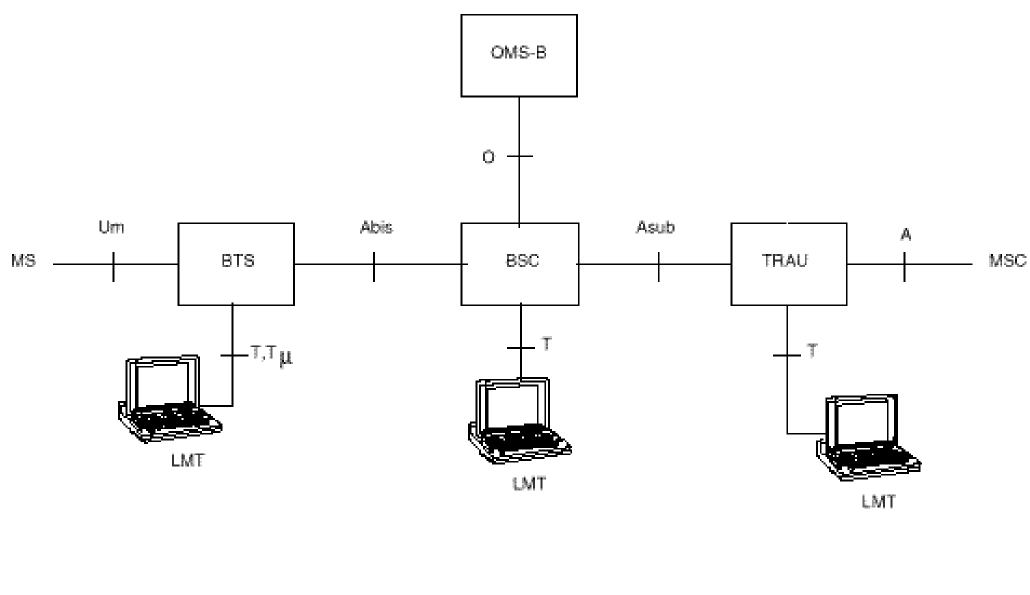
S-72.260
Laboratory Works in Radiocommunications

Laboratory Exercise 3

BSS Radio Parameters



Version history

Date	Version	Changes
14.3.1999/JSa	0.21	Comments from MHa.
17.3.1999/JSa	0.22	Corrections to P4. Appendix3 added.
13.7.1999/JSa	0.31	Update to BR4.0. Corrections to preliminary exercises and laboratory exercises.
6.9.1999/JSa	0.32	Updated.
28.9.2001/JVe	0.50	All preliminary and lab exercises completely changed.
1.10.2001/JVe	0.51	RF network picture changed
2.10.2001/JVe	0.52	Some specifications to preliminary exercises
2.11.2001/JVe	0.53	Preliminary and laboratory exercises clarified.

Some prior knowledge of GSM is needed in order to pass the laboratory exercise successfully. The background material given in this paper does not cover GSM basics.

You should be well prepared for this laboratory work. The preliminary exercises should be done with care. Otherwise you will not be able to finish laboratory exercises in time.

Please copy the file contained in the table when you receive material for the lab work.

File	Description
db37_1.hlp	DB Windows help file. Describes different parameters in detail.

The help file requires one 3½¨ floppy. Ask it from the assistant.

The database (DB) help file will be especially useful when you are reading the text and during the laboratory exercise. It is installed in the laboratory' s PCs, as well as the pdf documentation of SBS.

Background courses:

S-72.610 Mobile Communications Systems and Services
S-72.620 Radio Network Planning Methods

Literature:

Mouly, M., Pautet, M., "*The GSM system for mobile communications*", published by the authors, 1992
Redl, Siegmund M., Weber, Matthias K., Oliphant, Malcolm W., "*An introduction to GSM*", Artech House, Boston 1995

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BSS Radio Parameters

1 Introduction

In this laboratory work we investigate the radio parameters of a GSM Basestation Subsystem (BSS). By optimizing the radio interface, the network capacity can be increased considerably. There are well over a hundred different radio parameters specified for the BSS and some are controlled by the MSC. In the upcoming WCDMA system there will be even more radio interface control parameters and great effort is devoted to developing tools for designing and optimizing increasingly complex networks. Although the systems are different, the basic ideas remain the same.

Literature about this subject is not readily available. Some general information can be found in [Mou92] or other well-known GSM books like [Redl95]. The subject is mainly taught by operators and system manufacturers who have their own training material. In preparation of this document, reference [SBS95] was used. All the necessary information can also be found in the mammothian GSM specifications.

This laboratory work requires prior knowledge of GSM, specifically radio interface aspects. In the next chapters some topics encountered in the laboratory exercise are introduced at a general level.

2 GSM channel structure

2.1 Physical Channels

The GSM channels are divided in physical and logical channels. A physical channel designates a particular RFC (Radio Frequency Channel) and timeslot. There are eight physical channels per RFC. The physical channel structure is presented in Appendix 1.

2.2 Logical channels

The logical channel structure is presented in the following figure. Logical channels are mapped into physical channels according to the specifications [GSM0403, GSM0502].

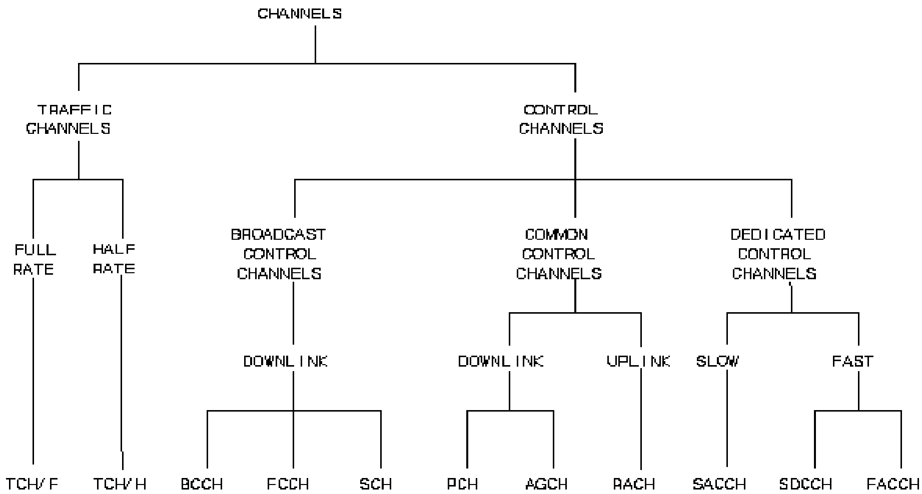


Figure 1. Logical channel structure [SBS95].

All logical channels have different functions. See figures 2-4.

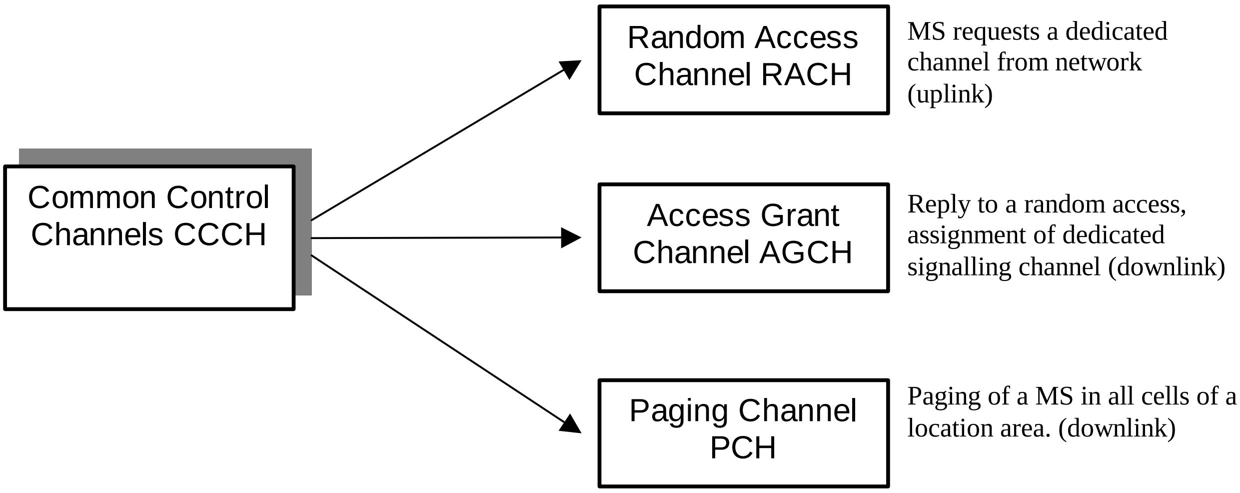


Figure 2. CCCH channels.

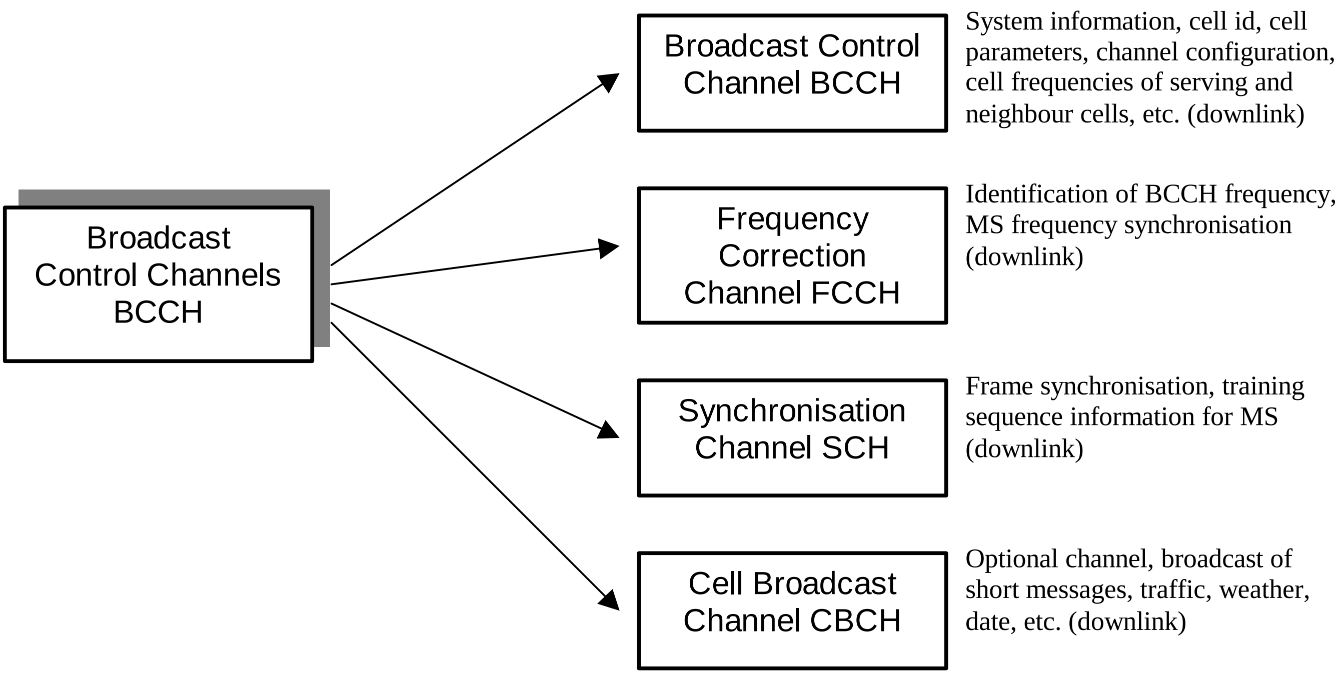


Figure 3. BCCH channels. FCCH transmits f-burst, SCH transmits s-burst (see Appendix 1).

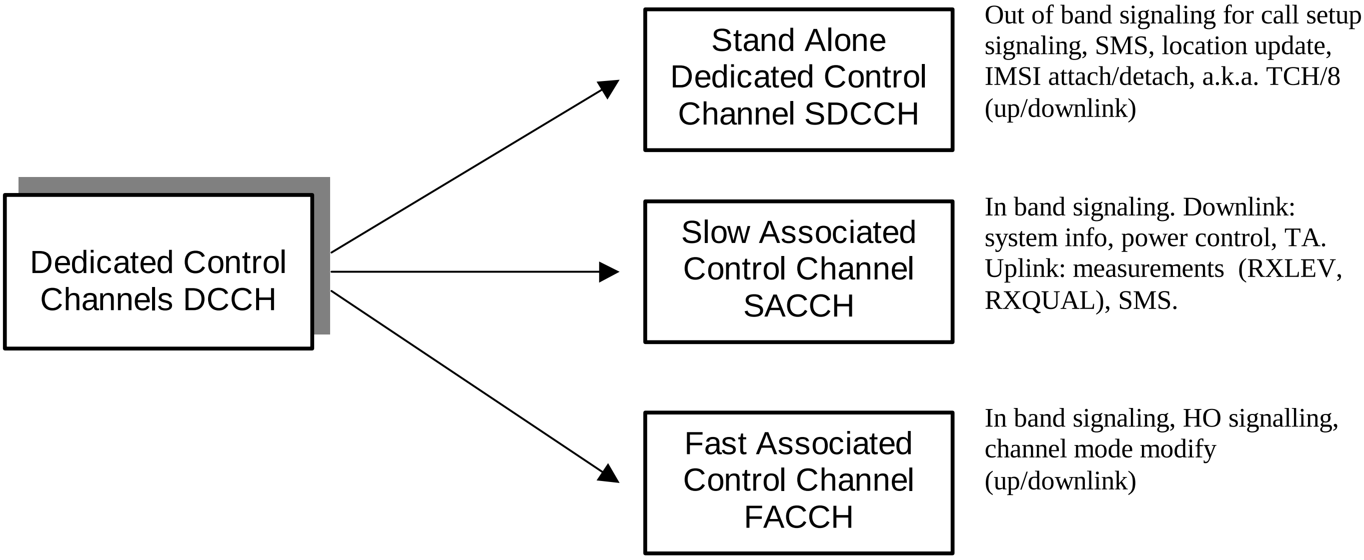


Figure 4. DCCH channels.

