ETSI TS 101 376-5-6 V3.3.1 (2012-12)

GEO-Mobile Radio Interface Specifications (Release 3);
Third Generation Satellite Packet Radio Service;
Part 5: Radio interface physical layer specifications;
Sub-part 6: Radio Subsystem Link Control;
GMR-1 3G 45.008

Reference

RTS/SES-00328-5-6

Keywords

3G, control, gateway, GMPRS, GMR, GPRS, GSM, GSO, interface, MES, mobile, MSC, MSS, radio, satellite, S-PCN

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Sous-Préfecture de Grasse (06) N° 7803/88

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Contents

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Foreword

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Version 3.m.n

where:

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- 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 6 of a multi-part deliverable covering the GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite 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; GMR-1 3G 45.001";

Sub-part 2: "Multiplexing and Multiple Access; Stage 2 Service Description; GMR-1 3G 45.002";

Sub-part 3: "Channel Coding; GMR-1 3G 45.003";

Sub-part 4: "Modulation; GMR-1 3G 45.004";

Sub-part 5: "Radio Transmission and Reception; GMR-1 3G 45.005";

Sub-part 6: "Radio Subsystem Link Control; GMR-1 3G 45.008";

Sub-part 7: "Radio Subsystem Synchronization; GMR-1 3G 45.010";

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 document is part of the GMR Release 3 specifications. Release 3 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).
- Release 3 specifications have a GMR-1 3G prefix in the title and a version number starting with "3" (V3.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.

The GMR release 3 specifications evolve packet mode services of GMR release 2 to 3rd generation UMTS compatible services. The GMR release 3 specifications introduce the GEO-Mobile Radio Third Generation (GMR-1 3G) service. Where applicable, GMR-1 3G is derived from the terrestrial digital cellular standard 3GPP and it supports access to 3GPP core networks.

Due to the differences between terrestrial and satellite channels, some modifications to the GSM or 3GPP standard are necessary. Some GSM and 3GPP specifications are directly applicable, whereas others are applicable with modifications. Similarly, some GSM and 3GPP specifications do not apply, while some GMR specifications have no corresponding GSM or 3GPP specification.

Since GMR is derived from GSM and 3GPP, the organization of the GMR specifications closely follows that of GSM or 3GPP as appropriate. The GMR numbers have been designed to correspond to the GSM and 3GPP numbering system. All GMR specifications are allocated a unique GMR number. This GMR number has a different prefix for Release 2 and Release 3 specifications as follows:

- Release 1: GMR n xx.zyy.
- Release 2: GMPRS n xx.zyy.
- Release 3: GMR-1 3G xx.zyy.

where:

- xx.0yy (z = 0) is used for GMR specifications that have a corresponding GSM or 3GPP specification. In this case, the numbers xx and yy correspond to the GSM or 3GPP numbering scheme.
- xx.2yy (z = 2) is used for GMR specifications that do not correspond to a GSM or 3GPP specification. In this case, only the number xx corresponds to the GSM or 3GPP 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 and 3GPP specifications as follows:

- If a GMR specification exists it takes precedence over the corresponding GSM or 3GPP specification (if any). This precedence rule applies to any references in the corresponding GSM or 3GPP specifications.

NOTE: Any references to GSM or 3GPP specifications within the GMR or 3GPP specifications are not subject to this precedence rule. For example, a GMR or 3GPP specification may contain specific references to the corresponding GSM or 3GPP specification.

- If a GMR specification does not exist, the corresponding GSM or 3GPP specification may or may not apply. The applicability of the GSM and 3GPP specifications is defined in TS 101 376-1-2 [9].

The clause numbering and the table numbering and figure numbering in the present document are aligned to the corresponding numbering of TS 101 376-5-6 (Release 1) [7] as far as possible. In several places, this means that the table numbering and figure numbering is non-continuous in the present document in order to maintain this alignment, the following rules apply:

- A table that uses the same table number replaces the corresponding table in TS 101 376-5-6 (Release 1) [7];

- A table that uses a different table number is a new additional table.

1 Scope

The present document specifies several control aspects for the radio link between the Mobile Earth Station (MES) and the Gateway Station (GS) in the GMR-1 3G Mobile Satellite System. It specifies the operation of power control and defines dead link detection. It makes requirements for DTX operation.

The present document also defines requirements for the MES for monitoring system information, as prerequisites to system access, and upon exit from dedicated mode. It makes requirements for spot beam selection and reselection. It defines the nature of the measurements that the MES uses to implement these processes.

Timing and frequency control aspects of link control are to be found in TS 101 376-5-7 [6], and messages for timing and frequency control are defined in TS 101 376-4-8 [3].

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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

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 necessary for the application of the present document.

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 Release 7 or to the latest version of that document in the latest release less than 7.

In the case of a reference to a GMR-1 3G document, a non-specific reference implicitly refers to the latest version of that document in the same Release as the present document.

[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".

NOTE: This is a reference to a GMR-1 Release 2 specification. See the introduction for more details.

[2] ETSI TS 101 376-3-10: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 3: Network specifications; Sub-part 10: Functions related to Mobile Earth Station (MES) in idle mode; GMR-1 3G 43.022".

[3] ETSI TS 101 376-4-8: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 8: Mobile Radio Interface Layer 3 Specifications; GMR-1 3G 44.008".

[4] ETSI TS 101 376-5-3: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 3: Channel Coding; GMR-1 3G 45.003".

[5] ETSI TS 101 376-5-5: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 5: Radio Transmission and Reception; GMR-1 3G 45.005".

[6] ETSI TS 101 376-5-7: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 7: Radio Subsystem Synchronization; GMR-1 3G 45.010".

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

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

[8] ETSI TS 101 376-4-12: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 12: Mobile Earth Station (MES) - Base Station System (BSS) interface; Radio Link Control/Medium Access Control (RLC/MAC) protocol; GMR-1 3G 44.060".

[9] ETSI TS 101 376-1-2: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 1: General specifications; Sub-part 2: Introduction to the GMR-1 family; GMR-1 3G 41.201".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

Not applicable.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TS 101 376-1-2 [9] and the following apply:

Average Power Used (APU): at the beginning of each call, the MES will start a running power-averaged PAS setting, expressed in dB

NOTE: This parameter will be transmitted upon receipt of an INFORMATION REQUEST message from the network, with a power control request code.

BCCH_FULL_LIST: list of all the Broadcast Control CHannel (BCCH) numbers used by the network

BCCH_NEIGHBOR_LIST: list of the neighbouring spot beams' BCCH numbers, starting timeslots, and system information cycle offsets

Call Quality Metric (CQM): at the beginning of each call, the MES will start a running average of the percentage of post-FEC burst errors occurring for the call

NOTE: This parameter will be transmitted upon receipt of an INFORMATION REQUEST message from the network, with a power control request code.

criterion C1: used by the MES for detecting the presence of the frequency control channel (FCCH) and switching out of the frequency search state

Link Quality Indication (LQI): amount of available link margin with respect to SQT, expressed in dB

NOTE: A positive value indicates the amount of additional link margin in reserve. A negative value indicates that power control is at saturation and that the SQT is not being met by the indicated value.

link margin: difference (in dB) between the SQI at the receiver corresponding to the maximum transmit power level and the SQT

Open Loop Threshold (Olthresh): parameter Olthresh is the threshold on the LQI estimate before activating open loop power control

Open Loop Gain (Olgain): parameter Olgain is the loop gain for open loop control

Power Attenuation Notification (PAN): attenuation, in dB, used by the transmitter in the power control loop, relative to the maximum transmit power level

Power Attenuation Request (PAR): attenuation, in dB, requested by the receiver in the power control loop, relative to the maximum transmit power level

power control loop gain: number by which the difference between SQT and SQI is multiplied to derive the power correction value

NOTE 1: Two loop gains are defined:

- **GainDn:** used as the loop gain if the difference between SQT and SQI is negative;
- **GainUp:** used as the loop gain otherwise (i.e. if the difference between SQT and SQI is not negative).

NOTE 2: The loop gain is a unit less number with a default value of 1,0.

Power Control Topped-Out (PCTO): at the beginning of each call, the MES will start a running average of the percentage of messages for which the calculated PAS is less than PASmin

NOTE: This parameter will be transmitted upon receipt of an INFORMATION REQUEST message from the network, with a power control request code.

radio link failure counter S: counter whose value of zero determines the failure of the radio link

reserve link margin: difference (in dB) between the SQI corresponding to the maximum transmit power level and the actual SQI at the receiver

RADIO_LINK_TIMEOUT: system parameter for deriving the maximum value of the radio link failure counter S

Received Signal Strength Indication (RSSI): root mean squared (rms) value of the signal received at the receiver antenna

NOTE: The RSSI estimate is compensated for all the time-varying processes (such as automatic gain control) that affect the estimation procedure for obtaining a relative measure to use in comparing the strength of signals received at different times.

SB_RESELECT_HYSTERESIS: value in dB by which a nonserving beam's BCCH power measurement exceed the serving beam's BCCH power before the MES switches to the nonserving beam

SB_SELECTION_POWER: during the spot beam selection and reselection, the MES selects only those BCCH carriers whose receive power is within SB_SELECTION_POWER dB of the strongest BCCH carrier

SB_RESELECTION_TIMER: maximum time interval between consecutive spot beam reselection procedures

Signal Quality Indication (SQI) or Signal Quality Measurement (SQM): estimate of the ratio of signal power to the noise and the interference power S / (N + I) formed at the receiver in the power control loop

NOTE 1: The terms SQI and SQM are used interchangeably in the present document. The term SQI is used for the descriptions related to circuit-switched operation, whereas the term SQM is used for the packet-data-related descriptions in the present document.

