3GPP TSG-RAN Working Group 1, Meeting #11 TDoc TSG RAN WG1 (00)0224
San Diego, USA, February 29 – March 3, 2000

Source: Siemens AG
Title: Signal Point Constellation
Agenda Item: Plenary
Document for: Approval

Introduction

The following changes are proposed in order to align the spreading and modulation procedure and the resulting signal point constellation with FDD. The modifications also lead to a uniform signal point constellation for midamble and data parts of a TDD burst.

1. The channelisation and spreading procedure has been aligned with FDD, i.e. the channelisation is now performed by a real valued channelisation code and the scrambling is performed by a complex valued scrambling code.

2. The definition of the Synchronisation Channel has been aligned with the FDD description and the Signal Point Constellation has been changed to an offset QPSK.

Conclusion

The proposed changes have been included in the following CRs: 25.223 CR006 and 25.221 CR 015.

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25.221	**CR**	**015**	Current Version:	3.1.0

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

For submission to:	TSG RAN#7	for approval	X	strategic		*(for SMG*
list expected approval meeting # here ↑		for information		non-strategic		*use only)*

Form: CR cover sheet, version 2 for 3GPP and SMG   The latest version of this form is available from: ftp://ftp.3gpp.org/Information/CR-Form-v2.doc

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

Source:	Siemens AG	**Date:**	2000-02-21
Subject:	Signal Point Constellation		
Work item:			

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

Reason for change:	Corresponds to modification in TS25.223 CR 006 regarding Signal Point Constellation
Clauses affected:	5.3.4

Other specs affected:	Other 3G core specifications	X	→ List of CRs:	25.223 CR 006
	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:	

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5.3.4 The physical synchronisation channel (PSCH)

In TDD mode code group of a cell can be derived from the synchronisation channel. Additional information, received from higher layers on SCH transport channel, is also transmitted to the UE in PSCH in case 3 from below. In order not to limit the uplink/downlink asymmetry the PSCH is mapped on one or two downlink slots per frame only.

There are three cases of PSCH and P-CCPCH allocation as follows:

Case 1) PSCH and P-CCPCH allocated in TS#k, k=0….14

Case 2) PSCH allocated in two TS: TS#k and TS#k+8, k=0…6; P-CCPCH allocated in TS#k.

Case 3) PSCH allocated in two TS, TS#k and TS#k+8, k=0…6, and the P-CCPCH allocated in TS#i, i=0…6, pointed by PSCH. Pointing is determined via the SCH from the higher layers.

These three cases are addressed by higher layers using the SCCH in TDD Mode. The position of PSCH (value of k) in frame can change on a long term basis in any case.

Due to this PSCH scheme, the position of PCCPCH is known from the PSCH.

Figure 15 is an example for transmission of PSCH, k=0, of Case 2 or Case 3.

