TSG-RAN Working Group1 meeting #12 TSGR1#12(00)0579

**Seoul, Korea., April 10 ~ April 13, 2000**

| | | |
|---|---|---|
| **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** |
| **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 orginal column position of column number x after permutation. So the p-bits insetion 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 $P_1$ 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 $P_1$. |
| $1^{st}$ IL | editorial | the column permutation function is noted $P1_{Fi}$ whereas it used to be noted either $P_1$ (no index by the column number) or $P_{Fi}$ (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 ASCII like notation $Np^{n}_{i,l}$ and $Np^{TTI,m}_{i,l}$ and $\Delta N^{TTI,m}_{i,l}$ by edited formulas $Np_{i,l}^{n}$ $Np_{i,l}^{TTI,m}$ . $\Delta N_{i,l}^{TTI,m}$ |
| RM, CM by punctureing | **correction** | In forumula $DN^{TTI,m}_{i,max} = S_{n=0}^{n=Fi} DN^{n}_{i,*}$ 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<br><br>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 $\Delta N_{\max}$ 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 | **correction** | On the e-mail reflector is 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 invite the proponents of the S formula to check whether it is P1 or its inverse that shall be used (since P1 is self-inverse there is no functional difference, but for the sake of clarity we should use the correct one).*** |
| 2nd IL | editorial | For the same reason as for the 1st IL, $R_2$, $C_2$ and $P_2$ have been renamed R2, C2, and P2. |
| 1st and 2nd IL | **clarification** | It has been clarified in the table giving the column permutation that the list given is (P(0), P(1), …, P(C-1)). Also curly brackets were replaced by round brackets. |
| In many places | editorial | Symbols not in italic were put in italic |

# 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 useless and confusing. It should be suppressed. Furthermore, in the same section, the formula $\Delta N_{i,\max}^{TTI,cm,m} = \Delta N_{i,\max}^{TTI,m} - Np_{i,\max}^{TTI,m}$ should be replaced by $\Delta N_{i,\max}^{TTI,cm,m} = DN_{max} - Np_{i,\max}^{TTI,m}$ where $DN_{max}$ replaces $\Delta N_{i,\max}^{TTI,m}$. We also don't understand the need for and the meaning the notation $N_{i,l}^{TTI,m}$. $N_{i,l}^{TTI}$ is the amount of bit input to the rate matching function for TrCH *i* and TF *l*. This amount is entierely 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.

**3GPP/SMG Meeting RAN WG1#12**
**Seoul, Korea, April 2000**

***Document* R1-000579**
*e.g. for 3GPP use the format TP-99xxx*
*or for SMG, use the format P-99-xxx*

# 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** | **72** | 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 | for approval | X | strategic | | *(for SMG use only)* |
| *list expected approval meeting # here ↑* | | for information | | 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:** *(at least one should be marked with an X)* | (U)SIM | | ME | X | UTRAN / Radio | X | Core Network | |

**Source:** Mitsubishi Electric    **Date:** 11th April 2000

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

**Work item:** TS 25.212

| **Category:** | | | | **Release:** | | |
|---|---|---|---|---|---|---|
| | F | Correction | | | Phase 2 | |
| | A | Corresponds to a correction in an earlier release | | | Release 96 | |
| *(only one category* | B | Addition of feature | | | Release 97 | |
| *shall be marked* | C | Functional modification of feature | X | | Release 98 | |
| *with an X)* | D | Editorial modification | X | | Release 99 | X |
| | | | | | Release 00 | |

**Reason for change:**

- P1 1st IL column permutation is not named clearly
- formula $DN^{TTI,m}_{i,max} = S_{n=0}^{n=Fi} DN^{n}_{i,*}$ 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 | | → 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:**

## 4.2.5 1st interleaving

In Compressed Mode by puncturing, bits marked with a fourth value on top of {0, 1, δ} and noted p, are introduced in the radio frames to be compressed, in positions corresponding to the first bits of the radio frames. They will be removed in a later stage of the multiplexing chain to create the actual gap. Additional puncturing has been performed in the rate matching step, over the TTI containing the compressed radio frame, to create room for these p-bits. The following subclause describes this feature.

### 4.2.5.1 Insertion of marked bits in the sequence to be input in first interleaver

In normal mode, compressed mode by higher layer scheduling, and compressed mode by spreading factor reduction:

$x_{ik} = z_{ik}$ and $X_i = Z_i$.

