TSG-RAN Working Group 1 meeting #7
Hannover, Germany
August 30 – September 3, 1999

TSGR1#7(99)b20

Agenda item:

Source: Ericsson, ETRI

Title: Uplink channelization code allocation in UTRA/FDD, revised

Document for: Decision

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1 Introduction

At WG1#5 in Cheju, it was decided that in UTRA/FDD uplink single-code transmission with as high spreading factor as possible should be performed at all times. Multi-code transmission is only applied with a spreading factor of 4. Hence, up to six parallel DPDCHs of SF=4 can be supported in uplink. The exact order of allocating the codes was not agreed though.

This contribution proposes a certain allocation procedure, and comes with a text proposal.

2 Proposal

When multi-code transmission with SF=4 is employed, the minimum gross bit rate will be (with the 4.096 Mcps chip rate) $2\times4.096\times10^6/4$ = 2048000 bit/s = 2048 kbps. For these very high bit rates, the scheme in Figure 2 in sub-clause 4.2.1 in 25.213 has been assumed up to now. For simplicity, we propose that a similar multi-code transmission scheme is maintained. The may also be simplified, since the maximum number of DPDCHs is 6. In TSGR1#6(99)828, the peak-to-average properties of the HPSK modulation with multi-code transmission is investigated. The allocation order proposed in that document is used in the text proposal below, ensuring that the peak-to-average values are as small as possible.

A text proposal incorporating the changes into 25.213 is found below. The text proposal addresses some additional issues:

- Some general cleanup of the text in sub-clauses 4.2 and 4.3.
- Numbering of channelization codes goes from 0 up to SF-1, since this is more consistent with the fact that they have to be signalled in binary format in many cases. Note that figure 3 has been updated with this new numbering.
- Figure 4 was modified to handle +1/-1 signals and not binary inverse.
- As pointed out in a discussion on the reflector, there was an error in the table with β-values. This has been corrected. Moreover, since all DPDCHs in multi-code has the same spreading factor, the power of all the DPDCHs will be the same.

Text proposal for 25.213

4.1 Overview

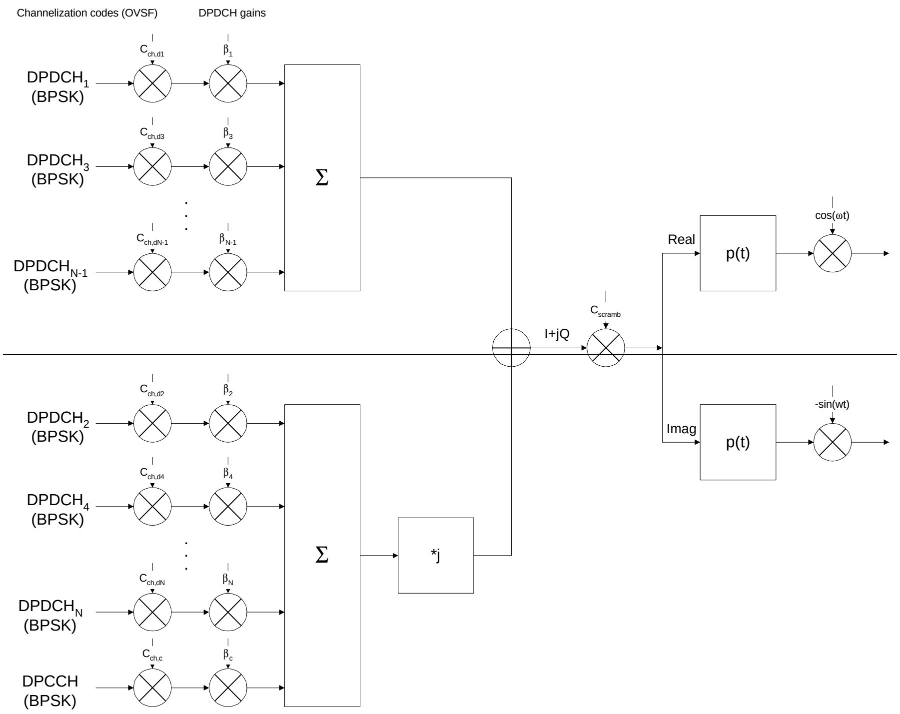
Spreading is applied ~~after modulation and~~ to the physical channels before pulse shaping and modulation. It consists of two operations. The first is the channelization operation, which transforms every data symbol into a number of chips, thus increasing the bandwidth of the signal. The number of chips per data symbol is called the Spreading Factor (SF). The second operation is the scrambling operation, where a scrambling code is applied to the spread signal.

