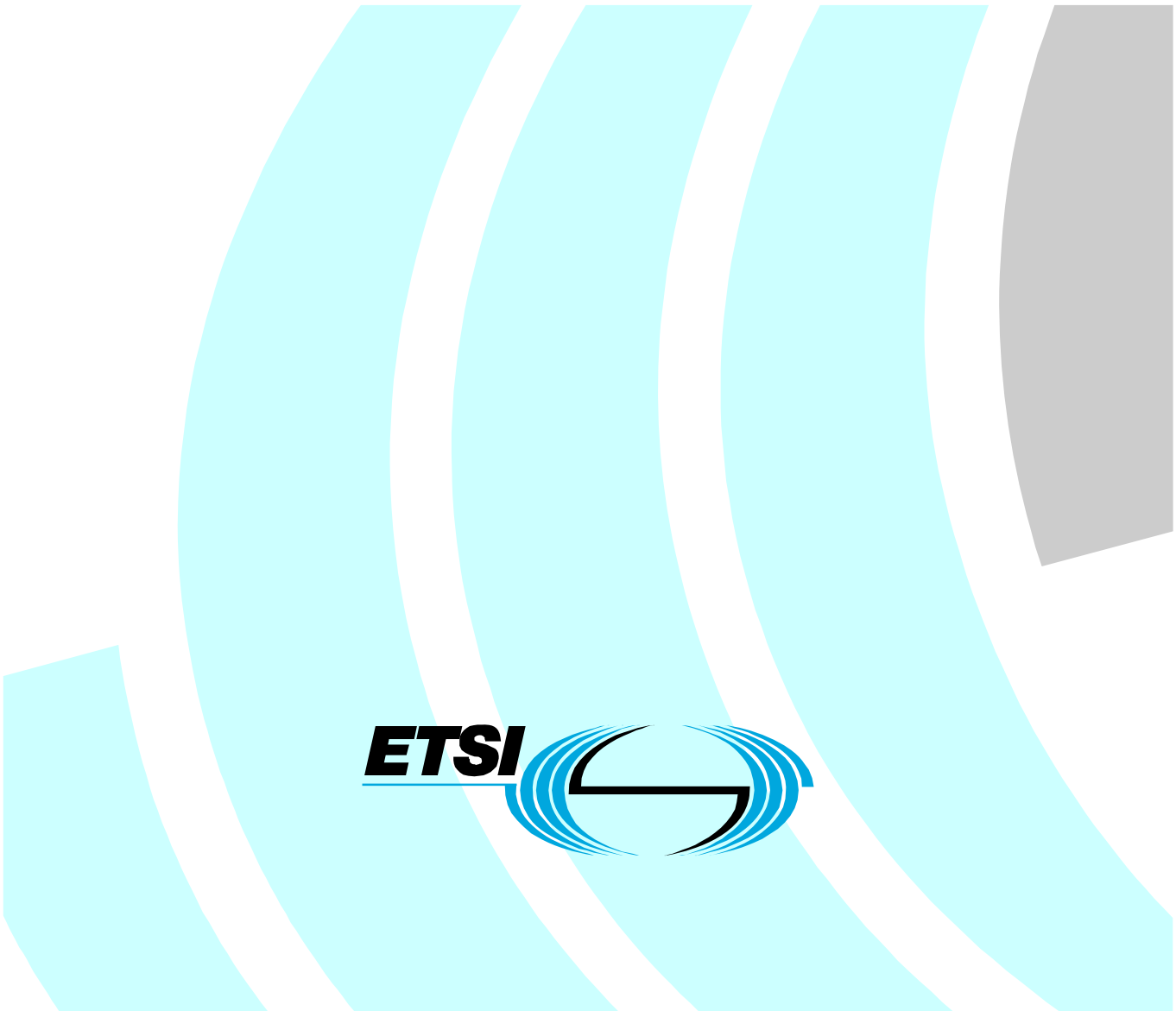
# ETSI TS 101 376-5-4 V2.3.1 (2008-08)

*Technical Specification*

**GEO-Mobile Radio Interface Specifications (Release 2);**
**General Packet Radio Service;**
**Part 5: Radio interface physical layer specifications;**
**Sub-part 4: Modulation;**
**GMPRS-1 05.004**



Reference
RTS/SES-00303-5-4

Keywords
GMPRS, GMR, GSM, GSO, interface, MES,
mobile, modulation, MSS, radio, satellite, S-PCN

***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

***Copyright Notification***

No part may be reproduced except as authorized by written permission.
The copyright and the foregoing restriction extend to reproduction in all media.

