User Description, Idle Mode Behaviour

Contents

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1 Introduction

A powered on mobile station (MS) that does not have a dedicated channel allocated is defined as being in idle mode. While in idle mode it is important that the mobile is both able to access and be reached by the system.

When a mobile is powered on, it immediately attempts to make contact with a GSM Public Land Mobile Network (PLMN). (In GSM 1900 systems the PLMN is known as PCN.) The particular PLMN contacted may be selected either automatically or manually. The MS will look for and select a suitable cell of the chosen PLMN. It will then tune to the control channel of the cell to receive information about the available services provided by the PLMN. This selection is known as “camping” on a cell. When an MS is in idle mode it will always try to camp on the best cell according to a signal strength based criterion.

The idle mode behaviour is managed by the MS. It can be controlled by parameters which the MS receives from the base station on the Broadcast Control Channel (BCCH). All of the main controlling parameters for idle mode behaviour are transmitted on the BCCH carrier in each cell. These parameters can be controlled on a per cell basis.

Moreover, to be able to access the system from anywhere in the network, regardless of where the MS was powered on/off, it has to be able to select a specific GSM base station, tune to its frequency and listen to the system information messages transmitted in that cell. It must also be able to register its current location to the network so that the network knows where to route incoming calls.

The PLMN selection mechanism, the cell selection and reselection algorithms in addition to the location updating procedure are the core of the idle mode behaviour. The purpose is to always ensure that the mobile is camped on the cell where it has the highest probability of successful communication.

1.1 What can be achieved

1.1.1 High probability for successful communication

The MS will at all times try to camp on the cell which has the highest probability of successful communication on both up- and downlink when accessing the system. This is achieved by means of the idle mode cell selection and reselection algorithms. These algorithms enable the MS to choose the most suitable cell to camp on, based on mainly signal strength. A cell is suitable if certain criteria, listed in Section 2.3.2 on page 10, are satisfied. Camping on the most suitable cell provides the MS with a high probability of good communication with the system.

The cell selection and reselection algorithms are governed by parameter settings. Using these parameters an operator can, on a per cell basis, make a specific cell more or less attractive to camp on for the MS. This makes it possible for the operator to achieve similar behaviour for MSs in idle mode as in dedicated mode. Well-designed parameter settings for cell selection and reselection in idle mode, will cause the MS to camp on the cell that would have been chosen if the MS had been in dedicated mode.

1.1.2 Control of the paging load

In idle mode the MS will notify the network when it changes location area by the location updating procedure. Thus, the network will be kept updated concerning which location area the MS is presently in. When the system receives an incoming call it knows in which location area it should page the MS, and does not need to page the MS throughout the whole MSC service area. This reduces the load on the system. If the MS does not respond to the first paging message, then the network can send a second paging message. Different paging strategies are described in Section 2.7.2 on page 21.

The MS can also, periodically and when powered on or off, notify the network of its present status by the location updating procedure, see Section 2.5 on page 17. This prevents the network from doing unnecessary pagings of MSs that have been powered off or have left the coverage area. This would otherwise cause unnecessary load on the system.

1.1.3 Low idle mode power consumption

In idle mode, the MS only occasionally monitors the system information being transmitted in the current cell, listens to its paging group or does measurements on neighbouring cells to see if a cell change should be initiated. However, most of the time it will be in “sleep mode”. Hence, the power consumption during idle mode will be low. This is also referred to as discontinuous reception (DRX).

2 Technical Description

2.1 General

While the MS is in idle mode it will continuously make measurements on the BCCH-carriers of serving and neighbouring cells to decide on which cell to camp on. It will also, if necessary, register its presence in the location area of the chosen cell by performing a location updating.

The purpose of camping on a cell is threefold:

1 it enables the MS to receive system information from the network,

2 the MS can initiate a call by accessing the network on the Random Access Channel (RACH) of the cell on which it is camped,

3 the network will know the location area of the cell in which the MS is camped (unless the MS has entered a limited service state as described in Section 2.4.3 on page 16) and can therefore page the MS when an incoming call is received.

The idle mode task can be subdivided into four processes:

- PLMN selection
- Cell selection
- Cell reselection
- Location updating.

The relationship between these processes is illustrated in Figure 1 on page 8 .

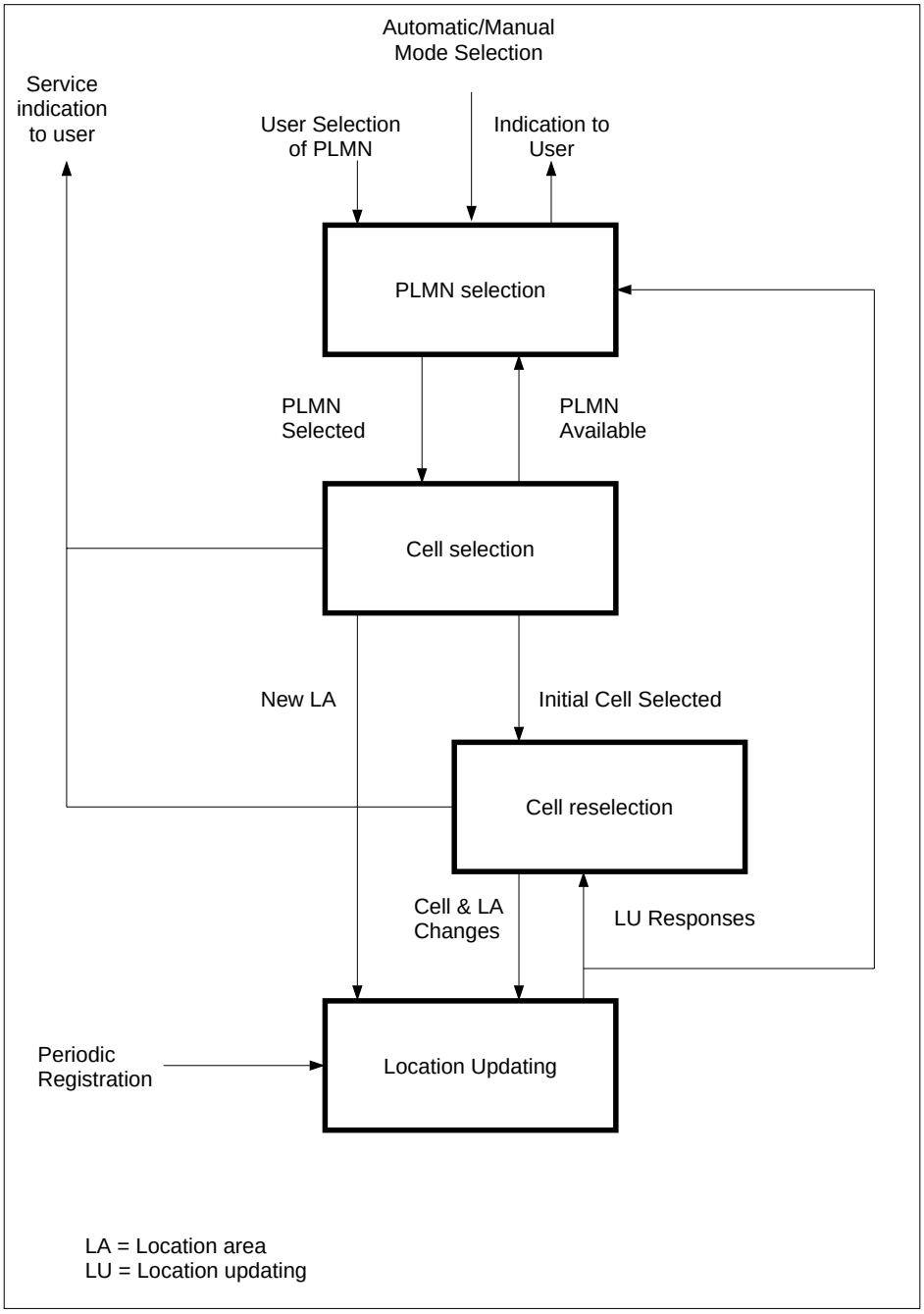

Figure 1 Overall idle mode processes

The concepts in Figure 1 on page 8 as well as the overall idle mode processes are explained in Section 2.2 on page 8 to Section 2.5 on page 17.

