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Technical Specification

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

Reference

RTS-SES-001-GMPRS-1-05005

Keywords

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

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Contents

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Foreword

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The present document is part 5, sub-part 5 of a multi-part deliverable covering the GEO-Mobile Radio Interface Specifications, 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; GMR-1 05.001";

Sub-part 2: "Multiplexing and Multiple Access; Stage 2 Service Description; GMR-1 05.002";

Sub-part 3: "Channel Coding; GMR-1 05.003";

Sub-part 4: "Modulation; GMR-1 05.004";

Sub-part 5: "Radio Transmission and Reception; GMPRS-1 05.005";

Sub-part 6: "Radio Subsystem Link Control; GMR-1 05.008";

Sub-part 7: "Radio Subsystem Synchronization; GMR-1 05.010";

Part 6: "Speech coding specifications";

Part 7: "Terminal adaptor specifications".

Introduction

GMR stands for GEO (Geostationary Earth Orbit) 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 specification 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 GMR-1 01.201.

1 Scope

The present document defines the performance requirements for the Mobile Earth Station (MES) radio transceiver for the GMR-1 Mobile Satellite System.

Requirements are defined for two categories of parameters:

- Those that are required to provide compatibility among the radio channels, connected either to separate or common antennas, which are used in the system. This category also includes parameters providing compatibility with existing systems in the same or adjacent frequency bands.
- Those that define the transmission quality of the system.

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 and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

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

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

[2] GMPRS-1 05.004 (ETSI TS 101 376-5-4): "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".

[3] GMPRS-1 05.008 (ETSI TS 101 376-5-6): "GEO-Mobile Radio Interface Specifications (Release 2); General Packet Radio Service Part 5: Radio interface physical layer specifications; Sub-part 6: Radio Subsystem Link Control; GMPRS-1 05.008".

[4] ETSI EN 301 681 (V1.3.2): "Satellite Earth Stations and Systems (SES); Harmonized EN for Mobile Earth Stations (MESs) of Geostationary mobile satellite systems, including handheld earth stations, for Satellite Personal Communications Networks (S-PCN) in the 1,5/1,6 GHz bands under the Mobile Satellite Service (MSS) covering essential requirements under Article 3.2 of the R&TTE Directive".

[5] ETSI GMR-1 05.005 (ETSI TS 101 376-5-5 (V1.2.1)): "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".

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

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

active transmission: defined as the combination of the ramp-up, ramp-down, and active burst transmission periods

average EIRP: burst EIRP averaged over at least 200 bursts

burst EIRP: instantaneous EIRP measured over 90 % of the active portion of a burst

carrier-off state: An MES is in this state when it does not transmit any signal and it is more than 20 ms away from any active transmission (i.e. the carrier-off state excludes the carrier-standby state).

carrier-on state: A MES is in this state when it transmits a signal (i.e. the carrier-on state corresponds to an active transmission).

carrier-standby state: A MES is in this state when it does not transmit any signal but it is within 20 ms of the carrier-on state (i.e. the carrier-standby state occurs for up to 20 ms immediately before, and up to 20 ms immediately after the carrier-on state).

3.2 Abbreviations

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

4 Frequency bands and channel arrangement

4.1 Frequency bands and duplex method

Same as clause 4.1 in GMR-1 05.005 [5] for circuit switched operation. For packet switched operation clause 4.1 in GMR-1 05.005 [5] is applicable, except that the FDM scheme may be operated in full duplex with any downlink (forward) RF carrier used with any uplink (return) RF carrier without necessarily having a fixed frequency offset between the two carriers.

4.2 RF carrier spacing and designation

Same as clause 4.2 in GMR-1 05.005 [5] with the following additional text.

For packet switched mode operation, the carriers are not paired and do not have a fixed frequency offset between transmit and receive. If a "frequency_plan_index" bit (b_{fpi}) is present in addition to the 11-bit ARFCN, then the carrier frequency has a positive shift of (b_{fpi} x 15,625 kHz), where b_{fpi} can have values 0 or 1.