In case of compressed mode by puncturing and fixed positions, sequence $x_{i,k}$ which will be input to first interleaver for TrCh *i* and TTI *m* within largest TTI, is built from bits $z_{i,k}$, $k=1, ..Z_i$, plus $Np^{TTI,m}_{i,max}$ bits marked p and $X_i = Z_i + Np^{TTI,m}_{i,max}$, as is described thereafter.

$Np^{TTI,m}_{i,max}$ is defined in the Rate Matching subclause 4.2.7.

$P1_{Fi}$~~[~~(x~~]~~) defines the inter column permutation function for a TTI of length Fi *10ms, as defined in Table 3 ~~above~~in section 4.2.5.2. $P1_{Fi}$~~[~~(x~~]~~) is the Bit Reversal function of x on $\log_2(F_i)$ bits.

NOTE 1: C[x], x= 0 to Fi – 1, the number of bits p which have to be inserted in each of the Fi segments of the TTI, where x is the column number before permutation, i.e. in each column of the first interleaver. C[$P1_{Fi}$(x)] is equal to $Np^{x}_{i,\max}$ ~~$Np^{x}_{i,max}$~~ for x equal 0 to $F_i$~~Fi~~ –1 for fixed positions . It is noted $Np^{x}_{i}$ ~~$Np^{x}_{i}$~~ in the following initialisation step.

NOTE 2: cbi[x], x=0 to Fi – 1, the counter of the number of bits p inserted in each of the Fi segments of the TTI, i.e. in each column of the first interleaver. x is the column number before permutation.

col = 0

**while** col < $F_i$ **do** -- here col is the column number after column permutation

C[$P1_{Fi}$(col)] = $Np^{col}_{i}$ ~~$Np^{col}_{i}$~~ -- initialisation of number of bits p to be inserted in each of the $F_i$~~Fi~~ segments of the TTI

cbi[$P1_{Fi}$(col)] = 0 -- initialisation of counter of number of bits p inserted in each of the $F_i$~~Fi~~ segments of the TTI

**end do**

n = 0, m = 0

**while** n < $X_i$ **do** -- from here col is the column number before column permutation

col = *n* mod $F_i$

**if** cbi[col] < C[~~$P_{Fi}$(~~col~~)~~] **do**

$x_{i,n}$ = p -- insert one p bit

cbi[col] = cbi[col]+1 -- update counter of number of bits p inserted

**else** -- no more p bit to insert in this segment

$x_{i,n} = z_{i,m}$

m = m+1

**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 $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$, 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 C1~~$C_I$~~ from table 3.

(2) Determine the number of rows R1~~$R_I$~~ defined as:

R1~~$R_I$~~ = $X_i$/ C1~~$X_i/C_I$~~

(3) Write the input bit sequence into the R1~~$R_I$~~× C1~~$C_I$~~ rectangular matrix row by row starting with bit $x_{i,1}$ in the first column of the first row and ending with bit $x_{i,(\mathrm{R1}\cdot\mathrm{C1})}$ ~~$x_{i,(R_I C_I)}$~~ in column C1~~$C_I$~~ of row R1~~$R_I$~~:

$$\begin{bmatrix} x_{i1} & x_{i2} & x_{i3} & \ldots & x_{i,\mathrm{C1}} \\ x_{i,(\mathrm{C1}+1)} & x_{i,(\mathrm{C1}+2)} & x_{i,(\mathrm{C1}+3)} & \ldots & x_{i,(2\mathrm{C1})} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ x_{i,((\mathrm{R1}-1)\mathrm{C1}+1)} & x_{i,((\mathrm{R1}-1)\mathrm{C1}+2)} & x_{i,((\mathrm{R1}-1)\mathrm{C1}+3)} & \ldots & x_{i,(\mathrm{R1}\cdot\mathrm{C1})} \end{bmatrix}$$

$$\begin{bmatrix} x_{i1} & x_{i2} & x_{i3} & \ldots & x_{iC_I} \\ x_{i,(C_I+1)} & x_{i,(C_I+2)} & x_{i,(C_I+3)} & \ldots & x_{i,(2C_I)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ x_{i,((R_I-1)C_I+1)} & x_{i,((R_I-1)C_I+2)} & x_{i,((R_I-1)C_I+3)} & \ldots & x_{i,(R_I C_I)} \end{bmatrix}$$