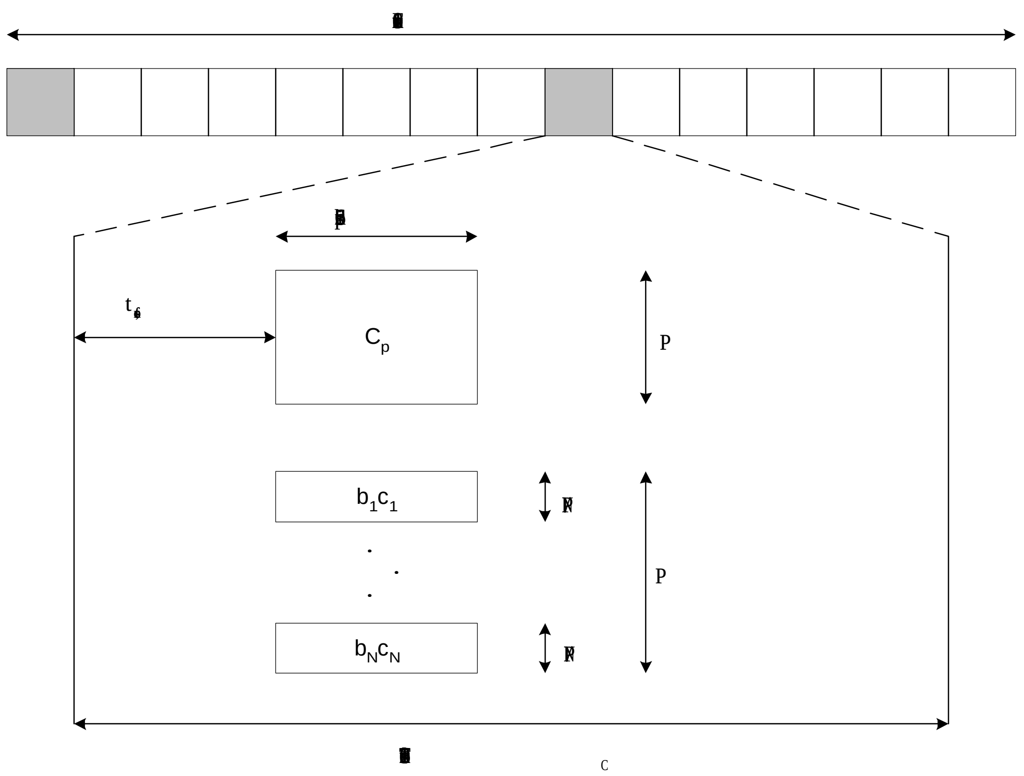

Figure 15: Scheme for Physical Synchronisation channel PSCH consisting of one primary sequence C_p and N=3 parallel secondary sequences in slot k and k+8

(example for k=0 in Case 2 or Case 3)

As depicted in figure 15, the PSCH consists of a primary and three secondary code sequences with 256 chips length. The primary and secondary code sequences are defined in [8] chapter 7 'Synchronisation codes'. ~~The secondary codes are transmitted either in the I channel or the Q channel, depending on the code group.~~

Due to mobile to mobile interference, it is mandatory for public TDD systems to keep synchronisation between base stations. As a consequence of this, a capture effect concerning PSCH can arise. The time offset t_{offset} enables the system to overcome the capture effect.

The time offset t_{offset} is one of 32 values, depending on the cell parameter, thus on the code group of the cell, cf. 'table 7 Mapping scheme for Cell Parameters, Code Groups, Scrambling Codes, Midambles and t_{offset}' in [8]. The exact value for t_{offset}, regarding column 'Associated t_{offset}' in table 7 in [8] is given by:

$$
\begin{aligned}
t_{offset,n} &= n \cdot T_c \left\lfloor \frac{2560 - 96 - 256}{31} \right\rfloor \\
&= n \cdot 71 T_c \ ; \quad n = 0, \ldots, 31
\end{aligned}
$$

Please note that $\lfloor x \rfloor$ denotes the largest integer number less or equal to x and that T_c denotes the chip duration.

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25.223	**CR**	**006**	Current Version:	3.1.0

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

For submission to:	TSG RAN#7	for approval	X	strategic		(for SMG use only)
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Form: CR cover sheet, version 2 for 3GPP and SMG The latest version of this form is available from: ftp://ftp.3gpp.org/Information/CR-Form-v2.doc

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

Source: Siemens AG **Date:** 2000-02-21

Subject: Signal Point Constellation

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:
-description of signal point constellation aligned to FDD
-channelisation and scrambling operation modified and aligned with FDD
-SCH description aligned with FDD and signal point constellation of SCH modified

Clauses affected: 3, 5.2, 5.2.1, 5.2.2, 6.1, 6.2, 6.3, 6.4, 6.5, 7.1, 7.2

Other specs affected:

Other 3G core specifications	X	→ List of CRs:	25.221 CR 015
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:

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3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CDMA	Code Division Multiple Access
P-CCPCH	Primary Common Control Physical Channel
PN	Pseudo Noise
PSCH	Physical Synchronisation Channel
QPSK	Quadrature Phase Shift Keying
PSC	Primary Synchronisation Code
RACH	Random Access Channel
SCH	Synchronisation Channel
SSC	Secondary Synchronisation Code

5 Data modulation

5.1 Symbol rate

The symbol duration T_S depends on the spreading factor Q and the chip duration T_C: $T_s = Q \times T_c$, where $T_c = \frac{1}{chiprate}$.

