ETSI TS 145 004 V9.0.0 (2010-02)

Technical Specification

Digital cellular telecommunications system (Phase 2+);
Modulation
(3GPP TS 45.004 version 9.0.0 Release 9)

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

Reference

RTS/TSGG-0145004v900

Keywords

GSM

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

Individual copies of the present document can be downloaded from:
http://www.etsi.org

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
http://portal.etsi.org/tb/status/status.asp

If you find errors in the present document, please send your comment to one of the following services:
http://portal.etsi.org/chaircor/ETSI_support.asp

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

Pursuant to the ETSI 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 ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

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

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Contents

Intellectual Property Rights 2
Foreword 2
Foreword 4
1 Scope 5
1.1 References 5
1.2 Abbreviations 5
2 Modulation format for GMSK 5
2.1 Modulating symbol rate 5
2.2 Start and stop of the burst 5
2.3 Differential encoding 6
2.4 Filtering 6
2.5 Output phase 7
2.6 Modulation 7
3 Modulation format for 8PSK 7
3.1 Modulating symbol rate 7
3.2 Symbol mapping 7
3.3 Start and stop of the burst 8
3.4 Symbol rotation 9
3.5 Pulse shaping 9
3.6 Modulation 9
4 Modulation format for 16QAM and 32QAM at the normal symbol rate 10
4.1 Modulating symbol rate 10
4.2 Symbol mapping 10
4.3 Start and stop of the burst 11
4.4 Symbol rotation 12
4.5 Pulse shaping 12
4.6 Modulation 12
5 Modulation format for QPSK, 16QAM and 32QAM at the higher symbol rate 12
5.1 Modulating symbol rate 12
5.2 Symbol mapping 13
5.3 Start and stop of the burst 13
5.4 Symbol rotation 13
5.5 Pulse shaping 13
5.6 Modulation 14
Annex A (normative): Tx filter coefficients for the spectrally wide pulse shape 15
Annex B (informative): Change history 16
History 17

Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The modulator receives the bits from the encryption unit, see 3GPP TS 45.001, and produces an RF signal. The filtering of the Radio Frequency (RF) signal necessary to obtain the spectral purity is not defined, neither are the tolerances associated with the theoretical filter requirements specified. These are contained in 3GPP TS 45.005.

1.1 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, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: 'Vocabulary for 3GPP Specifications'.

[2] 3GPP TS 45.001: 'Physical Layer on the Radio Path (General Description)'.

[3] 3GPP TS 45.002: 'Multiplexing and multiple access on the radio path'.

[4] 3GPP TS 45.005: 'Radio transmission and reception'.

[5] 3GPP TS 45.010: 'Radio subsystem synchronization'.

[6] 3GPP TS 44.060: 'Radio Link Control/ Medium Access Control (RLC/MAC) protocol'.

1.2 Abbreviations

Abbreviations used in this specification are listed in 3GPP TR 21.905.

2 Modulation format for GMSK

2.1 Modulating symbol rate

The modulating symbol rate is the normal symbol rate which is defined as 1/T = 1 625/6 ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to 1 625/6 kbit/s (i.e. 270.833 kbit/s). T is the normal symbol period (see 3GPP TS 45.010).

2.2 Start and stop of the burst

Before the first bit of the bursts as defined in 3GPP TS 45.002 enters the modulator, the modulator has an internal state as if a modulating bit stream consisting of consecutive ones ($d_i = 1$) had entered the differential encoder. Also after the last bit of the time slot, the modulator has an internal state as if a modulating bit stream consisting of consecutive ones ($d_i = 1$) had continued to enter the differential encoder. These bits are called dummy bits and define the start and the stop of the active and the useful part of the burst as illustrated in figure 1. Nothing is specified about the actual phase of the modulator output signal outside the useful part of the burst.