NOTE 2: This estimate, averaged over one burst, is denoted here as SQIj or SQM_j (estimate for jth burst). For the power control algorithm in the circuit-switched operation, MES averages this estimate is averaged over six frames and the averaged estimate is denoted as $\overline{SQI6}$.

Signal Quality Target (SQT): desired receive signal quality, and it is defined as the targeted value for the ratio of the signal power to the noise and interference power

NOTE: The SQT is derived from a reference threshold and an allowance for fading and Doppler shift.

3.2 Abbreviations

For the purposes of the present document, the abbreviations defined in TS 101 376-1-1 [1] and the following apply:

APU	Average Power Used
CQM	Call Quality Metric
Olgain	Open Loop gain
Olthresh	Open Loop threshold
PCTO	Power Control Topped Out
SQIR	Signal Quality Indicator Report
SQISDR	Signal Quality Standard Deviation
TX	Transmit
UTLQR	UT Link Quality Report

4 General

Same as clause 4 in TS 101 376-5-6 (Release 1) [7].

5 RF power control

Same as clause 5 in TS 101 376-5-6 (Release 1) [7] with the exception of the following modification to clause 5.3.3.

5.3.3 Message coding

Same as clause 5.3.3 in TS 101 376-5-6 (Release 1) [7] with the following addition for PAN message coding for MES operating in Iu mode with PNB3(1,6)-2,6 kbps DACCH allocation in uplink direction in packet shared mode. In this mode the PAR transmitted by the GS towards to MES is a 6-bit integer word as defined in clause 5.3.3 in TS 101 376-5-6 (Release 1) [7] but the PAN as transmitted by the MES is a 5-bit integer word.

The MES shall quantize each of the PAN values to a 5-bit integer word in this mode only. The 5-bit field permits 32 codes. Codes 0 to 30 represent power levels (see table 5.1a), and the remaining code, 31, represents an escape sequence.

The quantization coding scheme is shown here, with the term "value" representing the unquantized PAN value.

If value < 0,0 dB, code = 0.

If value > 24,0 dB, code = 30.

If 0,0 ≤ value ≤ 24,0 dB, code = $\lfloor$ (value/0,8)$\rfloor$,

where $\lfloor x \rfloor$ represents the largest integer less than or equal to *x*.

The decoding of the coded field shall be as follows:

Decoded value = 0,8 × code, where 0 ≤ code ≤ 30.

This is summarized in table 5.1a.

The MES shall transmit according to the resulting quantized PAN value (as decoded PAN value) and send the 5-bit PAN code over a single burst.

Table 5-1a: Power control message coding for PNB3(1,6)-2,6 kbps DACCH used in packet shared mode

PAN Code	PAN Value (dB)
0	0,00
1	0,80
2	1,60
3	2,40
4	3,20
5	4,00
6	4,80
…	…
27	21,60
28	22,40
29	23,20
30	24,0
31	Escape

6 Radio link failure

Same as clause 6 in TS 101 376-5-6 (Release 1) [7] for dedicated mode, with the following modifications:

For packet service in packet transfer mode and when MES is operating in Iu mode with packet channel (PDCH) allocation in downlink direction:

- Link failure may occur as result of adverse channel conditions. The MES shall detect link failure by determining that the received E_s/N_o is below 2,5 dB for terminal type A and D and below 3,0 dB for terminal type C. The MES shall detect link failure by determining that the received E_s/N_o is below 2,5 dB for terminal type E and above. This determination may be based on Bit Error Rate estimation. The Bit Error Rate estimate may be based on known bits within the packet bursts, or on an examination of the Golay decoder outputs.
- This detection procedure shall be performed for each successive link failure measurement interval.
- The measurement interval is defined as LINK_FAILURE_MEASUREMENT_INTERVAL. The GS shall broadcast the value of LINK_FAILURE_MEASUREMENT_INTERVAL as part of system information in BCCH (see TS 101 376-4-8 [3]), and the default value is 10 seconds.
- In case of the radio link failure detection, the MES shall perform the procedure specified in TS 101 376-4-12 [8].

When MES is operating in Iu mode with dedicated channel (DCH) allocation in downlink direction, the radio link failure criterion is based on a radio link failure counter S and the system information parameter RADIO_LINK_TIMEOUT.

1) At the assignment of a dedicated channel (DCH), the MES shall initialize the radio link failure counter S to a value of (RADIO_LINK_TIMEOUT × 25).

2) The MES shall never set the counter S to a value greater than (RADIO_LINK_TIMEOUT × 25). This restriction shall be a limitation on all following paragraphs of this clause.

3) If a PNB3(1,n) data burst (DACCH) or PNB3(1,n) speech burst or KAB3 (1,n) burst is received, the power control Golay code shall provide the criterion for judging the quality of the radio link. The Golay decoder, besides decoding the power control field, shall also perform error detection check. If this check passes, the counter S shall be incremented by 6, otherwise the counter S shall be decremented by 6. The MES shall have a full block of 6 consecutive frames to either increment or decrement S. In the event that the power control message framing has not been determined (i.e. synchronization is not achieved), a Golay decoding failure shall be assumed every 240 ms.

4) If S reaches 0, radio link failure shall be declared by the MES. In case of radio link failure, the MES shall be required to perform the procedure specified in TS 101 376-4-12 [8].

5) The counter S shall be reinitialized to (RADIO_LINK_TIMEOUT × 25) at dedicated channel reassignment.

7 Idle mode tasks

Same as clause 7 in TS 101 376-5-6 (Release 1) [7], with the following modifications:

- For terminals using FCCH3 bursts, clause 13 of the present document shall apply.

8 Network prerequisites

8.1 BCCH carriers with FCCH

Same as clause 8 in TS 101 376-5-6 (Release 1) [7].

8.2 BCCH carriers with FCCH3

When the FCCH3 is used, the network shall transmit two twelve-timeslot FCCH3s into every multiframe on a PC12d physical channel. The BCCH using a twelve-timeslot DC12 burst shall be transmitted once every eight frames in the second frame, following the FCCH3. All other control channels, e.g. the PCH, AGCH, and GBCH3 are time multiplexed onto this physical channel using a DC12 burst.

The BCCH carriers in adjacent spot beams shall have their transmission of FCCH3 and BCCH offset in time, either on different timeslots or on the same timeslot, but offset in frame number to facilitate the signal strength and quality measurements at the MES for spot beam selection and reselection. The neighbouring beams' BCCH carrier identification and the timing shall be broadcast in the BCCH.

9 Aspects of Discontinuous Transmission (DTX)

Same as clause 9 in TS 101 376-5-6 (Release 1) [7].

9.1 Rules of burst transmission (A/Gb mode)

This clause only applies to MES operating in A/Gb mode.

Same as clause 9.1 in TS 101 376-5-6 (Release 1) [7].

9.2 Rules of burst transmission on a Dedicated CHannel (DCH) (Iu mode)

This clause only applies to MES operating in Iu mode.

The rules for burst transmission of a Dedicated CHannel (DCH) are:

1) At the PHY layer, burst transmissions on a DCH shall be continuous (every frame) from the time the channel is setup until it is released. The continuous transmissions shall be comprised of either upper layer voice, data or control traffic bursts, or PHY layer KAB3 keep alive bursts.

2) Two transmission phases shall be defined on an assigned DCH: i) an initialization phase in which the upper layer provides data bursts for transmission in every TDMA frame, and, ii) a normal operating phase in which the upper layer is only required to ensure that upper layer bursts (voice, data or control) are provided for transmission no less frequently than once every 25 frames (1 second).

   i) The initialization phase shall extend for a period of 50 frames (2 seconds) from the time that the DCH is assigned. During the initialization phase only upper layer data bursts at a single MCS-defined transmission rate shall be transmitted on the DCH. The data transmission rate will be based on the channel type established on the DCH. Burst classification at the PHY layer shall therefore be restricted to a single data burst type, as specified by the upper layer (RLC/MAC), for the entire 50-frame initialization period. During the initialization phase all bursts shall be transmitted at maximum power.

   ii) The normal operating phase shall immediately follow the initialization phase and continue until the DCH is released. During the normal operating phase the upper layer shall provide voice, data or control traffic bursts for transmission at least once per 25 frames. The upper layer will provide dummy control bursts when there is no other upper layer traffic bursts to send on the channel. Once the requirement of one upper layer transmission burst per second is met, KAB3 keep alive bursts shall be transmitted when there are no other voice, data or control traffic bursts arriving for transmission. Burst classification at the PHY layer during the normal operating phase shall be based on the upper layer traffic types supported on the DCH. During the normal operating phase bursts shall be transmitted at a power level derived by the link adaptation power control applicable to the services supported on the channel.

3) When commanded to DCH handover, DCH bursts shall be transmitted at full power for 2 seconds with no restriction on burst types, including KAB3.

10 Radio link measurements

Same as clause 10 in TS 101 376-5-6 (Release 1) [7] with the following additions:

Table 10.3: SQI_j Estimation Accuracy for DC12 burst

Actual E_{bt}/N_o (dB)	Standard deviation of measurement error (dB)
-3	2,2
0	1,2
3	0,8
6	0,8
9	0,8
12	0,8

The SQM estimation bias at E_{bt}/N_o of -3 dB shall not exceed 0,5 dB.