5.2 Mapping of bits onto signal point constellation

5.2.1 Mapping for burst type 1 and 2

~~A certain number K of CDMA codes can be assigned to either a single user or to different users who are simultaneously transmitting bursts in the same time slot and the same frequency. The maximum possible number of CDMA codes, which is smaller or equal to 16, depends on the individual spreading factors, the actual interference situation and the service requirements. The applicable burst formats are shown in[7].~~ The data modulation is performed to the bits from the output of the physical channel mapping procedure in [8] and combines always 2 consecutive binary bits to a complex valued data symbol. Each user burst has two data carrying parts, termed data blocks:

$$\underline{\mathbf{d}}^{(k,i)} = (\underline{d}_1^{(k,i)}, \underline{d}_2^{(k,i)}, \ldots, \underline{d}_{N_k}^{(k,i)})^{\mathrm{T}} \quad i = 1, 2;\ k = 1,\ldots,K. \qquad (1)$$

N_k is the number of symbols per data field for the user k. This number is linked to the spreading factor Q_k as described in table 1 of [7].

Data block $\underline{\mathbf{d}}^{(k,1)}$ is transmitted before the midamble and data block $\underline{\mathbf{d}}^{(k,2)}$ after the midamble. Each of the N_k data symbols $\underline{d}_n^{(k,i)}$; i=1, 2; k=1,...,K; n=1,...,N_k; of equation 1 has the symbol duration $T_s^{(k)} = Q_k . T_c$ as already given.

The data modulation is QPSK, thus the data symbols $\underline{d}_n^{(k,i)}$ are generated from two ~~interleaved and encoded~~consecutive data bits from the output of the physical channel mapping procedure in [8]:

$$b_{l,n}^{(k,i)} \in \{0,1\} \qquad l = 1,2;\ k = 1,\ldots K;\ n = 1,\ldots,N_k;\ i = 1,2 \qquad (2)$$

using the ~~equation~~following mapping to complex symbols:

consecutive binary bit pattern	complex symbol
$b_{1,n}^{(k,i)}\ b_{2,n}^{(k,i)}$	$\underline{d}_n^{(k,i)}$
00	+j
01	+1
10	-1
11	-j

$$\begin{aligned} \mathrm{Re}\{\underline{d}_n^{(k,i)}\} &= \frac{1}{\sqrt{2}}(2b_{1,n}^{(k,i)} - 1) \\ \mathrm{Im}\{\underline{d}_n^{(k,i)}\} &= \frac{1}{\sqrt{2}}(2b_{2,n}^{(k,i)} - 1) \quad k = 1,\ldots,K;\ n = 1,\ldots,N_k;\ i = 1, 2. \end{aligned} \qquad \cancel{(3)}$$

The mapping~~Equation 3~~ corresponds to a QPSK modulation of the interleaved and encoded data bits $b_{l,n}^{(k,i)}$ of equation 2.

5.2.2 Mapping for PRACH burst type

In case of PRACH burst type, the definitions in subclause 5.2.1 apply with a modified number of symbols in the second data block.. For the PRACH burst type, the number of symbols in the second data block $\mathbf{d}^{(k,2)}$ is decreased by $\frac{96}{Q_K}$ symbols.

6 Spreading modulation

6.1 Basic spreading parameters

Spreading of data consists of two operations: Channelisation and Scrambling. Firstly, each complex valued data symbol $\underline{d}_n^{(k,i)}$ of equation 1 is spread with a ~~complex~~ real valued channelisation code $\mathbf{c}^{(k)}$ ~~$\underline{\mathbf{c}}^{(k)}$~~ of length $Q_k \in \{1,2,4,8,16\}$. The resulting sequence is then scrambled by a complex sequence ~~$\mathbf{v}$~~ $\underline{\mathbf{i}}$ of length 16.