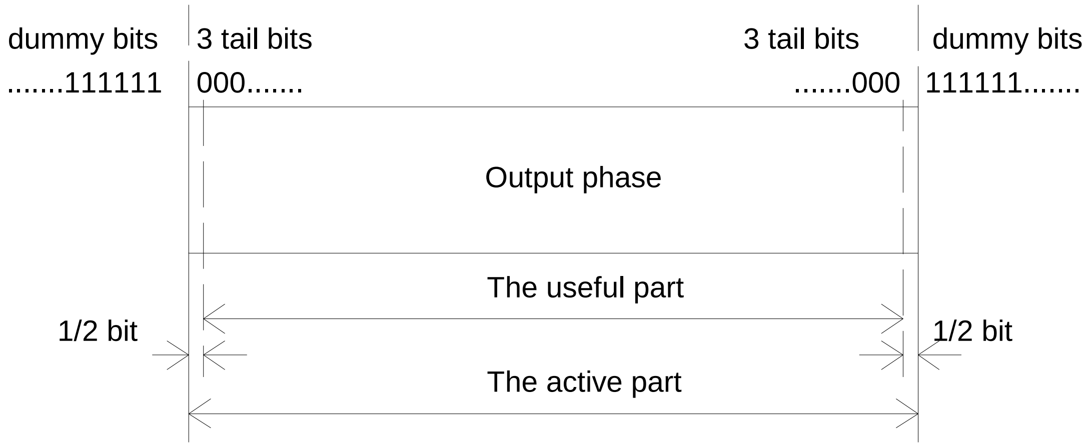

Figure 1: Relation between active part of burst, tail bits and dummy bits. For the normal burst the useful part lasts for 147 modulating bits

2.3 Differential encoding

Each data value $d_i = [0,1]$ is differentially encoded. The output of the differential encoder is:

$$\hat{d}_i = d_i \oplus d_{i-1} \qquad (d_i \in \{0,1\})$$

where ⊕ denotes modulo 2 addition.

The modulating data value α_i input to the modulator is:

$$\alpha_i = 1 - 2\hat{d}_i \qquad (\alpha_i \in \{-1,+1\})$$

2.4 Filtering

The modulating data values α_i as represented by Dirac pulses excite a linear filter with impulse response defined by:

$$g(t) = h(t) * rect\left(\frac{t}{T}\right)$$

where the function $rect(x)$ is defined by:

$$rect\left(\frac{t}{T}\right) = \frac{1}{T} \qquad for\ |t| < \frac{T}{2}$$

$$rect\left(\frac{t}{T}\right) = 0 \qquad otherwise$$

and * means convolution. $h(t)$ is defined by:

$$h(t) = \frac{\exp\left(\frac{-t^2}{2\delta^2 T^2}\right)}{\sqrt{(2\pi)}\ .\ \delta T}$$

where $$\delta = \frac{\sqrt{\ln(2)}}{2\pi BT} \qquad and \;\; BT = 0.3$$

where B is the 3 dB bandwidth of the filter with impulse response $h(t)$. This theoretical filter is associated with tolerances defined in 3GPP TS 45.005.

2.5 Output phase

The phase of the modulated signal is:

$$\varphi(t') = \sum_i \alpha_i \pi h \int_{-\infty}^{t'-iT} g(u)du$$

where the modulating index h is 1/2 (maximum phase change in radians is $\pi/2$ per data interval).

The time reference $t' = 0$ is the start of the active part of the burst as shown in figure 1. This is also the start of the bit period of bit number 0 (the first tail bit) as defined in 3GPP TS 45.002.

2.6 Modulation

The modulated RF carrier, except for start and stop of the TDMA burst may therefore be expressed as:

$$x(t') = \sqrt{\frac{2E_c}{T}} \; . \quad \cos(2\pi\, f_0\, t' + \varphi(t') + \varphi_0)$$

where E_c is the energy per modulating bit, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.

