrCH in a radio frame with transport format combination j .

I : Number of TrCHs in the CCTrCH.

Z_{ij} : Intermediate calculation variable.

F_i : Number of radio frames in the transmission time interval of TrCH i .

F_{max} Maximum number of radio frames in a transmission time interval used in the CCTrCH :

$$F_{max} = \max_{1 \leq i \leq I} F_i$$

n_i : Radio frame number in the transmission time interval of TrCH i ($0 \leq n_i < F_i$).

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

$P1_F(n_i)$: The ~~inverse interleaving 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 3 of section 4.2.5.2 (note that the $P1_F$ ~~inverse interleaving function is identical to the interleaving function itself for the 1st interleaver~~ is self-inverse). For rate matching, ~~Used~~ in uplink only.

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

$TF_i(j)$: Transport format of TrCH i for the transport format combination j .

$TFS(i)$ The set of transport format indexes l for TrCH i .

$TFCS$ The set of transport format combination indexes j .

e_{ini} Initial value of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.5.

e_{plus} Increment of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.5.

e_{minus} Decrement of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.5.

b : Indicates systematic and parity bits

$b=1$: Systematic bit. $X(t)$ 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.

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

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

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

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

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

4.2.7.1 Determination of rate matching parameters in uplink

4.2.7.1.1 Determination of SF and number of PhCHs needed

In uplink, puncturing can be applied to match the CCTrCH bit rate to the PhCH bit rate. The bit rate of the PhCH(s) is limited by the UE capability and restrictions imposed by UTRAN, through limitations on the PhCH spreading factor. The maximum amount of puncturing that can be applied is signalled from higher layers and denoted by PL . The number of available bits in the radio frames of one PhCH for all possible spreading factors is given in [2]. Denote these values by N_{256} , N_{128} , N_{64} , N_{32} , N_{16} , N_8 , and N_4 , where the index refers to the spreading factor. The possible number of bits available to the CCTrCH on all PhCHs, N_{data} , then are $\{N_{256}, N_{128}, N_{64}, N_{32}, N_{16}, N_8, N_4, 2N_4, 3N_4, 4N_4, 5N_4, 6N_4\}$. Depending on the UE capability and the restrictions from UTRAN, the allowed set of N_{data} , denoted SET0, can be a subset of $\{N_{256}, N_{128}, N_{64}, N_{32}, N_{16}, N_8, N_4, 2N_4, 3N_4, 4N_4, 5N_4, 6N_4\}$. $N_{data,j}$ for the transport format combination j is determined by executing the following algorithm:

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

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

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

else

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

Sort SET2 in ascending order

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

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

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

End while

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

End if

4.2.7.1.2 Determination of parameters needed for calculating the rate matching pattern

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

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

In compressed mode by higher layer scheduling, $N_{data,j}^{cm}$ is obtained by executing the algorithm in subclause 4.2.7.1.1

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

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

$$\left\{ \begin{array}{l} 15 - TGL, \text{ if } N_{first} + TGL \leq 15 \\ \end{array} \right.$$

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

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

In compressed mode by spreading factor reduction, $N_{data,j}^{cm} = 2N_{data,j} - 2N_{TGL}$, where $N_{TGL} = \frac{15 - N_{tr}}{15} N_{data,j}$

If $DN_{ij} = 0$ then the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.5 does not need to be executed.

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

4.2.7.1.2.1 Uncoded and convolutionally encoded TrCHs

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

if $R \neq 0$ and $2R \leq N_{ij}$

$$\text{then } q = \lceil N_{ij} / R \rceil$$

else

$$q = \lceil N_{ij} / (R - N_{ij}) \rceil$$

endif

-- note: q is a signed quantity.

if q is even

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

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

else

$$q' = q$$

endif

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

$$S[\lceil (x * q') \rceil \bmod F_i] = (\lceil x * q' \rceil \div F_i)$$

end for

$$\Delta N_i = \Delta N_{ij}$$

$$a = 2$$

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

$$X_i = N_{ij}, \text{ and}$$

$$e_{ini} = (a \cdot S[\lceil (P_{1,F_i}(n_i) + \Delta) \rceil \cdot \Delta N_i] + 1) \bmod (a \cdot N_{ij}).$$

$$e_{plus} = a \cdot N_{ij}$$

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

puncturing for $DN < 0$, repetition otherwise.