The packet services use nominal transmission bandwidths that are multiples (4 or 5) of the 31,25 basic carrier bandwidth: 125,00 kHz or 156,25 kHz. These different transmission bandwidths defined over the subbands are used to support transmission rates that are multiples of the basic symbol rate of 23,4 ksps. A 3-bit bandwidth suffix is added to the AFRCN to indicate the bandwidth and transmission rate of the modulated carrier. The association of transmission bandwidths to transmission rates is given in table 4.1.

Table 4.1: Transmission bandwidth and associated transmission rates

Bandwidth suffix	Channel bandwidth (kHz)	Symbol rate (ksps)
000	reserved	reserved
001	reserved	reserved
010	reserved	reserved
011	reserved	reserved
100	125,00	93,6
101	156,25	117,0
110	reserved	reserved
111	reserved	reserved

4.3 RF carrier used for synchronization and spot beam selection

Same as clause 4.3 in GMR-1 05.005 [5].

4.4 Frequency assignment to spot beams

Same as clause 4.4 in GMR-1 05.005 [5].

5 Stability requirements

5.1 Frequency and symbol timing stability

Same as clause 5.1 in GMR-1 05.005 [5].

5.1.1 Definition of operating conditions

Same as clause 5.1.1 in GMR-1 05.005 [5].

5.1.2 Frequency and timing stability requirement

Same as clause 5.1.2 in GMR-1 05.005 [5].

5.1.3 Frequency and timing stability requirements for packet data mode

In the tests of this clause, the MES shall be receiving the logical channel specified in table 5.1 and shall be transmitting a PDCH logical channel. In all test cases, AWGN shall be used.

The rms frequency and symbol timing error of the transmitted signal from the MES shall not exceed the values given in table 5.1 when the unit is receiving the logical channels given in the table E_s/N_o values listed in the table.

Table 5.1: Frequency and timing stability requirements

Received logical channel	Operational condition (see note)	E_s/N_o (dB)	RMS Frequency Error (Hz)	RMS timing error (µs)
PDCH (at 93,6 ksps)	Steady state	5	10	0,9
PDCH (at 117,0 ksps)	Steady state	5	10	0,9
NOTE: The Steady State operational condition is defined in GMR-1 05.005.				

5.2 Frequency switching time

Same as clause 5.2 in GMR-1 05.005 [5] with the following additional text.

For full duplex operation, the transmit (receive) to receive (transmit) frequency switching time is not applicable. In addition, the MES shall be capable of switching from any transmit frequency to any other transmit frequency with the same specification as the receiver frequency switching.

5.3 MES time alignment accuracy

Same as clause 5.3 in GMR-1 05.005 [5].

6 Transmitter characteristics

6.1 Power output characteristics and power class

Same as clause 6.1 in GMR-1 05.005 [5] with the additional specifications for new power classes for packet mode operation.

Table 6.1: Average EIRP for terminal types - extreme conditions

Power Class	Minimum EIRP (dBW), PAS = 0 dB (see note)	Maximum EIRP (dBW), PAS = 0 dB (see note)	Examples
8	11,1	14,9	Data terminal type A
8	11,1	14,9	Data terminal type B
NOTE: PAS (power attenuation setting) is defined in GMPRS-1 05.008 [3].			

Table 6.2: Average EIRP for terminal types - normal conditions

Power Class	Minimum EIRP (dBW), PAS = 0 dB (see note)	Maximum EIRP (dBW), PAS = 0 dB (see note)	Examples
8	12,1	14,9	Data terminal type A
8	12,1	14,9	Data terminal type B
NOTE: PAS (power attenuation setting) is defined in GMPRS-1 05.008 [3].			

In addition, the single burst EIRP shall satisfy the following:

a) The first ten bursts in the first five frames of each transmit activity that are not preceded in the past 60 seconds by a transmit activity of at least ten bursts long will satisfy the limits in table 6.3.

b) Each of the remaining bursts will satisfy the limits in table 6.4.

Requirements in tables 6.3 and 6.4 shall be met under the extreme environmental conditions defined in annex B.