© European Telecommunications Standards Institute 2008.
All rights reserved.

**DECT**™, **PLUGTESTS**™, **UMTS**™, **TIPHON**™, the TIPHON logo and the ETSI logo are Trade Marks of ETSI registered for the benefit of its Members.
**3GPP**™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

# Contents

# 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 Technical Committee Satellite Earth Stations and Systems (SES).

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

Version 2.m.n

where:

- the third digit (n) is incremented when editorial only changes have been incorporated in the specification;
- the second digit (m) is incremented for all other types of changes, i.e. technical enhancements, corrections, updates, etc.

The present document is part 5, sub-part 4 of a multi-part deliverable covering the GEO-Mobile Radio Interface Specifications (Release 2); General Packet Radio Service, as identified below:

Part 1: "General specifications";

Part 2: "Service specifications";

Part 3: "Network specifications";

Part 4: "Radio interface protocol specifications";

**Part 5: "Radio interface physical layer specifications";**

Sub-part 1: "Physical Layer on the Radio Path: General Description";

Sub-part 2: "Multiplexing and Multiple Access; Stage 2 Service Description";

Sub-part 3: "Channel Coding";

**Sub-part 4: "Modulation";**

Sub-part 5: "Radio Transmission and Reception";

Sub-part 6: "Radio Subsystem Link Control";

Sub-part 7: "Radio Subsystem Synchronization";

Part 6: "Speech coding specifications";

Part 7: "Terminal adaptor specifications".

# Introduction

GMR stands for Geostationary Earth Orbit (GEO) Mobile Radio interface, which is used for mobile satellite services (MSS) utilizing geostationary satellite(s). GMR is derived from the terrestrial digital cellular standard GSM and supports access to GSM core networks.

The present document is part of the GMR Release 2 specifications. Release 2 specifications are identified in the title and can also be identified by the version number:

- Release 1 specifications have a GMR-1 prefix in the title and a version number starting with "1" (V1.x.x.).
- Release 2 specifications have a GMPRS-1 prefix in the title and a version number starting with "2" (V2.x.x.).

The GMR release 1 specifications introduce the GEO-Mobile Radio interface specifications for circuit mode mobile satellite services (MSS) utilizing geostationary satellite(s). GMR release 1 is derived from the terrestrial digital cellular standard GSM (phase 2) and it supports access to GSM core networks.

The GMR release 2 specifications add packet mode services to GMR release 1. The GMR release 2 specifications introduce the GEO-Mobile Packet Radio Service (GMPRS). GMPRS is derived from the terrestrial digital cellular standard GPRS (included in GSM Phase 2+) and it supports access to GSM/GPRS core networks.

Due to the differences between terrestrial and satellite channels, some modifications to the GSM standard are necessary. Some GSM specifications are directly applicable, whereas others are applicable with modifications. Similarly, some GSM specifications do not apply, while some GMR specifications have no corresponding GSM specification.

Since GMR is derived from GSM, the organization of the GMR specifications closely follows that of GSM. The GMR numbers have been designed to correspond to the GSM numbering system. All GMR specifications are allocated a unique GMR number. This GMR number has a different prefix for Release 2 specifications as follows:

- Release 1: GMR-n xx.zyy.
- Release 2: GMPRS-n xx.zyy.

where:

- xx.0yy (z = 0) is used for GMR specifications that have a corresponding GSM specification. In this case, the numbers xx and yy correspond to the GSM numbering scheme.
- xx.2yy (z = 2) is used for GMR specifications that do not correspond to a GSM specification. In this case, only the number xx corresponds to the GSM numbering scheme and the number yy is allocated by GMR.
- n denotes the first (n = 1) or second (n = 2) family of GMR specifications.

A GMR system is defined by the combination of a family of GMR specifications and GSM specifications as follows:

- If a GMR specification exists it takes precedence over the corresponding GSM specification (if any). This precedence rule applies to any references in the corresponding GSM specifications.

NOTE: Any references to GSM specifications within the GMR specifications are not subject to this precedence rule. For example, a GMR specification may contain specific references to the corresponding GSM specification.

- If a GMR specification does not exist, the corresponding GSM specification may or may not apply. The applicability of the GSM specifications is defined in GMPRS-1 01.201 [2].