(4) Perform the inter-column permutation based on the pattern { $\mathrm{P1}_{\mathrm{C1}}$~~$P_I$~~ $(j)$} ($j$=0,1, ..., C1~~C~~-1) shown in table 3, where $\mathrm{P1}_{\mathrm{C1}}$ ~~$P_I$~~$(j)$ is the original column position of the $j$-th permuted column. After permutation of the columns, the bits are denoted by $y_{ik}$:

$$\begin{bmatrix} y_{i,1} & y_{i,(\mathrm{R1}+1)} & y_{i,(2\mathrm{R1}+1)} & \ldots & y_{i,((\mathrm{C1}-1)\mathrm{R1}+1)} \\ y_{i,2} & y_{i,(\mathrm{R1}+2)} & y_{i,(2\mathrm{R1}+2)} & \ldots & y_{i,((\mathrm{C1}-1)\mathrm{R1}+2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{i,\mathrm{R1}} & y_{i,(2\mathrm{R1})} & y_{i,(3\mathrm{R1})} & \ldots & y_{i,(\mathrm{C1}\cdot\mathrm{R1})} \end{bmatrix} \begin{bmatrix} y_{i1} & y_{i,(R_I+1)} & y_{i,(2R_I+1)} & \ldots & y_{i,((C_I-1)R_I+1)} \\ y_{i2} & y_{i,(R_I+2)} & y_{i,(2R_I+2)} & \ldots & y_{i,((C_I-1)R_I+2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{iR_I} & y_{i,(2R_I)} & y_{i,(3R_I)} & \ldots & y_{i,(C_I R_I)} \end{bmatrix}$$

(5) Read the output bit sequence $y_{i1}, y_{i2}, y_{i3}, \ldots, y_{i,(\mathrm{C1}\cdot\mathrm{R1})}$ ~~$y_{i1}, y_{i2}, y_{i3}, \ldots, y_{i,(C_I R_I)}$~~ of the 1st interleaving column by column from the inter-column permuted R1~~$R_I$~~ × C1~~$C_I$~~ matrix. Bit $y_{i,1}$ corresponds to the first row of the first column and bit $y_{i,(R_I C_I)}$ corresponds to row R1~~$R_I$~~ of column C1~~$C_I$~~.

**Table 3**

| TTI | Number of columns C1~~$C_I$~~ | Inter-column permutation patterns (P1C1(0), …, P1C1(C1-1)) |
|---|---|---|
| 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 $t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$ , 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 $d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$ , 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 subcaluse 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.

$\Delta N_{ij}$ : 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.

$Np_{i,l}^{TTI,m}$ ~~$Np^{TTI,m}_{i,l}$~~, $m=0$ 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 TrC~~h~~H *i* with transport format *l*. In case of fixed positions and compressed mode by puncturing, this value is noted $Np_{i,\max}^{TTI,m}$ ~~$Np^{TTI,m}_{i,max}$~~ since it is calculated for all TrC~~h~~H with their maximum number of bits; thus it is the same for all TFCs

Used in downlink only.

$Np_{i,l}^{n}$ ~~$Np^{n}_{i,l}$~~ $n=0$ 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 $Np_{i,\max}^{n}$ ~~$Np^{n}_{i,max}$~~ since it is calculated for all TrC~~h~~Hs 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 CCTrC~~h~~H.

$RM_i$: 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 :

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

$n_i$: 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). Used in uplink only.

~~$I_F$~~$P1_F(n_i)$: The ~~inverse interleaving~~ column permutation function of the 1st interleaver, $P1_F(x)$ is the original position of column 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, ~~U~~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 subclause 4.2.7.5.

$e_{plus}$ Increment of variable $e$ in the rate matching pattern determination algorithm of subclause4.2.7.5.

$e_{minus}$ 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 subcaluse 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** $\underline{x}$ **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:

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

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

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

### 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 $N_{\text{data}}$, 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 = { $N_{data}$ in SET0 such that $\min_{1\le y\le I}\{RM_y\}\cdot N_{data} - \sum_{x=1}^{I} RMx \cdot N_{x,j}$ 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

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

Sort SET2 in ascending order

$N_{data}$ = min SET2

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

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

End while

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

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 $N^{cm}_{data,j}$ in Equation 1. $N^{cm}_{data,j}$ is given as follows:

In compressed mode by higher layer scheduling, $N^{cm}_{data,j}$ 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:

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

$N_{first}$ 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

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

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

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 $F_i$ $F_i$-1

S($I_F$ (| $\lfloor x*q' \rfloor$ | mod $F_i$ $F_i$)) = (| $\lfloor x*q' \rfloor$ | div $F_i$ $F_i$)

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 subclause 4.2.7.5, where :

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

$e_{ini} = (a \cdot S([P1_{Fi}(n_i))] \cdot |\Delta N_i| + 1) \bmod (a \cdot N_{ij})$.