With the channelization, data symbol on so-called I- and Q-branches are independently multiplied with an OVSF code. With the scrambling operation, the resultant signals on the I- and Q-branches are further multiplied by complex-valued scrambling code, where I and Q denote real and imaginary parts, respectively~~. Note that before complex multiplication binary values 0 and 1 are mapped to +1 and -1, respectively~~.

4.2 Spreading

4.2.1 Uplink Dedicated Physical Channels (uplink DPDCH/DPCCH)

~~Figure 1 illustrates the spreading and modulation for the case of multiple uplink DPDCHs when total data rate is less than or equal to 1024kbps in the 5MHz band. Note that this figure only shows the principle, and does not necessarily describe an actual implementation. Figure 2 illustrates the case for data rate at 2048kbps in the 5 MHz band. Modulation is dual-channel QPSK (i.e.; separate BPSK on I- and Q-channel), where the uplink DPDCH and DPCCH are mapped to the I and Q branch respectively. The I and Q branches are then spread to the chip rate with two different channelization codes and subsequently complex scrambled by a UE specific complex scrambling code C_{scramb}.~~



~~**Figure 1 Spreading/modulation for uplink DPDCH/DPCCH for user services less than or equal to 1024kbps in the 5MHz band**~~

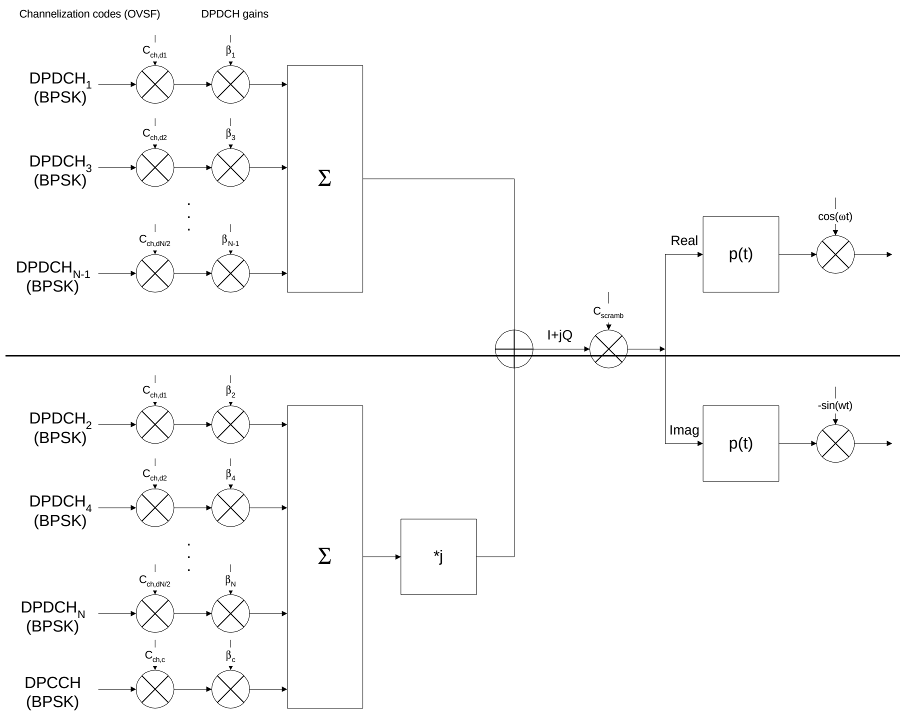


Figure 2. Spreading/modulation for uplink DPDCH/DPCCH for user services at 2048kbps in the 5MHz band

<Editor's note: pulse shaping will be moved to appropriate WG4 documentation.>

For a single uplink DPDCH transmission, only $DPDCH_1$ and DPCCH are transmitted.]

