TSG-RAN WORKING GROUP 1 MEETING NO. 17 *TSGR1-00-1341*

STOCKHOLM, SWEDEN, 21-24 NOV. 2000

Agenda Item:	AH99
Source:	Siemens AG
Title:	Transmission of Same Data on all Active Codes in a Downlink Time Slot
Document for:	Approval

1 INTRODUCTION

This paper examines the situation where the same data is transmitted on all codes in a downlink time slot. The situation could arise when a broadcast or multi-cast message is sent to all users. Under these circumstances the peak power requirement of the amplifier will be increased because of a property of the Walsh-Hadamard codes used for spreading results in a high peak power requirement for every data symbol transmitted.

The structure of the Walsh-Hadamard spreading codes is such that at one chip position the value of the code is the same in all codes. When the data symbols modulating the spreading sequence are random, then there is a low probability that the same data symbol will occur in all codes. The sum of 8, 12 and 16 Walsh-Hadamard sequences of length 16 is given in the table below:

8	12	16
8	12	16
0	0	0
0	0	0
0	0	0
0	4	0
0	0	0
0	0	0
0	0	0
8	4	0
0	0	0
0	0	0
0	0	0
0	4	0
0	0	0
0	0	0
0	0	0

Figure 1 Sum of Walsh Hadamard Sequences of Length 16

The relatively rare occurrence of random data giving rise to high peak powers, means that for normal operation occasional clipping could be tolerated without any significant effect on performance, but with the same data present on each code, all data symbols in a time slot will be affected, consequently the performance degradation will be higher.

2 PERFORMANCE WITH CURRENT SPREADING CODES

To examine the impact upon performance, simulations with a model of a non-linear power amplifier have been performed when both independent random data is present on all codes and when identical random data is present on all codes. The model used for the power amplifier takes measured AM/AM and AM/PM distortion curves for a typical class A amplifier and a polynomial fit is made to the data.

The most sensitive characteristic of the signal to non-linear distortion is the power spectrum. The influence of non-linear distortion upon bit error rate and error vector magnitude (EVM) is very much less pronounced.

In the results presented in Figure 2 and Figure 3, the measured power spectral density is given for the case where 12 codes are transmitted with independent data, and where 12 codes are transmitted all with the same data.

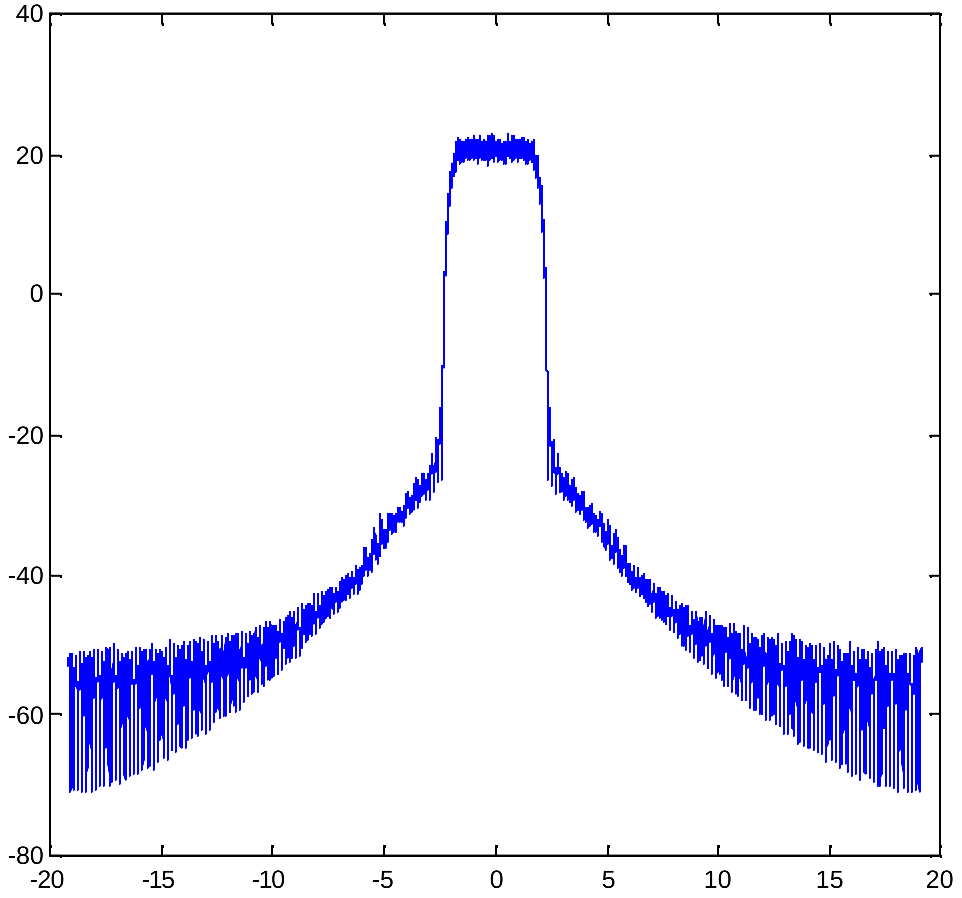

Figure 2 Power Spectral Density at Power Amplifier Output, 12 Codes with Independent Data