11 Control parameters

Same as clause 11 in TS 101 376-5-6 (Release 1) [7].

12 GMPRS mode tasks

12.1 GMPRS and GMR-1 3G spot beam selection and reselection

12.1.1 BCCH type identification (A/Gb mode only)

This clause only applies to MES operating in A/Gb mode.

For the purpose of MES idle mode operation, the MES shall be able to identify BCCH type. The BCCH can be either an Anchored BCCH (A-BCCH) or Temporary BCCH (T-BCCH).

An Anchor BCCH (A-BCCH) shall have the following features:

1) It shall use an ARFCN on the BCCH_FULL_LIST for the serving satellite.

2) It shall be illuminated permanently in a satellite system.

3) It shall always be transmitted with full BCCH power.

4) It may be listed on a neighbour BCCH list.

5) It may be used for RSSI based spot beam selection.

A Temporary BCCH (T-BCCH)shall have the following features:

1) It may use any frequency, i.e. it may be assigned to an ARFCN not given in the BCCH_FULL_LIST for the serving satellite.

2) It may not be illuminated or activated all the time.

3) It may not be transmitted with full BCCH power.

4) It shall not be listed in the neighbour BCCH list.

5) It shall not be used for RSSI based spot beam selection.

The BCCH type differentiation shall be based on the BCCH_Type_Flag (see TS 101 376-4-8 [3]) decoded from the System Information (SI).

12.1.2 Spot beam selection

For terminals using FCCH spot beam selection shall operate according to clause 7 of TS 101 376-5-6 (Release 1) [7]. For terminals using FCCH3 spot beam selection shall operate according to clause 13.

12.1.3 Spot beam reselection

For terminals using FCCH spot beam reselection shall operate according to clause 7.7 of TS 101 376-5-6 (Release 1) [7]. For terminals using FCCH3 spot beam selection shall operate according to clause 13.

12.2 Idle mode link loss (A/Gb model only)

This clause only applies to MES operating in A/Gb mode.

If an MES is camped on a T-BCCH, the MES shall check T-BCCH availability by receiving at least one burst every multiframe either from the PCH or the BCCH. If the MES is unable to read either the BCCH or PCH for 4 consecutive multiframes, the MES shall switch to one of the concurrent A-BCCHs. It shall then camp on the A-BCCH or any A-BCCH with the same spot beam ID as the dark T-BCCH. While camped on an A-BCCH in the same spot beam as the T-BCCH, the MES shall periodically read the system information broadcast on the A-BCCH as described in clause 7.10 of TS 101 376-5-6 (Release 1) [7]. If the concurrent list changes or if the MES reacquires the T-BCCH, it shall follow the procedures in TS 101 376-3-10 [2].

The BCCH read operation of clause 7.10, of TS 101 376-5-6 (Release 1) [7], shall apply to a MES camped on a T-BCCH or an A-BCCH in GMPRS mode.

12.3 Link adaptation

12.3.1 Objective and overall procedure

The objective of the link adaptation is to optimize the transmission throughput according to each user's channel environment while a reliable transmission is guaranteed.

For the forward link transmission to terminal type A, the code rate of the encoder is determined at the TBF initialization and is unchanged during the corresponding TBF. Note that the TX power level at the GS is not changed for the purpose of the forward link adaptation.

For the return link transmission from terminal type A, the code rate of the encoder and the initial TX power level of the MES are determined at the TBF initialization. While the code rate remains unchanged, the TX power level of the MES is adaptively controlled during the corresponding TBF.

For the forward link transmission to terminal type C, the code rate of the encoder at the GS may be adaptively controlled during the TBF. Note that the TX power level at the GS is not changed for the purpose of the forward link adaptation.

For the return link transmission from terminal type C, the code rate of the encoder and the initial TX power level of the MES are determined at the TBF initialization. Subsequently, the GS may adaptively change both the code rate and the TX power level during a TBF.

For the forward link transmission to terminal type D, the code rate and modulation of the encoder at the GS may be adaptively controlled during the TBF. Note that the TX power level at the GS is not changed for the purpose of the forward link adaptation.

For the return link transmission from terminal type D, the code rate and modulation of the encoder and the initial TX power level of the MES are determined at the TBF initialization. Subsequently, the GS may adaptively change both the code rate and the TX power level during a TBF.

For the forward link transmission to terminal types E and above the code rate and modulation of the encoder at the GS may be adaptively controlled during the TBF. Note that the TX power level at the GS is not changed for the purpose of the forward link adaptation, except for a DCH.

For the return link transmission from terminal types E and above the code rate and modulation of the encoder and the initial TX power level of the MES are determined at the TBF initialization. Subsequently, the GS may adaptively change both the code rate and the TX power level during a TBF.

12.3.2 Power control and link adaptation parameters

Power control and link adaptation requires five variables: PAR and PAN that are defined in clauses 5.3.1 and 5.3.2 of TS 101 376-5-6 (Release 1) [7], FQI, SQIR and SQISDR. PAR is created by the GS and sent to the corresponding MES. PAN, FQI, SQIR, and SQISDR are created by the MES and sent to the GS.

12.3.3 PAN, FQI, SQIR, and SQISDR transmission

12.3.3.1 Terminal Type A, C and D

The PAN is transmitted on PUblic Information (PUI). Refer to TS 101 376-4-12 [8] for radio block and Ieformat. The PAN value shall indicate the actual power level used to send this radio block. The PAN is transmitted on every transmitted radio block.

12.3.3.2 Terminal Type E and above

In the case of a DCH, the MES shall transmit three values to the GS: the FQI or the forward quality indicator that represents the Boolean CRC indicator for a burst received at the MES (FQI=1 indicates that CRC has passed, FQI=0 indicates that CRC has failed), the SQIR or the mean of its SQM and the PAN, which is the relative power at which the MES transmitted. The 1 bit FQI is sent to the GS every burst. The SQIR and the PAN are combined into a 12-bit word, PAN occupies the least significant 6 bits and SQIR occupies the most significant six bits. These 12 bits are Golay encoded to yield a 24 bit field. This field is segmented into six groups of 4 bits. Each PNB3(1,n) or KAB3(1,n) for n = 3, 6, and 8 burst carriers these 4 bits. Since each burst is 40 ms apart, the 24 bit message is conveyed over 240 ms; this 240 ms period is called the link adaptation control unit for a DCH.

In the case of MES transmitting low rate data over PNB3(1,6)-2,6 kbps DACCH burst in packet shared mode, the MESs send 5-bit PAN value within the status field of every burst.

In the case of a shared packet data channel, the MES sends the 6 bit PAN within the PUI of every burst. The MESs send the 6 bit mean and the 6 bit standard deviation of the SQM (the SQIR and the SQISDR) via PACCH. The MES also uses the PACCH to send the 6 bit FQI, which for a shared packet data channel represents the measured FER over the designated duration. For details on SQIR, SQISDR and FQI calculations and reports, refer to clause 12.3.8.

12.3.4 PAR transmission

12.3.4.1 Terminal Type A, C, and D

A PAR is transmitted on the RLC/MAC header of the radio block. Alternatively, if there is no active forward link TBF, the PAR can be transmitted on MAC/RLC header of any control message.

At the time of channel assignment, a PAR value is transmitted as a part of power control parameters to indicate the power level that the MES should use for its initial transmissions on the uplink PDCH. Refer to TS 101 376-4-12 [8] for the power control parameter IE format.

12.3.4.2 Terminal Type E and above

In the case of a DCH, the GS transmits one value to the MES: the PAR - the relative power at which the MES shall transmit. The PAR is encoded into a 6 bit word. These 6 bits are paired with 6 spare bits (spare bits occupy the most significant six bits and the PAR occupies the least significant six bits) and then Golay encoded to yield a 24 bit field. This field is segmented into six groups of 4 bits. Each PNB3(1,n) or KAB3(1,n) for n = 3, 6, and 8 burst carriers these 4 bits. Since each burst is 40 ms apart, the 24 bit message is conveyed over 240 ms; this 240 ms period is called the link adaptation control unit for a DCH.

In the case of a shared packet data channel, the GS sends the 6 bit PAR value every burst. Refer to TS 101 376-4-12 [8] for the power control parameter IE format; refer to TS 101 376-5-3 [4] for the power control bit FEC. The PAR value sent by the GS is normalized by the bandwidth adjustment factor. The MES shall subtract the bandwidth adjustment factor from this normalized PAR to compute its PAN value. The bandwidth adjustment factor is computed as $10 \times \log_{10}(B/31,25)$ where B is the carrier bandwidth, measured in kHz.

12.3.5 MES output power

12.3.5.1 Terminal Type A, C, D, E and above

A PAN shall be transmitted on the PUI of each transmitted radio block on PDCH/U. The PAN value shall represent the actual power level used to transmit the radio block. PAR shall be transmitted on either PACCH/D or on RLC/MAC header of the forward link burst.

In case a MES sends PNB bursts on return link direction without establishing a return link TBF, it uses the known initial power level, P_{init}, to transmit the corresponding burst. The definition of the known initial power level of MES, P_{init}, is shown in TS 101 376-5-5 [5].

12.3.5.2 Open-loop power control at a terminal type C MES

A terminal type C MES receiving PDCH(2,6) shall perform open-loop power control, as described in this clause. The open-loop power control is performed on every 400 ms basis.

12.3.5.2.1 Signal quality estimation

The MES shall estimate the signal quality of the received downlink bursts for the purpose of open-loop power control at MES.

