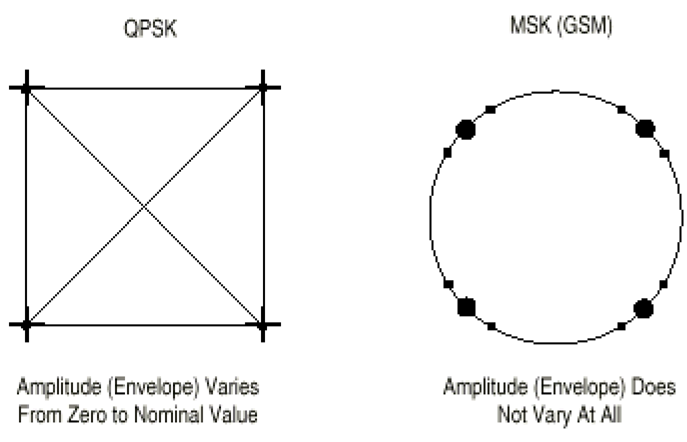
S-72.3250

Laboratory works in Radio Communications

GSM Transceiver Measurements



Version 1.54

Student laboratory is in the room SE306.

Check the links in the course home page. You might (or might not) find some extra information.

Grading: Accepted/not accepted.

This material in this document does not cover GSM basics. It is assumed that students have acquired prerequisites from previous courses, or books etc.

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, 1995

Mansikkaviita, J., Talvo, M.,”Johdatus solukkopuhelintekniikkaan” (in Finnish), Opetushallitus, Helsinki 1998

Carg, V.J., Wilkes, J.E., Principles and applications of GSM, Prentice-Hall Inc., Upper Saddle River 1999

Lab: GSM Transceiver Measurements

1 Introduction

In this laboratory work properties of GSM Mobile Stations (MS) are investigated. The goal is to learn the basics of a GSM transceiver and to investigate its error performance by measurements. A Rohde&Schwarz CTS-55 GSM tester used in the laboratory work is able to measure:

- Transmitted power of the MS
- Receiver sensitivity with different error measures (BER, RBER, FER)
- Frequency and phase error of the modulator
- Power ramp
- Transmitter timing errors

The tester performs measurements by emulating the radio interface of the GSM system, i.e. the MS sees the tester as an ordinary base station (BTS). Measurements can be made in all GSM frequency bands (900MHz, 1800MHz, 1900MHz).

A maintenance program by Nokia Mobile Phones is also used in some laboratory exercises to control Nokia 2110 MS transmitter. Spectrum analyser is used in measuring the power spectrum. Modulation errors are visualised with a vector signal analyser.

In preliminary exercises basic concepts of GSM engineering are reviewed. All preliminary exercises should be solved before coming to the lab shift.

The following sections contain a brief overview of GSM mobile phone testing. The goal is to give an idea of the matters that are dealt with in the laboratory work. More information can be found from literature, e.g. [Redl95], as well as course material used in the department of electrical and communications engineering. RF measurements are discussed in courses offered by Radio Laboratory (S-26). Also check out the course home page for latest information.

2 Receiver Measurements

Testing of a GSM transceiver, or any other digital mobile phone, may be divided in two parts: receiver measurements and transmitter measurements. The most important receiver measurements are the testing of sensitivity in various radio propagation conditions, and testing of interference sensitivity of the receiver. Transmitter tests include measurements on modulation errors, transmitter power accuracy and power ramp[1]. This section discusses receiver measurements.

2.1 Sensitivity of a GSM receiver

Receiver sensitivity means error performance as a function of received power. There are many error performance measures defined in the GSM specifications [GSM0505]. In this laboratory exercise mainly the error measures related to speech traffic channels are investigated. See section 2.1.3.

[1] Only physical layer parts are measured in this laboratory work; SW testing is an entirely different ballpark. Notice, however, that a large part of the receiver/transmitter is actually implemented in programmable DSPs.

2.1.1 The Principle of BER Sensitivity Measurement

The phone is connected to the GSM tester via external RF connector used for car mounting the MS. A special SIM card must be used so that the loop back of the received bits (Figure 1) can be activated.

