3GPP TSG-RAN Meeting #16 **RP-020311**
Marco Island, FL, U.S.A., 4 – 7, June, 2002

Title: **Agreed CRs (R99 and Rel-4/Rel-5 Category A) to TS 25.222**

Source: **TSG-RAN WG1**

Agenda item: **7.1.3**

No.	Spec	CR	Rev	R1 T-doc	Subject	Phase	Cat	Work Item	V_old	V_new
1	25.222	070	1	R1-02-0445	Second stage interleaving and physical channel mapping	R99	F	TEI	3.8.0	3.9.0
2	25.222	071	1	R1-02-0445	Second stage interleaving and physical channel mapping	Rel-4	A	TEI	4.3.0	4.4.0
3	25.222	077	-	R1-02-0445	Second stage interleaving and physical channel mapping	Rel-5	A	TEI	5.0.0	5.1.0
4	25.222	074	-	R1-02-0734	Zero padding for TFCI	R99	F	TEI	3.8.0	3.9.0
5	25.222	075	1	R1-02-0734	Zero padding for TFCI (3.84Mcps TDD)	Rel-4	A	TEI	4.3.0	4.4.0
6	25.222	076	1	R1-02-0734	Zero padding for TFCI (3.84Mcps TDD)	Rel-5	A	TEI	5.0.0	5.1.0

CR-Form-v4

CHANGE REQUEST

z	**25.222**	**CR**	**070**	z rev	**1**	z Current version:	**3.8.0** z

*For **HELP** on using this form, see bottom of this page or look at the pop-up text over the z symbols.*

Proposed change affects: z (U)SIM [ ] ME/UE [X] Radio Access Network [X] Core Network [ ]

Title: z	Second Stage Interleaving and Physical Channel Mapping			
Source: z	TSG RAN WG1			
Work item code: z	TEI		***Date:*** z	4 April 2002
Category: z	**F**		***Release:*** z	R99
	Use one of the following categories: ***F*** *(correction)* ***A*** *(corresponds to a correction in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* Detailed explanations of the above categories can be found in 3GPP TR 21.900.			*Use one of the following releases:* 2 *(GSM Phase 2)* *R96 (Release 1996)* *R97 (Release 1997)* *R98 (Release 1998)* *R99 (Release 1999)* *REL-4 (Release 4)* *REL-5 (Release 5)*

Reason for change: z	There are 2 inconsistencies: 1) The output from second stage frame related interleaving is not time slot segmented, but frame segmented. The input to physical channel mapping requires the output of the second stage interleaver be segmented in to slots, as defined in Fig1 of TS25.222. This segmentation process is not defined. 2) The number of physical channels is set by Rate Matching and is equal to P, where P<=Pmax. Therefore, the number of physical channels after physical channel mapping is P.
Summary of change: z	Correction of output from second stage frame related interleaving, and the number of physical channels after physical channel mapping.
Consequences if not approved: z	Ambiguous mapping of bits from second stage frame related interleaving to physical channel mapping. **Isolated Impact Analysis:** Correction to a function where the specification was : • ambiguous or not sufficiently explicit. • Would not affect implementations behaving like indicated in the CR, would affect implementations supporting the corrected functionality otherwise. The CR intends to clarify behaviour that has very likely been assumed in most implementations.

Clauses affected: z	4.2, 4.2.7, 4.2.7.1, 4.2.10, 4.2.11.1, 4.2.11.2, 4.2.12

Other specs affected:	z		Other core specifications Test specifications O&M Specifications	z	
Other comments:	z				

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1) Fill out the above form. The symbols above marked z contain pop-up help information about the field that they are closest to.

2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under ftp://ftp.3gpp.org/specs/ For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.

3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

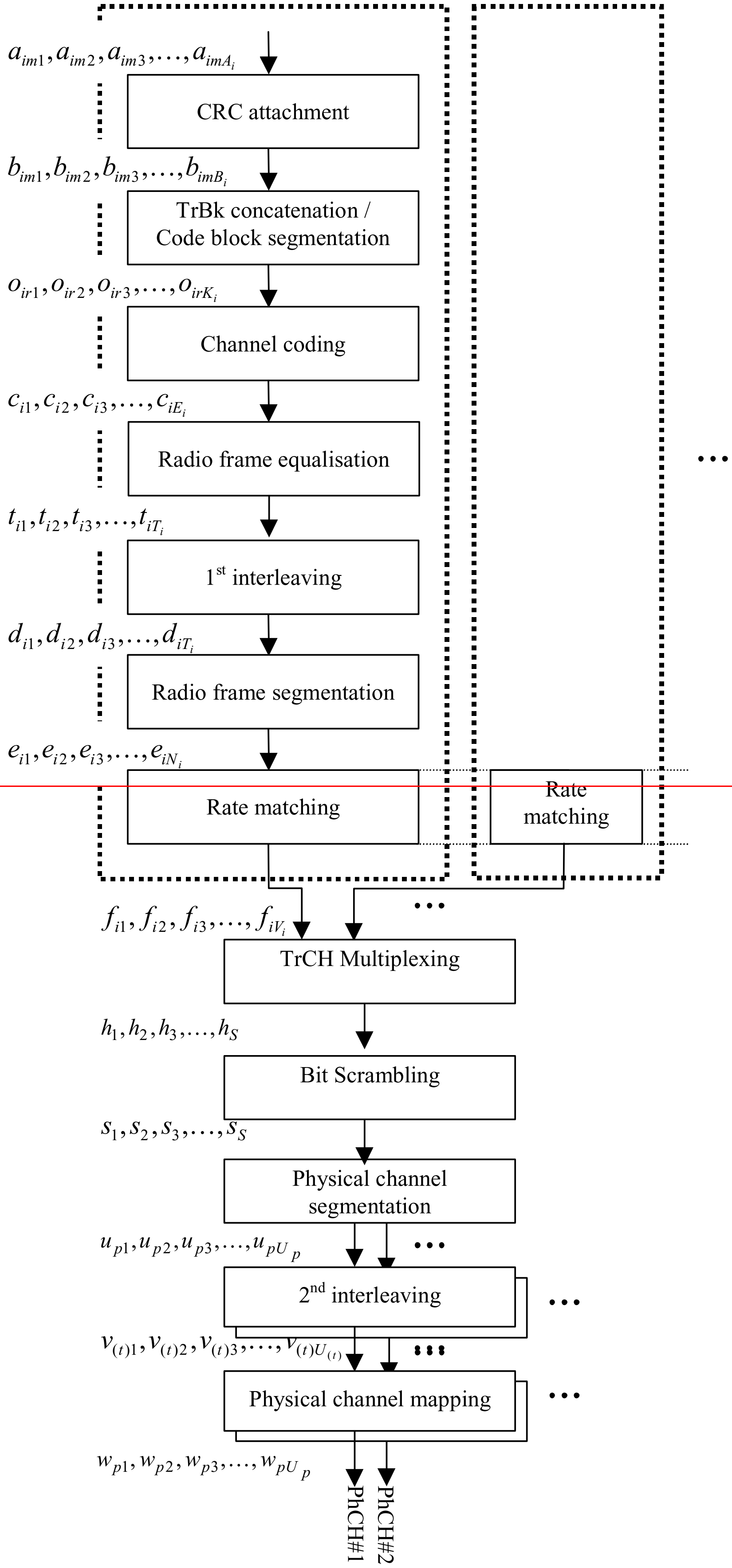
4.2 Transport channel coding/multiplexing

Figure 1 illustrates the overall concept of transport-channel coding and multiplexing. Data arrives to the coding/multiplexing unit in form of transport block sets, once every transmission time interval. The transmission time interval is transport-channel specific from the set {10 ms, 20 ms, 40 ms, 80 ms}.

The following coding/multiplexing steps can be identified:

- add CRC to each transport block (see subclause 4.2.1);
- TrBk concatenation / Code block segmentation (see subclause 4.2.2);
- channel coding (see subclause 4.2.3) ;
- radio frame size equalization (see subclause 4.2.4);
- interleaving (two steps, see subclauses 4.2.5 and 4.2.10);
- radio frame segmentation (see subclause 4.2.6);
- rate matching (see subclause 4.2.7);
- multiplexing of transport channels (see subclause 4.2.8);
- bit scrambling (see subclause 4.2.9);
- physical channel segmentation (see subclause 4.2.10);
- mapping to physical channels (see subclause 4.2.12).

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


$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$
CRC attachment
$b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$
TrBk concatenation / Code block segmentation
$o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$
Channel coding
$c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$
Radio frame equalisation
$t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$
1st interleaving
$d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$
Radio frame segmentation
$e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$
Rate matching
Rate matching
$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$
TrCH Multiplexing
$h_1, h_2, h_3, \ldots, h_S$
Bit Scrambling
$s_1, s_2, s_3, \ldots, s_S$
Physical channel segmentation
$u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU_p}$
2nd interleaving
$v_{(t)1}, v_{(t)2}, v_{(t)3}, \ldots, v_{(t)U_{(t)}}$
Physical channel mapping
$w_{p1}, w_{p2}, w_{p3}, \ldots, w_{pU_p}$
PhCH#1
PhCH#2

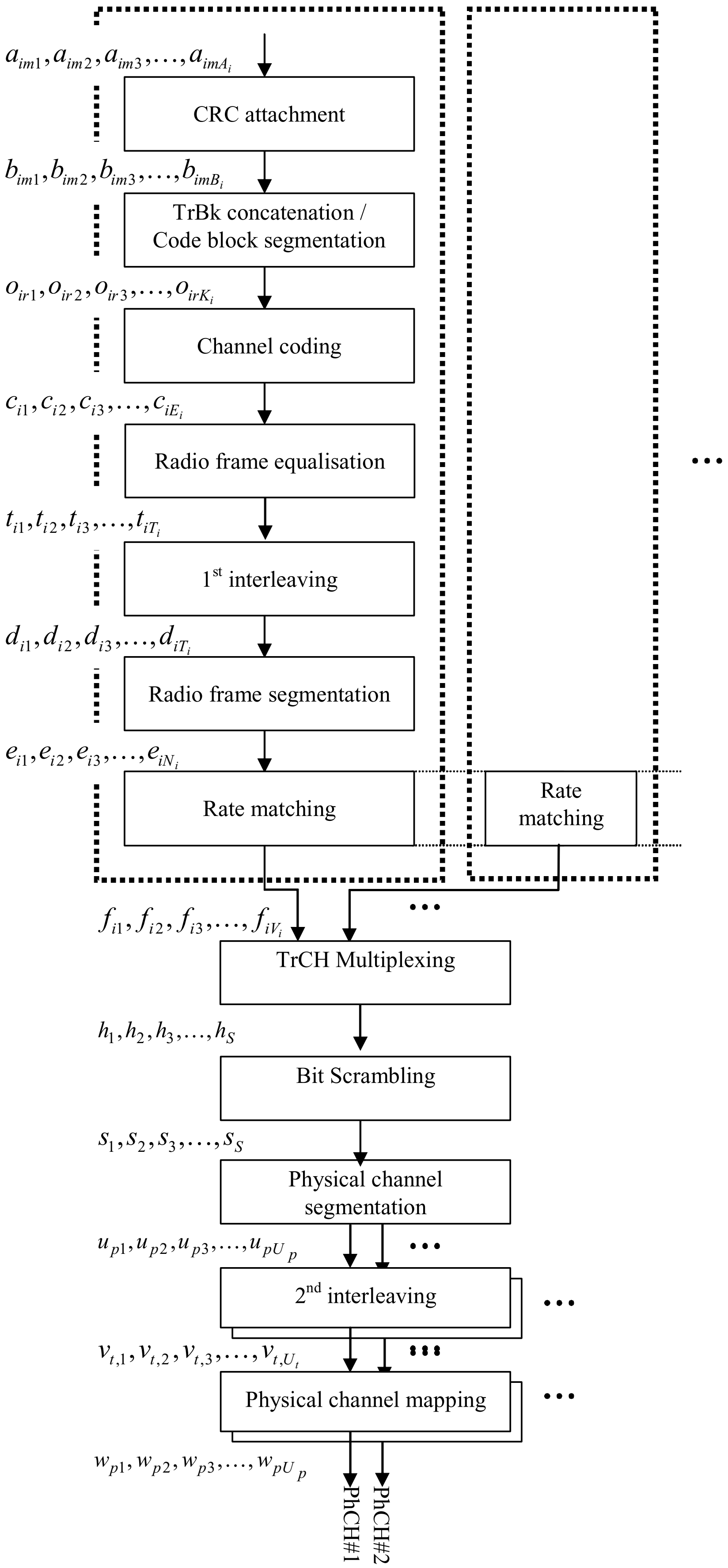


Figure 1: Transport channel multiplexing structure for uplink and downlink

Primarily, transport channels are multiplexed as described above, i.e. into one data stream mapped on one or several physical channels. However, an alternative way of multiplexing services is to use multiple CCTrCHs (Coded Composite Transport Channels), which corresponds to having several parallel multiplexing chains as in figure 1, resulting in several data streams, each mapped to one or several physical channels.

4.2.7 Rate matching

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

The number of bits on a TrCH can vary between different transmission time intervals. When the number of bits between different transmission time intervals is changed, bits are repeated to ensure that the total bit rate after TrCH multiplexing is identical to the total channel bit rate of the allocated physical channels.

If no bits are input to the rate matching for all TrCHs within a CCTrCH, the rate matching shall output no bits for all TrCHs within the CCTrCH.

Notation used in subclause 4.2.7 and subclauses:

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

$\Delta N_{i,j}$: If positive – number of bits to be repeated in each radio frame on TrCH *i* with transport format

If negative – number of bits to be punctured in each radio frame on TrCH *i* with transport format combination *j*.

RM_i : Semi-static rate matching attribute for TrCH *i*. Signalled from higher layers.

PL : Puncturing limit. This value limits the amount of puncturing that can be applied in order to minimise the number of physical channels. Signalled from higher layers. The allowed puncturing in % is actually equal to (1-PL)*100.

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

P : number of physical channels used in the current frame.

P_{max} : maximum number of physical channels allocated for a CCTrCH.

U_p : Number of data bits in the physical channel p with p = 1...P.

I : Number of TrCHs in a CCTrCH.

Z_{ij} : Intermediate calculation variable.

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

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

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

$P1_F(n_i)$: The column permutation function of the 1st interleaver, $P1_F(x)$ is the original position of column with number x after permutation. P1 is defined on table 4 of section 4.2.5 (note that $P1_F$ self-inverse).

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

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

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

e_{ini} : Initial value of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.