2.2 PLMN selection

2.2.1 General

The MS will select a PLMN when it is powered on or upon recovery from a lack of coverage. It will first try to select and register to the last registered PLMN if one exists. If a registration on a PLMN is

successful, the MS shows this PLMN on its display (the “registered PLMN”) and it is now capable of making and receiving calls. If there is no last registered PLMN, or if it is unavailable, the MS will try to select another PLMN either automatically or manually depending on it operating mode, see below. The automatic mode utilises a list of PLMNs in an order of priority whereas the manual mode leaves the decision to the user and only shows which PLMNs that are available.

The MS normally operates on its home PLMN. Another PLMN may be selected if, for example the MS loses coverage. The MS will register on a PLMN if the MS finds a suitable cell to camp on and if a location updating request is accepted. Registration has to be successful in order for the MS to be able to access that network. However, the MS does not need to perform location updating if it is located in the same location area belonging to the same PLMN as it was before it entered the “inactive” state.

2.2.2 Automatic mode

In automatic mode, ***if no last registered PLMN exists or is available*** the MS will select a PLMN, if it is available and allowed, in the following order :

1 home PLMN

2 each PLMN that has been stored in the Subscriber Identity Module (SIM) in priority order

3 other PLMNs with received signal level above -85 dBm in random order

4 all other PLMNs in order of decreasing signal strength.

2.2.3 Manual mode

In manual mode, the MS will first try to select the registered PLMN or home PLMN if no last registered PLMN exists. If this registration fails or if the user has initiated a PLMN reselection the MS will indicate to the user all available PLMNs. The user can then select a desired PLMN which causes the MS to initiate a registration on this PLMN. If the selected PLMN is not allowed, an indication to the user to select another PLMN will be given.

The user can at any time request the MS to initiate reselection and registration onto an alternative PLMN if available. This is done either using automatic or manual mode, depending on the mode selected by the user.

2.2.4 National roaming

The MS can select and register on a PLMN of its home country other than its home PLMN if roaming is permitted. In this case, the MS shall periodically attempt to obtain service on its home PLMN. For this purpose, a value T minutes may be stored in the SIM, T is either in the range 6 minutes to 8 hours in 6 minute steps or it indicates that no periodic attempts shall be made. If no value is stored in the SIM, a default value of 30 minutes is used.

The attempts to access the home PLMN are performed as specified below:

1. the periodic attempts are only performed in automatic mode when the MS is roaming in its home country;
2. after power on, a period of at least 2 minutes and at most T minutes is elapsed before the first attempt is made;
3. the MS makes an attempt if it is on the visiting PLMN at time T after the last attempt;
4. periodic attempts are only to be performed by the MS while in idle mode;
5. if the home PLMN is not found, the MS remains on the visiting PLMN.

2.3 Cell selection

2.3.1 General

The cell selection algorithm tries to find the most suitable cell of the selected PLMN according to various requirements. If no suitable cell is found and all available and permitted PLMNs have been tried, the MS will try to camp on a cell irrespective of PLMN identity and enter a limited service state. In this state the MS will be able to make emergency calls only. If the MS loses coverage it will return to the PLMN selection state and select another PLMN.

Two different strategies can be used during cell selection; normal cell selection or stored list cell selection. Stored list cell selection utilises a stored BCCH Allocation (BA) list to speed up the cell selection procedure whereas normal cell selection is performed when no such list is available.

2.3.2 Algorithm

Normal cell selection

During normal cell selection, the MS will try to select the most suitable cell to camp on.

A cell is considered suitable if:

- it belongs to the selected PLMN,
- it is not barred (when a cell is barred it will not be camped on by an MS in idle mode but a MS in dedicated mode can perform handover to it),
- it does not belong to a location area included in the list of “forbidden location areas for roaming”,

  (Only valid for mobiles supporting GSM phase 2. National roaming may be allowed only to certain location areas of another PLMN than the home PLMN. The location areas that are forbidden will, after an attempt to do a location updating has failed, be stored in the SIM as forbidden location areas for

national roaming. This list will be cleared when the mobile is powered off or the SIM is removed.)

- the cell selection criterion is fulfilled.

When the MS has no information on which BCCH frequencies that are used in the network, the MS will search all RF channels in its supported frequency band/s (i.e. 124 channels in the primary GSM 900 band, 374 in GSM 1800, or 299 in GSM 1900), take measurement samples of the received RF signal strength and calculate the received average level for each. The average is based on at least five samples per RF carrier spread evenly over a 3 to 5 second period. The MS then tunes to the carrier with the highest average signal strength level and determines whether this carrier is a BCCH carrier by searching for the frequency correction burst sent on the Frequency Correction Channel (FCCH). If it is a BCCH carrier, then the MS tunes to that carrier to read the Synchronisation Channel (SCH) for the Base Station Identity Code (**BSIC**), and the BCCH for the system information messages, for example the BA list. If the data is successfully decoded and the cell is suitable, the MS camps on it and performs all registrations necessary. If at least the 30 strongest GSM 900 RF channels or 40 strongest GSM 1800 RF channels or 40 strongest GSM 1900 RF channels have been tried and no suitable cell was found, the MS will select another PLMN according to the PLMN selection procedure and search for suitable cells there. For multiband operation, RF channels from both frequency bands are evaluated during cell selection, see ref. 1.

If the MS finds a cell that is part of the selected PLMN but ***not*** suitable, the MS will use the BA list obtained from that cell and subsequently only search BCCH carriers included in the list. This will speed up the procedure to some extent.

The BA list is defined by the **MBCCHNO** parameter. It indicates to the MS the frequencies that must be monitored and measured both in idle and dedicated mode. It is possible to define separate lists for idle and dedicated mode as described in Double BA-lists, ref. 2. This document only considers the idle BA list. The BA list is sent to the MS, in idle mode, in the system information messages on the BCCH. Up to 32 BCCH carriers can be defined by specifying their ARFCN using the **MBCCHNO** parameter.

Cells can have two levels of priority; normal and low. Suitable cells that are of low priority are only camped on if there are no other suitable cells of normal priority. The priority of a cell is controlled by the Cell Bar Qualify parameter **CBQ** (only valid for mobiles supporting GSM phase 2), in conjunction with the Cell Bar Access, **CB**, parameter, see Table 1 on page 11.

Table 1 Behaviour of the MS for different combinations of CBQ and CB

CBQ	CB	At cell selection	At cell reselection
HIGH	NO	Normal	Normal
HIGH	YES	Barred	Barred
LOW	NO	Low	Normal
LOW	YES	Low	Normal

If the BCCH of a cell of low priority is found by the MS at cell selection, the MS will continue to search for a cell of normal priority. If no cells of normal priority are found then the best cell of low priority will be selected. It should be also noted that if **CBQ** is set to low, barred cells (**CB** = YES) may be camped on at cell selection and reselection.

Stored list cell selection

The MS may include optional storage of the BA list when it is powered off. This information is stored in the SIM. For example, the MS may store the BA list in use by the PLMN selected when the MS was last in idle mode or in dedicated mode in the GSM network.

If an MS includes a stored BA list of the selected PLMN, it will perform the same measurements as for normal cell selection except that only the BCCH carriers in the list will be scanned. The BA list for a given PLMN stored in the MS will be reset and updated whenever the MS retrieves new BCCH data from that PLMN. If a stored list cell selection is not successful, then normal cell selection takes place.