Table 6.3: Single burst EIRP - each burst in the first 5 frames with at least 2 bursts per frame

Power Class	EIRP range (dBW), with PAS = 0 dB	Examples
8	9,1 to 14,9	Data terminal type A
8	9,1 to 14,9	Data terminal type B

Table 6.4: Single burst EIRP - frames 6 and on

Power Class	EIRP range (dBW), with PAS = 0 dB	Examples
8	10,1 to 14,9	Data terminal type A
8	10,1 to 14,9	Data terminal type B

In addition, the output power of an access burst for a packet mode terminal is defined in table 6.5.

Table 6.5: Access burst EIRP

Burst Types	EIRP range (dBW) for Data terminal type A	EIRP range (dBW) for Data terminal type B
RACH	$5{,}0^{+6{,}8}_{-0{,}7}$ (see note 1)	$12{,}1^{+2{,}8}_{-3}$ (see note 3)
PRACH	$12{,}1^{+2{,}8}_{-3}$ (see note 2)	$12{,}1^{+2{,}8}_{-3}$ (see note 3)
NOTE 1: RACH EIRP for Data terminal type A ranges from -0,7 dBW to +6,8 dBW around the nominal EIRP. NOTE 2: RACH EIRP for Data terminal type B ranges from -3 dBW to +2,8 dBW around the nominal EIRP. NOTE 3: PRACH EIRP ranges from -3 to +2,8 dBW around the nominal EIRP.		

6.2 Antenna radiation pattern

Same as clause 6.2 of GMR-1 05.005 [5] with the addition of the following text:

The antenna for the various packet terminals have the following gains when fully deployed with no conduction objects in the vicinity of the MES antenna:

Terminal type	Antenna gain
Data terminal type A	12,0 dBi
Data terminal type B	12,0 dBi

For all antenna types, the axial ratio of radiated wave over the operational frequency range shall be better than 2 dB at boresight and better than 5 dB over the 3 dB coverage of the antenna.

6.3 Transmit polarization

Same as clause 6.3 of GMR-1 05.005 [5] with the following additional text:

The antenna for Data terminal Type B shall be capable of transmitting right-hand circular polarization.

6.4 Carrier-off conditions

Same as clause 6.4 of GMR-1 05.005 [5] with the following additional text:

The maximum EIRP from an MES in the carrier-off state shall be less than -30 dBm.

This requirement shall be met under the extreme environmental conditions defined in annex B.