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

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

b : Indicates systematic and parity bits.

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

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

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

4.2.7.1 Determination of rate matching parameters

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

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

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

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

Puncturing can be used to minimise the required transmission capacity. The maximum amount of puncturing that can be applied is 1-PL, PL is signalled from higher layers. The possible values for N_{data} depend on the number of physical channels P_{max} , allocated to the respective CCTrCH, and on their characteristics (spreading factor, length of midamble and TFCI code word, usage of TPC and multiframe structure), which is given in [7].

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

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

Optionally, if indicated by higher layers for the UL the UE shall vary the spreading factor autonomously, so that N_{data} is one of the following values in ascending order:

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

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

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

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

The number of bits to be repeated or punctured, $\Delta N_{i,j}$, within one radio frame for each TrCH i is calculated with the relations given at the beginning of this subclause for all possible transport format combinations j and selected every radio frame. The number of physical channels corresponding to $N_{data,\,j}$, shall be denoted by P.

If $\Delta N_{i,j} = 0$ then the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.3 does not need to be executed.

Otherwise, the rate matching pattern is calculated with the algorithm described in subclause 4.2.7.3. For this algorithm the parameters e_{ini}, e_{plus}, e_{minus}, and X_i are needed, which are calculated according to the equations in subclauses 4.2.7.1.1 and 4.2.7.1.2.

4.2.10 Physical channel segmentation

When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $s_1, s_2, s_3, \ldots, s_S$, where S is the number of bits input to the physical channel segmentation block. The number of PhCHs after rate matching is denoted by P, as defined in subclause 4.2.7.1.

The bits after physical channel segmentation are denoted $u_{p,1}, u_{p,2}, u_{p,3}, \ldots, u_{p,U_p}$, where p is PhCH number and U_p is the in general variable number of bits in the respective radio frame for each PhCH. The relation between s_k and $u_{p,k}$ is given below.

Bits on first PhCH after physical channel segmentation:

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

Bits on second PhCH after physical channel segmentation:

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

…

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

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

4.2.11 2nd interleaving

The 2nd interleaving is a block interleaver and consists of bits input to a matrix with padding, the inter-column permutation for the matrix and bits output from the matrix with pruning. The 2nd interleaving can be applied jointly to all data bits transmitted during one frame, or separately within each timeslot, on which the CCTrCH is mapped. The selection of the 2nd interleaving scheme is controlled by higher layer.

4.2.11.1 Frame related 2nd interleaving

In case of frame related 2nd interleaving, the bits input to the block interleaver are denoted by $x_1, x_2, x_3, \ldots, x_U$, where U is the total number of bits after TrCH multiplexing transmitted during the respective radio frame with $S = U = \sum_p U_p$.

The relation between x_k and the bits $u_{p,k}$ in the respective physical channels is given below:

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

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

…

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

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

(1) Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

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

$U \leq$ R2 X C2.

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

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

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

where $y_k = x_k$ for k = 1, 2, …, U and if R2 $\times$ C2 > U, the dummy bits are padded such that y_k = 0 or 1 for k = U + 1, U + 2, …, R2 $\times$ C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle \mathrm{P2}(j) \rangle_{j \in \{0,1,\ldots,C2-1\}}$ that is shown in table 7, where $P_2(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by y'_k.

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

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted R2 $\times$ C2 matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits y'_k that corresponds to bits y_k with $k > U$ are removed from the output. The bits ~~after frame related 2nd interleaving~~ at the output of the block interleaver are denoted by ~~$v_1, v_2, \ldots, v_U$~~ $z_1, z_2, \ldots, z_U$, where ~~v_1~~ z_1 corresponds to the bit y'_k with smallest index k after pruning, ~~v_2~~ z_2 to the bit y'_k with second smallest index k after pruning, and so on.

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

$u_{1,k} = z_k$ k = 1, 2 , …, U_1

$u_{2,k} = z_{(k+U_1)}$ k = 1, 2 , …, U_2

…

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

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

Let T be the number of time slots in a CCTrCH during the respective radio frame, and $t = 1, \ldots, T$. The physical layer shall assign the time slot sequence number t in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In time slot t, R_t refers to the number of physical channels within the respective time slot and $r = 1,\ldots,R_t$. The relation between r and t and the physical channel sequence number p as detailed in 4.2.12 is given by:

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

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

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

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

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

…

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

4.2.11.2 Timeslot related 2nd interleaving

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

Let T be the number of time slots in a CCTrCH during the respective radio frame, and $t = 1,\ldots,T$. The physical layer shall assign the time slot sequence number t in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In ~~each~~ timeslot t, ~~the relation between $x_{t,k}$ and $u_{t,p,k}$ is given below with~~ R_t ~~P_t~~ refers~~ring~~ to the number of physical channels within the respective timeslot and $r = 1,\ldots,R_t$. ~~:~~ The relation between r and t and the physical channel sequence number p as detailed in 4.2.12 is given by:

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

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

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

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

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

…

$$\cancel{x_{t,(k+U_{t1}+\ldots+U_{t(P_t-1)})} = u_{t,P_t,k} \quad k = 1, 2, \ldots, U_{tP_t}}$$

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

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

(1) Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

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

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

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

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

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

where $y_{t,k} = x_{t,k}$ for k = 1, 2, …, U_t and if R2 × C2 > U_t, the dummy bits are padded such that $y_{t,k}$ = 0 or 1 for $k = U_t + 1, U_t + 2, \ldots$, R2 × C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle \mathrm{P2}(j) \rangle_{j \in \{0,1,\ldots,\mathrm{C2}-1\}}$ that is shown in table 7, where P2(j) is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by $y'_{t,k}$.

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

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits $y'_{t,k}$ that corresponds to bits $y_{t,k}$ with $k > U_t$ are removed from the output. The bits after time slot 2nd interleaving are denoted by $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$, where $v_{t,1}$ corresponds to the bit $y'_{t,k}$ with smallest index k after pruning, $v_{t,2}$ to the bit $y'_{t,k}$ with second smallest index k after pruning, and so on.

Table 7 Inter-column permutation pattern for 2nd interleaving

Number of Columns C2	Inter-column permutation pattern < P2(0), P2(1), …, P2(C2-1) >
30	<0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17>

4.2.12 Physical channel mapping

The PhCH for both uplink and downlink is defined in [6]. The bits after physical channel mapping are denoted by $w_{p,1}, w_{p,2}, \ldots, w_{p,U_p}$, where p is the PhCH number corresponding to the sequence number $1 \le p \le P$ ~~P_{max}~~ of this physical channel as detailed below, ~~and~~ U_p is the number of bits in one radio frame for the respective PhCH, and $P \le$.

$\underline{P_{max}}$~~.~~ The bits $w_{p,k}$ are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to *k*.

The physical layer shall assign the physical channel sequence number *p* to the physical channels of the CCTrCH in the respective radio frame, treating each allocated timeslot in ascending order. If within a timeslot there are multiple physical channels they shall first be ordered in ascending order of the spreading factor (*Q*) and subsequently by channelisation code index (*k*), as shown in [9].

~~The physical channel sequence number *p* are to be allocated by the physical layer in ascending order of the timeslots in which they appear. If more than one physical channel appears in a timeslot, they shall be allocated the sequence number in order of the timeslot first and then of their channelisation codes. The channelisation codes shall be ordered in ascending order of the spreading Factor (*Q*) and then channelisation index (*k*), as shown in [9].~~

The mapping of the bits $\underline{v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}}$ $\cancel{v_{(t),1}, v_{(t),2}, \ldots, v_{(t),U_{(t)}}}$ is performed like block interleaving, writing the bits into columns, but a PhCH with an odd number is filled in forward order, where~~-~~as a PhCH with an even number is filled in reverse order.

The mapping scheme, as described in the following subclause, shall be applied individually for each timeslot *t* used in the current frame. Therefore, the bits $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ are assigned to the bits of the physical channels $w_{t,1,1\ldots U_{t1}}, w_{t,2,1\ldots U_{t2}}, \ldots, w_{t,P_t,1\ldots U_{tP_t}}$ in each timeslot.

In uplink there are at most two codes allocated (P≤2). If there is only one code, the same mapping as for downlink is applied. Denote SF1 and SF2 the spreading factors used for code 1 and 2, respectively. For the number of consecutive bits to assign per code bs_k the following rule is applied:

if

SF1 >= SF2 then $bs_1 = 1$; $bs_2 =$ SF1/SF2 ;

else

SF2 > SF1 then $bs_1 =$ SF2/SF1; $bs_2 = 1$;

end if

In the downlink case bs_p is 1 for all physical channels.

4.2.12.1 Mapping scheme

Notation used in this subclause:

P_t: number of physical channels for timeslot t , $P_t = 1..2$ for uplink ; $P_t = 1...16$ for downlink

$U_{t,p}$: capacity in bits for the physical channel p in timeslot t

U_t: total number of bits to be assigned for timeslot t

bs_p: number of consecutive bits to assign per code

for downlink all $bs_p = 1$

for uplink if SF1 >= SF2 then $bs_1 = 1$; $bs_2 =$ SF1/SF2 ;

if SF2 > SF1 then $bs_1 =$ SF2/SF1; $bs_2 = 1$;

fb_p: number of already written bits for each code

pos: intermediate calculation variable

for p=1 to P_t -- reset number of already written bits for every physical channel

$fb_p = 0$

end for

```
p = 1                                   -- start with PhCH #1
for k=1  to U_t.
    do while (fb_p == U_t,p)                -- physical channel filled up already ?
        p = (p mod P_t) + 1;
    end do
    if (p mod 2) == 0
        pos = U_t,p - fb_p                  -- reverse order
    else
        pos = fb_p + 1                      -- forward order
    endif
    w_t,p,pos = v_t,k                   -- assignment
    fb_p = fb_p + 1                     -- Increment number of already written bits
    if (fb_p mod bs_p) == 0             -- Conditional change to the next physical channel
        p = (p mod P_t) + 1;
    end if
end for
```

3GPP TSG RAN Meeting #16
Marco Island, FL, U.S.A., 4 – 7, June 2002

R1-02-0445

CR-Form-v4

CHANGE REQUEST

z	**25.222**	**CR**	**071**	z	rev	**1**	z	Current version:	**4.3.0** z

*For **HELP** on using this form, see bottom of this page or look at the pop-up text over the z symbols.*

Proposed change affects: z (U)SIM [ ] ME/UE [X] Radio Access Network [X] Core Network [ ]

Title:	z	Second Stage Interleaving and Physical Channel Mapping		
Source:	z	TSG RAN WG1		
Work item code:	z	TEI	***Date:*** z	4 April 2002
Category:	z	**A**	***Release:*** z	REL-4
		Use one of the following categories: ***F*** *(correction)* ***A*** *(corresponds to a correction in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* Detailed explanations of the above categories can be found in 3GPP TR 21.900.		*Use one of the following releases:* 2 *(GSM Phase 2)* *R96 (Release 1996)* *R97 (Release 1997)* *R98 (Release 1998)* *R99 (Release 1999)* *REL-4 (Release 4)* *REL-5 (Release 5)*

Reason for change:	z	There are 2 inconsistencies: 1) The output from second stage frame related interleaving is not time slot segmented, but frame segmented. The input to physical channel mapping requires the output of the second stage interleaver be segmented in to slots, as defined in Fig1 of TS25.222. This segmentation process is not defined. 2) The number of physical channels is set by Rate Matching and is equal to P, where P<=Pmax. Therefore, the number of physical channels after physical channel mapping is P.
Summary of change:	z	Correction of output from second stage frame related interleaving, and the number of physical channels after physical channel mapping.
Consequences if not approved:	z	Ambiguous mapping of bits from second stage frame related interleaving to physical channel mapping. **Isolated Impact Analysis:** Correction to a function where the specification was : • ambiguous or not sufficiently explicit. • Would not affect implementations behaving like indicated in the CR, would affect implementations supporting the corrected functionality otherwise. The CR intends to clarify behaviour that has very likely been assumed in most implementations.

Clauses affected:	z	4.2,4.2.7, 4.2.7.1, 4.2.10, 4.2.11.1, 4.2.11.2, 4.2.12, 4.2.13

Other specs affected:	z		Other core specifications Test specifications O&M Specifications	z
Other comments:	z			

How to create CRs using this form:

Comprehensive information and tips about how to create CRs can be found at: http://www.3gpp.org/3G_Specs/CRs.htm. Below is a brief summary:

1) Fill out the above form. The symbols above marked z contain pop-up help information about the field that they are closest to.

2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under ftp://ftp.3gpp.org/specs/ For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.

