3GPP TSG RAN WG1 #2 **TSGR1#2(99)056**
Yokohama, Japan
March 22-25, 1999

Source: Temporary Editor

3GPP S1.23 V0.0.1 1999-02

Spreading and modulation (TDD)

Note: The layout of this document will be changed to 3GPP standard as soon as a common template is available. This includes references to the issuing organisation, copyright information, and IPR regulation on the next pages.

Reference

<Workitem>

Keywords

<keyword[, keyword]>

3GPP

Internet

http://www.3gpp.org

Copyright Notification

Contents

Note on this document

This document is created by merging the text of the ARIB Volume 3 specification (Version 1.0) into the ETSI UMTS XX.11 specification (Version 1.0.0). The merging procedure is based on TSGW#1(99) 17 (Proposal how to proceed with the merging of documents from ARIB and ETSI into the first 3GPP/WG1 documentation) accepted in the last TSG RAN WG1 meeting as the Editing policy.

Adding all text in Volume 3 specification (3.3.4 Modulation and modulation) to the ETSI document has performed the merging.

In order to distinguish between the two sources of the text, *the ARIB input is displayed in italic, using "Times New Roman" as font,* while the ETSI text is in the original "Times New Roman".

Use following editing classes:

Class A. ***if technical contents is the same, produce single text***
Class B. ***in case of minor differences make a recommendation and add editors note***
Class C. ***in case merge is not possible, add both alternatives in square brackets and add clarifying note***
Class D. ***contents only in ARIB or ETSI should be included and indicated with editors note.***

The status of this document is as follows:

1. Chip rate (section 4)
   ETSI: 4.096Mcps ARIB: 4.096Mcps(1.024,8.192,16.384 Mcps)
   -> take ARIB, chip rates in brackets as optional additional values
2. Spreading code (section 4 and section 6.3)
   ETSI: 1,2,4,8,16 ARIB: 1 to 512 @ 4.096Mcps
   -> take ETSI
3. Training sequence (section 5.2 and section 3.3.4.2.2.3)
   ETSI: TCH dedicated sequence (midamble)

   Time multiplexed in the middle of the burst
   ARIB: TCH dedicated pilot symbols. Option: TCH dedicated sequence (midamble)

   Time multiplexed in the middle of the burst
   -> take ETSI
4. DL Spreading modulation (section 6)
   ETSI: QPSK, phase transition restrictions
   ARIB: QPSK
   -> take ETSI
5. DL Scrambling code (cell identification) (section 6.4)
   ETSI: 16 chips ARIB: 10ms
   -> take ETSI
6. UL Spreading modulation (section 6)
   ETSI: QPSK, phase transition restrictions

   ARIB: HPSK
   -> take ETSI
7. UL Scrambling code (cell identification) (section 6.4)
   ETSI: 16 chips
   ARIB: 2^9 x 720 ms
   -> take ETSI

Intellectual Property Rights

[IPRs essential or potentially essential to the present deliverable may have been declared to ETSI/3GPP. The information pertaining to these essential IPRs, if any, is publicly available for ETSI members and non-members, free of charge. This can be found in the latest version of the ETSI Technical Report: ETR 314: "Intellectual Property Rights (IPRs); Essential or potentially Essential, IPRs notified to ETSI in respect of ETSI standards". The most recent update of ETR 314, is available on the ETSI web server or on request from the Secretariat.

Pursuant to the ETSI Interim IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in the ETR 314, which are, or may be, or may become, essential to the present document.]

Note: The content has to be reviewed according to the 3GPP IPR rules.

Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of this TS are subject to continuing work within 3GPP TSG RAN and may change following formal TSG RAN approval.

1 Scope

This document establishes the characteristics of the spreading and modulation in the TDD mode . The main objectives of the document are to be a part of the full description of the Layer 1, and to serve as a basis for the drafting of the actual technical specification (TS).

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, subsequent revisions do apply.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] Reference 1

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following definitions apply:
<defined term>: <definition>.