Traffic channels are used for speech and data transmission. TCH/FS indicates a full speed traffic channel where a full rate speech codec is utilised. There are also a variety of data channels.

Dedicated control channels are used in the dedicated mode. SDCCH is mapped into its own physical channel according to the channel combination used (see below). Like TCH, SDCCH has always a SACCH attached to it. FACCH is nothing but a TCH with a signaling payload instead of user data. Channel coding also differs from that of TCH. FACCH steals 20ms of user data, which may be heard as a crack in speech.

RACH is an uplink channel that “listens” constantly for MS random access bursts. PCH and AGCH are often called PAGCH (Paging and Access Grant CHannel) because they dynamically share bandwidth according to the current load on MTC or MOC. For example, if a cell has a higher MOC rate than MTC rate (usually the other way round [SBS95]), AGCH is given more blocks from CCCH capacity. This can be controlled by radio parameters.

Broadcast channels transmit general information about the cell. FCCH provides a frequency standard for MS to lock onto. When the MS is turned on, it first searches for a FCCH, and as soon as it finds one it immediately knows that the SCH can be found one frame later. The SCH contains crucial info for MS: training sequence code of the cell (usually the same as BSIC) and the current TDMA frame number which is needed at least for the A5 encryption algorithm and as a frequency hopping seed. Next MS tries to demodulate the BCCH which transmits a host of information. The BCCH broadcasts common cell parameters (like paging subgroup control) related to the serving cell, as well as the ARFCNs of neighbouring cells and other parameters (like HOMARGIN).

2.2.1 Structuring of logical channels into physical channels

Several different logical channel combinations are allowed. A list of some of the most common combinations is presented below [GSM0502]. A single physical channel can contain one of the allowed combinations. With GPRS the number of logical channels increases significantly, as does the complexity of the system. Only "basic GSM" combinations are considered here.

Different logical channel combinations:

I. TCH/F + FACCH/F + SACCH/TF

II. TCH/H(0,1) + FACCH/H(0,1) + SACCH/TH(0,1)

III. TCH/H(0,0) + FACCH/H(0,1) + SACCH/TH(0,1) + TCH/H(1,1)

IV. FCCH + SCH + BCCH + CCCH

V. FCCH + SCH + BCCH + CCCH + SDCCH/4(0..3) + SACCH/4(0..3)

VI. BCCH + CCCH

Combinations from I to III are used in physical channels reserved for traffic.

We shall give an example of combination V that is often used in cells with one or two TRX.

Figure 5 represents a single physical channel mapped into two signaling multiframes (2*51 frames). 102 frames is also the period after which the logical channel structure repeats itself. As in combination IV (figure 6), FCCH is repeated every 10^{th} frame followed by a SCH frame (excluding the last frame which is idle). In combination V there are also four SDCCH channels included. Each of these reserves four consecutive frames. In [Mou92] SDCCH is called TCH/8 because SDCCH is essentially a traffic channel whose bit rate is $^{1}/_{8}$ of TCH/FS. Like all traffic channels SDCCH needs a SACCH to transfer measurements to BTS.

Combination I is presented in figure 7. 24 frames out of the 26-frame multiframe (120ms) are used by traffic channels. One frame is used by SACCH associated with TCH and one frame is idle, in fact reserved for SACCH/HS in case half rate speech coding is used. Notice that, due to channel coding, a SACCH message requires a time span of four multiframes. FACCH steals 20ms of speech from TCH when necessary, during HO procedure for example.

In a single TRX cell the usual choice is combination I for traffic (7 time slots) and combination V (1 time slot) for signaling.

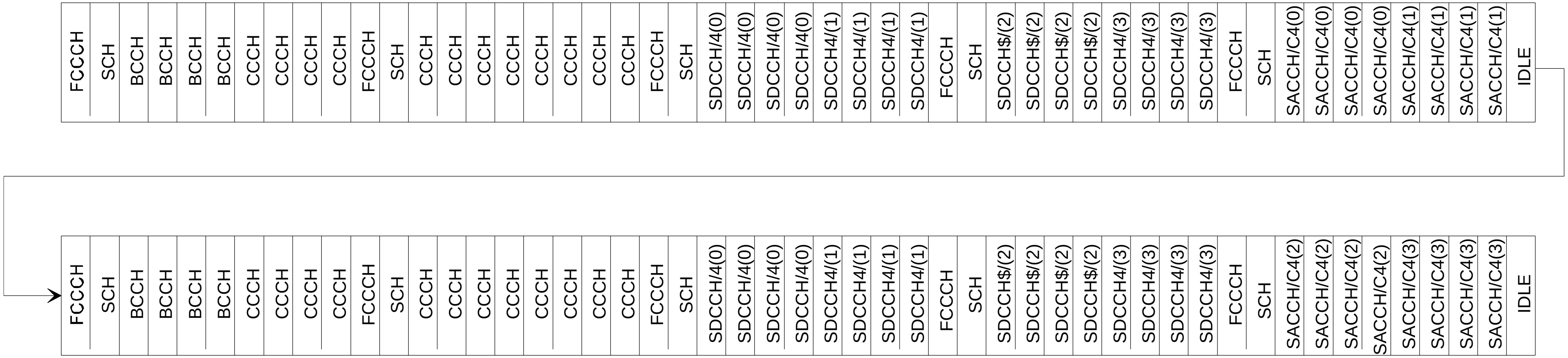


Figure 5. Combination V [GSM0502].

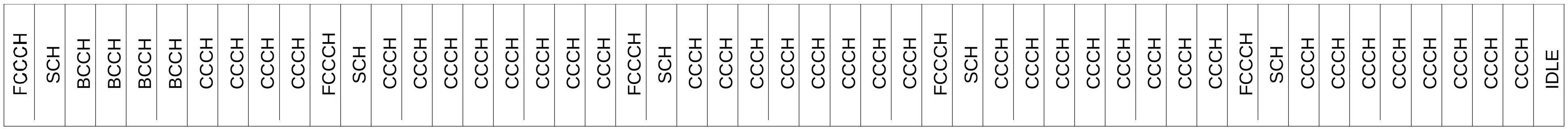


Figure 6. Combination IV [GSM0502].

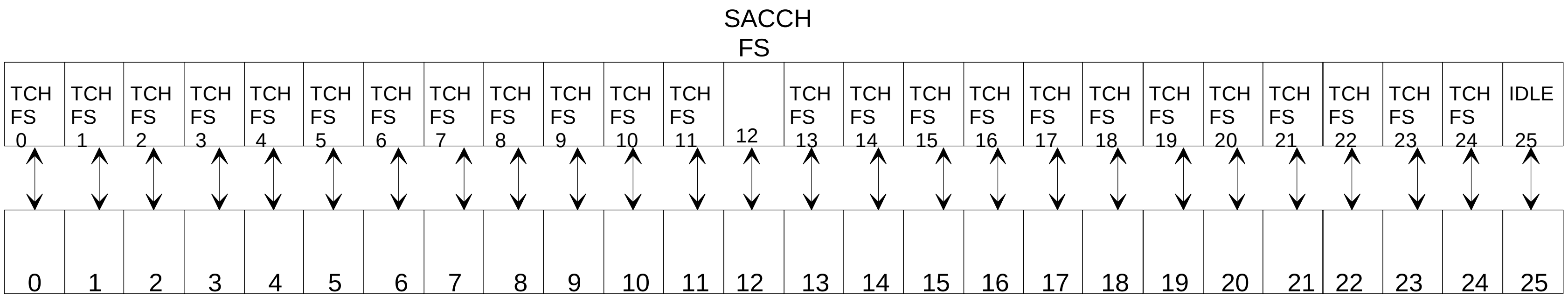


Figure 7. Combination I [GSM0502].

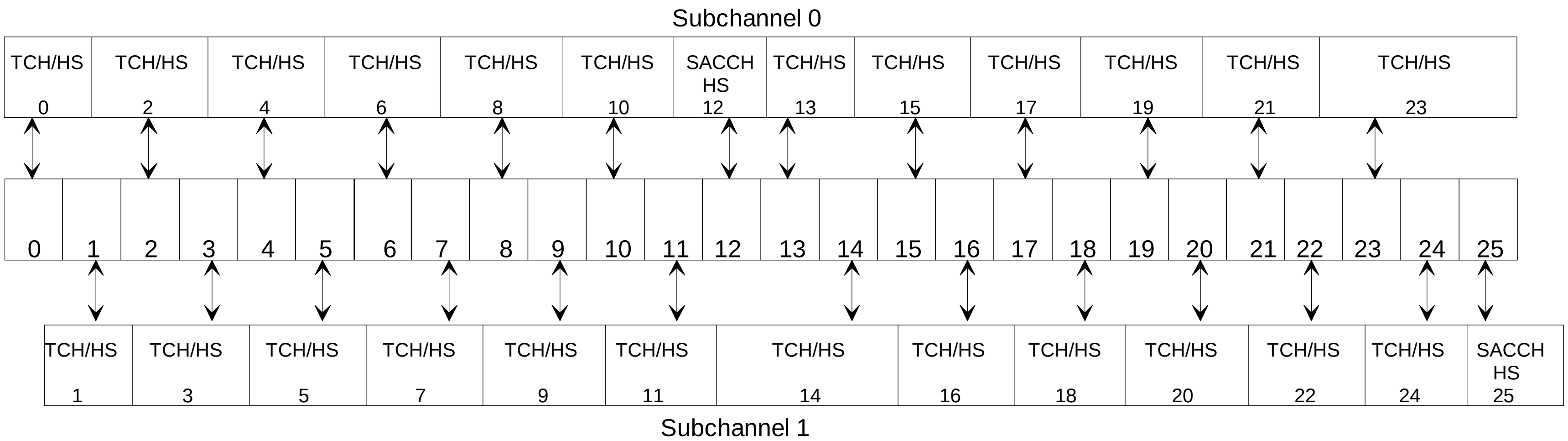


Figure 8. Combination II [GSM0502]. TDMA frame mapping for TCH/HS + SACCH/HS.

3 Cell selection and reselection

MS operates in two modes: idle mode and dedicated mode. In the idle mode, MS monitors the broadcast channels in order to "hear" if it is being paged. It also measures other BTSs' BCCH carrier and decides whether it should camp on another cell. This is called cell reselection and the reselection algorithm used in GSM is detailed in [GSM0508]. In dedicated mode (i.e. during a call), changing cell is called a handover (HO).

3.1 Cell selection

Cell selection is performed immediately after MS is switched on. If MS is located in the same cell it in which it was previously was switched off, the SIM card should have the local BCCH frequency stored in memory and MS should find network quite expeditiously. If MS has moved to another cell since it was turned off, it enters a cell selection procedure, which we shall skip here.

3.2 Cell reselection

3.2.1 Phase 1

Cell reselection is performed as MS traverses through a network in idle mode. MS continuously keeps list of the six strongest BCCH carriers. From the radio propagation point of view it is desirable that MS camps to a cell with the lowest path loss. The most favorable cell is indicated by the so called C1 parameter for a MS of phase 1, or by C2 for a MS of phase 2 capabilities. The parameter C2 is essentially an improved version of C1. C1 is evaluated separately for each cell and it is defined according to the criterion [GSM0508]

$$C1 = \left(A - \max\left(B,0\right)\right) \tag{1}$$

where A = Received average level – RX_ACCESS_MIN (in dBm)
B = MS_TXPWR_MAX_CCH –P (in dBm).

The received average level (AV_RXLEV) is found by averaging RXLEV samples over a period of 3-5 seconds [SBS95]. RX_ACCESS_MIN is a cell dependent parameter dictating the minimum allowed RXLEV for an MS to access that cell. MS_TXPWR_MAX_CCH is the maximum TX power an MS may use when accessing the system (using RACH). P is the maximum RF output power of the MS, usually 33 dBm for a handheld GSM900 and 30 dBm for a handheld GSM1800 MS. Often the latter term in C1 equals 0 and equation (1) can be simplified to

$$C1 = A = AV\_RXLEV - RX\_ACCESS\_MIN \ . \tag{2}$$

For example, if the minimum allowed level to gain access to a cell is –100dBm and the received average level at the cell's BCCH frequency is –80 dBm, MS calculates C1 as +20 for that particular cell. MS camps to the cell with the highest C1 value.