Cell selection criterion

While in idle mode, the MS continuously calculates the cell selection quantity, *C1*. (The name of this quantity in the GSM Technical Specifications is “path loss criterion parameter”. As the C1-criterion is based only on signal strength and not on path loss, the term used in this document is “cell selection quantity”.) The cell selection criterion is satisfied if *C1 > 0.*

The quantity C1 is calculated as follows:

$$C1 = (\textit{received signal level} - \textbf{ACCMIN}) - \max(\textbf{CCHPWR} - P, 0) \qquad (1)$$

where:

ACCMIN	is the cell parameter that indicates the minimum received signal level at the MS required for accessing the system.
CCHPWR	is the cell parameter that indicates the maximum transmitting power that an MS is allowed to use when accessing the system.
P	is the maximum power output of the MS according to its class.

The condition states that an MS must measure a signal strength higher than *ACCMIN* from a cell and that the MS must be able to transmit enough power in the uplink. Thus, the C1 criterion will limit access for MSs that receive high enough signal strength for successful downlink communication, but are weak in the uplink. If this is the case, the cell is probably not designed for MSs of that class.

For GSM 1900, the second part of Eq. 1 is always equal to zero. The reason is that only Class 1 mobiles are used in GSM 1900 systems.

2.4 Cell reselection

2.4.1 Algorithm

Cell reselection measurements

After a cell has been successfully selected, the MS will start the cell reselection tasks. It will continuously make measurements on its neighbouring cells to initiate cell reselection if necessary. For multiband MSs the strongest non-serving carriers may belong to different frequency bands.

The MS continuously monitors all neighbouring BCCH carriers, as indicated by the BA list, in addition to the BCCH carrier of the serving cell, to detect if it is more suitable to camp on another cell. At least five received signal level measurement samples are required for each defined neighbouring cell. A running average of the received signal level will be maintained for each carrier in the BA list.

All system information messages sent on BCCH must be read at least once every 30 seconds in order to monitor changes in cell parameters. The MS also tries to synchronise to and read the BCCH information that contains parameters affecting cell reselection for the six strongest non-serving carriers (in the BA list) at least every five minutes.

The MS also attempts to decode the **BSIC** parameter for each of the six strongest surrounding cells at least every 30 seconds, to confirm that it is still monitoring the same cells. The **BSIC** parameter consists of two parts; NCC, Network Colour Code and BCC, Base Station Colour Code. If another **BSIC** is detected, it will be treated as a new carrier and the BCCH data for this carrier will be determined. If the MS detects a PLMN colour code that is not permitted, according to parameter **NCCPERM** in the BCCH data of the serving cell, then that carrier will be ignored. **NCCPERM** tells the MS which NCC that it is allowed to monitor when in the current cell.

The MS will only take measurement samples while listening to its own paging group. The rest of the time it will be in sleep mode, see Section 2.7.1 on page 19. Table 2 on page 13 summarises how often the BSIC and the BCCH data must be decoded for the serving cell and neighbouring cells while in idle mode.

Table 2 Decoding of BSIC and BCCH data

	BSIC	BCCH data
Serving cell	-	at least every 30 s
Six neighbours	at least every 30 s	at least every 5 min

Cell reselection criteria

In order to control the traffic distribution between cells, Ericsson GSM System R7 allows the operator to favour certain cells in dedicated mode. Examples of this is Locating (ref. 3) and Hierarchical Cell Structures (ref. 4). In some situations, there can be a need for a similar behaviour in idle mode. In addition, in a microcell environment there

can be a need for controlling the cell reselection rate especially for fast moving mobiles.

For these purposes, additional cell reselection parameters, **CRO**, **TO** and **PT**, are broadcasted on the BCCH of each cell. These two parameters are supported by GSM phase 2 mobiles only. Before a phase 2 MS can change cell on which it is camping, it has to read these parameters from the BCCH of the potential target cells. Phase 1 mobiles will use *C1* for cell reselection.

The cell reselection algorithm consists of five different criteria. If any one of the criteria is satisfied it will cause a cell reselection to occur. The cell reselection process employs a cell reselection quantity *C2*. Whenever a cell reselection criterion is satisfied, a phase 2 MS will change to the cell with the highest *C2* value. *C2* is calculated as follows:

$$C2 = C1 + \mathbf{CRO} - \mathbf{TO} * H(\mathbf{PT} - T) \quad \text{for } \mathbf{PT} \neq 31 \qquad (2)$$

$$C2 = C1 - \mathbf{CRO} \quad \text{for } \mathbf{PT} = 31 \qquad (3)$$

where *C1* is defined by Eq. 1,

$$H(x) = \begin{cases} 0, x < 0 \\ 1, x \geq 0 \end{cases}$$

T is a timer and **CRO**, **TO** and **PT** are parameters.

CRO applies an offset to the *C2* reselection quantity for the cell. **TO** applies a temporary negative offset to *C2* for the duration of **PT**. This prevents fast moving MSs from selecting the cell. The value 31 of the **PT** parameter is reserved to change the sign of **CRO**. In this case, the value of **TO** is ignored, as indicated by equation 3. *T* is initiated from zero when the MS places the neighbouring cell on the list of the six strongest carriers. *T* will be reset to zero whenever the cell is no longer on that list.

The MS continuously recalculates the value of *C1* and *C2* for the serving and neighbouring cells when a new measurement has been made. It will reselect and camp on another cell if any of the following criteria is satisfied:

- the serving cell becomes barred;
- the MS has unsuccessfully tried to access the network the allowed number of times, as defined by the **MAXRET** parameter;
- the MS detects a downlink signalling failure, see subsection “Downlink signalling failure criterion” below;
- *C1* for the serving cell falls below zero for a period of five seconds which would indicate that the path loss to the cell has become too high and that the MS needs to change cell;
- the value of *C2* for a non-serving cell exceeds the value of *C2* for the serving cell for a period of five seconds. This would indicate an appearance of a better cell. However, if the new cell belongs

to a different location area, a cell reselection hysteresis parameter, **CRH**, also applies, see Section 2.4.2 on page 15.

Downlink signalling failure criterion

The downlink signalling failure criterion make use of the downlink signalling failure counter. The algorithm is of the type “leaky bucket”, and bases the decisions on successfully decoded paging messages. When the MS camps on a cell, the counter is initialised to a value equal to the nearest integer to *90/N* where *N* is the multiframes parameter, **MFRMS**, for that cell. Thereafter, when the MS attempts to decode a message on its paging group and the message is unsuccessfully decoded, the counter is decreased by 4, otherwise the counter is increased by 1. However the counter is never increased beyond the nearest integer to *90/N*. The MS is required to attempt to decode a message every time its paging group is sent. If the counter reaches zero, a downlink signalling failure is declared. A downlink signalling failure will result in a cell reselection.

The downlink signalling failure counter is reinitiated to the value equal to the nearest integer to *90/N* every time the MS changes cell to camp on. The main use of the **MFRMS** parameter is in conjunction with paging groups, see Section 2.7.1 on page 19.

2.4.2 Borders between location areas

If the MS is moving in a border area between location areas, it might repeatedly change between cells of different location areas. Each change of location area would require a location updating to be performed, which would cause a heavy signalling load and thereby also increasing the risk of paging messages being lost. To prevent this, a cell reselect hysteresis parameter, **CRH**, is used. A cell in a different location area is only selected if it is “better”, in terms of the quantity *C2* (*C1* for GSM phase 1 mobiles), than all the cells in the current location area by at least the value of **CRH**. This is illustrated in Figure 2 on page 16.

