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<b>25.212</b>		<b>CR 059r1</b>		Current Version: <b>V3.1.0</b>
GSM (AA.BB) or 3G (AA.BBB) specification number ↑		↑ CR number as allocated by MCC support team		
For submission to: <b>RAN #7</b>	for approval	<input checked="" type="checkbox"/>	strategic	(for SMG use only)
list expected approval meeting # here ↑	for information	<input type="checkbox"/>	non-strategic	

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:**    Panasonic    **Date:**    25 Feb 2000

**Subject:**    Revision: Editorial correction to the calculation of Rate Matching parameters

**Work item:**    TS25.212

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

**Reason for change:**    In current specification, there is no description of calculating order of a \* b /c. Result is sometimes incorrect according to the order of calculation.

**Clauses affected:**    \_\_\_\_\_

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

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## 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 section 4.2.7 and subsections:

$N_{ij}$ : 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.

$\Delta N_{ij}$  : 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).

$\Delta N_{il}^{TTI}$  : If positive - number of bits to be repeated in each transmission time interval on TrCH  $i$  with transport format  $j$ .

If negative - number of bits to be punctured in each transmission time interval on TrCH  $i$  with transport format  $j$ .

Used in downlink only.

$RM_i$ : 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  $i$ .

$n_i$ : 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.

$I_F(n_i)$ : The inverse interleaving function of the 1<sup>st</sup> interleaver (note that the inverse interleaving function is identical to the interleaving function itself for the 1<sup>st</sup> interleaver). Used in uplink only.

$S(n_i)$ : The shift of the puncturing or repetition pattern for radio frame  $n_i$ . 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 section 4.2.7.5.
- $e_{plus}$  Increment of variable  $e$  in the rate matching pattern determination algorithm of section 4.2.7.5.
- $e_{minus}$  Decrement of variable  $e$  in the rate matching pattern determination algorithm of section 4.2.7.5.
- $b$ : Indicates systematic and parity bits
- $b=1$ : Systematic bit.  $X(t)$  in section 4.2.3.2.1.
- $b=2$ : 1<sup>st</sup> parity bit (from the upper Turbo constituent encoder).  $Y(t)$  in section 4.2.3.2.1.
- $b=3$ : 2<sup>nd</sup> parity bit (from the lower Turbo constituent encoder).  $Y'(t)$  in section 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  $\underline{x}$  do  $X_x = Y$** ". In the right wing of an assignment, the meaning is that " $Y = X_*$ " is equivalent to "**take any  $\underline{x}$  and do  $Y = X_x$** ".

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

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

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

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

#### 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 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 values of  $N_{data}$  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:

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

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

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

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 section 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 from the following relation:

$$N_{data,j}^{cm} = 2N_{data,j} - 2N_{TGL}, \text{ for compressed mode by spreading factor reduction}$$

$$N_{data,j}^{cm} = N_{data,j} - N_{TGL}, \text{ for compressed mode by higher layer scheduling}$$

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

$N_{first}$  and  $TGL$  are defined in section 4.4.

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 section 4.2.7.5 does not need to be executed.

If  $DN_{ij} \neq 0$  the parameters listed in sections 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

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

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

then  $q' = q + \gcd(|q|, F_i)/F_i$  -- where  $\gcd(|q|, F_i)$  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  $F_i-1$

$S(I_F(|\lfloor x \cdot q' \rfloor| \bmod F_i)) = (\lfloor x \cdot q' \rfloor \bmod F_i)$

end for

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

$a = 2$

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

$X_i = N_{i,j}$ , and

$e_{\text{ini}} = (a \cdot S(n_i) \cdot |\Delta N_i| + 1) \bmod (a \cdot N_{i,j})$ .

$e_{\text{plus}} = a \cdot N_{i,j}$

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

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 section 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 ( $b=1$ ), 1<sup>st</sup> parity ( $b=2$ ), and 2<sup>nd</sup> parity bit ( $b=3$ ).

$a=2$  when  $b=2$

$a=1$  when  $b=3$

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

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

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

if ( $q \leq 2$ )

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

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

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 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 section 4.2.7.5, where:

$X_i$  is as above,

$e_{\text{ini}} = (a \cdot S(n_i) \cdot |\Delta N_i| + X_i) \bmod (a \cdot X_i)$ , if  $e_{\text{ini}} = 0$  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.

##### 4.2.7.2.1 Determination of rate matching parameters for fixed positions of TrCHs

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

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

The computation of the  $\Delta N_{i,l}^{TTI}$  parameters is then performed in for all TrCH  $i$  and all TF  $l$  by the following formula, where  $\Delta N_{i,*}$  is derived from  $N_{i,*}$  by the formula given at section 4.2.7:

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

If  $\Delta N_{\text{max}} = 0$  then, for TrCH  $i$ , the output data of the rate matching is the same as the input data and the rate matching algorithm of section 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  $\Delta N_{\text{max}} \neq 0$  the parameters listed in sections 4.2.7.2.1.1 and 4.2.7.2.1.2 shall be used for determining  $e_{\text{ini}}$ ,  $e_{\text{plus}}$ , and  $e_{\text{minus}}$ .

##### 4.2.7.2.1.1 Uncoded and convolutionally encoded TrCHs

$$\Delta N_i = \Delta N_{\text{max}}$$

$a=2$

$$N_{max} = \max_{l \in TFS(i)} N_{il}^{TTI}$$

For each transmission time interval of TrCH  $i$  with TF  $l$ , the rate-matching pattern is calculated with the algorithm in section 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI}$$

$$e_{ini} = 1$$

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

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

Puncturing if  $\Delta N_i < 0$ , repetition otherwise. The values of  $\Delta N_{i,l}^{TTI}$  may be computed by counting repetitions or puncturing when the algorithm of section 4.2.7.5 is run.