# 1 Scope

The present document defines the modulation used within the GMR-1 Mobile Satellite System. It includes the various modulation formats that are required for different physical channel types. It also defines the concept of the transmission burst and the mapping of modulated symbols to the burst, describes the required transmit filtering in general terms, and specifies the modulation accuracy.

# 2 References

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

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

For online referenced documents, information sufficient to identify and locate the source shall be provided. Preferably, the primary source of the referenced document should be cited, in order to ensure traceability. Furthermore, the reference should, as far as possible, remain valid for the expected life of the document. The reference shall include the method of access to the referenced document and the full network address, with the same punctuation and use of upper case and lower case letters.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

## 2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

[1] ETSI TS 101 376-1-1: "GEO-Mobile Radio Interface Specifications (Release 2) General Packet Radio Service; Part 1: General specifications; Sub-part 1: Abbreviations and acronyms; GMPRS-1 01.004".

[2] ETSI TS 101 376-1-2: "GEO-Mobile Radio Interface Specifications (Release 2); General Packet Radio Service; Part 1: General specifications; Sub-part 2: Introduction to the GMR-1 family; GMPRS-1 01.201".

[3] ETSI TS 101 376-5-2: "GEO-Mobile Radio Interface Specifications (Release 2); General Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 2: Multiplexing and Multiple Access; Stage 2 Service Description; GMPRS-1 05.002".

[4] ETSI TS 101 376-5-4 (V1.3.1): "GEO-Mobile Radio Interface Specifications (Release 1); Part 5: Radio interface physical layer specifications; Sub-part 4: Modulation; GMR-1 05.004".

NOTE: This is a reference to a GMR-1 Release 1 specification. See the introduction for more details.

## 2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TS 101 376-5-5: "GEO-Mobile Radio Interface Specifications (Release 2); General Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 5: Radio Transmission and Reception; GMPRS-1 05.005".

# 3 Definitions and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in GMPRS-1 01.201 [2] apply.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in GMPRS-1 01.004 [1] apply.

# 4 Burst structure

## 4.1 Signal representation

Same as clause 4.1 in GMR-1 05.004 [4].

## 4.2 Modulating symbol rate

Same as clause 4.2 in GMR-1 05.004 [4].

## 4.3 Start and stop of the burst

Same as clause 4.3 in GMR-1 05.004 [4].

## 4.4 Data bits and data symbols

Same as clause 4.4 in GMR-1 05.004 [4].

## 4.5 Packet burst structure

### 4.5.1 Modulating symbol rate

Packet Normal Bursts (PNBs) are modulated at a symbol rate of 23,4 × *m* ksps, where *m* is an integer *m* = 1,2, 4 or 5. The symbol period time for PNB(*m*,*n*), where *m* is the bandwidth factor and *n* is the duration of the burst in timeslots, is defined as 1/(23,4 × *m*) seconds, where {*m* = 4 or 5; and *n* = 3} or {*m* = 1 or 2; and *n* = 6} or {*m* = 5; and *n* = 12}.

Packet Access Burst (PAB) is modulated at a symbol rate of 23,4 ksps.

## 4.5.2 Start and stop of the burst

For packet normal bursts, the time interval [0, 39*nT*] is the burst time window, where $n = 3$,$n = 6$, and $n = 12$ for the burst types defined in GMPRS-1 05.002 [3] and T is as defined in clause 4.2. The time interval [2,5*T*, 39*nT*-2,5*T*] is the burst time window corresponding to the active part of this burst, where {$m = 4$ or 5; and $n = 3$} or {$m = 5$; and $n = 12$}. The time interval [2,5T/*m*, 39*n*T-2,5T/*m*] is the burst time window corresponding to the active part of this burst, $m = 1$ or 2; and $n = 6$. The content of this part corresponds to data symbols, i.e. reference and free symbols. The remaining time corresponds to the guard intervals (see GMPRS-1 05.002 [3]). These guard intervals correspond to the transition from no signal to a continuous carrier and vice-versa.