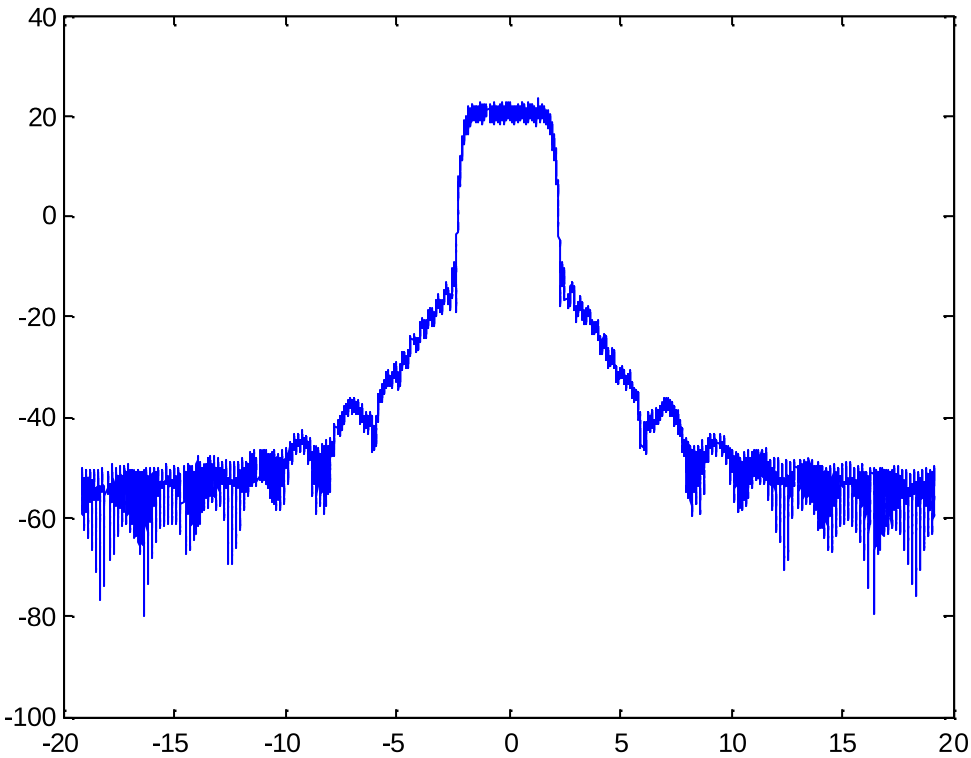

Figure 3 Power Spectral Density at Power Amplifier Output, 12 Codes with Same Data

Of importance is the adjacent channel leakage power ratio (ACLR). This is the ratio of power in the wanted to that in an adjacent channel measured through a root raised cosine filter with a roll-off factor of 0.22. When the same data is present on all codes this degrades by 8dB.

The above situation represents a worst case, in practice there will be a continuous degradation in the ACLR for a given back-off as the proportion of the data in a burst is the same across all codes. To illustrate this the power spectral density is shown in Figure 4 below where 10% of the data symbols across all codes have different values.