3.2 Symbols

For the purposes of the present document, the following symbols apply:
<symbol> <Explanation>

3.3 Abbreviations

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

CDMA Code Division Multiple Access
PN Pseudo Noise
QPSK Quadrature Phase Shift Keying
RACH Random Access Channel

4 General

<Editor's Note: Class C. Regarding Spreading characteristics and chip rate in Table 1, there is major deference between ETSI and ARIB. Other parameters are the same>

< Documentation status: A chip rate equal to the FDD mode, 4.096 Mcps, is to be considered as working assumption. >

In the following, a separation between the data modulation and the spreading modulation has been made. The data modulation is defined in section 5 and the spreading modulation in section 6.

Table 1: Basic modulation parameters.

Chip rate	same as FDD basic chiprate, 4.096 Mchip/s [(1.024,8.192,16.384Mcps)]
Carrier spacing	5.0 MHz
Data modulation	QPSK
Chip modulation	same as FDD chip modulation, root-raised cosine roll-off $\alpha = 0.22$
Spreading characteristics	Orthogonal Q chips/symbol, where $Q = 2^p$, $0 <= p <= 4$

5 Data modulation

< Documentation status: Everything in this section is to be considered as working assumption, except otherwise explicitly stated. >

3.3.4.1 Data Modulation

<Editor's Note: Class B. Time Multiplexing of DPDCH and DPCCH is the same. Both in ETSI and ARIB, the control part (called DPCCH in ARIB), contain pilot/midamble bits and TPC/TFCI bits. >

The modulation is QPSK with time-multiplexed DPDCH and DPCCH in reverse link and forward link.

5.1 Symbol rate

<Editor's Note: Class A. This technical content is the same>

The symbol rate and duration are indicated below:

$T_s = Q \times T_c$, where $T_c = \frac{1}{chiprate} = 0.24414\ \mu s$, reflecting the dependence of the symbol time T_s upon the spreading factor Q.

5.2 Mapping of bits onto signal point constellation

<Editor's Note: Class C and D. Major difference ARIB/ETSI and only mentioned in ETSI. But ETSI midamble scheme is optional in ARIB. See section 3.3.4.2.2.3 in this text. >

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. In UMTS XX.09 examples of bodies of such spread bursts associated with a particular user are shown. Each user burst has two data carrying parts, termed data blocks:

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

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 XX.09.

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 data bits

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

using the equation

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

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

5.3 Pulse shape filtering

<Editor's Note: Class A. This technical content is the same>

< Documentation status: The use of root-raised cosine pulse shaping is the working assumption. Another proposal exist in Tdoc SMG2 UMTS-L1 17/98. >

The pulse shape filtering is applied to each chip at the transmitter. In this context the term chip represents a single element $\underline{c}_q^{(k)}$ with k=1,...,K; q=1,...,Q_k; of a spreading code $\underline{\mathbf{c}}^{(k)}$; see also section 6.2.

The impulse response of the above mentioned chip impulse filter $Cr_0(t)$ shall be a root-raised cosine. The corresponding raised cosine impulse $C_0(t)$ is defined as

$$C_0(t) = \frac{\sin p \frac{t}{T_c}}{p \frac{t}{T_c}} \cdot \frac{\cos ap \frac{t}{T_c}}{1 - 4a^2 \frac{t^2}{T_c^2}} \qquad (4)$$

The roll-off factor shall be $\alpha = 0.22$. T_c is the chip duration:

$$T_c = \frac{1}{chiprate} = 0.24414 ms$$

The impulse response $C_0(t)$ according to equation 4 and the energy density spectrum $\Phi_{C0}(f)$ of $C_0(t)$ are depicted in figure 1 below:

$C_0(t)$

Grafikname:
Erstellt in:
Erstellt am:

$\Phi_{C0}(f)$ in dB

Grafikname:
Erstellt in:
Erstellt am:

Figure 1: Basic impulse $C_0(t)$ and the corresponding energy density spectrum $\Phi_{C0}(f)$ of $C_0(t)$

6 Spreading modulation

< Documentation status: Everything in this section is to be considered as working assumption, except otherwise explicitly stated. >

3.3.4.2 Spreading modulation

<Editor's Note: Class C and D. Major difference ARIB/ETSI and only mentioned in ARIB.>

This is the same as FDD mode. It consists of two operations. The first is the spreading operation and the second operation is the scrambling operation. Both reverse link and forward link have the same scrambling code periods as FDD mode. At transmission timeslot, scrambling code generator must output the same value when scrambling code generator is performed during reception timeslot.