## 4.5.3 Data bits and data symbols

For packet normal bursts, there are 78*mn* binary data bits defined in {0,1} in each burst, including header and payload (as defined in GMPRS-1 05.002 [3]), for π/4-CQPSK (Coherent Quadrature Phase-Shift Keying) modulation. For π/4-CQPSK, the burst bits are represented by [$b_0\, b_1\, b_2\, b_3 \ldots b_{78mn-2}\, b_{78mn-1}$], where $b_0$ to $b_{5m-1}$ and $b_{78mn-5m}$ to $b_{78mn-1}$ are guard bits for $m = 1$, 4, and 5, and where $b_0$ to $b_4$ and $b_{78mn-5}$ to $b_{78mn-1}$ are guard bits for $m = 2$. When modulating these bits, we want to avoid grouping one guard bit with one information bit. Thus, for π/4-CQPSK with $m = 1$, 2, and 5, the mapping rule from data bits to data symbols shall be:

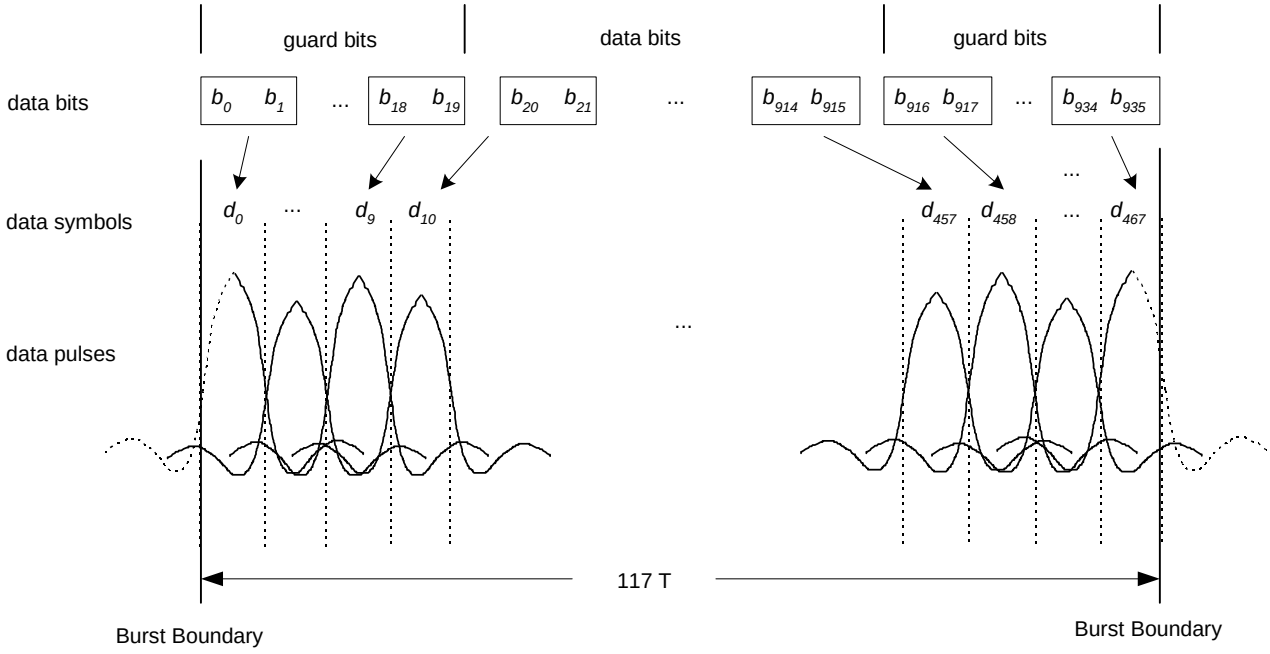
$$d_k = (b_{2k-1} b_{2k}), \qquad k = 0, 1, \ldots, 39mn$$

which results in 39*mn* + 1 different symbols being transmitted during 39*nT* (39*mn* symbol duration). However, the signals contained in the first and the last half-symbol duration are not actually transmitted according to the burst window definition in clause 4.5.2. To generate the first and the last symbols, one needs to use two dummy bits, which are represented by $b_{-1}$ and $b_{78mn}$. The dummy bits can be either of the two binary values {0,1}.

For π/4-CQPSK with $m = 4$, the mapping rule from data bits to data symbols shall be:

$$d_k = (b_{2k} b_{2k+1}), \qquad k = 0,\ 1, \ldots, 39mn\text{-}1$$

which results in 39*mn* different symbols being transmitted during 39*nT* (39*mn* symbol duration) as shown in figure 4.1.




Note: The vertical dotted lines represent the symbol boundaries

**Figure 4.1: Relationship of data bits, data symbols, burst timing, and symbol timing for PNB(4,3)**

For Packet Access Burst (PAB), there are 234 binary data bits defined {0,1} in each burst.

Finally, the mapping of $\{d_k\}$ to the constellation points is defined in clause 5.3.

# 5 Normal burst

Same as clause 5 in GMR-1 05.004 [4].