For a given SQI measurement period T, estimation of the signal quality is performed as follows:

$$SQM_{avg} = \frac{1}{N}\sum_{j=1}^{N} SQM_j ,$$

$$SQM_{dev} = \sqrt{\frac{1}{N-1}\left(\sum_{j=1}^{N} SQM_j^2\right) - \frac{N}{N-1} SQM_{avg}^2} ,$$

$$SQM'_{avg} = SQM_{avg} - SQIfactor \times SQM_{dev}$$

Where N is the number of PNBs that the MES receives and SQMj is the SQM measurement of the j-th received burst during the measurement period T. See clause 12.3.5.1.2 for measurement period for open loop power control. The SQM'_{avg} is calculated only when the number of received PNBs during measurement period T is no less than 4.

12.3.5.2.2 Open-loop power control procedure

This clause is identical to clause 5.4 in TS 101 376-5-6 (Release 1) [7], with the following changes:

1) Step 1.1 shall be removed.

2) Step 2 shall be removed.

3) Step 3 shall be replaced with: The PAR value is extracted from RLC/MAC header of the latest burst received.

4) Step 4 shall be removed.

5) Step 5.1.1 shall be replaced with: PANbasic = decoded PAR value.

6) Step 6 shall be replaced with: Suppose the current 400 ms period as nth period, then the open loop control described in step 6 shall be performed only when the following two conditions are both met:

   a) The number of PNB received by the MES during nth 400 ms period is no less than 4.

   b) The number of PNB received by the MES during (n-n2)th 400 ms period to (n-n1)th 400 ms period is no less than 4.

7) Steps 6.1 and 6.2 shall be replaced with the following:

6.1 With the SQM'_{avg} corresponding to the current T = 400 ms period (the nth period) denoted as $SQM'_{avg,(n-1)T,nT}$, and the SQM'_{avg} corresponding to the period from (n-n2)th 400 ms period to (n-n1)th 400ms period as $SQM'_{avg,(n-n2-1)T,(n-n1)T}$, the MES shall calculate $SQM'_{avg,(n-1)T,nT}$ and $SQM'_{avg,(n-n2-1)T,(n-n1)T}$ as specified in clause 12.3.5.1.1.

6.2 Open_loop_power_deficit = $SQM'_{avg,(n-n2-1)T,(n-n1)T}$ - $SQM'_{avg,(n-1)T,nT}$.

8) In steps 6.3 and 6.4, "open_loop_step" shall be removed.

9) Step 9 shall be replaced with: This value of PAN is then coded and used to form the PUI.

12.3.6 GS output power

GS output power control is not applicable, i.e. MES is not required to send PAR to the GS.

12.3.7 Radio link measurements and accuracy requirements

The MES and the GS shall achieve the measurement accuracy in estimating SQM for PDCH(4,3) and PDCH(5,3), PDCH3(5,3), PDCH3(5,12), and PDCH3(10,3) as shown in table 12.1(a). For PDCH(1,6), PDCH3(1,6), PDCH(2,6), PDCH3(2,6), DCH(1,3), DCH(1,6), and DCH(1,8) the MES shall achieve the measurement accuracy as shown in table 12.1(b):

Table 12.1(a): SQM measurement accuracy for PDCH(4,3), PDCH(5,3), PDCH3(5,3), PDCH3(5,12), and PDCH3(10,3)

Actual E_{bt}/N_o (dB)	Standard deviation of measurement error (dB)
0	0,9
3	0,4
6	0,4
9	0,4
12	0,4

Table 12.1(b): SQM measurement accuracy for PDCH(1,6), PDCH3(1,6), PDCH(2,6), PDCH3(2,6), DCH(1,3), DCH(1,6), and DCH(1,8)

Actual E_{bt}/N_o (dB)	Standard deviation of measurement error (dB)
0	1,3
3	0,4
6	0,4
9	0,4
12	0,4

Where the measurement error of the burst j, *Ej*, is defined as:

$$Ej = True\{E_{bt}/N_o\} - SQMj.$$

The standard deviation of measurement error, STD:

$$STD = \sqrt{\frac{1}{N} \times \sum_{j=1}^{N} E_j^{\,2}} .$$

The number N of estimates used for averaging shall be any integer number greater than 2 000.

The bias of the SQM is defined as follows:

SQM Estimation Bias = *True{*E_{bt}/N_o*}- Mean{SQM}.*

The SQM estimation E_{bt}/N_o of 0 dB shall not exceed 0,6 dB for PDCH(4,3) and PDCH(5,3). For PDCH(2,6), the SQM estimation bias at E_{bt}/N_o of 0 dB shall not exceed 0,6 dB for code rate 3/5, 0,9 dB for code rate 7/10 and 1,2 dB for code rate 4/5.

12.3.8 Signal Quality Indicator Report (SQIR) and Signal Quality Standard Deviation (SQISDR) transmissions

The MES shall compute a parameter Signal Quality Indicator Report (SQIR) based on monitoring of the forward link PDCH or DCH. The SQIR indicates an average of received E_{bt}/N_o over multiple bursts. Additionally, a terminal type C MES on the downlink shall also compute a parameter SQISDR, which indicates the standard deviation of the (E_{bt}/N_o). A terminal type D MES shall use the Es/No to compute the SQIR and SQISDR. Terminal types E and above MES shall use the Es/No to compute the SQIR and SQISDR based on monitoring of either the forward PDCH link or forward DCH link. MES shall report only SQIR using DCH in-band signalling when it has a forward DCH. MES shall report the SQIR and SQISDR when the it has a forward shared packet data channel every T_{sqir}. In addition it shall also report SQIR using DCH in-band signalling if it has an uplink DCH.

When using a downlink shared packet data channel, the value of $T_{sqir,}$ is 8 seconds for a terminal type A MES. For a terminal type C, D MES the value of T_{sqir} is 4 seconds. For terminal type E and above MES, the value of T_{sqir} depends on the allocated uplink channel type and presence of voice traffic. The following summarize the different value of T_{sqir}:

- if the MES has only uplink DCH with no voice flow, the value of T_{sqir} is 4 seconds;
- if the MES has only uplink DCH with a voice flow, the value of T_{sqir} is 16 seconds;
- if the MES has uplink PDCH, the value of T_{sqir} is 4 seconds;
- if the MES has only a fixed uplink PDCH carrying voice traffic and measurement report message transmission does not fit in the existing burst with all the voice flows, the MES shall pre-empt a voice flow. The pre-empted voice flow shall be chosen in a round robin fashion among the existing flows.

For terminal type C and D, and all terminal types E and above MES using a downlink shared packet data channel, the parameters SQM_{avg} and SQM_{dev} are calculated by taking running averages over all bursts as follows:

$$SQM_{avg,n} = \beta_n \cdot SQM_n + (1-\beta_n) \cdot SQM_{avg,n-1}$$

$$SQM_{dev,n} = \sqrt{\beta_n \cdot (SQM_n - SQM_{avg,n})^2 + (1-\beta_n) \cdot SQM_{dev,n-1}^2}$$

Where n = 2,3,… denotes the index of received PNB bursts since the establishment of the TBF, and the forgetting factor β_n is given by:

$$\beta_n = \begin{cases} \frac{1}{2^{n-1}} & if \quad 1 < n \le 8 \\ \frac{1}{256} & if \quad n > 8 \end{cases}$$

and the initial SQM_{avg} and SQM_{dev} values are:

$$SQM_{avg,1} = SQM_1$$
$$SQM_{dev,1} = 0$$

Terminal types E and above MES, when using a downlink DCH, shall compute a block average of 240 ms to compute the SQM_{avg} as follows:

$$SQM_{avg,n} = \frac{1}{N}\sum_{j=1}^{N} SQM_j$$

The MES encodes the average SQM, SQM_{avg}, to an SQIR value. The specification for encoding is shown in table 12.2. The encoded SQIR values are converted into 6-bit wise binary format and transmitted to the GS.

Table 12.2: SQIR encoding

Terminal Type A and C	**Terminal Types D**	**Terminal Types E and above**	
SQM (dB)	**SQM (dB)**	**SQM (dB)**	**Code value of SQIR**
SQM_{avg} < 0,5	SQM_{avg} < 0,5	SQM_{avg} < -3,5	0
0,5 ≤ SQM_{avg} < 0,7	0,5 ≤ SQM_{avg} < 0,9	-3,5 ≤ SQM_{avg} < -3,1	1
0,7 ≤ SQM_{avg} < 0,9	0,9 ≤ SQM_{avg} < 1,3	-3,1 ≤ SQM_{avg} < -2,7	2
0,9 ≤ SQM_{avg} < 1,1	1,3 ≤ SQM_{avg} < 1,7	-2,7 ≤ SQM_{avg} < -2,3	3
1,1 ≤ SQM_{avg} < 1,3	1,7 ≤ SQM_{avg} < 2,1	-2,3 ≤ SQM_{avg} < -1,9	4
1,3 ≤ SQM_{avg} < 1,5	2,1 ≤ SQM_{avg} < 2,5	-1.9 ≤ SQM_{avg} < -1,5	5
1,5 ≤ SQM_{avg} < 1,7	2,5 ≤ SQM_{avg} < 2,9	-1,5 ≤ SQM_{avg} < -1,1	6
…….	…….	…….	
11,7 ≤ SQM_{avg} < 11,9	22,9 ≤ SQM_{avg} < 23,3	18,9 ≤ SQM_{avg} < 19,3	57
11,9 ≤ SQM_{avg} < 12,1	23,3 ≤ SQM_{avg} < 23,7	19,3 ≤ SQM_{avg} < 19,7	58
12,1 ≤ SQM_{avg} < 12,3	23,7 ≤ SQM_{avg} < 24,1	19,7 ≤ SQM_{avg} < 20,1	59
12,3 ≤ SQM_{avg} < 12,5	24,1 ≤ SQM_{avg} < 24,5	20,1 ≤ SQM_{avg} < 20,5	60
12,5 ≤ SQM_{avg}	24,5 ≤ SQM_{avg}	20,5 ≤ SQM_{avg}	61
Reserved	Reserved	Reserved	62
No Meaningful Value	No Meaningful Value	No Meaningful Value	63

The parameter SQISDR is obtained after a six-bit quantization of SQM_{dev}, the unquantized standard deviation measure. The specification of the encoding is shown in table 12.3.