3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

4.2 Transport channel coding/multiplexing

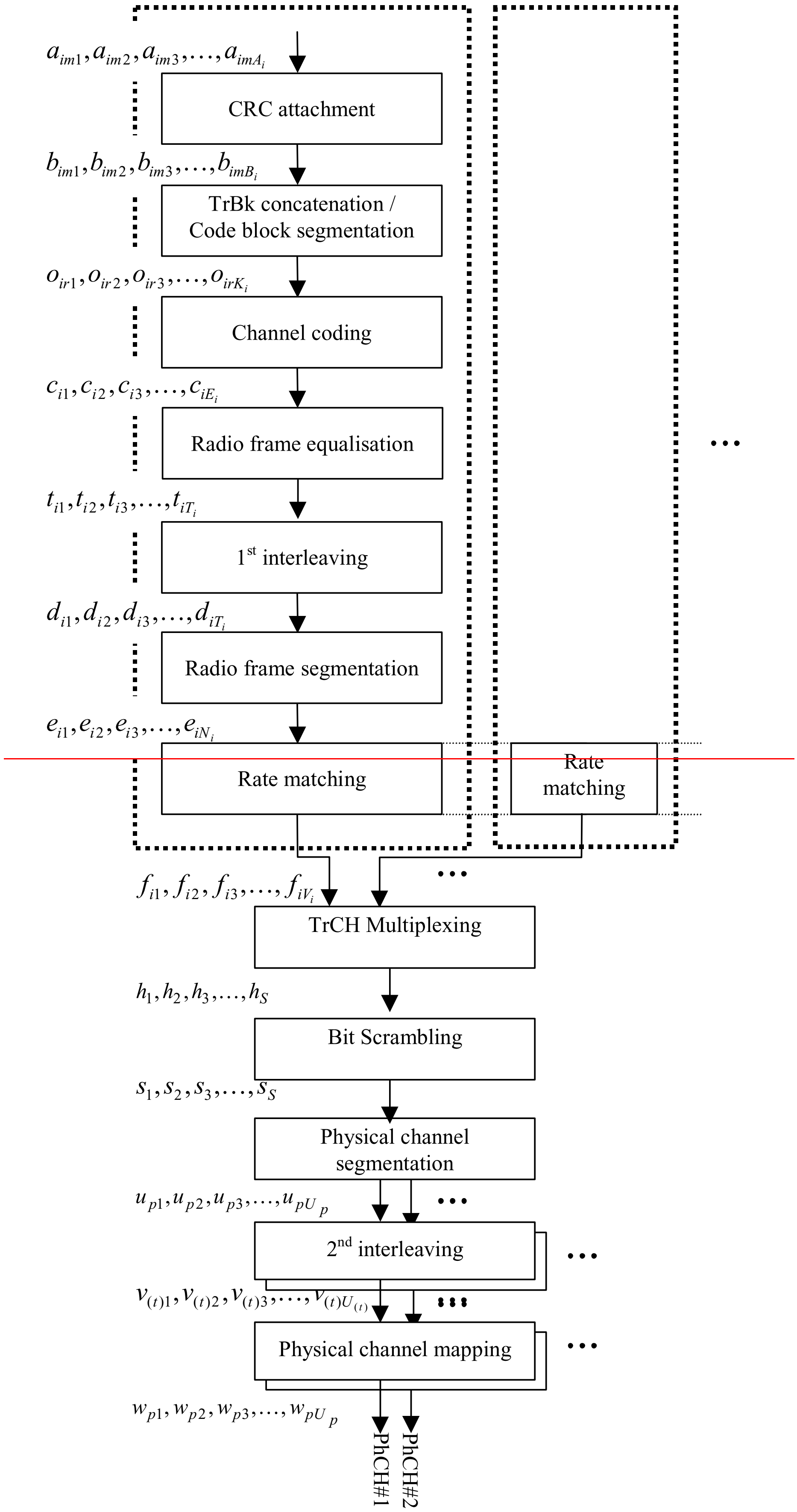
Figure 1 illustrates the overall concept of transport-channel coding and multiplexing. Data arrives to the coding/multiplexing unit in form of transport block sets, once every transmission time interval. The transmission time interval is transport-channel specific from the set {5 ms(*1), 10 ms, 20 ms, 40 ms, 80 ms}.

Note: (*1) may be applied for PRACH for 1.28 Mcps TDD

The following coding/multiplexing steps can be identified:

- add CRC to each transport block (see subclause 4.2.1);
- TrBk concatenation / Code block segmentation (see subclause 4.2.2);
- channel coding (see subclause 4.2.3) ;
- radio frame size equalization (see subclause 4.2.4);
- interleaving (two steps, see subclauses 4.2.5 and 4.2.10);
- radio frame segmentation (see subclause 4.2.6);
- rate matching (see subclause 4.2.7);
- multiplexing of transport channels (see subclause 4.2.8);
- bit scrambling (see subclause 4.2.9);
- physical channel segmentation (see subclause 4.2.10);
- sub-frame segmentation(see subclause 4.2.12 only for 1.28Mcps TDD)
- mapping to physical channels (see subclause 4.2.13).

The coding/multiplexing steps for uplink and downlink are shown in figures 1 and 2.


CRC attachment
TrBk concatenation / Code block segmentation
Channel coding
Radio frame equalisation
1st interleaving
Radio frame segmentation
Rate matching
Rate matching
TrCH Multiplexing
Bit Scrambling
Physical channel segmentation
2nd interleaving
Physical channel mapping
PhCH#1
PhCH#2

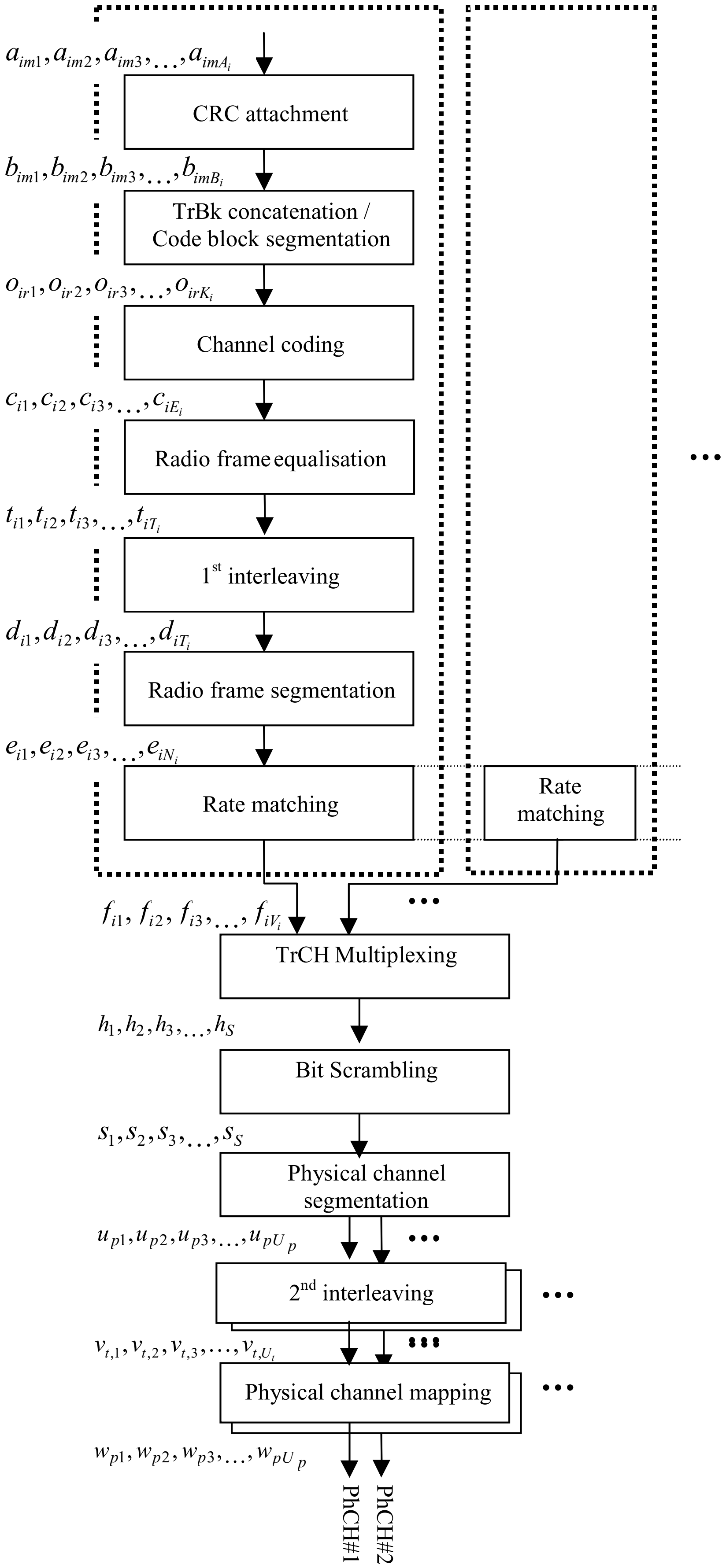
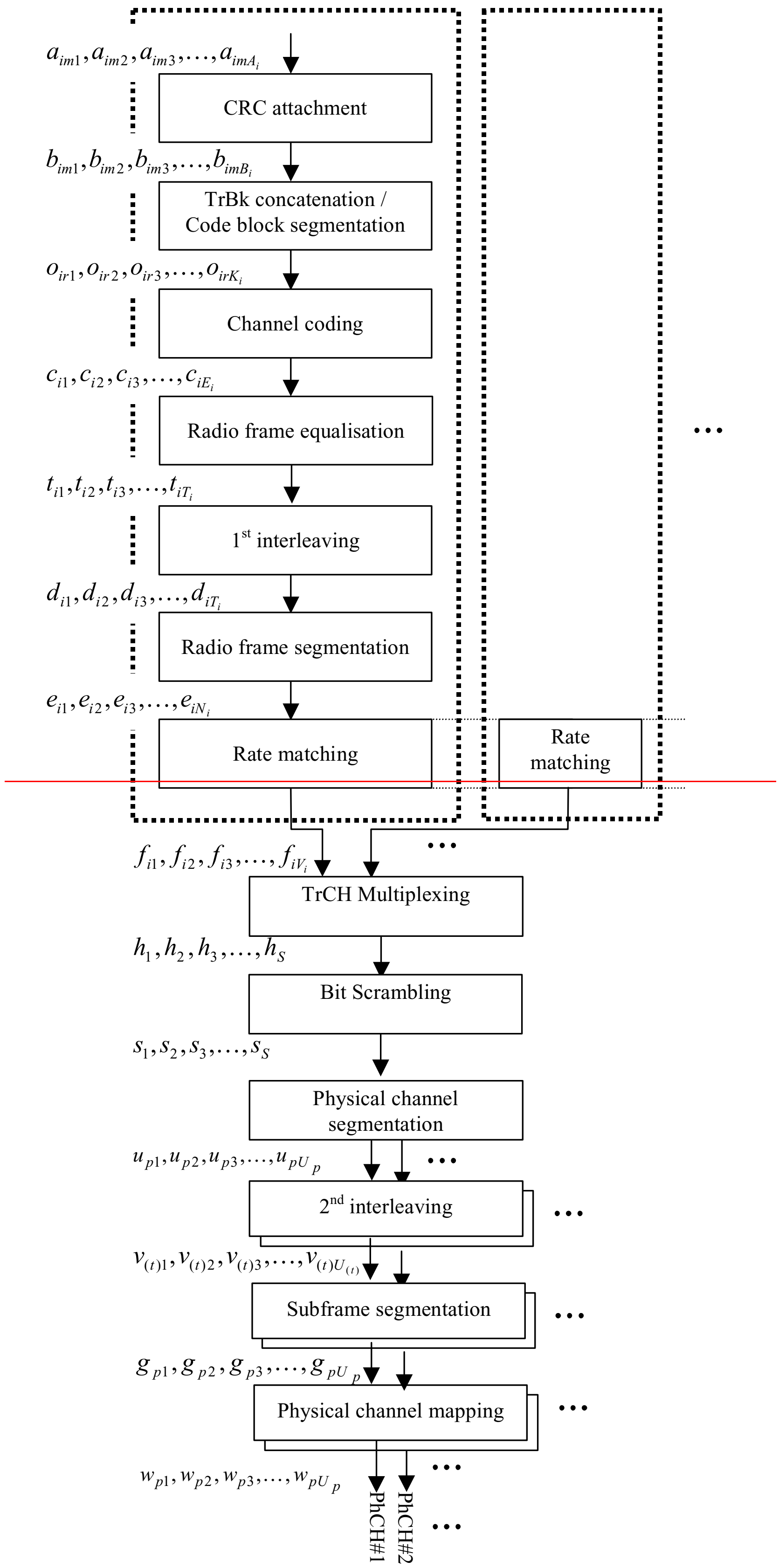


Figure 1: Transport channel multiplexing structure for uplink and downlink for 3.84Mcps TDD


$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$
CRC attachment
$b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$
TrBk concatenation / Code block segmentation
$o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$
Channel coding
$c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$
Radio frame equalisation
$t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$
1st interleaving
$d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$
Radio frame segmentation
$e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$
Rate matching
Rate matching
$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$
TrCH Multiplexing
$h_1, h_2, h_3, \ldots, h_S$
Bit Scrambling
$s_1, s_2, s_3, \ldots, s_S$
Physical channel segmentation
$u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU_p}$
2nd interleaving
$v_{(t)1}, v_{(t)2}, v_{(t)3}, \ldots, v_{(t)U_{(t)}}$
Subframe segmentation
$g_{p1}, g_{p2}, g_{p3}, \ldots, g_{pU_p}$
Physical channel mapping
$w_{p1}, w_{p2}, w_{p3}, \ldots, w_{pU_p}$
PhCH#1
PhCH#2

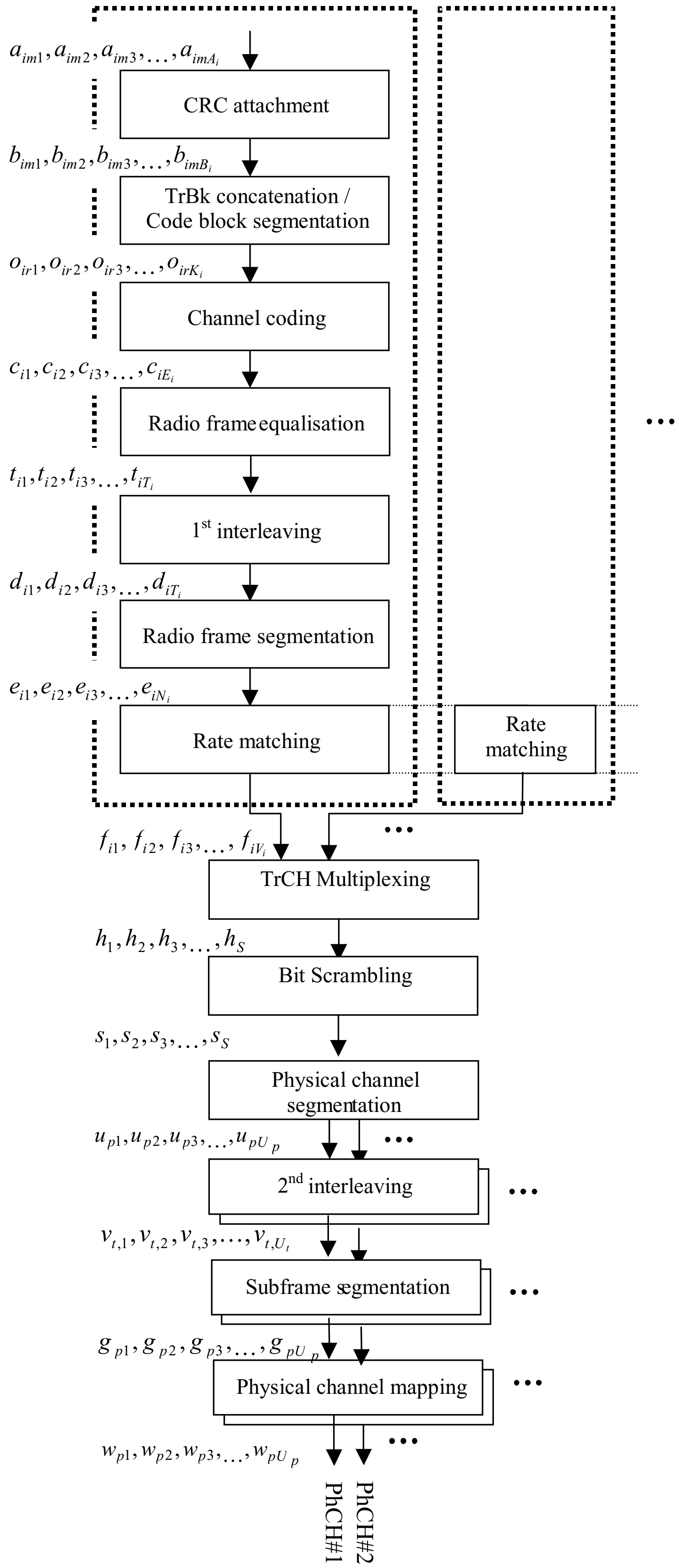


Figure 2: Transport channel multiplexing structure for uplink and downlink of 1.28Mcps TDD

Primarily, transport channels are multiplexed as described above, i.e. into one data stream mapped on one or several physical channels. However, an alternative way of multiplexing services is to use multiple CCTrCHs (Coded Composite Transport Channels), which corresponds to having several parallel multiplexing chains as in figures 1 and 2, resulting in several data streams, each mapped to one or several physical channels.