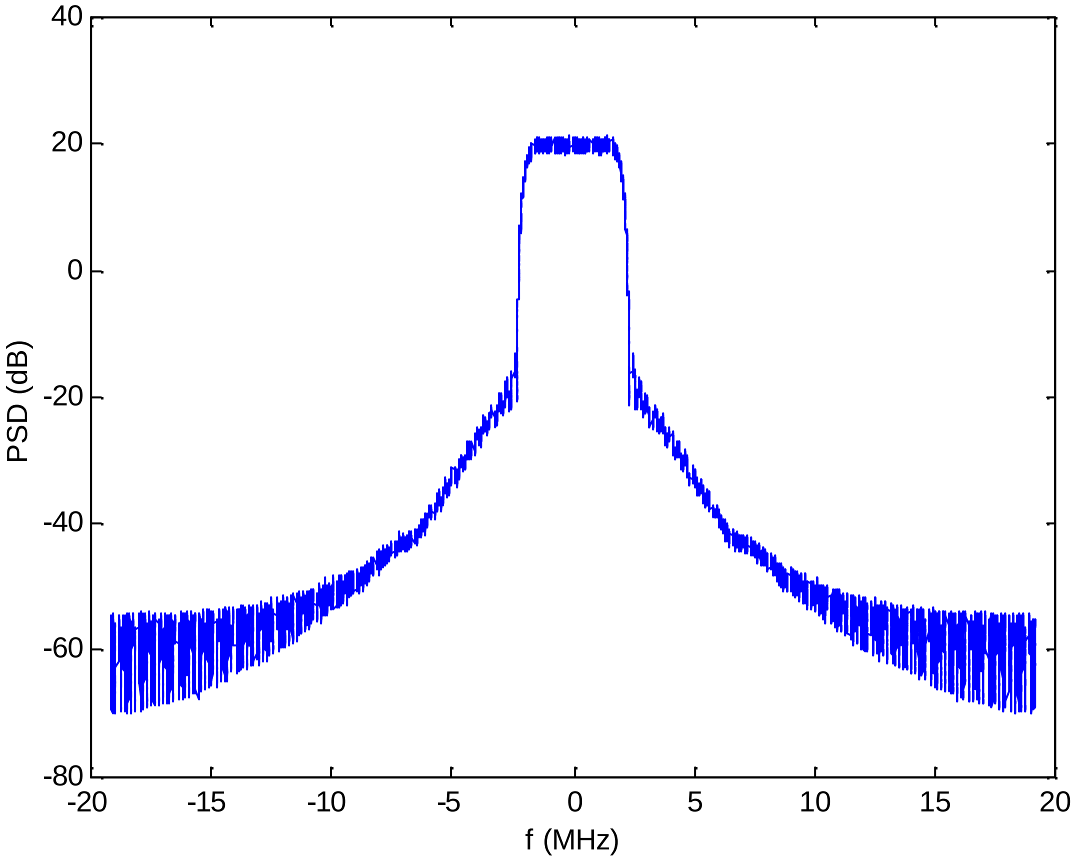

Figure 4 Power Spectral Density at Power Amplifier Output, 12 Codes with 10% of Data Being Different

The ACLR where 10% of data symbols are different is degraded 5dB relative to the case where independent data is present on all codes.

3 MODIFICATION TO SPREADING CODES

The increased peak to mean ratio of the signal when the same data is present on all codes will cause the transmit spectrum to degrade if a power amplifier is operated at the same back-off as with independent data on each code. Strictly the spectral emissions mask in TS 25.105 should be independent of the data and number of codes transmitted. The worst case test is when the same data is present on all codes, and this would set the back-off of the power amplifier. To remove the dependence upon the data content of the codes it would be possible to apply a fixed phase shift to each code. For spreading factor SF and spreading code k, the chips of the spreading code are multiplied by the following:

$$s_q^{(k)} \leftarrow s_q^{(k)} \exp\left(j\frac{2\pi}{SF}p_k\right)$$

Where p_k is a permutation of the integer set [1,SF]. The impact upon complexity at both transmitter and receiver is negligible. An example of the modulus of the sum of Walsh Hadamard codes with the phase offset applied is shown below in Figure 5. The permutation of the integer set [1,SF] used is [10,7,12,4,16,1,3,14,6,8,11,15,13,9,5,2].

8	12	16
1.41	0.3902	0.0
1.84	1.97	2.165
0.812	3.56	4.06
1.264	2.22	4.65
4.73	6.00	5.89
4.36	4.21	3.92
2.51	4.95	5.89
2.93	4.40	5.02
1.41	2.69	2.82
1.84	2.23	1.85
0.81	2.61	2.44
1.26	2.54	3.74
4.74	3.49	3.69
4.36	4.74	5.12
2.51	2.51	5.55
2.93	2.45	1.10

Figure 5 Sum of Walsh Hadamard Sequences of Length 16 With Phase Offset Applied to Each Code

It should be noted that applying a fixed phase offset to each of the codes means that the codes still retain their orthogonality. The power spectral density that results when a fixed phase offset is applied to each code is shown below in Figure 6 below. The drive level for the power amplifier is identical to the results shown in Figure 2 and Figure 3.