3 Modulation format for 8PSK

3.1 Modulating symbol rate

The modulating symbol rate is the normal symbol rate which is defined as 1/T = 1 625/6 ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to 3*1 625/6 kbit/s (i.e. 812.5 kbit/s). T is the normal symbol period (see 3GPP TS 45.010).

3.2 Symbol mapping

The modulating bits are Gray mapped in groups of three to 8PSK symbols by the rule

$$s_i = e^{j2\pi l/8}$$

where l is given by table 1.

Table 1: Mapping between modulating bits and the 8PSK symbol parameter *l*.

Modulating bits $d_{3i}, d_{3i+1}, d_{3i+2}$	Symbol parameter l
(1,1,1)	0
(0,1,1)	1
(0,1,0)	2
(0,0,0)	3
(0,0,1)	4
(1,0,1)	5
(1,0,0)	6
(1,1,0)	7

This is illustrated in figure 2.

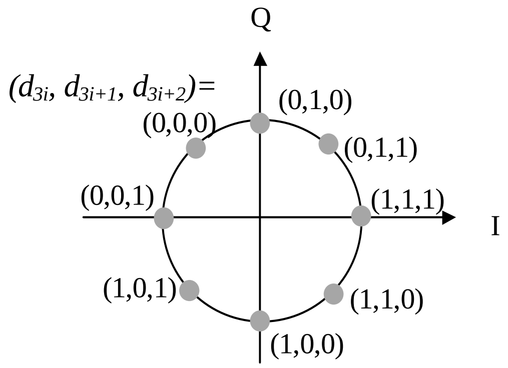

Figure 2: Symbol mapping of modulating bits into 8PSK symbols.

3.3 Start and stop of the burst

Before the first bit of the bursts as defined in 3GPP TS 45.002 enters the modulator, the state of the modulator is undefined. Also after the last bit of the burst, the state of the modulator is undefined. The tail bits (see 3GPP TS 45.002) define the start and the stop of the active and the useful part of the burst as illustrated in figure 3. Nothing is specified about the actual phase of the modulator output signal outside the useful part of the burst.

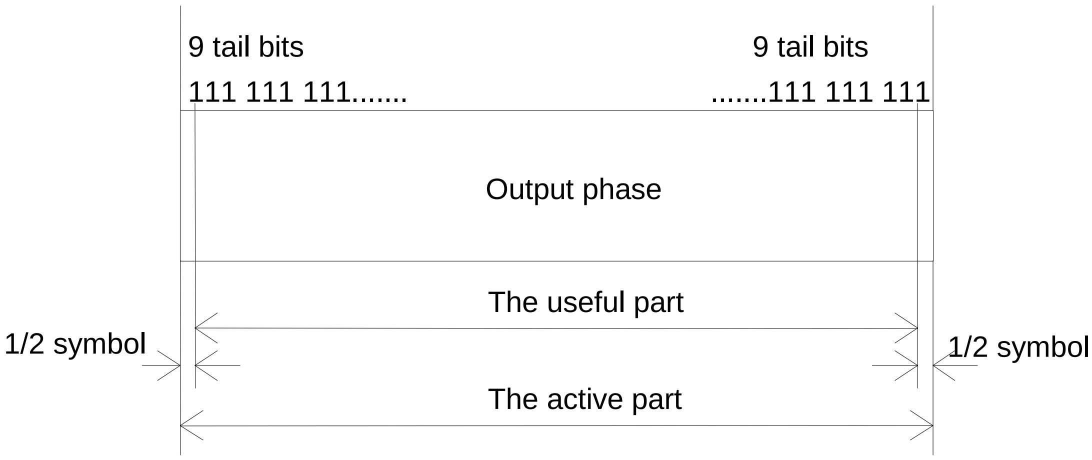

Figure 3: Relation between active part of burst and tail bits. For the normal burst the useful part lasts for 147 modulating symbols