6.2 Channelisation codes

The elements $c_q^{(k)}$ ~~$\underline{c}_q^{(k)}$~~; k=1,...,K; q=1,...,Q_k; of the real valued ~~complex~~ channelisation codes $\mathbf{c}^{(k)}=(c_1^{(k)},c_2^{(k)},...,c_{Q_k}^{(k)})$ ~~$\underline{\mathbf{c}}^{(k)}=(\underline{c}_1^{(k)},\underline{c}_2^{(k)},...,\underline{c}_{Q_k}^{(k)})$~~; k=1,...,K; shall be taken from the ~~complex~~ set

$$\cancel{\underline{V}_c = \{1, j, -1, -j\}}\ V_c = \{1, -1\} \qquad (\cancel{3}4)$$

~~In equation 4 the letter j denotes the imaginary unit. A complex channelisation code $\underline{\mathbf{c}}^{(k)}$ is generated from the binary codes $\mathbf{a}_{Q_k}^{(k)} = (a_1^{(k)}, a_2^{(k)},...,a_{Q_k}^{(k)})$ of length Q_k shown in figure 2 allocated to the k^{th} user. The relation between the elements $\underline{c}_q^{(k)}$ and $\underline{a}_q^{(k)}$ is given by:~~

$$\cancel{\underline{c}_q^{(k)} = (j)^q \cdot a_q^{(k)} \quad a_q^{(k)} \in \{1,-1\};\ q = 1,...,Q_k.} \qquad \cancel{(5)}$$

~~Hence, the elements $\underline{c}_q^{(k)}$ of the complex channelisation codes $\underline{\mathbf{c}}^{(k)}$ are alternating real and imaginary.~~

The $\mathbf{c}_{Q_k}^{(k)}$ ~~$\mathbf{a}_{Q_k}^{(k)}$~~ are Orthogonal Variable Spreading Factor (OVSF) codes, allowing to mix in the same timeslot channels with different spreading factors while preserving the orthogonality. The OVSF codes can be defined using the code tree of figure ~~2~~1.

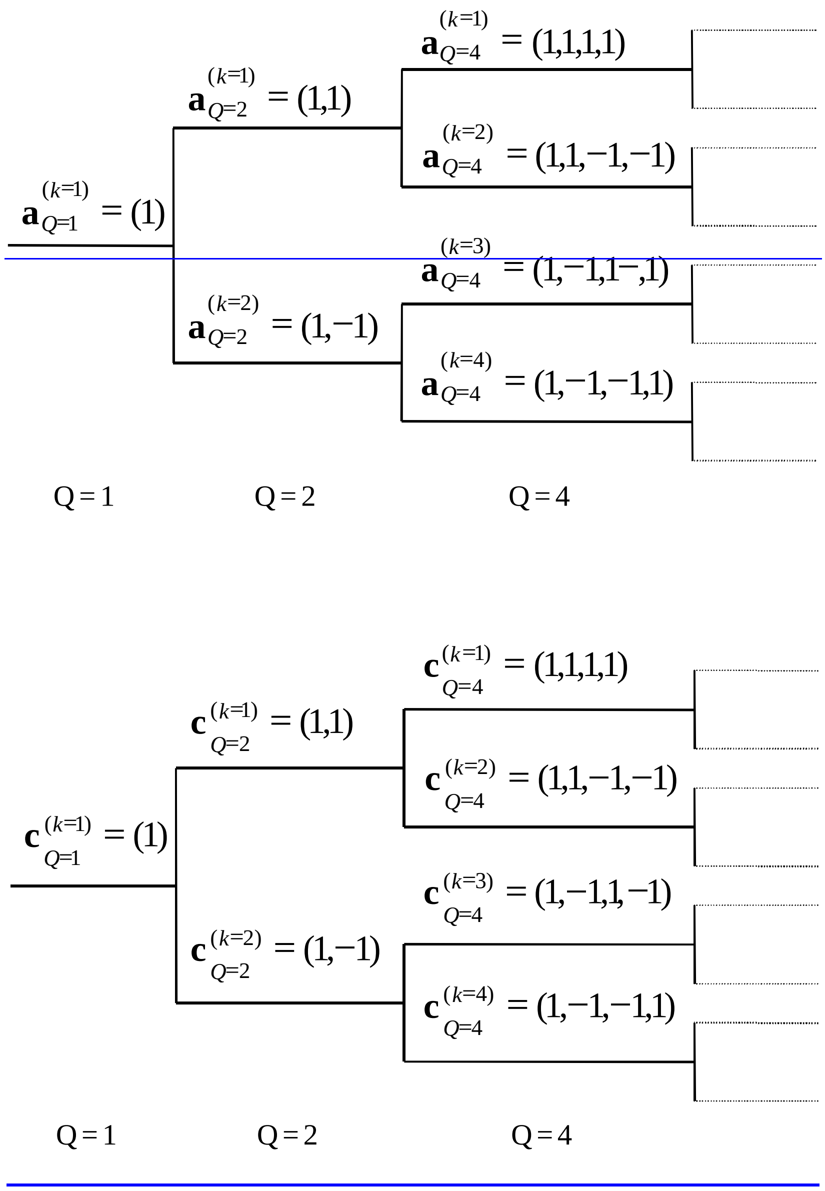


Figure 1: Code-tree for generation of Orthogonal Variable Spreading Factor (OVSF) codes for Channelisation Operation

