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Contents

Foreword

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1 Scope

The present document describes spreading and modulation for UTRA Physical Layer TDD mode.

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.
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[1] 3GPP TS 25.201: "Physical layer - general description".

[2] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".

[3] 3GPP TS 25.212: "Multiplexing and channel coding (FDD)".

[4] 3GPP TS 25.213: "Spreading and modulation (FDD)".

[5] 3GPP TS 25.214: "Physical layer procedures (FDD)".

[6] 3GPP TS 25.215: "Physical layer – Measurements (FDD)".

[7] 3GPP TS 25.221: "Physical channels and mapping of transport channels onto physical channels (TDD)".

[8] 3GPP TS 25.222: "Multiplexing and channel coding (TDD)".

[9] 3GPP TS 25.102: "UTRA (UE) TDD; Radio Transmission and Reception".

[10] 3GPP TS 25.105: "UTRA (BS) TDD; Radio Transmission and Reception".

[11] 3GPP TS25.308: "High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2".

[12] 3GPP TS25.224: 'Physical Layer Procedures (TDD)'

[13] 3GPP TS25.321: 'Medium Access Control (MAC) protocol specification'

3 Symbols and abbreviations

3.1 Symbols

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

C_p: PSC
C_i: i:th secondary SCH code
$C_{CSC,\,m}^{(k)}$: CSC derived as *k*:th offset version from *m*:th applicable constituent Golay complementary pair

3.2 Abbreviations

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

16QAM	16 Quadrature Amplitude Modulation
CCTrCH	Coded Composite Transport Channel
CDMA	Code Division Multiple Access
CSC	Cell Synchronisation Code
DPCH	Dedicated Physical Channel
FDD	Frequency Division Duplex
HS-PDSCH	High Speed Physical Downlink Shared Channel
IMB	Integrated Mobile Broadcast
MBSFN	MBSM over a Single Frequency Network
MIB	Master Information Block
MU-MIMO	Multi-User Multiple Input Multiple Output
OVSF	Orthogonal Variable Spreading Factor
P-CCPCH	Primary Common Control Physical Channel
PN	Pseudo Noise
PRACH	Physical Random Access Channel
PSC	Primary Synchronisation Code
QPSK	Quadrature Phase Shift Keying
RACH	Random Access Channel
SCH	Synchronisation Channel
SF	Spreading Factor
SFN	System Frame Number
TDD	Time Division Duplex
TFC	Transport Format Combination
UE	User Equipment
UL	Uplink

4 General

In the following, a separation between the data modulation and the spreading modulation has been made. The data modulation for 3.84Mcps TDD (including 3.84 Mcps MBSFN IMB) and 7.68Mcps TDD is defined in clause 5 'Data modulation for the 3.84 Mcps and 7.68Mcps options', the data modulation for 1.28Mcps TDD is defined in clause 5A 'Data modulation for the 1.28 Mcps option' and the spreading modulation in clause 6 'Spreading modulation'.

Table 1 shows the basic modulation parameters for the 7.68Mcps, 3.84Mcps (including 3.84 Mcps MBSFN IMB) and 1.28Mcps TDD options.

Table 1: Basic modulation parameters

Chip rate	7.68 Mchip/s	same as FDD basic chiprate: 3.84 Mchip/s and 3.84 Mcps MBSFN IMB	Low chiprate: 1.28 Mchip/s
Data modulation	QPSK,16QAM (HS-PDSCH, MBSFN S-CCPCH and E-PUCH only)	QPSK,16QAM (HS-PDSCH, MBSFN S-CCPCH and E-PUCH only)	QPSK, 8PSK,16QAM (HS-PDSCH, E-PUCH, MBSFN S-CCPCH only), 64QAM (HS-PDSCH only)
Spreading characteristics	Orthogonal Q chips/symbol, where $Q = 2^p$, $0 <= p <= 5$	Orthogonal Q chips/symbol, where $Q = 2^p$, $0 <= p <= 4$ (For 3.84 Mcps MBSFN IMB $Q = 2^p$, where p = 4 or 8 only)	Orthogonal Q chips/symbol, where $Q = 2^p$, $0 <= p <= 4$