For services less than or equal to 1024kbps in the 5MHz band, the DPCCH is spread by the channelization code $C_{ch,c}$ and each $DPDCH_i$ is spread by a predefined individual channelization codes, $C_{ch,di}$ (di=1,2,…). For 2048kbps rate in the 5MHz band, the DPCCH is spread by the channelization code $C_{ch,c}$ and each pair of $DPDCH_{2di-1}$ and $DPDCH_{2di}$ is spread by a predefined individual channelization codes, $C_{ch,di}$. The data symbols of both the DPDCHs and the DPCCH are BPSK-modulated and the channelization codes are real-valued. The real-valued signals of the I- and Q-branches are then summed and treated as a complex signal. This complex signal is then scrambled by the complex-valued scrambling code, C_{scramb}.

Figure 1 illustrates the principle of the uplink spreading of DPCCH and DPDCHs. The binary DPCCH and DPDCHs to be spread are represented by real-valued sequences, i.e. the binary value "0" is mapped to the real value +1, while the binary value "1" is mapped to the real value –1. The DPCCH is spread to the chip rate by the channelization code $C_{ch,0}$, while the *n*:th DPDCH called $DPDCH_n$ is spread to the chip rate by the channelization code $C_{ch,n}$. One DPCCH and up to six parallel DPDCHs can be transmitted simultaneously, i.e. $0 \leq n \leq 6$.

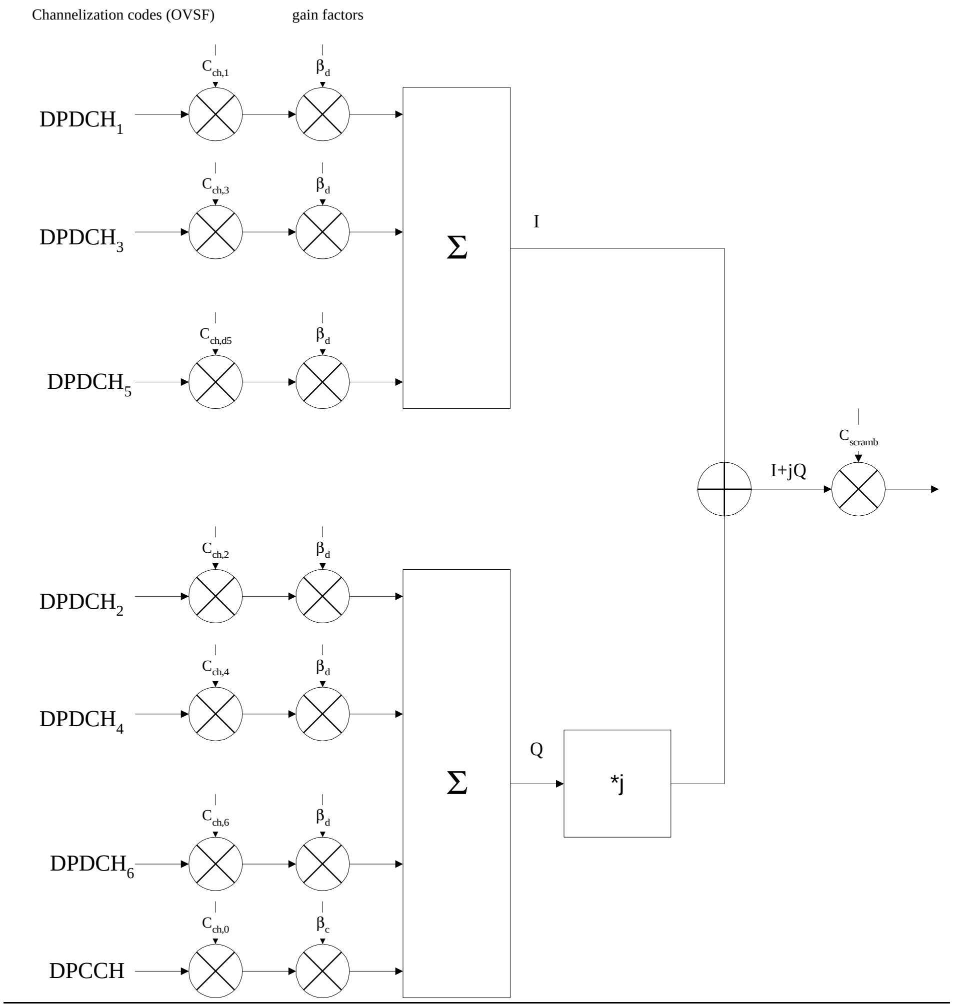


Figure 2: Spreading/modulation for uplink DPCCH and DPDCHs.