There is an exception to the standard procedure described above. When MS evaluates C1 values for cells belonging to a different Location Area (LA), it subtracts a parameter called CELL_RESELECT_HYSTERESIS from the C1 value, which means that those cells are given a negative offset. The reason for this is that changing LA requires a Location Update (LU) procedure that consumes network signaling capacity. Thus, by assigning a negative offset to C1, unnecessary LUs caused by slow fading can be reduced. MS receives information of the cell dependent CELL_RESELECT_HYSTERESIS values through BCCH.

3.2.2 Phase 2

Cell reselection criterion C2 is defined as

$$C2 = C1 + CELL\_RESELECT\_OFFSET - TEMPORARY\_OFFSET \quad (3)$$

when timer T < PENALTY_TIME and

$$C2 = C1 + CELL\_RESELECT\_OFFSET \quad (4)$$

otherwise.

The timer T is started separately for each cell in the list of the six strongest cells immediately after it is placed on the list. This is illustrated in the following picture. MS camps in the cell with the highest C2 value.

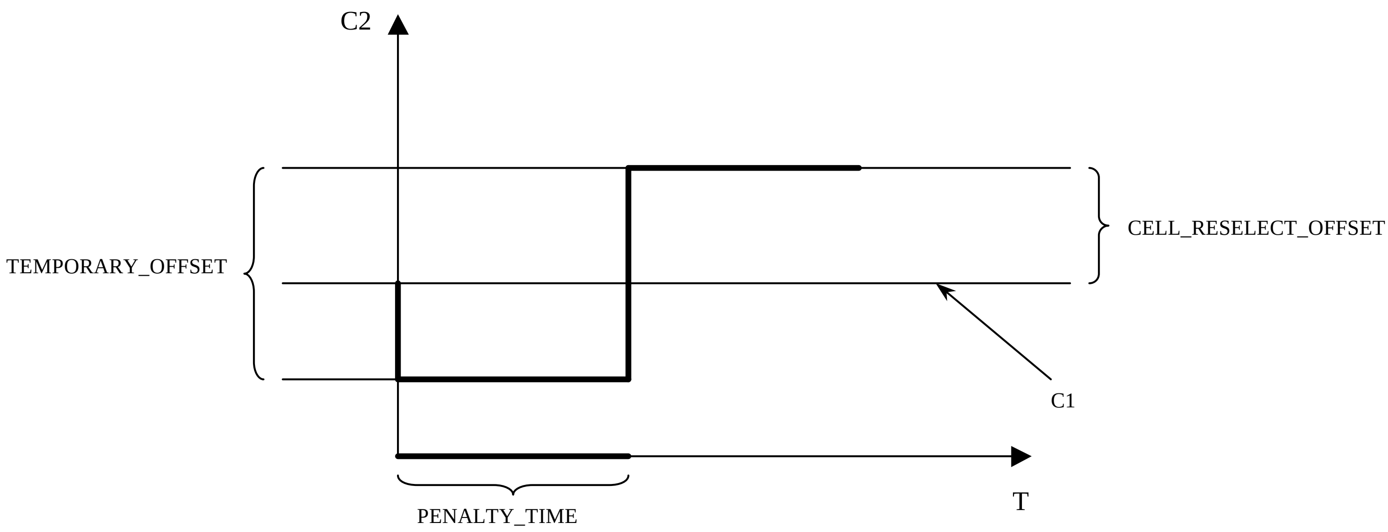


Figure 9. An example of C2 criterion calculated for a cell [SBS95].

The criterion C2 is applied in hierarchical cell structures to keep fast moving MS in an upper layer and slow moving MS in micro cells. It is assumed that a fast moving MS passes through the micro cell before PENALTY_TIME is reached. This efficiently prevents unnecessary LUs and thus saves network signaling capacity.

As in the case of C1, MS receives the C2 parameter information through BCCH.

A parameter called CELL_RESELECT_PARAM_IND informs MS about which reselection criterion (C1 or C2) is used in the cell. It is broadcast on the BCCH.

4 Handover (HO)

The handover algorithm decides when, why, how and to which cell the HO is made. Some of the many aspects of HO are touched upon briefly in the following discussion. In the GSM system MS takes active part in HO process. This type of HO is called Mobile Assisted Handover (MAHO).

4.1 Handover types

There are many different types of HOs. They can be enabled or disabled by using several flags in the BSS parameter database.

The different HO types, in the order of signaling complexity, are:

1. Intracell HO
2. Intra-BSS HO
3. Intra-MSC HO
4. Inter-MSC HO

Intracell HO can be executed whenever the co-channel interference is too high and some other physical channel in cell has less interference.

4.2 Handover causes

There are four causes for HO defined.

1. Quality, RXQUAL too high
2. Received level, RXLEV too low
3. MS⇔BTS distance too large, maximum radius of a GSM cell is about 35 km
4. Better cell, power budget for another cell is more favorable, i.e., path loss is smaller

If the network is strictly noise limited (very low interference), RXLEV HO (or more preferably power budget HO) should be the dominant reason for a HO. In an interference limited network (i.e. urban area) power budget related HO should be the overwhelming HO cause because this guarantees that MS expends as little RF power as possible (assuming that uplink power control is used) thus creating less interference and saving MS battery.

4.3 Handover measurements

During each SACCH multiframe the MS measures the following parameters:

1. RXQUAL, quality of reception, depends on BER [GSM0508]
2. RXLEV, received power level from “home” BTS
3. RXLEV_NCELL(n), received power level from neighbor cells defined on home cell BCCH.

The measurement results are transmitted to BTS during the next SACCH multiframe for processing.

BTS carries out similar measurements in uplink, in addition to

4. MS_BS_DIST, distance between MS and BTS, evaluated from Timing Advance (TA)
5. Interference level, measured in unallocated time slots

4.3.1 Measurement preprocessing

The information gathered by BTS and MS is preprocessed within BTS before making a decision on HO. Several BSS parameters influence this algorithm. The measurement results are averaged and weighted. Discontinuous transmission (DTX) affects preprocessing because SID frames are considered less reliable. The averaging window size and the importance weight given to SID frames can be adjusted for each of the parameters listed in the previous section.

For instance, A_LEV_HO is the parameter that controls averaging window size for measured RXLEV values. A_LEV_HO = 10 means that the last ten measured RXLEV values are averaged for HO decision purposes. W_LEV_HO = 2 means that measured RXLEV values for normal speech frames are weighted by a factor of two, as compared to RXLEV measured for SID frames.

4.4 Handover decision

The HO decision is controlled by numerous parameters. Some examples are given in the table below [SBS95].

Table 1. Decision criteria for different HO types.

HO type	Decision Criteria
RXLEV HO	1. RXLEV_XX < L_RXLEV_XX_H 2. XX_TXPWR = min(XX_TXPWR_MAX, P)
DIST HO	1. MS_BS_DIST > MS_RANGE_MAX
PBGT HO	1. RXLEV_NCELL(n) > RXLEV_MIN(n) + max(0,MS_TXPWR_MAX(n) – P) 2. PBGT(n) > HOMARGIN(n)
RXQUAL HO	1. RXQUAL_XX > L_RXQUAL_XX_H 2. RXLEV_XX < L_RXLEV_XX_IH 3. XX_TXPWR = min(XX_TXPWR_MAX, P)
RXQUAL HO intracell	1. RXQUAL_XX > L_RXQUAL_XX_H 2. RXLEV_XX > L_RXLEV_XX_IH

Here	XX	= UL or DL (uplink or downlink)
	MS_TX_PWR_MAX	= Maximum allowed TX power of the MS in the serving cell
	MS_TX_PWR_MAX(n)	= Maximum allowed TX power of the MS in the adjacent cell n
	P [dBm]	= Maximum power capability of the MS

From the decision criteria listed it can be seen that HO due to quality or received level is performed only if transmit power in DL and UL is on its maximum. This means that power control should function before HO.

Example: L_RXLEV_UL_H = 20. MS_TXPWR = MS_TXPWR_MAX = 26 dBm (MS transmits maximum power allowed in the cell i.e. MS power control has done all it can). P = 30 dBm (handheld GSM1800 MS TX power capability). RXLEV_UL = 15 (received averaged level). Now the received level is smaller than the threshold L_RXLEV_UL_H by 5 steps and HO is initiated.

The following flowchart depicts the HO algorithm based on criteria of table 1.

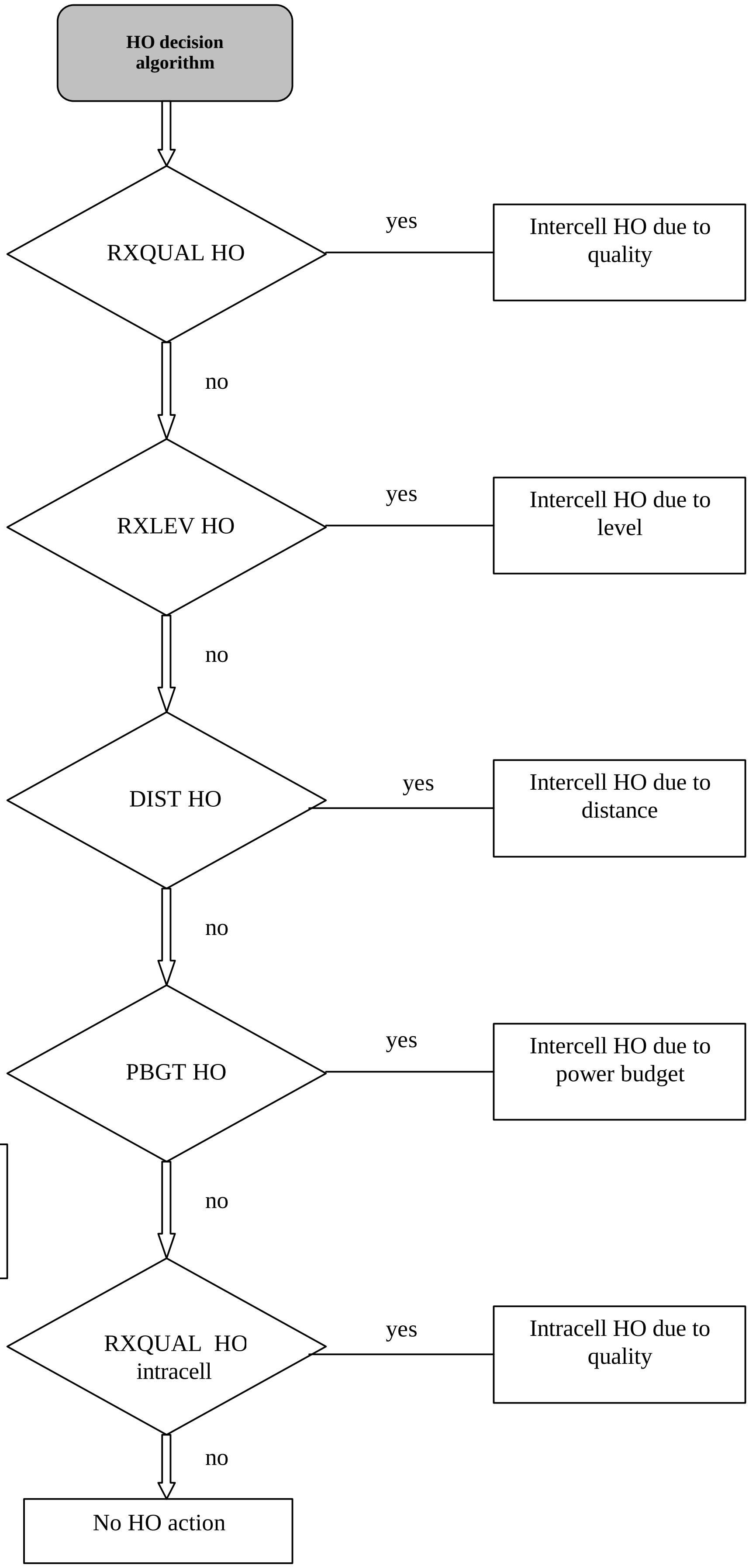


Figure 10. HO decision algorithm [SBS95].

The Power budget is computed for all cells separately and it is expressed for cell n as

$$PBGT(n) = RX\_LEV\_NCELL(n) - \left(RXLEV\_DL + PWR\_C\_D\right) + \min\left(MS\_TX\_PWR\_MAX, P\right) - \min\left(MS\_TX\_PWR\_MAX(n), P\right) \tag{5}$$

Here PWR_C_D is the averaged difference between the maximum downlink RF power BS_TXPWR_MAX, and the actual used downlink power due to power control.

In a simplified case the downlink power control is not used and MS_TXPWR_MAX is the same for all cells. Power budget can now be written as

$$PBGT(n) = RX\_LEV\_NCELL(n) - RXLEV\_DL \tag{6}$$

which portrays the path loss difference between cell *n* compared to serving cell, if the TX power of both BTS is the same.

In order to initiate a power budget HO to cell *n*, PBGT(*n*) must exceed PBGT of the serving cell by at least HOMARGIN(n) which is also defined separately for each cell. HOMARGIN assures that MS will not bounce back and forth between cells due to slow fading or minor user movements. In other words, the condition

$$PBGT(n) > HOMARGIN(n) \tag{7}$$

must be fulfilled in order to initiate a power budget HO to cell n. The different HO regions are illustrated in figure 11.