Table 12.3: SQISDR encoding

SQM deviation, SQMdev, (dB)	**Code value**
SQM_{dev} < 0,1	0
0,1 ≤ SQM_{dev} < 0,2	1
0,2 ≤ SQM_{dev} < 0,3	2
0,3 ≤ SQM_{dev} < 0,4	3
0,4 ≤ SQM_{dev} < 0,5	4
0,5 ≤ SQM_{dev} < 0,6	5
0,6 ≤ SQM_{dev} < 0,7	6
…….	
5,7 ≤ SQM_{dev} < 5,8	57
5,8 ≤ SQM_{dev} < 5,9	58
5,9 ≤ SQM_{dev} < 6,0	59
6,0 ≤ SQM_{dev} < 6,1	60
6,1 ≤ SQM_{dev}	61
Reserved	62
No Meaningful Value	63

The network shall use a SQIR received from the MES for link adaptation except when the SQIR is within the Link Quality Report message. When a SQIR is received within a Link Quality Report message, the network shall use the SQIR for link performance monitoring only. The requirements relating to the transmission of link performance monitoring SQIRs are described in clause 12.4.

The duration between the transmission by the MES of any two messages containing valid link adaptation SQIR, or SQIR and SQISDR shall be T_{sqir} seconds during a forward TBF. The MES shall transmit a valid link adaptation SQIR at forward TBF release regardless of the duration since the last valid link adaptation SQIR transmission.

A SQIR or SQISDR value of 63 indicates that no meaningful link adaptation SQIR or SQISDR value is present. The MES shall send this value when transmitting a message during a forward TBF in which the link adaptation SQIR or SQISDR information element is mandatory but the duration since the previous transmission of a link adaptation SQIR or SQISDR is less than T_{sqir} seconds.

Refer to TS 101 376-4-12 [8] for the mechanism by which the MES conveys the parameters SQIR and SQISDR to the network.

12.3.8a Forward Quality Indicator (FQI) transmissions

MES types E and above shall compute a parameter Forward Quality Indicator (FQI) based on monitoring of the forward link PDCH or DCH. In the case of a forward shared packet data channel, the 6 bit FQI would represent the FER measured at the MES over some time duration, T_{FQI}. If the MES has a return shared packet data channel, the value of T_{FQI} is 4 seconds and reporting shall be done on shared packet data channel using Packet Uplink Dummy Control Block or Packet Link Quality Report Type 2. If the MES has uplink DCH channel only and does not have voice traffic, the value of T_{FQI} is 4 seconds. If the MES has uplink DCH channel only carrying voice traffic, the value of T_{FQI} is 16 seconds. The MES shall report FQI on Packet Downlink ACK/NACK or Packet Control Acknowledgment if the MES is polled for any of these messages and 4 seconds have elapsed since the last report regardless of uplink channel type. The MES starts a new measurement period after every report. Refer to TS 101 376-4-12 [8] for details on the MAC control messages.

The measured FER is mapped into the 6 bit word as shown in the table 12.4.

Table 12.4: FQI encoding

FER	Code value	FER	Code value
FER ≥ 9E-1	0	3E-3 ≤ FER < 4E-3	24
8E-1 ≤ FER < 9E-1	1	2E-3 ≤ FER < 3E-3	25
7E-1 ≤ FER < 8E-1	2	1E-3 ≤ FER < 2E-3	26
6E-1 ≤ FER < 7E-1	3	9E-4 ≤ FER < 1E-3	27
5E-1 ≤ FER < 6E-1	4	8E-4 ≤ FER < 9E-4	28
4E-1 ≤ FER < 5E-1	5	7E-4 ≤ FER < 8E-4	29
3E-1 ≤ FER < 4E-1	6	6E-4 ≤ FER < 7E-4	30
2E-1 ≤ FER < 3E-1	7	5E-4 ≤ FER < 6E-4	31
1E-1 ≤ FER < 2E-1	8	4E-4 ≤ FER < 5E-4	32
9E-2 ≤ FER < 1E-1	9	3E-4 ≤ FER < 4E-4	33
8E-2 ≤ FER < 9E-2	10	2E-4 ≤ FER < 3E-4	34
7E-2 ≤ FER < 8E-2	11	1E-4 ≤ FER < 2E-4	35
6E-2 ≤ FER < 7E-2	12	9E-5 ≤ FER < 1E-4	36
5E-2 ≤ FER < 6E-2	13	8E-5 ≤ FER < 9E-5	37
4E-2 ≤ FER < 5E-2	14	7E-5 ≤ FER < 8E-5	38
3E-2 ≤ FER < 4E-2	15	6E-5 ≤ FER < 7E-5	39
2E-2 ≤ FER < 3E-2	16	5E-5 ≤ FER < 6E-5	40
1E-2 ≤ FER < 2E-2	17	4E-5 ≤ FER < 5E-5	41
9E-3 ≤ FER < 1E-2	18	3E-5 ≤ FER < 4E-5	42
8E-3 ≤ FER < 9E-3	19	2E-5 ≤ FER < 3E-5	43
7E-3 ≤ FER < 8E-3	20	1E-5 ≤ FER < 2E-5	44
6E-3 ≤ FER < 7E-3	21	FER < 1E-5	45
5E-3 ≤ FER < 6E-3	22	Reserved	46 to 62
4E-3 ≤ FER < 5E-3	23	No Meaningful Value	63

In the case of forward DCH, the one bit FQI would represent the CRC pass or fail status of the forward burst received at the MES.

12.3.9 Code rate adaptation

The physical layer supports multiple coding rates and multiple transmission rates to provide a means to adapt the data transfer rate according to the radio link condition. Refer to TS 101 376-5-3 [4] for coding schemes available.

12.3.9.1 Terminal type A

The code rate to be used by the MES for the return link is determined by the GS and is made available to the MES upon TBF initialization in either AGCH, PAGCH or PACCH as specified in TS 101 376-4-8 [3] and TS 101 376-4-12 [8]. The MES shall apply this code rate for the TBF associated with the initialization and the code rate shall not be changed during the TBF transmission.

The code rate for each forward link burst received by the MES is specified in the PUI of the received burst according to TS 101 376-5-3 [4]. The MES shall decode the payload portion of the burst using this code rate. The code rate of the forward link shall not be changed during the TBF transmission.

In case a MES sends PNB bursts on return link direction without establishing a return link TBF, the code rate of the corresponding burst shall be r = 1/2.

12.3.9.2 Terminal type C

The code rate to be used by the MES for the return link is determined by the GS and is made available to the MES upon TBF initialization in either AGCH, PAGCH or PACCH as specified in TS 101 376-4-8 [3] and TS 101 376-4-12 [8]. The MES shall apply this code rate for the TBF associated with the initialization. The code rate may be changed during the TBF transmission.

When the MES applies the new code rate in response to the code rate change message received during a TBF to its transmit burst, the MES shall use the latest PAR value and shall not use any PAR value received prior to the reception of the code rate change message. See clause 12.5 for PAR response time.

MES's code rate change response time during a TBF shall be the same as the T_{RESP-2} (refer to TS 101 376-5-7 [6] for definition of T_{RESP-2}).

The code rate for each forward link burst received by the MES is specified in the PUI of the received burst according to TS 101 376-5-3 [4]. The MES shall decode the payload portion of the burst using this code rate. The code rate of the forward link may be changed during the TBF transmission.

In case a MES sends PNB bursts on return link direction without establishing a return link TBF, the code rate of the corresponding burst shall be r = 3/5.

12.3.9.3 Terminal type D

The code rate and modulation to be used by the MES for the return link is determined by the GS and is made available to the MES upon TBF initialization in either AGCH, PAGCH or PACCH as specified in TS 101 376-4-8 [3] and TS 101 376-4-12 [8]. The MES shall apply this code rate and modulation for the TBF associated with the initialization. The code rate and modulation may be changed during the TBF transmission.

When the MES applies the new code rate in response to the code rate change message received during a TBF to its transmit burst, the MES shall use the latest PAR value and shall not use any PAR value received prior to the reception of the code rate change message. See clause 12.5 for PAR response time.

When the MES applies the new modulation in response to the modulation change message received during a TBF to its transmit burst, the MES shall use the latest PAR value and shall not use any PAR value received prior to the reception of the modulation change message. See clause 12.5 for PAR response time.

MES's code rate and modulation change response time during a TBF shall be the same as the T_{RESP-1} (refer to TS 101 376-5-7 [6] for definition of T_{RESP-1}).