4.2.7.1.2.2 Turbo encoded TrCHs

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

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

$a=2$ when $b=2$

$a=1$ when $b=3$

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

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

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

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

if ($q \leq 2$)

for $x=0$ to F_i-1

$$S[\lfloor (3x+b-1) \bmod F_i \rfloor] = x \bmod 2;$$

end for

else

if q is even

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

else $q' = q$

endif

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

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

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

endfor

endif

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

X_i is as above:

$$e_{\text{ini}} = (a \cdot S[\lfloor (P-1) \bmod F_i \rfloor] \cdot |\Delta N_i| + X_i) \bmod (a \cdot X_i), \text{ if } e_{\text{ini}} = 0 \text{ then } e_{\text{ini}} = a \cdot X_i.$$

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

$$e_{\text{minus}} = a \cdot \lfloor \Delta N_i \rfloor$$

4.2.7.2 Determination of rate matching parameters in downlink

For downlink $N_{\text{data},j}$ does not depend on the transport format combination j . $N_{\text{data},*}$ is given by the channelization code(s) assigned by higher layers. Denote the number of physical channels used for the CCTrCH by P . $N_{\text{data},*}$ is the number of bits available to the CCTrCH in one radio frame and defined as $N_{\text{data},*} = P(15N_{\text{data}1} + 15N_{\text{data}2})$, where $N_{\text{data}1}$ and $N_{\text{data}2}$ are

defined in [2]. Note that contrary to the uplink, the same rate matching patterns are used in normal and compressed mode by spreading factor reduction or higher layer scheduling.

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

Additional calculations for compressed mode by puncturing in case of fixed positions are performed to determine this total amount of rate matching needed.

For compressed mode by puncturing, in TTIs where some compressed radio frames occur, the puncturing is increased or the repetition is decreased compared to what is calculated according to the rate matching parameters provided by higher layers. This allows to create room for later insertion of marked bits, noted p-bits, which will identify the positions of the gaps in the compressed radio frames.

The amount of additional puncturing corresponds to the number of bits to create the gap in the TTI for TrCH_i . In case of fixed positions, it is calculated in addition to the amount of rate matching indicated by higher layers. It is noted

$$Np_{i,\max}^{TTI,m} - Np_{i,\max}^{TTI,m}$$

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

In case of compressed mode by puncturing and fixed positions, for some calculations, $N'_{data,*}$ is used for radio frames with gap instead of $N_{data,*}$, where $N'_{data,*} = P(15N'_{data1} + 15N'_{data2})$. N'_{data1} and N'_{data2} are the number of bits in the data fields of the slot format used for the current compressed mode, i.e. slot format A or B as defined in [2] corresponding to the Spreading Factor and the number of transmitted slots in use.

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

For each radio frame k of the TTI, $N_{TGL}[k]$ is given by the relation:

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

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

Note that $N_{TGL}[k] = 0$ if radio frame k is not compressed.

4.2.7.2.1 Determination of rate matching parameters for fixed positions of TrCHs

4.2.7.2.1.1 Calculation of DN_{max} for normal mode and compressed mode by higher layer scheduling and spreading factor reduction

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

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

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

$$\Delta N_{i,*} = F_i \cdot \Delta N_{i,*}$$

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

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

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

4.2.7.2.1.2 Calculations for compressed mode by puncturing

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

First an intermediate calculation variable $N_{i,*}^n$ ~~$N_{i,*}^n$~~ is calculated for all transport channels i and all frames n in TTI m within the largest TTI, using the same formula as for normal mode above by replacing $N_{i,l}^{TTI}$ ~~$N_{i,l}^{TTI}$~~ by $N_{i,l}^{TTI,m}$ ~~$N_{i,l}^{TTI,m}$~~ , the number of bits in TTI m .