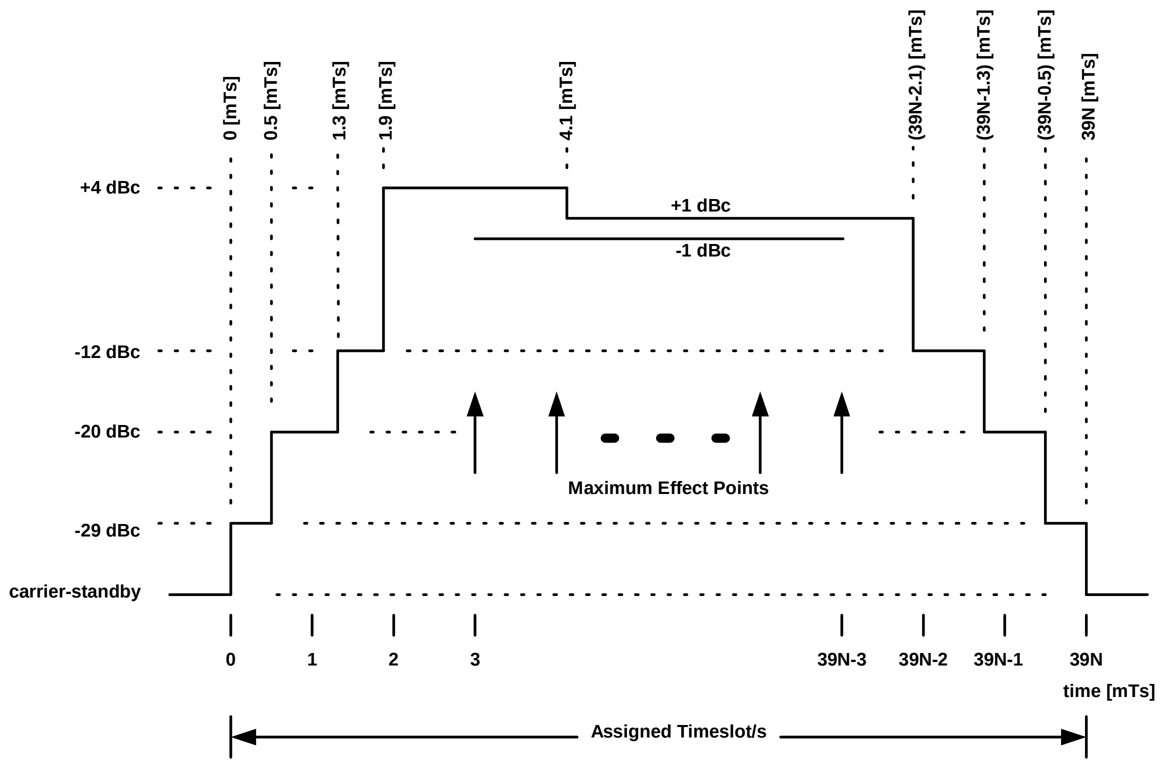
6.4a Carrier-standby conditions

The maximum EIRP from an MES in the carrier-standby state shall be less than -8 dBm.

This requirement shall be met under the extreme environmental conditions defined in annex B.

6.5 Ramp-up and ramp-down

The transition from the carrier-standby state to the active transmit state is the burst ramp-up, and the corresponding transition at the end of the burst is the burst ramp-down. The precise structure of the burst and the mapping of data bits into data symbols and transmit waveform is defined in GMPRS-1 05.004 [2]. The positions of the ramp-up and ramp-down periods relative to the slot boundaries and the maximum effect points of the transmitted symbols from the MES are shown in figure 6.1.



NOTE: T_S is the symbol period and is equal to 5/(117 x m) msec; i.e.(1/(23,4 x m)) ksps.

Figure 6.1: Ramp-up and ramp-down in relation to the rest of the burst

6.6 Power control range and accuracy

6.6.1 Approach

Same as clause 6.6.1 in GMR-1 05.005 [5].

6.6.2 Procedures and timing

Same as clause 6.6.2 in GMR-1 05.005 [5].

6.6.3 Range

Same as clause 6.6.3 in GMR-1 05.005 [5].

6.6.4 Accuracy

Same as clause 6.6.4 in GMR-1 05.005 [5].

6.6.5 Attenuation step size

Same as clause 6.6.5 in GMR-1 05.005 [5].

6.6.6 Monotonicity

Same as clause 6.6.6 in GMR-1 05.005 [5].

6.6.7 Initial power level P_{init}

The definition and the usage of the initial power level, P_{init}, is given in GMPRS-1 05.008 [3]. P_{init} is 12,1 dBW.

6.7 Adjacent channel interference

Same as clause 6.7 in GMR-1 05.005 [5].

6.7.1 Interference due to modulation

Same as clause 6.7.1 in GMR-1 05.005 [5] with the following additional text:

A factor "m" defines the transmitted signal symbol rate. "m" is equal to the ratio of the signal's transmit symbol rate to 23 400 symbols/sec. The interference shall be less than the levels given in table 6.6 as seen by a matched filter with a bandwidth of m x 23,400 kHz. The channel centres for measurement are also scaled by the factor "m", as given in table 6.6.

Table 6.6: Adjacent channel interference due to modulation

Power Class	1st Adjacent channels, ± m x 31,25 kHz	2nd Adjacent channels, ± m x 62,5 kHz	3rd Adjacent channels, ± m x 93,75 kHz	4th Adjacent channels and Beyond (see note)	Examples
8	-25 dBc	-40 dBc	-53 dBc	-60 dBc	Data terminal type A, B
NOTE: This requirement applies to all adjacent channels that are integrally contained in the band that extends from 2 MHz below the lower end of the transmit band to 2 MHz above the upper end of the transmit band.					

The transmitter shall also meet the spectral requirements defined in EN 301 681 [4]. In the event of any conflict the more stringent limit shall apply.