6.1 Basic spreading parameters

<Editor's Note: Class C and D. Major difference ARIB/ETSI (maximum spreading factor) and only mentioned in ETSI>

Each data symbol $\underline{d}_n^{(k,i)}$ of equation 1 is spread with a spreading code $\underline{\mathbf{c}}^{(k)}$ of length $Q_k \in \{1,2,4,8,16\}$. The resulting sequence is then scrambled by a sequence ν of length 16.

6.2 Modulation Scheme

<Editor's Note: Class D. Major difference ARIB/ETSI and only mentioned in ARIB >

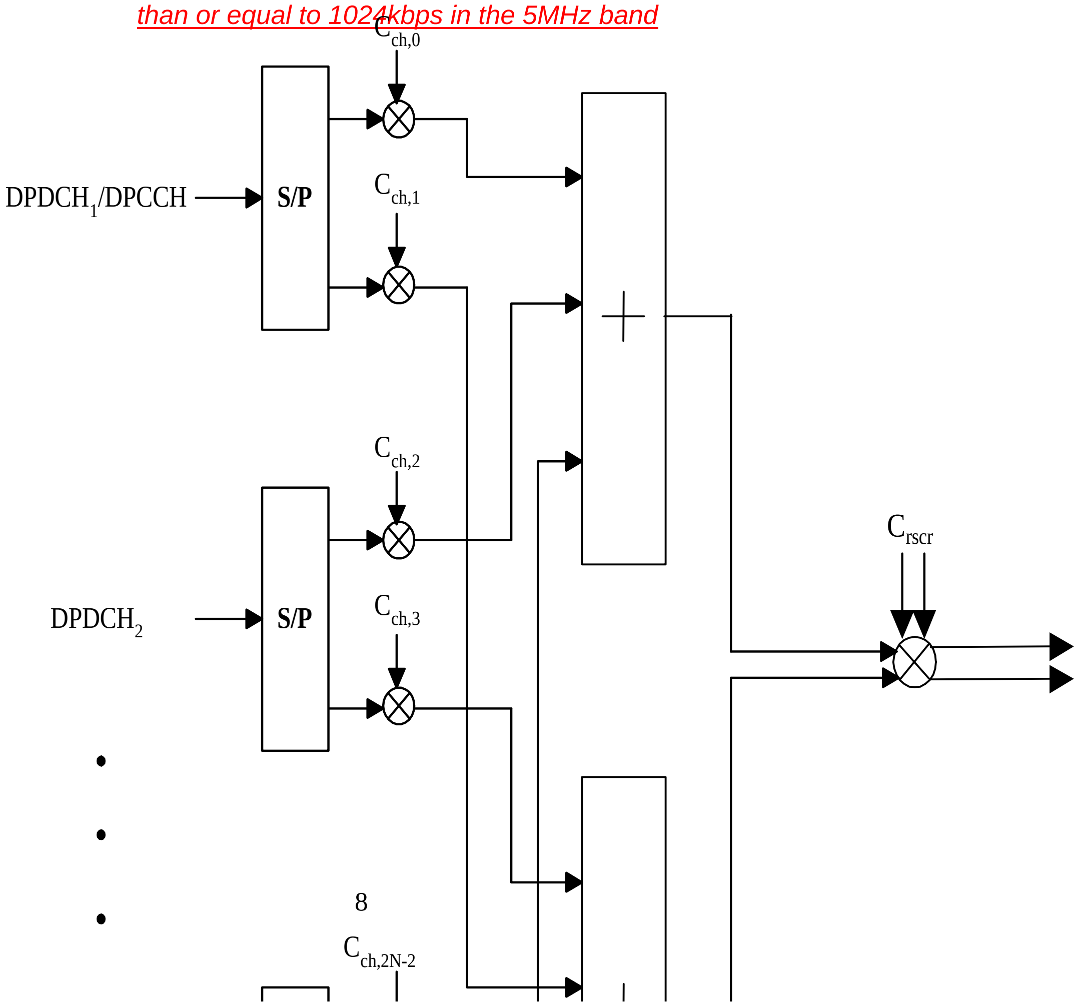
3.3.4.2.1.1 Forward Link Spreading Modulation Scheme