4.2.7 Rate matching

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

The number of bits on a TrCH can vary between different transmission time intervals. When the number of bits between different transmission time intervals is changed, bits are repeated to ensure that the total bit rate after TrCH multiplexing is identical to the total channel bit rate of the allocated physical channels.

If no bits are input to the rate matching for all TrCHs within a CCTrCH, the rate matching shall output no bits for all TrCHs within the CCTrCH.

Notation used in subclause 4.2.7 and subclauses:

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

$\Delta N_{i,j}$: If positive – number of bits to be repeated in each radio frame on TrCH *i* with transport format

If negative – number of bits to be punctured in each radio frame on TrCH *i* with transport format combination *j*.

RM_i : Semi-static rate matching attribute for TrCH *i*. Signalled from higher layers.

PL : Puncturing limit. This value limits the amount of puncturing that can be applied in order to minimise the number of physical channels. Signalled from higher layers. The allowed puncturing in % is actually equal to (1-PL)*100.

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

P : number of physical channels used in the current frame.

P_{max} : maximum number of physical channels allocated for a CCTrCH.

U_p : Number of data bits in the physical channel p with p = 1...P.

I : Number of TrCHs in a CCTrCH.

Z_{ij} : Intermediate calculation variable.

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

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

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

$P1_F(n_i)$: The column permutation function of the 1st interleaver, $P1_F(x)$ is the original position of column with number x after permutation. P1 is defined on table 5 of section 4.2.5 (note that $P1_F$ self-inverse).

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

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

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

e_{ini} : Initial value of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.

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

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

b : Indicates systematic and parity bits.

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

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

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

4.2.7.1 Determination of rate matching parameters

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

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

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

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

Puncturing can be used to minimise the required transmission capacity. The maximum amount of puncturing that can be applied is 1-PL, PL is signalled from higher layers. The possible values for N_{data} depend on the number of physical channels P_{max} , allocated to the respective CCTrCH, and on their characteristics (spreading factor, length of midamble and TFCI code word, usage of TPC and multiframe structure), which is given in [7].

For each physical channel an individual minimum spreading factor Sp_{min} is transmitted by means of the higher layers. Denote the number of data bits in each physical channel by $U_{p,Sp}$, where *p* indicates the sequence number $1 \le p \le P_{max}$ and *Sp* indicates the spreading factor with the possible values {*16, 8, 4, 2, 1*} of this physical channel. The index *p* is described in section 4.2.13 with the following modifications: spreading factor (*Q*) is replaced by the minimum spreading factor Sp_{min} and *k* is replaced by the channelization code index at $Q= Sp_{min}$. Then, for N_{data} one of the following values in ascending order can be chosen:

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

Optionally, if indicated by higher layers for the UL the UE shall vary the spreading factor autonomously, so that N_{data} is one of the following values in ascending order:

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

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

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

$N_{data,j}$ = min SET1

The number of bits to be repeated or punctured, $\Delta N_{i,j}$, within one radio frame for each TrCH i is calculated with the relations given at the beginning of this subclause for all possible transport format combinations j and selected every radio frame. The number of physical channels corresponding to $N_{data,j}$, shall be denoted by P.

If $\Delta N_{i,j}$ = 0 then the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.3 does not need to be executed.

Otherwise, the rate matching pattern is calculated with the algorithm described in subclause 4.2.7.3. For this algorithm the parameters e_{ini}, e_{plus}, e_{minus}, and X_i are needed, which are calculated according to the equations in subclauses 4.2.7.1.1 and 4.2.7.1.2.

4.2.10 Physical channel segmentation

When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $s_1, s_2, s_3, \ldots, s_S$, where S is the number of bits input to the physical channel segmentation block. The number of PhCHs after rate matching is denoted by *P*, as defined in subclause 4.2.7.1.

The bits after physical channel segmentation are denoted $u_{p,1}, u_{p,2}, u_{p,3}, \ldots, u_{p,U_p}$, where *p* is PhCH number and U_p is the in general variable number of bits in the respective radio frame for each PhCH. The relation between s_k and $u_{p,k}$ is given below.

Bits on first PhCH after physical channel segmentation:

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

Bits on second PhCH after physical channel segmentation:

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

…

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

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

4.2.11 2nd interleaving

The 2^{nd} interleaving is a block interleaver and consists of bits input to a matrix with padding, the inter-column permutation for the matrix and bits output from the matrix with pruning. The 2nd interleaving can be applied jointly to all data bits transmitted during one frame, or separately within each timeslot, on which the CCTrCH is mapped. The selection of the 2nd interleaving scheme is controlled by higher layer.

4.2.11.1 Frame related 2nd interleaving

In case of frame related 2^{nd} interleaving, the bits input to the block interleaver are denoted by $x_1, x_2, x_3, \ldots, x_U$, where *U* is the total number of bits after TrCH multiplexing transmitted during the respective radio frame with $S = U = \sum_p U_p$.

The relation between x_k and the bits $u_{p,k}$ in the respective physical channels is given below:

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

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

…

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

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

(1) Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

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

$U \le$ R2 X C2.

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

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

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

where $y_k = x_k$ for k = 1, 2, …, U and if R2 × C2 > U, the dummy bits are padded such that y_k = 0 or 1 for k = U + 1, U + 2, …, R2 × C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle \mathrm{P}2(j) \rangle_{j\in\{0,1,\ldots,\mathrm{C2}-1\}}$ that is shown in table 7, where $P_2(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by y'_k.

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

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits y'_k that corresponds to bits y_k with $k > U$ are removed from the output. The bits ~~after frame related 2nd interleaving~~at the output of the block interleaver are denoted by $\cancel{v_1, v_2, \ldots, v_U}$ $z_1, z_2, \ldots, z_U$, where ~~v_1~~ $z_1$corresponds to the bit y'_k with smallest index k after pruning, ~~v_2~~ z_2 to the bit y'_k with second smallest index k after pruning, and so on.

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

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

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

…

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

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

Let T be the number of time slots in a CCTrCH during the respective radio frame (where for 1.28Mcps TDD, the respective radio frame includes subframes 1 and 2), and $t = 1, \ldots, T$. The physical layer shall assign the time slot sequence number t in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In time slot *t*, R_t refers to the number of physical channels within the respective time slot and $r = 1,\ldots,R_t$. The relation between *r* and *t* and the physical channel sequence number *p* as detailed in 4.2.13.1 is given by:

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

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

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

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

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

…

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

4.2.11.2 Timeslot related 2nd interleaving

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

Let *T* be the number of time slots in a CCTrCH during the respective radio frame (where for 1.28Mcps TDD, the respective radio frame includes subframes 1 and 2), and $t = 1,\ldots,T$. The physical layer shall assign the time slot sequence number *t* in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In ~~each~~ timeslot *t*, ~~the relation between $x_{t,k}$ and $u_{t,p,k}$ is given below with~~ R_t ~~P_t~~ refers~~ring~~ to the number of physical channels within the respective timeslot and $r = 1,\ldots,R_t$. ~~:~~ The relation between *r* and *t* and the physical channel sequence number *p* as detailed in 4.2.13.1 is given by:

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

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

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

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

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

…

$$\cancel{x_{t,(k+U_{t1}+\ldots+U_{t(P_t-1)})} = u_{t,P_t,k} \quad k = 1, 2, \ldots, U_{tP_t}}$$

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

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

(1) Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

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

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

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

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

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

where $y_{t,k} = x_{t,k}$ for k = 1, 2, …, U_t and if R2 × C2 > U_t, the dummy bits are padded such that $y_{t,k}$ = 0 or 1 for $k = U_t + 1, U_t + 2, \ldots$, R2 × C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle \text{P}2(j) \rangle_{j\in\{0,1,\ldots,\text{C2}-1\}}$ that is shown in table 7, where P2(j) is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by $y'_{t,k}$.

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

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits $y'_{t,k}$ that corresponds to bits $y_{t,k}$ with $k > U_t$ are removed from the output. The bits after time slot 2nd interleaving are denoted by $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$, where $v_{t,1}$ corresponds to the bit $y'_{t,k}$ with smallest index k after pruning, $v_{t,2}$ to the bit $y'_{t,k}$ with second smallest index k after pruning, and so on.

Table 7 Inter-column permutation pattern for 2nd interleaving

Number of Columns C2	Inter-column permutation pattern < P2(0), P2(1), …, P2(C2-1) >
30	<0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17>

4.2.12 Sub-frame segmentation for the 1.28 Mcps option

In the 1.28Mcps TDD, it is needed to add a sub-frame segmentation unit between 2nd interleaving unit and physical channel mapping unit. The operation of rate-matching guarantees that the bit streams is a even number and can be subdivided into 2 sub-frames. The transport channel multiplexing structure for uplink and downlink is shown in figure 2.

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$ where i is the TrCH number and X_i is the number bits. The two output bit sequences per radio frame are denoted by $y_{i,n_i1}, y_{i,n_i2}, y_{i,n_i3}, \ldots, y_{i,n_iY_i}$ where ni is the sub-frame number in current radio frame and Y_i is the number of bits per radio frame for TrCH i. The output sequences are defined as follows:

$y_{i,n_i k} = x_{i,((n_i-1)\cdot Y_i)+k}$, n_i = 1 or 2, k = 1…Y_i

where

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

x_{ik} is the k^th bit of the input bit sequence and

$y_{i,n_i k}$ is the k^th bit of the output bit sequence corresponding to the n^th sub-frame

The input bit sequence to the sub-frame segmentation is denoted by $v_{t,1}, v_{t,2}, v_{t,3}, \ldots, v_{t,U_t}$ ~~$v_{(t)1}, v_{(t)2}, \ldots, v_{(t)U_{(t)}}$~~ , $x_{ik} = v_{\cancel{(t)}t,k}$ and $X_i = U_{\cancel{(t)}}$.

The output bit sequence corresponding to subframe n_i is denoted by $g_{p1}, g_{p2}, \ldots, g_{pU_p}$, where p is the PhCH number and U_p is the number of bits in one subframe for the respective PhCH. Hence, $g_{pk} = y_{i,n_i k}$ and $U_p = Y_i$.

4.2.13 Physical channel mapping

4.2.13.1 Physical channel mapping for the 3.84 Mcps option

The PhCH for both uplink and downlink is defined in [6]. The bits after physical channel mapping are denoted by $w_{p,1}, w_{p,2}, \ldots, w_{p,U_p}$, where p is the PhCH number corresponding to the sequence number $1 \le p \le P$ ~~P_{max}~~ of this physical channel as detailed below, ~~and~~ U_p is the number of bits in one radio frame for the respective PhCH, and $P \le P_{max}$. The bits $w_{p,k}$ are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k.

The physical layer shall assign the physical channel sequence number p to the physical channels of the CCTrCH in the respective radio frame, treating each allocated timeslot in ascending order. If within a timeslot there are multiple physical channels they shall first be ordered in ascending order of the spreading factor (Q) and subsequently by channelisation code index (k), as shown in [9].

~~The physical channel sequence number *p* are to be allocated by the physical layer in ascending order of the timeslots in which they appear If more than one physical channel appears in a timeslot, they shall be allocated the sequence number in order of the timeslot first and then of their channelisation codes. The channelisation codes shall be ordered in ascending order of the spreading Factor (*Q*) and then channelisation index (*k*), as shown in [9].~~

The mapping of the bits ~~$v_{(t),1}, v_{(t),2}, \ldots, v_{(t),U_{(t)}}$~~ $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ is performed like block interleaving, writing the bits into columns, but a PhCH with an odd number is filled in forward order, whereas a PhCH with an even number is filled in reverse order.

The mapping scheme, as described in the following subclause, shall be applied individually for each timeslot t used in the current frame. Therefore, the bits $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ are assigned to the bits of the physical channels $w_{t,1,1\ldots U_{t1}}, w_{t,2,1\ldots U_{t2}}, \ldots, w_{t,P_t,1\ldots U_{tP_t}}$ in each timeslot.

In uplink there are at most two codes allocated (P≤2). If there is only one code, the same mapping as for downlink is applied. Denote SF1 and SF2 the spreading factors used for code 1 and 2, respectively. For the number of consecutive bits to assign per code bs_k the following rule is applied:

if

SF1 >= SF2 then $bs_1 = 1$; $bs_2 =$ SF1/SF2 ;

else

SF2 > SF1 then $bs_1 =$ SF2/SF1; $bs_2 = 1$;

end if

In the downlink case bs_p is 1 for all physical channels.