In testing state the MS loops back all received information i.e. the phone demodulates and detects the pseudo-random bits sent in the downlink by the GSM tester, and then transmits the bits in the uplink direction back to the measuring equipment. The measuring equipment demodulates the signal and calculates the bit error ratio by comparing the received bits with the transmitted ones.

The transmission power of the GSM tester can be controlled. Thus, the virtual radio path attenuation, L_{path}, can be changed. By decreasing downlink TX power and simultaneously reading the applicable error measures error sensitivity performance of the MS can be determined.

It should be noticed that with the used measurement method the uplink direction can be assumed error-free, since the measurement cable attenuation is typically only about 0.5 dB.

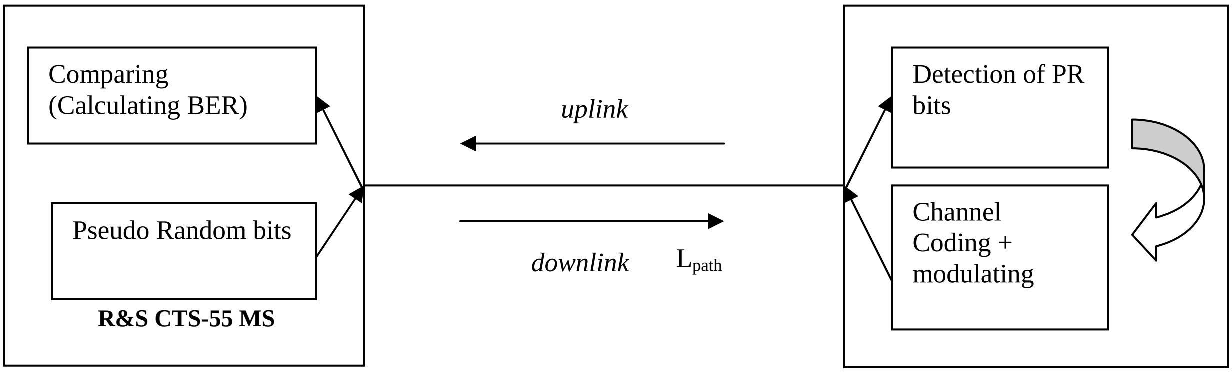


Figure 1. The principle of BER measurement.

2.1.2 Requirements for Sensitivity

Specifications [GSM0505] define required sensitivity levels in different radio propagation conditions (see appendix). For example, in GSM1800 band, TU50 propagation environment (Typical Urban, 50 km/h), half speed FACCH without Frequency Hopping (FH) the sensitivity is the average received power level in which FER has dropped to 7.2%. This power level should be below the *reference* sensitivity of the transceiver type.

The required sensitivity level for different types of GSM transceivers has been defined in [GSM0505], see also appendix. For handheld GSM900 and GSM1800 MS the reference sensitivity level is –104dBm [2]. Car mounted MS have reference sensitivity of –104dBm. Naturally there are many exceptions.

2.1.3 Error measures: FER, RBERxx, BER→RXQUAL

The definitions of different error ratios go hand in hand with channel coding and burst formatting which is different for each logical channel. For example, speech frames are encoded differently from signalling frames.

[2] See appendix for exceptions.

Convolution coding, along with interleaving, is used extensively in GSM. The 50 first bits of speech frame (Figure 2) are considered especially important for the speech quality and no errors are allowed in these bits.

50 bits class Ia	132 bits class Ib	78 bits class II

Figure 2. A GSM speech frame before channel coding. Full rate speech channel, TCH/FS.

Error ratios used in conjunction with GSM speech channels:

- Frame Erasure Rate, FER, is defined as the amount of swept speech frames (260 bits each) divided by the amount of transmitted speech frames. The speech frame is swept if even one of its most important 50 bits is observed not to be correct. The three parity bits following the 50 class Ia bits are used for error detection.
- Bit Error Rate, BER, is the ratio of erroneously received bits to all received bits. It is important to notice that BER is evaluated *before* channel decoding, i.e. after equaliser. BER is used for defining the RXQUAL value according to Table 1.
- Residual Bit Error Rate, RBER, is the ratio of erroneous bits to all bits *after* frame erasure. It is estimated separately for class Ib and class II bits. Example: After frame erasures, a thousand frames have been passed to the speech decoder, with a total of 5000 bit errors in class II bits. Thus, the estimated RBERII is 5000/78000≈6.4%.