3.4 Symbol rotation

The 8PSK symbols are continuously rotated with 3π/8 radians per symbol before pulse shaping. The rotated symbols are defined as

$$\hat{s}_i = s_i \cdot e^{ji3\pi/8}$$

3.5 Pulse shaping

The modulating 8PSK symbols $\hat{s}_i$ as represented by Dirac pulses excite a linear pulse shaping filter. This filter is a linearised GMSK pulse, i.e. the main component in a Laurant decomposition of the GMSK modulation. The impulse response is defined by:

$$c_0(t) = \begin{cases} \prod_{i=0}^{3} S(t+iT), & for\ 0 \le t \le 5T \\ 0, & else \end{cases}$$

where

$$S(t) = \begin{cases} \sin\left(\pi \int_0^t g(t')dt'\right), & for\ 0 \le t \le 4T \\ \sin\left(\frac{\pi}{2} - \pi \int_0^{t-4T} g(t')dt'\right), & for\ 4T < t \le 8T \\ 0, & else \end{cases}$$

$$g(t) = \frac{1}{2T}\left(Q\left(2\pi \cdot 0.3 \frac{t-5T/2}{T\sqrt{\log_e(2)}}\right) - Q\left(2\pi \cdot 0.3 \frac{t-3T/2}{T\sqrt{\log_e(2)}}\right)\right)$$

and

$$Q(t) = \frac{1}{\sqrt{2\pi}} \int_t^{\infty} e^{-\frac{\tau^2}{2}} d\tau .$$

The base band signal is

$$y(t') = \sum_i \hat{s}_i \cdot c_0(t' - iT + 2T)$$

The time reference $t' = 0$ is the start of the active part of the burst as shown in figure 3. This is also the start of the symbol period of symbol number 0 (containing the first tail bit) as defined in 3GPP TS 45.002.

3.6 Modulation

The modulated RF carrier during the useful part of the burst is therefore:

$$x(t') = \sqrt{\frac{2E_s}{T}} \operatorname{Re}\left[y(t') \cdot e^{j(2\pi f_0 t' + \varphi_0)}\right]$$

where E_S is the energy per modulating symbol, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.

4 Modulation format for 16QAM and 32QAM at the normal symbol rate

4.1 Modulating symbol rate

The modulating symbol rate is the normal symbol rate which is defined as 1/T = 1625/6 ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to 4*1625/6 kbit/s (i.e. approximately 1083.3 kbit/s) for 16QAM and to 5*1625/6 kbit/s (i.e. approximately 1354.2 kbit/s) for 32QAM. T is the normal symbol period (see 3GPP TS 45.010).

4.2 Symbol mapping

The modulating bits are mapped to symbols according to Table 2 for 16QAM and Table 3 for 32QAM.

Table 2: Mapping between modulating bits and 16QAM symbols.

Modulating bits $d_{4i}, d_{4i+1}, d_{4i+2}, d_{4i+3}$	16QAM symbol s_i	
	I	Q
(0,0,0,0)	$1/\sqrt{10}$	$1/\sqrt{10}$
(0,0,0,1)	$1/\sqrt{10}$	$3/\sqrt{10}$
(0,0,1,0)	$3/\sqrt{10}$	$1/\sqrt{10}$
(0,0,1,1)	$3/\sqrt{10}$	$3/\sqrt{10}$
(0,1,0,0)	$1/\sqrt{10}$	$-1/\sqrt{10}$
(0,1,0,1)	$1/\sqrt{10}$	$-3/\sqrt{10}$
(0,1,1,0)	$3/\sqrt{10}$	$-1/\sqrt{10}$
(0,1,1,1)	$3/\sqrt{10}$	$-3/\sqrt{10}$
(1,0,0,0)	$-1/\sqrt{10}$	$1/\sqrt{10}$
(1,0,0,1)	$-1/\sqrt{10}$	$3/\sqrt{10}$
(1,0,1,0)	$-3/\sqrt{10}$	$1/\sqrt{10}$
(1,0,1,1)	$-3/\sqrt{10}$	$3/\sqrt{10}$
(1,1,0,0)	$-1/\sqrt{10}$	$-1/\sqrt{10}$
(1,1,0,1)	$-1/\sqrt{10}$	$-3/\sqrt{10}$
(1,1,1,0)	$-3/\sqrt{10}$	$-1/\sqrt{10}$
(1,1,1,1)	$-3/\sqrt{10}$	$-3/\sqrt{10}$

Table 3: Mapping between modulating bits and 32QAM symbols.