Each level in the code tree defines a spreading factor indicated by the value of Q in the figure. All codes within the code tree cannot be used simultaneously in a given timeslot. A code can be used in a timeslot 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 in this timeslot. This means that the number of available codes in a slot is not fixed but depends on the rate and spreading factor of each physical channel.

The spreading factor goes up to Q_{MAX}=16.

6.3 Scrambling codes

The spreading of data by a ~~complex~~ real valued channelisation code $\mathbf{c}^{(k)}$ of length Q_k is followed by a cell specific complex scrambling sequence ~~v=(v1, v2, … vQMAX)~~ $\underline{\mathbf{v}} = (\underline{v}_1, \underline{v}_2, ..., \underline{v}_{16})$. The elements $\underline{v}_i; i = 1,...,16$ of the complex valued scrambling codes shall be taken from the complex set

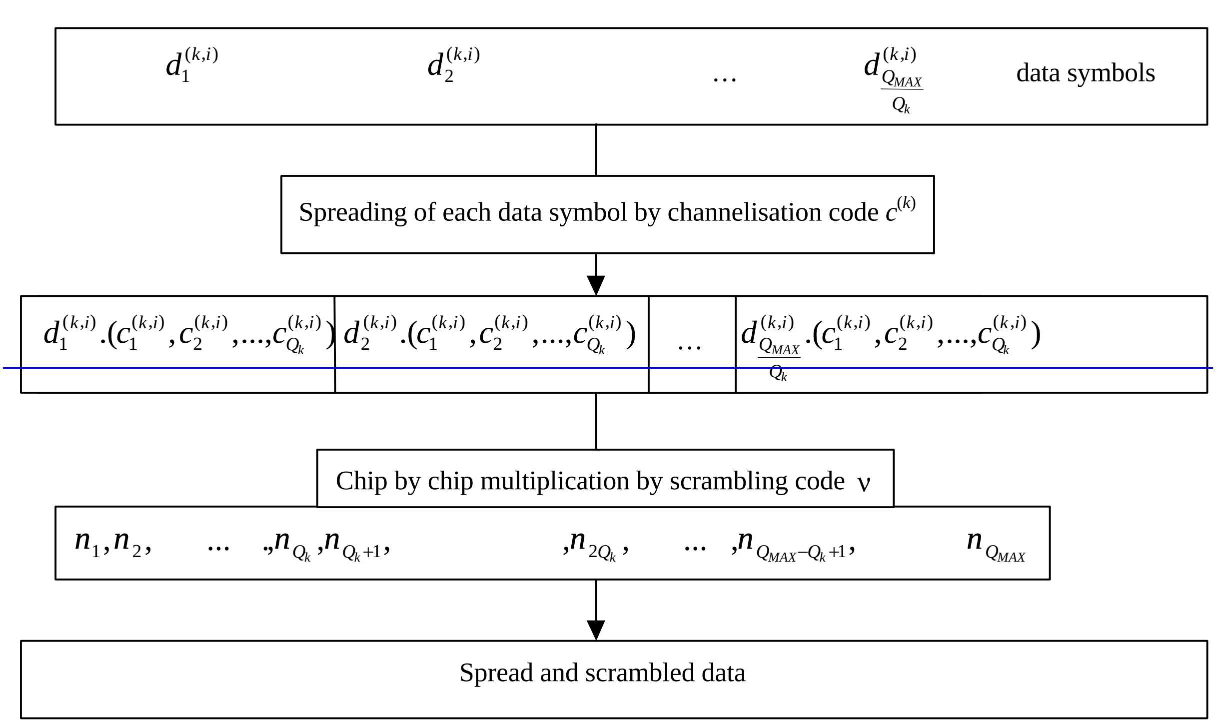
$$\underline{V}_{\underline{v}} = \{1, j, -1, -j\} \quad (5)$$