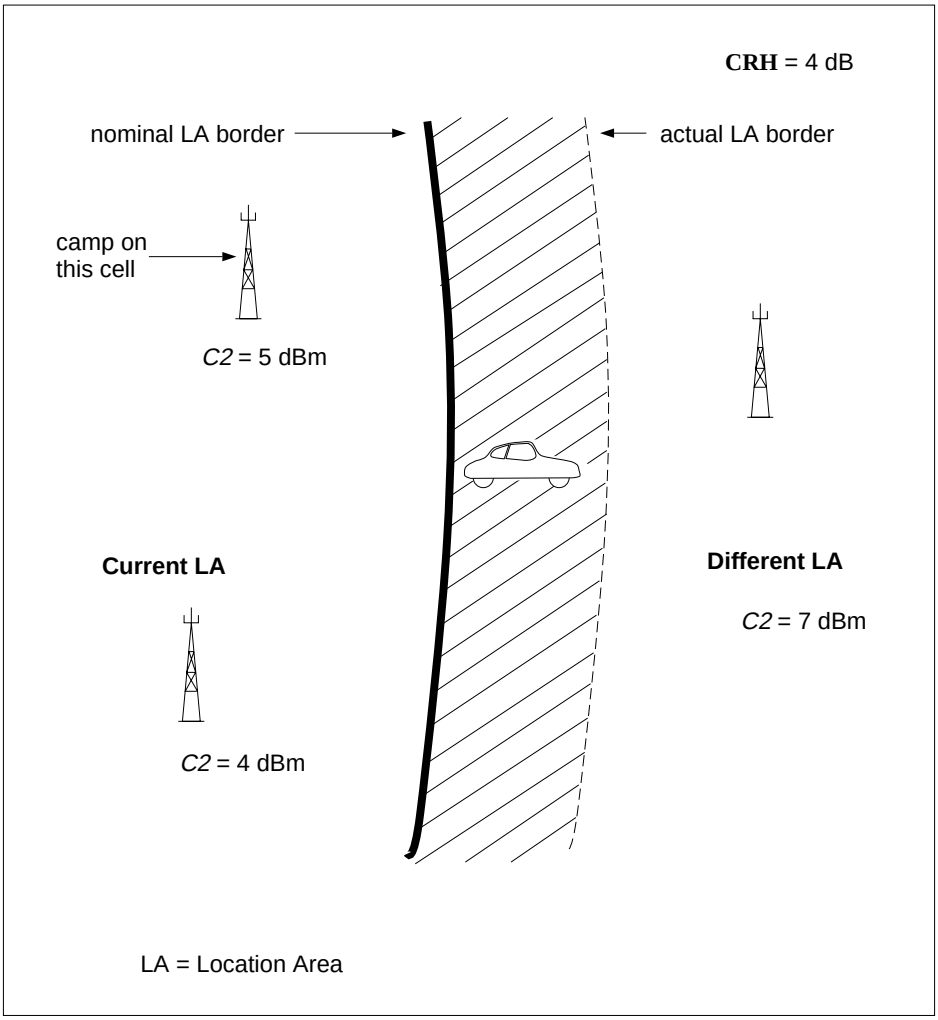

Figure 2 Cell reselect hysteresis near location area border

The **CRH** parameter is broadcast on the BCCH. Since the value of **CRH** may be different for each cell, the **CRH** parameter used is the one being broadcast by the current serving cell.

2.4.3 Limited service state

There are a number of situations in which the MS is unable to obtain normal service from a PLMN which will result in that the MS goes into a limited service state. These include:

- Failure to find a suitable cell of the registered PLMN.
- A “PLMN not allowed” response to a location update.
- Certain responses to a location updating, such as “illegal MS”, “illegal Mobile Equipment” (i.e. MS with no SIM) or “IMSI unknown in HLR” response to a location update.

The MS will, under any of these conditions, try to camp on an acceptable cell irrespective of its PLMN identity, so that emergency calls can be made if necessary. In the limited service state the presence of the MS does not need to be known by the PLMN on whose cell it

has camped. Cell reselection takes place as normally, except that a zero dB value of the cell reselection hysteresis parameter, **CRH**, is used.

2.5 Location updating

2.5.1 General

To make it possible for the mobile subscriber to receive a call, the network must know where the MS is located. To keep the network updated on the location of the MS, the system is informed by the MS on a regular basis. This is called Location Updating.

There are three different types of location updating defined; normal, periodic registration and IMSI attach. The MS may also inform the network when it enters an inactive state, IMSI detach.

2.5.2 Normal

Normal location updating is initiated by the MS when it detects that it has entered a new location area. When the MS is listening to the system information transmitted on the BCCH carrier for the serving cell, it will compare the broadcast Location Area Identity (LAI) with the one stored in the MS. If the broadcast LAI differs from the one stored, a location updating type normal will be initiated and the new LAI will be stored in the MS. If the location updating fails, for example due to entering of a forbidden location area, the MS will either try to select another cell or return to the PLMN selection state.

2.5.3 Periodic registration

To reduce unnecessary paging of a mobile that has left the coverage area, has run out of battery power or for any other reason has the wrong status in the MSC/VLR, there is a type of location updating called periodic registration.

When the MS listens to the system information on the BCCH carrier it is told if periodic registration is used in that cell and how often it shall inform the network that it is still attached (reachable). This is controlled by the **T3212** parameter, which is a timeout value broadcast to the MS in the system information messages. The interval ranges between six minutes (**T3212** = 1) and 25.5 hours (**T3212** = 255).

The periodic registration timer is implemented in the MS. It will be reinitiated every time the MS returns to idle mode after being in dedicated mode. If a change in the timeout value, **T3212**, occurs, for example at a change of **T3212** broadcast, the timer will be reloaded so that the new time to expire will be “old time to expiration” modulo “new timeout value”.

Example:

Assume the following situation:

old time to expiration = 5.6 decihours

new T3212 = 3 decihours

the new time to expire will be: 5.6 mod 3 = 2.6 decihours.

If the “new T3212” is instead 7 decihours, the new time to expire will become 5.6 mod 7 which is equal to 5.6. Thus, when changing the timer to a value greater than the "old time to expire" value the MS will keep the “old time to expire” value. However when the new timer value is less than the remainder of the old timer, the timer will be initiated with a new value between zero and the new timeout value.

Because the “old time to expire” value will be different for each mobile, this procedure will cause the mobiles to reinitiate their timers to different values. This minimises the risk of a high peak load on the system due to too many location updatings occurring at the same time, after a change of the **T3212** parameter.

2.5.4 IMSI attach/detach

The IMSI attach/detach operation is an action taken by an MS to indicate to the network that it has entered into idle mode/inactive state. When an MS is powered on, an IMSI attach message is sent to the MSC/VLR. When an MS is powered off, an IMSI detach message is sent. A flag is set in VLR in order to indicate the present state of a certain MS. This prevents unnecessary pagings of powered off mobiles. The **ATT** parameter, broadcasted by the serving cell in the system information messages, will inform the MS whether or not it is requested to send a message to the system every time it is turned on or off. The MS may also be marked as detached (implicit detach) by the MSC. This happens when there has been no successful contact between the MS and the network for a time determined by a timeout value, **BTDM**, plus a guard period, **GTDM**. Thus, the MS supervision time is the sum of these two periods. The base time duration **BTDM** must be coordinated with the periodic location updating time in the interworking BSC, **T3212**. Otherwise the mobile will be unexpectedly removed from the system before a periodic location updating is performed, see further Section 3.3 on page 26.

2.6 Combinations of control channels

Only certain combinations of control channels are allowed. The following three types of BCCH are available specified with the **BCCHTYPE** parameter:

Non-combined: BCCH and CCCH (see note below)

Combined: BCCH, CCCH and SDCCH/4

Combined including a CBCH: BCCH, CCCH, SDCCH/4 and CBCH (the CBCH replaces SDCCH subchannel number 2)

Note: CCCH is a combination of PCH, AGCH and RACH.