The computation of the $\Delta N_{i,max}^{TTI,m}$ ~~$\Delta N_{i,max}^{TTI,m}$~~ parameters is then performed for all TrCH i by the following formula,

$$\Delta N_{i,max}^{TTI,m} = \sum_{n=0}^{n=F_i-1} \Delta N_{i,*}^n$$

where all $\Delta N_{i,*}^n$ ~~$\Delta N_{i,*}^n$~~ are derived from $N_{i,*}^n$ ~~$N_{i,*}^n$~~ for all TrCH i and all frames n in TTI m , from the formula given at subclause 4.2.7 using $N_{data,*}$, for the non compressed frames of TTI m and using $N'_{data,*}$ instead of $N_{data,*}$, for the compressed frames of TTI m .

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

Let $Np_{i,max}^n$ ~~$Np_{i,max}^n$~~ be the number of bits to eliminate on TrCH i to create the gap for compressed mode, in each radio frame k of the TTI, calculated for the Transport Format Combination of TrCH i , in which the number of bits of TrCH i is at its maximum.

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

Intermediate variables Z_i for $i = 1$ to I are calculated using the formula (1) in 4.2.7, by replacing $N_{data,j}$ by $N_{TGL}[k]$.

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

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

$$Np_{i,max}^{TTI,m} = \sum_{n=0}^{n=F_i-1} Np_{i,max}^n$$

$$Np_{i,max}^{TTI,m} = \sum_{n=0}^{F_i-1} Np_{i,max}^n$$

If $DN_{max} = Np_{i,max}^{TTI,m} Np_{i,max}^{TTI,m}$, then, for TrCH i , the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.5 does not need to be executed. If $DN_{max} < Np_{i,max}^{TTI,m} Np_{i,max}^{TTI,m}$, then, for TrCH i , the rate matching algorithm of subclause 4.2.7.5 needs to be executed with an amount $\Delta N_{i,max}^{TTI,cm,m}$ of rate matching given by the following formula :

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

4.2.9.2 2nd insertion of DTX indication bits

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

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

In normal mode $R = \frac{N_{data,*}}{P} = 15N_{data1} + 15N_{data2}$, where N_{data1} and N_{data2} are defined in [2].

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

In case of compressed mode by puncturing and fixed positions, DTX shall be inserted until $N'_{data,*}$ bits, since the exact room for the gap is already reserved thanks to the earlier insertion of the p-bits. Therefore R is defined as $R = N'_{data,*} / P$.

In compressed mode by SF reduction and by higher layer scheduling, additional DTX shall be inserted if the transmission time reduction method does not exactly create a transmission gap of the desired TGL. The number of bits available to the CCTrCH in one radio frame in compressed mode by SF reduction and by higher layer scheduling is

denoted by $N_{data,*}^{cm}$ and $R = \frac{N_{data,*}^{cm}}{P}$. The exact value of $N_{data,*}^{cm}$ is dependent on the TGL and the transmission time reduction method, which are signalled from higher layers. For transmission time reduction by SF/2 method in compressed mode $N_{data,*}^{cm} = \frac{N'_{data,*}}{2}$, and for other methods it can be calculated as $N_{data,*}^{cm} = N'_{data,*} - N_{TGL}$. For

every transmission time reduction method $N'_{data,*} = P(15N'_{data1} + 15N'_{data2})$, where N'_{data1} and N'_{data2} are the number of bits in the data fields of a slot for slot format A or B as defined in [2]. N_{TGL} is the number of bits that are located within the transmission gap and defined as:

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

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

NOTE : In compressed mode by SF/2 method DTX is also added in physical channel mapping stage (subclause 4.2.12.2). During 2nd DTX insertion the number of CCTrCH bits is kept the same as in normal mode.

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

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

$$w_k = \mathbf{d} \quad k = S+1, S+2, S+3, \dots, \mathbf{PPR}$$

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

4.2.10 Physical channel segmentation

When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $x_1, x_2, x_3, \dots, x_X$ ~~$x_1, x_2, x_3, \dots, x_Y$~~ , where ~~$Y$~~ X is the number of bits input to the physical channel segmentation block. The number of PhCHs is denoted by P .

