EUROPEAN TELECOMMUNICATION STANDARD

ETS 300 911

June 1998

Fourth Edition

Source: SMG

Reference: RE/SMG-020508QR4

ICS: 33.020

Key words: Digital cellular telecommunications system, Global System for Mobile communications (GSM)

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

Digital cellular telecommunications system (Phase 2+); Radio subsystem link control (GSM 05.08 version 5.6.1)

ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: F-06921 Sophia Antipolis CEDEX - FRANCE
Office address: 650 Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE
Internet: secretariat@etsi.fr - http://www.etsi.fr - http://www.etsi.org

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

Contents

Foreword

This European Telecommunication Standard (ETS) has been produced by the Special Mobile Group (SMG) of the European Telecommunications Standards Institute (ETSI).

This ETS specifies the Radio sub-system link control implemented in the Mobile Station (MS), Base Station System (BSS) and Mobile Switching Centre (MSC) of the digital mobile cellular and personal communication systems operating in the 900 MHz and 1 800 MHz band (GSM 900 and DCS 1 800).

The contents of this ETS is subject to continuing work within SMG and may change following formal SMG approval. Should SMG modify the contents of this ETS, it will be resubmitted for OAP by ETSI with an identifying change of release date and an increase in version number as follows:

Version 5.x.y

where:

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

Transposition dates	
Date of adoption of this ETS:	5 June 1998
Date of latest announcement of this ETS (doa):	30 September 1998
Date of latest publication of new National Standard or endorsement of this ETS (dop/e):	31 March 1999
Date of withdrawal of any conflicting National Standard (dow):	31 March 1999

Blank page

1 Scope

This European Telecommunication Standard (ETS) specifies the Radio sub-system link control implemented in the Mobile Station (MS), Base Station System (BSS) and Mobile Switching Centre (MSC) of the GSM and DCS 1 800 systems.

Unless otherwise specified, references to GSM also include DCS 1 800.

1.1 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

[1] GSM 01.04 (ETR 350): "Digital cellular telecommunications system (Phase 2+); Abbreviations and acronyms".

[2] GSM 03.03 (ETS 300 927): "Digital cellular telecommunications system (Phase 2+); Numbering, addressing and identification".

[3] GSM 03.09: "Digital cellular telecommunications system (Phase 2+); Handover procedures".

[4] GSM 03.22 (ETS 300 930): "Digital cellular telecommunications system (Phase 2+); Functions related to Mobile Station (MS) in idle mode and group receive mode".

[5] GSM 04.04 (ETS 300 936): "Digital cellular telecommunications system; Layer 1; General requirements".

[6] GSM 04.06 (ETS 300 938): "Digital cellular telecommunications system (Phase 2+); Mobile Station - Base Station System (MS - BSS) interface; Data Link (DL) layer specification".

[7] GSM 04.08 (ETS 300 940): "Digital cellular telecommunications system (Phase 2+); Mobile radio interface layer 3 specification".

[8] GSM 05.02 (ETS 300 908): "Digital cellular telecommunications system (Phase 2+); Multiplexing and multiple access on the radio path".

[9] GSM 05.05 (ETS 300 910): "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception".

[10] GSM 05.10 (ETS 300 912): "Digital cellular telecommunications system (Phase 2+); Radio subsystem synchronization".

[11] GSM 06.11 (ETS 300 962): "Digital cellular telecommunications system; Full rate speech; Substitution and muting of lost frames for full rate speech channels".

[12] GSM 08.08: "Digital cellular telecommunications system (Phase 2+); Mobile-services Switching Centre - Base Station System (MSC - BSS) interface, Layer 3 specification".

[13] GSM 08.58: "Digital cellular telecommunications system (Phase 2+); Base Station Controller - Base Transceiver Station (BSC - BTS) interface; Layer 3 specification".

[14] GSM 11.10 (ETS 300 607): "Digital cellular telecommunications system (Phase 2+); Mobile Station (MS) conformity specification".

[15] GSM 03.64: "Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Overall description of the GPRS Radio Interface; Stage 2".

1.2 Abbreviations

Abbreviations used in this ETS are listed in GSM 01.04.

2 General

The radio sub-system link control aspects that are addressed are as follows:

- Handover;
- RF Power control;
- Radio link Failure;
- Cell selection and re-selection in Idle mode, and in Group Receive mode.

Handover is required to maintain a call in progress as a MS engaged in a point-to-point call or with access to the uplink of a channel used for a voice group call passes from one cell coverage area to another and may also be employed to meet network management requirements, e.g. relief of congestion.

Handover may occur during a call from one TCH or multiple TCHs (in the case of multislot configuration) to another TCH or multiple TCHs. It may also occur from DCCH to DCCH or from DCCH to one or multiple TCH(s), e.g. during the initial signalling period at call set-up.

The handover may be either from channel(s) on one cell to other channel(s) on a surrounding cell, or between channels on the same cell which are carried on the same frequency band. Examples are given of handover strategies, however, these will be determined in detail by the network operator.

For a multiband MS, specified in GSM 02.06, the handover described is also allowed between any channels on different cells which are carried on different frequency bands, e.g. between a GSM 900/TCH and a DCS 1 800/TCH. Handover between two co-located cells, carried on different frequency bands, is considered as inter-cell handover irrespective of the handover procedures used.

Adaptive control of the RF transmit power from an MS and optionally from the BSS is implemented in order to optimize the uplink and downlink performance and minimize the effects of co-channel interference in the system.

The criteria for determining radio link failure are specified in order to ensure that calls which fail either from loss of radio coverage or unacceptable interference are satisfactorily handled by the network. Radio link failure may result in either re-establishment or release of the call in progress. For channels used for a voice group call, an radio uplink failure results in the freeing up of the uplink.

Procedures for cell selection and re-selection whilst in Idle mode (i.e. not actively processing a call), are specified in order to ensure that a mobile is camped on a cell with which it can reliably communicate on both the radio uplink and downlink. The operations of an MS in Idle Mode are specified in GSM 03.22.

An MS listening to a voice group call or a voice broadcast use cell re-selection procedures to change cell. This may be supported by a list of cells carrying the voice group or voice broadcast call downlink, provided to the MS by the network. The operations of an MS in Group Receive Mode are specified in GSM 03.22.

Information signalled between the MS and BSS is summarized in tables 1 and 2. A full specification of the Layer 1 header is given in GSM 04.04, and of the Layer 3 fields in GSM 04.08.

3 Handover

3.1 Overall process

The overall handover process is implemented in the MS, BSS and MSC. Measurement of radio subsystem downlink performance and signal strengths received from surrounding cells, is made in the MS. These measurements are signalled to the BSS for assessment. The BSS measures the uplink performance for the MS being served and also assesses the signal strength of interference on its idle traffic channels. Initial assessment of the measurements in conjunction with defined thresholds and handover strategy may be performed in the BSS. Assessment requiring measurement results from other BTS or other information resident in the MSC, may be performed in the MSC.

GSM 03.09 describes the handover procedures to be used in PLMNs.

3.2 MS measurement procedure

A procedure shall be implemented in the MS by which it monitors the downlink RX signal level and quality from its serving cell and the downlink RX signal level and BSIC of surrounding BTS. The method of identification of surrounding BTS is described in subclause 7.2. The requirements for the MS measurements are given in subclause 8.1.

3.3 BSS measurement procedure

A procedure shall be implemented in the BSS by which it monitors the uplink RX signal level and quality from each MS being served by the cell. In the case of a multislot configuration the evaluation shall be performed on a timeslot per timeslot basis. A procedure shall be implemented by which the BSS monitors the levels of interference on its idle traffic channels.

3.4 Strategy

The handover strategy employed by the network for radio link control determines the handover decision that will be made based on the measurement results reported by the MS/BSS and various parameters set for each cell. Network directed handover may also occur for reasons other than radio link control, e.g. to control traffic distribution between cells. The exact handover strategies will be determined by the network operator, a detailed example of a basic overall algorithm appears in annex A. Possible types of handover are as follows:

Inter-cell handover:

> Intercell handover from the serving cell to a surrounding cell will normally occur either when the handover measurements show low RXLEV and/or RXQUAL on the current serving cell and a better RXLEV available from a surrounding cell, or when a surrounding cell allows communication with a lower TX power level. This typically indicates that an MS is on the border of the cell area.
>
> Intercell handover may also occur from the DCCH on the serving cell to a TCH or multislot configuration on another cell during call establishment. This may be used as a means of providing successful call establishment when no TCH resource is available on the current serving cell.
>
> Inter-cell handover between cells using different frequency bands is allowed for a multi band MS.

Intra-cell handover:

> Intra-cell handover from one channel/timeslot in the serving cell to another channel/timeslot in the same cell will normally be performed if the handover measurements show a low RXQUAL, but a high RXLEV on the serving cell. This indicates a degradation of quality caused by interference even though the MS is situated within the serving cell. The intra-cell handover should provide a channel with a lower level of interference. Intra-cell handover can occur either to a timeslot on a new carrier or to a different timeslot on the same carrier. Similarly, intra-cell handover may occur between different multislot configurations in the same cell. These multislot configurations may comprise different number of timeslots and may partly overlap.
>
> Intra-cell handover from one of the bands of operation to another one is allowed for a multiband MS.

GSM 08.08 defines the causes for handover that may be signalled from BSS to MSC.

4 RF power control

4.1 Overall process

RF power control is employed to minimize the transmit power required by MS or BSS whilst maintaining the quality of the radio links. By minimizing the transmit power levels, interference to co-channel users is reduced.

4.2 MS implementation

RF power control shall be implemented in the MS.

The power control level to be employed by the MS on each uplink channel, is indicated by means of the power control information sent either in the layer 1 header of each SACCH message block (see GSM 04.04) on the corresponding downlink channel, or in a dedicated signalling block (see GSM 04.08).

The MS shall employ the most recently commanded power control level appropriate to each channel for all transmitted bursts on either a TCH (including handover access burst), FACCH, SACCH or SDCCH.

The MS shall confirm the power control level that it is currently employing in the SACCH L1 header on each uplink channel. The indicated value shall be the power control level actually used by the mobile for the last burst of the previous SACCH period.

In case of a multislot configuration, each bi-directional channel shall be power controlled individually by the corresponding SACCH. Power control information on downlink unidirectional channels shall be neglected.

When accessing a cell on the RACH (random access) and before receiving the first power command during a communication on a DCCH or TCH (after an IMMEDIATE ASSIGNMENT), all GSM and class 1 and class 2 DCS 1 800 MS shall use the power level defined by the MS_TXPWR_MAX_CCH parameter broadcast on the BCCH of the cell. The class 3 DCS 1 800 MS shall use the power level defined by MS TXPWR MAX CCH plus the value POWER OFFSET also broadcast on the BCCH of the cell.

If a power control level defined in GSM 05.05 is received but the level is not supported by the MS, the MS shall use the supported output power which is closest to the output power indicated by the received power control level.

4.3 MS power control range

The range over which a MS shall be capable of varying its RF output power shall be from its maximum output down to its minimum, in steps of nominally 2 dB.

GSM 05.05 gives a detailed definition of the RF power level step size and tolerances.

4.4 BSS implementation

RF power control may optionally be implemented in the BSS.

4.5 BSS power control range

The range over which the BSS shall be capable of reducing its RF output power from its maximum level shall be nominally 30 dB, in 15 steps of nominally 2 dB.

GSM 05.05 gives a detailed definition of the RF power level step size and tolerances.

4.6 Strategy

The RF power control strategy employed by the network determines the ordered power level that is signalled to the MS, and the power level that is employed by the BSS.

The power level to be employed in each case will be based on the measurement results reported by the MS/BTS and various parameters set for each cell. The exact strategies will be determined by the network operator. A detailed example of a basic algorithm appears in annex A.

4.7 Timing

Upon receipt of a command from an SACCH to change its power level on the corresponding uplink channel, the MS shall change to the new level at a rate of one nominal 2 dB power control step every 60 ms (13 TDMA frames), i.e. a range change of 15 steps should take about 900 ms. The change shall commence at the first TDMA frame belonging to the next reporting period (as specified in subclause 8.4). The MS shall change the power one nominal 2 dB step at a time, at a rate of one step every 60 ms following the initial change, irrespective of whether actual transmission takes place or not.