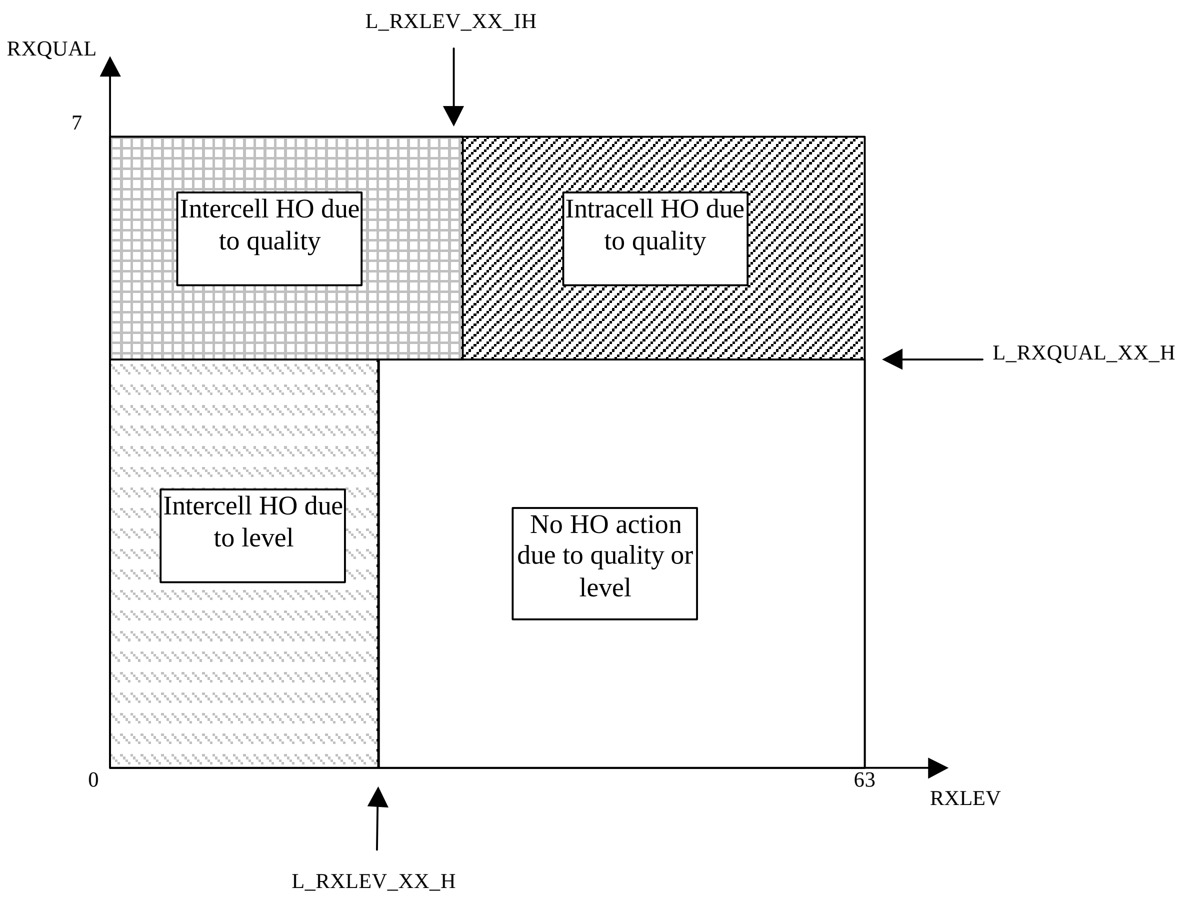


Figure 11. Handover regions for RXQUAL and RXLEV [SBS95].

In the following figure, the limits for different RXLEV HO thresholds are presented. The innermost limit indicates RXLEV_MIN, the minimum required RXLEV for a MS to enter the cell by HO. The outermost limit indicates the largest possible radius of the cell limited by the MS receiver sensitivity. It should be noted that the figure represents "sensible" threshold settings. One could adjust the parameters to any ridiculous value.

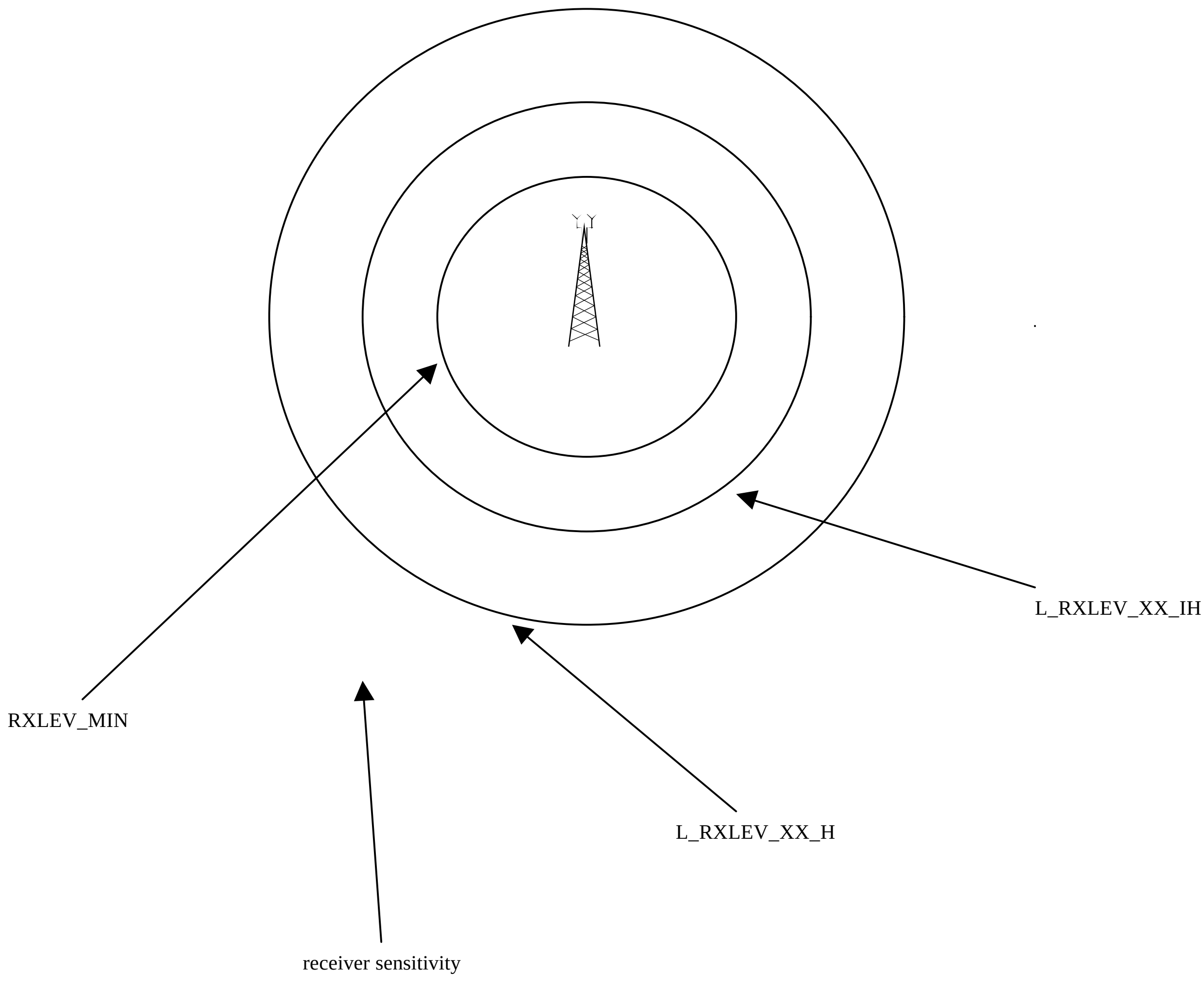


Figure 12. Relation between RXLEV HO thresholds [SBS95].

4.4.1 Speed sensitive HO algorithm

A subclass of the power budget HO is the speed sensitive power budget HO that is employed in hierarchical cell structures. A hierarchical cell structure consists of overlayer macro cells and embedded underlayer micro cells. This kind of architecture is often utilized in high traffic areas. The network is interference limited and the power budget HO is the dominant HO mechanism to in minimizing TX power. Ideally, the macro cell layer serves fast moving mobiles, and pedestrian mobiles stay in the micro cell layer. This can be achieved by means of C2 cell reselection (idle mode) and the speed sensitive HO algorithm (dedicated mode).

There are quite a few BSS parameters associated with hierarchical cell structures, priority layers and ways to control them. This is beyond the scope of this text and we shall only take a brief look at the speed sensitive HO algorithm to exemplify the possibilities of modern radio network design and optimization.

Speed sensitive HO is analogous to C2 cell reselection. It differs from the ordinary power budget HO in that HO_MARGIN(n) is replaced by HO_MARGIN_TIME(n). Thus HO is initiated if the condition

$$PBGT(n) > HO\_MARGIN\_TIME(n) \tag{8}$$

is fulfilled.

The time dependent handover margin is given by

$$HO\_MARGIN\_TIME(n) = HO\_MARGIN(n) + HO\_STATIC\_OFFSET(n) \tag{9}$$

when timer T < DELAY_TIME and

$$HO\_MARGIN\_TIME(n) = HO\_MARGIN(n) + HO\_STATIC\_OFFSET(n) - HO\_DYNAMIC\_OFFSET(n) \tag{10}$$

when T > DELAY_TIME.

The parameter DELAY_TIME is measured in SACCH multiframes and the static and dynamic offsets are measured in dBm. By setting a large static offset, HO can be prevented during the runtime of the timer T for that cell [SBS95].

5 Power control

Like frequency hopping and DTX, power control is a tool for reducing the interference in the network. This can be understood easily if we consider a case of only one allowed transmit power for MS. Mobiles far from BTS will not produce unnecessary interference because they would have to use more RF power to reach the quality target anyway. But if mobiles near the BTS expend the same amount of power, most of this power will be wasted and the overall power level in the network increases and “excess” interference is created. This situation is known as the near-far problem and it is even more harmful in CDMA systems.

Power control can be used in both uplink and downlink. All MS have power control capability; this is required by the specifications. It is up to the operator whether to use power control or not.

The TX power can be controlled by BSS parameters. This is done much in the same way as for HO. For instance, a RXQUAL threshold for power increase can be set. If RXQUAL falls under the set threshold level, MS (or BTS) is ordered to increase the TX power by an amount that is defined by the according parameters.

Example: L_RX_QUAL_UL_P = 5, U_RX_QUAL_UL_P = 3, POW_INCR_STEP_SIZE = 4dB, POW_RED_STEP_SIZE = 2 dB. The downlink power control is disabled. Assume we have interference causing the averaged RXQUAL at MS (which is reported to BTS on SACCH) to rise to 5. BTS commands MS on SACCH to increase the TX power by one step, i.e., 4dB. The C/I value increases by 4 dB as well and we presume that RXQUAL falls to 3. This should trigger the upper threshold and BTS commands MS to lower its TX power by one step, i.e., 2 dB. Now RXQUAL falls to the "deadband" region which in this case is RXQUAL = 4 and no further power control commands are issued for a while.

The example is totally fictious and its purpose is to clarify the power control process. See the appendix for a table of power control parameters.

Note that the HO thresholds and power control thresholds have similar parameter names. The difference is in the last letter, H and P, respectively.

The power control and HO threshold limits should usually be set in such a way that the power control acts before HO.