4.2.13.1.1 Mapping scheme

Notation used in this subclause:

P_t: number of physical channels for timeslot t , $P_t = 1..2$ for uplink ; $P_t = 1...16$ for downlink

$U_{t,p}$: capacity in bits for the physical channel p in timeslot t

$U_{t.}$: total number of bits to be assigned for timeslot t

bs_p: number of consecutive bits to assign per code

for downlink all $bs_p = 1$

for uplink if SF1 >= SF2 then $bs_1 = 1$; $bs_2 =$ SF1/SF2 ;

if SF2 > SF1 then $bs_1 =$ SF2/SF1; $bs_2 = 1$;

fb_p: number of already written bits for each code

pos: intermediate calculation variable

```
for p=1 to P_t                      -- reset number of already written bits for every physical channel
    fb_p = 0
end for
p = 1                               -- start with PhCH #1
for k=1 to U_t.
    do while (fb_p == U_t,p)            -- physical channel filled up already ?
        p = (p mod P_t) + 1;
    end do
    if (p mod 2) == 0
        pos = U_t,p - fb_p              -- reverse order
    else
        pos = fb_p + 1                  -- forward order
    endif
    w_t,p,pos = v_t,k               -- assignment
    fb_p = fb_p + 1                 -- Increment number of already written bits
    if (fb_p mod bs_p) == 0         -- Conditional change to the next physical channel
        p = (p mod P_t) + 1;
```

end if

end for

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R1-02-0734

CR-Form-v5

CHANGE REQUEST

z	**25.222**	**CR**	**074**	z **rev**	**-** z	Current version: **3.8.0** z

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Proposed change affects: z (U)SIM [ ] ME/UE [X] Radio Access Network [X] Core Network [ ]

Title: z	Zero padding for TFCI			
Source: z	TSG RAN WG1			
Work item code: z	TEI		***Date:*** z	April 4, 2002
Category: z	**F**		***Release:*** z	R99
	Use one of the following categories: ***F*** *(correction)* ***A*** *(corresponds to a correction in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* Detailed explanations of the above categories can be found in 3GPP TR 21.900.			*Use one of the following releases:* 2 *(GSM Phase 2)* *R96 (Release 1996)* *R97 (Release 1997)* *R98 (Release 1998)* *R99 (Release 1999)* *REL-4 (Release 4)* *REL-5 (Release 5)*

Reason for change: z	The coding method for TFCI in case that TFCI bit number is less than 10bits or 5bits is not clearly written.
Summary of change: z	In case of coding for long TFCI length, if the TFCI consist of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. In case of coding for short TFCI using bi-orthogonal codes, if the TFCI consist of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero.
Consequences if not approved: z	Ambiguous information in the specification.

Clauses affected: z	4.3.1.1, 4.3.1.2.2	
Other specs affected: z	[ ] Other core specifications [ ] Test specifications [ ] O&M Specifications	z
Other comments: z	Isolated impact analysis: the wording is added to avoid the misleading interpretation of the information.	

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1) Fill out the above form. The symbols above marked z contain pop-up help information about the field that they are closest to.

2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be

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3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change reques.

4.3 Coding for layer 1 control

4.3.1 Coding of transport format combination indicator (TFCI)

Encoding of the TFCI depends on its length. If there are 6-10 bits of TFCI the channel encoding is done as described in subclause 4.3.1.1. Also specific coding of less than 6 bits is possible as explained in subclause 4.3.1.2.

4.3.1.1 Coding of long TFCI lengths

The TFCI is encoded using a (32, 10) sub-code of the second order Reed-Muller code. The coding procedure is as shown in figure 7.

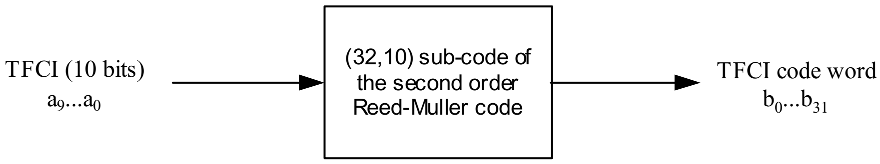

Figure 7: Channel coding of the TFCI bits

If the TFCI consists of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. TFCI is encoded by the (32,10) sub-code of second order Reed-Muller code. The code words of the (32,10) sub-code of second order Reed-Muller code are linear combination of some among 10 basis sequences. The basis sequences are as follows in table 8.

Table 8: Basis sequences for (32,10) TFCI code

I	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{I,4}$	$M_{i,5}$	$M_{i,6}$	$M_{i,7}$	$M_{i,8}$	$M_{i,9}$
0	1	0	0	0	0	1	0	0	0	0
1	0	1	0	0	0	1	1	0	0	0
2	1	1	0	0	0	1	0	0	0	1
3	0	0	1	0	0	1	1	0	1	1
4	1	0	1	0	0	1	0	0	0	1
5	0	1	1	0	0	1	0	0	1	0
6	1	1	1	0	0	1	0	1	0	0
7	0	0	0	1	0	1	0	1	1	0
8	1	0	0	1	0	1	1	1	1	0
9	0	1	0	1	0	1	1	0	1	1
10	1	1	0	1	0	1	0	0	1	1
11	0	0	1	1	0	1	0	1	1	0
12	1	0	1	1	0	1	0	1	0	1
13	0	1	1	1	0	1	1	0	0	1
14	1	1	1	1	0	1	1	1	1	1
15	1	0	0	0	1	1	1	1	0	0
16	0	1	0	0	1	1	1	1	0	1
17	1	1	0	0	1	1	1	0	1	0
18	0	0	1	0	1	1	0	1	1	1
19	1	0	1	0	1	1	0	1	0	1
20	0	1	1	0	1	1	0	0	1	1
21	1	1	1	0	1	1	0	1	1	1
22	0	0	0	1	1	1	0	1	0	0
23	1	0	0	1	1	1	1	1	0	1
24	0	1	0	1	1	1	1	0	1	0
25	1	1	0	1	1	1	1	0	0	1
26	0	0	1	1	1	1	0	0	1	0
27	1	0	1	1	1	1	1	1	0	0
28	0	1	1	1	1	1	1	1	1	0
29	1	1	1	1	1	1	1	1	1	1
30	0	0	0	0	0	1	0	0	0	0
31	0	0	0	0	1	1	1	0	0	0

The TFCI bits a_0 , a_1 , a_2 , a_3 , a_4 , a_5 , a_6 , a_7 , a_8 , a_9 (where a_0 is LSB and a_9 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output TFCI code word bits b_i are given by:

$$b_i = \sum_{n=0}^{9} (a_n \times M_{i,n}) \bmod 2$$

where $i = 0,\ldots,31$. $N_{\text{TFCI code word}} = 32$.

4.3.1.2 Coding of short TFCI lengths

4.3.1.2.1 Coding very short TFCIs by repetition

If the number of TFCI bits is 1 or 2, then repetition will be used for coding. In this case each bit is repeated to a total of 4 times giving 4-bit transmission ($N_{\text{TFCI code word}}=4$) for a single TFCI bit and 8-bit transmission ($N_{\text{TFCI code word}}=8$) for 2 TFCI bits. The TFCI bit(s) b_0 (or b_0 and b_1 where b_0 is the LSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame. In the case of two TFCI bits denoted b_0 and b_1 the TFCI code word shall be { b_0, b_1, b_0, b_1, b_0, b_1, b_0, b_1 }.

4.3.1.2.2 Coding short TFCIs using bi-orthogonal codes

If the number of TFCI bits is in the range 3 to 5 the TFCI is encoded using a (16, 5) bi-orthogonal (or first order Reed-Muller) code. The coding procedure is as shown in figure 8.

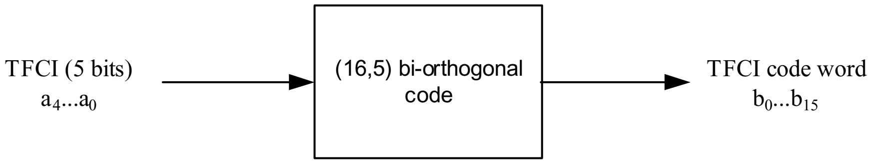

Figure 8: Channel coding of short length TFCI bits

If the TFCI consists of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero. The code words of the (16,5) bi-orthogonal code are linear combinations of 5 basis sequences as defined in table 9.

Table 9: Basis sequences for (16,5) TFCI code

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$
0	1	0	0	0	1
1	0	1	0	0	1
2	1	1	0	0	1
3	0	0	1	0	1
4	1	0	1	0	1
5	0	1	1	0	1
6	1	1	1	0	1
7	0	0	0	1	1
8	1	0	0	1	1
9	0	1	0	1	1
10	1	1	0	1	1
11	0	0	1	1	1
12	1	0	1	1	1
13	0	1	1	1	1
14	1	1	1	1	1
15	0	0	0	0	1

The TFCI bits a_0 , a_1 , a_2 , a_3 , a_4 (where a_0 is LSB and a_4 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output code word bits b_j are given by:

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

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

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R1-02-0734

CR-Form-v5

CHANGE REQUEST

z	**25.222**	**CR**	**075**	z **rev**	**1**	z Current version:	**4.3.0** z

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Proposed change affects: z (U)SIM [ ] ME/UE [X] Radio Access Network [X] Core Network [ ]

Title:	z	Zero padding for TFCI (3.84Mcps TDD)
Source:	z	TSG RAN WG1
Work item code:	z	TEI
Date:	z	May 9, 2002
Category:	z	**A**
Release:	z	REL-4

Use one of the following categories:
F *(correction)*
A *(corresponds to a correction in an earlier release)*
B *(addition of feature),*
C *(functional modification of feature)*
D *(editorial modification)*
Detailed explanations of the above categories can be found in 3GPP TR 21.900.

Use one of the following releases:
2 (GSM Phase 2)
R96 (Release 1996)
R97 (Release 1997)
R98 (Release 1998)
R99 (Release 1999)
REL-4 (Release 4)
REL-5 (Release 5)

Reason for change:	z	The coding method for TFCI in case that TFCI bit number is less than 10bits or 5bits is not clearly written.
Summary of change:	z	In case of coding for long TFCI length, if the TFCI consist of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. In case of coding for short TFCI using bi-orthogonal codes, if the TFCI consist of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero.
Consequences if not approved:	z	Ambiguous information in the specification.

Clauses affected:	z	4.3.1.1, 4.3.1.2.2
Other specs affected:	z	[ ] Other core specifications z [ ] Test specifications [ ] O&M Specifications
Other comments:	z	Isolated impact analysis: the wording is added to avoid the misleading interpretation of the information.

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4.3 Coding for layer 1 control for the 3.84 Mcps option

4.3.1 Coding of transport format combination indicator (TFCI)

Encoding of the TFCI depends on its length. If there are 6-10 bits of TFCI the channel encoding is done as described in subclause 4.3.1.1. Also specific coding of less than 6 bits is possible as explained in subclause 4.3.1.2.

4.3.1.1 Coding of long TFCI lengths

The TFCI is encoded using a (32, 10) sub-code of the second order Reed-Muller code. The coding procedure is as shown in figure 7.

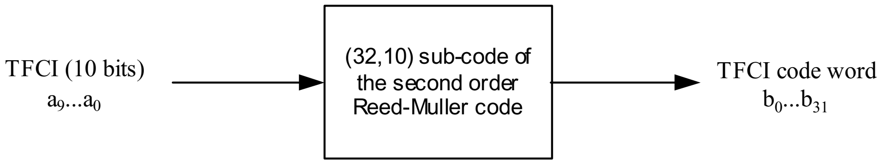

Figure 7: Channel coding of the TFCI bits

If the TFCI consists of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. TFCI is encoded by the (32,10) sub-code of second order Reed-Muller code. The code words of the (32,10) sub-code of second order Reed-Muller code are linear combination of some among 10 basis sequences. The basis sequences are as follows in table 9.

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I	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{I,4}$	$M_{i,5}$	$M_{i,6}$	$M_{i,7}$	$M_{i,8}$	$M_{i,9}$
0	1	0	0	0	0	1	0	0	0	0
1	0	1	0	0	0	1	1	0	0	0
2	1	1	0	0	0	1	0	0	0	1
3	0	0	1	0	0	1	1	0	1	1
4	1	0	1	0	0	1	0	0	0	1
5	0	1	1	0	0	1	0	0	1	0
6	1	1	1	0	0	1	0	1	0	0
7	0	0	0	1	0	1	0	1	1	0
8	1	0	0	1	0	1	1	1	1	0
9	0	1	0	1	0	1	1	0	1	1
10	1	1	0	1	0	1	0	0	1	1
11	0	0	1	1	0	1	0	1	1	0
12	1	0	1	1	0	1	0	1	0	1
13	0	1	1	1	0	1	1	0	0	1
14	1	1	1	1	0	1	1	1	1	1
15	1	0	0	0	1	1	1	1	0	0
16	0	1	0	0	1	1	1	1	0	1
17	1	1	0	0	1	1	1	0	1	0
18	0	0	1	0	1	1	0	1	1	1
19	1	0	1	0	1	1	0	1	0	1
20	0	1	1	0	1	1	0	0	1	1
21	1	1	1	0	1	1	0	1	1	1
22	0	0	0	1	1	1	0	1	0	0
23	1	0	0	1	1	1	1	1	0	1
24	0	1	0	1	1	1	1	0	1	0
25	1	1	0	1	1	1	1	0	0	1
26	0	0	1	1	1	1	0	0	1	0
27	1	0	1	1	1	1	1	1	0	0
28	0	1	1	1	1	1	1	1	1	0
29	1	1	1	1	1	1	1	1	1	1
30	0	0	0	0	0	1	0	0	0	0
31	0	0	0	0	1	1	1	0	0	0

The TFCI bits a_0 , a_1 , a_2 , a_3 , a_4 , a_5 , a_6 , a_7 , a_8 , a_9 (where a_0 is LSB and a_9 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output TFCI code word bits b_i are given by:

$$b_i = \sum_{n=0}^{9} (a_n \times M_{i,n}) \bmod 2$$

where $i = 0,\ldots,31$. $N_{\text{TFCI code word}} = 32$.

4.3.1.2 Coding of short TFCI lengths

4.3.1.2.1 Coding very short TFCIs by repetition

If the number of TFCI bits is 1 or 2, then repetition will be used for coding. In this case each bit is repeated to a total of 4 times giving 4-bit transmission ($N_{\text{TFCI code word}}$ =4) for a single TFCI bit and 8-bit transmission ($N_{\text{TFCI code word}}$ =8) for 2 TFCI bits. The TFCI bit(s) b_0 (or b_0 and b_1 where b_0 is the LSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame. In the case of two TFCI bits denoted b_0 and b_1 the TFCI code word shall be { $b_0, b_1, b_0, b_1, b_0, b_1, b_0, b_1$ }.

4.3.1.2.2 Coding short TFCIs using bi-orthogonal codes

If the number of TFCI bits is in the range 3 to 5 the TFCI is encoded using a (16, 5) bi-orthogonal (or first order Reed-Muller) code. The coding procedure is as shown in figure 8.

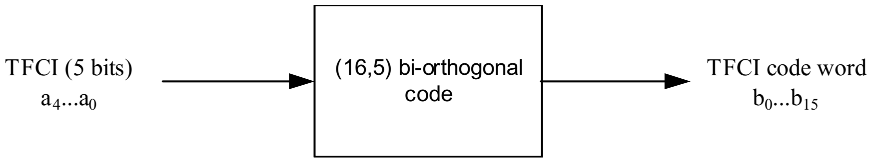

Figure 8: Channel coding of short length TFCI bits

If the TFCI consists of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero. The code words of the (16,5) bi-orthogonal code are linear combinations of 5 basis sequences as defined in table 10.