There are also four combination types for SDCCH channel:

SDCCH/8: each physical channel consists of eight SDCCH subchannels, that is, eight MSs can be given dedicated channels at the same time.

SDCCH/8 including a CBCH: the CBCH subchannel replaces SDCCH subchannel number 2. Only seven MSs can thus be given dedicated channels simultaneously.

SDCCH/4: this is a combination of four SDCCH subchannels with BCCH and CCCH. four MSs can be given dedicated channels at the same time.

SDCCH/4 including CBCH: this combination consists of three SDCCH subchannels, BCCH, CCCH and a CBCH subchannel. The CBCH subchannel replaces SDCCH subchannel number 2. Only three MSs can thus be given dedicated channels simultaneously.

The number of required SDCCH/8 is specified by the **SDCCH** parameter. The CBCH is defined by the **CBCH** parameter. Only one CBCH can be specified, that is, either the channel combination SDCCH/4 including a CBCH or SDCCH/8 including a CBCH can be defined in a cell.

2.7 Paging

2.7.1 Paging groups

After an MS tunes to the BCCH carrier and decodes the system information data, it performs an evaluation, taking into account the IMSI number, that determines to which paging group it belongs. The particular method by which an MS determines to which paging group it belongs, and hence, which particular CCCH block of the available blocks on the paging channel that is to be monitored, is defined in the GSM specifications, ref. 5. When there are no paging messages to be transmitted to MSs in a certain paging group dummy pagings will be sent instead. The MS stays in sleep mode to minimise power consumption in the time gap between when its own paging group occurs. This is illustrated in Figure 3 on page 20. However, the MS must still read the BCCH data sent by the serving cell at least every 30 seconds.

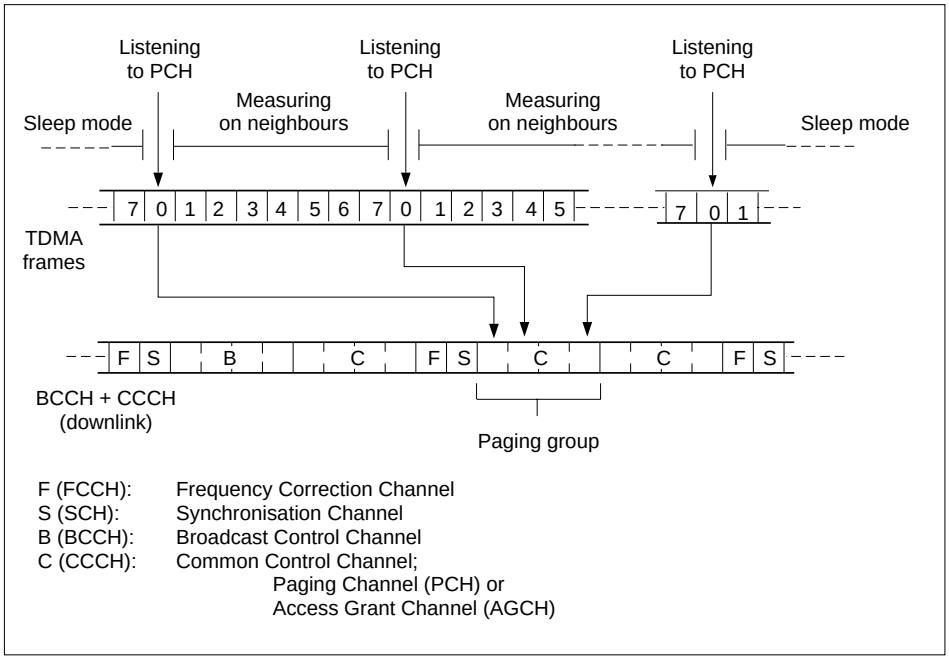

Figure 3 Idle mode measurements during own paging group

The CCCH blocks are also used to send access grant messages on the AGCH to the MS. The structure of the CCCH regarding paging messages and access grant messages is controlled by the two parameters **AGBLK** and **MFRMS**.

In each downlink non-combined BCCH 51 frame multiframe there are nine different CCCH blocks and in the combined BCCH/SDCCH there are three different CCCH blocks. **AGBLK** is the number of reserved CCCH blocks for the AGCH. The remaining CCCH blocks (9 - **AGBLK**, for non-combined BCCH and 3 - **AGBLK**, for combined BCCH) are used as PCH.

Access grant messages are given priority over paging messages even if no CCCH blocks are reserved for the AGCH, that is when **AGBLK** = 0. Therefore no reservation of blocks is needed. However, if system information 7 and 8 have to be sent, or if the cell uses a non combined BCCH and Cell broadcast is used, **AGBLK** must not be 0, see further Section 2.8 on page 22. For Ericsson RBS 200 and RBS 2000 series BTS, only **AGBLK** = 0 and 1 is supported.

Table 3 The relation between MFRMS, AGBLK, number of paging groups and time between transmission of each paging group

MFRMS	Time between transmission of each paging group	Number of paging groups, Combined BCCH		Number of paging groups, non combined BCCH	
		AGBLK = 0	**AGBLK = 1**	**AGBLK = 0**	**AGBLK = 1**
2	0.47 sec	6	4	18	16
3	0.71 sec	9	6	27	24
4	0.94 sec	12	8	36	32
5	1.18 sec	15	10	45	40

6	1.41 sec	18	12	54	48
7	1.65 sec	21	14	63	56
8	1.89 sec	24	16	72	64
9	2.12 sec	27	18	81	72

2.7.2 Paging strategies

The paging procedure in the Ericsson GSM System is managed by the MSC. (The description of the paging parameters and the different paging strategies refers to the Ericsson MSC, HLR and VLR.) Different paging strategies are possible, e.g. not to send any second paging or to send the second paging as global paging. An operator can control the paging procedure with parameter settings in the MSC.

The paging attempts, including both the first and the repeated attempts, is either local or global depending on whether or not the Location Area Identity is stored in the VLR, see Figure 4 on page 37 in Appendix A. Local pagings are performed only within one location area whereas global pagings are performed within a whole MSC service area. A second paging may be initiated if no response from the MS is received before a first timer expires. The timer is called **PAGTIMEFRST1LA** for local pagings and **PAGTIMEFRSTGLOB** for global pagings.

If the first paging was a local paging the **PAGREP1LA** parameter defines whether or not a second paging shall be initiated and, in that case, if it shall be local or global. After the second paging has been sent, the MSC waits for the **PAGTIMEREP1LA** timer, indicating a local second paging, or **PAGTIMEREPGLOB**, indicating a global second paging, to expire before it concludes that the paging attempt was unsuccessful.

If the first paging was a global paging and no response was received before the first timer expired, the **PAGREPGLOB** parameter will define whether a second global paging will be initiated. If the second global paging is sent, the MSC will wait for the **PAGTIMEREPGLOB** timer to expire before it considers the MS unreachable.

Equal access and Transit Network Selection in MSC/VLR and GMSC

In the GSM 1900 system, a paging can be done according to selection of a certain subscriber. The purpose of this function is to provide the subscribers with the option of choosing an inter-exchange carrier for calls across Local Access and Transport Area (LATA) boundary. It can be implemented in the MSC and may effect how paging is repeated. LATA is a geographical region corresponding to a charging area. A LATA can be defined to consist of one or more location areas.

It may be served by one or several MSCs. If the concept of LATA is used, indicated by parameter **LATAUSED**, it is possible to do a second page only with one LATA, using parameters **PAGLATA** and **PAGREPCT1LA**.

2.8 System information

The system information messages, sent by the BTS, contain data about the network that the MSs need in order to communicate with the network in an appropriate manner.