Modulating bits $d_{5i}, d_{5i+1}, d_{5i+2}, d_{5i+3}, d_{5i+4}$	32QAM symbol s_i	
	I	Q
(0,0,0,0,0)	$-3/\sqrt{20}$	$-5/\sqrt{20}$
(0,0,0,0,1)	$-1/\sqrt{20}$	$-5/\sqrt{20}$
(0,0,0,1,0)	$-3/\sqrt{20}$	$5/\sqrt{20}$
(0,0,0,1,1)	$-1/\sqrt{20}$	$5/\sqrt{20}$
(0,0,1,0,0)	$-5/\sqrt{20}$	$-3/\sqrt{20}$
(0,0,1,0,1)	$-5/\sqrt{20}$	$-1/\sqrt{20}$
(0,0,1,1,0)	$-5/\sqrt{20}$	$3/\sqrt{20}$
(0,0,1,1,1)	$-5/\sqrt{20}$	$1/\sqrt{20}$
(0,1,0,0,0)	$-1/\sqrt{20}$	$-3/\sqrt{20}$
(0,1,0,0,1)	$-1/\sqrt{20}$	$-1/\sqrt{20}$
(0,1,0,1,0)	$-1/\sqrt{20}$	$3/\sqrt{20}$
(0,1,0,1,1)	$-1/\sqrt{20}$	$1/\sqrt{20}$
(0,1,1,0,0)	$-3/\sqrt{20}$	$-3/\sqrt{20}$
(0,1,1,0,1)	$-3/\sqrt{20}$	$-1/\sqrt{20}$
(0,1,1,1,0)	$-3/\sqrt{20}$	$3/\sqrt{20}$
(0,1,1,1,1)	$-3/\sqrt{20}$	$1/\sqrt{20}$
(1,0,0,0,0)	$3/\sqrt{20}$	$-5/\sqrt{20}$
(1,0,0,0,1)	$1/\sqrt{20}$	$-5/\sqrt{20}$
(1,0,0,1,0)	$3/\sqrt{20}$	$5/\sqrt{20}$
(1,0,0,1,1)	$1/\sqrt{20}$	$5/\sqrt{20}$
(1,0,1,0,0)	$5/\sqrt{20}$	$-3/\sqrt{20}$
(1,0,1,0,1)	$5/\sqrt{20}$	$-1/\sqrt{20}$
(1,0,1,1,0)	$5/\sqrt{20}$	$3/\sqrt{20}$
(1,0,1,1,1)	$5/\sqrt{20}$	$1/\sqrt{20}$
(1,1,0,0,0)	$1/\sqrt{20}$	$-3/\sqrt{20}$
(1,1,0,0,1)	$1/\sqrt{20}$	$-1/\sqrt{20}$
(1,1,0,1,0)	$1/\sqrt{20}$	$3/\sqrt{20}$
(1,1,0,1,1)	$1/\sqrt{20}$	$1/\sqrt{20}$
(1,1,1,0,0)	$3/\sqrt{20}$	$-3/\sqrt{20}$
(1,1,1,0,1)	$3/\sqrt{20}$	$-1/\sqrt{20}$
(1,1,1,1,0)	$3/\sqrt{20}$	$3/\sqrt{20}$
(1,1,1,1,1)	$3/\sqrt{20}$	$1/\sqrt{20}$

4.3 Start and stop of the burst

Before the first bit of the bursts as defined in 3GPP TS 45.002 enters the modulator, the state of the modulator is undefined. Also after the last bit of the burst, the state of the modulator is undefined. The tail symbols (see 3GPP TS 45.002) define the start and the stop of the active and the useful part of the burst as illustrated in figure 4. Nothing is specified about the actual phase of the modulator output signal outside the useful part of the burst.