In case of channel change, the commanded power level shall be applied on each new channel immediately.

4.8 Dedicated channels used for a voice group call or voice broadcast

The network shall not allocate the uplink of the channel used for a voice group call to more than one MS. If marked busy, no other MS shall transmit on the channel. This marking is indicated by the network, as defined in GSM 03.68 and 04.08. Any MS allocated the uplink of a channel used for a voice group call shall only transmit if the uplink is marked busy, and shall stop using the uplink if it happens to become marked free. An MS not allocated the uplink may perform a random access procedure on the uplink to gain access to talk, only if the uplink is marked as free.

On a channel used during a voice group call, the uplink power control shall only apply to the MS currently allocated that uplink, and the MS power control level ordered by the network shall be ignored by all other MSs listening to the downlink.

When performing a random access on a cell to gain access to the uplink of a channel used for a voice group call, until receiving the first dedicated power command from the network, the MS shall use the last received power level command as defined by the MS_TXPWR_MAX_CCH parameter broadcast on the BCCH of the cell, or if MS_TXPWR_MAX_CCH corresponds to a power control level not supported by the MS as defined by its power class in GSM 05.05, the MS shall act as though the closest supported power control level had been broadcast.

RF downlink power control will normally not be applied on channels used for a voice group call or voice broadcast.

5 Radio link failure

5.1 Criterion

The criterion for determining Radio Link Failure in the MS shall be based on the success rate of decoding messages on the downlink SACCH. For a circuit switched multislot configuration, only the main SACCH shall be used for determining Radio Link Failure.

5.2 MS procedure

The aim of determining radio link failure in the MS is to ensure that calls with unacceptable voice/data quality, which cannot be improved either by RF power control or handover, are either re-established or released in a defined manner. In general the parameters that control the forced release should be set such that the forced release will not normally occur until the call has degraded to a quality below that at which the majority of subscribers would have manually released. This ensures that, for example, a call on the edge of a radio coverage area, although of bad quality, can usually be completed if the subscriber wishes.

The radio link failure criterion is based on the radio link counter S. If the MS is unable to decode a SACCH message (BFI = 1),S is decreased by 1. In the case of a successful reception of a SACCH message (BFI = 0) S is increased by 2. In any case S shall not exceed the value of RADIO_LINK_TIMEOUT. If S reaches 0 a radio link failure shall be declared. The action to be taken is specified in GSM 04.08. The RADIO_LINK_TIMEOUT parameter is transmitted by each BSS in the BCCH data (see table 1).

The MS shall continue transmitting as normal on the uplink until S reaches 0.

The algorithm shall start after the assignment of a dedicated channel and S shall be initialized to RADIO_LINK_TIMEOUT.

The detailed operation shall be as follows:

- The radio link time-out algorithm shall be stopped at the reception of a channel change command.

- (Re-)initialization and start of the algorithm shall be done whenever the MS switches to a new channel (this includes the old channel in assignment and handover failure cases), at the latest when the main signalling link (see GSM 04.08) has been established.

- The RADIO_LINK_TIMEOUT value used at (re-)initialization shall be that used on the previous channel (in the Immediate Assignment case the value received on the BCCH), or the value received on SACCH if the MS has received a RADIO_LINK_TIMEOUT value on the new channel before the initialization.

- If the first RADIO_LINK_TIMEOUT value on the SACCH is received on the new channel after the initialization, the counter shall be re-initialized with the new value.

An MS listening to a voice group call or a voice broadcast, upon a downlink radio link failure shall return to idle mode and perform cell re-selection.

5.3 BSS procedure

The criteria for determining radio link failure in the BSS should be based upon either the error rate on the uplink SACCH(s) or on RXLEV/RXQUAL measurements of the MS. The exact criteria to be employed shall be determined by the network operator.

For channels used for a voice group call, the radio link failure procedures in the BSS shall be reset upon the re-allocation of the uplink to another MS. Upon a uplink radio failure, the network shall mark it as free, see subclause 4.8.

Whenever the uplink is not used, and for channels used for voice broadcast, the BSS radio link failure procedures shall not apply on that channel.

6 Idle mode tasks

6.1 Introduction

Whilst in idle mode, an MS shall implement the cell selection and re-selection procedures described in GSM 03.22. These procedures make use of measurements and sub-procedures described in this clause.

The procedures ensure that the MS is camped on a cell from which it can reliably decode downlink data and with which it has a high probability of communications on the uplink. Once the MS is camped on a cell, access to the network is allowed.

This clause makes use of terms defined in GSM 03.22.

The MS shall not use the discontinuous reception (DRX) mode of operation (i.e. powering itself down when it is not expecting paging messages from the network) while performing the cell selection algorithm defined in GSM 03.22. However use of powering down is permitted at all other times in idle mode.

For the purpose of cell selection and reselection, the MS shall be capable of detecting and synchronizing to a BCCH carrier and read the BCCH data at reference sensitivity level and reference interference levels as specified in GSM 05.05. An MS in idle mode shall always fulfil the performance requirement specified in GSM 05.05 at levels down to reference sensitivity level or reference interference level. The allowed error rates (see GSM 05.05) might impact the cell selection and reselection procedure, e.g. trigger cell reselection. Moreover, one consequence of the allowed error rates is that in the case of no frequency hopping and a TU3 (TU1.5 for DCS 1 800) propagation profile it can not be expected that an MS will respond to paging unless the received level is 2 dB higher than the specified reference level.

For the purposes of cell selection and reselection, the MS is required to maintain an average of received signal strengths for all monitored frequencies. These quantities termed the "receive level averages", shall be unweighted averages of the received signal strengths measured in dBm. The accuracy of the signal strength measurements for idle mode tasks shall be the same as for radio link measurements (see subclause 8.1.2).

The times given in subclauses 6.2, 6.3 and 6.6 refer to internal processes in the MS required to ensure that the MS camps as quickly as possible to the most appropriate cell.

For the cell selection, the MS shall be able to select the correct (fourth strongest) cell and be able to respond to paging on that cell within 30 seconds of switch on, when the three strongest cells are not suitable. This assumes a valid SIM with PIN disabled and ideal radio conditions.

The tolerance on all the timing requirements in clause 6 is ± 10 %, except for PENALTY_TIME where it is ± 2 s.

6.2 Measurements for normal cell selection

The measurements of this clause shall be performed by an MS which has no prior knowledge of which GSM or DCS 1 800 RF channels are BCCH carriers.

The MS shall search all RF channels in the system (124 for P-GSM, 174 for E-GSM, 194 for R-GSM, and 374 for DCS 1 800), take readings of received RF signal strength on each RF channel, and calculate the received level average for each. The averaging is based on at least five measurement samples per RF carrier spread over 3 to 5 s, the measurement samples from the different RF carriers being spread evenly during this period.

A multi band MS shall search all channels within its bands of operation as specified above. The number of channels searched will be the sum of channels on each band of operation.

BCCH carriers can be identified by, for example, searching for frequency correction bursts. On finding a BCCH carrier, the MS shall attempt to synchronize to it and read the BCCH data.

The maximum time allowed for synchronization to a BCCH carrier is 0.5 s, and the maximum time allowed to read the BCCH data, when being synchronized to a BCCH carrier, is 1.9 s. An exception is allowed for system information messages that are broadcast only once every n:th (n>1) occurrence of the 8 multiframes (see GSM 05.02). For these system information messages the allowed decoding time is extended according to the applied scheduling of the system information broadcast, i.e. n*1.9 s.

6.3 Measurements for stored list cell selection

The MS may include optional storage of BCCH carrier information when switched off as detailed in GSM 03.22. For example, the MS may store the BCCH carriers in use by the PLMN selected when it was last active in the GSM 900 or DCS 1 800 network. The BCCH list may include BCCH carriers from more than one band in a multi band operation PLMN. A MS may also store BCCH carriers for more than one PLMN which it has selected previously (e.g. at national borders or when more than one PLMN serves a country), in which case the BCCH carrier lists must be kept quite separate.

The stored BCCH carrier information used by the MS may be derived by a variety of different methods. The MS may use the BA_RANGE information element, which, if transmitted in the channel release message (see GSM 04.08), indicates ranges of carriers which include the BCCH carriers in use over a wide area or even the whole PLMN. It should be noted that the BA(BCCH) list might only contain carriers in use in the vicinity of the cell on which it was broadcast, and therefore might not be appropriate if the MS is switched off and moved to a new location.

The BA_RANGE information element contains the Number of Ranges parameter (defined as NR) as well as NR sets of parameters RANGEi_LOWER and RANGEi_HIGHER. The MS should interpret these to mean that all the BCCH carriers of the network have ARFCNs in the following ranges:

Range*1* = ARFCN(RANGE*1*_LOWER) to ARFCN(RANGE*1*_HIGHER);
Range*2* = ARFCN(RANGE*2*_LOWER) to ARFCN(RANGE*2*_HIGHER);
Range*NR* = ARFCN(RANGE*NR*_LOWER) to ARFCN(RANGE*NR*_HIGHER).

If RANGEi_LOWER is greater than RANGEi_HIGHER, the range shall be considered cyclic and encompasses carriers with ARFCN from range RANGEi_LOWER to 1 023 and from 0 to RANGEi_HIGHER. If RANGEi_LOWER equals RANGEi_HIGHER then the range shall only consist of the carrier whose ARFCN is RANGEi_LOWER.

If an MS includes a stored BCCH carrier list of the selected PLMN it shall perform the same measurements as in subclause 6.2 except that only the BCCH carriers in the list need to be measured.

If stored list cell selection is not successful, then as defined in GSM 03.22, normal cell selection shall take place. Since information concerning a number of channels is already known to the MS, it may assign high priority to measurements on the strongest carriers from which it has not previously made attempts to obtain BCCH information, and omit repeated measurements on the known ones.

6.4 Criteria for cell selection and reselection

The path loss criterion parameter C1 used for cell selection and reselection is defined by:

C1 = (A - Max(B,0))

where

A	=	Received Level Average - RXLEV_ACCESS_MIN
B	=	MS_TXPWR_MAX_CCH - P
except for the class 3 DCS 1 800 MS where:		
B	=	MS_TXPWR_MAX_CCH + POWER OFFSET - P
RXLEV_ACCESS_MIN	=	Minimum received level at the MS required for access to the system.
MS_TXPWR_MAX_CCH	=	Maximum TX power level an MS may use when accessing the system until otherwise commanded.
POWER OFFSET	=	The power offset to be used in conjunction with the MS TXPWR MAX CCH parameter by the class 3 DCS 1 800 MS.
P	=	Maximum RF output power of the MS.

All values are expressed in dBm.

The path loss criterion (GSM 03.22) is satisfied if C1 > 0.

The reselection criterion C2 is used for cell reselection only and is defined by:

C2 = C1 + CELL_RESELECT_OFFSET - TEMPORARY OFFSET * H(PENALTY_TIME - T)
for PENALTY_TIME <> 11111
C2 = C1 - CELL_RESELECT_OFFSET for PENALTY_TIME = 11111

where

For non-serving cells:

H(x) = 0 for x < 0
= 1 for x ≥ 0

For serving cells:

H(x) = 0

T is a timer implemented for each cell in the list of strongest carriers (see subclause 6.6.1). T shall be started from zero at the time the cell is placed by the MS on the list of strongest carriers, except when the previous serving cell is placed on the list of strongest carriers at cell reselection. In this, case, T shall be set to the value of PENALTY_TIME (i.e. expired).

CELL_RESELECT_OFFSET applies an offset to the C2 reselection criterion for that cell.

NOTE: CELL_RESELECT_OFFSET may be used to give different priorities to different bands when multiband operation is used.

TEMPORARY_OFFSET applies a negative offset to C2 for the duration of PENALTY_TIME after the timer T has started for that cell.

PENALTY_TIME is the duration for which TEMPORARY_OFFSET applies The all ones bit pattern on the PENALTY_TIME parameter is reserved to change the sign of CELL_RESELECT_OFFSET and the value of TEMPORARY_OFFSET is ignored as indicated by the equation defining C2.