## 5.1 π/4-CQPSK modulation

Same as clause 5.1 in GMR-1 05.004 [4].

### 5.1.1 Filtering

Same as clause 5.1.1 of GMR-1 05.004 [4].

### 5.1.2 Power ramp

Same as clause 5.1.2 of GMR-1 05.004 [4].

## 5.2 π/4-CBPSK modulation

Same as clause 5.2 of GMR-1 05.004 [4].

## 5.3 PNB modulation

PNBs are modulated by π/4-CQPSK, 16-APSK or 32-APSK. The complex envelope of the transmitted signal is defined as follows:

$$x(t) = p(t)\left[ e^{j\varphi_o} \sum_{k=-\infty}^{\infty} \alpha_k h(t-kT) \right]$$

where $\varphi_o$ is a random phase, $h(t)$ is the impulse response of a shaping filter defined in clause 5.1.1, $p(t)$ is the ramp function as defined in clause 5.1.2, and $\{\alpha_k\}$ is the modulating symbol, defined as follows:

$$\begin{cases} k < 0: & \alpha_k = 0 \\ 0 \le k \le 39mn: & \text{see table 5.1} \\ k > 39mn: & \alpha_k = 0 \end{cases} \quad \text{for different modulation schemes}$$

where {$m$ = 4 or 5; and $n$ = 3} and {$m$ = 1 or 2; and $n$ = 6}, or {$m$ = 5; and $n$ = 12} depending on the type of the burst. For PNB2(5,12) and PNB2(5,3), the PRI can be modulated either in π/4-CQPSK, 16 APSK, and 32 APSK. The modulating symbols for π/4-CQPSK are derived from the data symbols (free and reference symbols) according to table 5.1a.

**Table 5.1a: π/4-CQPSK bits-to-symbols mapping**

| $a_{k-1}$ | $a_k$ | Modulating symbols |
|---|---|---|
| 0 | 0 | (1 + j0) exp(jkπ/4) |
| 0 | 1 | (0 + j1) exp(jkπ/4) |
| 1 | 1 | (-1 + j0) exp(jkπ/4) |
| 1 | 0 | (0 -j1) exp(jkπ/4) |

**Table 5.1b: QPSK bits-to-symbols mapping**

| $a_{k-1}$ | $a_k$ | Modulating symbols |
|---|---|---|
| 0 | 0 | (1 + j0) |
| 0 | 1 | (0 + j1) |
| 1 | 1 | (-1 + j0) |
| 1 | 0 | (0 -j1) |

The constellation points for APSK modulation can be written as:

$$\begin{cases} r_1 \exp\left\{ j\left( \frac{2\pi}{n_1} k + \theta_1 \right) \right\} \text{ for } k = 0,\ 1,\ ..., n_1\text{-}1 \\ r_2 \exp\left\{ j\left( \frac{2\pi}{n_2} k + \theta_2 \right) \right\} \text{ for } k = 0,\ 1,\ ..., n_2\text{-}1 \\ ... \\ r_N \exp\left\{ j\left( \frac{2\pi}{n_N} k + \theta_N \right) \right\} \text{for } k = 0,\ 1,\ ..., n_N\text{-}1 \end{cases}$$

The parameters for 16-APSK and 32-APSK are listed in table 5.1c.

**Table 5.1c: 16 APSK and 32 APSK constellation parameters**

| | $n_1$ | $n_2$ | $n_3$ | $r_1$ | $r_2 / r_1$ | $r_3 / r_1$ | $\theta_1$ | $\theta_2$ | $\theta_3$ |
|---|---|---|---|---|---|---|---|---|---|
| 16 APSK | 4 | 12 | N/A | 0,4182 | 2,7 | N/A | $\pi/4$ | $\pi/12$ | N/A |
| 32 APSK | 4 | 12 | 16 | 0,2637 | 2,7 | 4,8 | $\pi/4$ | $\pi/12$ | $\pi/8$ |

The mapping of π/4-CQPSK modulating symbols to data bits is defined in table 5.1a. The mapping of QPSK modulating symbols to data bits is defined in table 5.1b. The mapping of the 16 APSK modulating symbols to data bits is defined in table 5.1d. The mapping of the 32 APSK modulating symbols to data bits is defined in table 5.1e.