After channelization, the real-valued spread signals are weighted~~The powers of the DPDCHs may be adjusted~~ by gain factors, β_c for DPCCH and ~~,~~ β_{d}~~i~~ for all DPDCHs

At every instant in time, at least one of the values β_c and β_d has the amplitude ratio 1.0. ~~The channel with maximum power has always $b_i \equiv 1.0$ and the others have $b_i \leq 1.0$, where i is in the range 1, 2, .. N, c~~ The β-values are quantized into 4-bit~~s~~ words.~~, and t~~The quantization steps are given in Table 1.

Signalling values for β_c and β_d	Quantized amplitude ratios β_c and β_d ~~(b_{quant})~~
15	1.0
14	0.9333~~0.9375~~
13	0.8667~~0.875~~
12	0.8000~~0.8125~~
11	0.7333~~0.75~~
10	0.6667~~0.6875~~
9	0.6000~~0.625~~
8	0.5333~~0.5625~~
7	0.4667~~0.5~~
6	0.4000~~0.4375~~
5	0.3333~~0.375~~
4	0.2667~~0.3125~~
3	0.2000~~0.25~~
2	0.1333~~0.1875~~
1	0.0667~~0.125~~
0	Switch off

Table 1: The quantization of the gain parameters.

After the weighting, the stream of real-valued chips on the I- and Q-branches are then summed and treated as a complex-valued stream of chips. This complex-valued signal is then scrambled by the complex-valued scrambling code C_{scramb}. After pulse-shaping (described in TS 25.101), QPSK modulation is performed.

4.2.2 PRACH

The spreading and modulation of the message part of the r~~R~~andom-a~~A~~ccess burst is basically the same as for the uplink dedicated physical channels, see , where the uplink DPDCH and uplink DPCCH are replaced by the data part and the control part respectively. The scrambling code for the message part is chosen based on the ~~base-station-specific~~ preamble code.

4.3 Code generation and allocation

4.3.1 Channelization codes

The channelization codes of are Orthogonal Variable Spreading Factor (OVSF) codes that preserve the orthogonality between a user's different physical channels. The OVSF codes can be defined using the code tree of Figure 3.

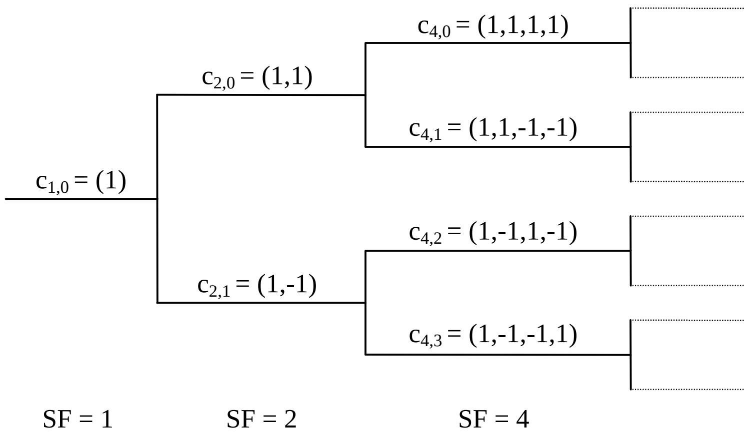


Figure 3. Code-tree for generation of Orthogonal Variable Spreading Factor (OVSF) codes.

In Figure 3, the ~~OVSF~~channelization codes are uniquely ~~is~~ described as c~~C~~$_{SF,}$~~code number~~$_{k}$, where SF is the spreading factor of the code and *k* is the code number, $0 \leq k \leq SF-1$. ~~, where SF$_{d,n}$ represents the spreading factor of nth DPDCH. Then the DPCCH is spread by code number 1 with a spreading factor of SF$_c$.~~

Each level in the code tree defines channelization codes of length SF, corresponding to a spreading factor of SF in Figure 3. ~~All codes within the code tree cannot be used simultaneously by one mobile station. A code can be used by a UE if and only if no other code on the path from the specific code to the root of the tree or in the sub-tree below the specific code is used by the same mobile station. This means that the number of available channelization codes is not fixed but depends on the rate and spreading factor of each physical channel.~~