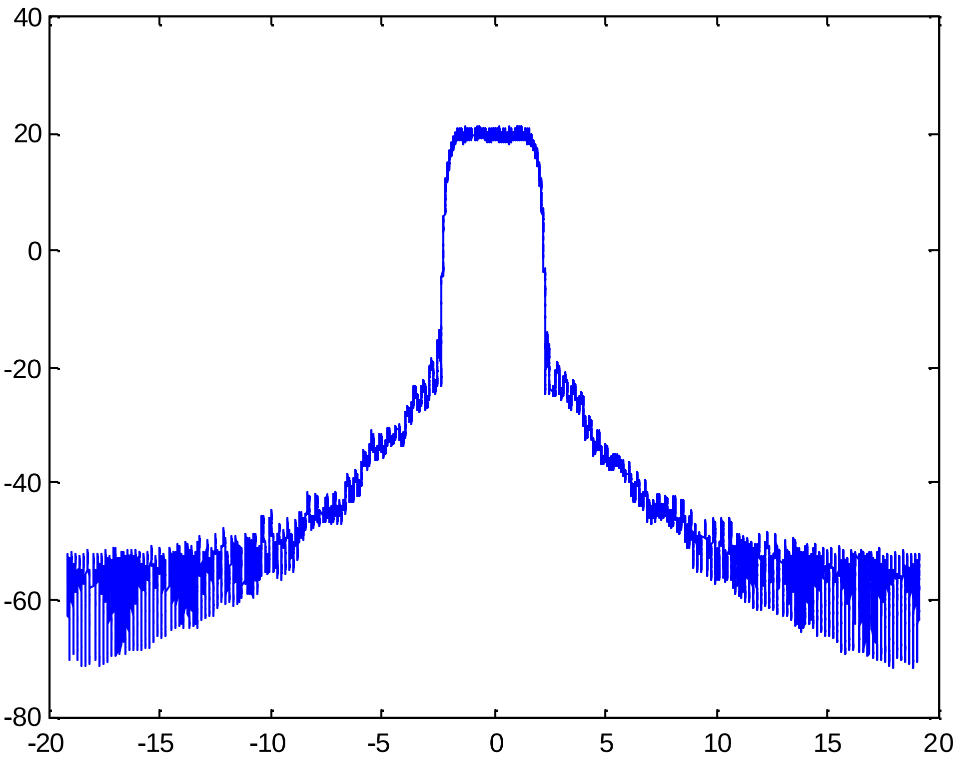

Figure 6 Power Spectral Density at Power Amplifier Output, 12 Codes with Same Data and Phase Offset Applied to Each Code

Comparing the results of Figure 2 with those of Figure 6, by applying a phase offset to each code the power spectral density is restored, and the ACLR achieved is identical.

It is also interesting to examine the distribution of the envelope with random data symbols applied to the spreading codes. In Figure 7 below no phase offsets are applied to the spreading codes and the distribution of the envelope of the sum of 16 codes is presented.

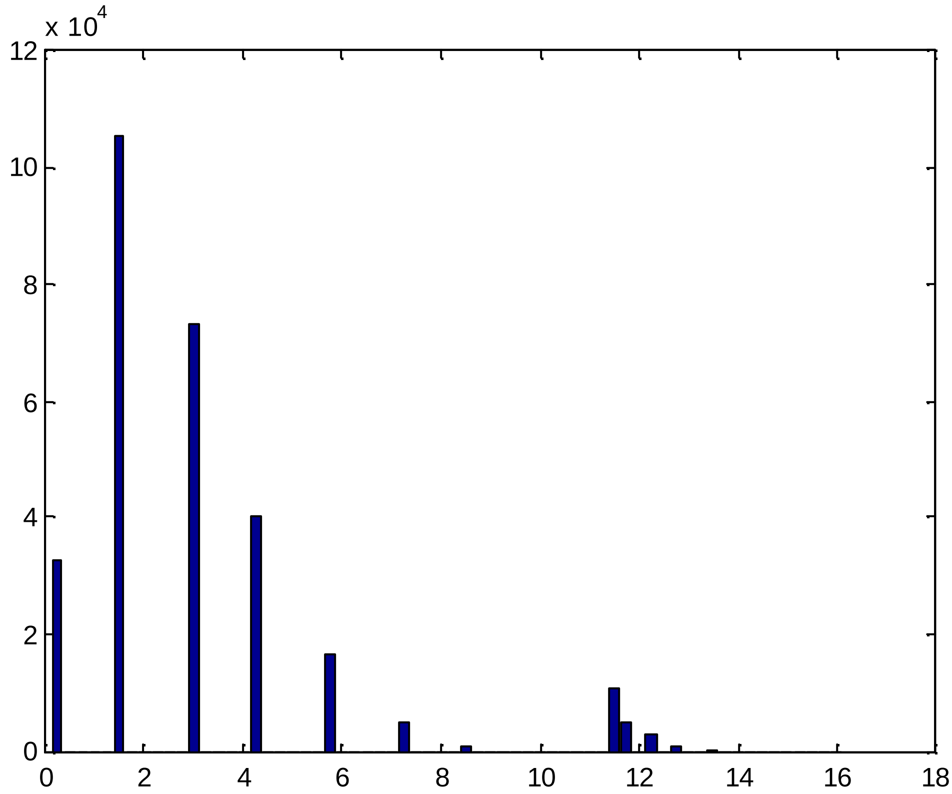

Figure 7 Distribution of Envelope of Sum of 16 Codes – No Phase Offsets Applied

With a random permutation of phase offsets applied to the spreading codes, with phase offsets limited to multiples of ?/2 a slight improvement in the tail of the distribution occurs, as illustrated in Figure 8 below.