In equation 5 the letter j denotes the imaginary unit. A complex scrambling code í is generated from the binary scrambling codes $v = (n_1, n_2, \ldots, n_{16})$ of length 16 shown in Annex A. The relation between the elements í and í is given by:

$$\underline{v}_i = (j)^i \cdot n_i \qquad n_i \in \{1, -1\},\ i = 1, \ldots, 16 \quad (6)$$

Hence, the elements $\underline{n}_i$ of the complex scrambling code í 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 3 below and is described in more detail in section 6.4. ~~The applicable scrambling codes are shown in Annex A.~~



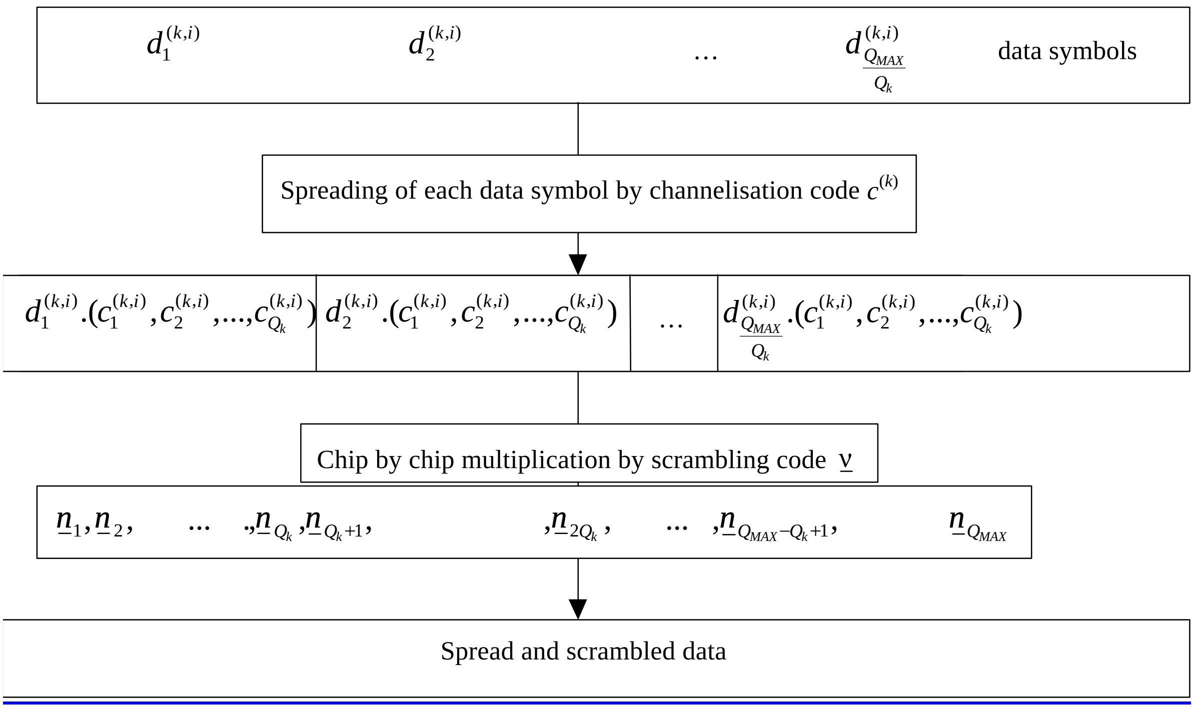


Figure 2: Spreading of data symbols

6.4 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 $\mathbf{s}^{(k)} = \left(s_p^{(k)}\right)$ with

$s_p^{(k)} = c^{(k)}_{1+[(p-1)\bmod Q_k]} \cdot \acute{I}_{1+[(p-1)\bmod Q_{MAX}]}$ ~~$s_p^{(k)} = c^{(k)}_{1+[(p-1)\bmod Q_k]} \cdot \acute{I}_{1+[(p-1)\bmod Q_{MAX}]}$~~, k=1,…,K, p=1,…,$N_kQ_k$.