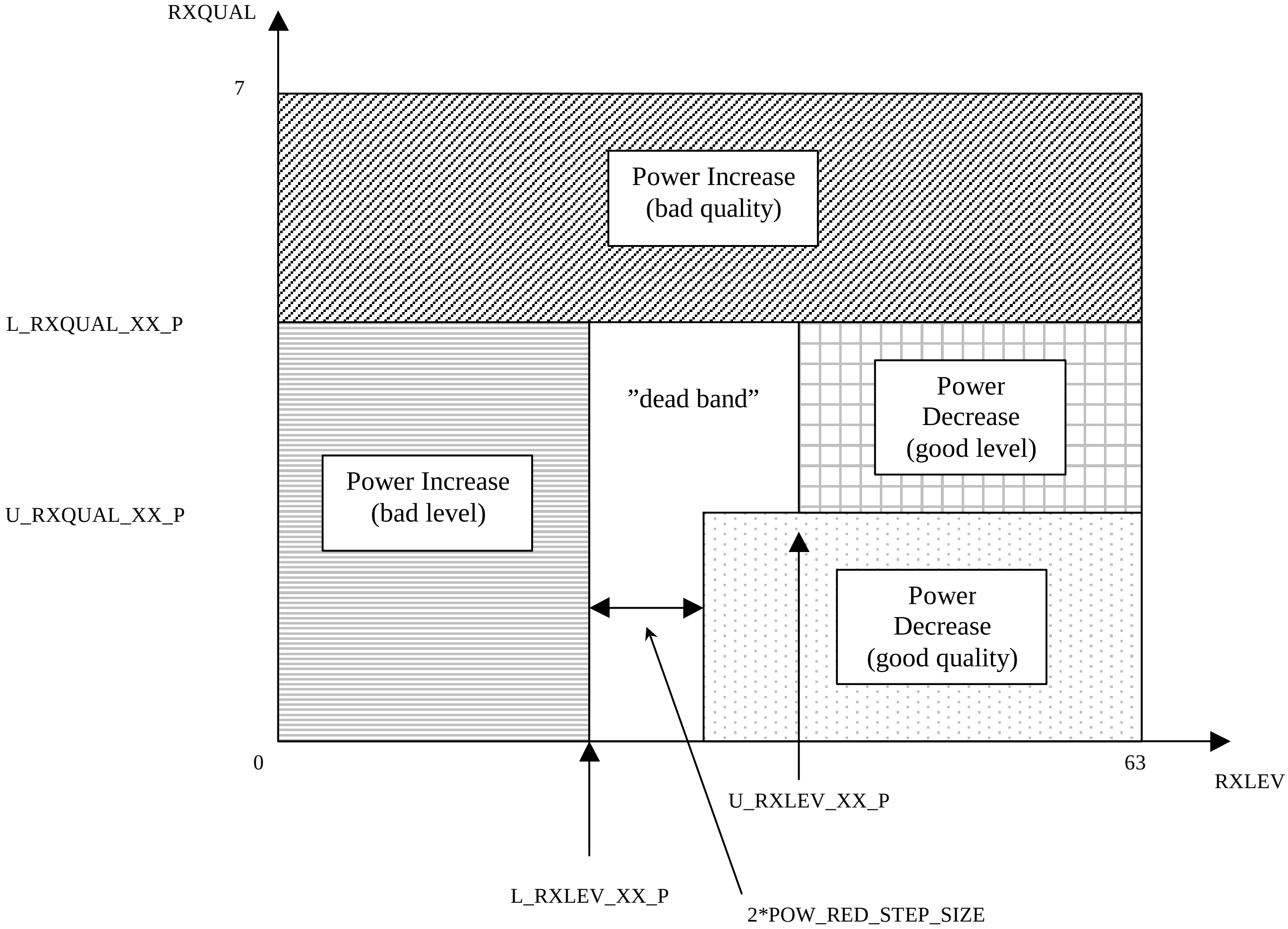


Figure 13. Power Control threshold regions [SBS95].

6 Laboratory Exercise

In the laboratory exercise a number of BSS parameters are investigated. The objective is to understand why and how network optimization can be achieved using BSS radio parameters. Real networks have a large amount of cells and numerous parameters influence the capacity of the network. Computer simulations and experience play an important role in optimizing such a large system.

The configuration of the laboratory BSS system is depicted in the figure below.

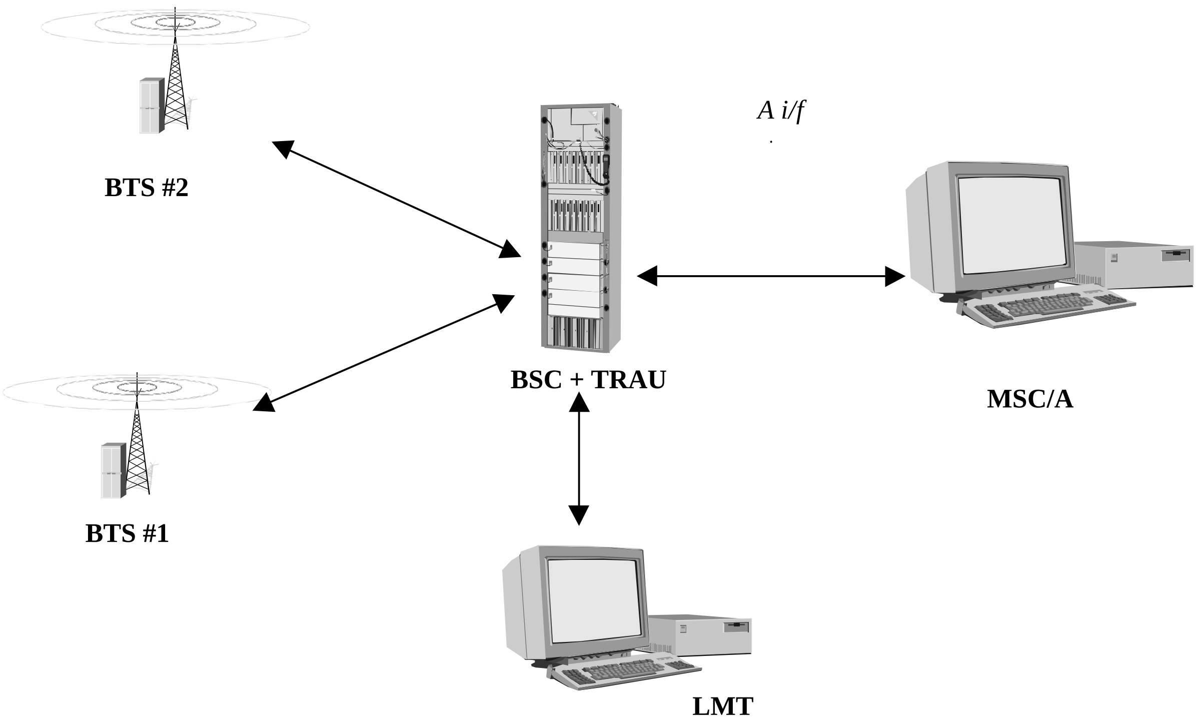


Figure 14. Laboratory equipment.

There are two BS-11 base stations with one TRX each. A NetHawk simulator running in a Win95 PC simulates the A interface. The BSS parameters are adjusted with Local Maintenance Terminal (LMT).

Due to frequency regulations, the BTS antennas are disconnected and replaced by an RF network utilising coaxial cables, attenuators and power splitters. By adjusting the attenuation, a variable path loss can be "simulated".

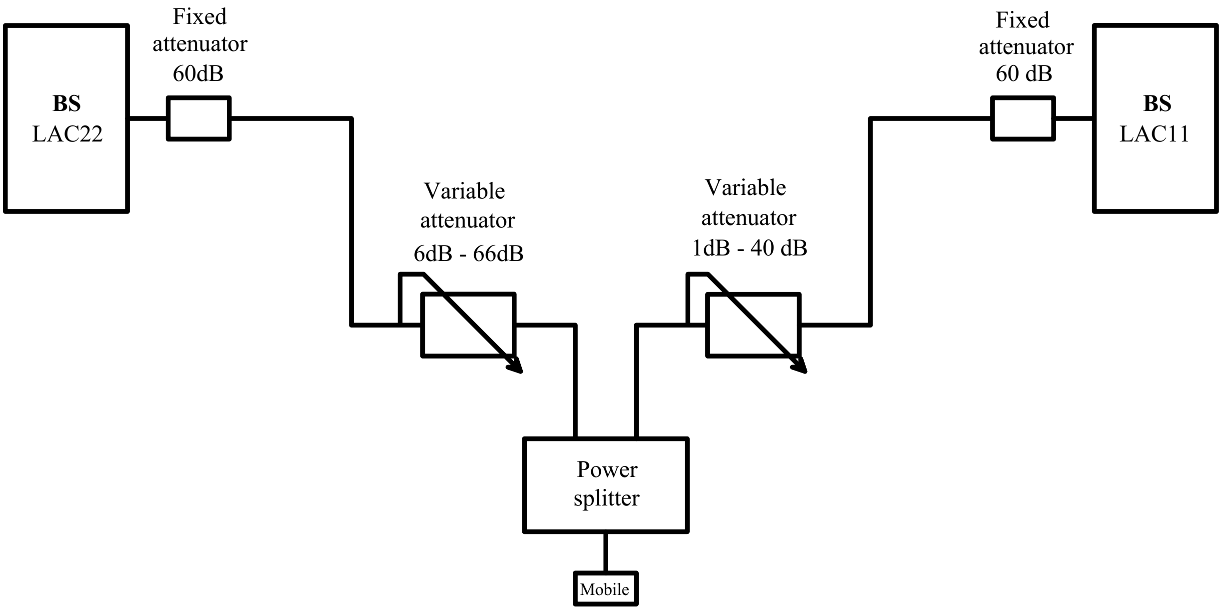


Figure 15. RF network.

Power splitters are ideal in forward direction and have 3 dB loss in combining direction. The coaxial cables are of type RG214 and the loss of these cables is L_1 = 4 dB at 1800 MHz. The loss of the connection cable to MS has loss L_2 = 4 dB.

Information about the BTS configuration is given in the next table.

Table 2. BTS information.

	BTS #1	**BTS #2**
GSM1800 ARFCN	620	624
MCC MNC LAI CI	123 45 11 1	123 45 22 2
Max PA RF output power	22 dBm	22 dBm

Appendices

1. Physical channel structure
2. Some BSS parameters
3. Channel organization in the 51 -frame multiframe [GSM 05.01]

References

[GSM0508] GSM 05.08, "Radio subsystem link control", version 6.1.1 (phase 2+), ETSI, April 1998

[GSM0502] GSM 05.02, "Multiplexing and multiple access on the radio path" , version 6.2.0 (phase 2+), ETSI July 1997

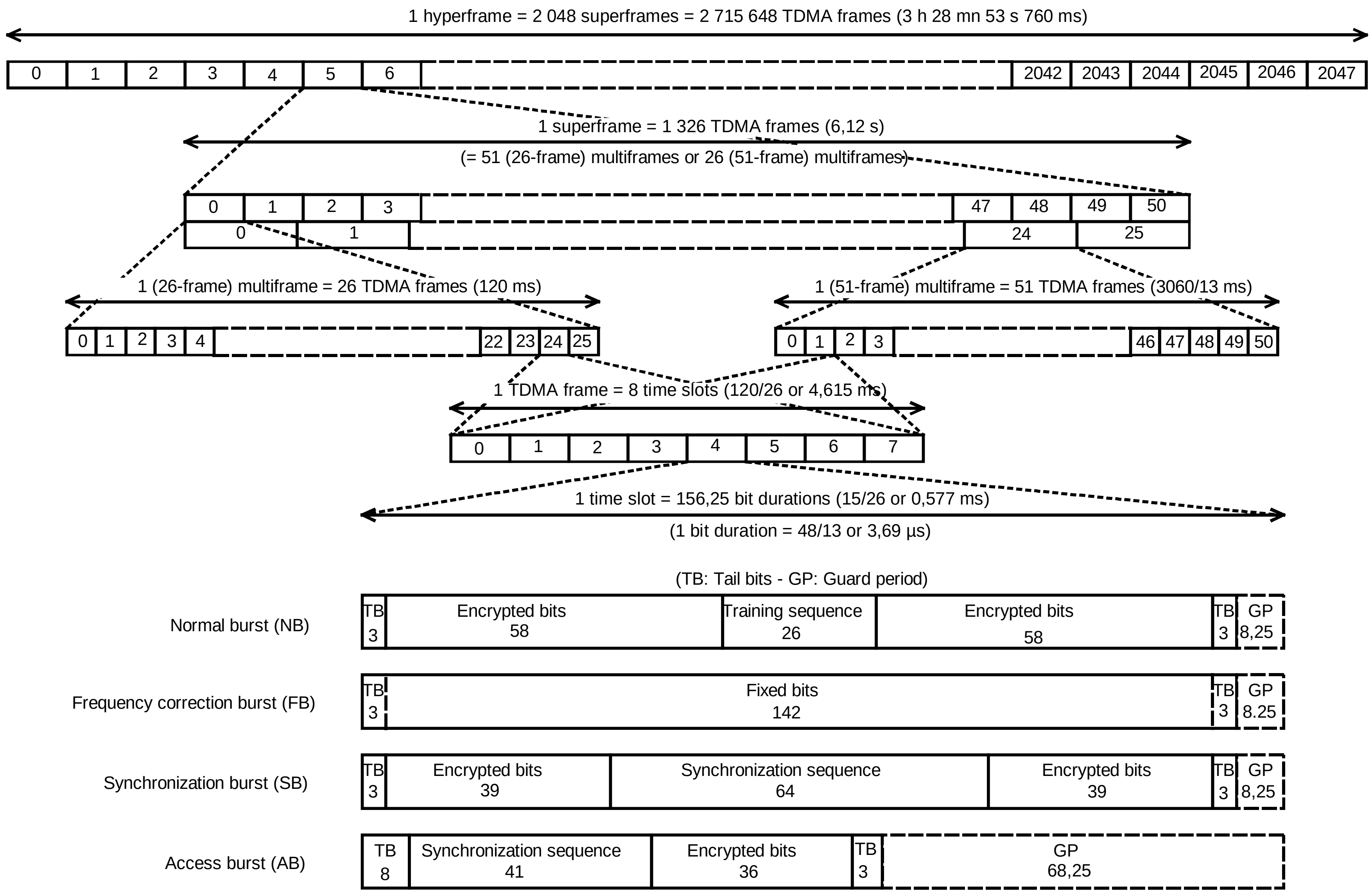
[GSM0403] GSM 04.03, "Channel structures and access capabilities", version 5.3.0 (phase 2+), ETSI January 1998

[Redl95] Redl, Siegmund M., Weber, Matthias K., Oliphant, Malcolm W., "An introduction to GSM", Artech House, 1995

[SBS95] "BSS Radio Network Parameters", training material, Siemens 1995

[Mou92] Mouly M., Pautet M., "The GSM System for Mobile Communications", published by the authors, 1992

Appendix 1. Physical channel structure. (GSM 05.01 version 6.1.0) ETSI 1998



Appendix 2. Selected BSS parameters

This is a list of parameters that could be helpful in the laboratory exercise. More information can be found in the Windows help file *db37_1.hlp*. This help file has detailed information about parameters in the release BR3.7 of Siemens Base Station System (SBS). GSM specifications [GSM0502, GSM0508] contain the most accurate information available.