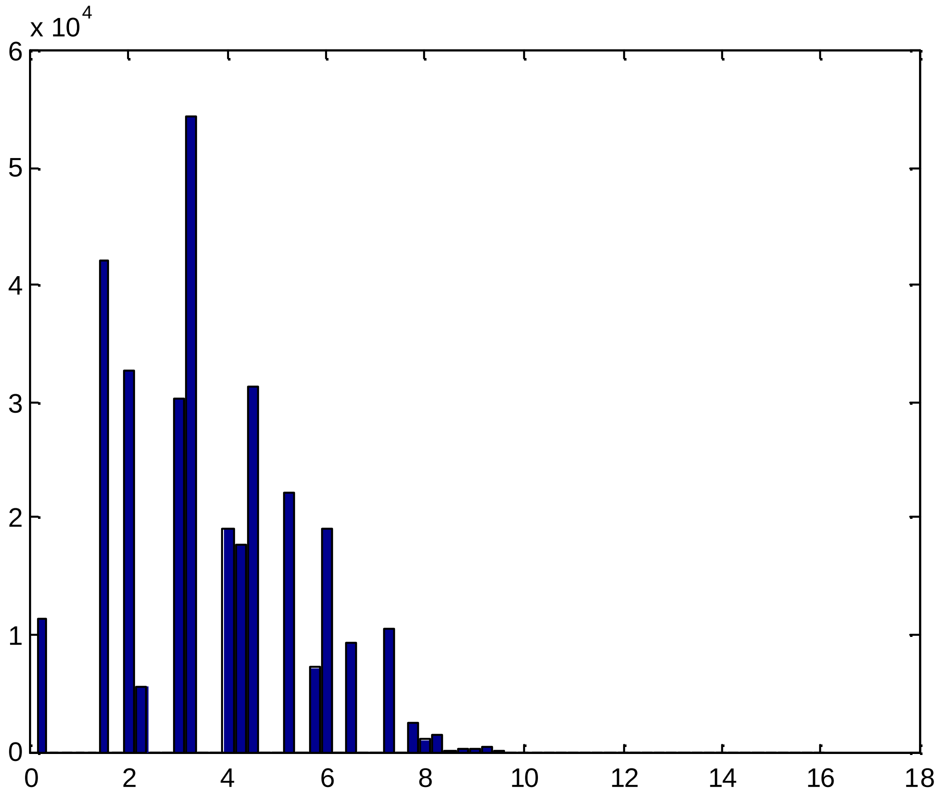

Figure 8 Distribution of Envelope of Sum of 16 Codes – ? **/2 Phase Offsets Applied**

With a random permutation of phase offsets taking values that are multiples of ?/8, a further slight improvement in the tail of the distribution occurs compared to using phase offsets with multiples of ?/2, as illustrated in **Error! Reference source not found.** below.

4 CONCLUSION

This document has shown a potential problem that may occur if the same data is transmitted on all or at least some DL physical channels within one slot. Due to the particular channelisation code construction and the time alignment in TDD, a high peak power will occur in this situation on the first chip of each symbol. Power clipping of this regular peak pattern will result in an 8dB degradation in ACLR.

In order to overcome this problem, it is proposed to apply a code specific phase offset of multiples of ?/8. The appropriate CR for TS25.223 can be found in this TDoc. It has been shown that this technique will improve the peak to average power ratio also for independant data.

3GPP TSG RAN WG1 Meeting #17
Stockholm, Sweden, 21-24 November 2000

***Document* R1-001341**
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

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

25.223	**CR**	**015**	Current Version:	

GSM (AA.BB) or 3G (AA.BBB) specification number ? *? CR number as allocated by MCC support team*

For submission to: RAN#10 — for approval: X — for information: — strategic: — non-strategic: — *(for SMG use only)*
list expected approval meeting # here ?

Form: CR cover sheet, version 2 for 3GPP and SMG. The latest version of this form is available from: ftp://ftp.3gpp.org/Information/CR-Formv2.doc

Proposed change affects: (U)SIM: — ME: X — UTRAN / Radio: X — Core Network: —
(at least one should be marked with an X)

Source: Siemens AG **Date:** 2000-11-14

Subject: Transmission of Same Data on all Active Codes in a Downlink Time Slot

Work item:

Category: *(only one category shall be marked with an X)*

F	Correction	X
A	Corresponds to a correction in an earlier release	
B	Addition of feature	
C	Functional modification of feature	
D	Editorial modification	

Release:

Phase 2	
Release 96	
Release 97	
Release 98	
Release 99	X
Release 00	

Reason for change: Corrects the high peak to average power ratio in case of same data on all active codes.