According to some research the most important error measure in speech applications is FER even though RXQUAL value is used as a handover criterion [Haa97]. RXQUAL does not take into account channel coding; even if RXQUAL is bad the speech quality may still be satisfactory due to channel coding and the fact that speech is not very sensitive to errors in bits other than class Ia.

Table 1. Definition of RXQUAL and its reliability [GSM0508].

Quality Band	**Range of actual BER**	**Probability that the correct RXQUAL band is reported by MS shall exceed**		
		Full rate Channel	**Half rate Channel**	**DTX Mode**
RXQUAL_0	Less than 0,1%	90%	90%	65%
RXQUAL_1	0,26% to 0,30%	75%	60%	35%
RXQUAL_2	0,51% to 0,64%	85%	70%	45%
RXQUAL_3	1,0 % to 1,3%	90%	85%	45%
RXQUAL_4	1,9% to 2,7%	90%	85%	60%
RXQUAL_5	3,8% to 5,4%	95%	95%	70%
RXQUAL_6	7,6% to 11,0%	95%	95%	80%
RXQUAL_7	Greater than 15,0%	95%	95%	85%
NOTE1: For the full rate channel RXQUAL_FULL is based on 104 TDMA frames. NOTE2: For the half rate channel RXQUAL_FULL is based on 52 TDMA frames. NOTE3: For the DTX mode RXQUAL_SUB is based on 12 TDMA frames.				

2.1.4 Accuracy of Received Power Level (RXLEV) Measurement

A GSM receiver constantly measures the power of the received signal, and reports the measurement results to the base station as an RXLEV value. RXLEV gets values between 0-63 so that 0 corresponds to level under –110dBm and 63 to level over –48dBm with one dB steps in between. The BSC can use the reported downlink RXLEV for power control and handover decisions.

The accuracy of the received power measurement can be accomplished by tuning the downlink transmission power to a suitable value, and reading the measurement reports sent by the mobile station from the display of the GSM tester.

Accurate measurement of absolute RF power is complicated especially for burst signals. The error can easily be in the order of decibel. This is worth considering when interpreting any results related to RXLEV measurement of an MS. However, the measuring of relative power (the change in power) can be performed more accurately. The required absolute accuracy for RXLEV measurement at received power levels -110dBm…-70dBm is ±4 dBm [GSM0508].

3 Transmitter Measurements

3.1 Phase and frequency error

Phase and frequency errors measure the accuracy of the modulator.

Frequency and phase are connected to one another by the formula

$$d \qquad \frac{d}{dt} \, . \tag{1}$$

The GMSK modulator is not ideal and phase error is produced in the process. This error is defined as difference of the measured signal and ideal reference signal [Redl95]. Ideal reference signal is generated at the measurement equipment, usually a vector signal analyzer (VSA). See also [Ttd00] for an excellent review on modulation error measurements.

3.2 The Power Spectrum of Modulated Signal

Means of modulation in GSM is GMSK i.e. Gaussian MSK. Gaussian refers to the filter used to reduce bandwidth of the MSK power spectrum. Narrowing in frequency domain corresponds to widening in time domain, so the result is a compromise to avoid excessive ISI. One way is to implement GMSK-modulator is shown in Figure 2.

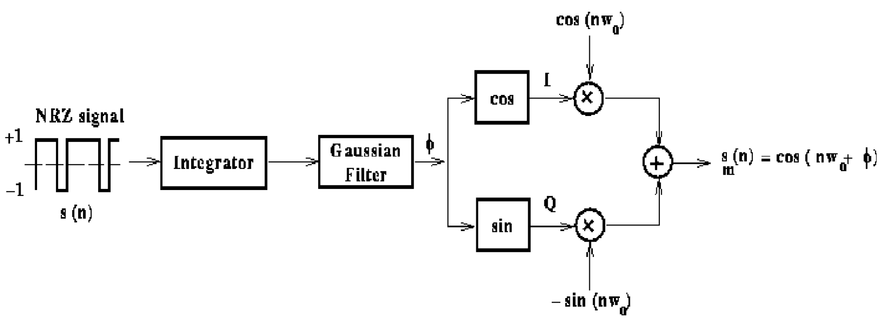


Figure 3 . GMSK-modulator [Tur96]

The constantly changing angle ϕ(t) is converted into sine- and cosine-components whose resultant draws a circle with constant amplitude on the IQ plane. The modulator is usually implemented with DSP [Man98]. After DA conversion the signal is fed to the mixer.