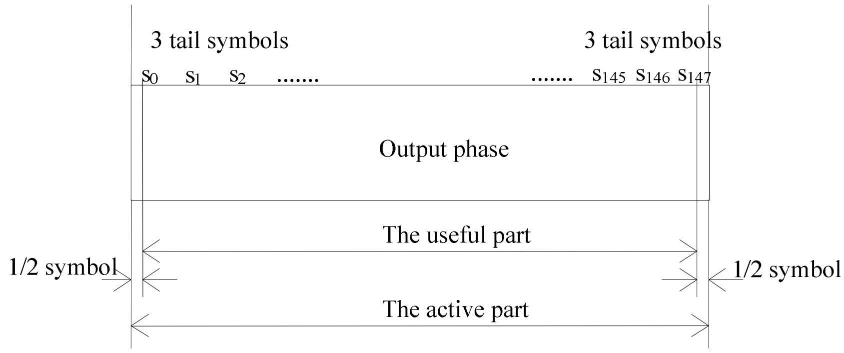

Figure 4: Relation between active part of burst and tail symbols. For the normal burst the useful part lasts for 147 modulating symbols.

4.4 Symbol rotation

The symbols are continuously rotated with φ radians per symbol before pulse shaping, where φ = π/4 and -π/4 for 16QAM and 32QAM respectively. The rotated symbols are defined as

$$\hat{s}_i = s_i \cdot e^{ji\varphi}$$

4.5 Pulse shaping

The modulating symbols $\hat{s}_i$ as represented by Dirac pulses excite a linear pulse shaping filter. This filter is the linearised GMSK pulse as defined in 3.5.

4.6 Modulation

The modulated RF carrier during the useful part of the burst is:

$$x(t') = \sqrt{\frac{2E_s}{T}} \, \mathrm{Re}\left[y(t') \cdot e^{j(2\pi f_0 t' + \varphi_0)} \right]$$

where *y(t')* is the base band signal (see 3.5),, E_S is the energy per modulating symbol, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.

5 Modulation format for QPSK, 16QAM and 32QAM at the higher symbol rate

5.1 Modulating symbol rate

The modulating symbol rate is the higher symbol rate which is defined as 1/T = 325 ksymb/s, which corresponds to 650 kbit/s for QPSK, to 1300 kbit/s for 16QAM and to 1625 kbit/s for 32QAM. T is the reduced symbol period (see 3GPP TS 45.010).

5.2 Symbol mapping

The modulating bits are mapped to symbols according to Table 4 for QPSK, Table 2 for 16QAM and Table 3 for 32QAM..

Table 4: Mapping between modulating bits and QPSK symbols.

Modulating bits d_{2i}, d_{2i+1}	QPSK symbol s_i	
	I	Q
(0,0)	$1/\sqrt{2}$	$1/\sqrt{2}$
(0,1)	$1/\sqrt{2}$	$-1/\sqrt{2}$
(1,0)	$-1/\sqrt{2}$	$1/\sqrt{2}$
(1,1)	$-1/\sqrt{2}$	$-1/\sqrt{2}$

5.3 Start and stop of the burst

Before the first bit of the bursts as defined in 3GPP TS 45.002 enters the modulator, the state of the modulator is undefined. Also after the last bit of the burst, the state of the modulator is undefined. The tail symbols (see 3GPP TS 45.002) define the start and the stop of the active and the useful part of the burst as illustrated in figure 5. Nothing is specified about the actual phase of the modulator output signal outside the useful part of the burst.