The tables summarize the official GSM specification parameter name, the name of the parameter in the SBS Data Base (DB), the object and package where the parameter can be found, and range of the parameter (T/F = TRUE/FALSE).

NOTE: In release BR4.0 some parameter names have changed in DB.

Table 1. Parameters affiliated with cell selection/reselection.

Parameter	DB name	Object/Package	Range	Step size
BA	BCCHFREQ	ADJC	0…1023	-
SYS_ID	SYSID	BTS/BTSB	BB900 GSM1800 F2ONLY900 EXT900 GSMR PCS1900	-
CELL_BAR_ACCESS	CELLBARR	BTS/BTSO	T/F	-
MS_TXPWR_MAX_CCH	MTPWRCCH	BTS/BTSC	0…31	2 dB
POWER_OFFSET	POWEROFF	BTS/BTSC	0…3	2 dB
RXLEV_ACCESS_MIN	RXLEVAMI	BTS/BTSB	0…63	1 dB
CELL_RESELECT_HYSTERESIS	CELLRESH	BTS/BTSB	0…7	2 dB
CELL_BAR_QUALIFY	CBQ	BTS/BTSB	0…1	-
CELL_RESELECT_PARAM_IND	CRESPARI	BTS/BTSB	0…1	-
PENALTY_TIME	PENTIME	BTS/BTSB	0…30 and 31 (special)	20 sec
TEMPORARY_OFFSET	TEMPOFF	BTS/BTSB	0…6 and 7 infinity	10 dB
CELL_RESELECT_OFFSET	CRESOFF	BTS/BTSB	0…63	2 dB

Table 2. Parameters affiliated with HO decision.

Parameter	DB name	Object/Package	Range	Step size
L_RXQUAL_DL_H	HOLTQUDL	HAND	0…7	Special
L_RXQUAL_UL_H	HOLTQUUL	HAND	0…7	Special
L_RXLEV_DL_H	HOLOWTDL	HAND	0…63	1 dB
L_RXLEV_UL_H	HOLOWTUL	HAND	0…63	1 dB
MS_RANGE_MAX	MSRNGMAX	HAND	0…35	1 km
L_RXLEV_DL_IH	HOTDLINT	HAND	0…63	1 dB
L_RXLEV_UL_IH	HOTULINT	HAND	0…63	1 dB
MS_TXPWR_MAX	MSTXPWMX	BTS/BTSB	0…15 (GSM1800)	2 dB
MS_TXPWR_MAX(n)	MSTXPWAX	ADJC	0…15 (GSM1800)	2 dB
RXLEV_MIN(n)	RXLEVMIN	ADJC	0…63	1 dB
HO_MARGIN(n)	HOM	ADJC	-24…24	1 dB

Appendix 2. Selected BSS parameters

Table 3. Parameters for HO measurement preprocessing.

Parameter	DB name	Object/Package	Range	Step size
A_QUAL_HO	HOAVQUAL *AQUALHO*	HAND	1…31	-
W_QUAL_HO	HOAVQUAL *WQUALHO*	HAND	1..3	-
A_LEV_HO	HOAVELEV *ALEVHO*	HAND	1…31	-
W_LEV_HO	HOAVELEV *WLEVHO*	HAND	1…3	-
A_DIST_HO	HOAVDIST	HAND	1…31	-
A_PBGT_HO	HOAVPWRB	HAND	1…31	-

Table 4. HO activation parameters.

Parameter	DB name	Object/ Package	Meaning
EN_INTER_HO	INTERCH	HAND	Flag to enable/disable all HO types and causes except for intracell HO.
EN_INTRA_HO	INTRACH	HAND	Flag to enable/disable a intracell HO.
EN_BSS_INTER_HO	LOTERCH	HAND	Flag to enable/disable a BSS internal intercell HO, i.e. if disabled the HO is handled as an inter BSS HO even if the first cell in the target list belongs to the same BSS as the serving cell.
EN_BSS_INTRA_HO	LOTRACH	HAND	Flag to enable/disable a BSS internal intracell HO, i.e. if disabled the HO is handled as an inter BSS HO and the MSC is involved.
EN_RXQUAL_HO	RXQUALHO	HAND	Flag to enable/disable intercell HO due to quality.
EN_RXLEV_HO	RXLEVHO	HAND	Flag to enable/disable intercell HO due to received level.
EN_DIST_HO	DISTHO	HAND	Flag to enable/disable intercell HO due to distance.
EN_PBGT_HO	PWRBGTHO	HAND	Flag to enable/disable better cell (power budget) HO.

Table 5. Parameters for mobile speed sensitive HO.

Parameter	DB name	Object/Package	Range	Step size
EN_PBGTD_HO	ENDPWBHO	HAND	T/F	-
HO_STATIC_OFFSET	HOMSOFF	ADJC	0…127	1 dB
HO_DYNAMIC_OFFSET	HOMDOFF	ADJC	0…127	1 dB
DELAY_TIME	HOMDTIME	ADJC	0…255	T_{sacch}
HO_MARGIN	HOMARGIN	ADJC	-24…24	1 dB
MICRO_CELL	MICROCELL	ADJC	T/F	-

Appendix 2. Selected BSS parameters

Table 6. Parameters for power control measurement preprocessing.

Parameter	DB name	Object/Package	Range	Step size
A_QUAL_PC	PAVRQUAL *AQUALPC*	PWRC	1…31	-
W_QUAL_PC	PAVRQUAL *WQUALPC*	PWRC	1..3	-
A_LEV_PC	PAVRLEV *ALEVPC*	PWRC	1…31	-
W_LEV_PC	PAVRLEV *WLEVPC*	PWRC	1…3	-

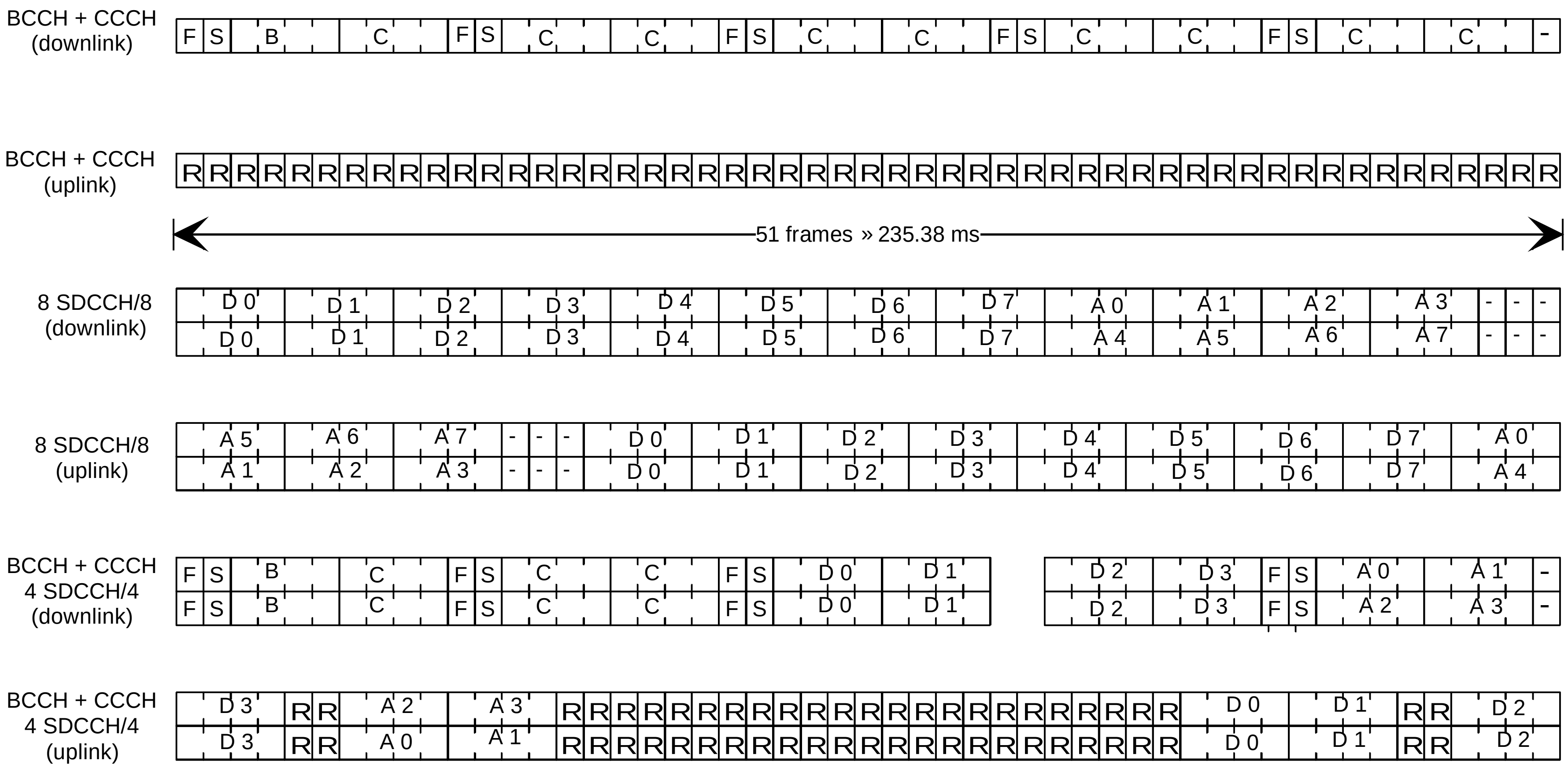
Table 7. Parameters for power control execution.

Parameter	DB name	Object/Package	Range	Step size
MS_TXPWR_MAX	MSTXPWMX	BTS/BTSB	0…15 (GSM1800)	2 dB
BS_TXPWR_RED	PWRRED	TRX	0…6	2 dB
POW_INCR_STEP_SIZE	PWRINCSS	PWRC	1,2,3	2 dB
POW_RED_STEP_SIZE	PWRREDSS	PWRC	1,2	2 dB

Table 8. Parameters for Control Channel configuration.

Parameter	DB name	Object/Package	Range	Step size
CH_TYPE	CHTYPE	CHAN	TCHFULL SDCCH MAINBCCH MBCCHC CCCH SCBCH BCBCH TCHF&HLF	-
RACH_BUSY_THRES	RACHBT	BTS/BTSB	0…255	- 1 dBm
MAX_RETRANS	MAXRETR	BTS/BTSC	1,2,4,7	-
TX_INTEGER	NSLOTST	BTS/BTSC	0…15	special
BS_AG_BLKS_RES	NBLKACGR	BTS/BTSC	0…7	-
BS_PA_MFRMS	NFRAMEPG	BTS/BTSC	2…9	$T_{multiframe}$

Appendix 3: Channel organization in the 51-frame multiframe [GSM 05.01]



F: TDMA frame for frequency correction burst
S: TDMA frame for synchronization burst
B: TDMA frame for BCCH
C: TDMA frame for CCCH
D: TDMA frame for SDCCH
A: TDMA frame for SACCH/C
R: TDMA frame for RACH

Quick guide to LMT [BSC99]

Local Maintenance Terminal (LMT) is a Windows program that can be used to adjust BSS parameters. There are different versions of LMT for different Network Elements (NE). In this laboratory exercise, BSC version of LMT is used.

Chapter 1.9 in [BSC99] gives an introduction to LMT.

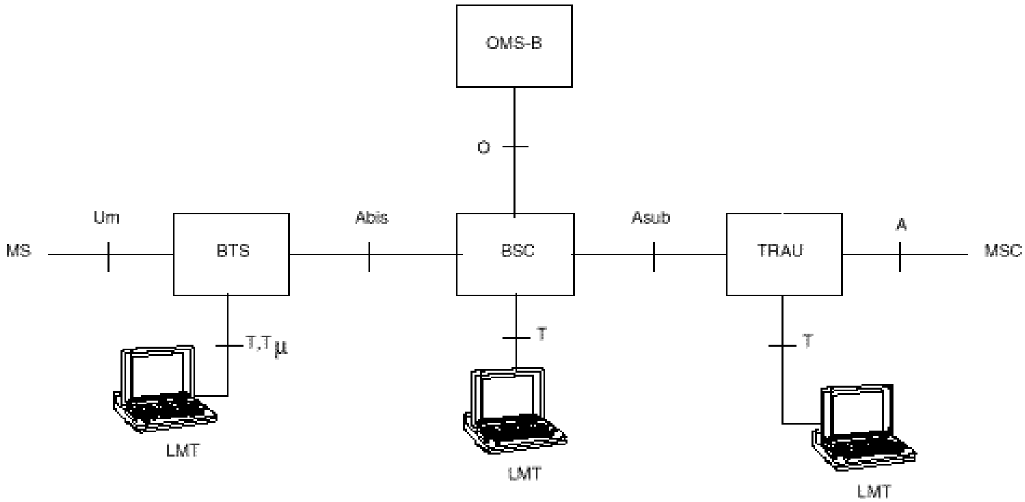


Figure 1. LMT connection to BSS.

