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Spreading and modulation (TDD)

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Reference

<Workitem>

Keywords

<keyword[, keyword]>

3GPP

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Contents

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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).

<Editor's note: The content has to be reviewed according to the 3GPP rules. >

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

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

5.1 Symbol rate

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

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 document S1.21 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:

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

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 document S1.21.

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

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

using the equation

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

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

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

$$C_0(t) = \frac{\sin \pi \frac{t}{T_c}}{\pi \frac{t}{T_c}} \cdot \frac{\cos \alpha\pi \frac{t}{T_c}}{1 - 4\alpha^2 \frac{t^2}{T_c{}^2}} \tag{4}$$

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

$$T_c = \frac{1}{chiprate} = 0.24414\mu\mathrm{s}$$

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:

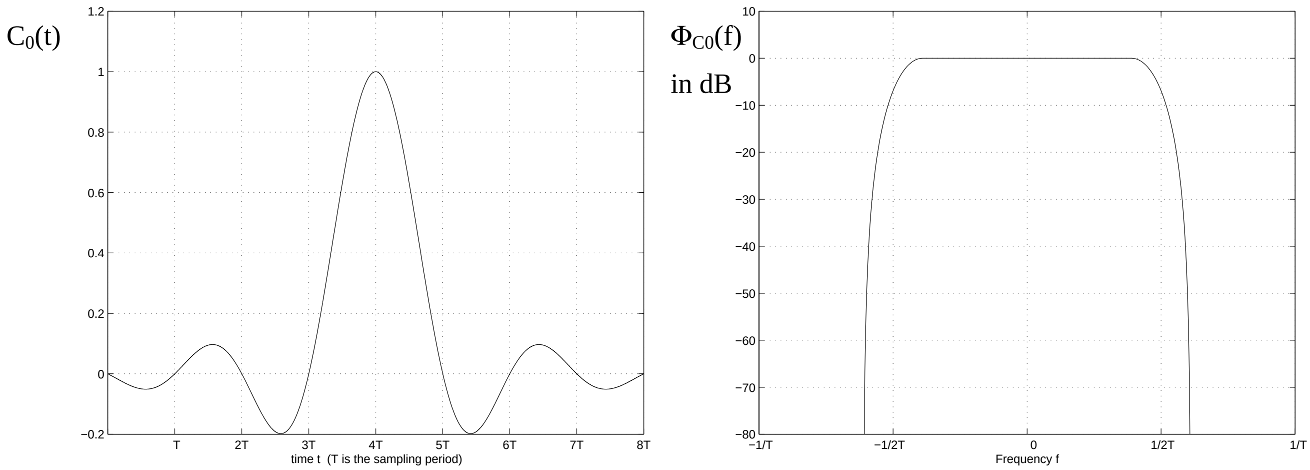

Figure 1: Basic impulse $C_0(t)$ and the corresponding energy density spectrum $\Phi_{C0}(f)$ of $C_0(t)$

6 Spreading modulation

6.1 Basic spreading parameters

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 Spreading codes

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

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

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:

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

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.

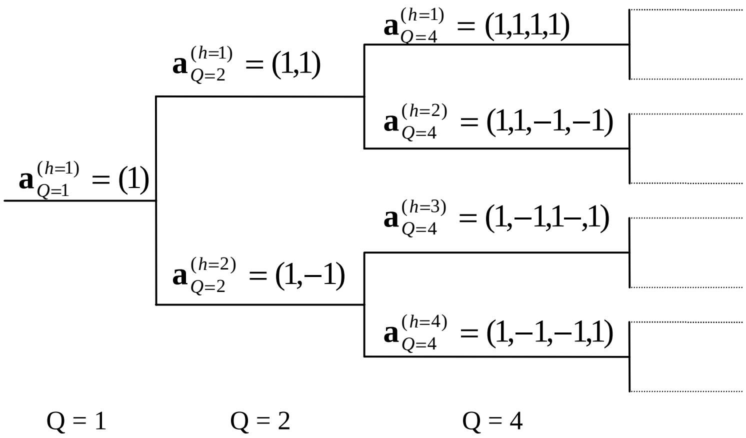

Figure 2: Code-tree for generation of Orthogonal Variable Spreading Factor (OVSF) codes.