Clauses affected: 6.3 - 6.6

Other specs Affected:

Other 3G core specifications		? List of CRs:
Other GSM core specifications		? List of CRs:
MS test specifications		? List of CRs:
BSS test specifications		? List of CRs:
O&M specifications		? List of CRs:

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

6.3 Channelisation Code Specific Multiplier

Associated with each channelisation code is a multiplier $w_{Q_k}^{(k)}$ taking values from the set $\{e^{j2\pi/Q_k \cdot p_k}\}$, where p_k is a permutation of the integer set {0, ..., Q_k -1} and Q_k denotes the spreading factor. The multiplier is applied to the data sequence modulating each channelisation code. The values of the multiplier for each channelisation code are given in the table below:

k	$w_{Q=1}^{(k)}$	$w_{Q=2}^{(k)}$	$w_{Q=4}^{(k)}$	$w_{Q=8}^{(k)}$	$w_{Q=16}^{(k)}$
1	1	1	-j	$e^{7(j\pi/4)}$	$e^{15(j\pi/8)}$
2	-	+j	1	-j	$e^{9(j\pi/8)}$
3	-	-	+j	$e^{5(j\pi/4)}$	$e^{5(j\pi/4)}$
4	-	-	-1	$e^{(j\pi/4)}$	-1
5	-	-	-	+j	$e^{7(j\pi/8)}$
6	-	-	-	-1	$e^{3(j\pi/8)}$
7	-	-	-	1	$e^{3(j\pi/4)}$
8	-	-	-	$e^{3(j\pi/4)}$	$e^{(j\pi/8)}$
9	-	-	-	-	$e^{(j\pi/4)}$
10	-	-	-	-	-j
11	-	-	-	-	$e^{7(j\pi/4)}$
12	-	-	-	-	$e^{5(j\pi/8)}$
13	-	-	-	-	$e^{13(j\pi/8)}$
14	-	-	-	-	$e^{11(j\pi/8)}$
15	-	-	-	-	+1
16	-	-	-	-	+j

6.4 Scrambling codes

The spreading of data by a real valued channelisation code $\mathbf{c}^{(k)}$ of length Q_k is followed by a cell specific complex scrambling sequence $\underline{\mathbf{v}} = (\underline{v}_1, \underline{v}_2, ..., \underline{v}_{16})$. The elements $\underline{v}_i; i = 1,...,16$ of the complex valued scrambling codes shall be taken from the complex set

$$\underline{V}_2 = \{1, j, -1, -j\} \tag{4}$$

In equation 4 the letter j denotes the imaginary unit. A complex scrambling code $\underline{\mathbf{v}}$ is generated from the binary scrambling codes $\mathbf{v} = (v_1, v_2, ..., v_{16})$ of length 16 shown in Annex A. The relation between the elements $\underline{\mathbf{v}}$ and $\mathbf{v}$ is given by:

$$\underline{v}_i = (j)^i \cdot v_i \qquad v_i \in \{1, -1\}, \; i = 1,...,16 \tag{5}$$

Hence, the elements $\underline{v}_i$ of the complex scrambling code $\underline{\mathbf{v}}$ are alternating real and imaginary.

The length matching is obtained by concatenating Q_{MAX}/Q_k spread words before the scrambling. The scheme is illustrated in figure 2 and is described in more detail in subclause 6.4.