**Table 5.1d: 16 APSK bits-to-symbols mapping (r1 = 0,4182 and r2 = 1,1292)**

| $a_{k-3}$ | $a_{k-2}$ | $a_{k-1}$ | $a_k$ | Modulating symbols |
|---|---|---|---|---|
| 1 | 1 | 0 | 0 | $r_1 \cdot \exp\left\{ j(\frac{2\pi}{4} \cdot 0 + \frac{\pi}{4}) \right\}$ |
| 1 | 1 | 1 | 0 | $r_1 \cdot \exp\left\{ j(\frac{2\pi}{4} \cdot 1 + \frac{\pi}{4}) \right\}$ |
| 1 | 1 | 1 | 1 | $r_1 \cdot \exp\left\{ j(\frac{2\pi}{4} \cdot 2 + \frac{\pi}{4}) \right\}$ |
| 1 | 1 | 0 | 1 | $r_1 \cdot \exp\left\{ j(\frac{2\pi}{4} \cdot 3 + \frac{\pi}{4}) \right\}$ |
| 0 | 1 | 0 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 0 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 0 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 1 + \frac{\pi}{12}) \right\}$ |
| 1 | 0 | 0 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 2 + \frac{\pi}{12}) \right\}$ |
| 1 | 0 | 1 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 3 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 1 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 4 + \frac{\pi}{12}) \right\}$ |
| 0 | 1 | 1 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 5 + \frac{\pi}{12}) \right\}$ |
| 0 | 1 | 1 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 6 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 1 | 1 | $r_2 \cdot \exp\left\{ (j\frac{2\pi}{12} \cdot 7 + \frac{\pi}{12}) \right\}$ |
| 1 | 0 | 1 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 8 + \frac{\pi}{12}) \right\}$ |
| 1 | 0 | 0 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 9 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 0 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 10 + \frac{\pi}{12}) \right\}$ |
| 0 | 1 | 0 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 11 + \frac{\pi}{12}) \right\}$ |

**Table 5.1e: 32 APSK bits-to-symbols mapping (r1 = 0,2637, r2 = 0,7120 and r3 = 1,2658)**

| $a_{k-4}$ | $a_{k-3}$ | $a_{k-2}$ | $a_{k-1}$ | $a_k$ | Modulating symbols |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 1 | $r_1 \cdot \exp\left\{ j(\frac{2\pi}{4} \cdot 0 + \frac{\pi}{4}) \right\}$ |
| 1 | 0 | 1 | 0 | 1 | $r_1 \cdot \exp\left\{ j(\frac{2\pi}{4} \cdot 1 + \frac{\pi}{4}) \right\}$ |
| 1 | 0 | 1 | 1 | 1 | $r_1 \cdot \exp\left\{ (j\frac{2\pi}{4} \cdot 2 + \frac{\pi}{4}) \right\}$ |
| 1 | 0 | 0 | 1 | 1 | $r_1 \cdot \exp\left\{ j(\frac{2\pi}{4} \cdot 3 + \frac{\pi}{4}) \right\}$ |
| 1 | 0 | 0 | 0 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 0 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 0 | 0 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 1 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 0 | 0 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 2 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 1 | 0 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 3 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 1 | 0 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 4 + \frac{\pi}{12}) \right\}$ |
| 1 | 0 | 1 | 0 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 5 + \frac{\pi}{12}) \right\}$ |
| 1 | 0 | 1 | 1 | 0 | $r_2 \cdot \exp j\left\{ (\frac{2\pi}{12} \cdot 6 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 1 | 1 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 7 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 1 | 1 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 8 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 0 | 1 | 1 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 9 + \frac{\pi}{12}) \right\}$ |
| 0 | 0 | 0 | 1 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 10 + \frac{\pi}{12}) \right\}$ |
| 1 | 0 | 0 | 1 | 0 | $r_2 \cdot \exp\left\{ j(\frac{2\pi}{12} \cdot 11 + \frac{\pi}{12}) \right\}$ |
| 0 | 1 | 0 | 0 | 0 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 0 + \frac{\pi}{8}) \right\}$ |
| 1 | 1 | 0 | 0 | 1 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 1 + \frac{\pi}{8}) \right\}$ |
| 0 | 1 | 0 | 0 | 1 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 2 + \frac{\pi}{8}) \right\}$ |