CELL_RESELECT_OFFSET, TEMPORARY_OFFSET and PENALTY_TIME are cell reselection parameters which are broadcast on the BCCH of the cell when CELL_RESELECT_PARAM_IND (see table 1) is set to 1. If CELL_RESELECT_PARAM_IND is set not received or received and set to 0, then the MS should take CELL_BAR_QUALIFY as 0, also in this case the cell reselection parameters take a value of 0 and therefore C2 = C1. The use of C2 is described in GSM 03.22.

These parameters are used to ensure that the MS is camped on the cell with which it has the highest probability of successful communication on uplink and downlink.

6.5 Downlink signalling failure

The downlink signalling failure criterion is based on the downlink signalling failure counter DSC. When the MS camps on a cell, DSC shall be initialized to a value equal to the nearest integer to 90/N where N is the BS_PA_MFRMS parameter for that cell (see GSM 05.02). Thereafter, whenever the MS attempts to decode a message in its paging subchannel; if a message is successfully decoded (BFI = 0) DSC is increased by 1, however never beyond the initial value, otherwise DSC is decreased by 4. When DSC $\leq$ 0, a downlink signalling failure shall be declared.

NOTE: The network sends the paging subchannel for a given MS every BS_PA_MFRMS multiframes or, in case DRX period split is supported, every 64/SPLIT_PG_CYCLE multiframes. The requirement for network transmission on the paging subchannel is specified in GSM 04.08. The MS is required to attempt to decode a message every time its paging subchannel is sent.

A downlink signalling failure shall result in cell reselection.

6.6 Measurements for Cell Reselection

Upon completion of cell selection and when starting the cell reselection tasks, the MS shall synchronize to and read the BCCH information for the 6 strongest non-serving carriers (in the BA) as quickly as possible within the times specified in subclause 6.6.1. For multi band MSs the strongest non-serving carriers may belong to different frequency bands. If system information message type 2 ter is used in the serving cell, and the MS has decoded all relevant serving cell BCCH data, except system information message 2 ter, then the MS shall start cell reselection measurements based on the know part of the BA, until system information message 2 ter is decoded and the full BA can be used.

6.6.1 Monitoring of received level and BCCH data

Whilst in idle mode an MS shall continue to monitor all BCCH carriers as indicated by the BCCH allocation (BA - See table 1). A running average of received level in the preceding 5 to:

Max {5 , ((5 * N + 6) DIV 7) * BS_PA_MFRMS / 4}

seconds shall be maintained for each carrier in the BCCH allocation. N is the number of non-serving cell BCCH carriers in BA and the parameter BS_PA_MFRMS is defined in GSM 05.02.

The same number of measurement samples shall be taken for all non-serving cell BCCH carriers of the BA list, and the samples allocated to each carrier shall as far as possible be uniformly distributed over each evaluation period. At least 5 received level measurement samples are required per receive level average value. New sets of receive level average values shall be calculated as often as possible.

For the serving cell, receive level measurement samples shall be taken at least for each paging block of the MS. The receive level average shall be a running average determined using samples collected over a period of 5 s to Max {5s, five consecutive paging blocks of that MS}. The samples shall as far as possible be uniformly distributed over each evaluation period. At least 5 received level measurement samples are required per receive level average. New receiving level average value shall be calculated as often as possible.

The list of the 6 strongest non-serving carriers shall be updated at least as often as the duration of the running average defined for measurements on the BCCH allocation and may be updated more frequently.

In order to minimize power consumption, MS that employ DRX (i.e. power down when paging blocks are not due) should monitor the signal strengths of non-serving cell BCCH carriers during the frames of the paging block that they are required to listen to. The MS shall include the BCCH carrier of the current serving cell (i.e. the cell the MS is camped on) in this measurement routine. Received level measurement samples can thus be taken on several non-serving cell BCCH carriers and on the serving carrier during each paging block.

The MS shall attempt to decode the full BCCH data of the serving cell at least every 30 seconds.

The MS shall attempt to decode the BCCH data block that contains the parameters affecting cell reselection for each of the 6 strongest non-serving cell BCCH carriers at least every 5 minutes. When the MS recognizes that a new BCCH carrier has become one of the 6 strongest, the BCCH data shall be decoded for the new carrier within 30 seconds.

The MS shall attempt to check the BSIC for each of the 6 strongest non-serving cell BCCH carriers at least every 30 seconds, to confirm that it is monitoring the same cell. If a change of BSIC is detected then the carrier shall be treated as a new carrier and the BCCH data redetermined.

When requested by the user, the MS shall determine which PLMNs are available (Manual Mode) or available and allowable (Automatic Mode) (see GSM 03.22) within 15 seconds (for GSM 900) or 20 seconds (for DCS 1 800). A multi band MS shall perform the same procedures in all bands of operation within the sum of time constraints in the respective band of operation.

In both cases, this monitoring shall be done so as to minimize interruptions to the monitoring of the PCH.

The maximum time allowed for synchronization to a BCCH carrier is 0,5 s, and the maximum time allowed to read the BCCH data, when being synchronized to a BCCH carrier, is 1,9 s. An exception is allowed for system information messages that are broadcast only once every n:th (n>1) occurrence of the 8 multiframes (see GSM 05.02). For these system information messages the allowed decoding time is extended according to the applied scheduling of the system information broadcast, i.e. n*1.9 s.

6.6.2 Path loss criteria and timings for cell re-selection

The MS is required to perform the following measurements (see GSM 03.22) to ensure that the path loss criterion to the serving cell is acceptable.

At least every 5 s the MS shall calculate the value of C1 and C2 for the serving cell and re-calculate C1 and C2 values for non serving cells (if necessary). The MS shall then check whether:

i) The path loss criterion (C1) for current serving cell falls below zero for a period of 5 seconds. This indicates that the path loss to the cell has become too high.

ii) The calculated value of C2 for a non-serving suitable cell exceeds the value of C2 for the serving cell for a period of 5 seconds, except;

  a) in the case of the new cell being in a different location area in which case the C2 value for the new cell shall exceed the C2 value of the serving cell by at least CELL_RESELECT_HYSTERESIS dB as defined by the BCCH data from the current serving cell, for a period of 5 seconds;

  or

  b) in case of a cell reselection occurring within the previous 15 seconds in which case the C2 value for the new cell shall exceed the C2 value of the serving cell by at least 5 dB for a period of 5 seconds.

This indicates that it is a better cell.

Cell reselection for any other reason (see GSM 03.22) shall take place immediately, but the cell that the MS was camped on shall not be returned to within 5 seconds if another suitable cell can be found. If valid receive level averages are not available, the MS shall wait until these values are available and then perform the cell reselection if it is still required. The MS may accelerate the measurement procedure within the requirements in subclause 6.6.1 to minimize the cell reselection delay.

If no suitable cell is found within 10 seconds, the cell selection algorithm of GSM 03.22 shall be performed. Since information concerning a number of channels is already known to the MS, it may assign high priority to measurements on the strongest carriers from which it has not previously made attempts to obtain BCCH information, and omit repeated measurements on the known ones.

6.7 Release of TCH and SDCCH

6.7.1 Normal case

When the MS releases all TCHs or SDCCH and returns to idle mode, it shall, as quickly as possible, camp on the BCCH carrier of the cell whose channel has just been released. If the full BCCH data for that cell was not decoded in the preceding 30s, the MS shall then attempt to decode the full BCCH data. Until the MS has decoded the BCCH data required for determining the paging group, it shall also monitor all paging blocks on timeslot 0 of the BCCH carrier for possible paging messages that might address it. If the MS receives a page before having decoded the full BCCH data for the cell, the MS shall store the page and respond once the full BCCH data has been decoded, provided that the cell is not barred and the MS's access class is allowed.

If at the release of the connection the MS has the knowledge that the cell whose channel is being released is not suitable (see GSM 03.22), the MS is allowed to camp on any suitable cell.

NOTE: The received level measurements on surrounding cells made during the last 5 seconds on the TCH or SDCCH may be averaged and used, where possible, to speed up the process. However, it should be noted that the received level monitoring while on the TCH or SDCCH is on carriers in BA (SACCH), while the carriers to be monitored for cell reselection are in BA (BCCH).

After decoding the full BCCH data the MS shall perform cell reselection as specified in GSM 03.22.

6.7.2 Call re-establishment

In the event of a radio link failure, call re-establishment may be attempted (according to the procedure in GSM 04.08). The MS shall perform the following algorithm to determine which cell to use for the call re-establishment attempt.

i) The received level measurement samples taken on the carriers indicated in the BA (SACCH) received on the serving cell and on the serving cell BCCH carrier in the last 5 seconds shall be averaged, and the carrier with the highest average received level with a permitted NCC as indicated on the SACCH of the serving cell (see subclause 7.2) shall be taken.

ii) On this carrier the MS shall attempt to decode the BCCH data block containing the parameters affecting cell selection.

iii) If the parameter C1 is greater than zero, it is part of the selected PLMN, the cell is not barred, and call re-establishment is allowed, call re-establishment shall be attempted on this cell.

iv) If the MS is unable to decode the BCCH data block or if the conditions in iii) are not met, the carrier with the next highest average received level with a permitted NCC shall be taken, and the MS shall repeat steps ii) and iii) above.

v) If the cells with the 6 strongest average received level values with a permitted NCC have been tried but cannot be used, the call re-establishment attempt shall be abandoned, and the algorithm of subclause 6.7.1 shall be performed.

The MS is under no circumstances allowed to access a cell to attempt call re-establishment later than 20 seconds after the detection within the MS of the radio link failure causing the call re-establishment attempt. In the case where the 20 seconds elapses without a successful call re-establishment the call re-establishment attempt shall be abandoned, and the algorithm of subclause 6.7.1 shall be performed.

Call re-establishment shall not be applied for voice group calls.

6.8 Abnormal cases and emergency calls

When in the limited service state (see GSM 03.22) 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 MS shall monitor the signal strength of all RF channels within it bands of operation (124 for P-GSM, 174 for E-GSM, 194 for R-GSM, and 374 for DCS 1 800), and search for a BCCH carrier which has C1 > 0 and which is not barred. When such a carrier is found, the MS shall camp on that cell, irrespective of the PLMN identity.

b) The MS shall search the strongest RF channels to determine which PLMNs are available (Manual Mode) or available and allowable (Automatic Mode). This information shall be processed according to the PLMN selection algorithm defined in GSM 03.22.

c) The MS shall perform cell reselection at least among the cells of the PLMN of the cell on which the MS has camped, according to the algorithm of GSM 03.22, except that a zero value of CELL_RESELECT_HYSTERESIS shall be used.

Condition			**Tasks to be performed as a minimum:**		
SIM Present	**Other**	**MS camped on a cell**	**a)**	**b)**	**c)**
X	X	No	Yes	No	No
No	X	Yes	No	No	Yes
Yes	"IMSI Unknown", "illegal MS"	Yes	No	No	Yes
Yes	No suitable cell of selected PLMN or "PLMN not allowed"	Yes	No	Yes	Yes

X = "Don't care state"

In this mode, only emergency calls may be made (and these may only be made if task c) was being performed). Powering down of the MS is permitted.

7 Network pre-requisites

7.1 BCCH carriers

The BCCH carrier shall be continuously transmitted on all timeslots and without variation of RF level. However, the RF power level may be ramped down between timeslots to facilitate switching between RF transmitters. On the PCH the network shall send valid layer 3 messages according to GSM 04.08. Unused signalling blocks on the CCCH/BCCH shall contain L2 fill frames. Other unused timeslots shall transmit dummy bursts.

NOTE: This BCCH organization enables MS to measure the received signal level from surrounding cells by tuning and listening to their BCCH carriers. Providing that an MS tunes to the list of BCCH carriers indicated by the network it will, providing the list is sufficiently complete, have listened to all possible surrounding cells, i.e. the surrounding cell list for handover purposes is effectively defined by the MS. Refer to GSM 03.22 for definitions of the BCCH carrier lists. This can be achieved without inter-base station synchronization.