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

$$\underline{d}^{(k,1)}(t) = \sum_{n=1}^{N_k} \underline{d}_n^{(k,1)} \sum_{q=1}^{Q_k} s^{(k)}_{(n-1)Q_k+q} \cdot Cr_o(t-(q-1)T_c-(n-1)Q_kT_c) \tag{6}$$

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

$$\underline{d}^{(k,2)}(t) = \sum_{n=1}^{N_k} \underline{d}_n^{(k,2)} \sum_{q=1}^{Q_k} s^{(k)}_{(n-1)Q_k+q} \cdot Cr_0(t-(q-1)T_C-(n-1)Q_kT_c-N_kQ_kT_c-L_mT_c). \tag{7}$$

where L_m is the number of midamble chips.

6.5 Modulation

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

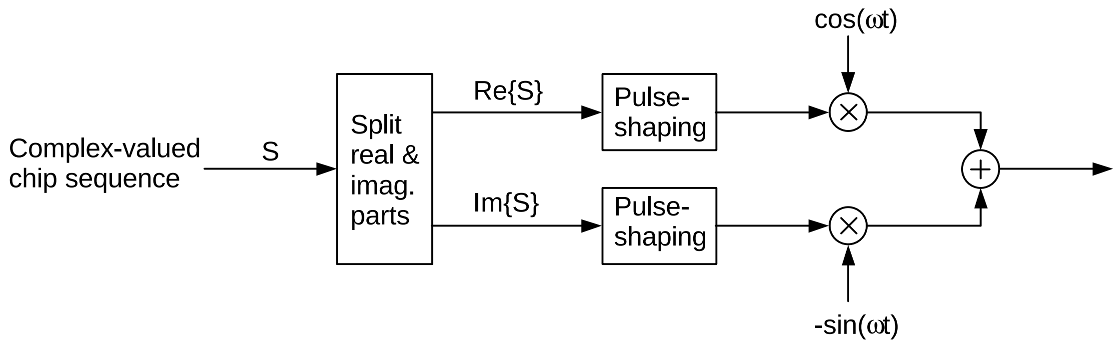


Figure 3: Modulation of complex valued chip sequences

7 Synchronisation codes

7.1 Code Generation

~~The Primary code sequence, C_p is constructed as a so-called generalised hierarchical Golay sequence. The Primary SCH is furthermore chosen to have good aperiodic auto correlation properties.~~

~~Letting a = < x_1, x_2, x_3, …, x_{16} > = < 0, 0, 0, 0, 0, 0, 1, 1, 0, 1,0, 1, 0, 1, 1, 0 > and~~

~~b = $< x_1, \ldots, x_8, \overline{x}_9, \ldots, \overline{x}_{16} >$ = <0,0,0,0,0,0,1,1,1,0,1,0,1,0,0,1>~~

~~The PSC code is generated by repeating sequence 'a' modulated by a Golay complementary sequence.~~

~~Letting $y = < a, a, a, \overline{a}, \overline{a}, a, \overline{a}, \overline{a}, a, a, a, \overline{a}, a, \overline{a}, a, a >$~~

~~The definition of the PSC code word C_p follows (the left most index corresponds to the chip transmitted first in each time slot):~~

~~C_p=< y(0),y(1),y(2),...,y(255) >.~~

~~Let the length 256 mask sequence z be given as, z =~~ $\cancel{< b,b,b,\bar{b},b,b,\bar{b},\bar{b},b,\bar{b},b,\bar{b},\bar{b},\bar{b},\bar{b},\bar{b} >}$.

~~Then the Secondary Synchronization code words, {C_0,…,C_{15}} are constructed as the position wise addition modulo 2 of a Hadamard sequence and the sequence z.~~

~~The Hadamard sequences are obtained as the rows in a matrix H_8 constructed recursively by:~~

$$\cancel{H_0 = (0)}$$

$$\cancel{H_k = \begin{pmatrix} H_{k-1} & H_{k-1} \\ H_{k-1} & \overline{H_{k-1}} \end{pmatrix}, \quad k \geq 1}$$

~~The rows are numbered from the top starting with row *0* (the all zeros sequence), h_0.~~

~~The Hadamard sequence *h* depends on the chosen code number *n* and is denoted h_n in the sequel.~~