| $a_{k-4}$ | $a_{k-3}$ | $a_{k-2}$ | $a_{k-1}$ | $a_k$ | Modulating symbols |
|---|---|---|---|---|---|
| 0 | 1 | 1 | 0 | 1 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 3 + \frac{\pi}{8}) \right\}$ |
| 1 | 1 | 1 | 0 | 1 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 4 + \frac{\pi}{8}) \right\}$ |
| 0 | 1 | 1 | 0 | 0 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 5 + \frac{\pi}{8}) \right\}$ |
| 1 | 1 | 1 | 0 | 0 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 6 + \frac{\pi}{8}) \right\}$ |
| 1 | 1 | 1 | 1 | 0 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 7 + \frac{\pi}{8}) \right\}$ |
| 0 | 1 | 1 | 1 | 0 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 8 + \frac{\pi}{8}) \right\}$ |
| 1 | 1 | 1 | 1 | 1 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 9 + \frac{\pi}{8}) \right\}$ |
| 0 | 1 | 1 | 1 | 1 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 10 + \frac{\pi}{8}) \right\}$ |
| 0 | 1 | 0 | 1 | 1 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 11 + \frac{\pi}{8}) \right\}$ |
| 1 | 1 | 0 | 1 | 1 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 12 + \frac{\pi}{8}) \right\}$ |
| 0 | 1 | 0 | 1 | 0 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 13 + \frac{\pi}{8}) \right\}$ |
| 1 | 1 | 0 | 1 | 0 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 14 + \frac{\pi}{8}) \right\}$ |
| 1 | 1 | 0 | 0 | 0 | $r_3 \cdot \exp\left\{ j(\frac{2\pi}{16} \cdot 15 + \frac{\pi}{8}) \right\}$ |

Figures 5.1, 5.2 and 5.3 illustrate the symbol constellations and bit mapping for QPSK, 16 APSK, and 32 APSK, respectively.