7.2 Identification of surrounding BSS for handover measurements

It is essential for the MS to identify which surrounding BSS is being measured in order to ensure reliable handover. Because of frequency re-use with small cluster sizes, the BCCH carrier frequency may not be sufficient to uniquely identify a surrounding cell, i.e. the cell in which the MS is situated may have more than one surrounding cell using the same BCCH frequency. Thus it is necessary for the MS to synchronize to and demodulate surrounding BCCH carriers and identify the base station identification code (BSIC). The MS shall be able to perform this task at levels down to the reference sensitivity level or reference interference levels as specified in GSM 05.05.

The MS shall use at least 4 spare frames per SACCH block period for the purpose of decoding the BSICs (e.g. in the case of TCH/F, the four idle frames per SACCH block period). These frames are termed "search" frames.

A 6 bit Base Station Identity Code (BSIC), as defined in GSM 03.03, shall be transmitted on each BCCH carrier. The PLMN part of the BSIC can be regarded as a "PLMN colour code".

The MS shall demodulate the SCH on the BCCH carrier of each surrounding cell and decode the BSIC as often as possible, and as a minimum at least once every 10 seconds. A list containing information about the timing of the surrounding cells at the accuracy required for accessing a cell (see GSM 05.10) including the absolute times derived from the parameters T1, T2, T3 shall be kept by the MS. This information may be used to schedule the decoding of BSIC and shall be used in connection with handover in order to keep the switching time at a minimum.

If, after averaging measurement results over 2 SACCH block periods, the MS detects one or more BCCH carriers, among the 6 strongest, whose BSICs are not currently being assessed, then the MS shall as a matter of priority attempt to decode their BSICs.

In the case of a multi band MS, the MS shall attempt to decode the BSIC, if any BCCH carrier with unknown BSIC is detected among the number of strongest BCCH carriers in each band as indicated by the Multiband Reporting parameter.

Thus an MS shall, for a period of up to 5 seconds, devote all search frames to attempting to decode these BSICs. If this fails then the MS shall return to confirming existing BSICs. Having re-confirmed existing BSICs, if there are still BCCH carriers, among the six strongest, with unknown BSICs, then the decoding of these shall again be given priority for a further period of up to 5 seconds.

If either no BSIC can be demodulated on a surrounding cell BCCH carrier, or the NCC part of the BSIC is not one of the permitted NCCs, then the signal strength measurements on that channel shall be discarded. The permitted NCCs are defined by the NCC_PERMITTED parameter transmitted in the BCCH data. This is an 8 bit map that relates to the NCC part of BSIC. (e.g. NCC_PERMITTED = 01101001, defines that only carriers having a BSIC with the NCC part = 000, 011, 101,110 shall be reported).

If a change of BSIC is detected on a carrier, then any existing signal strength measurement shall be discarded and a new averaging period commenced. This occurs when the MS moves away from one surrounding cell and closer to another co-channel cell.

If the BSIC cannot be decoded at the next available opportunities re-attempts shall be made to decode this BSIC. If the BSIC is not decoded for more than three successive attempts it will be considered lost and any existing signal strength measurement shall be discarded.

Details of the synchronization mechanisms appear in GSM 05.10. The procedure for monitoring surrounding BTS with respect to HO measurement shall begin at least at the time of assignment of a dedicated channel.

When a BCCH carrier is found to be no longer among the reported, timing and BSIC information shall be retained for at least 10 seconds. (This is in case a handover is commanded to this cell just after the MS stops reporting RXLEV and RXQUAL on this cell).

8 Radio link measurements

Radio link measurements are used in the handover and RF power control processes.

In particular, radio-subsystem directed handover is defined as a change of channel(s) during a call either because of degradation of the quality of one or more of the current serving channel(s), or because of the availability of other channel(s) which can allow communication at a lower TX power level, or to prevent a MS grossly exceeding the planned cell boundaries.

Additional measurements, so called Extended measurements, can e.g. be used for frequency planning purposes.

The measurements are made over each SACCH multiframe, which is 104 TDMA frames (480 ms) for a TCH and 102 TDMA frames (470,8 ms) for an SDCCH.

8.1 Signal strength

8.1.1 General

The received signal level may be employed as a criterion in the RF power control and handover processes.

8.1.2 Physical parameter

The R.M.S received signal level at the receiver input shall be measured by the MS and the BSS over the full range of -110 dBm to -48 dBm with an absolute accuracy of ± 4 dB from -110 dBm to -70 dBm under normal conditions and ± 6 dB over the full range under both normal and extreme conditions.

If the received signal level falls below the reference sensitivity level for the type of MS or BSS, then the measured level shall be within the range allowing for the absolute accuracy specified above. In case the upper limit of this range is below the reference sensitivity level for the type of MS or BSS, then the upper limit shall be considered as equal to the reference sensitivity level.

The relative accuracy shall be as follows:

If signals of level x1 and x2 dBm are received (where $x1 \le x2$) and levels y1 and y2 dBm respectively are measured, if $x2 - x1 < 20$ dB and x1 is not below the reference sensitivity level, then y1 and y2 shall be such that:

$(x2 - x1) - a \le y2 - y1 \le (x2 - x1 + b)$ if the measurements are on the same or on different RF channel within the same frequency band;

and

$(x2 - x1) - c \le y2 - y1 \le (x2 - x1 + d)$ if the measurements are on different frequency bands:

a, b, c and d are in dB and depend on the value of x1 as follows:

	a	b	c	d
$x1 \ge s+14$	2	2	4	4
$s+14 > x1 \ge s+1$	3	2	5	4
$s+1 > x1$	4	2	6	4

For single band MS or BTS and measurements between ARFN in the same band for a multiband

MS or BTS;

s = reference sensitivity level as specified in GSM 05.05.

For measurements between ARFCN in different bands;

s = the reference sensitivity level as specified in GSM 05.05 for the band including x1.

At extreme temperature conditions an extra 2 dB shall be added to c and d in above table.

The selectivity of the received signal level measurement shall be as follows:

- for adjacent (200 kHz) channel ≥ 16 dB;
- for adjacent (400 kHz) channel ≥ 48 dB;
- for adjacent (600 kHz) channel ≥ 56 dB.

The selectivity shall be met using random, continuous, GSM-modulated signals with the wanted signal at the level 20 dB above the reference sensitivity level.

8.1.3 Statistical parameters

For each channel, the measured parameters (RXLEV) shall be the average of the received signal level measurement samples in dBm taken on that channel within the reporting period of length one SACCH multiframe defined in 8.4. In averaging, measurements made during previous reporting periods shall always be discarded.

When assigned a TCH or SDCCH the MS shall make a received signal level measurement:

- in every TDMA frame on at least one of the BCCH carriers indicated in the BCCH allocation (BA), one after another. Optionally, measurements during up to 4 frames per SACCH multiframe may be omitted.

  NOTE: These four frames are those immediately preceding the search frames, in order to allow the MS to search for BCCH synchronization over a full TDMA frame.

- for each assigned bi-directional channel, on all bursts of the associated physical channel (see GSM 05.02), including those of the SACCH. If frequency hopping is being used on the associated physical channel and if, in the BCCH Cell Options, the Power Control Indicator PWRC is set, measurements on the bursts on the BCCH frequency shall not be used in the RXLEV averaging process.

Unless otherwise specified by the operator, for any TCH or SDCCH assigned to an MS, the BSS shall make a received signal level measurement on all time slots of the associated physical channel including those of the SACCH, but excluding the idle timeslots.

8.1.4 Range of parameter

The measured signal level shall be mapped to an RXLEV value between 0 and 63, as follows:

RXLEV	0	=	less than		-110 dBm.
RXLEV	1	=	-110 dBm	to	-109 dBm.
RXLEV	2	=	-109 dBm	to	-108 dBm.
		:			
		:			
RXLEV	62	=	-49 dBm	to	-48 dBm.
RXLEV	63	=	greater than		-48 dBm.

6 bits are required to define RXLEV for each carrier measured.

8.2 Signal quality

8.2.1 General

The received signal quality shall be employed as a criterion in the RF power control and handover processes.

8.2.2 Physical parameter

The received signal quality shall be measured by the MS and BSS in a manner that can be related to an equivalent average BER before channel decoding (i.e. chip error ratio), assessed over the reporting period of 1 SACCH block.

For example, the measurement may be made as part of the channel equalization process, decoding process, pseudo-error rate measurement etc.

8.2.3 Statistical parameters

For each channel, the measured parameters (RXQUAL) shall be the received signal quality, averaged on that channel over the reporting period of length one SACCH multiframe defined in subclause 8.4. In averaging, measurements made during previous reporting periods shall always be discarded.

Contrary to RXLEV measurements, in calculating RXQUAL values, measurements on bursts on the BCCH carrier shall always be included in the averaging process.

8.2.4 Range of parameter

When the quality is assessed over the full-set and sub-set of frames defined in subclause 8.4, eight levels of RXQUAL are defined and shall be mapped to the equivalent BER before channel decoding as follows:

RXQUAL_0			BER	<	0,2 %	Assumed value = 0,14 %
RXQUAL_1	0,2 %	<	BER	<	0,4 %	Assumed value = 0,28 %
RXQUAL_2	0,4 %	<	BER	<	0,8 %	Assumed value = 0,57 %
RXQUAL_3	0,8 %	<	BER	<	1,6 %	Assumed value = 1,13 %
RXQUAL_4	1,6 %	<	BER	<	3,2 %	Assumed value = 2,26 %
RXQUAL_5	3,2 %	<	BER	<	6,4 %	Assumed value = 4,53 %
RXQUAL_6	6,4 %	<	BER	<	12,8 %	Assumed value = 9,05 %
RXQUAL_7	12,8 %	<	BER			Assumed value = 18,10 %

The assumed values may be employed in any averaging process applied to RXQUAL.

The BER values used to define a quality band are the estimated error probabilities before channel decoding, averaged over the full set or sub set of TDMA frames as defined in subclause 8.4. The accuracy to which an MS shall be capable of estimating the error probabilities when on a TCH under static channel conditions is given in the following table. Note the exception of subclause 8.4 on data channels using interleaving depth 19 and on half rate speech channel.

Quality Band	**Range of actual BER**	**Probability that the correct RXQUAL band is reported by MS shall exceed**		
		Full rate Channel	**Half rate Channel**	**DTX Mode**
RXQUAL_0	Less than 0,1 %	90 %	90 %	65 %
RXQUAL_1	0,26 % to 0,30 %	75 %	60 %	35 %
RXQUAL_2	0,51 % to 0,64 %	85 %	70 %	45 %
RXQUAL_3	1,0 % to 1,3 %	90 %	85 %	45 %
RXQUAL_4	1,9 % to 2,7 %	90 %	85 %	60 %
RXQUAL_5	3,8 % to 5,4 %	95 %	95 %	70 %
RXQUAL_6	7,6 % to 11,0 %	95 %	95 %	80 %
RXQUAL_7	Greater than 15,0 %	95 %	95 %	85 %
NOTE 1: For the full rate channel RXQUAL_FULL is based on 104 TDMA frames. NOTE 2: For the half rate channel RXQUAL_FULL is based on 52 TDMA frames. NOTE 3: For the DTX mode RXQUAL_SUB is based on 12 TDMA frames.				

The accuracy to which an MS shall be capable of estimating the error probabilities when on a TCH under TU50 channel conditions is given in the following table. Note the exception of subclause 8.4 on data channels using interleaving depth 19 and on half rate speech channel.

Range of actual BER	Expected RXQUAL_FULL	Probability that expected RXQUAL_FULL is reported shall exceed
Less than 0,1 %	RXQUAL_0/1	85 %
0,26 % to 0,30 %	RXQUAL_1/0/2	85 %
0,51 % to 0,64 %	RXQUAL_2/1/3	85 %
1,0 % to 1,3 %	RXQUAL_3/2/4	90 %
1,9 % to 2,7 %	RXQUAL_4/3/5	90 %
3,8 % to 5,4 %	RXQUAL_5/4/6	90 %
7,6 % to 11,0 %	RXQUAL_6/5/7	90 %
Greater than 15,0 %	RXQUAL_7/6	90 %

It should be noted that in the testing, the System Simulator (SS) or (BSSTE) Base Station System Test Equipment will have to measure the average error rate over a large number of TDMA frames.