For MSs in idle mode, system information message types 1, 2, 3, 4, 7 and 8 are sent on the BCCH. (System information types 5 and 6 are transmitted to MSs in dedicated mode and are therefore not treated here.) In a GSM 1800 or GSM 1900 system, the function also uses message type 2bis and 5bis when the neighbouring cell information elements of message type 2 and 5 have to be extended.

In a dual band system, the function uses message type 2ter and 5ter to inform the mobiles of which frequencies from the other band they are allowed to measure on. If the BTS supports phase 2 system information, the message types 7 and 8 may also be used as an extension mechanism for message type 4. Message types 7 and 8 include cell reselection (*C2*) parameters.

The distribution of system information messages 1, 7 and 8 may be switched on and off (only valid for cells which are connected to BTS equipment that supports GSM phase 2) and is controlled by the **SIMSG** and **MSGDIST** parameters. The **SIMSG** parameter specifies which system information message(s) to be turned on or off and the **MSGDIST** parameter specifies whether they are turned on or off.

Table 4 on page 22 lists the contents of the different system information messages that are transmitted to MSs in idle mode. System information message types 7 and 8 are only used as an extension mechanism in GSM phase 2 for system information message type 4. Note that **AGBLK** may not be zero when system information message types 7 and 8 are utilised. The reason is that PCH, AGCH and message types 7 and 8 share the same CCCH blocks.

For further information about the contents in the different system information messages, see the GSM specification, ref. 6.

Table 4 Contents of system information messages type 1 to 4.

	System information message type					
Contents	1	2	2bis	2ter	3	4
Cell channel description	X	X				
RACH control parameters	X	X	X		X	X
Neighbour cells description		X				
PLMN permitted		X				
Location area identity					X	X
Cell identity					X	
Control channel description					X	
Cell options					X	
Cell selection parameters					X	X
Radio link time-out					X	

CBCH description						X
Neighbour cells description (extension)			X			
Neighbour cells description (other band)				X		
Additional multiband information				X		
CBCH channel description (optional)						X
CBCH mobile allocation (optional)						X

An extension band, G1, is defined for GSM 900. This band together with the existing primary GSM 900 band (P-GSM) form the Extended GSM 900 band (E-GSM). The RF channels available is increased from 124 to 174 for GSM 900. Another extension band, UIC, is defined for GSM 900. This band together with the E-GSM form the Railways GSM 900 band (R-GSM). This gives 194 channels for GSM 900. Messages handling the BA list, System Information 2 and System Information 5, have been changed to cater for the increased frequency range. System Information 2, 2bis and 2ter shall be sent according to Table 5. The System Information messages 2, 2bis and 2ter contain lists of BCCH frequencies used in the neighbouring cells. The way that the neighbour cell description information element of System Information Type 2 is distributed is dependant on serving and neighbouring cell BCCH carrier frequencies as shown.

Table 5 Distribution of System Information type 2

Band for BCCH in serving cell	**Measurement Frequency Band P**	**Measurement Frequency Band G1/UIC**	**Measurement Frequency Band GSM 1800 or GSM 1900**
P	2	2TER	2TER
G1/UIC	2	2BIS	2TER
GSM 1800/GSM 1900	2TER	2TER	2 + 2BIS

2.9 Short message service, cell broadcast

Short Message Service Cell Broadcast (SMS CB) provides an operator with the capability to distribute short messages to idle subscribers within the PLMN. Before SMS CB data can be distributed, the cell must be configured with a CBCH, see Section 2.6 on page 18, and the number of reserved access grant blocks, **AGBLK**, may not be zero if a non-combined BCCH is used in the cell. The SMS CB function distributes the messages to all idle MSs within a certain coverage area. Message data can contain 15 pages and each cell can process up to 96 pages. Each page contains up to 82 octets.

The SMS CB message could contain traffic reports, weather reports or charging information. The frequency of distribution to the MSs is determined by the repetition interval. It can be set by command

(RLMTI) per cell. Reception of a SMS CB message by an MS is only possible in idle mode.

The end user have to choose to receive SMS CB messages. This issue differs between different MS suppliers.

2.10 Main changes in Ericsson GSM System R7/BSS R7.0

The function uses message types 2bis and 5bis when neighbouring cell information elements of types 2 and 5 have to be extended in a GSM 1800 and GSM 1900 system.

In a dual band system, the function uses message types 2ter and 5ter to inform the mobiles of which frequencies the other band they are allowed to measure on.

2.11 Main changes in Ericsson GSM System R7/BSS R7.1

System messages type 2 and 5 have been changed to cater for the increased frequency range due to E-GSM and R-GSM.

3 Engineering Guidelines

3.1 Cell selection

Cell selection can be controlled by the setting of **ACCMIN**. Different **ACCMIN** values between cells will make some cells more attractive to camp on, i.e. a low **ACCMIN**, yields a low requirement on signal strength, will result in more MSs being able to camp on that cell (i.e. C1 > 0 for a larger area). At the same time, there will be an increased risk of dropped calls since MSs in areas of low signal strength will be able to access the system.

Some mobiles tend to have problems getting attached to the system fast enough after a temporary drop in signal strength below **ACCMIN**. This may cause mobiles to be detached from the network, even though they have sufficient signal strength for a successful call.

The recommendation is to use the lowest possible value, **ACCMIN**= -110 dBm.

In order to reduce cell selection time, **CBQ** should be set to HIGH. This will also ensure **CB** functions as expected for both Phase 1 and Phase 2 MSs.

If the MS maximum possible output power, *P*, is lower than **CCHPWR** then the requirement on the signal strength increases by the difference between *P* and **CCHPWR**. This means that if the MS can not reach the maximum allowed output power, the requirement on the signal strength in the downlink must be harder. This will restrict access for mobiles where system balance can not be maintained. The recommended setting for **CCHPWR** is the same value as the maximum allowed transmitted power in active mode, i.e. **CCHPWR**=**MSTXPWR**.

3.2 Cell reselection

The setting of **CRO** allows control of how phase 2 mobiles behave during cell reselection. It is possible to make mobiles behave similar to the way they behave in active mode whilst in idle mode.

Example:

Suppose a cell has a large negative offset (**KOFFSET**) towards its neighbours, in order not to take as much traffic. The idle mode cell borders according to the *C1* criterion will significantly differ from the cell borders in the active mode (assume the same **ACCMIN** for both cells). This will make some of the mobiles camp on the "wrong" cell from a Locating point of view. These mobiles will, after the call set up, either make an assignment to better cell (provided that this feature is activated), or perform a handover shortly after the assignment of a traffic channel. This causes SDCCH load in the wrong cells and increases the handover signalling in the BSC. A suitable setting of **CRO**, about the same value as **KOFFSET** in this example, may reduce the number of handovers and assignments to better cell.

It should be noted that this requires that **KOFFSET** has the same value towards all cell neighbours since it is a cell to cell relation parameter while **CRO** is a cell parameter.

If the Hierarchical cell structure feature is used for indoor applications, **ACCMIN** can be set to the same value as a well tuned **LEVTHR**. The parameter **CRO** can also be chosen to a very high value, e.g. 50 (i.e. an offset of 100 dB). This will cause phase 2 mobiles to camp on the indoor cell once the received signal strength level goes above **LEVTHR**. Phase 1 mobiles, on the other hand, will see the outdoor cells as being better to camp on by the difference in **ACCMIN** between the two cells. A balance should be found between the setting of **ACCMIN** and **CRO** for the case of a network with both phase 1 and phase 2 mobiles.

CRH applies between different location areas. If the **CRH** value is set too low, the fluctuations in signal strength may lead to a ping-pong effect for location updating. This will cause an undesired increase in the signalling load on the SDCCH. If the parameter is set too high, the mobile may camp on the wrong cell (not the strongest one) for too long when entering a new location area.