Table 10: Basis sequences for (16,5) TFCI code

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$
0	1	0	0	0	1
1	0	1	0	0	1
2	1	1	0	0	1
3	0	0	1	0	1
4	1	0	1	0	1
5	0	1	1	0	1
6	1	1	1	0	1
7	0	0	0	1	1
8	1	0	0	1	1
9	0	1	0	1	1
10	1	1	0	1	1
11	0	0	1	1	1
12	1	0	1	1	1
13	0	1	1	1	1
14	1	1	1	1	1
15	0	0	0	0	1

The TFCI bits a_0 , a_1 , a_2 , a_3 , a_4 (where a_0 is LSB and a_4 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output code word bits b_j are given by:

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

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

 R1-02-0734

CR-Form-v5

CHANGE REQUEST

z	**25.222**	**CR**	**076**	z **rev**	**1**	z	Current version:	**5.0.0**	z

*For **HELP** on using this form, see bottom of this page or look at the pop-up text over the z symbols.*

Proposed change affects: z (U)SIM [ ] ME/UE [X] Radio Access Network [X] Core Network [ ]

Title:	z	Zero padding for TFCI (3.84Mcps TDD)		
Source:	z	TSG RAN WG1		
Work item code:	z	TEI	***Date:*** z	May 9, 2002
Category:	z	**A** *Use one of the following categories:* ***F*** *(correction)* ***A*** *(corresponds to a correction in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* Detailed explanations of the above categories can be found in 3GPP TR 21.900.	***Release:*** z	REL-5 *Use one of the following releases:* *2 (GSM Phase 2)* *R96 (Release 1996)* *R97 (Release 1997)* *R98 (Release 1998)* *R99 (Release 1999)* *REL-4 (Release 4)* *REL-5 (Release 5)*

Reason for change:	z	The coding method for TFCI in case that TFCI bit number is less than 10bits or 5bits is not clearly written.
Summary of change:	z	In case of coding for long TFCI length, if the TFCI consist of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. In case of coding for short TFCI using bi-orthogonal codes, if the TFCI consist of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero.
Consequences if not approved:	z	Ambiguous information in the specification.

Clauses affected:	z	4.3.1.1, 4.3.1.2.2		
Other specs affected:	z	[ ] Other core specifications [ ] Test specifications [ ] O&M Specifications	z	
Other comments:	z	Isolated impact analysis: the wording is added to avoid the misleading interpretation of the information.		

How to create CRs using this form:

Comprehensive information and tips about how to create CRs can be found at: http://www.3gpp.org/3G_Specs/CRs.htm. Below is a brief summary:

1) Fill out the above form. The symbols above marked z contain pop-up help information about the field that they are closest to.

2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be

downloaded from the 3GPP server under ftp://ftp.3gpp.org/specs/ For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.

3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change reques.

4.3 Coding for layer 1 control for the 3.84 Mcps option

4.3.1 Coding of transport format combination indicator (TFCI)

Encoding of the TFCI depends on its length. If there are 6-10 bits of TFCI the channel encoding is done as described in subclause 4.3.1.1. Also specific coding of less than 6 bits is possible as explained in subclause 4.3.1.2.

4.3.1.1 Coding of long TFCI lengths

The TFCI is encoded using a (32, 10) sub-code of the second order Reed-Muller code. The coding procedure is as shown in figure 7.

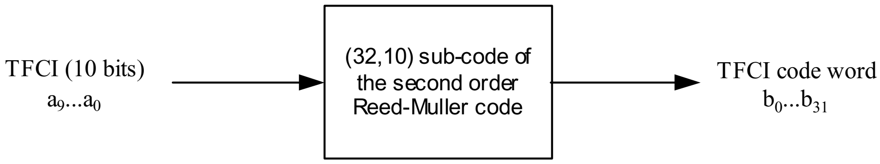

Figure 7: Channel coding of the TFCI bits

If the TFCI consists of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. TFCI is encoded by the (32,10) sub-code of second order Reed-Muller code. The code words of the (32,10) sub-code of second order Reed-Muller code are linear combination of some among 10 basis sequences. The basis sequences are as follows in table 9.

Table 9: Basis sequences for (32,10) TFCI code

I	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{I,4}$	$M_{i,5}$	$M_{i,6}$	$M_{i,7}$	$M_{i,8}$	$M_{i,9}$
0	1	0	0	0	0	1	0	0	0	0
1	0	1	0	0	0	1	1	0	0	0
2	1	1	0	0	0	1	0	0	0	1
3	0	0	1	0	0	1	1	0	1	1
4	1	0	1	0	0	1	0	0	0	1
5	0	1	1	0	0	1	0	0	1	0
6	1	1	1	0	0	1	0	1	0	0
7	0	0	0	1	0	1	0	1	1	0
8	1	0	0	1	0	1	1	1	1	0
9	0	1	0	1	0	1	1	0	1	1
10	1	1	0	1	0	1	0	0	1	1
11	0	0	1	1	0	1	0	1	1	0
12	1	0	1	1	0	1	0	1	0	1
13	0	1	1	1	0	1	1	0	0	1
14	1	1	1	1	0	1	1	1	1	1
15	1	0	0	0	1	1	1	1	0	0
16	0	1	0	0	1	1	1	1	0	1
17	1	1	0	0	1	1	1	0	1	0
18	0	0	1	0	1	1	0	1	1	1
19	1	0	1	0	1	1	0	1	0	1
20	0	1	1	0	1	1	0	0	1	1
21	1	1	1	0	1	1	0	1	1	1
22	0	0	0	1	1	1	0	1	0	0
23	1	0	0	1	1	1	1	1	0	1
24	0	1	0	1	1	1	1	0	1	0
25	1	1	0	1	1	1	1	0	0	1
26	0	0	1	1	1	1	0	0	1	0
27	1	0	1	1	1	1	1	1	0	0
28	0	1	1	1	1	1	1	1	1	0
29	1	1	1	1	1	1	1	1	1	1
30	0	0	0	0	0	1	0	0	0	0
31	0	0	0	0	1	1	1	0	0	0

The TFCI bits a_0 , a_1 , a_2 , a_3 , a_4 , a_5 , a_6 , a_7 , a_8 , a_9 (where a_0 is LSB and a_9 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output TFCI code word bits b_i are given by:

$$b_i = \sum_{n=0}^{9} (a_n \times M_{i,n}) \bmod 2$$

where $i = 0,\ldots,31$. $N_{\text{TFCI code word}} = 32$.

4.3.1.2 Coding of short TFCI lengths

4.3.1.2.1 Coding very short TFCIs by repetition

If the number of TFCI bits is 1 or 2, then repetition will be used for coding. In this case each bit is repeated to a total of 4 times giving 4-bit transmission ($N_{\text{TFCI code word}}$ =4) for a single TFCI bit and 8-bit transmission ($N_{\text{TFCI code word}}$ =8) for 2 TFCI bits. The TFCI bit(s) b_0 (or b_0 and b_1 where b_0 is the LSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame. In the case of two TFCI bits denoted b_0 and b_1 the TFCI code word shall be { $b_0, b_1, b_0, b_1, b_0, b_1, b_0, b_1$ }.

4.3.1.2.2 Coding short TFCIs using bi-orthogonal codes

If the number of TFCI bits is in the range 3 to 5 the TFCI is encoded using a (16, 5) bi-orthogonal (or first order Reed-Muller) code. The coding procedure is as shown in figure 8.

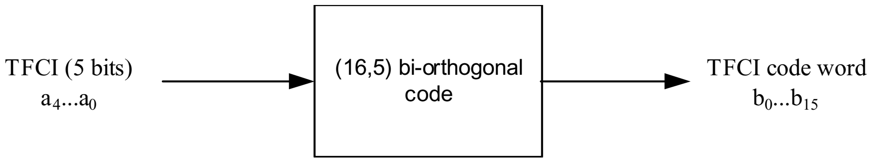

Figure 8: Channel coding of short length TFCI bits

If the TFCI consists of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero. The code words of the (16,5) bi-orthogonal code are linear combinations of 5 basis sequences as defined in table 10.

Table 10: Basis sequences for (16,5) TFCI code

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$
0	1	0	0	0	1
1	0	1	0	0	1
2	1	1	0	0	1
3	0	0	1	0	1
4	1	0	1	0	1
5	0	1	1	0	1
6	1	1	1	0	1
7	0	0	0	1	1
8	1	0	0	1	1
9	0	1	0	1	1
10	1	1	0	1	1
11	0	0	1	1	1
12	1	0	1	1	1
13	0	1	1	1	1
14	1	1	1	1	1
15	0	0	0	0	1

The TFCI bits a_0 , a_1 , a_2 , a_3 , a_4 (where a_0 is LSB and a_4 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output code word bits b_j are given by:

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

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

3GPP TSG RAN Meeting #16
Marco Island, FL, U.S.A., 4 – 7, June 2002

R1-02-0445

CR-Form-v4

CHANGE REQUEST

z	**25.222 CR 077**	z	rev	**-**	z	Current version: **5.0.0** z

For ***HELP*** *on using this form, see bottom of this page or look at the pop-up text over the z symbols.*

Proposed change affects: z (U)SIM [ ] ME/UE [X] Radio Access Network [X] Core Network [ ]

Title:	z	Second Stage Interleaving and Physical Channel Mapping		
Source:	z	TSG RAN WG1		
Work item code:	z	TEI	***Date:*** z	4 April 2002
Category:	z	**A**	***Release:*** z	REL-5
		Use one of the following categories: ***F*** *(correction)* ***A*** *(corresponds to a correction in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* Detailed explanations of the above categories can be found in 3GPP TR 21.900.		*Use one of the following releases:* *2 (GSM Phase 2)* *R96 (Release 1996)* *R97 (Release 1997)* *R98 (Release 1998)* *R99 (Release 1999)* *REL-4 (Release 4)* *REL-5 (Release 5)*

Reason for change:	z	There are 2 inconsistencies: 1) The output from second stage frame related interleaving is not time slot segmented, but frame segmented. The input to physical channel mapping requires the output of the second stage interleaver be segmented in to slots, as defined in Fig1 of TS25.222. This segmentation process is not defined. 2) The number of physical channels is set by Rate Matching and is equal to P, where P<=Pmax. Therefore, the number of physical channels after physical channel mapping is P.
Summary of change:	z	Correction of output from second stage frame related interleaving, and the number of physical channels after physical channel mapping.
Consequences if not approved:	z	Ambiguous mapping of bits from second stage frame related interleaving to physical channel mapping. **Isolated Impact Analysis:** Correction to a function where the specification was : • ambiguous or not sufficiently explicit. • Would not affect implementations behaving like indicated in the CR, would affect implementations supporting the corrected functionality otherwise. The CR intends to clarify behaviour that has very likely been assumed in most implementations.

Clauses affected:	z	4.2,4.2.7, 4.2.7.1, 4.2.10, 4.2.11.1, 4.2.11.2, 4.2.12, 4.2.13

Other specs affected:	z	[ ] Other core specifications [ ] Test specifications [ ] O&M Specifications	z	
Other comments:	z			

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2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under ftp://ftp.3gpp.org/specs/ For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.

3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

4.2 Transport channel coding/multiplexing

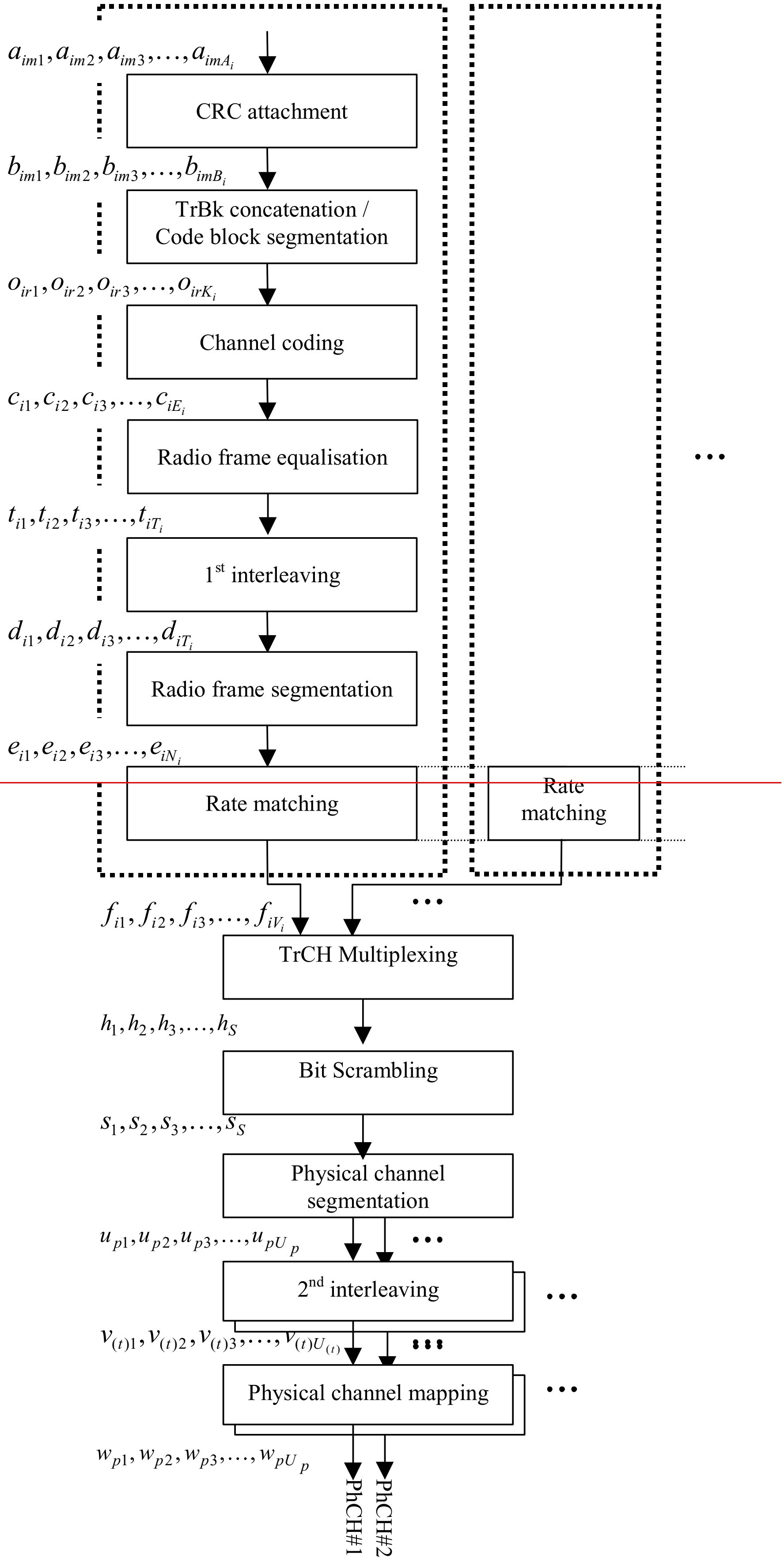
Figure 1 illustrates the overall concept of transport-channel coding and multiplexing. Data arrives to the coding/multiplexing unit in form of transport block sets, once every transmission time interval. The transmission time interval is transport-channel specific from the set {5 ms$^{(*1)}$, 10 ms, 20 ms, 40 ms, 80 ms}.