8.3 Aspects of discontinuous transmission (DTX)

When DTX is employed on a TCH, not all TDMA frames may be transmitted, however, the following subset shall always be transmitted, and hence can be employed to assess quality and signal level during DTX.

Type of channel	TDMA frame subset always to be transmitted TDMA frame number (FN) modulo 104
TCH/F	52, 53, 54, 55, 56, 57, 58, 59
TCH/HS,subchannel 0	0, 2, 4, 6, 52, 54, 56, 58
TCH/HS,subchannel 1	14, 16, 18, 20, 66, 68, 70, 72
TCH/H,data,subchannel 0,uplink	52, 54, 56, 58, 60, 62, 65, 67, 69, 71
TCH/H,data,subchannel 0,downlink	56, 58, 60, 62, 65, 67, 69, 71, 73, 75
TCH/H,data,subchannel 1,uplink	70, 72, 74, 76, 79, 81, 83, 85, 87, 89
TCH/H,data,subchannel 1,downlink	66, 68, 70, 72, 74, 76, 79, 81, 83, 85

On any TCH this subset of TDMA frames is always used for transmission during DTX. For speech, when no signalling or speech is to be transmitted these TDMA frames are occupied by the SID (Silence Descriptor) speech frame, see GSM 06.12 and TSM GSM 06.31 for detailed specification of the SID frame and its transmission requirements. In other cases when no information is required to be transmitted, e.g. on data channels, the L2 fill frame (see GSM 04.06 subclause 5.4.2.3) shall be transmitted as a FACCH in the TDMA frame subset always to be transmitted.

On the SDCCH and on the half rate traffic channel TCH/H in signalling only mode DTX is not allowed. In these cases and on the TCH/F in signalling only mode when DTX is not used, the same L2 fill frame shall be transmitted in case there is nothing else to transmit.

8.4 Measurement reporting

8.4.1 Measurement reporting for the MS on a TCH

For a TCH, the reporting period of length 104 TDMA frames (480 ms) is defined in terms of TDMA frame numbers (FN) as follows:

Timeslot number (TN)			TDMA frame number (FN) modulo 104	
TCH/F	**TCH/H,subch.0**	**TCH/H,subch.1**	**Reporting period**	**SACCH Message block**
0	0 and 1		0 to 103	12, 38, 64, 90
1		0 and 1	13 to 12	25, 51, 77, 103
2	2 and 3		26 to 25	38, 64, 90, 12
3		2 and 3	39 to 38	51, 77, 103, 25
4	4 and 5		52 to 51	64, 90, 12, 38
5		4 and 5	65 to 64	77, 103, 25, 51
6	6 and 7		78 to 77	90, 12, 38, 64
7		6 and 7	91 to 90	103, 25, 51, 77

For a multislot configuration, the reporting period and SACCH Message block for each timeslot is defined as for TCH/F for TN = 0.

When on a TCH, the MS shall assess during the reporting period and transmit to the BSS in the next SACCH message block the following:

- RXLEV for the BCCH carrier of the 6 cells with the highest RXLEV among those with known and allowed NCC part of BSIC. For a multi band MS the number of cells, for each frequency band supported, which shall be included is specified in subclause 8.4.3.

  NOTE 1: Since there are 104 TDMA frames in each SACCH multiframe (and measurement in 4 frames is optional), the number of samples on each BCCH carrier will depend on the number of carriers defined in the BCCH Allocation (BA) and may be different. The following table gives examples of this.

Number of BCCH carriers in BCCH Allocation	Number of samples per carrier in SACCH multiframe
32	3-4
16	6-7
10	10-11
8	12-13
:	:
:	:

  These figures are increased if the MS is able to make measurements on more than one BCCH carrier during each TDMA frame.

- RXLEV_FULL and RXQUAL_FULL:
  RXLEV and RXQUAL for the full set of TCH and SACCH TDMA frames. The full set of TDMA frames is either 100 (i.e. 104 - 4 idle) frames for a full rate TCH or 52 frames for a half-rate TCH.

- RXLEV_SUB and RXQUAL_SUB:
  RXLEV and RXQUAL for the subset of 4 SACCH frames and the SID TDMA frames/L2 fill frames defined in 8.3. In case of data traffic channels TCH/F9.6, TCH/F4.8, TCH/H4.8 and TCH/H2.4, the RXQUAL_SUB report shall include measurements on the TDMA frames given in the table of subclause 8.3 only if L2 fill frames have been received as FACCH frames at the corresponding frame positions. If no FACCH frames have been received at the corresponding frame positions, the RXQUAL_SUB report shall include measurements on the 4 SACCH frames only. The performance requirements of subclause 8.2.4 do not apply in this case for RXQUAL_SUB. In case of half rate speech channel TCH/HS, if an SID frame or a speech frame as defined in subclause 8.3 is replaced by an FACCH frame, the RXQUAL measurement on these frames shall be excluded from the RXQUAL SUB report. The performance requirements of subclause 8.2.4 do not apply in this case for RXQUAL SUB. In case of half rate traffic channel TCH/H in signalling only mode, -SUB values are set equal to the -FULL values in the SACCH message, since DTX is not allowed in this case.

  NOTE 2: If measurement on the BCCH carrier is not used, the number of TDMA frames used in the RXLEV averaging process may be lower than the number of TDMA frames in the set see subclause 8.1.3.

In case of a multislot configuration, the MS shall report the following according to the definition above:

- on the main SACCH: the RXLEV values from the adjecent cells, RXLEV_FULL and RXLEV_SUB from the main channel and the worst RXQUAL_FULL values and RXQUAL_SUB values from the main channel and the unidirectional channels;

- on each other bi-directional SACCH: the RXLEV values from the adjecent cells, RXLEV_FULL, RXLEV_SUB, RXQUAL_FULL and RXQUAL_SUB from the corresponding channel.

8.4.2 Measurement reporting for the MS on a SDCCH

For a SDCCH, the reporting period of length 102 TDMA frames (470.8 ms) is defined in terms of TDMA frame numbers (FN) as follows:

	TDMA frame number (FN) modulo 102
SDCCH/8	12 to 11
SDCCH/4	37 to 36

NOTE 1: Some SDCCH data or TCH speech, data or SID message blocks are spread over two reporting periods. In these cases, the RXLEV and/or RXQUAL information from the SDCCH or TCH message blocks may either be sent as part of the measurement report of the second period, or shared between the reports of the two periods.

When on a SDCCH, the MS shall assess during the reporting period and transmit to the BSS in the next SACCH message block the following:

- RXLEV for the BCCH carrier of the 6 cells with the highest RXLEV among those with known and allowed NCC part of BSIC. For a multi band MS the number of cells, for each frequency band supported, which shall be included is specified in subclause 8.4.3.

  NOTE 2: With only 102 TDMA frames in each SACCH multiframe, the number of samples used to calculate RXLEV per BCCH carrier may be slightly different from the case of TCH described above.

- RXLEV and RXQUAL for the full set of 12 (8 SDCCH and 4 SACCH) frames within the reporting period. As DTX is not allowed on the SDCCH, -SUB values are set equal to the -FULL values in the SACCH message.

  NOTE 3: If measurement on the BCCH carrier is not used, the number of TDMA frames used in the RXLEV averaging process may be lower than the number of TDMA frames in the full set see subclause 8.1.3.

8.4.3 Additional cell reporting requirements for multi band MS

For a multi band MS the number of cells, for each frequency band supported, which shall be included in the measurement report is indicated by the parameter, MULTIBAND_REPORTING. The meaning of different values of the parameter is specified as follows:

Value	**Meaning**
00	Normal reporting of the six strongest cells, with known and allowed NCC part of BSIC, irrespective of the band used.
01	The MS shall report the strongest cell, with known and allowed NCC part of BSIC, in each of the frequency bands in the BA list, excluding the frequency band of the serving cell. The remaining positions in the measurement report shall be used for reporting of cells in the band of the serving cell. If there are still remaining positions, these shall be used to report the next strongest identified cells in the other bands irrespective of the band used.

10	The MS shall report the two strongest cells, with known and allowed NCC part of BSIC, in each of the frequency bands in the BA list, excluding the frequency band of the serving cell. The remaining positions in the measurement report shall be used for reporting of cells in the band of the serving cell. If there are still remaining positions, these shall be used to report the next strongest identified cells in the other bands irrespective of the band used.
11	The MS shall report the three strongest cells, with known and allowed NCC part of BSIC, in each of the frequency bands in the BA list, excluding the frequency band of the serving cell. The remaining positions in the measurement report shall be used for reporting of cells in the band of the serving cell. If there are still remaining positions, these shall be used to report the next strongest identified cells in the other bands irrespective of the band used.

8.4.4 Common aspects for the MS on a TCH or a SDCCH

Whether the MS is on a TCH or a SDCCH, if the next SACCH message block is used for a different Layer 3 message, the averaged data which would otherwise be sent in that block is discarded and a new average started for the current block. I.e., any SACCH message will report the average data for the previous reporting period only.

The MS shall also transmit a bit (DTX_USED) in the next SACCH message block, which indicates whether or not it has employed DTX during the reporting period. This bit shall be set even if just one burst in a TDMA frame in the reporting period was not transmitted due to DTX.

NOTE: A speech or user data frame subject to DTX may cross the "border" between two reporting periods, in which case both of the associated SACCH message blocks will have the DTX_USED flag set.

The measurements in the MS shall be based on the current BA list and the current NCC_PERMITTED (see table 1), available at the beginning of the reporting period. At the transition from idle mode to a TCH or a SDCCH the current BA list is the BA(BCCH), later the latest received complete BA(SACCH). At the transition from idle mode to a TCH or a SDCCH the current NCC is the NCC_PERMITTED received on the BCCH, later the latest NCC_PERMITTED received on the SACCH. The measurement process on carriers contained in both lists is, therefore, continuous.

If the current BA list does not refer to the serving cell, e.g. after a handover, this shall be indicated and no measurement values for cells in the BA list shall be reported.

If the MS returns to the previous cell after a failure of the handover procedure the description above applies. As a consequence, a BA list (and/or NCC_PERMITTED) received on the SAACCH in the cell to which the handover failed shall be regarded as the current ones, which may lead to interruptions in the measurement reporting as the BA list does not refer to the serving cell. As an option, the MS may in this case remember the last received BA list and NCC_PERMITTED in the old cell and regard those as the current ones when returning.

8.4.5 Measurement reporting for the BSS

Unless otherwise specified by the operator, the BSS shall make the same RXLEV (full and sub) and RXQUAL (full and sub) assessments as described for the MS for all TCH's and SDCCH's assigned to an MS, using the associated reporting periods. These values, together with the reported values from the MS, shall be transmitted to the BSC as described in the GSM 08.58.

8.4.6 Extended measurement reporting

When on a TCH or SDCCH, the mobile station may receive an Extended Measurement Order (EMO) message. The mobile station shall then, during one reporting period, perform signal strength measurements according to the frequency list contained in the EMO message. BSIC decoding is not required for these frequencies. The mobile station shall in the next SACCH message block transmit the Extended Measurement Report message, containing the following:

- RXLEV (as defined in section 8.1.4) for the carriers specified by the last received EMO message. If the EMO contains more than 21 carriers, only the 21 first carriers in the sorted EXTENDED MEASUREMENT FREQUENCY LIST (in the EMO) are measured and reported.

- DTX USED, as defined in section 8.4.4.

If extended measurements are not possible due to the requirements on reporting of normal measurements (see GSM 04.08), the extended measurements shall be suppressed and scheduled at the next possible opportunity. If reporting is not possible due to requirements to send other Layer 3 messages, the measurements shall be discarded and new measurements scheduled at the next possible opportunity. If extended measurements can not be reported within 10 seconds after the triggering EMO was received, they shall be discarded (and not reported).

If the EMO message contains frequencies outside the MS' frequency band, the MS shall set the corresponding RXLEV value(s) to zero.

After a successful channel change, no Extended Measurement Report shall be sent if the EMO was received before that channel change.

After having performed Extended Measurements during one reporting period, the mobile station shall resume the measurements according to the current BA list. This applies for each rescheduling of the Extended measurements.

8.5 Absolute MS-BTS distance

8.5.1 General

The Absolute MS-BTS distance may be employed by the network as a criterion in the handover processes.