This is the same as FDD mode.

3.3.4.2.1.2 Reverse Link Spreading Modulation Scheme

Figure 3.3.4-1 and Figure 3.3.4-2 schematically shows the reverse link spreading modulation scheme. Note that Figure 3.3.4-1 and Figure 3.3.4-2 only show the principle, and not necessarily an actual implementation. DPDCH and DPCCH are time-multiplexed and data modulation is QPSK such that each pair of two bits is serial to parallel converted. For services less than or equal to 1024kbps in the 5MHz band, the DPCCH/DPDCH$_1$ is serial to parallel converted and spread by the spreading codes, $C_{ch,0}$ and $C_{ch,1}$. Each subsequent DPDCH$_i$ is serial to parallel converted and spread by a predefined individual spreading codes, $C_{ch,2i-2}$ and $C_{ch,2i-1}$ (Figure 3.3.4-1). For 2048kbps service in the 5MHz band, the DPCCH/DPDCH$_1$ is serial to *parallel converted and spread by the spreading code, $C_{ch,0}$. Each subsequent DPDCH$_i$ is serial to parallel converted and spread by a predefined individual spreading codes, $C_{ch,i-1}$ (Figure 3.3.4-2). 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_{rscr}. The generation of the complex-valued scrambling codes is described in section 3.3.4.2.2.2.2.1.*

Figure 3.3.4-1: Spreading modulation for Reverse Link Dedicated Physical Channel for services less than or equal to 1024kbps in the 5MHz band