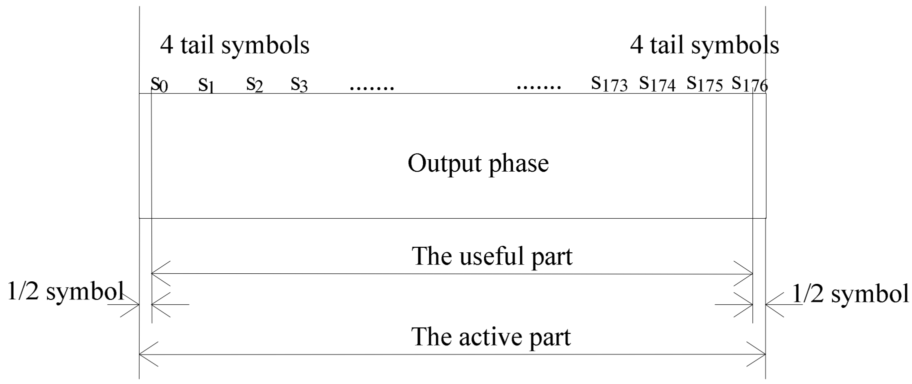

Figure 5: Relation between active part of burst and tail symbols. For the higher symbol rate burst (see 3GPP TS 45.001) the useful part lasts for 176 modulating symbols.

5.4 Symbol rotation

The symbols are continuously rotated with φ radians per symbol before pulse shaping, where φ = 3π/4, π/4 and -π/4 for QPSK, 16QAM and 32QAM respectively. The rotated symbols are defined as

$$\hat{s}_i = s_i \cdot e^{ji\varphi}$$

5.5 Pulse shaping

The modulating symbols $\hat{s}_i$ as represented by Dirac pulses excite one of the following linear pulse shaping filters:

- A spectrally wide pulse shape $c'(t)$, where $c'(t)$ is the continuous time representation of a discrete time pulse shape $c_n = c'((n-1)T_s)$, which is defined in Annex A, where T_s is the sampling period which for the purpose of the pulse shape definition, is $T/16$, and n = 1, 2, ..., 97.

  The base band signal is

$$y(t') = \sum_i \hat{s}_i \cdot c'(t' - iT + 2.5T)$$

NOTE: A closed-form expression of $c'(t)$ is not available because the spectrally wide pulse shape was numerically optimised based on a set of discrete filter coefficients. The continuous time function can be obtained by:

- low-pass filtering the discrete time function with a pass-band of 400 kHz and a stop-band beginning at 2600 kHz and;

- truncating the duration to the time interval [0, 6T].

An example for such a low-pass filter is a raised cosine filter with the impulse response

r(t) = si(2πt•2600 kHz)•cos(2πt•2200 kHz)/(1–(4 t•2200 kHz)²)

with si(x)=sin(x)/x,

resulting in $c'(t) = \sum_{n=1}^{97} c_n r(t-(n-1)T_s)$ for $0 \le t \le 6T$ and $c'(t) = 0$ for $t < 0$ or $t > 6T$.

- A spectrally narrow pulse shape, $c_0(t)$, which is the linearised GMSK pulse as defined in subclause 3.5 for the normal symbol period.

NOTE: The linearised GMSK pulse is not scaled to the reduced symbol period. Hence its duration in terms of the reduced symbol period is 6T.

The base band signal is

$$y(t') = \sum_i \hat{s}_i \cdot c_0(t' - iT + 2.5T)$$

The time reference t' = 0 is the start of the active part of the burst as shown in figure 3. This is also the start of the symbol period of symbol number 0 (containing the first tail bit) as defined in 3GPP TS 45.002.

For the uplink, the pulse shape that shall be used when transmitting a burst is dependent on the parameter 'Pulse format' that is sent during assignment (see 3GPP TS 44.060). For the downlink the spectrally narrow pulse shape shall be used.