8.5.2 Physical parameter

The information being used by the BSS to perform "adaptive frame alignment" (GSM 05.10) in the MS is a representation of the absolute distance of the MS to the serving BTS.

This absolute distance may be used by the BSS to prevent MS from grossly exceeding the planned cell boundaries.

The allowable distance is administered on a cell by cell basis by the network operator.

9 Control parameters

The parameters employed to control the radio links are shown in tables 1 and 2.

Table 1: Radio sub-system link control parameters

Parameter name	Description	Range	Bits	Channel
BSIC	Base station Identification Code	0-63	6	SCH D/L
BA	BCCH Allocation	-	-	BCCH D/L
BA_IND	Sequence number of BA	0/1	1	BCCH D/L
MS_TXPWR_MAX_CCH	The maximum TX power level an MS may use when accessing the system until otherwise commanded.	0/31	5	BCCH D/L
POWER OFFSET	The power offset will be used in conjunction with the MS TXPWR MAX CCH parameter by the class 3 DCS 1 800 MS: 0 = 0 dB 1 = 2 dB 2 = 4 dB 3 = 6 dB	0-3	2	BCCH D/L
RXLEV_ACCESS_MIN	Minimum received level at the MS required for access to the system.	0-63	6	BCCH D/L
RADIO_LINK_TIMEOUT	The maximum value of the radio link counter 4-64 SACCH blocks, 15 steps of 4 SACCH blocks	-	4	BCCH D/L SACCH D/L
CELL_RESELECT_HYSTERESIS	RXLEV hysteresis for required cell re-selection. 0-14 dB, 2 dB steps, i.e. 0 = 0 dB, 1 = 2 dB, etc.	0-7	3	BCCH D/L
NCC_PERMITTED	Bit map of NCCs for which the MS is permitted to report measurement results. Bit map relates to NCC part of BSIC.	-	8	BCCH D/L
CELL_BAR_ACCESS	See table 1a.	0/1	1	BCCH D/L
CELL_BAR_QUALIFY	See table 1a	0/1	1	BCCH D/L
CELL_RESELECT_PARAM_IND	Indicates the presence of C2 cell reselection parameters (1 = parameters present)	0/1	1	BCCH D/L
CELL_RESELECT_OFFSET	Applies an offset to the C2 reselection criterion. 0 - 126 dB, 2 dB steps, i.e. 0 = 0 dB, 1 = 2 dB, etc.	0-63	6	BCCH D/L
TEMPORARY_OFFSET	Applies a negative offset to C2 for the duration of PENALTY_TIME. 0 - 60 dB, 10 dB steps i.e. 0 = 0 dB,. 1 = 10 dB, etc. and 7 = infinity	0-7	3	BCCH D/L
PENALTY_TIME	Gives the duration for which the temporary offset is applied. 20 to 620 s, 20 s steps, i.e. 0 = 20 s, 1 = 40 s, etc. 31 is reserved to indicate that CELL_RESELECT_OFFSET is subtracted from C2 and TEMPORARY_OFFSET is ignored.	0-31	5	BCCH D/L

Table 1a: Parameters affecting cell priority for cell selection

CELL_BAR QUALIFY	CELL_BAR ACCESS	Cell selection priority	Status for cell reselection
0	0	normal	normal
0	1	barred	barred
1	0	low	normal (see note 2)
1	1	low	normal (see note 2)

If all the following conditions are met, then the "Cell selection priority" and the "Status for cell reselection" shall be set to normal:

- the cell belongs to the MS HPLMN;
- the MS is in cell test operation mode;
- the CELL_BAR_ACCESS is set to "1";
- the CELL_BAR_QUALIFY is set to "0";
- the Access Control class 15 is barred.

NOTE 1: A low priority cell is only selected if there are no suitable cells of normal priority (see GSM 03.22).

NOTE 2: Two identical semantics are used for cross phase compatibility reasons. This allows an operator to declare a cell always as a low priority one for a phase 2 MS, but keeps the opportunity for an operator to decide whether a phase 1 MS is permitted to camp on such a cell or not.

Table 2: Handover and power control parameters - slow ACCH

Parameter name	Description	Range	Bits	Message
MS_TXPWR_REQUEST (ordered MS power level)	The power level to be used by an MS	0-31	5	L1 header downlink
MS_TXPWR_CONF. (actual MS power level)	Indication of the power level in use by the MS.	0-31	5	L1 header uplink
POWER_LEVEL	The power level to be used by an MS on the indicated channel	0-31	5	HO/assignment command
RXLEV_FULL_SERVING_CELL	The RXLEV in the current serving cell accessed over all TDMA frames	0-63	6	Measurement results
RXLEV_SUB_SERVING_CELL	The RXLEV in the current serving cell accessed over a subset of TDMA frames	0-63	6	Measurement results
RXQUAL_FULL_SERVING_CELL	The RXQUAL in the current serving cell, assessed over all TDMA frames.	0-7	3	Measurement results
RXQUAL_SUB_SERVING_CELL	The RXQUAL in the current serving a cell, assessed over subset of TDMA frames.	0-7	3	Measurement results
DTX_USED	Indicates whether or not the MS used DTX during the previous measurement period.	-	1	Measurement results
BA_USED	Value of BA_IND for BCCH allocation used	0/1	1	Measurement results
RXLEV_NCELL_(1-6)	The RXLEV assessed on BCCH carrier as indicated in the BCCH Allocation	0-63	6	Measurement results
BCCH_FREQ_NCELL_(1-6)	The BCCH carrier RF channel number in NCELL.	0-31	5	Measurement results
BSIC_NCELL_(1-6)	Base station identification code for NCELL.	0-63	6	Measurement results
MULTIBAND_REPORTING	Indication of the number of cells to be reported for each band in multiband operation.	0-3	2	BACCH D/L and SACCH D/L

NOTE 1: RXLEV and RXQUAL fields are coded as described in clause 8.

NOTE 2: BCCH_FREQ_NCELL_(1-6) is coded in accordance with GSM 04.08 as the position in the list of BA carriers which is arranged in increasing numerical order according to the absolute RF channel number. The lowest position is coded 0.

NOTE 3: For the details of the Measurement Result message see GSM 04.08.

10 spare

Annex A (informative): Definition of a basic GSM or DCS 1 800 handover and RF power control algorithm

A.1 Scope

This annex specifies a basic overall handover algorithm and RF power control process that may be implemented in the GSM or DCS 1 800 system.

The specification includes a set of algorithms that are sufficient to allow the successful implementation of an initial GSM or DCS 1 800 system, and from which more complex algorithms may be developed.

The basic solution is not mandatory for network operators.

A.2 Functional requirement

The present algorithm is based on the following assumptions:

- Single cell BSS.

- The necessity to make a handover according to radio criteria is recognized in the BSS. It can lead to either an (internal) intracell handover or an intercell handover.

- Evaluation of a preferred list of target cells is performed in the BSS.

- Cell allocation is done in the MSC.

- Intracell handover for radio criteria (interference problems) may be performed directly by the BSS.

- The necessity to make a handover because of traffic reason (network directed handover) is recognized by the MSC and it is performed by sending a "handover candidate enquiry message" to BSS.

- The RF power control algorithm shall be implemented in order to optimize the RF power output from the MS (and BSS if power control is implemented) ensuring at the same time that the level received at the BSS (MS) is sufficient to keep adequate speech/data quality.

- All parameters controlling the handover and power control processes shall be administered on a cell by cell basis by means of O&M. The overall handover and power control process is split into the following stages:

  i) BSS pre-processing and threshold comparisons.
  ii) BSS decision algorithm.
  iii) MSC cell allocation algorithm.

A BSS decision algorithm is specified such that the BSS can fulfil the mandatory requirement of being able to produce a preferred list of target cells for handover.

It should be noted that since measurement results can also be sent to the MSC in the "handover required" message, the handover decision algorithm may be implemented in either the MSC or the BSS.

A.3 BSS pre-processing and threshold comparisons

For the purpose of handover and RF power control processing, the BSS shall store the parameters and thresholds shown in table A.1. These shall be administered on a cell by cell basis and downloaded to the BSS by O&M procedures.

The parameters and thresholds related to the downlink power control process are stored and used only if BSS RF power control is implemented.

The following measurements shall be continuously processed in the BSS:

i) Measurements reported by MS on SACCH:
- Down link RXLEV;
- Down link RXQUAL;
- Down link surrounding cell RXLEV (RXLEV_NCELL (n) on BCCH as indicated in the BCCH Allocation).

ii) Measurements performed in BTS:
- Uplink RXLEV;
- Uplink RXQUAL;
- MS-BTS distance;
- Interference level in unallocated time slots.

Every SACCH multiframe (480 ms) a new processed value for each of the measurements shall be calculated.

A.3.1 Measurement averaging process

The BSS shall be capable of pre-processing the measurements by any of the following processes:

- Unweighted average;
- Weighted average, with the weightings determined by O&M;
- Modified median calculation, with exceptionally high and low values (outliers) removed before the median calculation.

The timing of the processing shall be controlled by parameters, set by O&M, as follows:

a) RXLEV_XX (XX = DL or UL):
For every connection and for both links at least the last 32 samples shall be stored (a sample is the value evaluated by the MS and BSS during a period of 480 ms). Every 480 ms, with these samples, the BSS shall evaluate the averaged value of the received power as defined by the parameters Hreqave and Hreqt, applicable to RXLEV.

b) RXLEV_DL on BCCH carriers (RXLEV_NCELL (n)):
For every connection and for each of up to 16 defined cells the BSS shall store the values related to the last 32 samples. The BSS shall average these samples as defined by the parameters Hreqave, Hreqt, applicable to RXLEV.

c) RXQUAL_XX (XX = DL or UL):
For every connection and for both links at least 32 samples shall be stored (a sample is the value calculated by the MS and BSS during period of 480 ms). Every 480 ms, with these samples, the BSS shall evaluate the received signal quality as defined by the parameters Hreqave and Hreqt, applicable to RXQUAL.

d) MS-BTS distance:
For every connection the BSS shall average the adaptive frame alignment value as defined by the parameters Hreqave and Hreqt, to derive an estimate of the MS-BTS distance.

e) Interference level in unallocated time slots:
The BSS shall average the interference level in unallocated timeslots as defined by the Intave parameter. The averaged results shall be mapped into five interference categories (see GSM 08.08) whose limit O-X5 are adjusted by O&M.

f) Power Budget:
This assessment process may be employed by the network as a criterion in the handover process, by setting a flag in the BSS by O&M command. If the process is employed, every 480 ms, for every connection and for each of allowable 32 adjacent cells, the BSS shall evaluate the following expression:

PBGT(n) = (Min(MS_TXPWR_MAX,P) - RXLEV_DL - PWR_C_D) - (Min(MS_TXPWR_MAX(n),P) - RXLEV_NCELL(n))

Where the values of RXLEV_NCELL(n) and RXLEV_DL are obtained with the averaging processes defined above. PWR_C_D is the difference between the maximum downlink RF power permitted in the cell and the actual downlink power due to the BSS power control. MS_TXPWR_MAX is the maximum RF TX power an MS is permitted to use on a traffic channel in the serving cell. MS_TXPWR_MAX (n) is the maximum RF TX power an MS is permitted to use on a traffic channel in adjacent cell n. P is the maximum TX power capability of the MS.

g) Hreqave and Hreqt:
The values of Hreqt and Hreqave are defined by O&M for each cell for the averaging of reported measurements. The values of Hreqave and Hreqt can be different for each of the parameters being averaged.

Hreqave:
defines the period over which an average is produced, in terms of the number of SACCH blocks containing measurement results, i.e. the number of measurements contributing to each averaged measurement.

Hreqt:
is the number of averaged results that are maintained.