The default value, **CRH** = 4 is recommended. If an unusually high number of location updatings occur in a location area border cell, a higher **CRH** can be tried in order to reduce it.

3.3 Location updating

A location updating is performed on the signalling SDCCH channel. The frequency of location updates performed by the mobiles affects the dimensioning requirements for the SDCCH as well as the load in the BSC. A recommended value is between 1 hour (**T3212** = 10) and 4 hours (**T3212** = 40).

BTDM should be set equal to **T3212**. A recommended value is between one hour (**T3212** = 10) and four hours (**T3212** = 40). If the MS supervision time in the MSC (i.e. **BTDM** + **GTDM**) is smaller than the periodic location updating then mobiles may be unexpectedly removed from the system before periodic location updating is performed. Note that the unit for **BTDM** is hours while for **T3212**, it is decihours.

3.4 Paging

MFRMS is, as mentioned before, the multiframe period and defines the transmission interval of paging messages to the same paging group. Together with **AGBLK**, **MFRMS** indicates how many different paging groups exist. A higher value of **MFRMS** means more battery saving in the MSs, and also some increase in the paging capacity of the system. However, a specific paging group would then appear less frequently, making call set-up times for mobile terminating calls longer. See the following example:

Example:

If the number of CCCH blocks within a multiframe is 9 and **AGBLK** is set to 0, there are nine different paging groups within a 51 frame multiframe. If **MFRMS** is set to five, there will be 5 * 9 = 45 different paging groups totally, spread out over five multiframes. At most, **MFRMS** can be equal to nine, which consequently would mean 81 different paging groups (using a non-combined BCCH, see Table 3). In

this case the mobile listens to its own paging group every ninth 51-frame multiframe, which means approximately every 2.1 seconds (9 * 235.4 ms).

The advantage with a higher value is a lower power consumption in idle mode. The drawback is that the average call setup time for mobile terminated calls slightly increases. The impact of **MFRMS** on the battery consumption may differ for different mobiles. The trade-off between low battery consumption and short call set up times for mobile terminated calls has to be done based on the operators preferences.

Recommended setting of **AGBLK** is 0, unless another setting is required.

Parameter **ATT** should always be set to YES so that the system is alerted when the mobile powers on or off. This will prevent unnecessary pagings of the mobile when it is no longer available.

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4 Parameters

4.1 Main controlling parameters

4.1.1 Parameters transmitted on SCH

BSIC is the Base Station Identity Code, defined per cell and expressed as NCC+BCC where:

NCC =	Network colour code
BCC =	Base station colour code

4.1.2 Parameters transmitted on BCCH

Idle Mode parameters are listed here in correspondence with the content of the system information messages as listed in Table 3 on page 20.

Neighbour cells description

MBCCHNO indicates the absolute RF channel number for the BCCH frequencies to be measured on by MSs in a cell, i.e. the BCCH allocation (BA) list. It is defined on a per cell basis.

PLMN permitted

NCCPERM defines the permitted network colour code, NCC, to be monitored. It is defined per cell.

Control channel description

BCCHTYPE identifies the type of BCCH to be used and is defined per cell:

COMB =	Combined; Indicates that the cell has a combined BCCH and SDCCH/4
COMBC =	Combined with CBCH; Indicates that the cell has a combined BCCH and SDCCH/4 with a CBCH subchannel
NCOMB =	No combined; Indicates that the cell does not have a combined BCCH and SDCCH/4.

SDCCH is the required number of SDCCH/8. It is defined per cell or per channel group.

MFRMS is the multiframes period and defines the period of transmission for paging messages to the same paging group. It is defined per cell.

T3212 defines the timeout value that controls the periodic registration procedure. It is defined per cell.

Cell selection parameters

ACCMIN is the minimum received signal level in dBm at the MS for permission to access the system on a control channel. It is defined per cell.

CCHPWR is the maximum output power level in dBm an MS may use when accessing the system on a control channel. It is defined per cell.

CRH is the receiving signal strength hysteresis in dB for required cell reselection over a location area border. It is defined per cell.

CBCH description

CBCH is the cell broadcast channel and indicates whether or not a CBCH shall be included in one of the SDCCH/8 subchannels for the cell or channel group. It is defined per cell or per channel group.

4.2 Additional parameters

4.2.1 Parameters transmitted on BCCH

RACH control parameters

CB is used to define if a certain cell is barred for access. It is defined per cell.

MAXRET is the maximum number of retransmissions an MS may do when accessing the system. It is defined per cell.

Control channel description

ATT indicates if IMSI attach/detach is used in the cell. It is defined per cell.

AGBLK is the number of CCCH blocks reserved for the access grant channel. The remaining CCCH blocks are used as paging channels. It is defined per cell.

Cell reselection parameters

CBQ is used to control the priority of a cell. The priority of the cell is controlled by parameter **CBQ** in conjunction with **CB**, see Table 1. It is defined per cell.

CRO defines an signal strength offset to encourage or discourage MSs to reselect that cell. It is defined per cell.

TO defines a negative temporary offset applied to *C2*. It is defined per cell.

PT is the duration for which the temporary offset, **TO**, is applied. **PT** is defined per cell.

LATA parameters

LATAUSED defines the usage of LATA administration. The parameter is only valid if the function Equal Access and Transit network Selection in MSC/VLR and GMSC is implemented.

0 =	LATA administration is not used.
1 =	LATA administration is used.

PAGLATA indicates if LATA paging is used for mobile terminating calls or not.

0 =	LATA paging is not used.
1 =	LATA paging is used.

PAGREPCT1LA defines how the paging in one location area is repeated, if the first paging attempt was local. This parameter is only valid when **PAGLATA**=1.

0 =	Paging in one location area is not repeated.
1 =	Paging in one location area is repeated with either TMSI or IMSI.
2 =	Paging in one location area is repeated with IMSI.
3 =	Paging is repeated as call delivery LATA paging with IMSI.

PAGTIMEREPLATA defines the time supervision for page response of repeated LATA paging. After expiration of this timer no new paging repetition for this call is done.

4.2.2 Configuration parameters

SIMSG is the system information BCCH message parameter. It specifies which system information message(s) to be turned on or off. It is defined per cell.

MSGDIST is the system information BCCH message distribution parameter. It specifies if the system information messages specified with the **SIMSG** parameter are turned on or off. It is defined per cell.

BTDM is the base time duration of implicit detach of a mobile subscriber by the network. It is an MSC parameter (Ericsson MSC only).

GTDM is the guard time for implicit detach. It is an MSC parameter (Ericsson MSC only).

4.2.3 Paging parameters set in the MSC

PAGTIMEFRST1LA defines the time supervision for the paging response of the first paging attempt in one location area. After

expiration of this timer, the paging is repeated according to the **PAGREP1LA** parameter.

PAGTIMEFRSTGLOB defines the time supervision for the paging response of the first global paging attempt. After expiration of this timer the paging is repeated according to the **PAGREPGLOB** parameter.

PAGREP1LA defines how the paging in one location area is repeated, if the first paging attempt was local.

0 = Paging in one location area is not repeated.

1 = Paging in one location area is repeated with either TMSI or IMSI.

2 = Paging in one location area is repeated with IMSI.

3 = Paging is repeated as global paging with IMSI.

PAGREPGLOB defines how the global paging is repeated, if the first paging attempt was global.

0 = Global paging is not repeated.

1 = Global paging is repeated with IMSI.

PAGTIMEREP1LA defines the time supervision for the paging response of repeated paging in one location area. After the expiration of this timer, no new paging repetition for this call is performed.

PAGTIMEREPGLOB defines the time supervision for paging response of repeated global paging. After the expiration of this timer, no new paging repetition for this call is performed.