6.7.2 Interference due to switching transients

Same as clause 6.7.2 in GMR-1 05.005 [5] with the following additional text:

Table 6.7: Adjacent channel interference due to switching transients

Power Class	1st Adjacent channels, ± m x 31,25 kHz	2nd Adjacent channels, ± m x 62,5 kHz	3rd Adjacent channels, ± m x 93,75 kHz	4th Adjacent channels and Beyond (see note)	Examples
8	-18 dBc	-33 dBc	-46 dBc	-53 dBc	Data terminal type A, B
NOTE: This requirement applies to all adjacent channels that are integrally contained in the band that extends from 2 MHz below the lower end of the transmit band to 2 MHz above the upper end of the transmit band.					

6.8 Unwanted emissions

6.8.1 Unwanted emissions in the carrier-on state and carrier-standby state

For an MES in the carrier-on state, or in the carrier-standby state, the maximum EIRP density of the unwanted emissions from the MES outside the band 1 626,5 MHz to 1 660,5 MHz shall not exceed the carrier-on limits defined in table 3 of EN 301 681 [4].

6.8.2 Unwanted emissions in the carrier-off state

For an MES in the carrier-off state, the maximum EIRP density of the unwanted emissions from the MES shall not exceed the carrier-off limits defined in table 5 of EN 301 681 [4].

7 Receiver characteristics

7.1 Receive antenna pattern

Same as clause 7.1 in GMR-1 05.005 [5] with the following addition:

The antenna for the various packet terminals have the following gains when fully deployed and with no conduction objects in the vicinity of the MES antenna:

Terminal type	Antenna gain
Data terminal type A	12,0 dBi
Data terminal type B	12,0 dBi

For all antenna types, the axial ratio of radiated wave over the operational frequency range shall be better than 2 dB at boresight and better than 5 dB over the 3 dB coverage of the antenna.

7.2 Receive polarization

Same as clause 7.2 in GMR-1 05.005 [5] with the following addition:

The antenna for the packet data terminal type B shall be capable of receiving right-hand circular polarization.

7.3 Receiver figure of merit

Same as clause 7.3 in GMR-1 05.005 [5] with the following additional text:

The gain/temperature (G/T) ratio of the various packet data terminals in the direction of the peak antenna gain under clear sky conditions, with the antenna fully deployed and with no conducting objects in the vicinity of the unit, at 20°C, will exceed the following G/T values at elevations over 20 degrees:

Terminal type	G/T
Data terminal type A	-16,2 dB/K
Data terminal type B	-16,2 dB/K

For elevations over 5 degrees, the Data terminal type B shall exceed the G/T of -16,7 dB/K.

7.4 Receiver sensitivity

Same as clause 7.4 in GMR-1 05.005 [5] with the following additional text:

The receiver sensitivity is defined for the various transmission rates used for the packet services as the maximum power required at the antenna connector to provide the required performance with the nominal antenna.

7.4.1 Receiver BER in static conditions

Same as clause 7.4.1 of GMR-1 05.005 [5] with the following additional text:

Table 7.1a: BER in static conditions

Power Class	C/No at antenna connector (dB/Hz)	G/T (dB/K)	BER	User data rate (kbps)	Convolutional coding constraint length	Coding rate	Example
8	38,6	-16,2 (see note)	$1,0 \times 10^{-6}$	0,9	7	1/2	Data terminal type B
8	58,8	-16,2	$1,0 \times 10^{-6}$	116,8	7	3/4	Data terminal type A, Pnb(4,3)
8	57,8	-16,2	$1,0 \times 10^{-6}$	97,6	7	5/8	Data terminal type A Pnb(4,3)
8	56,2	-16,2	$1,0 \times 10^{-6}$	78,4	7	1/2	Data terminal type A Pnb(4,3)
8	59,8	-16,2	$1,0 \times 10^{-6}$	148,8	7	3/4	Data terminal type A Pnb(5,3)
8	58,8	-16,2	$1,0 \times 10^{-6}$	124,8	7	5/8	Data terminal type A Pnb(5,3)
8	57,2	-16,2	$1,0 \times 10^{-6}$	99,2	7	1/2	Data terminal type A Pnb(5,3)
NOTE: This G/T value applies for elevations over 20 degrees.							

7.4.2 Receiver BER in Rician fading

Same as clause 7.4.2 in GMR-1 05.005 [5].

7.4.3 FER of logical channels

Same as clause 7.4.3 in GMR-1 05.005 [5].