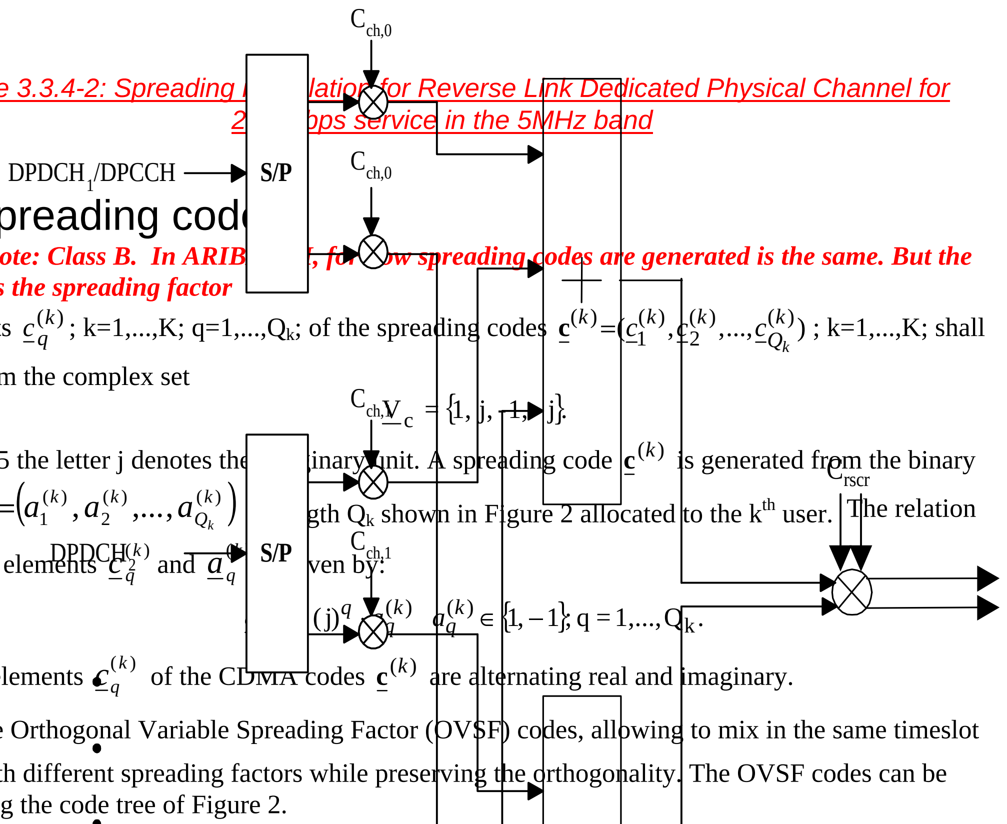


Figure 3.3.4-2: Spreading Modulation for Reverse Link Dedicated Physical Channel for 2[illegible]bps service in the 5MHz band

6.3 Spreading codes

<Editor's Note: Class B. In ARIB[illegible], for how spreading codes are generated is the same. But the difference is the spreading factor

The elements $\underline{c}_q^{(k)}$; k=1,...,K; q=1,...,Q_k; of the spreading codes $\underline{\mathbf{c}}^{(k)}=(\underline{c}_1^{(k)},\underline{c}_2^{(k)},...,\underline{c}_{Q_k}^{(k)})$; k=1,...,K; shall be taken from the complex set

$$\underline{V}_c = \{1, j, -1, -j\}. \qquad (5)$$

In equation 5 the letter j denotes the imaginary unit. A spreading code $\underline{\mathbf{c}}^{(k)}$ is generated from the binary codes $\mathbf{a}_{Q_k}^{(k)} = \left(a_1^{(k)}, a_2^{(k)}, ..., a_{Q_k}^{(k)}\right)$ 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:

$$\underline{c}_q^{(k)} = (j)^q \cdot a_q^{(k)} \quad a_q^{(k)} \in \{1, -1\}, \; q = 1,...,Q_k. \qquad (6)$$

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

The $\mathbf{a}_{Q_k}^{(k)}$ 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.

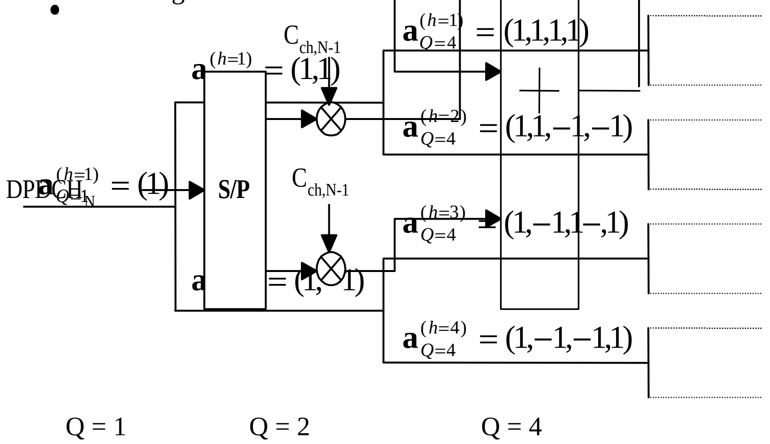


Figure 2: Code-tree for generation of Orthogonal Variable Spreading Factor (OVSF) codes.

Each level in the code tree defines a spreading factors 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.

3.3.4.2.2.1 Spreading Code Generation

<Editor's Note: Class B. >

3.3.4.2.2.1.1 Forward Link Spreading Code Generation

This is the same as FDD mode.

3.3.4.2.2.1.1.1 Spreading Code Generation for symbols other than 1st and 2nd Search Codes

This is the same as FDD mode.

3.3.4.2.2.1.1.2 Spreading Code Generation for Search Codes

This is the same as FDD mode.

3.3.4.2.2.1.2 Reverse Link Spreading Code Generation

This is the same as FDD mode.