5 Data modulation for the 3.84 Mcps and 7.68Mcps options

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

5.2.1.1 QPSK modulation

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:

$$\underline{\mathbf{d}}^{(k,i)} = \left(\underline{d}_1^{(k,i)}, \underline{d}_2^{(k,i)}, \ldots, \underline{d}_{N_k}^{(k,i)}\right)^T \quad i = 1,2; k = 1,\ldots,K_{Code} \qquad (1)$$

K_{Code} is the number of used codes in a time slot: for 3.84Mcps, max K_{Code} =16; for 7.68Mcps, max K_{Code} =32. N_k is the number of symbols per data field for the code k. This number is linked to the spreading factor Q_k [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_{Code}; 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 consecutive data bits from the output of the physical channel mapping procedure in [8]:

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

using the 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

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

5.2.1.2 16QAM modulation

The data modulation is performed to the bits from the output of the physical channel mapping procedure. In case of 16QAM, modulation 4 consecutive binary bits are represented by one complex valued data symbol. Each user burst has two data carrying parts, termed data blocks:

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

N_k is the number of symbols per data field for the user k. This number is linked to the spreading factor Q_k.

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 2b has the symbol duration $T_s^{(k)} = Q_k . T_c$ as already given.

The data modulation is 16QAM, thus the data symbols $\underline{d}_n^{(k,i)}$ are generated from 4 consecutive data bits from the output of the physical channel mapping procedure in [8]:

$$b_{l,n}^{(k,i)} \in \{0,1\}, \quad l = 1,2,3,4; \; k = 1,..., K_{code}; \; n = 1,...N_k; \; i = 1,2 \qquad (2c)$$

using the following mapping to complex symbols:

Consecutive binary bit pattern $b_{1,n}^{(k,i)}\ b_{2,n}^{(k,i)}\ b_{3,n}^{(k,i)}\ b_{4,n}^{(k,i)}$	complex symbol $\underline{d}_n^{(k,i)}$
0000	$j\frac{1}{\sqrt{5}}$
0001	$-\frac{1}{\sqrt{5}}+j\frac{2}{\sqrt{5}}$
0010	$\frac{1}{\sqrt{5}}+j\frac{2}{\sqrt{5}}$
0011	$j\frac{3}{\sqrt{5}}$
0100	$\sqrt{\frac{1}{5}}$
0101	$\frac{2}{\sqrt{5}}-j\frac{1}{\sqrt{5}}$
0110	$\frac{2}{\sqrt{5}}+j\frac{1}{\sqrt{5}}$
0111	$\frac{3}{\sqrt{5}}$
1000	$-\frac{1}{\sqrt{5}}$
1001	$-\frac{2}{\sqrt{5}}+j\frac{1}{\sqrt{5}}$
1010	$-\frac{2}{\sqrt{5}}-j\frac{1}{\sqrt{5}}$
1011	$-\frac{3}{\sqrt{5}}$
1100	$-j\frac{1}{\sqrt{5}}$
1101	$\frac{1}{\sqrt{5}}-j\frac{2}{\sqrt{5}}$
1110	$-\frac{1}{\sqrt{5}}-j\frac{2}{\sqrt{5}}$
1111	$-j\frac{3}{\sqrt{5}}$

The mapping corresponds to a 16QAM modulation of the interleaved and encoded data bits $b_{l,n}^{(k,i)}$ of the table above and $\underline{d}_n^{(k,i)}$ of equation 2b.

5.2.2 Mapping for burst type 3

In case of burst type 3, the definitions in subclause 5.2.1.1 and subclause 5.2.1.2 apply with a modified number of symbols in the second data block. For the burst type 3, the number of symbols in the second data block $\underline{\mathbf{d}}^{(k,2)}$ is decreased by $\frac{96}{Q_K}$ symbols for 3.84Mcps TDD and is decreased by $\frac{192}{Q_k}$ symbols for 7.68Mcps TDD.