5.6 Modulation

The modulated RF carrier during the useful part of the burst is:

$$x(t') = \sqrt{\frac{2E_s}{T}} \operatorname{Re}\left[y(t') \cdot e^{j(2\pi f_0 t' + \varphi_0)}\right]$$

where E_S is the energy per modulating symbol, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.

Annex A (normative): Tx filter coefficients for the spectrally wide pulse shape

For an oversampling factor of 16, i.e. 5200 ksamples/s, there are 97 Tx filter coefficients c_1 to c_{97} for the spectrally wide pulse shape. The coefficients are symmetric to c_{49}, i.e. $c_{49-k} = c_{49+k}$. The coefficients of c_1 to c_{49} are listed:

0.00225918460000
0.00419757900000
0.00648420700000
0.00931957020000
0.01259397500000
0.01605878900000
0.01959156100000
0.02292214900000
0.02570190500000
0.02767928100000
0.02852115300000
0.02791904300000
0.02568913000000
0.02166792700000
0.01579963100000
0.00821077000000
-0.00089211394000
-0.01114601700000
-0.02201830600000
-0.03289439200000
-0.04302811700000
-0.05156392200000
-0.05764086800000
-0.06034025400000
-0.05876224400000
-0.05209962100000
-0.03961692000000
-0.02072323500000
0.00496039200000
0.03765364500000
0.07732192300000
0.12369249000000
0.17639444000000
0.23478700000000
0.29768326000000
0.36418213000000
0.43311409000000
0.50316152000000
0.57298225000000
0.64120681000000
0.70645485000000
0.76744762000000
0.82295721000000
0.87187027000000
0.91325439000000
0.94628290000000
0.97030623000000
0.98493838000000
0.99006899000000

Annex B (informative): Change history

SMG	SPEC	VERS	NEW_VE	PHA	SUBJECT
S27	05.04	5.0.1	6.0.0	R97	Conversion to Release 97 EN
S28	05.04	6.0.0	8.0.0	R99	Introduction of 8PSK for EDGE
S30b	05.04	8.0.0	8.1.0	R99	Correction of mistake for range alpha-sub-i in Clause 2.3
		8.1.0	8.1.1		Figure 3 replaced (as it was corrupted)
G03	05.04	8.1.1	8.2.0	R99	Correction of symbol period notation
G04	45.004	8.2.0	4.0.0	Rel-4	New version for Release 4
G05	45.004	4.0.0	4.1.0	Rel-4	Correction of Timing Alignment for GMSK and 8-PSK Signals

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2001-11	07	GP-012359	002		Correction of tail bits for 8PSK normal burst	4.1.0	4.2.0
2001-11	07	GP-012372	004		Correction of references to relevant 3GPP TSs	4.1.0	4.2.0
2001-11	07	GP-012360	003		Correction of tail bits for 8PSK normal burst	4.2.0	5.0.0
2002-06	10	GP-021436	005		Corrections and clean up	5.0.0	5.1.0
2003-09					Correction of wrong Release number in the front page	5.1.0	5.1.1
2005-01	23				Version for Release 6	5.1.1	6.0.0
2007-08	35	GP-071544	0006	2	Introduction of QPSK, 16QAM and 32QAM for RED HOT and HUGE	6.0.0	7.0.0
2007-11	36	GP-072015	0008		Spectrally wide pulse shape for HUGE B	7.0.0	7.1.0
2008-02	37	GP-080105	0009		Spectrally wide pulse shape for HUGE B	7.1.0	7.2.0
2008-08	39	GP-081068	0010		Correction of modulating bit rate for 32QAM at the higher symbol rate	7.2.0	7.3.0
2008-12	40				Version for Release 8	7.3.0	8.0.0
2009-12	44				Version for Release 9	8.0.0	9.0.0

History

Document history		
V9.0.0	February 2010	Publication