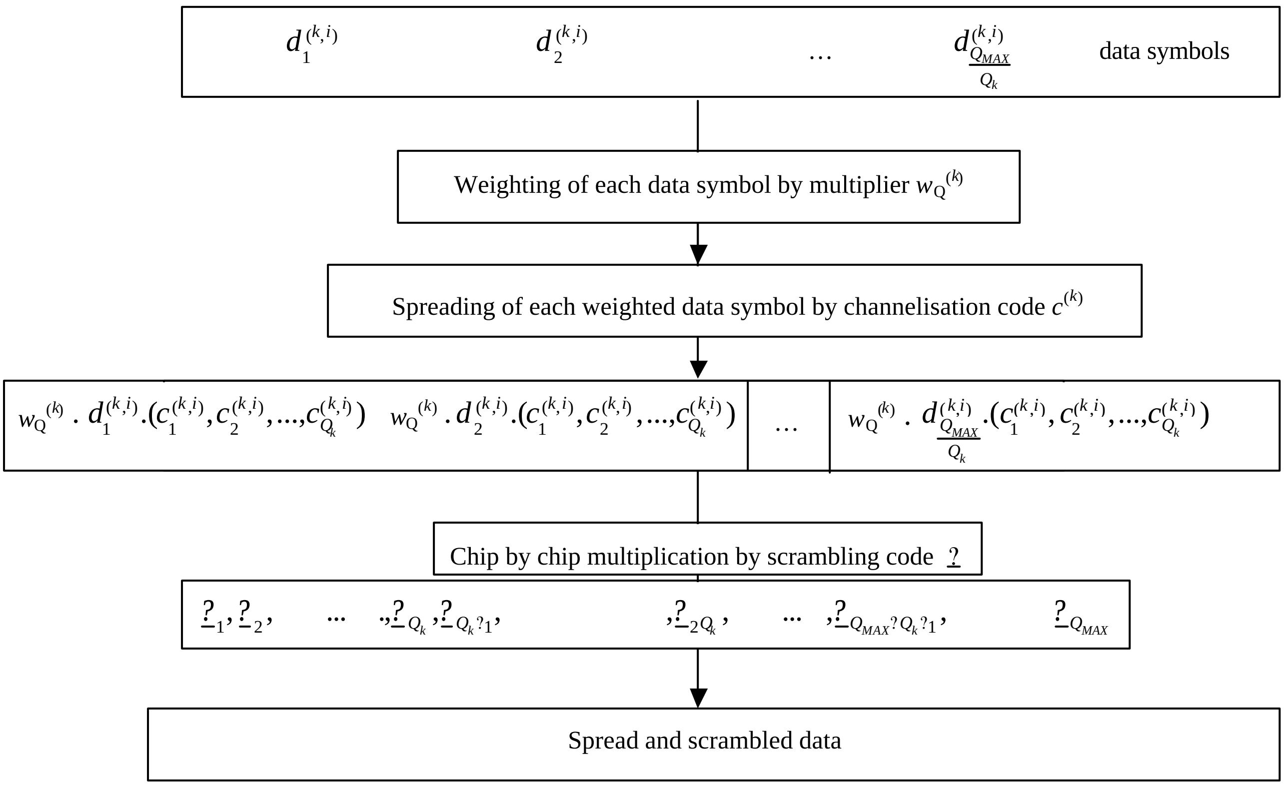

Figure 2: Spreading of data symbols

6.5 Spread signal of data symbols and data blocks

The combination of the user specific channelisation and cell specific scrambling codes can be seen as a user and cell specific spreading code $\mathbf{s}^{(k)} = \{s_p^{(k)}\}$ with

$$s_p^{(k)} = c^{(k)}_{1+[(p-1) \bmod Q_k]} \cdot \underline{v}_{1+[(p-1) \bmod Q_{MAX}]}$$, k=1,…,K, p=1,…,$N_k Q_k$.

With the root raised cosine chip impulse filter $Cr_0(t)$ the transmitted signal belonging to the data block $\underline{\mathbf{d}}^{(k,1)}$ of equation 1 transmitted before the midamble is

$$d^{(k,1)}(t) = \sum_{n=1}^{N_k} d_n^{(k,1)} w_{Q_k}^{(k)} \sum_{q=1}^{Q_k} s_{(n-1)Q_k+q}^{(k)} .Cr_0(t-(q-1)T_c-(n-1)Q_k T_c) \qquad (6)$$

and for the data block $\underline{\mathbf{d}}^{(k,2)}$ of equation 1 transmitted after the midamble

$$d^{(k,2)}(t) = \sum_{n=1}^{N_k} d_n^{(k,2)} w_{Q_k}^{(k)} \sum_{q=1}^{Q_k} s_{(n-1)Q_k+q}^{(k)} .Cr_0(t-(q-1)T_c-(n-1)Q_k T_c - N_k Q_k T_c - L_m T_c) \qquad (7)$$

where L_m is the number of midamble chips.

6.6 Modulation

The complex-valued chip sequence is QPSK modulated as shown in figure 3.

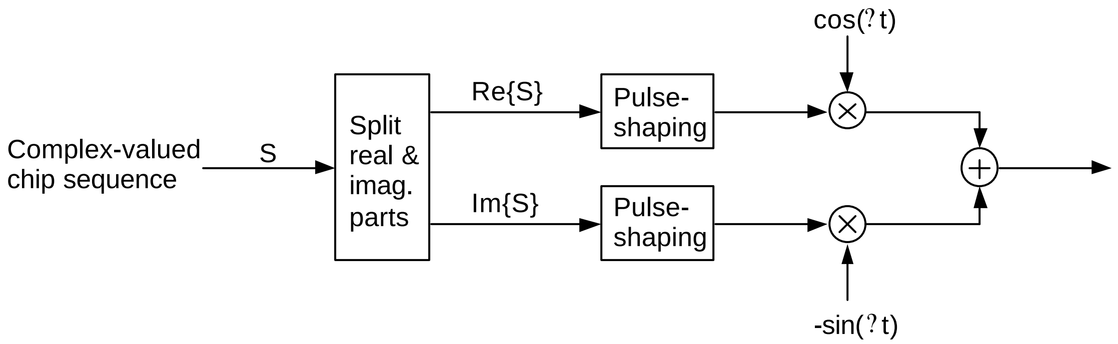

Figure 3: Modulation of complex valued chip sequences

The pulse-shaping characteristics are described in [9] and [10].