It may be said that GMSK is a purely European choice since elsewhere in the world – primarily in the US and Japan – another method, the π/4 DQPSK-modulation, has been chosen. The advantage of this modulation method is larger spectrum efficiency compared to GMSK, since π/4 DQPSK is a four-level modulation method. This means that two bits are transferred each symbol period. The disadvantage of this method is susceptibility to the effects of non-linearities in the transmitter that partly consumes the benefits from higher spectrum efficiency. According to the results of simulating the methods are quite equal when it comes to error performance in Rice- and Rayleigh-channels when also considering the non-linearity of power amplifier [Sor94].

3.3 Power mask

The bursts sent by the phone have to stay within certain limits that have been defined in specifications GSM 05.05 (Appendix 3). The power ramp of the MS transmitter can be measured with the GSM tester. Timing error of the burst can also be measured. Measuring of the timing error is important because the burst sent to the base station by a MS must fit the time mask so that it won't collide with bursts sent by other MS using the same transceiver (TRX).

3.4 Accuracy of the MS Transmission Power

In the GSM system all mobile stations are capable of transmission power control. The BSC directs the transmission power of the MS and the BTS. Power transmission accuracy requirements are defined in appendix 5.

The accuracy of the MS transmission power may be measured by sending a power command to the MS under test and observing the actual transmitted power using the CTS-55.

Appendices

1) About Reference Sensitivity Requirements, excerpt from [GSM0505]
2) Reference Sensitivity and Interference Sensitivity Performance Requirements [GSM0505]
3) Time Mask for a Normal Burst [GSM0505]
4) Frequency Mask of the Modulation Spectrum [GSM0505]
5) Accuracy Requirements of MS Transmission Power [GSM0505]

References

[Tur96] Turletti, Thierry, "GMSK in a Nutshell", http://www.sds.lcs.mit.edu/~turletti/gmsk/

[GSM0505] GSM 05.05, "Radio transmission and reception", version 6.1.0 (phase 2+), ETSI, April 1998

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

[Haa97] Haataja Jussi, “Taajuushyppelyn vaikutus DCS1800/1900- järjestelmän yhteyden laatuun”, diplomityö, sähkö- ja tietoliikennetekniikan osasto, TKK 1997

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

[Sor94] Sorbara, D., Visintin, M., “Performance Comparison of GMSK- and $\pi/4$ –DQPSK Modulations in a Mobile Radio Environment”, Lecture notes in computer science, Springer-Verlag 1994

[Man98] Mansikkaviita, J., Talvo, M., “Johdatus solukkopuhelintekniikkaan”, Opetushallitus, Helsinki 1998

[Ttd00] "Testing and Troubleshooting Digital RF Communications Transmitter Designs", Agilent Technologies application note 1313, literature number 5968-3578E.

Appendix 1: About Reference Sensitivity Requirements, excerpt from [GSM0505]

…

6.2 Reference sensitivity level

The reference sensitivity performance in terms of frame erasure, bit error, or residual bit error rates (whichever appropriate) is specified in table 1, according to the type of channel and the propagation condition. The actual sensitivity level is defined as the input level for which this performance is met. The actual sensitivity level shall be less than a specified limit, called the reference sensitivity level. The reference sensitivity level shall be:

-	for DCS 1 800 class 1 or class 2 MS	:	-100 / -102 dBm *
-	for DCS 1 800 class 3 MS	:	-102 dBm
-	for GSM 900 small MS	:	-102 dBm
-	for other GSM 900 MS and normal BTS	:	-104 dBm
-	for GSM 900 micro BTS M1	:	-97 dBm
-	for GSM 900 micro BTS M2	:	-92 dBm
-	for GSM 900 micro BTS M3	:	-87 dBm
-	for DCS 1 800 micro BTS M1	:	-102 dBm
-	for DCS 1 800 micro BTS M2	:	-97 dBm
-	for DCS 1 800 micro BTS M3	:	-92 dBm

The above specifications for BTS shall be met when the two adjacent timeslots to the wanted are detecting valid GSM signals at 50 dB above the power on the wanted timeslot. For MS the above specifications shall be met with the two adjacent timeslots 20 dB above the own timeslot and the static channel.

* For all DCS 1800 class 1 and class 2 MS to be type approved after 1st December 1999, the -102 dBm level shall apply for the reference sensitivity performance as specified in table 1 for the normal conditions defined in Annex D and -100 dBm level shall be used to determine all other MS performances.

Appendix 2: Reference Sensitivity and Interference Sensitivity Performance Requirements [GSM0505]

Table 1: Reference sensitivity performance

GSM 900						
Type of Channel		Propagation conditions				
		static	TU50 (no FH)	TU50 (ideal FH)	RA250 (no FH)	HT100 (no FH)
FACCH/H	(FER)	0,1 %	6,9 %	6,9 %	5,7 %	10,0 %
FACCH/F	(FER)	0,1 %	8,0 %	3,8 %	3,4 %	6,3 %
SDCCH	(FER)	0,1 %	13 %	8 %	8 %	12 %
RACH	(FER)	0,5 %	13 %	13 %	12 %	13 %
SCH	(FER)	1 %	16 %	16 %	15 %	16 %
TCH/F14,4	(BER)	10^{-5}	2,5 %	2 %	2 %	5 %
TCH/F9,6 & H4,8	(BER)	10^{-5}	0,5 %	0,4 %	0,1 %	0,7 %
TCH/F4,8	(BER)	-	10^{-4}	10^{-4}	10^{-4}	10^{-4}
TCH/F2,4	(BER)	-	$2\ 10^{-4}$	10^{-5}	10^{-5}	10^{-5}
TCH/H2,4	(BER)	-	10^{-4}	10^{-4}	10^{-4}	10^{-4}
TCH/FS	(FER)	0,1α %	6α %	3α %	2α %	7α %
	class Ib (RBER)	0,4/α %	0,4/α %	0,3/α %	0,2/α %	0,5/α %
	class II (RBER)	2 %	8 %	8 %	7 %	9 %
TCH/EFS	(FER)	< 0,1 %	8 %	3 %	3 %	7 %
	(RBER Ib)	< 0,1 %	0,21 %	0,11 %	0,10 %	0,20 %
	(RBER II)	2,0 %	7 %	8 %	7 %	9 %
TCH/HS	(FER)	0,025 %	4,1 %	4,1 %	4,1 %	4,5 %
	class Ib (RBER, BFI=0)	0,001 %	0,36 %	0,36 %	0,28 %	0,56 %
	class II (RBER, BFI=0)	0,72 %	6,9 %	6,9 %	6,8 %	7,6 %
	(UFR)	0,048 %	5,6 %	5,6 %	5,0 %	7,5 %
class Ib (RBER,(BFI or UFI)=0)		0,001 %	0,24 %	0,24 %	0,21 %	0,32 %
	(EVSIDR)	0,06 %	6,8 %	6,8 %	6,0 %	9,2 %
	(RBER, SID=2 and (BFI or UFI)=0)	0,001 %	0,01 %	0,01 %	0,01 %	0,02 %
	(ESIDR)	0,01 %	3,0 %	3,0 %	3,2 %	3,4 %
	(RBER, SID=1 or SID=2)	0,003 %	0,3 %	0,3 %	0,21 %	0,42 %
DCS 1 800						
Type of channel		Propagation conditions				
		static	TU50 (no FH)	TU50 (ideal FH)	RA130 (no FH)	HT100 (no FH)
FACCH/H	(FER)	0,1 %	7,2 %	7,2 %	5,7 %	10,4 %
FACCH/F	(FER)	0,1 %	3,9 %	3,9 %	3,4 %	7,4 %
SDCCH	(FER)	0,1 %	9 %	9 %	8 %	13 %
RACH	(FER)	0,5 %	13 %	13 %	12 %	13 %
SCH	(FER)	1 %	19 %	19 %	15 %	25 %
TCH/F14,4	(BER)	10^{-5}	2,1 %	2 %	2 %	6,5 %
TCH/F9,6 & H4,8	(BER)	10^{-5}	0,4 %	0,4 %	0,1 %	0,7 %
TCH/F4,8	(BER)	-	10^{-4}	10^{-4}	10^{-4}	10^{-4}
TCH/F2,4	(BER)	-	10^{-5}	10^{-5}	10^{-5}	10^{-5}
TCH/H2,4	(BER)	-	10^{-4}	10^{-4}	10^{-4}	10^{-4}
TCH/FS	(FER)	0,1α %	3α %	3α %	2α %	7α %
	class Ib (RBER)	0,4/α %	0,3/α %	0,3/α %	0,2/α %	0,5/α %
	class II (RBER)	2 %	8 %	8 %	7 %	9 %
TCH/EFS	(FER)	< 0,1 %	4 %	4 %	3 %	7 %
	(RBER Ib)	< 0,1 %	0,12 %	0,12 %	0,10 %	0,24 %
	(RBER II)	2,0 %	8 %	8 %	7 %	9 %