6.4 Scrambling codes

<Editor's Note: Class C. Major differences ARIB/ETSI for how scrambling codes are generated. >

The spreading of data by a code $\mathbf{c}^{(k)}$ of length Q_k is followed by a cell specific scrambling sequence $\nu=(\nu 1, \nu 2, \ldots \nu_{QMAX})$. 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 6.5

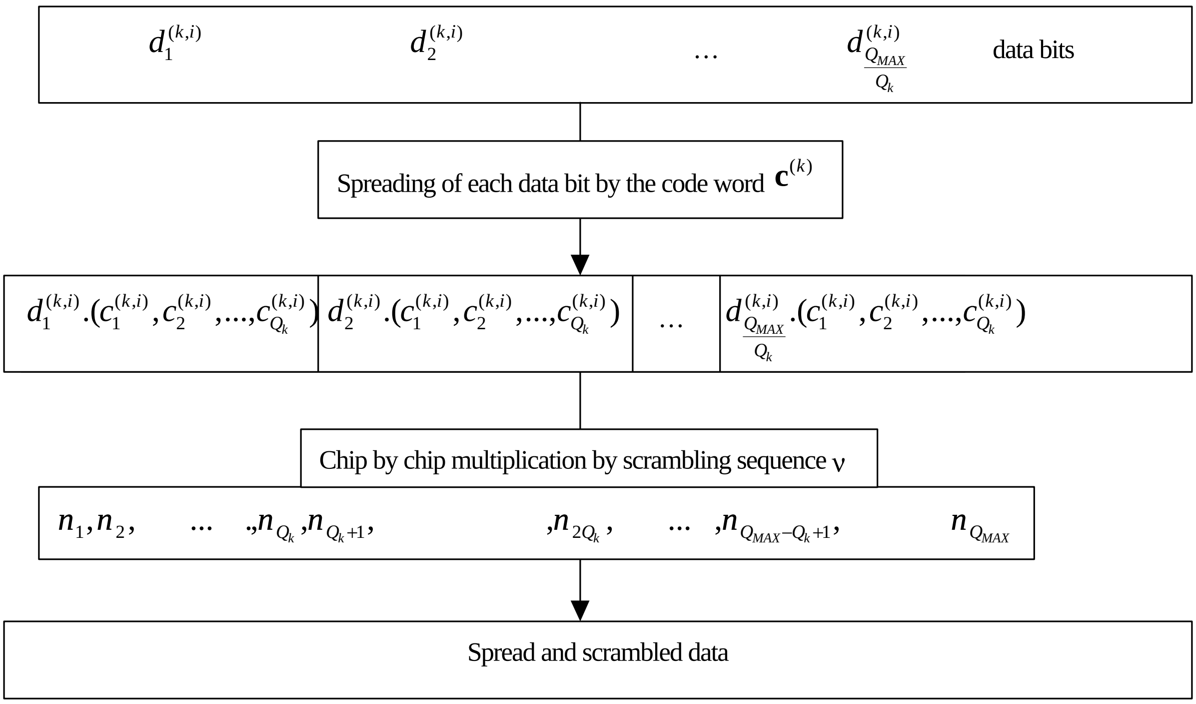


Figure 3: Spreading and subsequent scrambling of data bits.

3.3.4.2.2.2 Scrambling Code Generation

<Editor's Note: Class C. Major differences ARIB/ETSI for how scrambling codes are generated. >

3.3.4.2.2.2.1 Forward Link Scrambling Code Generation

This is the same as FDD mode.

3.3.4.2.2.2 Reverse Link Scrambling Code Generation

3.3.4.2.2.2.1 Normal Reverse Link Scrambling Code Generation

This is the same as FDD mode.

3.3.4.2.2.2.2 Short Reverse Link Scrambling Code Generation (option)

This is the same as FDD mode.