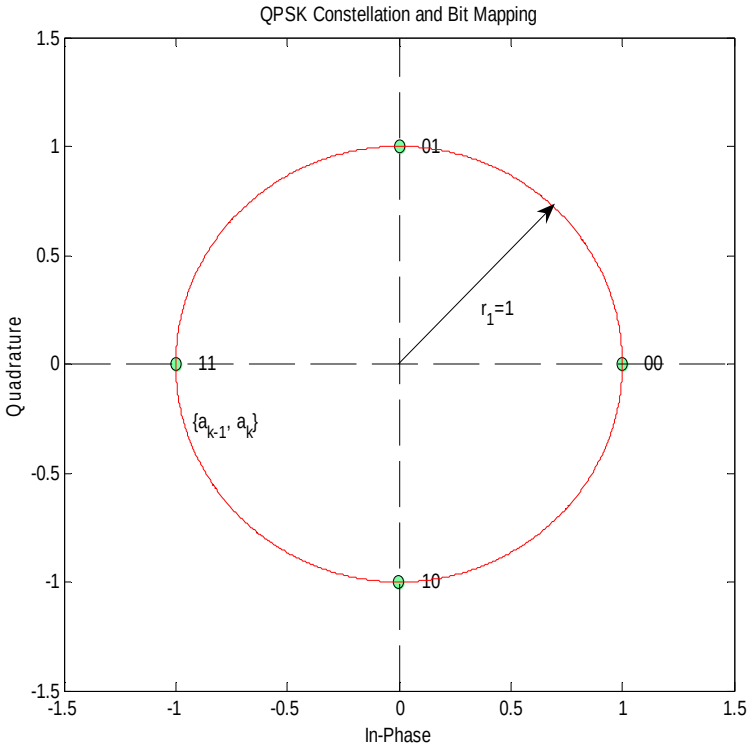



**Figure 5.1: QPSK Constellation and Bit Mapping**

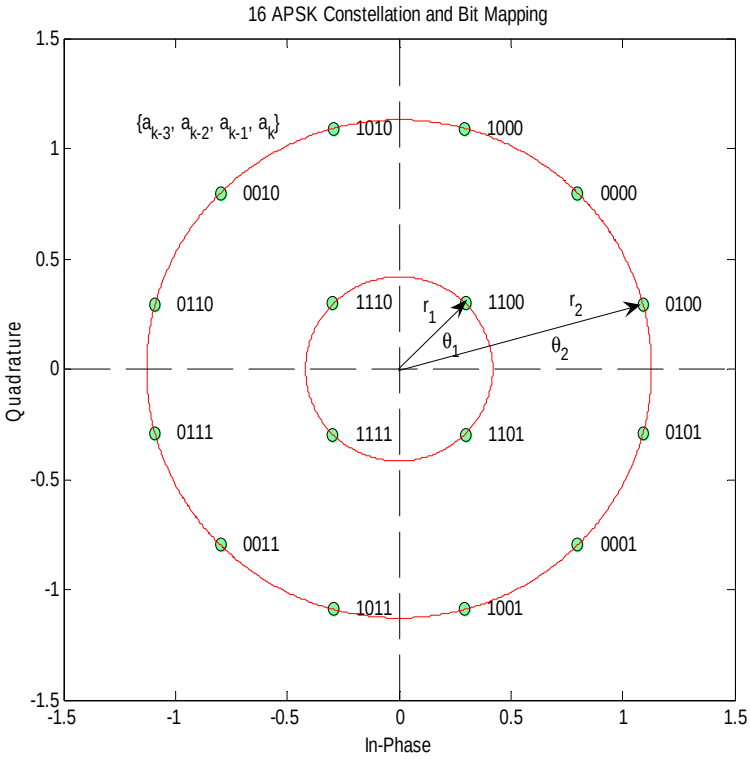



**Figure 5.2: 16 APSK Constellation and Bit Mapping**

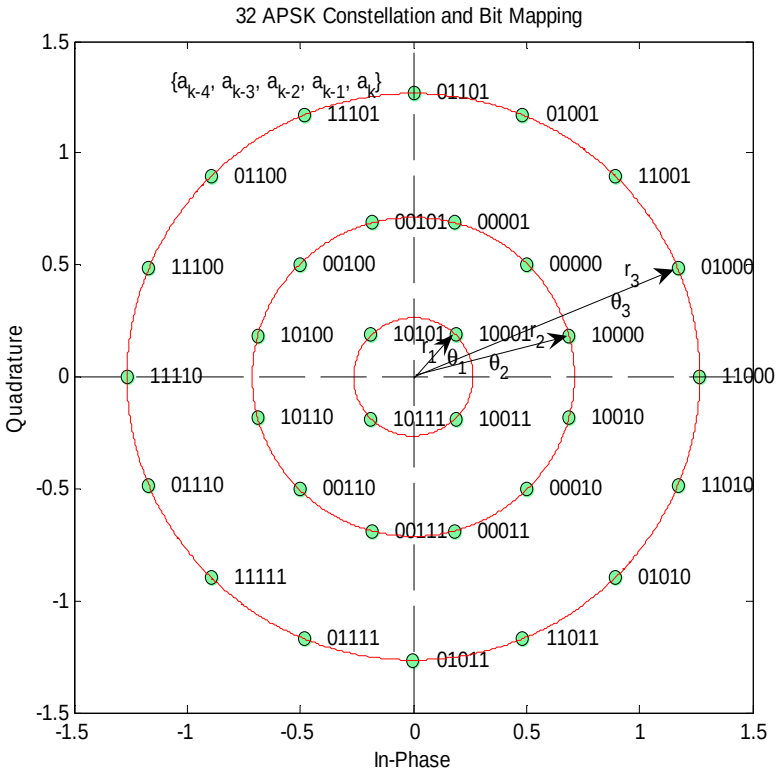



**Figure 5.3: 32 APSK Constellation and Bit Mapping**

# 6 DKABs

## 6.1 π/4-DBPSK modulation

Same as clause 6.1 of GMR-1 05.004 [4].

# 7 BACH

Same as clause 7 of GMR-1 05.004 [4].

## 7.1 Modulation format

Same as clause 7.1 of GMR-1 05.004 [4].

# 8 Frequency correction burst

## 8.1 Modulation format

Same as clause 8.1 of GMR-1 05.004 [4].

# 9 Modulation accuracy

Same as clause 9 of GMR-1 05.004 [4]. For the burst carrying more than one modulation type, the rms vector error measurement shall be applied to each modulation type, separately. Then the measurements are averaged across the multiple type modulation types with weights proportional to the number of associated symbols for each modulation type divided by total number of symbols within the burst.

# Annex A (informative): Change Record

This annex lists the CRs that have been applied to the present document.

| CR | REV | CATEGORY | SUBJECT |
|---|---|---|---|
| CR002 | 1 | Editorial | Missing "m" factor [modified proposal in rev 1] |
| CR003 | 1 | Editorial | Incorrect length of UW |
| | | | |
| | | | |
| | | | |

# History

| Document history | | |
|---|---|---|
| V2.1.1 | March 2003 | Publication |
| V2.2.1 | March 2005 | Publication |
| V2.3.1 | August 2008 | Publication |
| | | |
| | | |