4.3 Value ranges and default values

Table 6 SCH parameters

Parameter name	Default value	Recommended value	Value range	Unit
BSIC	-	-	NCC: 0 to 7 BCC: 0 to 7	

Table 7 RACH control parameters

Parameter name	Default value	Recommended value	Value range	Unit
CB	NO		YES, NO	
MAXRET	4		1, 2, 4, 7	

Table 8 Neighbour cells description

Parameter name	Default value	Recommended value	Value range	Unit
MBCCHNO				
GSM 900	-		1 to 124	ARFCN
GSM 1800	-		512 to 885	ARFCN
GSM 1900	-		512 to 810	ARFCN

Table 9 PLMN permitted

Parameter name	Default value	Recommended value	Value range	Unit
NCCPERM	-		0 to 7	

Table 10 Control channel description

Parameter name	Default value	Recommended value	Value range	Unit
BCCHTYPE	NCOMB		COMB, COMBC, NCOMB	
SDCCH	1		0 to 16	
MFRMS	6		2 to 9	CCCH multiframes
T3212	40		0 to 255 (0 = infinite)	decihours
ATT	YES	YES	YES, NO	

Table 11 Cell selection parameters

Parameter name	Default value	Recommended value	Value range	Unit
ACCMIN	-110	-110	-47 to -110	dBm
CCHPWR		MSTXPWR		
GSM 900	-		13 to 43 in steps of 2	dBm
GSM 1800	-		4 to 30 in steps of 2	dBm
GSM 1900	-		4 to 30 in steps of 2	dBm
CRH	4	4	0 to 14 in steps of 2	dB
CBQ	HIGH	HIGH	HIGH, LOW	
CRO	0		0 to 63	2 dB
TO	0		0 to 7 7 = infinite	10 dB
PT	0		0 to 31 (1)	

(1) **PT** = 1 indicates that the cell reselect offset is negated and the temporary offset is ignored, see equation 3.

Table 12 CBCH parameters

Parameter name	Default value	Recommended Value	Value range	Unit
CBCH	NO		YES (1), NO	

(1) When a CBCH is defined, parameter **AGBLK** must not be zero.

Table 13 Configuration parameters

Parameter name	Default value	Recommended value	Value range	Unit
SIMSG	-		1, 7, 8	
MSGDIST	Type 1 = ON Type 7 = OFF Type 8 = OFF		ON, OFF	
AGBLK	1	0	0 to 1 (1) 0 to 7 (2)	
BTDM	OFF	T3212	6 to 1530, OFF	minutes
GTDM	-		0 to 255	minutes

(1) For RBS 200 and RBS 2000 BTSs, only **AGBLK**=0 and 1 is supported.
(2) **AGBLK** can take the value 0 to 7 if a non-combined BCCH is used, and 0 to 2 if the BCCH is combined with any typ of SDCCH.

Table 14 Paging parameters

Parameter name	Default value	Recommended value	Value range	Unit
PAGTIMEFRST1LA	4		2 to 10	seconds
PAGTIMEFRSTGLOB	4		2 to 10	seconds
PAGREP1LA	2		0, 1, 2, 3	
PAGREPGLOB	0		0, 1	
PAGTIMEREP1LA	7		2 to 10	seconds
PAGTIMEREPGLOB	7		2 to 10	seconds
LATAUSED	0		0, 1	
PAGLATA	0		0, 1	
PAGREPCT1LA	2		0, 1, 2, 3	
PAGTIMEREPLATA	7		2 to 10	seconds

Note: The description of the paging parameters refers to the Ericsson MSC, HLR and VLR.

5 References

1 User Description, Multiband Operation.

2 User Description, Double BA Lists.

3 User Description, Locating.

4 User Description, Hierarchical Cell Structures.

5 GSM Technical Specification 05.02.

6 GSM Technical Specification 04.08.

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6 Appendix A

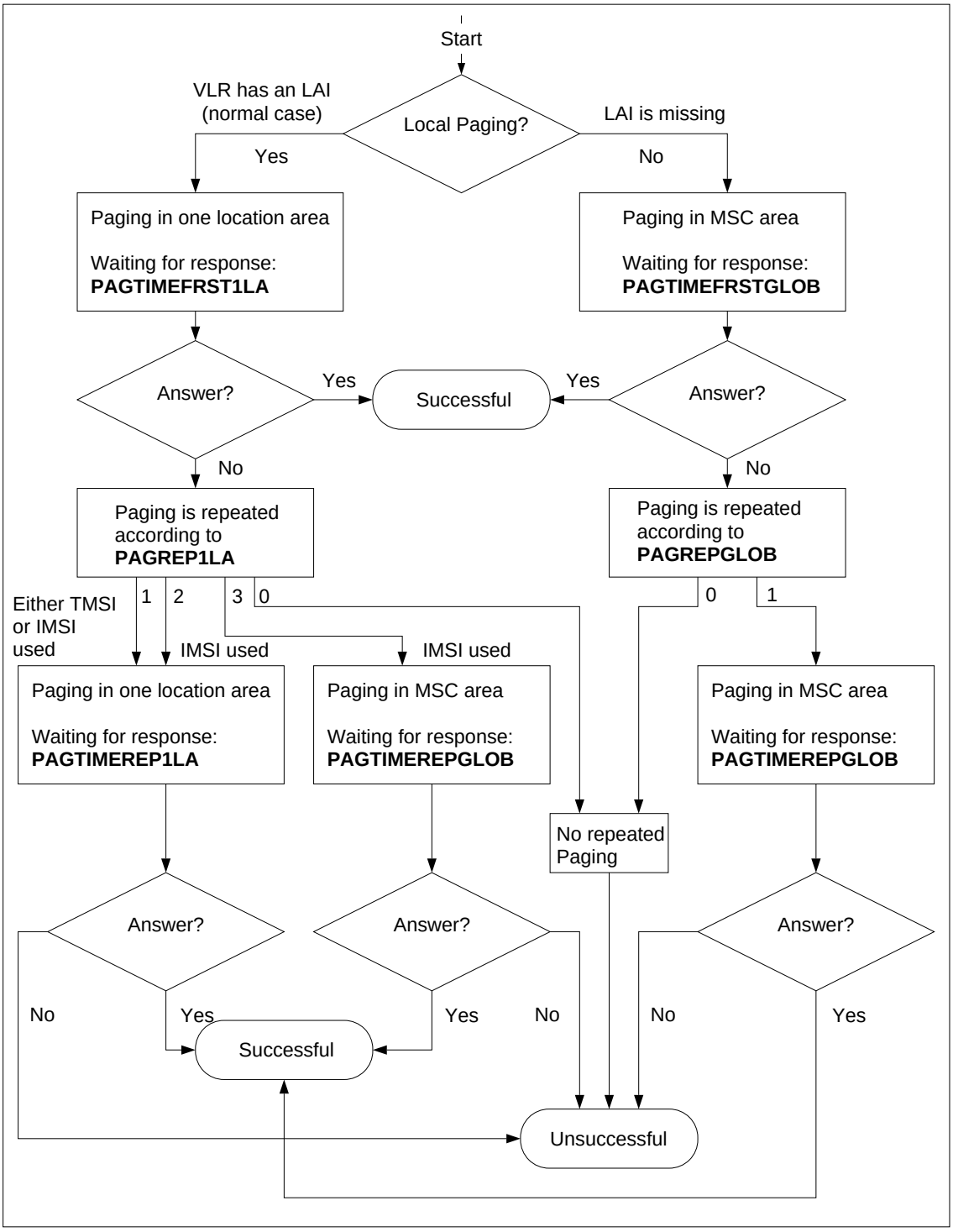

Figure 4 Flowchart illustrating different paging strategies