6.5 Spread and scrambled signal of data symbols and data blocks

The combination of the spreading 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 $s_p^{(k)} = c^{(k)}_{1+[(p-1) \bmod Q_k]} \cdot \acute{\imath}_{1+[(p-1) \bmod Q_{MAX}]}$, 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

$$\underline{d}^{(k,1)}(t) = \sum_{n=1}^{N_k} \underline{d}_n^{(k,1)} \sum_{q=1}^{Q_k} s^{(k)}_{(n-1)Q_k+q} \cdot Cr_o(t-(q-1)T_c-(n-1)Q_k T_c) \qquad (7)$$

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

$$\underline{d}^{(k,2)}(t) = \sum_{n=1}^{N_k} \underline{d}_n^{(k,2)} \sum_{q=1}^{Q_k} s^{(k)}_{(n-1)Q_k+q} \cdot Cr_0(t-(q-1)T_C-(n-1)Q_k T_c - N_k Q_k T_c - L_m T_c). \qquad (8)$$

where L_m is the number of midamble chips.

6.6 Code Allocation Method

<Editor's Note: Class D. Major difference ARIB/ETSI and only mentioned in ARIB. >

6.6.1 Forward Link Code Allocation

6.6.1.1 Forward Link Spreading Code Allocation Method for Symbols other than First and Second Search Codes

[TBD]

6.6.1.2 Forward Link Scrambling Code Allocation Method for Symbols other than First and Second Search Codes

[TBD]

6.6.1.3 Spreading Code Allocation for Search Codes

This is the same as FDD mode.

6.6.1.3.1 Spreading Code Allocation for First Search Code

This is the same as FDD mode.

6.6.1.3.2 Spreading Code allocation for Second Search Code

This is the same as FDD mode.

6.6.3.2 Reverse Link Code Allocation

6.6.3.2.1 Reverse Link Spreading Code Allocation Method

This is the same as FDD mode

6.6.3.2.2 Reverse Link Scrambling Code Allocation Method

[TBD]

6.6.3.2.2.1 Reverse Link Scrambling Code Allocation Method for Normal Spreading Modulation

[TBD]

6.6.3.2.2.2 Reverse Link Scrambling Code Allocation Method for Alternative RSTS

[TBD]

3.3.4.2.2.3 Special Scrambling Codes for Joint Channel Estimation of Active Users in Time Slots (option)

<Editor's Note: Class D. Major difference ARIB/ETSI and only mentioned in ARIB as an option technology. >

The Special Pilot Scrambling Codes (PSC) for different users are generated from one Basic Code. The method shown here enables a joint low-cost channel estimation of all active users within a time slot with high reliability and performance, especially suited for advanced receiver structures, e.g. joint detection receivers.

In each cell, the PSC for the different Users are elaborated from one single Basic code, see Figure 3.3.4-2. The P elements $m_i;\ i=1,\dots,P,$ *of the basic code* m_P *are contained in the vector*

$$\mathbf{m}_P = (m_1, m_2, \dots, m_P)^T. \qquad (1)$$

With W being the number of taps of the impulse response of the mobile radio channels, the L_m *binary elements* $m_i^{(k)};\ i=1,\dots,L_m;\ k=1,\dots,K;$ *of the PSC for the K users are generated from a periodic extension of the Basic Code, the Periodic Basic Code m of length* $L_m+(K-1)W$ *according to the following rules:*

$$\mathbf{m} = \left(m_1, m_2, \dots, m_{L_m+(K-1)W}\right)^T \qquad m_i \in \{1,\ -1\};\ \ i=1,\dots,(L_m+(K-1)W). \qquad (2)$$

Hence, the elements $m_i;\ i=1,\dots,(L_m+(K-1)W),$ *of fulfill the relation*

$$m_i = m_{i-P} \quad \text{for the subset} \quad i=(P+1),\dots,(L_m+(K-1)W). \qquad (3)$$