The code rate and modulation for each forward link burst received by the MES is specified in the PUI of the received burst according to TS 101 376-5-3 [4]. The MES shall decode the payload portion of the burst using this code rate and modulation. The code rate and modulation of the forward link may be changed during the TBF transmission.

In case a MES sends PNB bursts on return link direction without establishing a return link TBF, the modulation and code rate for the burst shall correspond to QPSK Rate ½ or an MCS value of $(0011)_{binary}$ (refer to TS 101 376-4-12 [8] for the MCS definition).

12.3.9.4 Terminal type E and above

The code rate and modulation to be used by the MES for the return link is determined by the GS and is made available to the MES upon TBF initialization in either AGCH, PAGCH or PACCH as specified in TS 101 376-4-8 [3] and TS 101 376-4-12 [8]. The MES shall apply this code rate and modulation for the TBF associated with the initialization. The code rate and modulation may be changed during the TBF transmission.

When the MES applies the new code rate in response to the code rate change message received during a TBF to its transmit burst, the MES shall use the latest PAR value and shall not use any PAR value received prior to the reception of the code rate change message. See clause 12.5 for PAR response time.

When the MES applies the new modulation in response to the modulation change message received during a TBF to its transmit burst, the MES shall use the latest PAR value and shall not use any PAR value received prior to the reception of the modulation change message. See clause 12.5 for PAR response time.

MES's code rate and modulation change response time during a TBF shall be the same as the T_{RESP-1} and T_{RESP-2} (refer to TS 101 376-5-7 [6] for definition of $T_{RESP-1}$and T_{RESP-2}).

The code rate and modulation for each forward link burst received by the MES is specified in the PUI of the received burst according to TS 101 376-5-3 [4]. The MES shall decode the payload portion of the burst using this code rate and modulation. The code rate and modulation of the forward link may be changed during the TBF transmission.

In case a MES sends PNB bursts on return link direction without establishing a return link TBF, the modulation and code rate for the burst shall correspond to the most robust MCS scheme.

12.4 UT Link Quality Report (UTLQR) handling

The MES shall report UTLQR to the GS as described in TS 101 376-4-12 [8]. The Packet Link Quality Report message is described in TS 101 376-4-12 [8].

When a MES inserts a SQIR value for UTLQR, it shall use the present SQM_{avg} value in the running averaging filter in the MES. Also, the MES shall include the present TX EIRP value of the corresponding burst in the UTLQR.

The MES shall transmit the Packet Link Quality Report message with the duration described in TS 101 376-4-12 [8].

12.5 Timing for the power level adjustment

MES's PAR response time shall be the same as the T_{RESP-1} or T_{RESP-2} depending on channel type (refer to TS 101 376-5-7 [6] for definitions of T_{RESP-1} and T_{RESP-2}). The PAR response time is defined as the time between the end of the downlink burst containing the PAR and the time at which the PAR is applied to the uplink burst ready for transmission.

13 Idle Mode Tasks with FCCH3

13.1 Introduction

While in idle mode, an MES shall implement the spot beam selection and reselection procedures described in TS 101 376-3-10 [2], TS 101 376-4-8 [3], and TS 101 376-5-5 [5]. These procedures make use of measurements and procedures described in this clause.

This clause makes use of terms defined in TS 101 376-3-10 [2].

These procedures ensure that the MES is camped on a spot beam:

- from which it can reliably decode downlink data and with which it has a high probability of communications on the return link; and
- that is the optimum or close to optimum beam for communication.

The MES shall not make use of the discontinuous reception (DRX) mode of operation (i.e. powering itself down between reception of paging messages from the network) during the spot beam selection defined in TS 101 376-3-10 [2]. Use of the DRX is permitted at all other times in idle mode.

For the purposes of spot beam selection and reselection, the MES shall be capable of detecting and synchronizing to a BCCH carrier and reading the BCCH data at reference sensitivity and reference interference levels as specified in TS 101 376-5-5 [5].

For the purposes of spot beam selection and reselection, the MES is required to obtain an average of the received signal strength for all the monitored frequencies.

The times shown throughout clause 13 refer to internal processes in the MES that are required to ensure that the MES camps as quickly as possible on the most appropriate spot beam signal.

The tolerance on all the timing requirements in this clause is ±10 %.

13.2 Measurements for stored list spot beam selection

The MES shall store BCCH_FULL_LIST(s) when switched off as detailed in TS 101 376-3-10 [2].

A BCCH_FULL_LIST contains the carrier number for at least one BCCH carrier in every spot beam of GMR-1 3G system. There may multiple satellites in each GMR-1 3G system but there is only one BCCH_FULL_LIST per GMR-1 3G system. The MES may have more than one BCCH_FULL_LIST.

The MES shall search for the frequency control channel (FCCH3) to acquire frequency and timing synchronization. To minimize camp-on time, the MES may first scan BCCH_FULL_LISTs, if available. The MES should order its scan of stored lists by PLMN priority order specified in TS 101 376-3-10 [2]. The MES may also scan stored carriers (that might or might not be in a BCCH_FULL_LIST) in an implementation dependent manner to accelerate spot beam selection.

13.3 All LMSS band carrier spot beam search

It may be necessary to scan all potential BCCH carriers. (See TS 101 376-3-10 [2]).

The MES may measure the carriers in any order. The search process shall ensure that the carrier measurements continue through all candidates prior to retrying previously failed measurements.

If the MES finds a BCCH carrier, it shall attempt to read System Information and scan the BCCH_FULL_LIST, if it has not already done so, as described in the previous clause. It should then perform spot beam selection, before resuming the full LMSS band scan. When resuming the full LMSS band scan, the MES shall measure carriers in a sequence that ensures that all carriers are eventually observed. For example, the search should not restart from the same carrier as previous searches.

13.4 Criteria for Spot Beam Selection and Reselection

The network shall synchronize the FCCH3 and the BCCH transmissions in neighbouring spot beams so that they are orthogonal in time. (They do not overlap, and allow time for synthesizer tuning. See TS 101 376-5-5 [5]). The MES shall be able to schedule measurements for at least six neighbouring BCCH broadcasts so that they can be measured concurrently with the selected BCCH broadcast. An example is shown in figure 13.1.

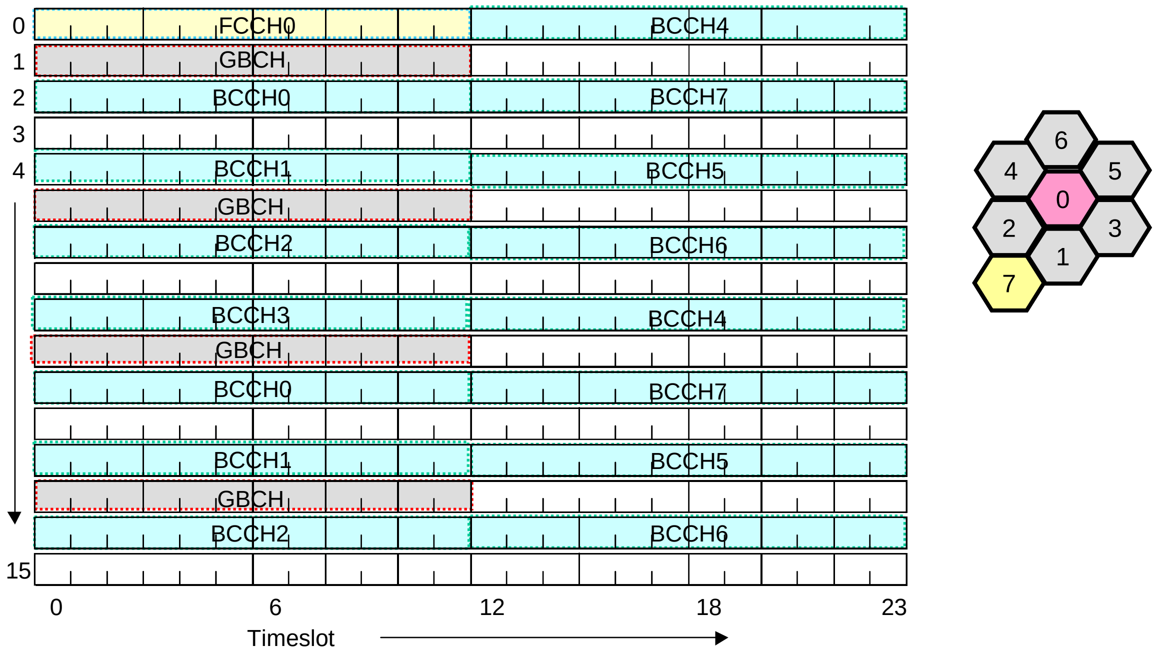

Figure 13.1: Scheduled FCCH3 and BCCH measurements for neighbouring spot

The CICH shall not be broadcast and shall not be used by the terminal.

TS 101 376-3-10 [2] defines the MES idle mode procedures and the processes that trigger idle mode spot beam selection/re-selection.

Idle mode spot beam selection is based on a series of physical measurements performed by the MES, in combination with logical considerations described in 43.022. As power resources and margins are critical in a satellite environment, spot beam selection is important to ensuring that an MES can determine the physical beam or beams that provide the best radio coverage of the MES location. That is, spot beam selection will only allow determination of the satellite coverage beam that is optimal, or close to optimal, from a signal quality perspective.

The physical measurements described here lead to determination of a set of Broadcast Control Channels (BCCHs) that are suitable for consideration for camping - the "suitable list".