The bits after physical channel segmentation are denoted $u_{p1}, u_{p2}, u_{p3}, \dots, u_{pU}$, where p is PhCH number and U is the number of bits in one radio frame for each PhCH, i.e. $U = (\del{Y}X - N_{TGL}) / P$ for compressed mode by puncturing, and

$U = \frac{X}{P}$ ~~$U = \frac{Y}{P}$~~ otherwise. The relation between x_k and u_{pk} is given below.

For all modes, some bits of the input flow are mapped to each code until the number of bits on the code is ~~Y~~ U . For modes other than compressed mode by puncturing, all bits of the input flow are taken to be mapped to the codes. For compressed mode by puncturing, only the bits of the input flow not corresponding to bits p are taken to be mapped to the codes, each bit p is removed to ensure creation the gap required by the compressed mode, as described below.

Bits on first PhCH after physical channel segmentation:

$$u_{1,k} = x_{i,f(k)} \quad k = 1, 2, \dots, U$$

Bits on second PhCH after physical channel segmentation:

$$u_{2,k} = x_{i,f(k+U)} \quad k = 1, 2, \dots, U$$

...

Bits on the P^{th} PhCH after physical channel segmentation:

$$u_{P,k} = x_{i,f(k+(P-1)U)} \quad k = 1, 2, \dots, U$$

where f is such that :

- for modes other than compressed mode by puncturing, $x_{i,f(k)} = x_{i,k}$, i.e. $f(k) = k$, for all k .
- for compressed mode by puncturing, bit $u_{1,1}$ corresponds to the bit $x_{i,k}$ with smallest index k when the bits p are not counted, bit $u_{1,2}$ corresponds to the bit $x_{i,k}$ with second smallest index k when the bits p are not counted, and so on for bits $u_{1,3}, \dots, u_{1,\del{Y}U}$, $u_{2,1}, u_{2,2}, \dots, u_{2,\del{Y}U}$, $\dots, u_{P,1}, u_{P,2}, \dots, u_{P,\del{Y}U}$,

4.2.11 2nd interleaving

The 2nd interleaving is a block interleaver with inter-column permutations. The bits input to the 2nd interleaver are denoted $u_{p1}, u_{p2}, u_{p3}, \dots, u_{pU}$, where p is PhCH number and U is the number of bits in one radio frame for one PhCH.

- (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:

$$U \leq R_2 \cdot C_2$$

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

$$\begin{bmatrix} u_{p,1} & u_{p,2} & u_{p,3} & \dots & u_{p,30} \\ u_{p,31} & u_{p,32} & u_{p,33} & \dots & u_{p,60} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ u_{p,((R_2-1)30+1)} & u_{p,((R_2-1)30+2)} & u_{p,((R_2-1)30+3)} & \dots & u_{p,(R_2 \cdot 30)} \end{bmatrix}$$

- (4) Perform the inter-column permutation based on the pattern $\{P_2(j)\}$ ($j = 0, 1, \dots, C_2 - 1$) that is shown in table 6, 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_{pk} .

$$\begin{bmatrix} y_{p,1} & y_{p,(R_2+1)} & y_{p,(2R_2+1)} & \dots & y_{p,(29R_2+1)} \\ y_{p,2} & y_{p,(R_2+2)} & y_{p,(2R_2+2)} & \dots & y_{p,(29R_2+2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{p,R_2} & y_{p,(2R_2)} & y_{p,(3R_2)} & \dots & y_{p,(30R_2)} \end{bmatrix}$$

- (5) The output of the 2nd interleaving is the bit sequence read out column by column from the inter-column permuted $R_2 \times C_2$ matrix. The output is pruned by deleting bits that were not present in the input bit sequence, i.e. bits y_{pk} that corresponds to bits u_{pk} with $k > U$ are removed from the output. The bits after 2nd interleaving are denoted by $v_{p1}, v_{p2}, \dots, v_{pU}$, where v_{p1} corresponds to the bit y_{pk} with smallest index k after pruning, v_{p2} to the bit y_{pk} with second smallest index k after pruning, and so on.

Table 6

Number of column C_2	Inter-column permutation pattern $(P_2(0), P_2(1), \dots, P_2(29))$
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}