7.5 Receiver selectivity

Receiver selectivity is a measure of a receiver's ability to operate in the presence of a single modulated interferer at some power level and at some defined frequency spacing from the received signal. The interferer will be modulated as defined in GMR-05.004 [2] with random data, and a symbol rate of 23,4 ksym/sec.

Under the interference conditions in table 7.4, the receiver performs as defined in the static sensitivity requirement with 0,5 dB greater signal power.

Table 7.2: Void

Table 7.3: Void

Table 7.4: Receiver Selectivity Interference Conditions

Case	Interference Level Relative to Sensitivity	Interference Frequency Offset
1	+ 15 dB	m x 31,25 kHz
2	+ 25 dB	m x 93,75 kHz
3	+45 dB	>500 kHz

where "m" defines the bandwidth of the received signal in units of 31,25 kHz channels.

7.6 Receiver intermodulation

Same as clause 7.6 in GMR-1 05.005 [5].

7.7 Receiver blocking characteristics

Same as clause 7.7 in GMR-1 05.005 [5].

7.8 Receive signal strength

Same as clause 7.8 in GMR-1 05.005 [5].

8 GPS receiver characteristics

Same as clause 8 in GMR-1 05.005 [5].

Annex A (normative): Antenna factor equation

Same as annex A in GMR-1 05.005 [5].

Annex B (normative): Environmental conditions

Same as annex B in GMR-1 05.005 [5].

Annex C (normative): Channel model

Same as annex C in GMR-1 05.005 [5].

Annex D (informative): Derivation of receiver sensitivity specifications

D.1 Introduction

This annex describes the derivation of the sensitivity specifications used elsewhere in the present document. The purpose is to clearly define the meaning of the specification and the calculations used in the derivation.

The system requirements define transmissions at two symbol rates (PNB(4,3) and PNB(5,3)) and three different coding rates (3/4, 5/8 and 1/2) which provide a specification for the E_b/N_o at the input to the demodulator that is required to achieve a Bit Error Rate specification. Calculations have been provided for all combinations of symbol and coding rates.

D.2 Definitions

Three definitions of the receiver sensitivity are defined as follows.

D.2.1 Integral sensitivity

The integral sensitivity is the conducted power collected by the receiver antenna that achieves the desired BER assuming the antenna remains connected to the receiver. The integral sensitivity is specified in dBm.

The integral sensitivity may be considered to be that conducted power incident at the input of the receiver that has been collected by the antenna at the radiated sensitivity specification, considering the performance parameters of the antenna.

The integral sensitivity may be calculated from the definition and specification of G/T. The system noise temperature of the receiver may be calculated from the following formula expressed in logarithmic form:

$$G/T = G - 10\log(T^{s})$$

where G/T is specified,

G = antenna gain (dBi)

T_s = System noise temperature (referred to the antenna connector)

The integral sensitivity is defined as the product of the system noise floor (kT_s) and the required C/N_o.

$$Integral\ Sensitivity = 10\log(kT^{s}) + (C/N_0)$$

where k is the Boltzman constant (1,38 x 10^{-23} J/K) and (C/N_o) is expressed in logs. The (C/N_o) may then be expanded to give:

$$Integral\ Sensitivity = 10\log(kT_S) + (E_b/N_0) + 10\log(R_b)$$

$$Integral\ Sensitivity = 10\log(kT_S R_b) + (E_b/N_0)$$

where R_b is the bit rate and (E_b/N_o) is expressed in logs.

D.2.2 Radiated sensitivity

The radiated sensitivity is the radiated power flux density incident at the receiver antenna that achieves the desired BER. The radiated sensitivity is specified in dBm/m^2.

The radiated sensitivity is calculated from the integral sensitivity and including the effective area of the receive antenna as follows:

$$Radiated\ Sensitivity = Integral\ Sensitivity - 10\log(A_e)$$

Where A_e is the effective antenna area. Using the definition of effective antenna area:

$$A_e = \frac{G_l \lambda^2}{4\pi}$$

where G_l is the gain of the antenna relative to an isotropic radiator in linear form, and the formula for integral sensitivity derived above,

$$Radiated\ Sensitivity = 10\log\left(\frac{4\pi k T_s R_b}{\lambda^2}\right) + (E_b / N_0) - G$$

where λ is the free space wavelength and G is the gain expressed in logarithmic form (dBi).