13.4.1 MES Capabilities and Operating Environment

A GMR-1 3G MES may contain a GPS receiver allowing for MES GPS position determination (with the performance defined in TS 101 376-5-5 [5]). The GS shall provide system information broadcasts that permit quick GPS position acquisition (see TS 101 376-4-8 [3]) and that allow GPS position to be used in spot beam selection.

If an MES supports GPS position determination, then that MES shall perform spot beam selection based on GPS position where conditions permit GPS position to be obtained. Position-Based Spot Beam Selection is described in clause 13.4.2.

If an MES does not support GPS position determination, or if conditions do not allow a GPS-equipped MES to derive GPS position (e.g. due to shadowing of GPS satellites), then the MES shall perform spot beam selection based on power measurements of Broadcast Control Channels. Power-Based Spot Beam Selection is described in clause 13.4.3.

13.4.2 Position-Based Spot Beam Selection

Each physical satellite spot beam shall be defined in terms of a beam centre and up to six beam vertices. The combination of beam centre and vertices, specified in latitude, longitude coordinates, constitute the Beam Definition. The Beam Definition associated with a given spot beam shall be broadcast by the GS as part of that beam's BCCH system information, as described in TS 101 376-4-8 [3].

An MES shall maintain a record of Beam Definitions. This record may be initialized prior to operation of the MES, and the record shall be updated as the MES reads spot beam BCCH system information during operation. The capability for recording this information should exceed 100 Beam Definitions.

When beginning a new position-based selection process, the MES shall check whether the GPS position lies within any of the recorded Beam Definitions. If the GPS position does lie within one or more beam definitions, then the MES should use one of the related beams as the basis for building the suitable list. If more than one beam covers the MES's location, then the MES may select the Beam Definition to use based on algorithms that consider the age of the information and the terminal's proximity to each candidate beam's centre.

Neighbouring Spot Beams are almost equivalent in terms of their support for physical performance in areas close to the beam boundaries. For example, a terminal that happens to be close to a beam vertex could achieve satisfactory performance from any of three Spot Beams.

A single parameter, SB_SELECTION_DISTANCE in each beam (see TS 101 376-4-8 [3]) defines the suitability of neighbouring beams in terms of location. Note that a similar parameter (SB_SELECTION_POWER) is applied for the same purpose during power-based selection.

Figure 13.2 illustrates how SB_SELECTION_DISTANCE defines a region within a Candidate Spot Beam in which the associated neighbour would be considered suitable. Note that the "region of suitability" has six vertices.

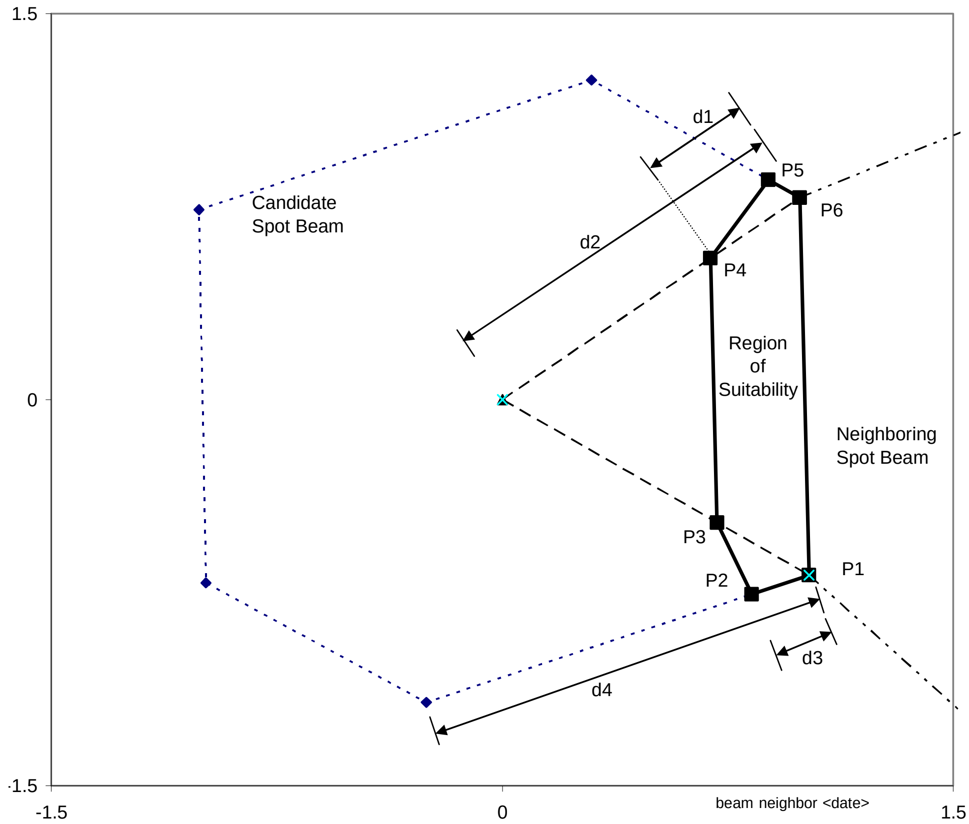

Figure 13.2: Illustration of "region of suitability"

The region of suitability for the identified Neighbouring Spot Beam is defined by the following vertices (P1 through P6), which should be calculated with resolution of less than 0,01 degrees:

- P1 and P6 are the vertices of the candidate Spot Beam.
- P3 and P4 are defined as being on the lines between the vertices of the candidate Spot Beam and the centre of the candidate Spot Beam. The distance along those lines from the vertices is defined by SB_SELECTION_DISTANCE. That is, SB_SELECTION_DISTANCE = d1/d2 where d1 and d2 are as measured in the figure. For example, if the value of SB_SELECTION_DISTANCE is set to 3 [11 binary] (see TS 101 376-4-8 [3]), then P3 and P4 will be 30 % of the distance from the vertices to the centre. That is, d1/d2 in the figure is 30 %.
- P2 and P5 are defined as being on the adjacent edges of the candidate Spot Beam. The distance from the vertex (P1) shared with the neighbour to P2, say, is defined as half of the percentage defined by SB_SELECTION_DISTANCE on the line to the next vertex of the candidate Spot Beam. That is, 0,5*SB_SELECTION_DISTANCE= d3/d4 where d3 and d4 are as measured in the figure. That is, d3/d4 for the example in the figure would be 15 %.

13.4.3 Power-Based Spot Beam Selection

A satellite generates Spot Beam antenna patterns that consist of main lobes directed at some area on the ground, and side lobes outside that area. Main lobes are defined as areas over which the flux density is monotonically decreasing from the peak. Side lobes could have local flux density maxima.

At a specific MES's location in the coverage of a satellite, some flux density will be present from every Spot Beam broadcast. Several Spot Beams may cover the MES's location with their main lobes. The objective of Power-Based selection is to find the Spot Beam that covers the MES location with the highest flux density.

NOTE: The area over which the Spot Beam antenna pattern generates the highest flux density should coincide with the related Beam Definition.

An MES should maintain a record of channel identifiers (ARFCN's) corresponding to BCCH carriers on which it has recently camped, or are otherwise likely to lead to successful camping.

An MES should attempt to acquire FCCH3 signals from the recorded list with the objective of identifying a BCCH of reasonable strength. Once such a BCCH has been identified, the MES should execute the "hill-climbing" process described below (Spot Beam BCCH Power Comparison) to find the BCCH with the maximum signal strength.

If the MES identifies a BCCH with maximum flux density, but the search that led to that determination did not consider all possible ARFCN's, then the "C1" criterion (see "BCCH Flux Density Criterion" below) shall be applied. The purpose of this check is to ensure that the selected BCCH originates in a main lobe of the antenna pattern.

If a BCCH meets the C1 criterion, and BCCH's originating in neighbouring beams have relative power within SB_SELECTION_POWER, then both the observed BCCH and those neighbouring BCCH's are eligible for entry to the suitable list. The neighbouring BCCH's need not be checked for compliance to the C1 criteria.

An MES should search through a sequence of likely ARFCN's as described. In addition, an MES may apply supplementary search strategies, with the goal of finding suitable BCCH's. If the MES identifies one or more compliant BCCHs, then the MES should use them as the basis for building the suitable list.

13.4.3.1 Spot Beam BCCH Power Comparison

Given a candidate BCCH, a terminal will follow a "hill-climbing" strategy to move (if necessary) to a BCCH from the Spot Beam with the highest flux density.

NOTE: The term "candidate" spot beam is used to refer to the centre beam of clusters of (up to) 7 beams that are being compared.

The hill-climbing strategy begins by comparing the candidate BCCH's power with the power of its (up to) six neighbours. If a neighbouring spot beam is observed to have higher power, then the hill-climbing process will move on to the cluster cantered on the higher-powered neighbour BCCH. This process continues until the candidate BCCH is also the highest powered BCCH.

More specifically, after selecting a candidate spot beam the MES shall schedule relative RSSI measurements of the candidate BCCH and the BCCHs in the BCCH_NEIGHBOUR_LIST of the candidate spot beam. These measurements (in dB units) shall be averaged, and shall be used to rank order the power in neighbouring BCCHs.

Estimates of Power and Signal-to-Noise Ratio within bursts are provided by RSSI and SQI calculations (described in annex A of TS 101 376-5-6 (Release 1) [7]).