#### 4.2.7.2.1.2 Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e.  $\Delta N_{max} > 0$ , the parameters in section 4.2.7.2.1.1 are used.

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

$$a=2 \text{ when } b=2$$

$$a=1 \text{ when } b=3$$

The bits indicated by  $b=1$  shall not be punctured.

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

$$N_{max} = \max_{l \in TFS(i)} (N_{il}^{TTI} / 3)$$

For each transmission time interval of TrCH  $i$  with TF  $l$ , the rate-matching pattern is calculated with the algorithm in section 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI} / 3$$

$$e_{ini} = N_{max}$$

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

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

The values of  $\Delta N_{i,l}^{TTI}$  may be computed by counting repetitions or puncturing when the algorithm of section 4.2.7.5 is run.

#### 4.2.7.2.2 Determination of rate matching parameters for flexible positions of TrCHs

First an intermediate calculation variable  $N_{ij}$  is calculated for all transport channels  $i$  and all transport format combinations  $j$  by the following formula:

$$N_{i,j} = \frac{1}{F_i} \cdot N_{i,TF_i(j)}^{TTI}$$

Then rate matching ratios  $RF_i$  are calculated for each the transport channel  $i$  in order to minimise the number of DTX bits when the bit rate of the CCTrCH is maximum. The  $RF_i$  ratios are defined by the following formula:

$$RF_i = \frac{N_{data,*}}{\max_{j \in TFCS} \sum_{i=1}^{I} (RM_i \cdot N_{i,j})} \cdot RM_i$$

The computation of  $\Delta N_{i,l}^{TTI}$  parameters is then performed in two phases. In a first phase, tentative temporary values of  $\Delta N_{i,l}^{TTI}$  are computed, and in the second phase they are checked and corrected. The first phase, by use of the  $RF_i$  ratios, ensures that the number of DTX indication bits inserted is minimum when the CCTrCH bit rate is maximum, but it does not ensure that the maximum CCTrCH bit rate is not greater than  $N_{data,*}$  per 10ms. The latter condition is ensured through the checking and possible corrections carried out in the second phase.

At the end of the second phase, the latest value of  $\Delta N_{i,l}^{TTI}$  is the definitive value.

The first phase defines the tentative temporary  $\Delta N_{i,l}^{TTI}$  for all transport channel  $i$  and any of its transport format  $l$  by use of the following formula:

$$\Delta N_{i,l}^{TTI} = F_i \cdot \left[ \frac{RF_i \cdot N_{i,l}^{TTI}}{F_i} \right] - N_{i,l}^{TTI} = F_i \cdot \left[ \frac{N_{data,*} \cdot RM_i \cdot N_{i,l}^{TTI}}{F_i \cdot \max_{j \in TFCS} \sum_{i=1}^I (RM_i \cdot N_{i,j})} \right] - N_{i,l}^{TTI}$$

The second phase is defined by the following algorithm:

for all  $j$  in  $TFCS$  do -- for all TFC

$$D = \sum_{i=1}^{I} \frac{N_{i,TF_i(j)}^{TTI} + \Delta N_{i,TF_i(j)}^{TTI}}{F_i} \quad \text{-- CCTrCH bit rate (bits per 10ms) for TFC } l$$

if  $D > N_{data,*}$  then

for  $i = 1$  to  $I$  do -- for all TrCH

$$\Delta N = F_i \cdot \Delta N_{i,j} \quad \text{-- } \Delta N_{i,j} \text{ is derived from } N_{i,j} \text{ by the formula given at section 4.2.7.}$$

if  $\Delta N_{i,TF_i(j)}^{TTI} > \Delta N$  then

$$\Delta N_{i,TF_i(j)}^{TTI} = \Delta N$$

end-if

end-for

end-if

end-for

NOTE: The order in which the transport format combinations are checked does not change the final result.



If  $\Delta N_{i,l}^{TTI} = 0$  then, for TrCH  $i$  at TF  $l$ , the output data of the rate matching is the same as the input data and the rate matching algorithm of section 4.2.7.5 does not need to be executed.

If  $\Delta N_{i,l}^{TTI} \neq 0$  the parameters listed in sections 4.2.7.2.2.1 and 4.2.7.2.2.2 shall be used for determining  $e_{ini}$ ,  $e_{plus}$ , and  $e_{minus}$ .

#### 4.2.7.2.2.1 Uncoded and convolutionally encoded TrCHs

$$\Delta N_i = \Delta N_{il}^{TTI}$$

$$a=2$$

For each transmission time interval of TrCH  $i$  with TF  $l$ , the rate-matching pattern is calculated with the algorithm in section 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI}$$

$$e_{ini} = 1$$

$$e_{plus} = a \cdot N_{il}^{TTI}$$

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

puncturing for  $\Delta N_i < 0$ , repetition otherwise.

#### 4.2.7.2.2.2 Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e.  $\Delta N_{il}^{TTI} > 0$ , the parameters in section 4.2.7.2.2.1 are used.

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

$$a=2 \text{ when } b=2$$

$$a=1 \text{ when } b=3$$

The bits indicated by  $b=1$  shall not be punctured.

$$\Delta N_i = \begin{cases} \left\lfloor \frac{\Delta N_{il}^{TTI}}{2} \right\rfloor, & b=2 \\ \left\lfloor \frac{\Delta N_{il}^{TTI}}{2} \right\rfloor, & b=3 \end{cases}$$

For each transmission time interval of TrCH  $i$  with TF  $l$ , the rate-matching pattern is calculated with the algorithm in section 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI} / 3N,$$

$$e_{ini} = X_i,$$

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

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