The BSS shall support values of Hreqave and Hreqt such that

0 < Hreqav < 32
and 0 < Hreqt < 32

where Hreqave * Hreqt < 32

A.3.2 Threshold comparison process

A.3.2.1 RF power control process

Every SACCH multiframe, the BSS shall compare each of the processed measurements with the relevant thresholds. The threshold comparison processes and the actions to be taken are as follows:

a) Comparison of RXLEV_XX with L_RXLEV_XX_P (XX = DL or UL)

The algorithm shall be applied to the averaged RXLEV values (defined in subclause A.3.1:a). The comparison process shall be defined by the parameters P1 and N1 as follows:

- Increase XX_TXPWR if at least P1 averages out of N1 averages are lower than L_RXLEV_XX_P. (e.g. P1 = 10 and N1 = 12)

b) Comparison of RXLEV_XX with U_RXLEV_XX_P (XX = DL or UL)

The algorithm shall be applied to the averaged RXLEV values (defined in subclause A.3.1:a). The comparison process shall be defined by the parameters P2 and N2 as follows:

- Decrease XX_TXPWR if at least P2 averages out of N2 averages are greater than U_RXLEV_XX_P. (e.g. P2 = 19 and N2 = 20)

c) Comparison of RXQUAL_XX with L_RXQUAL_XX_P (XX = DL or UL)

The algorithm shall be applied to the averaged RXQUAL values (defined in subclause A.3.1:c) The comparison process shall be defined by the parameters P3 and N3 as follows:

- Increase XX_TXPWR if at least P3 averaged values out of N3 averaged values are greater (worse quality) than L_RXQUAL_XX_P. (e.g. P3 = 5 and N3 = 7)

d) Comparison of RXQUAL_XX with U_RXQUAL_XX_P (XX = DL or UL) The algorithm shall be applied to the averaged RXQUAL values (defined in subclause A.3.1:c) The comparison process shall be defined by the parameters P4 and N4 as follows:
   - Decrease XX_TXPWR if at least P4 averaged values out of N4 averaged values are lower (better quality) than U_RXQUAL_XX_P. (e.g. P4 = 15, N4 = 18)

A.3.2.2 Handover Process

Every SACCH multiframe, the BSS shall compare each of the processed measurements with the relevant thresholds. The threshold comparison processes and the actions to be taken are as follows:

a) Comparison of RXLEV_XX with L_RXLEV_XX_H (XX = DL or UL)

   The algorithm shall be applied to the averaged RXLEV values (defined in subclause A.3.1:a). The comparison process shall be defined by the parameters P5 and N5 as follows:

   - If at least P5 averaged values out of N5 averaged values are lower than L_RXLEV_XX_H a handover, cause XX_RXLEV, might be required. (e.g. P5 = 10 and N5 = 12).

b) Comparison of RXQUAL_XX with L_RXQUAL_XX_H (XX = DL or UL)

   The algorithm shall be applied to the averaged RXQUAL values (defined in subclause A.3.1:c) The comparison process shall be defined by the parameters P6 and N6 as follows:

   - If at least P6 averaged values out of N6 averaged values are greater (worse quality) than L_RXQUAL_XX_H a handover, cause XX_RXQUAL, might be required. (e.g. P6 = 5 and N6 = 7).

c) Comparison of RXLEV_XX with RXLEV_XX_IH (XX= DL or UL)

   The algorithm shall be applied to the averaged RXLEV values (defined in subclause A.3.1:a). The comparison process shall be defined by the parameters P7 and N7 as follows:

   - If at least P7 averaged values out of N7 averaged values are greater than RXLEV_XX_IH an internal handover might be required if RXQUAL_XX is also greater (worse quality) than L_RXQUAL_XX_H (e.g. P7 = 10 and N7 = 12).

d) Comparison of MS-BTS distance with the MAX_MS_RANGE

   This comparison process may be employed by the network as a criterion in the handover process by setting a flag in the BSS by O&M. If the process is employed, the algorithm shall be applied to the averaged values defined in subclause A.3.1:d. The comparison process shall be defined by the parameters P8 and N8 as follows:

   - If at least P8 averaged values out of N8 values are greater than MS_RANGE_MAX a handover, cause DISTANCE, might be required. (e.g. P8 = 8 and N8 = 10).

e) Comparison of PBGT(n) with the HO_MARGIN(n)

   If the process is employed, the action to be taken is as follows:

   - If PBGT(n) > O and PBGT(n) > HO_MARGIN(n) a handover, cause PBGT(n), might be required.

   This comparison enables handover to be performed to ensure that the MS is always linked to the cell with the minimum path loss, even though the quality and level thresholds may not have been exceeded.

A.4 BSS decision algorithm

Recognizing the necessity to request a handover the BSS shall send a "handover required message" to the MSC containing the preferred list of target cells.

The "handover required message" shall be also generated in answer to a "handover candidate enquiry message" sent by the MSC.

The BSS decision algorithm shall be based on the following strategy:

RXLEV_NCELL(n) > RXLEV_MIN(n) + Max (O, Pa) (1)

where: Pa = (MS_TXPWR_MAX(n)-P)

(Min(MS_TXPWR_MAX,P) - RXLEV_DL - PWR_C_D) -(Min(MS_TXPWR_MAX(n),P) - RXLEV_NCELL(n)) - HO_MARGIN(n) > 0 (2)

All these expressions shall be evaluated using the averaged values defined by the parameters Hreqt and Hreqave.

The BSS shall evaluate the equation (2) for each of the adjacent cells that satisfies the expression (1) and shall compile the list of the preferred adjacent cells ordinated depending on the value of equation (2) (i.e. in the first position is the cell for which the value is the maximum, in the second position is the cell with the second best value and so on).

If there are any adjacent cells for which the values of RXLEV_MIN(n), HO_MARGIN(n) and MS_TXPWR_MAX(n) are not known, i.e. the MS has reported values from an undefined adjacent cell, then the default parameters shall be used to evaluate equations 1 and 2, i.e. RXLEV_MIN_DEF, HO_MARGIN_DEF, MS_TXPWR_MAX_DEF. This enables handover to occur in situations where a call is set up in unexpected coverage area of a cell, without defined adjacent cells.

If there are several cells that satisfy the equation (2) with the same results, the first cell in the list will be that one with the best "positive trend". The trend shall be evaluated by the BSS using the last Hreqt averaged values of RXLEV_NCELL(n).

If the handover is considered imperative, that is one of the following events is verified as the cause:

a) The power level (UL and/or DL) is below the thresholds despite power control (the MS or/and the BSS have reached the maximum allowed power).

b) The quality of the link (UL and/or DL) is below the threshold while at the same time the RXLEV approximates the threshold.

c) The distance between MS and BTS exceeds the MAX_MS_RANGE.

The list of the preferred cells shall be compiled including any candidates for which the result of the equation (2) is lower than 0. Also in this case the list shall be compiled in a decreasing order of priority.

A.4.1 Internal intracell handover according to radio criteria: (Interference problems)

The two conditions RXQUAL_XX > L_RXQUAL_XX_H (bad quality) and RXLEV_XX > RXLEV_XX_IH, if verified at the same time, indicate a high probability of the presence of co-channel interference.

This situation can be solved by changing the channel within the cell with an intracell handover.

If internal intracell handover is supported by the BSS it shall be performed as described in GSM 08.08.

If the BSS does not support internal intracell handover, then the handover shall be initiated by sending a "handover required message" to the MSC in which the serving cell is indicated as first priority.

A.4.2 Internal handover according to other criteria

Apart from radio criteria there are other criteria that may require internal handover:

- O&M criteria;
- Resource management criteria.

In these cases, internal handover shall be triggered by the OMC or by the resource management of the BSS.

A.4.3 General considerations

Since the RF power control process and the handover process are closely linked, particular care shall be taken in order to avoid undesired interactions between them.

In particular, the following interactions should be avoided, where possible:

- A "power increase command" or a "handover for RXLEV or for RXQUAL" subsequent to a "power reduction command" (e.g. by checking that the averaged power level reduced by the Pow_Red_Step_Size plus the tolerances is greater than the L_RXLEV_XX_P or L_RXLEV_XX_H).

- A "power reduction command" subsequent to a "power increase command".

After an action of power control the set of samples related to the previous power level, in the corresponding link, shall not be used in the processing.

If, during the decision process, the condition for the "handover required message" is satisfied at the same time by different reasons. The "cause field" in the "handover required message" sent to the MSC, shall contain the reasons taking account of the following order of priority:

- RXQUAL;
- RXLEV;
- DISTANCE;
- PBGT.

A.5 Channel allocation

As described in GSM 08.08 the available channels shall be divided into five interference categories whose limits O-X5 are adjusted by O&M command.

For handover, the channel allocated should be from the category with the lowest interference level, since determination of the expected value of C/I is not possible by the new BSS.

A.6 Handover decision algorithm in the MSC

The MSC shall select the cell to which an MS is to be handed over by the following criteria:

- Handover for radio criteria shall be handled taking into account the following order of priority:

    - RXQUAL;
    - RXLEV;
    - DISTANCE;
    - PBGT.

e.g. if there are more handover bids to a cell than there are free traffic channels, then the bids with cause "RXQUAL" shall take highest priority.

- In order to avoid overload in the network, for every cell and with reference to each of 16 adjacent cells, it shall be possible to define (by O&M) for each adjacent cell one of at least 8 priority levels. These shall be considered together with the list of candidates and the interference levels in the choice of the new cell. For example, if there are two cells which meet the criteria for handover, then the cell with the highest priority shall be used. This enables umbrella cells, for instance, to be given a lower priority, and only handle calls when no other cell is available.

- Channel congestion on the best cell shall cause the choice of the second best cell, if available, and so on. If no cell is found and call queuing is employed in the MSC, then the MSC shall queue the request on the best cell for a period equal to H_INTERVAL (H_INTERVAL < T_Hand_RQD shall be set by O&M). This handover shall have priority over the queue handling new calls.

Table A.1: Parameters and thresholds stored for handover purposes

L_RXLEV_UL_P	RXLEV threshold on the uplink for power increase. Typical range - 103 to - 73 dBm.
U_RXLEV_UL_P	RXLEV threshold on the uplink for power reduction.
L_RXQUAL_UL_P	RXQUAL threshold on the uplink for power increase.
U_RXQUAL_UL_P	RXQUAL threshold on the uplink for power reduction.
L_RXLEV_DL_P	RXLEV threshold on the downlink for power increase. Typical range - 103 to - 73 dBm.
U_RXLEV_DL_P	RXLEV threshold on the downlink for power reduction.
L_RXQUAL_DL_P	RXQUAL threshold on the downlink for power increase.
U_RXQUAL_DL_P	RXQUAL threshold on the downlink for power reduction.
L_RXLEV_UL_H	RXLEV threshold on the uplink for handover process to commence. Typical range - 103 to - 73 dBm.
L_RXQUAL_UL_H	RXQUAL threshold on the uplink for handover process to commence.
L_RXLEV_DL_H	RXLEV threshold on the downlink for handover process to commence. Typical range - 103 to - 73 dBm.
L_RXQUAL_DL_H	RXQUAL threshold on the downlink for handover process to commence.
MS_RANGE_MAX	Threshold for the maximum permitted distance between MS and current BTS. Range (2, 35 Km); step size 1.0 Km.
RXLEV_UL_IH	RXLEV threshold on uplink for intracell (interference) handover. Typical range - 85 to - 40 dBm.
RXLEV_DL_IH	RXLEV threshold on downlink for intracell (interference) handover; typical range - 85 to - 40 dBm.
RXLEV_MIN(n)	Minimum RXLEV required for an MS to be allowed to handover to cell "n".
RXLEV_MIN_DEF	Default value of RXLEV_MIN, used to evaluate handover to undefined adjacent cells.
HO_MARGIN(n)	A parameter used in order to prevent repetitive handover between adjacent cells. It may be also used as a threshold in the power budget process. Range (0, 24 dB); step size 1 dB.
HO_MARGIN_DEF	Default value of HO_MARGIN, used to evaluate handover to undefined adjacent cells.
N_CELL list	List of allowable adjacent cells for handover. Range (0, 32).
MS_TXPWR_MAX	Maximum TX power a MS may use in the serving cell. Range (5, 39 dBm) for GSM and (0,36 dBm) for DCS 1 800; step size 2 dB.
MS_TXPWR_MAX(n)	Maximum TX power a MS may use in the adjacent cell "n". Range (5, 39 dBm) for GSM and (0,36 dBm) for DCS 1 800; step size 2 dB.
MS_TXPWR_MAX_DEF	Default value of MS_TXPWR_MAX, used to evaluate handover to undefined adjacent cells.
BS_TXPWR_MAX	Maximum TX power used by the BTS.
O .X5	Boundary limits of five interference bands for the unallocated time slots. Typical range -115 to -85 dBm. (See GSM 08.08).
Hreqave	RXLEV, RXQUAL and MS_BTS Distance averaging periods defined in terms of number of SACCH multiframes. Range (1, 31); step size 1.
Hreqt	The number of averaged results that can be sent in a "handover required message" from BSS to MSC. Range (1, 31); step size 1.
Intave	Interference averaging period defined in terms of the number of SACCH multiframes. Range (1, 31); step size 1.
N1..N8,P1..P8	The number of samples used in the threshold comparison processes. Range (1, 31); step size 1.
P_Con_INTERVAL	Minimum interval between changes in the RF power level. Range (0, 30 s) step size 0.96 s.
T_Hand_RQD	Minimum interval between handover required messages related to the same connection. Range (0, 30 s); step size 0.96 s.
Pow_Incr_Step_Size	Range 2, 4 or 6 dB.
Pow_Red_Step_Size	Range 2 or 4 dB.
Number of Ranges (NR)	Number of ranges in BA_RANGE indicating the number of ranges of ARFCNs containing BCCH carriers for use as stored BCCH information.
RANGEi_LOWER	Lowest ARFCN in the ith range of carriers containing BCCH carriers for use as stored BCCH information.
RANGEi_HIGHER	Highest ARFCN in the ith range of carriers containing BCCH carriers for use as stored BCCH information.