There is also a BTS version of LMT installed in the laboratory's computers. This program can be used to control the BS-11 base station.

Figure 2. LMT main screen [BSC99].

The radio parameters used in the laboratory work can be controlled with the LMT Input Handler program. Manageable objects are organized hierarchically in a tree. Clicking an object gives all possible commands related to it in a separate window.

Message buffer can be browsed with the LMT Message Handler program.

During the laboratory exercise, several command scripts will have to be executed. This can be done using the CL (Command Line) interface tool, which can be opened from Input Handler. Scripts can be found from the directory *c:\lab3* .

The following objects and packages will be used in the laboratory work. Refer to [DBH98, BCM99] for more information about parameters in these packages.

Table 1. Key packages in the laboratory work.

Object/Package	**Description**
ADJC	Adjacent cell parameters, like Cell Id, HOMARGIN etc
BTS/BTSB	Basic parameters of BTS
BTS/BTSC	Control Channel parameters
HAND	Handover parameters, enabling/disabling, thresholds etc
PWRC	Power Control parameters, enabling/disabling, threshold
TRX	Parameters that affect TRX, like PA static power control

In the LMT Input Handler, these objects can be found under MANAGED-ELEMENT/BSS-FUNCTIONAL/ .

References

[BSC99] "*Introduction, Base Station Controller*", user documentation, Siemens 1999
[DBH98] *db37_1.hlp*, Database help file (unofficial), Siemens 1998
[BCM99] "*Commands, Base Station Controller*", user documentation, Siemens 1999

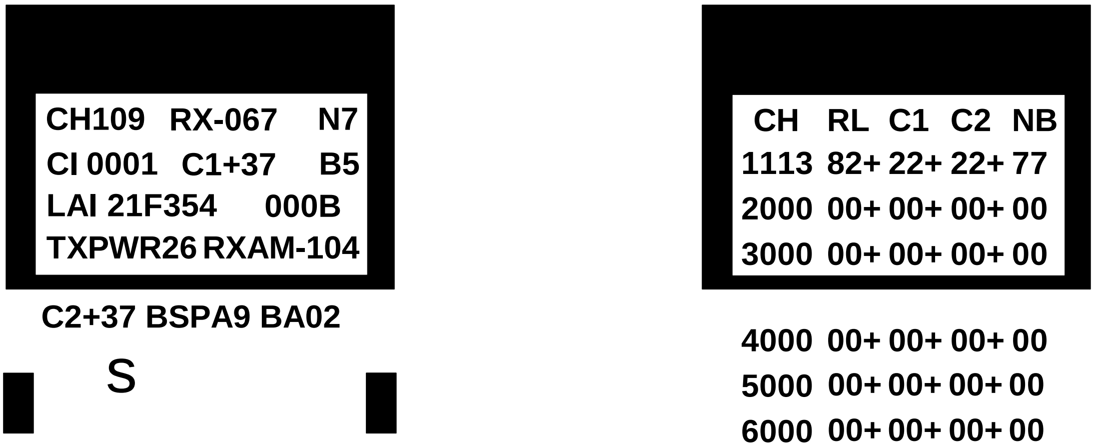
Minimonitorin käyttö Siemens S6 GSM1800-puhelimessa

Yleistä

Minimonitori näyttää tietoja esimerkiksi käytetystä GSM-kanavasta, vastaanotetusta tehosta sekä matkapuhelimen mittaamia suureita sekä soluparametreja, jotka puhelin dekoodaa BCCH-kanavalta. Tarkemman selostuksen eri parametrien sisällöstä saa vaikkapa kirjasta M. Mouly, M.B. Pautet, “The GSM System for Mobile Communications” tai GSM-spesifikaatioista.

Monitorin käyttö

Monitorinäyttö saadaan esiin painamalla näppäinyhdistelmä `Valikko-0-Valitse`. Monitorinäytöstä poistutaan painamalla muutaman kerran puhelunlopetusnäppäintä (punainen).



Kuva 1. Monitorin näyttö ilman puhelua. Oikean näytön (naapurikanavanäyttö) saa näkyville painamalla näytön alla olevaa oikeanpuoleista valikkonäppäintä. Näytön alapuolella olevat tiedot saa esille vasemmalla valikkonäppäimellä.

Perusnäyttö

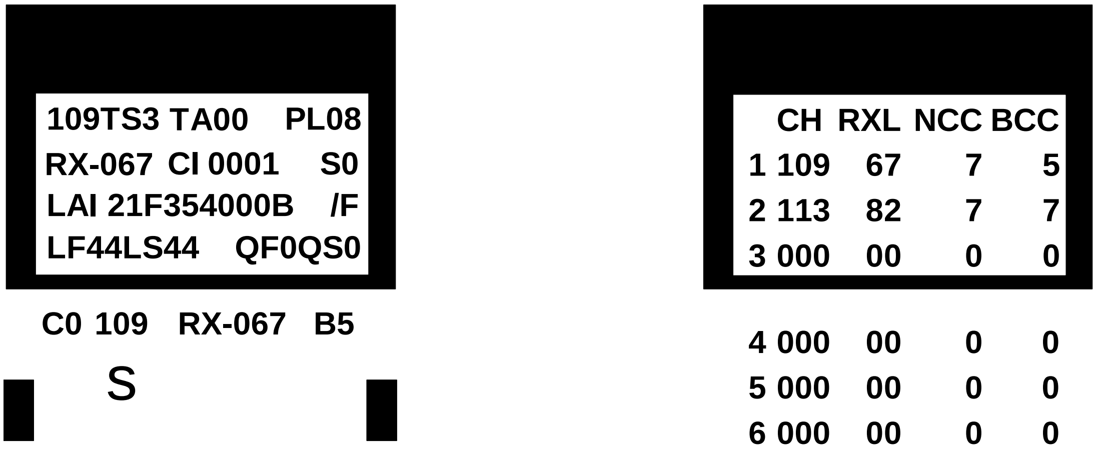
CH109	RFC-numero. Näytössä järjestysnumero kanavataulukosta. Kanava numero saadaan seuraavasti 109+511=620.
RX-067	Vastaanotettu tehotaso, yksikkö dBm (tässä -67 dBm)
N7	NCC Network Color Code. Tässä esimerkissä 7.
CI 0001	Cell Id heksadesimaali muodossa. Tässä esimerkissä 0001.
C1+37	C1-arvo solulle, johon MS on leiriytynyt
B5	BCC Base station Color Code. Tässä esimerkissä 5.
LAI 21F354 000B	LAI=MCC,MNC LAC. Mobile Country Code (123), Mobile Network Code(45), Location Area Code (11).
TXPWR26	Suurin sallittu lähetysteho RACH-kanavalla solussa.Yksikkö dBm Tässä esimerkissä 26 dBm
RXAM-104	RX_LEVEL_ACCESS_MINIMUM. Alhaisin sallittu vastaanotettu tehotaso, jolla MS voi yrittää pääsyä verkkoon.
C2+37	C2-arvo solulle, johon MS on leiriytynyt
BSPA9	BS_PA_MFRMS. Aikaväli (multiframes), jonka välein saman paging groupin lohkot toistuvat
BA02	BA_ALLOCATION. Kertoo mitattavien BCCH-kantoaaltojen määrän.

Naapuritukiasemanäyttö

CH	Tukiaseman paremmuus järjestys ja GSM-radiokanavan numero lasketaan kuten yllä.
RL	Vastaanotettu tehotaso yksikkö dBm. Huomioi että esim. -102 dBm=02, koska käytössä on ainoastaan 2 numeroa käytössä.
C1	C1
C2	C2
NB	NCC ja BCC. Esimerkissä DCS radiokanava 113, NCC=7 ja BCC=7

Monitorinäyttö puhelun aikana (dedicated mode)

Puhelun aikana monitori näyttää puhelukohtaisia tietoja.
Puhelun aikana monitori näyttö saadaan esille painamalla `Valikko-0-Valitse.`



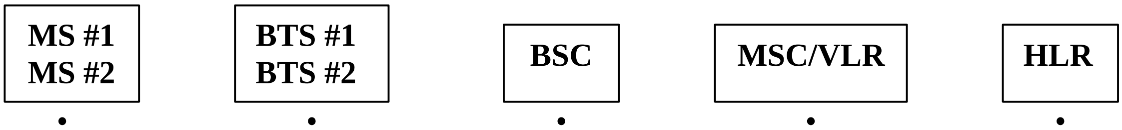
Kuva 2. Monitorin näyttö puhelun aikana

Perusnäyttö

109TS3	RFC-numero 109 ja radiokanavan aikaväli 3, TS=Time Slot
TA00	Timing Advance yksikkö 1/4 bitin kesto ≈ 550 m
PL08	Power Level. MS lähetys teho 30dBm ≡ 0. Yksi askel = -2 dB. Esim. PL8 ≡14 dBm.
RX-067	Vastaanotettu tehotaso yksikkö dBm.
CI 0001	Cell Id heksadesimaali muodossa. Tässä esimerkissä 0001.
S0	??
LAI 21F354000B	LAI=MCC,MNC,LAC kuten edellä.
/F	
LF44LS44	Level Full 44 Level Sub44. Vastaanotettu tehotaso/Vastaanotettu tehotaso DTX-tilassa.
QF0 QS0	Quality Full 0. Vastaanotettu laatu 0=0% BER, 7=12.8% BER. Quality Sub 0. Vastaanotettu laatu 0=0% BER, 7=12.8% BER DTX-tilassa

Naapuritukiasemanäyttö

CH	Tukiasemien paremmuus järjestys, ensimmäisenä palvelevan DCS radiokanavan numero jne.
RXL	Vastaanotettu tehotaso yksikkö dBm. Huomioi että esim. -102 dBm=02, koska käytössä on ainoastaan 2 numeroa käytössä.
NCC	NCC Network Color Code.
BCC	BCC Base station Color Code.


MS #1
MS #2
BTS #1
BTS #2
BSC
MSC/VLR
HLR

PRELIMINARY PROBLEMS

The preliminary problems consist of two parts, just like the laboratory experiments. In the first you should determine suitable values for macro cell radio parameters. The macro cell is located on top of the main post office building in Mannerheimintie. In the second part you determine parameters values for a pico cell located inside the Forum building. The purpose of the pico cell is to serve mobile stations inside the Forum building, which is a traffic hot spot. Your parameter settings will be tested during the laboratory part.

Notice that there is no single correct solution to most configuration problems here. It is very important that you justify your choice of parametrization in each problem and think about the interplay between different parameters. Write down the right parameter values, as well as the values in decibels. The Windows help file and the appendix 2 in the material can be very useful.

Macro cell configuration

Basic link budget parameters

The transmission power of the BCCH TRX is set to 22 dBm; this has been decided after some field measurements since then the range of the cell for outdoor mobiles (@ -75 dBm[1]) becomes roughly 1 km. Find suitable values for the following parameters. Explain the reasoning behind your selection.

1) MS_TX_PWR_MAX, the maximum MS tx power on dedicated mode

2) MS_TXPWR_MAX_CCH, the maximum MS tx power on RACH, i.e. the power level at which access bursts are transmitted in the cell.

The MS receiver sensitivity is -100 dBm and the BTS diversity receiver sensitivity is assumed to be -104 dBm.

[1] We assume here that indoor-outdoor attenuation is 25 dB. In this case the indoor level at the nominal cell boundary is –100 dBm.

Idle mode parameters

Configure idle mode parameters. Explain the reasoning behind your selection.

3) RX_ACCESS_LEV_MIN. What is the relation of this parameter to MS_TX_PWR_MAX_CCH?

4) CELL_RESELECT_HYSTERESIS. Suppose that an MS (in idle mode) is walking around a small area where the average[2] received levels from the home cell and a neighbouring cell are equal. The cells belong to different Location Areas. We wish to prevent the MS from selecting the neighbouring cell - and performing radio resource consuming performing Location Update – with 95 % probability. The standard deviation of the log-normally distributed slow fading is 6 dB. How should the CELL_RESELECT_HYSTERESIS be set?

   How is this parameter connected to cell reselection?

Dedicated mode parameters, handovers

Configure handover thresholds for RXLEV, RXQUAL, and interference handover. Explain the reasoning behind your selection.

5) RXLEV_MIN to adjacent cells

6) handover threshold (L_RXLEV_DL_H).

7) RXQUAL handover threshold (L_RXQUAL_DL_H).

8) Interference handover thresholds (L_RXLEV_DL_IH).

9) HO_MARGIN. Suppose that an MS (in dedicated mode) is walking around a small area where the average received levels from the serving cell and a neighbouring cell are equal. We wish to prevent the MS from making a power budget HO to the neighbouring cell - and risk dropping the call – with 95 % probability. The standard deviation of the log-normally distributed slow fading is 6 dB. How should the HO_MARGIN be set?

[2] Here we mean averaging over slow fading and fast fading.