(continued)

Appendix 2: Reference Sensitivity and Interference Sensitivity Performance Requirements [GSM0505]

Table 1 (concluded): Reference sensitivity performance

DCS 1 800					
TCH/HS (FER)	0,025 %	4,2 %	4,2 %	4,1 %	5,0 %
class Ib (RBER, BFI=0)	0,001 %	0,38 %	0,38 %	0,28 %	0,63 %
class II (RBER, BFI=0)	0,72 %	6,9 %	6,9 %	6,8 %	7,8 %
(UFR)	0,048 %	5,7 %	5,7 %	5,0 %	8,1 %
class Ib (RBER, (BFI or UFI)=0)	0,001 %	0,26 %	0,26 %	0,21 %	0,35 %
(EVSIDR)	0,06 %	7,0 %	7,0 %	6,0 %	9,9 %
(RBER, SID=2 and (BFI or UFI)=0)	0,001 %	0,01 %	0,01 %	0,01 %	0,02 %
(ESIDR)	0,01 %	3,0 %	3,0 %	3,2 %	3,9 %
(RBER, SID=1 or SID=2)	0,003 %	0,33 %	0,33 %	0,21 %	0,45 %

NOTE 1: The specification for SDCCH applies also for BCCH, AGCH, PCH, SACCH. The actual performance of SACCH, should be better.

NOTE 2: Definitions:
FER: Frame erasure rate (frames marked with BFI=1)
UFR: Unreliable frame rate (frames marked with (BFI or UFI)=1)
EVSIDR: Erased Valid SID frame rate (frames marked with (SID=0) or (SID=1) or ((BFI or UFI)=1) if a valid SID frame was transmitted)
ESIDR: Erased SID frame rate (frames marked with SID=0 if a valid SID frame was transmitted)
BER: Bit error rate
RBER, BFI=0: Residual bit error rate (defined as the ratio of the number of errors detected over the frames defined as "good" to the number of transmitted bits in the "good" frames). RBER, (BFI or UFI)=0: Residual bit error rate (defined as the ratio of the number of errors detected over the frames defined as "reliable" to the number of transmitted bits in the "reliable" frames).
RBER, SID=2 and (BFI or UFI)=0: Residual bit error rate of those bits in class I which do not belong to the SID codeword (defined as the ratio of the number of errors detected over the frames that are defined as "valid SID frames" to the number of transmitted bits in these frames, under the condition that a valid SID frame was sent).
RBER, SID=1 or SID=2: Residual bit error rate of those bits in class I which do not belong to the SID codeword (defined as the ratio of the number of errors detected over the frames that are defined as "valid SID frames" or as "invalid SID frames" to the number of transmitted bits in these frames, under the condition that a valid SID frame was sent).