All thresholds shall be able to take any value within the range of the parameter to which they apply. Typical operating ranges are given for some thresholds.

Annex B (informative): Power Control Procedures

Power control is important for spectrum efficiency as well as for power consumption in a cellular system. For good spectrum efficiency quality based power control is required. Power control for a packet oriented connection is more complicated than for a circuit switched connection, since there is no continuos two-way connection.

The power control formula for the MS is specified in subclause 6.5.8.1 (formula 1):

$$P = \Gamma_{CH} - \alpha C \qquad \text{(all power calculations in dB)}$$

This is a flexible tool that can be used for different power control algorithms. For the BTS, there is no need to specify any algorithm, but a similar formula can be used. The following are examples of possible algorithms for uplink power control:

- Open loop control.
  With this method the output power is based on the received signal strength assuming the same path loss in uplink and downlink. This is useful in the beginning of a packet transmission.

- Closed loop control.
  With this method the output power is commanded by the network based on signal strength measurements made in the BTS in a similar way as for a circuit switched connection.

- Quality based control.
  This method can be used in combination with any of the two methods above.

B.1 Open loop control

A pure open loop is achieved by setting $\alpha = 1$ and keeping Γ_{CH} constant. The output power will than be:

$$P = \Gamma_{CH} - C$$

The value Γ_{CH} can be calculated as follows to give a target value for the received signal, SS_b, at the BTS.

The received signal strength at the MS:

$$SS_m = P_{BTS} - P_b - L$$

where P_{BTS} = BTS maximum output power
P_b = BTS power reduction due to power control (transferred to MS)
L = path loss

The C value (normalised signal strength):

$$C = SS_m + P_b = P_{BTS} - L$$

The MS output power: $P = \Gamma_{CH} - C = \Gamma_{CH} - P_{BTS} + L$

The received signal strength at the BTS:

$$SS_b = P - L = \Gamma_{CH} - P_{BTS}$$

The constant value of Γ_{CH}:

$$\Gamma_{CH} = P_{BTS} + SS_b$$

B.2 Closed loop control

A pure closed loop is achieved by setting $\alpha = 0$. The output power will than be:

$$P = \Gamma_{CH}$$

In this case, Γ_{CH} is the actual power level commanded by network. It can be based on the received signal level measured at the BTS. Power control commands can be sent when required in order to achieve the target received signal strength.

B.3 Quality based control.

In order to achieve the best performance the power control should be quality based. The algorithm must also consider the path loss for stability. The algorithm is not specified, it is the responsibility of the manufacturer and/or the operator.

An example of a quality based power control algorithm is:

$$P_{n+1} = P_{max} - \alpha\, ((C/I_n - C/I_{min}) - (P_n - P_{max})) = P_{ref} - \alpha\, (C/I_n - P_n)$$

where
- P is the output power from the MS.
- C/I is the received carrier to interference value at the BTS.
- P_{max}, C/I_{min} and P_{ref} are reference values.
- α is a weighting factor.
- n is the iteration index.

In the closed loop case, this formula determines Γ_{CH}:

$$\Gamma_{CH} = P_{n+1}\ .$$

For the open loop case, we rewrite the formula. The carrier to interference can be written:

$$C/I = C_{BTS} - I_{BTS} = P - L - I_{BTS}$$

where
- C_{BTS} is the received signal level at the BTS.
- I_{BTS} is the received interference level at the BTS.

thus $P_{n+1} = P_{ref} - \alpha\, (P_n - L_n - I_{BTS,n} - P_n) = P_{ref} + \alpha\, (L_n + I_{BTS,n})$

As shown above, the path loss is:

$$L = P_{BTS} - C$$

The formula can therefore be written as (dropping the iteration index):

$$P = P_{ref} + \alpha\, (P_{BTS} - C + I_{BTS}) = \Gamma_{CH} - \alpha\, C$$

Thus, for the open loop case:

$$\Gamma_{CH} = P_{ref} + \alpha\, (P_{BTS} + I_{BTS})$$

The interference level I_{BTS} is measured in the BTS. The parameter Γ_{CH} is estimated based on these measurements, considering the appropriate weighting factor α, and the known parameters P_{ref} and P_{BTS}. The Γ_{CH} values are transferred to the MS in the Packet Assignment command, the Ack/Nack messages or in Power Control commands.

B.4 BTS power control

The same algorithm as above can be used for downlink power control. The formula for quality based control in the MS

$$P_{n+1} = P_{ref} + \alpha\, (L_n + I_{BTS,n})$$

can be written for the BTS as:

$$Pd_{n+1} = P_{ref} + \alpha\, (L_n + \gamma_{CH,n})$$

where
- Pd is the BTS output power (equal to $P_{BTS} - P_b$).
- γ_{CH} is the received interference level at the MS.

Substituting the path loss and dropping the iteration index gives:

$$P_d = P_{ref} + \alpha (P_{BTS} - C + \gamma_{CH})$$

The received signal C and interference γ_{CH} is measured in the MS and transferred to the BTS, which can calculate the output power.

B.5 Example

Figure B.1 illustrates an example of the uplink power control function.

In the wait state, the MS measures the C value on PPCH with an intensity of N_{AVG} measurements per T_{AVG_W} multiframes. Meanwhile, the BSS measures the interference of the candidate PDCHs in order to have Γ_{CH} values ready for the first transfer period. This is transferred to the MS in the Packet Assignment command.

In the transfer state, the MS measures the C value on the assigned PDCHs and updates its output power once every T_{AVG_T} multiframe. The BSS updates the MS specific Γ_{CH} values at the same rate. The updated Γ_{CH} values are transferred to the MS in the Ack/Nack messages or in Power Control commands only when needed, i.e. when the interference level has changed.

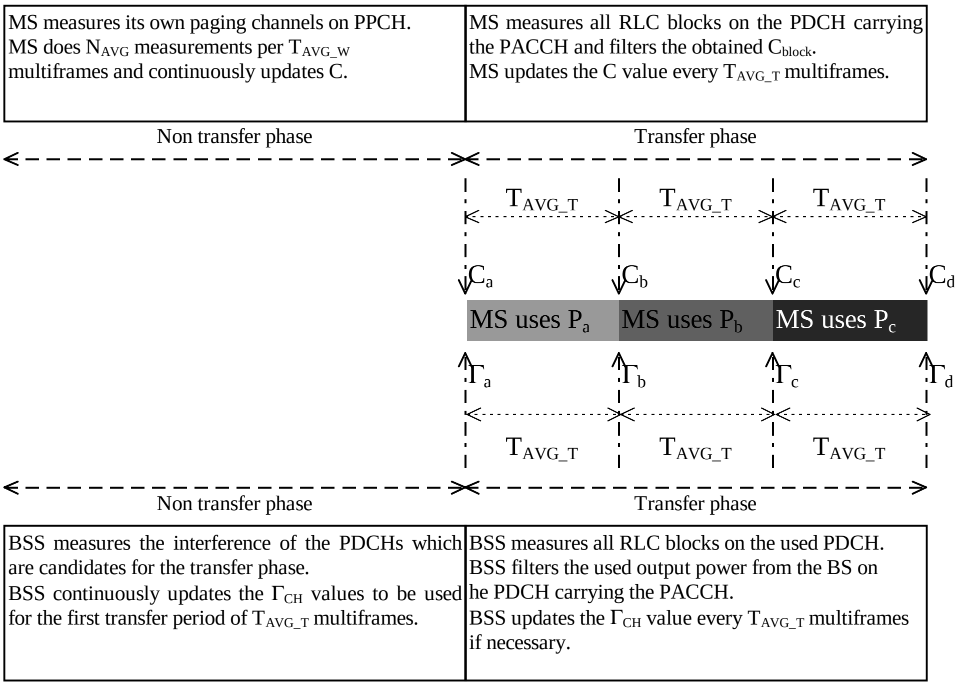

Figure B.1: Traffic example of uplink power control

Figure B.2 illustrates an example of the downlink power control function.

In the Wait state, the MS measures the C value on PPCH with an intensity of N_{AVG} measurements per T_{AVG_W} multiframes and the γ_{CH} values on some candidate PDCHs with an intensity of N_{AVG_I} measurements per T_{AVG_I} multiframes. These values are transferred to the BTS in the Packet Paging Response, and used to calculate the output power for the first transfer period.

In the Transfer state, the MS measures the C value on the PDCH where the MS transmits PACCH and the γ_{CH} values on all channels on the same carrier. These are transferred to the BTS in the Ack/Nack messages. The BSS then updates the output power.

If the Packet Paging Response is not sent, the BTS may use the maximum power for the first transfer period. In this case the polling for Ack/Nack should be set as soon as possible to get the measured values.

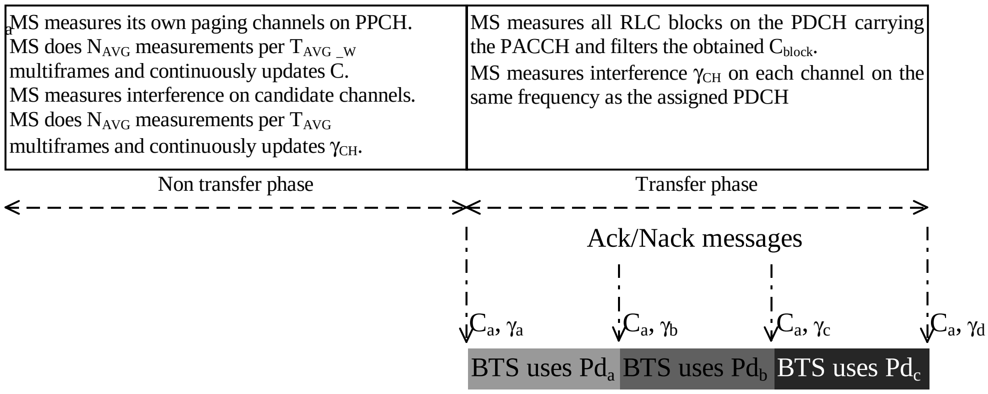

Figure B.2: Traffic example of downlink power control

History

Document history			
December 1996	Unified Approval Procedure	UAP 60:	1996-12-02 to 1997-04-11
March 1997	One-step Approval Procedure (Second Edition)	OAP 9729:	1997-03-21 to 1997-07-18
May 1997	First Edition		
July 1997	One-step Approval Procedure (Third Edition)	OAP 9747:	1997-07-21 to 1997-11-28
August 1997	Second Edition		
December 1997	Third Edition		
January 1998	One-step Approval Procedure (Fourth Edition)	OAP 9822:	1998-01-30 to 1998-05-29
June 1998	Fourth Edition		

ISBN 2-7437-2216-9
Dépôt légal : Juin 1998