Note: $^{(*1)}$ may be applied for PRACH for 1.28 Mcps TDD

The following coding/multiplexing steps can be identified:

- add CRC to each transport block (see subclause 4.2.1);
- TrBk concatenation / Code block segmentation (see subclause 4.2.2);
- channel coding (see subclause 4.2.3) ;
- radio frame size equalization (see subclause 4.2.4);
- interleaving (two steps, see subclauses 4.2.5 and 4.2.10);
- radio frame segmentation (see subclause 4.2.6);
- rate matching (see subclause 4.2.7);
- multiplexing of transport channels (see subclause 4.2.8);
- bit scrambling (see subclause 4.2.9);
- physical channel segmentation (see subclause 4.2.10);
- sub-frame segmentation(see subclause 4.2.12 only for 1.28Mcps TDD)
- mapping to physical channels (see subclause 4.2.13).

The coding/multiplexing steps for uplink and downlink are shown in figures 1 and 2.


$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$
CRC attachment
$b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$
TrBk concatenation / Code block segmentation
$o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$
Channel coding
$c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$
Radio frame equalisation
$t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$
1st interleaving
$d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$
Radio frame segmentation
$e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$
Rate matching
Rate matching
$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$
TrCH Multiplexing
$h_1, h_2, h_3, \ldots, h_S$
Bit Scrambling
$s_1, s_2, s_3, \ldots, s_S$
Physical channel segmentation
$u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU_p}$
2nd interleaving
$v_{(t)1}, v_{(t)2}, v_{(t)3}, \ldots, v_{(t)U_{(t)}}$
Physical channel mapping
$w_{p1}, w_{p2}, w_{p3}, \ldots, w_{pU_p}$
PhCH#1
PhCH#2

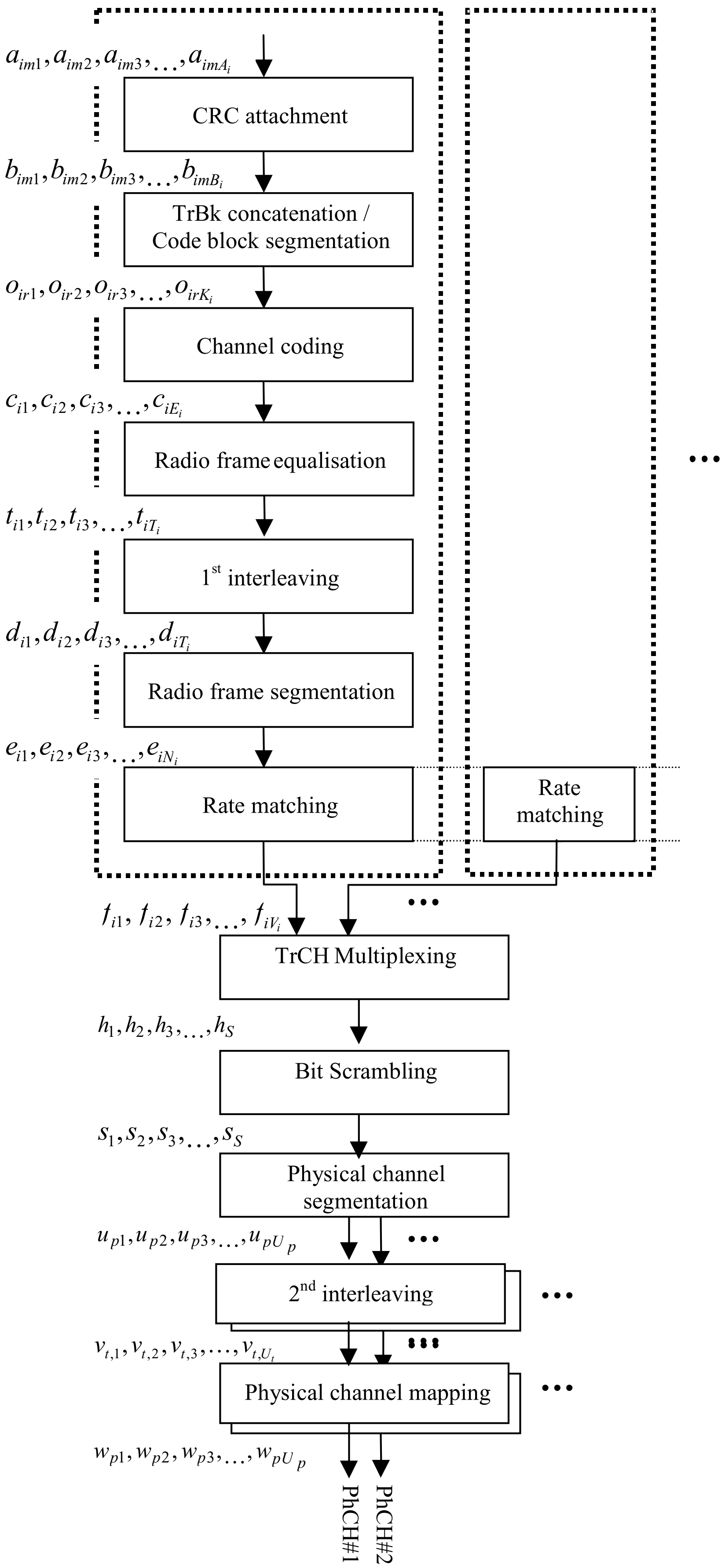
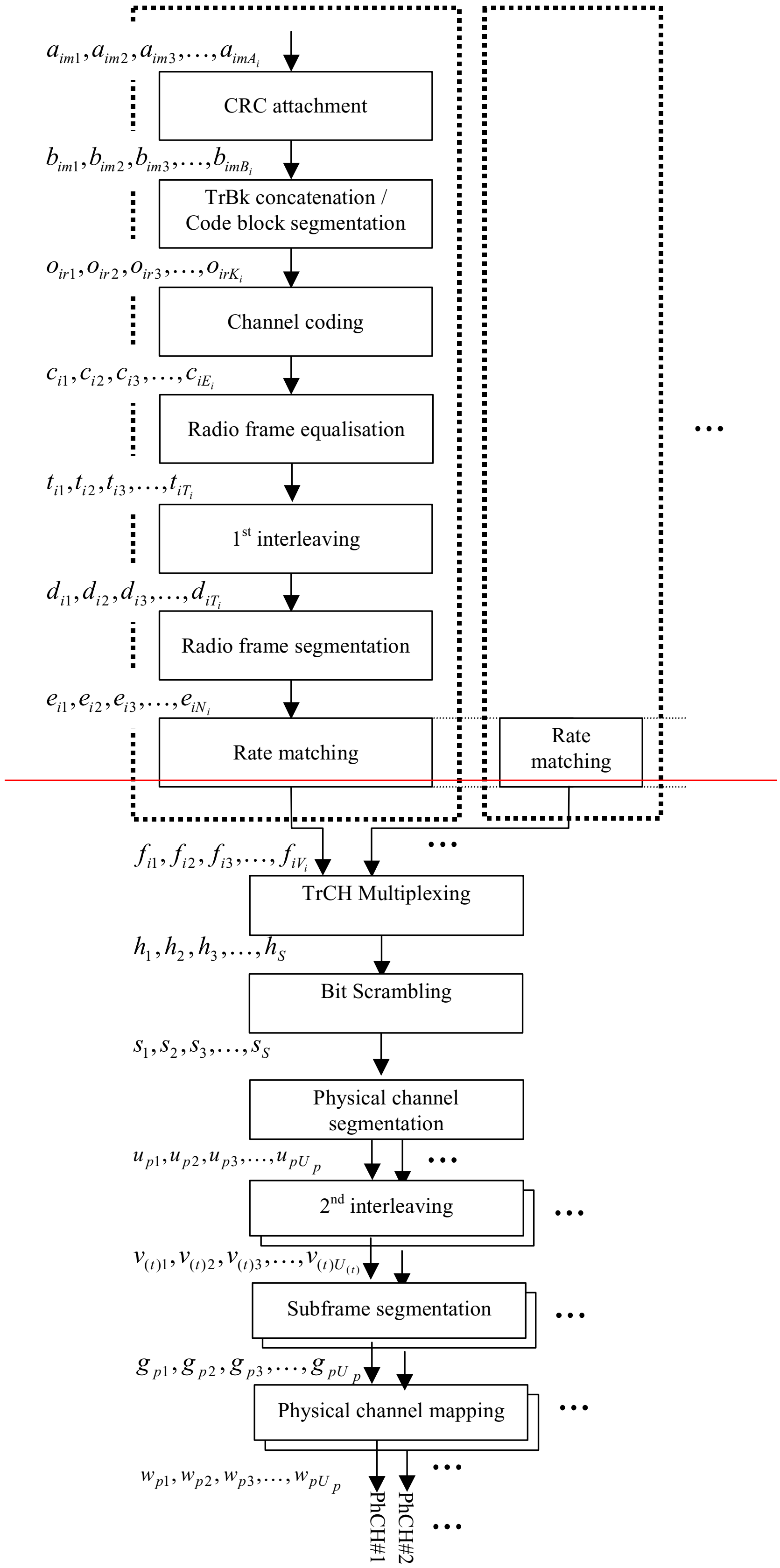


Figure 1: Transport channel multiplexing structure for uplink and downlink for 3.84Mcps TDD



$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$
CRC attachment
$b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$
TrBk concatenation / Code block segmentation
$o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$
Channel coding
$c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$
Radio frame equalisation
$t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$
1st interleaving
$d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$
Radio frame segmentation
$e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$
Rate matching
Rate matching
$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$
TrCH Multiplexing
$h_1, h_2, h_3, \ldots, h_S$
Bit Scrambling
$s_1, s_2, s_3, \ldots, s_S$
Physical channel segmentation
$u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU_p}$
2nd interleaving
$v_{(t)1}, v_{(t)2}, v_{(t)3}, \ldots, v_{(t)U_{(t)}}$
Subframe segmentation
$g_{p1}, g_{p2}, g_{p3}, \ldots, g_{pU_p}$
Physical channel mapping
$w_{p1}, w_{p2}, w_{p3}, \ldots, w_{pU_p}$
PhCH#1
PhCH#2

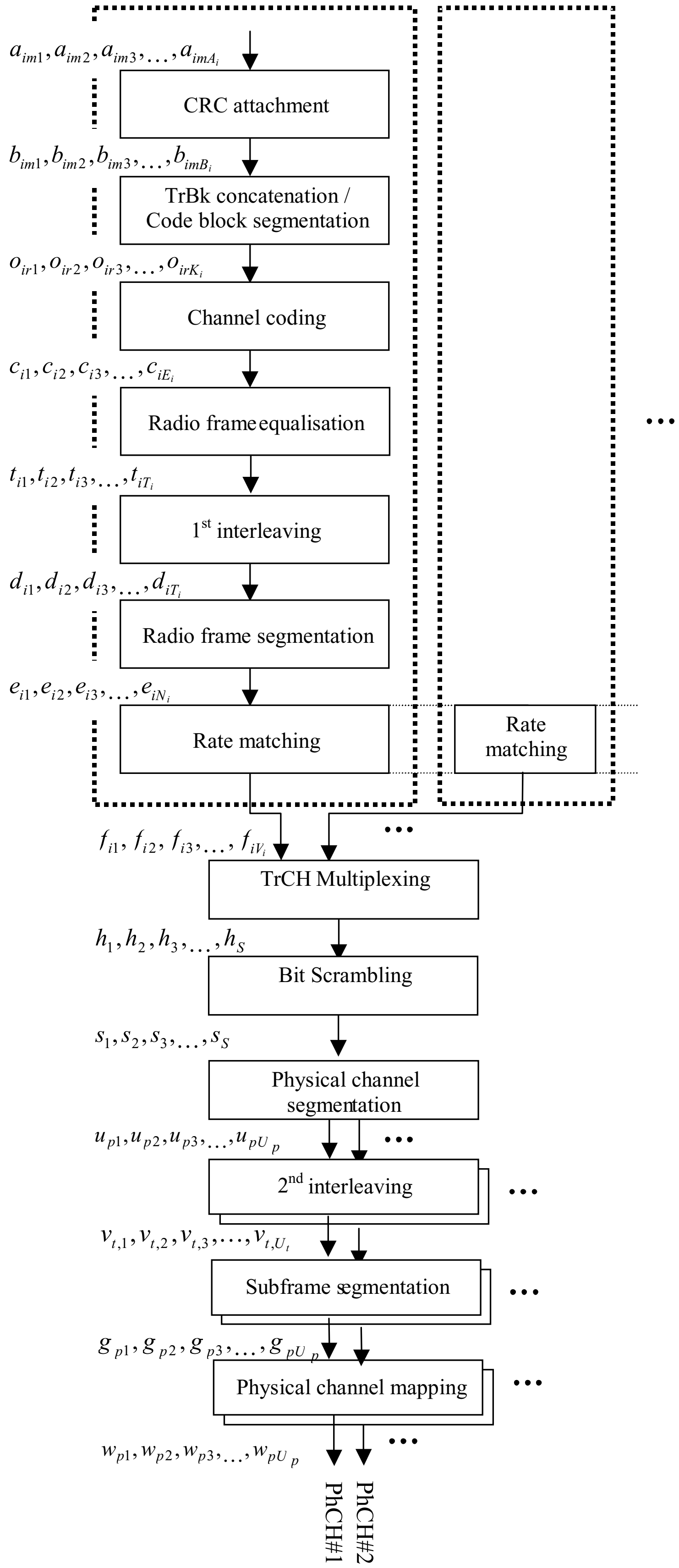


Figure 2: Transport channel multiplexing structure for uplink and downlink of 1.28Mcps TDD

Primarily, transport channels are multiplexed as described above, i.e. into one data stream mapped on one or several physical channels. However, an alternative way of multiplexing services is to use multiple CCTrCHs (Coded Composite Transport Channels), which corresponds to having several parallel multiplexing chains as in figures 1 and 2, resulting in several data streams, each mapped to one or several physical channels.