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

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

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 $b=3$

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

If $\Delta N_i$ 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($q \le 2$)

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

S[~~$I_F$[~~(3x+b-1) mod $F_i$ ~~$F_i$]~~] = x mod 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 = ⌈ x*q' ⌉ mod ~~$F_i$~~ $F_i$;

S[~~$I_F$[~~(3r+b-1) mod ~~$F_i$~~ $F_i$~~]~~] = ⌈ x*q' ⌉ div ~~$F_i$~~ $F_i$;

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:

$e_{ini}$ = (a·S[~~(~~$P1_{F_i}$($n_i$)~~)~~]·|$\Delta N_i$| + $X_i$) mod (a·$X_i$), if $e_{ini}$ =0 then $e_{ini}$ = a·$X_i$.

$e_{plus} = a \cdot X_i$

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

### 4.2.7.2 Determination of rate matching parameters in downlink

For downlink $N_{data,j}$ does not depend on the transport format combination $j$. $N_{data,*}$ is given by the channelization code(s) assigned by higher layers. Denote the number of physical channels used for the CCTrCH by $P$. $N_{data,*}$ is the number of bits available to the CCTrCH in one radio frame and defined as $N_{data,*}=P(15N_{data1}+15N_{data2})$, where $N_{data1}$ and $N_{data2}$ 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 $Np^{TTI,m}{}_{i,max}$.

In fixed positions case, to obtain the total rate matching $\Delta N_{i,\max}^{TTI,cm,m}$ to be performed on the TTI $m$, $Np^{TTI,m}{}_{i,max}$ is sub-stracted from $DN^{TTI,m}\ i,_{max}$ (calculated based on higher layers RM parameters as for normal rate matching). This allows to create room for the $Np^{TTI,m}{}_{i,max}$ 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, 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:

$$N_{TGL} = \begin{cases} \dfrac{TGL}{15} N^{'}_{data,*}, \text{ if } N_{first} + TGL \le 15 \\[2ex] \dfrac{15 - N_{first}}{15} N^{'}_{data,*}, \text{ in first radio frame of the gap if } N_{first} + TGL > 15 \\[2ex] \dfrac{TGL - (15 - N_{first})}{15} N^{'}_{data,*}, \text{ in second radio frame of the gap if } N_{first} + TGL > 15 \end{cases}$$

$N_{first}$ 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 $\Delta N_{max}$ by the following formula, where $\Delta N_{i,*}$ is derived from $N_{i,*}$ by the formula given at subclause 4.2.7:

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

If $\Delta N_{max} = 0$ then, for TrCH *i*, the output data of the rate matching is the same as the input data and the rate matching algorithm of 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 $\Delta N_{max} \neq 0$ the parameters listed in subclauses 4.2.7.2.1.3 and 4.2.7.2.1.4 shall be used for determining $e_{ini}$, $e_{plus}$, and $e_{minus}$, and $\Delta N_{i,l}^{TTI}$ .

#### 4.2.7.2.1.2 Calculations for compressed mode by puncturing

Calculations of $\Delta N_{i,\max}^{TTI,m}$ ~~$DN^{TTI,m}_{i,max}$,~~ for all TTI *m* within largest TTI, for all TrC~~h~~H *i*

First an intermediate calculation variable $N_{i,*}$ ~~$N^{n}_{i,*}$~~ 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 $N_{i,l}^{TTI}$ ~~$N^{TTI}_{i,l}$~~ by $N_{i,l}^{TTI,m}$ ~~$N^{TTI,m}_{i,l}$~~ , the number of bits in TTI *m*.

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

~~$DN^{TTI,m}_{i,max} = S_{n=0}^{n=Fi} DN^{n}_{i,*}$~~

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

where all $\Delta N_{i,*}^{n}$ ~~$\Delta N^{n}_{i,*}$~~ are derived from $N_{i,*}^{n}$ ~~$N^{n}_{i,*}$~~ for all TrC~~h~~H ~~i~~ *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 $Np_{i,\max}^{n}$ ~~$Np^{n}_{i,max}$~~ and $Np_{i,\max}^{TTI,m}$ ~~$Np^{TTI,m}_{i,max}$~~