5.2.3 Mapping for 3.84 Mcps MBSFN IMB

5.2.3.1 Modulation mapping for data

Mapping of data bits onto a QPSK or 16-QAM signal point constellation shall be accomplished as described in subclause 5.1.1.1 or 5.1.1.2 of [4] respectively.

5.2.3.2 Modulation mapping for TFCI

In the case of S-CCPCH frame type 1 and S-CCPCH frame type 2 using QPSK modulation for data, TFCI bits shall be QPSK modulated according to subclause 5.1.1.1 of [4].

In the case of S-CCPCH frame type 2 using 16-QAM modulation for data, each consecutive pair of binary-valued TFCI bits $\{b_{2q}, b_{2q+1}\}$, with q = {0,1,2,…} shall be mapped according to the rotated QPSK constellation given by the following table.

$\{b_{2q}, b_{2q+1}\}$	I branch	Q branch
{0,0}	0.4472	1.3416
{0,1}	1.3416	-0.4472
{1,0}	-1.3416	0.4472
{1,1}	-0.4472	-1.3416

5A Data modulation for the 1.28 Mcps option

5A.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 $T_c = \frac{1}{chiprate}$.

5A.2 Mapping of bits onto signal point constellation

5A.2.1 QPSK modulation

The mapping of bits onto the signal point constellation for QPSK modulation is the same as in the 3.84Mcps TDD cf. [5.2.1.1 QPSK modulation].

5A.2.2 8PSK modulation

The data modulation is performed to the bits from the output of the physical channel mapping procedure. In case of 8PSK modulation 3 consecutive binary bits are represented by one complex valued data symbol. Each user burst has two data carrying parts, termed data blocks:

$$\underline{\mathbf{d}}^{(k,i)} = \left(\underline{d}_1^{(k,i)}, \underline{d}_2^{(k,i)}, \ldots, \underline{d}_{N_k}^{(k,i)}\right)^T, \quad i = 1,2; k = 1,\ldots,K_{Code} \qquad (1a)$$

N_k is the number of symbols per data field for the code k. This number is linked to the spreading factor Q_k.

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_{Code}; 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 8PSK, thus the data symbols $\underline{d}_n^{(k,i)}$ are generated from 3 consecutive data bits from the output of the physical channel mapping procedure in [8]:

$$b_{l,n}^{(k,i)} \in \{0,1\} \quad l = 1,2,3; k = 1,\ldots,K_{Code}; n = 1,\ldots,N_k; i = 1,2 \qquad (2a)$$

using the following mapping to complex symbols:

Consecutive binary bit pattern	complex symbol
$b_{1,n}^{(k,i)}\ b_{2,n}^{(k,i)}\ b_{3,n}^{(k,i)}$	$\underline{d}_n^{(k,i)}$
000	cos(11pi/8)+ jsin(11pi/8)
001	cos(9pi/8)+ jsin(9pi/8)
010	cos(5pi/8)+ jsin(5pi/8)
011	cos(7pi/8)+ jsin(7pi/8)
100	cos(13pi/8)+ jsin(13pi/8)
101	cos(15pi/8)+ jsin(15pi/8)
110	cos(3pi/8)+ jsin(3pi/8)
111	cos(pi/8)+ jsin(pi/8)

The mapping corresponds to a 8PSK modulation of the interleaved and encoded data bits $b_{l,n}^{(k,i)}$ of the table above and $\underline{d}_n^{(k,i)}$ of equation 1a.

5A.2.3 16QAM modulation

The mapping of bits onto the signal point constellation for 16QAM modulation is the same as in the 3.84Mcps TDD cf. [5.2.1.2 16QAM modulation].

5A.2.4 64QAM modulation

The data modulation is performed to the bits from the output of the physical channel mapping procedure. In case of 64QAM, modulation 6 consecutive binary bits are represented by one complex valued data symbol. Each user burst has two data carrying parts, termed data blocks:

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

N_k is the number of symbols per data field for the user k. This number is linked to the spreading factor Q_k.

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 1c has the symbol duration $T_s^{(k)} = Q_k.T_c$ as already given.