6.6.1 Combination of physical channels in uplink

Figure 4 illustrates the principle of combination of two different physical uplink channels within one timeslot. The DPCHs to be combined belong to same CCTrCH, did undergo spreading as described in sections before and are thus represented by complex-valued sequences. First, the amplitude of all DPCHs is adjusted according to UL open loop power control as described in [10]. Each DPCH is then separately weighted by a weight factor $?_i$ and combined using complex addition. After combination of Physical Channels the gain factor $?_j$ is applied, depending on the actual TFC as described in [10].

In case of different CCTrCH, principle shown in Figure 4 applies to each CCTrCH separately.

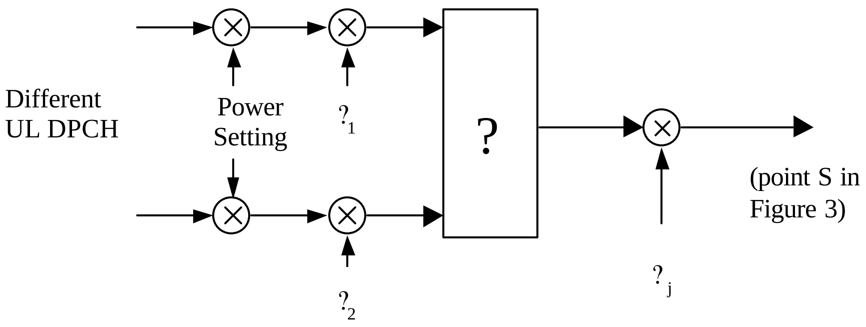

Figure 4: Combination of different physical channels in uplink

The values of weight factors $?_i$ are depending on the spreading factor SF of the corresponding DPCH:

SF of DPCH$_i$	$?_i$
16	1
8	$\sqrt{2}$
4	2
2	$2\sqrt{2}$
1	4

The possible values for gain factors $?_j$ (corresponding to *j*–th TFC) are listed in table below:

Signalling value for $?_j$	Quantized value $?_j$
15	16/8
14	15/8
13	14/8
12	13/8
11	12/8
10	11/8
9	10/8
8	9/8
7	8/8
6	7/8
5	6/8
4	5/8
3	4/8
2	3/8
1	2/8
0	1/8

6.6.2 Combination of physical channels in downlink

Figure 5 illustrates how different physical downlink channels are combined within one timeslot. Each complex-valued spread channel is separately weighted by a weight factor G_i. If a timeslot contains the SCH, the complex-valued SCH, as described in [7] is separately weighted by a weight factor G_{SCH}. All downlink physical channels are then combined using complex addition.

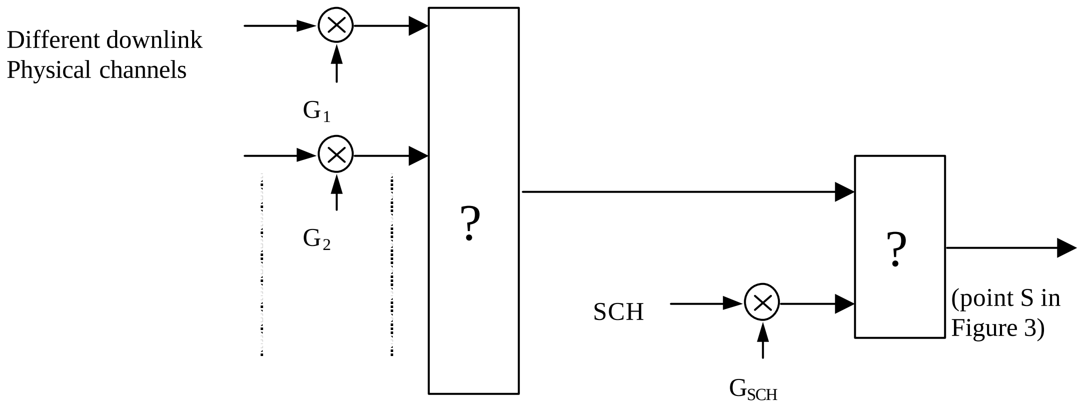

Figure 5: Combination of different physical channels in downlink in case of SCH timeslot