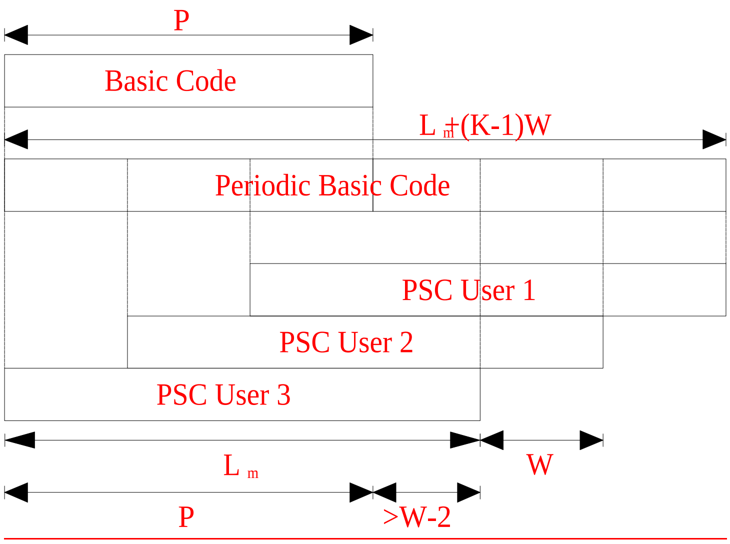


Figure 3.3.4-2: Evaluation of User-PSC from one Basic Code. Shown case: K=3 Users.

With m according to the L_m *binary elements* $m_i^{(k)};\ i=1,\dots,L_m;\ k=1,\dots,K;$ *of for the PSC of the K users are generated from*

$$m_i^{(k)} = m_{i+(K-k)W} \qquad i=1,\dots,L_m;\quad k=1,\dots,K \qquad (4)$$

The L_m complex elements $\underline{m}_i^{(k)}$; $i = 1,\ldots,L_m$; $k = 1,\ldots,K$; of the PSC $\underline{\mathbf{m}}^{(k)}$; $k = 1,\ldots,K$; of the K users shall fulfill the relation

$$\underline{m}_i^{(k)} = (\mathrm{j})^i \cdot m_i^{(k)} \qquad m_i^{(k)} \in \{1,\ -1\};\ i = 1,\ldots,L_m;\ k = 1,\ldots,K. \qquad (5)$$

Hence, the elements $\underline{m}_i^{(k)}$ of the complex PSC $\underline{\mathbf{m}}^{(k)}$ of the K users are alternating real and imaginary.

The term PSC set or PSC family denotes K specific scrambling codes $\underline{\mathbf{m}}^{(k)}$; $k = 1,\ldots,K$, based on the same period $\mathbf{m}_\mathrm{P}$ according. Different special scrambling code sets $\underline{\mathbf{m}}^{(k)}$; $k = 1,\ldots,K$; are based on different periods $\mathbf{m}_\mathrm{P}$.

In adjacent cells of the cellular mobile radio system, different PSC sets $\underline{\mathbf{m}}^{(k)}$; $k = 1,\ldots,K$; should be used to guarantee a proper channel estimation.

In the forward link, 2K data blocks are transmitted in a burst simultaneously. Also in the reverse link, if K' > 1 CDMA codes are assigned to a single user, 2K' data blocks are transmitted in a burst simultaneously by this user. This is the so called multi-code reverse link situation. In the forward link and the multi-code reverse link, the mean power used to transmit the scrambling codes on the one hand and the 2K (or 2K') data blocks on the other hand shall be equal. This shall be achieved by multiplying the scrambling codes $\underline{\mathbf{m}}^{(k)}$, $k = 1,\ldots,K$, with a proper real factor to achieve an equal mean power.

Identification procedure of normal pilot sequence and PSC on MS and the specific method of implementation to system are F.F.S.

History

Document history		
Date	**Version**	**Comment**
February 1999	0.0.1	Document created. Based on ETSI XX.11,v1.0.0 and ARIB Vol.3,v1.0-1.0.
Rapporter (temporarily) for 3GPP S1.23 is:		

Kenji Ito
Siemens K.K.
Tel.: +81-3-5423-8520
e-mail: **Error! Reference source not found.**

Michel Jansen
Ericsson Business Mobile Networks BV
Tel: +46-85-8533-693
E_mail: **Error! Reference source not found.**

This document is written in Microsoft Word Version 97 SR-1 and saved in Rich Text Format.