Dedicated mode parameters, power control

Set the power control window for RXQUAL and RXLEV.

10) RXQUAL window, lower and upper (L_RXQUAL_UL_P and U_RXQUAL_UL_P)

11) RXLEV window, lower and upper (L_RXLEV_UL_P and U_RXLEV_UL_P). Notice the relationship between corresponding handover thresholds; you should leave some margin between HO thresholds and lower power control thresholds. Why?

Pico cell configuration

Idle mode parameters

We wish to configure cell reselection parameters in such a way that outdoor mobile stations passing by Forum do not reselect the pico cell inside Forum. This could create problems for instance when outdoor mobile stations initiate/receive calls using the pico cell inside Forum. Unnecessary HO to outdoor macro cell would be needed when the outdoor MS moves farther, and the pico cell traffic channels could become congested by outdoor calls. On the other hand it is desirable that the indoor pico cell serves mobiles inside Forum since this will reduce the traffic channel load in the outdoor cell. This is the reason for placing the pico cell inside Forum in the first place.

Using pico BTS maximum output power of 22 dBm the following received levels have been measured.

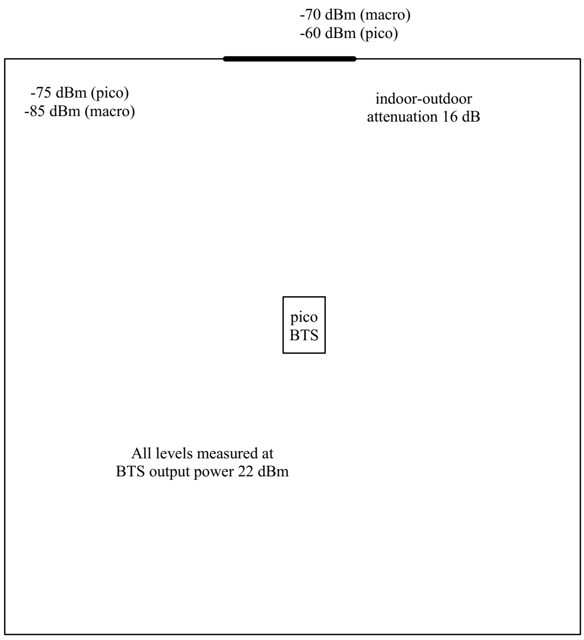


Figure 1. The cell lay-out and received signal levels.

12) Configure idle mode parameters and/or link budget parameters in such a way that mobile stations outside Forum do not select the indoor pico cell. However once the outdoor MS enters the Forum building it should reselect the indoor pico cell as soon as possible. Nearby cells in the Helsinki city center area belong to the same location area so no location updates are needed, which means that you don't have to take CELL_RESELECT_HYSTERESIS into account. You may use any of the following parametrization approaches or a combination of them.

- C2 parameters: CELL_RESELECT_OFFSET, TEMPORARY_OFFSET, PENALTY_TIME.
- RX_ACCESS_LEV_MINIMUM. This can be used to control the idle mode cell boundary.
- Control the pico BTS output power by using BS_TXPWR_RED. By default the maximum output power of 22 dBm is used in the pico BTS. It is usually advisable to use as low BTS output power as possible. Why?

Hint: The first step is to calculate C1 values in the following places: outside the front door, inside next to the door and inside in the corner. Next step is to calculate C2 values in these places. At the beginning neglect the effect of CELL_RESELECT_OFFSET and TEMPORARY_OFFSET. After that you can take these parameters in use if necessary.

Dedicated mode parameters, power budget handover

Configure power budget handover margin HO_MARGIN(macro→pico) so that the MS makes a power budget handover after it enters Forum, but not before that. Also configure HO_MARGIN(pico→macro) so that the MS makes the power budget HO to the macro cell only after exiting the Forum building.

13) HO_MARGIN(macro)

14) HO_MARGIN(pico)

LABORATORY EXPERIMENTS

- RF cables and connectors used in the measurements are very susceptible to any rough or careless treatment. Treat them with care.
- Every time you have to increase the attenuation, do it slowly.
- Remember the reasoning behind your parameter configuration.

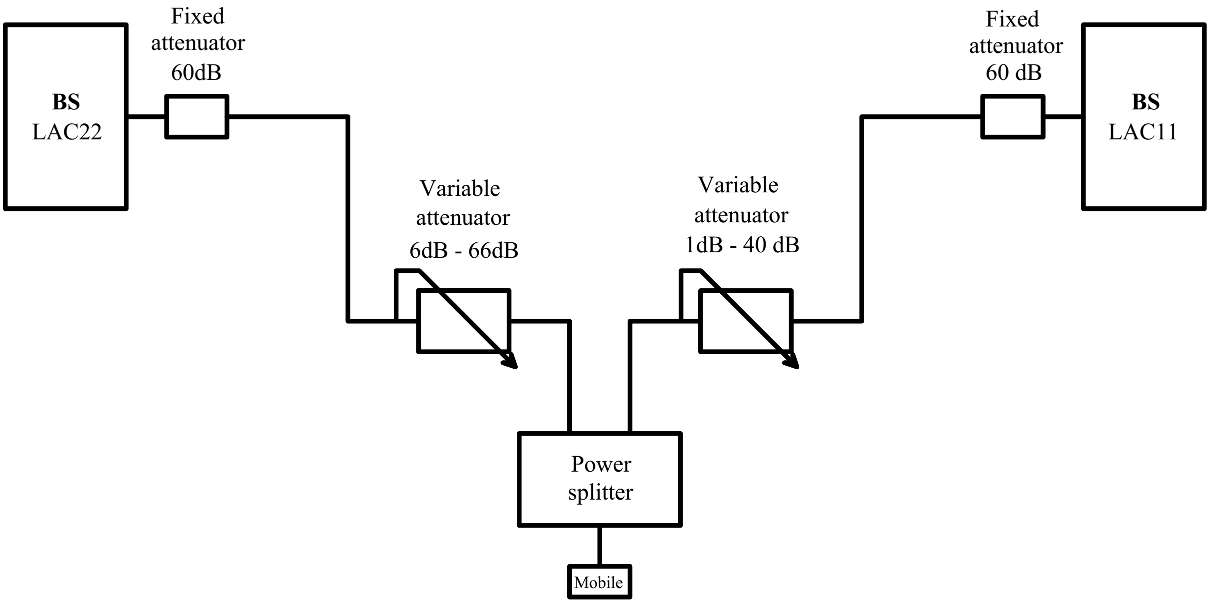


Figure 1. RF network used in this laboratory work.

Macro cell configuration

First you have to put all the planned macro cell (not the pico cell) parameter values into the database. Note that many parameter abbreviations in the database are not the same as in the preliminary problems (L_RXLEV_DL_H = HOLTHLVDL, L_RXQUAL_DL_H = HOLTHQUDL, L_RXLEV_DL_IH = HOTDLINT and so on). See the appendix 2 in the material. This appendix greatly helps you when putting the parameters into the database. Be careful that you change only the values of BTS#1. BTS#1 output power is 10 dBm. LAC of this BTS is 22. In the pico cell configuration, BTS#0 becomes a pico cell. LAC of this BTS is 11.

Basic link budget parameters

1) When the mobile is in idle mode, the channel 113 (signal from BTS#1) should be stronger than the channel 109 (signal from BTS#0). You can adjust the received power level by increasing and decreasing the attenuation between the mobile and BS. Make a mobile originating call to the number 1234 and verify MS_TX_PWR_MAX parameter value. The value can be seen at the display of the mobile phone (PL value).

Idle mode parameters

2) The received level of the channel 113 should be higher than the level of the channel 109. Increase the attenuation from BTS#1 direction when the phone is in idle mode. What happens and why, when you increase the attenuation sufficiently? What effect has CELL_RESELECT_HYSTERESIS parameter value in this case?

3) Take away the cable with the blue tape in your connection (now you have only BTS#1 in use). Put both RX_ACCESS_LEV_MIN and MS_TX_PWR_MAX_CCH parameter values in minimum (RX_ACCESS_LEV_MIN = 0 and MS_TX_PWR_MAX_CCH = 15). Increase the attenuation so that RXLEV is –108 dBm. Make a mobile originating call. What happens?

   Now put your planned MS_TX_PWR_MAX_CCH parameter value into the database. Make a mobile originating call. What do you notice?

   How is MS_TX_PWR_MAX_CCH related to RX_ACCESS_LEV_MIN? You can give an example.

Dedicated mode, HO parameters

4) Verify that you have once again the original connection (both base stations are in use). Make sure that in the database L_RXLEV_UL_H parameter value is sufficiently low, for example 5 (-105 dBm). Now the handover depends on DL direction. Disable the power budget handover function

PBGTHO. Now you have the mobile phone in the dedicated mode (make a phone call) connected to the channel 113. Increase the attenuation from BTS#1 direction so that your RXLEV is lower than the threshold value for handover (L_RXLEV_DL_H). What happens?

5) The mobile phone should be connected to the channel 113. Increase the attenuation from BTS#0 direction (you may need an extra attenuator), so that RXLEV from that BTS is smaller than RXLEV_MIN. Increase the attenuation from BTS#1 direction so that your RXLEV is lower than the threshold value for handover (L_RXLEV_DL_H). What happens now?

6) The mobile phone should be connected to the channel 113 and the received power level should be better than L_RXLEV_DL_IH. Take the "Rohde&Schwarz CTS55 Digital Radio Tester" in use and put some interference into your MS so that the received quality becomes worse than L_RXQUAL_DL_H. (See the figure 11 in the material, page 13.) The frequency has to be 1827.8 MHz, which corresponds to an adjacent channel for the channel 113. Make a mobile originating call. What do you notice?

   Verify that the mobile is once again connected to the channel 113. Increase the attenuation from BTS#1. The received power level has to be worse than L_RXLEV_DL_IH and turn on the interference generator so that the received quality is worse than L_RXQUAL_DL_H. What do you notice?

Dedicated mode, power control parameters

7) Let's investigate the uplink power control. The mobile phone should be in dedicated mode, connected to the channel 113. From MS to BTS the attenuation is 3 dB (power splitter) + 1 dB (cable#1) + 5 dB (cable#2) 60 dB (attenuator in BTS) + x (attenuator in your connection) = (69 + x) dB. Make a mobile originating call so that the received power level in BTS#1 is greater than U_RXLEV_UL_P. Note that the received power level in the base station is not the same as RXLEV at the display of the mobile phone! Now you can set EMSPWRC parameter to TRUE (in other words the power control in MS is enabled) and note how PL (power level, which can be seen at the display of MS) behaves.

Increase the attenuation from BTS#1 so that the received level in BTS#1 is weaker than L_RXLEV_UL_P. How does PL behave?

How does PL change when the received level in BTS is between U_RXLEV_UL_P…L_RXLEV_UL_P?

Pico cell configuration

Put the planned RX_ACCESS_LEV_MIN parameter value for pico cell into database (BTS#0 becomes a pico cell). Set CELL_RESELECT_HYSTERESIS to 0 for both cells and disable power control (set EMSPWRC to FALSE). Using the pico BTS maximum output power of 22 dBm the following received levels have been measured.

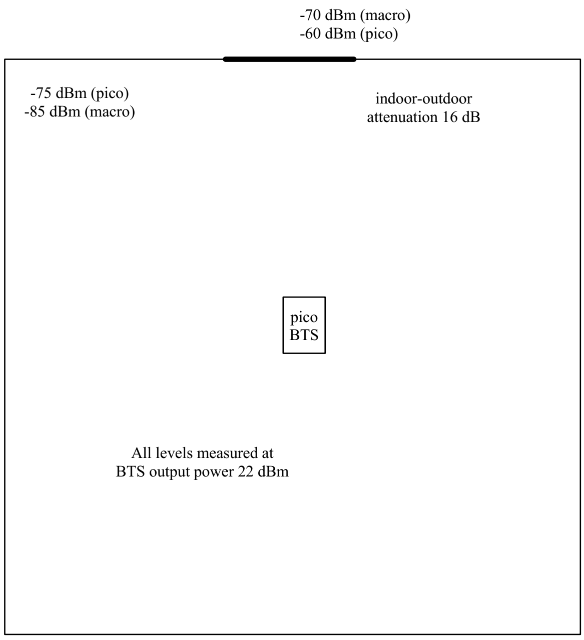


Figure 2. The cell lay-out and received signal levels.

8) Now you approach the Forum building (your MS is in the macro cell) in idle mode. Simulate the situation by increasing and decreasing the attenuation. At the beginning you are far away from the Forum building, so you can simulate the situation taking off the cable with the blue tape. Enter to the Forum and go to the corner of that building. What is wrong with the network behavior?

The situation has to be fixed. Put the rest of the planned pico cell parameter values into the database. Note that you have to put the following parameters at the same time: CELL_RESELECT_PARAM_IND (1), CELL_RESELECT_OFFSET, TEMPORARY_OFFSET, PENTIME and CBQ (0).

9) Repeat the test you have just done (see the exercise number 8). What is the effect of PENTIME? Does the network function correctly?

10) Enable power budget handover for both cells (set PBGTHO to TRUE). Make a mobile originating call. Enter to Forum and then leave the building. Where do you notice a handover?