~~This code word is chosen from every 16th row of the matrix H_8., which yields 16 possible codewords *n* = 0, 1,…,15.~~

~~Furthermore, let $h_n(i)$ and $z(i)$ denote the *i*:th symbol of the sequence h_n and z, respectively.~~

~~The definition of the *n*:th SCH code word follows (the left most index correspond to the chip transmitted first in each slot):~~

~~$C_{SCH,n}$ = < $h_n(0)$+ z(0), $h_n(1)$+ z(1), $h_n(2)$+ z(2), …,$h_n(255)$+ z(255) >,~~

~~All sums of symbols are taken modulo 2.~~

~~These PSC and SSC binary code words are converted to real valued sequences by the transformation '0' -> '+1', '1' -> '-1'.~~

~~The Secondary SCHcode words are defined in terms of $C_{SCH,n}$ and the definition of {C_0,…,C_{15}} now follows as:~~

~~C_i = $C_{SCH,i}$, i=0,…,15~~

The Primary code sequence, C_{psc} is constructed as a so-called generalised hierarchical Golay sequence. The PSC is furthermore chosen to have good aperiodic auto correlation properties.

Define a = < x_1, x_2, x_3, …, x_{16} > = < 1, 1, 1, 1, 1, 1, -1, -1, 1, -1, 1, -1, 1, -1, -1, 1 >

The PSC is generated by repeating the sequence 'a' modulated by a Golay complementary sequence and creating a complex-valued sequence with identical real and imaginary components.

The PSC C_{psc} is defined as C_{psc}=< y(0),y(1),y(2),...,y(255) >

where $y = (1+\mathrm{j}) \times < a,a,a,-a,-a,a,-a,-a,a,a,a,-a,a,-a,a,a >$

and the left most index corresponds to the chip transmitted first in each time slot.

The 16 secondary synchronization codes, {C_0,…,C_{15}} are complex valued with identical real and imaginary components, and are constructed from the position wise multiplication of a Hadamard sequence and a sequence z, defined as

z = $< b,b,b,-b,b,b,-b,-b,b,-b,b,-b,-b,-b,-b,-b >$, where

b = $< x_1,\ldots,x_8,-x_9,\ldots,-x_{16} >$ = <1, 1, 1, 1, 1, 1, -1, -1, -1, 1, -1, 1, -1, 1, 1, -1>.

The Hadamard sequences are obtained as the rows in a matrix H_8 constructed recursively by:

$$H_0 = (1)$$

$$H_k = \begin{pmatrix} H_{k-1} & H_{k-1} \\ H_{k-1} & -H_{k-1} \end{pmatrix}, \quad k \geq 1$$

The rows are numbered from the top starting with row *0* (the all zeros sequence).

Denote the *n*:th Hadamard sequence as a row of H_8 numbered from the top, n = 0, 1, 2, …, 255, in the sequel.

Furthermore, let $h_m(i)$ and $z(i)$ denote the *i*:th symbol of the sequence h_m and z, respectively where *i* = 0, 1, 2, …, 255 and *i* = 0 corresponds to the leftmost symbol.

The i:th SSC, $C_{SSC,i}$, i = 0, …, 15 is then defined as

C_{SSC} = $(1 + j) \times <h_m(0) \times z(0), h_m(1) \times z(1), h_m(2) \times z(2), \ldots, h_m(255) \times z(255)>$, where m = (16×i) and the leftmost chip in the sequence corresponds to the chip transmitted first in time .

This code word is chosen from every 16th row of the matrix H_8., which yields 16 possible codewords. The SSC words are defined in terms of $C_{SSC,n}$ and the definition of $\{C_0,\ldots,C_{15}\}$ now follows as:

$C_i = C_{SSC,i}$, i=0,…,15

7.2 Code Allocation

Three ~~SCH codes~~SSC's are QPSK modulated and transmitted in parallel with the primary synchronization code. The QPSK modulation carries the following information.

- The code group that the base station belongs to (5 bits; Cases 1,2,3)
- The position of the frame within an interleaving period of 20 msec (1 bit, Cases 1,2,3)
- The position of the slot within the frame (1 bit, Cases 2,3)
- SCH transport channel information, e.g. the location of the Primary CCPCH (3 bits, Case 3)