The algorithm used for power comparison shall be:

i) Measure consecutively the BCCH relative power (dB) of beam 1, 2, …, 7 at measurement iteration j as $RSSI_1^j, RSSI_2^j, ..., RSSI_7^j$. Repeat for j = 1 to k. (k shall have a value of 15.)

ii) Calculate the mean power, m_i for beam *i*, in dB for the k measurement cycles as:

$$m_i = \frac{1}{k}\sum_{j=1}^{k} RSSI_i^j$$

iii) If the strongest spot beam is not the candidate spot beam and was not a previous candidate, go back to step (i) with the strongest spot beam as the candidate spot beam.

iv) Otherwise, select that spot beam and all the spot beams that are within SB_SELECTION_POWER dB of the strongest spot beam, provided that C1 is met for the candidate spot beam. If SB_SELECTION_POWER is configured to a value of 0, then only the strongest spot beam shall be selected.

If multiple spot beams meet these selection criteria, the MES shall select among them according to the rules in TS 101 376-3-10 [2]. If spot beam(s) contain more than one BCCH carrier, the MES shall select among the BCCH carriers according to the rules in TS 101 376-3-10 [2].

13.4.3.2 BCCH Flux Density Criterion (C1)

In the side lobe of a satellite's BCCH transmission, the flux density cannot exceed a determinable level. The C1 criterion is applied by MES's to ensure that the flux density exceeds the determined maximum level that could be seen in a side lobe. Compliance to the C1 criterion ensures that the terminal is in a main lobe of a spot beam, and thus that the hill-climbing strategy described in clause 13.4.3.1 will find the global maximum. Given the thermal noise resulting from a terminal's G/T, the C1 criterion can be defined as a threshold in the perceived Signal-to-Noise Ratio (SNR).

The flux densities in side lobes can vary as a function of satellite performance and choices in operation of a system (e.g. the number of beams generated in a satellite's coverage). Therefore, a controlling parameter (RXLEV_SELECT_MIN) is provided via System Information to vary the threshold level used for the C1 criterion. The threshold value of Es/No (dB) is defined by this parameter as (21,0-0,5*RXLEV_SELECT_MIN) dB.

Specified G/T differs according to terminal type. RXLEV_SELECT_MIN is defined for the case of a terminal with a specified reference G/T of -24 dB/K. Terminals shall modify the SNR threshold corresponding to C1 based on their specified G/T.

The following example illustrates the implementation of the C1 criterion:

- Assume RXLEV_SELECT_MIN is set to define a threshold of 12 dB in Es/No. (RXLEV_SELECT_MIN = 0010010 [binary] = 18 [decimal], so the threshold is 21,0-(18*0,5) = 12,0 dB).
- Assume the terminal G/T = -18 dB/K, i.e. 6 dB more sensitive than the reference baseline (-24 dB/K).
- The threshold in Es/No shall be 12 dB + 6 dB = 18 dB.

For terminals with Terminal Type Identifier 0x38 and below, the value of RXLEV_SELECT_MIN shall be set by a 5 bit parameter (see TS 101 376-4-8 [3]). For all other terminals, the value shall be set by appending 2 most significant bits (defined by RXLEV_SELECT_MIN_msbs) to the 5-bit RXLEV_SELECT_MIN value, yielding a 7-bit value.

The Signal Quality Indicator (SQI) (defined in annex A of TS 101 376-5-6 (Release 1) [7] provides an estimate of Es/No [dB]). The C1 criterion shall be applied to the average value of SQI measured during the relative RSSI measurements described in clause 13.4.3.1. The following equation shall be applied to generate the average SQI during the comparison of signal strength.

NOTE: The value of SQI_av is only needed for the candidate BCCH (identified by the sub-script i) (not the neighbours).

$$SQI\_av_i = \frac{1}{k}\sum_{j=1}^{k} SQI_i^j$$

13.5 Minimum Signal Strength for Transmission Via the RACH3

The MES shall only transmit RACH3 bursts if either:

- the estimated frame error rate on the BCCH3, the PCH3, the AGCH3 bursts is less than 1 %; or
- the system access is designated as "emergency".

13.6 Spot beam reselection

The MES shall perform spot beam reselection at least every SB_RESELECTION_TIMER seconds to ensure that the serving spot beam is acceptable. If the MES moves to alerting mode from paging mode, it shall continue to update the SB_RESELECTION_TIMER counter. If the MES reverts back to the paging mode from the alerting mode, and if the SB_RESELECTION_TIMER counter is expired, it shall immediately perform the spot beam reselection. The MES shall also perform the spot beam reselection immediately after returning to paging mode from the dedicated mode, if the timer has expired.

Spot beam reselection consists of the following steps:

1) The MES shall perform the procedure described in clause 13.4, using either the position-based or power-based algorithms. If the algorithm determines that the MES is now in another beam then reselection may proceed.

2) Depending on the algorithm applied:

   - Power-Based: If the MES is not camped on a BCCH carrier of the strongest spot beam, the MES shall then check whether the calculated value of the RSSI of the nonserving spot beam exceeds the value of the RSSI for the serving spot beam by at least SB_RESELECT_HYSTERESIS dB. If this condition is satisfied, the MES then selects as "suitable" the spot beam within the highest RSSI value as well as the spot beams that are within SB_SELECTION_POWER dB of the strongest spot beam.

   - Position-Based: If the MES is located outside a spot beam matching the broadcast (SI) beam definition, then the MES shall perform beam reselection using the neighbouring beam with a beam definition within which its position lies.

3) Spot beam selection among multiple beams, and BCCH selection among multiple BCCH carriers, is performed according to TS 101 376-3-10 [2].

13.7 BCCH read operation

The MES shall decode the full BCCH data immediately after final selection of a BCCH after power on or after a change of selected BCCH. The MES shall attempt to decode the new BCCH data of the selected BCCH at least every 30 seconds in paging mode and immediately after returning to paging mode from alerting mode. New BCCH data shall consist of Class I system information and all other system information classes which have changed since the last time the MES read them (see TS 101 376-4-8 [3]).

13.8 Abnormal cases and emergency calls

When in the limited service state, as defined in TS 101 376-3-10 [2], the aim is to gain normal service rapidly, and the following tasks shall be performed, depending on the conditions, as given in the table below.

a) The MES shall conduct an All LMSS Band Spot Beam Search. When a suitable carrier is found, the MES shall camp on that spot beam, irrespective of the PLMN identity.

b) The MES shall monitor the signal strength of all RF channels in its BCCH_FULL_LISTs. The information associated with BCCHs that can be read shall be processed according to the PLMN selection algorithm defined in TS 101 376-3-10 [2].

c) The MES shall perform spot beam reselection to find the spotbeam that provides the best radio coverage. A zero value SB_SELECTION_DISTANCE shall be used for the case of position-based beam selection, and a zero value SB_SELECTION_POWER and a small but non-zero value of SB_RESELECT_HYSTERESIS shall be used for the case of power-based beam selection.

In this limited service state, only emergency system access may be initiated. Powering down of the MES is permitted.

Table 13.1: Schedule of tasks for emergency and abnormal calls

Condition			**Tasks To Be Performed as a Minimum:**		
SIM Present (see note 1)	**Other**	**MES camped on a spotbeam**	**a)**	**b)**	**c)**
X	In Manual PLMN selection mode only	No	Yes	No	No
No	X	Yes	No	No	Yes
Yes	"IMSI Unknown", illegal MES	Yes	No	No	Yes
Yes	No suitable spot beam of selected PLMN or "PLMN not allowed"	Yes	No	Yes	(see note 2)
NOTE 1: X ="Don't care" state. NOTE 2: Perform normal reselection.					

In GMR-1 3G mode, if the terminal has a GPS receiver and can acquire GPS position, it shall use this position to determine the correct spot beam.

Annex A (informative): Pseudocode for power control

Same as annex A in TS 101 376-5-6 (Release 1) [7].

Annex B (informative): Per-burst SQI estimation

Same as annex B in TS 101 376-5-6 (Release 1) [7].

Annex C (informative): Position determination at the MES

Same as annex C in TS 101 376-5-6 (Release 1) [7].

Annex D (informative): Bibliography

GMR-1 04.006 (ETSI TS 101 376-4-6): "GEO-Mobile Radio Interface Specifications; Part 4: Radio interface protocol specifications; Sub-part 6: Mobile earth Station-Gateway Station Interface Data Link Layer Specifications".

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

GMR-1 04.022 (ETSI TS 101 376-4-11): "GEO-Mobile Radio Interface Specifications; Part 4: Radio interface protocol specifications; Sub-part 11: Radio Link Protocol (RLP) for Data Services".

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

GMR-1 3G 45.002 (ETSI TS 101 376-5-2): "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 2: Multiplexing and Multiple Access; Stage 2 Service Description".

GMR-1 06.012: (ETSI TS 101 376-6-4): "GEO-Mobile Radio Interface Specifications; Part 6: Speech coding specifications; Sub-part 4: Vocoder: Comfort Noise Aspects".

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

GMR-1 06.031: (ETSI TS 101 376-6-5): "GEO-Mobile Radio Interface Specifications; Part 6: Speech coding specifications; Sub-part 5: Vocoder: Discontinuous Transmission (DTX)".

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

GMR-1 06.032: (ETSI TS 101 376-6-6): "GEO-Mobile Radio Interface Specifications; Part 6: Speech coding specifications; Sub-part 6: Vocoder: Voice Activity Detection (VAD)".

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

History

Document history		
V3.1.1	July 2009	Publication
V3.2.1	February 2011	Publication
V3.3.1	December 2012	Publication