The generation method for the channelization code ~~can also be explained in Figure 4.~~is defined as:

$$c_{1,0} = 1,$$

$$\begin{bmatrix} c_{2,0} \\ c_{2,1} \end{bmatrix} = \begin{bmatrix} c_{1,0} & c_{1,0} \\ c_{1,0} & -c_{1,0} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$\begin{bmatrix} c_{2(n+1),0} \\ c_{2(n+1),1} \\ c_{2(n+1),2} \\ c_{2(n+1),3} \\ \vdots \\ c_{2(n+1),2(n+1)-2} \\ c_{2(n+1),2(n+1)-1} \end{bmatrix} = \begin{bmatrix} c_{2^n,0} & c_{2^n,0} \\ c_{2^n,0} & -c_{2^n,0} \\ c_{2^n,1} & c_{2^n,1} \\ c_{2^n,1} & -c_{2^n,1} \\ \vdots & \vdots \\ c_{2^n,2^n-1} & c_{2^n,2^n-1} \\ c_{2^n,2^n-1} & -c_{2^n,2^n-1} \end{bmatrix}$$

The leftmost value in each channelization code word corresponds to the chip transmitted first in time.

$$c_{1,1} = 1$$

$$\begin{bmatrix} c_{2,1} \\ c_{2,2} \end{bmatrix} = \begin{bmatrix} c_{1,1} & c_{1,1} \\ c_{1,1} & -c_{1,1} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$\begin{bmatrix} C_{4,1} \\ C_{4,2} \\ C_{4,3} \\ C_{4,4} \end{bmatrix} = \begin{bmatrix} C_{2,1} & C_{2,1} \\ C_{2,1} & \overline{C_{2,1}} \\ C_{2,2} & C_{2,2} \\ C_{2,2} & \overline{C_{2,2}} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

$$\vdots \quad \vdots$$

Figure 4. Spreading Code Generation Method

Binary code words are equivalent to the real valued sequences by the transformation '0' -> '+1', '1' -> '-1'.

The spreading code cycle is the symbol cycle. Thus, for a given chip rate, the spreading code cycle depends on the symbol rate. Furthermore, the number of codes that can be used also differs according to the symbol rate. The relations between symbol rate, spreading code types, spreading code cycle and number of spreading codes is listed in Table 2.

The spreading code phase synchronises with the modulation/demodulation symbols. In other words, the head chip of the symbol is spreading code phase=0.

Symbol rate (ksps)				spreading code cycle(chip) SF	No. of Spreading codes
Chip rate= [1.024 Mcps]	4.096 Mcps	[8.192 Mcps]	[16.384 Mcps]		
[256]	1024	[2048]	4096]	4	4
[128]	512	[1024]	2048]	8	8
[64]	256	[512]	[1024]	16	16
[32]	128	[256]	[512]	32	32
[16]	64	[128]	[256]	64	64
[8]	32	[64]	[128]	128	128
-	16	[32]	[64]	256	256
-	[8]	[16]	[32]	512	512
-	-	[8]	[16]	1024	1024

			~~[8]~~	~~2048~~	~~2048~~

~~**Table 2. Correspondence between Symbol Rate and Spreading Code Types**~~

For the DPCCH and DPDCHs the following applies:

- The DPCCH is always spread by code $c_{256,0}$~~number 1 in any code tree as described in Section 4.3.1~~, i.e. $C_{ch,0} = c_{256,0}$~~-~~.

- When only one DPDCH is to be transmitted, $DPDCH_1$ ~~The first DPDCH~~ is spread by the code $C_{ch,1} = c_{SF,k}$, where SF is the spreading factor of $DPDCH_1$ and k = ~~code number (~~$SF_{d,1}$ / 4 ~~+ 1)~~.

- When more than one DPDCH is to be transmitted, all DPDCHs have spreading factors equal to 4. $DPDCH_n$ is spread by the the code $C_{ch,n} = c_{4,k}$, where $k = 1$ if $n \in \{1, 2\}$, $k = 3$ if $n \in \{3, 4\}$, and $k = 2$ if $n \in \{5, 6\}$. ~~Subsequently added DPDCHs for multi-code transmission are spread by codes in ascending order starting from code number 2 excepting the one used for the first DPDCH. However to guarantee the orthogonality between channels, any subtree below the specified node is not used for the channelization code of a DPDCH.~~

~~<Editor's Note: The case of OVSF code allocation with multiple DPDCHs with different spreading factors is for further study~~