4.2.7 Rate matching

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

The number of bits on a TrCH can vary between different transmission time intervals. When the number of bits between different transmission time intervals is changed, bits are repeated to ensure that the total bit rate after TrCH multiplexing is identical to the total channel bit rate of the allocated physical channels.

If no bits are input to the rate matching for all TrCHs within a CCTrCH, the rate matching shall output no bits for all TrCHs within the CCTrCH.

Notation used in subclause 4.2.7 and subclauses:

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

$\Delta N_{i,j}$: If positive – number of bits to be repeated in each radio frame on TrCH *i* with transport format

If negative – number of bits to be punctured in each radio frame on TrCH *i* with transport format combination *j*.

RM_i : Semi-static rate matching attribute for TrCH *i*. Signalled from higher layers.

PL : Puncturing limit. This value limits the amount of puncturing that can be applied in order to minimise the number of physical channels. Signalled from higher layers. The allowed puncturing in % is actually equal to (1-PL)*100.

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

P : number of physical channels used in the current frame.

P_{max} : maximum number of physical channels allocated for a CCTrCH.

U_p : Number of data bits in the physical channel p with p = 1...P.

I : Number of TrCHs in a CCTrCH.

Z_{ij} : Intermediate calculation variable.

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

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

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

$P1_F(n_i)$: The column permutation function of the 1st interleaver, $P1_F(x)$ is the original position of column with number x after permutation. P1 is defined on table 5 of section 4.2.5 (note that $P1_F$ self-inverse).

S[n] : The shift of the puncturing or repetition pattern for radio frame n_i when $n = \mathrm{P1}_{F_i}(n_i)$.

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

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

e_{ini} : Initial value of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.

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

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

b : Indicates systematic and parity bits.

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

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

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

4.2.7.1 Determination of rate matching parameters

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

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

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

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

Puncturing can be used to minimise the required transmission capacity. The maximum amount of puncturing that can be applied is 1-PL, PL is signalled from higher layers. The possible values for N_{data} depend on the number of physical channels P_{max} , allocated to the respective CCTrCH, and on their characteristics (spreading factor, length of midamble and TFCI code word, usage of TPC and multiframe structure), which is given in [7].

For each physical channel an individual minimum spreading factor Sp_{min} is transmitted by means of the higher layers. Denote the number of data bits in each physical channel by $U_{p,Sp}$, where p indicates the sequence number $1 \le p \le P_{max}$ and Sp indicates the spreading factor with the possible values $\{16, 8, 4, 2, 1\}$ of this physical channel. The index p is described in section 4.2.13 with the following modifications: spreading factor (Q) is replaced by the minimum spreading factor Sp_{min} and k is replaced by the channelization code index at $Q = Sp_{min}$. Then, for N_{data} one of the following values in ascending order can be chosen:

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

Optionally, if indicated by higher layers for the UL the UE shall vary the spreading factor autonomously, so that N_{data} is one of the following values in ascending order:

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

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

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

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

The number of bits to be repeated or punctured, $\Delta N_{i,j}$, within one radio frame for each TrCH i is calculated with the relations given at the beginning of this subclause for all possible transport format combinations j and selected every radio frame. The number of physical channels corresponding to $N_{data,j}$, shall be denoted by P.

If $\Delta N_{i,j} = 0$ then the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.3 does not need to be executed.

Otherwise, the rate matching pattern is calculated with the algorithm described in subclause 4.2.7.3. For this algorithm the parameters e_{ini}, e_{plus}, e_{minus}, and X_i are needed, which are calculated according to the equations in subclauses 4.2.7.1.1 and 4.2.7.1.2.

4.2.10 Physical channel segmentation

When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $s_1, s_2, s_3, \ldots, s_S$, where S is the number of bits input to the physical channel segmentation block. The number of PhCHs after rate matching is denoted by *P*, as defined in subclause 4.2.7.1.

The bits after physical channel segmentation are denoted $u_{p,1}, u_{p,2}, u_{p,3}, \ldots, u_{p,U_p}$, where *p* is PhCH number and U_p is the in general variable number of bits in the respective radio frame for each PhCH. The relation between s_k and $u_{p,k}$ is given below.

Bits on first PhCH after physical channel segmentation:

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

Bits on second PhCH after physical channel segmentation:

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

…

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

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

4.2.11 2nd interleaving

The 2nd interleaving is a block interleaver and consists of bits input to a matrix with padding, the inter-column permutation for the matrix and bits output from the matrix with pruning. The 2nd interleaving can be applied jointly to all data bits transmitted during one frame, or separately within each timeslot, on which the CCTrCH is mapped. The selection of the 2nd interleaving scheme is controlled by higher layer.

4.2.11.1 Frame related 2nd interleaving

In case of frame related 2nd interleaving, the bits input to the block interleaver are denoted by $x_1, x_2, x_3, \ldots, x_U$, where *U* is the total number of bits after TrCH multiplexing transmitted during the respective radio frame with $S = U = \sum_p U_p$.

The relation between x_k and the bits $u_{p,k}$ in the respective physical channels is given below:

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

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

…

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

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

(1) Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

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

$U \le$ R2 X C2.

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

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

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

where $y_k = x_k$ for k = 1, 2, …, U and if R2 × C2 > U, the dummy bits are padded such that y_k = 0 or 1 for k = U + 1, U + 2, …, R2 × C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle P2(j) \rangle_{j \in \{0,1,\ldots,C2-1\}}$ that is shown in table 7, where $P_2(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by y'_k.

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

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits y'_k that corresponds to bits y_k with $k > U$ are removed from the output. The bits ~~after frame related 2nd interleaving~~at the output of the block interleaver are denoted by $\cancel{v_1, v_2, \ldots, v_U}$ $z_1, z_2, \ldots, z_U$, where $\cancel{v_1}$ z_1 corresponds to the bit y'_k with smallest index k after pruning, $\cancel{v_2}$ z_2 to the bit y'_k with second smallest index k after pruning, and so on.

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

$u_{1,k} = z_k$ k = 1, 2 , …, U_1

$u_{2,k} = z_{(k+U_1)}$ k = 1, 2 , …, U_2

…

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

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

Let T be the number of time slots in a CCTrCH during the respective radio frame (where for 1.28Mcps TDD, the respective radio frame includes subframes 1 and 2), and $t = 1, \ldots, T$. The physical layer shall assign the time slot sequence number t in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In time slot t, R_t refers to the number of physical channels within the respective time slot and $r = 1, \ldots, R_t$. The relation between r and t and the physical channel sequence number p as detailed in 4.2.13.1 is given by:

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

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

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

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

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

…

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

4.2.11.2 Timeslot related 2nd interleaving

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

Let *T* be the number of time slots in a CCTrCH during the respective radio frame (where for 1.28Mcps TDD, the respective radio frame includes subframes 1 and 2), and $t = 1, \ldots, T$. The physical layer shall assign the time slot sequence number *t* in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In ~~each~~ timeslot *t*, ~~the relation between $x_{t,k}$ and $u_{t,p,k}$ is given below with~~ R_t ~~P_t~~ refers~~ring~~ to the number of physical channels within the respective timeslot and $r = 1, \ldots, R_t$. ~~:~~ The relation between *r* and *t* and the physical channel sequence number *p* as detailed in 4.2.13.1 is given by:

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

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

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

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

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

…

$$\cancel{x_{t,(k+U_{t1}+\ldots+U_{t(P_t-1)})} = u_{t,P_t,k} \quad k = 1, 2, \ldots, U_{tP_t}}$$

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

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

(1) Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

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

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

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

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

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

where $y_{t,k} = x_{t,k}$ for k = 1, 2, …, U_t and if R2 × C2 > U_t, the dummy bits are padded such that $y_{t,k}$ = 0 or 1 for $k = U_t + 1, U_t + 2, \ldots$, R2 × C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle \mathrm{P2}(j) \rangle_{j\in\{0,1,\ldots,\mathrm{C2}-1\}}$ that is shown in table 7, where P2(j) is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by $y'_{t,k}$.

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

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits $y'_{t,k}$ that corresponds to bits $y_{t,k}$ with $k > U_t$ are removed from the output. The bits after time slot 2nd interleaving are denoted by $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$, where $v_{t,1}$ corresponds to the bit $y'_{t,k}$ with smallest index k after pruning, $v_{t,2}$ to the bit $y'_{t,k}$ with second smallest index k after pruning, and so on.

Table 7 Inter-column permutation pattern for 2nd interleaving

Number of Columns C2	Inter-column permutation pattern < P2(0), P2(1), …, P2(C2-1) >
30	<0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17>

4.2.12 Sub-frame segmentation for the 1.28 Mcps option

In the 1.28Mcps TDD, it is needed to add a sub-frame segmentation unit between 2nd interleaving unit and physical channel mapping unit. The operation of rate-matching guarantees that the bit streams is a even number and can be subdivided into 2 sub-frames. The transport channel multiplexing structure for uplink and downlink is shown in figure 2.

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$ where i is the TrCH number and X_i is the number bits. The two output bit sequences per radio frame are denoted by $y_{i,n_i1}, y_{i,n_i2}, y_{i,n_i3}, \ldots, y_{i,n_iY_i}$ where ni is the sub-frame number in current radio frame and Y_i is the number of bits per radio frame for TrCH i. The output sequences are defined as follows:

$y_{i,n_ik} = x_{i,((n_i-1)\cdot Y_i)+k}$, n_i = 1 or 2, k = 1…Y_i

where

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

x_{ik} is the k[th] bit of the input bit sequence and

$y_{i,n_i k}$ is the k[th] bit of the output bit sequence corresponding to the n[th] sub-frame

The input bit sequence to the sub-frame segmentation is denoted by $v_{t,1}, v_{t,2}, v_{t,3}, \ldots, v_{t,U_t}$ $\cancel{v_{(t)1}, v_{(t)2}, \ldots, v_{(t)U_{(t)}}}$, $x_{ik} = v_{\cancel{(t)}t,k}$ and $X_i = U_{\cancel{(t)}}$.

The output bit sequence corresponding to subframe n_i is denoted by $g_{p1}, g_{p2}, \ldots, g_{pU_p}$, where p is the PhCH number and U_p is the number of bits in one subframe for the respective PhCH. Hence, $g_{pk} = y_{i,n_i k}$ and $U_p = Y_i$.

4.2.13 Physical channel mapping

4.2.13.1 Physical channel mapping for the 3.84 Mcps option

The PhCH for both uplink and downlink is defined in [6]. The bits after physical channel mapping are denoted by $w_{p,1}, w_{p,2}, \ldots, w_{p,U_p}$, where *p* is the PhCH number corresponding to the sequence number $1 \le p \le P$ $\cancel{P_{max}}$ of this physical channel as detailed below, ~~and~~ U_p is the number of bits in one radio frame for the respective PhCH, and $P \le P_{max}$. The bits $w_{p,k}$ are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to *k*.

The physical layer shall assign the physical channel sequence number *p* to the physical channels of the CCTrCH in the respective radio frame, treating each allocated timeslot in ascending order. If within a timeslot there are multiple physical channels they shall first be ordered in ascending order of the spreading factor (*Q*) and subsequently by channelisation code index (*k*), as shown in [9].

~~The physical channel sequence number *p* are to be allocated by the physical layer in ascending order of the timeslots in which they appear If more than one physical channel appears in a timeslot, they shall be allocated the sequence number in order of the timeslot first and then of their channelisation codes. The channelisation codes shall be ordered in ascending order of the spreading Factor (*Q*) and then channelisation index (*k*), as shown in [9].~~

The mapping of the bits $\cancel{v_{(t),1}, v_{(t),2}, \ldots, v_{(t),U_{(t)}}}$ $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ is performed like block interleaving, writing the bits into columns, but a PhCH with an odd number is filled in forward order, where~~-~~as a PhCH with an even number is filled in reverse order.

The mapping scheme, as described in the following subclause, shall be applied individually for each timeslot *t* used in the current frame. Therefore, the bits $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ are assigned to the bits of the physical channels $w_{t,1,1 \ldots U_{t1}}, w_{t,2,1 \ldots U_{t2}}, \ldots, w_{t,P_t,1 \ldots U_{tP_t}}$ in each timeslot.

In uplink there are at most two codes allocated (P≤2). If there is only one code, the same mapping as for downlink is applied. Denote SF1 and SF2 the spreading factors used for code 1 and 2, respectively. For the number of consecutive bits to assign per code bs_k the following rule is applied:

if

SF1 >= SF2 then $bs_1 = 1$; $bs_2 =$ SF1/SF2 ;

else

SF2 > SF1 then bs_1 = SF2/SF1; bs_2 = 1 ;

end if

In the downlink case bs_p is 1 for all physical channels.

4.2.13.1.1 Mapping scheme

Notation used in this subclause:

P_t: number of physical channels for timeslot t , P_t = 1..2 for uplink ; P_t = 1...16 for downlink

$U_{t,p}$: capacity in bits for the physical channel p in timeslot t

$U_{t.}$: total number of bits to be assigned for timeslot t

bs_p: number of consecutive bits to assign per code

for downlink all bs_p = 1

for uplink if SF1 >= SF2 then bs_1 = 1 ; bs_2 = SF1/SF2 ;

if SF2 > SF1 then bs_1 = SF2/SF1; bs_2 = 1 ;

fb_p: number of already written bits for each code

pos: intermediate calculation variable

```
for p=1 to P_t                  -- reset number of already written bits for every physical channel
    fb_p = 0
end for
p = 1                           -- start with PhCH #1
for k=1 to U_t.
    do while (fb_p == U_t,p)        -- physical channel filled up already ?
        p = (p mod P_t) + 1;
    end do
    if (p mod 2) == 0
        pos = U_t,p - fb_p          -- reverse order
    else
        pos = fb_p + 1              -- forward order
    endif
    w_t,p,pos = v_t,k           -- assignment
    fb_p = fb_p + 1             -- Increment number of already written bits
    if (fb_p mod bs_p) == 0     -- Conditional change to the next physical channel
        p = (p mod P_t) + 1;
    end if
end for
```