D.2.3 Conducted sensitivity

The conducted sensitivity is the conducted power incident at the receiver connector, with the receive antenna disconnected, assuming a signal source at the ambient temperature has been impedance matched (to 50 Ω) to the receiver. The conducted sensitivity is specified in dBm.

The calculation of conducted sensitivity is similar to the integral sensitivity, with a noise temperature that considers the signal source, such that:

$$T_{cond} = T_S - T_{ant} + T_{amb}$$

where, T_{cond} = Noise Temperature of Conducted System (referred to the connector):

T_{ant} = Noise Temperature of Antenna

T_{amb} = Ambient Temperature (e.g. 290 K)

T_s = System Noise Temperature from G/T specification

All temperatures are expressed in Kelvin (K).

$$\therefore Conducted\ Sensitivity = 10\log(kT_{cond} R_b) + (E_b / N_0)$$

D.3 Calculated parameters

Table D.3 shows the parameters used in the calculations that are common to all modulation rates and coding schemes.

Table D.3.1: Common parameters

Parameter	Symbol	Value	Derivation
G/T	G/T	-16,2 dB	The present document
Antenna Gain	G	12 dBi	The present document
Boltzmann Constant	k	1,38 x 10^{-23} J/K	Physical Constant
Free Space Wavelength	λ	0,194m	Calculated using frequency at the centre of the Rx band
Effective Antenna Area	A_e	-13,22 dB $metre^2$	Calculated from antenna gain and wavelength
Antenna Noise Temperature	T_{ant}	150 K	Antenna Specification
System Noise Temperature	T_s	660,7 K	Calculated from G/T and antenna gain
System Noise Floor	$10log(kT_s)$	-170,4 dBm/Hz	Calculated
Conducted Noise Temperature	T_{cond}	800,7K	Calculated with Tamb at 290 K
Conducted Noise Floor	$10log(kT_{cond})$	-169,6 dBm/Hz	Calculated

The following tables present the specifications for each transmitted symbol rate in turn.

Table D.3.2: Void

Table D.3.3: Void

Table D.3.4: Void

Table D.3.5: PNB(4,3)

Number Of Channels	4		
Symbol Rate (sps)	93600		
Transmitted Bit Rate (bps)	187200		
Coding Rate (K=7)	3/4	5/8	1/2
Target E_b/N_o for 10^{-6} BER (dB)	6,1	5,1	3,5
C/N_0 (dB)	58,8	57,8	56,2
Integral Sensitivity (dBm)	-111,6	-112,6	-114,2
Radiated Sensitivity (dBm/m^2)	-98,4	-99,4	-101,0
Conducted Sensitivity (dBm)	-110,7	-111,7	-113,3

Table D.3.6: PNB(5,3)

Number Of Channels	5		
Symbol Rate (sps)	117 000		
Transmitted Bit Rate (bps)	234 000		
Coding Rate (K=7)	3/4	5/8	1/2
Target E_b/N_o for 10^{-6} BER (dB)	6,1	5,1	3,5
C/N_0 (dB)	59,8	58,8	57,2
Integral Sensitivity (dBm)	-110,6	-111,6	-113,2
Radiated Sensitivity (dBm/m^2)	-97,4	-98,4	-100,0
Conducted Sensitivity (dBm)	-109,8	-110,8	-112,4

Annex E (informative): Bibliography

- GMPRS-1 03.022 (ETSI TS 101 376-3-10): "GEO-Mobile Radio Interface Specifications (Release 2); General Packet Radio Service Part 3: Network specifications; Sub-part 10: Functions related to Mobile Earth Station (MES) in idle mode; GMPRS-1 03.022".
- GMPRS-1 05.010 (ETSI TS 101 376-5-7): "GEO-Mobile Radio Interface Specifications (Release 2); Part 5: Radio interface physical layer specifications; Sub-part 7: Radio Subsystem Synchronization; GMPRS-1 05.010".
- William C. Jakes "Microwave Mobile Communications", ed. IEEE Press, 1994.

History

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