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.

6.3 Scrambling codes

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 6.4

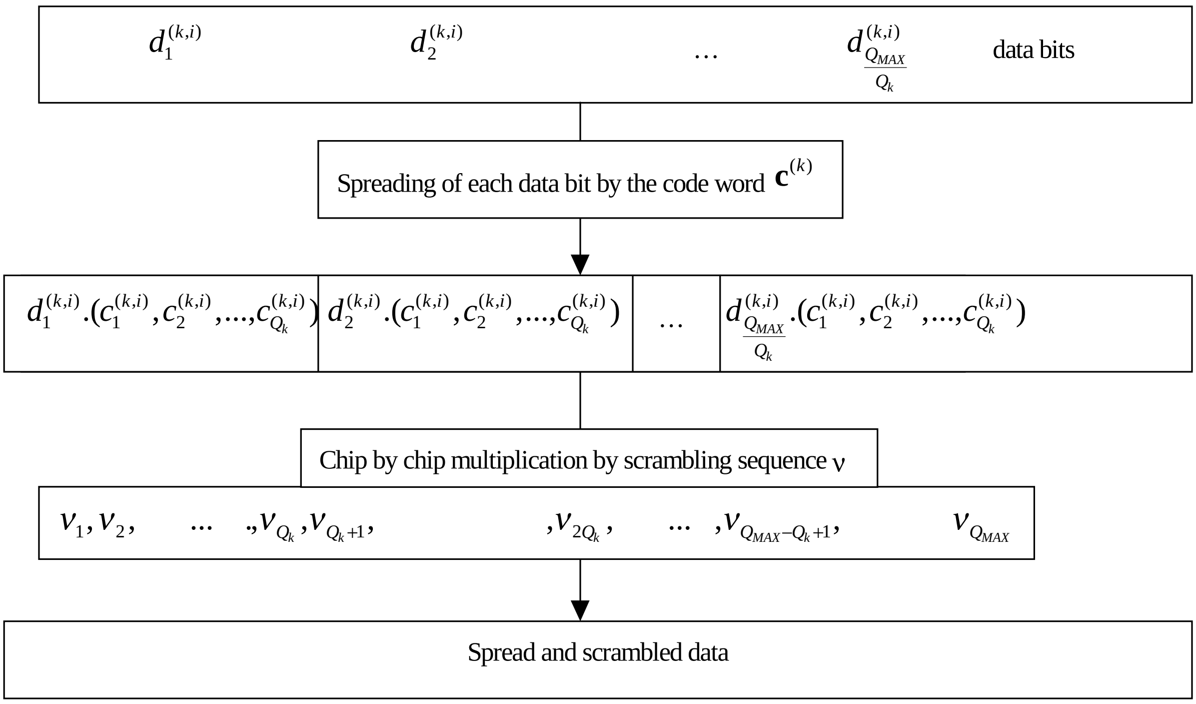

Figure 3: Spreading and subsequent scrambling of data bits.

<Editor's note: longer scrambling code over Qmax is FFS on Ad Hoc 1 (TDD) in case of insufficient performance of the current scrambling code v. >

6.4 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 $s_p^{(k)} = c^{(k)}_{1+[(p-1)\bmod Q_k]} .\acute{\imath}_{1+[(p-1)\bmod Q_{MAX}]}$, 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

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

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

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

where L_m is the number of midamble chips.

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.
23rd Feb.1999	0.0.2	Document updated according to TSGR1#2(99)076 which was agreed in TSG RAN WG1 meeting#2, Yokohama, February 23, 1999
25th Feb. 1999	0.1.0	Numbering increased due to approval by TSG RAN WG1 meeting #2 in Yokohama

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