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

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

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

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

~~$Np^{TTI,m}_{i,max} = S_{n=0}^{Fi-1} Np^{n}_{i,max}$~~

If $DN_{max}$ = $Np_{i,\max}^{TTI,m}$ ~~$Np^{TTI,m}_{i,max}$~~, 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 $DN_{max}$ ¹ $Np_{i,\max}^{TTI,m}$ ~~$Np^{TTI,m}_{i,max}$~~, 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 TTI,m i,max~~ - $Np_{i,\max}^{TTI,m}$ ~~Np TTI, m i,max~~

#### 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 $s_1, s_2, s_3, \ldots, s_S$,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 $N^{cm}_{data,*}$ and $R = \frac{N^{cm}_{data,*}}{P}$. The exact value of $N^{cm}_{data,*}$ 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 $N^{cm}_{data,*} = \frac{N'_{data,*}}{2}$, and for other methods it can be calculated as $N^{cm}_{data,*} = N'_{data,*} - N_{TGL}$. 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:

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

$N_{first}$ 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 $w_1, w_2, w_3, \ldots, w_{(PR)}$. 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:

$w_k = s_k$ k = 1, 2, 3, …, S

$w_k = d$ k = S+1, S+2, S+3, …, ~~P~~$P \cdot R$

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

## 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 $x_1, x_2, x_3, \ldots, x_X$ $x_1, x_2, x_3, \ldots, x_Y$, 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 $u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU}$, where $p$ is PhCH number and $U$ is the number of bits in one radio frame for each PhCH, i.e. $U = (Y\ X - N_{TGL}) / P$ 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 VU. 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:

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

Bits on second PhCH after physical channel segmentation:

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

…

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

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

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 $u_{1,3}, \ldots u_{1,V}, u_{2,1}, u_{2,2}, \ldots u_{2,V}, \ldots u_{P,1}, u_{P,2}, \ldots u_{P,VU}$,

## 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 $u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU}$, 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 C2$C_2$ = 30. The columns are numbered 0, 1, 2, …, C2$C_2$-1 from left to right.

(2) Determine the number of rows R2$R_2$ by finding minimum integer R2$R_2$ such that:

$U$ £ R2·C2$R_2 C_2$.

(3) The bits input to the 2nd interleaving are written into the R2 × C2$R_2 \times C_2$ rectangular matrix row by row.

$$\begin{bmatrix} u_{p1} & u_{p2} & u_{p3} & \ldots & u_{p30} \\ u_{p31} & u_{p32} & u_{p33} & \ldots & u_{p60} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ u_{p,((R2-1)30+1)} & u_{p,((R2-1)30+2)} & u_{p,((R2-1)30+3)} & \ldots & u_{p,(R2 \cdot 30)} \end{bmatrix}$$

$$\begin{bmatrix} u_{p1} & u_{p2} & u_{p3} & \ldots & u_{p30} \\ u_{p31} & u_{p32} & u_{p33} & \ldots & u_{p60} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ u_{p,((R_2-1)30+1)} & u_{p,((R_2-1)30+2)} & u_{p,((R_2-1)30+3)} & \ldots & u_{p,(R_2 30)} \end{bmatrix}$$

(4) Perform the inter-column permutation based on the pattern { P2$P_2$(j)} (j = 0, 1, ..., C2$C_2$-1) that is shown in table 6, where P2$P_2$(j) is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by $y_{pk}$.

$$\begin{bmatrix} y_{p,1} & y_{p,(R2+1)} & y_{p,(2 \cdot R2+1)} & \ldots & y_{p,(29 \cdot R2+1)} \\ y_{p,2} & y_{p,(R2+2)} & y_{p,(2 \cdot R2+2)} & \ldots & y_{p,(29 \cdot R2+2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{p,R2} & y_{p,(2 \cdot R2)} & y_{p,(3 \cdot R2)} & \ldots & y_{p,(30 \cdot R2)} \end{bmatrix} \begin{bmatrix} y_{p1} & y_{p,(R_2+1)} & y_{p,(2R_2+1)} & \ldots & y_{p,(29R_2+1)} \\ y_{p2} & y_{p,(R_2+2)} & y_{p,(2R_2+2)} & \ldots & y_{p,(29R_2+2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{pR_2} & y_{p,(2R_2)} & y_{p,(3R_2)} & \ldots & y_{p,(30R_2)} \end{bmatrix}$$

(5) The output of the 2nd interleaving is the bit sequence read out column by column from the inter-column permuted R2 × C2$R_2 \times C_2$ 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 $v_{p1}, v_{p2}, \ldots, v_{pU}$, 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 $C_2$ C2 | Inter-column permutation pattern (P2(0), P2(1), …,P2(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)} |