NOTE 3: $1 \le \alpha \le 1.6$. The value of α can be different for each channel condition but must remain the same for FER and class Ib RBER measurements for the same channel condition.

NOTE 4: FER for CCHs takes into account frames which are signalled as being erroneous (by the FIRE code, parity bits, or other means) or where the stealing flags are wrongly interpreted.

NOTE 5: Ideal FH case assumes perfect decorrelation between bursts. This case may only be tested if such a decorrelation is ensured in the test. For TU50 (ideal FH), sufficient decorrelation may be achieved with 4 frequencies spaced over 5 MHz.

Appendix 2: Reference Sensitivity and Interference Sensitivity Performance Requirements [GSM0505]

Table 2: Reference interference performance

GSM 900						
Type of channel		Propagation conditions				
		TU3 (no FH)	TU3 (ideal FH)	TU50 (no FH)	TU50 (ideal FH)	RA250 (no FH)
FACCH/H	(FER)	22 %	6,7 %	6,7 %	6,7 %	5,7 %
FACCH/F	(FER)	22 %	3,4 %	9,5 %	3,4 %	3,5 %
SDCCH	(FER)	22 %	9 %	13 %	9 %	8 %
RACH	(FER)	15 %	15 %	16 %	16 %	13 %
SCH	(FER)	17 %	17 %	17 %	17 %	18 %
TCH/F14,4	(BER)	10 %	3 %	4,5 %	3 %	3 %
TCH/F9,6 & H4,8	(BER)	8 %	0,3 %	0,8 %	0,3 %	0,2 %
TCH/F4,8	(BER)	3 %	10^{-4}	10^{-4}	10^{-4}	10^{-4}
TCH/F2,4	(BER)	3 %	10^{-5}	10^{-4}	10^{-5}	10^{-5}
TCH/H2,4	(BER)	4 %	10^{-4}	$2\ 10^{-4}$	10^{-4}	10^{-4}
TCH/FS	(FER)	21α %	3α %	6α %	3α %	3α %
	class Ib (RBER)	2/α %	0,2/α %	0,4/α %	0,2/α %	0,2/α %
	class II (RBER)	4 %	8 %	8 %	8 %	8 %
TCH/EFS	(FER)	23 %	3 %	9 %	3 %	4 %
	(RBER Ib)	0,20 %	0,10 %	0,20 %	0,10 %	0,13 %
	(RBER II)	3 %	8 %	7 %	8 %	8 %
TCH/HS	(FER)	19,1 %	5,0 %	5,0 %	5,0 %	4,7 %
	class Ib (RBER, BFI=0)	0,52 %	0,27 %	0,29 %	0,29 %	0,21 %
	class II (RBER, BFI=0)	2,8 %	7,1 %	7,1 %	7,1 %	7,0 %
	(UFR)	20,7 %	6,2 %	6,1 %	6,1 %	5,6 %
	class Ib (RBER,(BFI or UFI)=0)	0,29 %	0,20 %	0,21 %	0,21 %	0,17 %
	(EVSIDR)	21,9 %	7,1 %	7,0 %	7,0 %	6,3 %
	(RBER, SID=2 and (BFI or UFI)=0)	0,02 %	0,01 %	0,01 %	0,01 %	0,01 %
	(ESIDR)	17,1 %	3,6 %	3,6 %	3,6 %	3,4 %
	(RBER, SID=1 or SID=2)	0,5 %	0,27 %	0,26 %	0,26 %	0,20 %
DCS 1 800						
Type of channel		Propagation conditions				
		TU1,5 (no FH)	TU1,5 (ideal FH)	TU50 (no FH)	TU50 ideal FH)	RA130 (no FH)
FACCH/H	(FER)	22 %	6,7 %	6,9 %	6,9 %	5,7 %
FACCH/F	(FER)	22 %	3,4 %	3,4 %	3,4 %	3,5 %
SDCCH	(FER)	22 %	9 %	9 %	9 %	8 %
RACH	(FER)	15 %	15 %	16 %	16 %	13 %
SCH	(FER)	17 %	17 %	19 %	19 %	18 %
TCH/F14,4	(BER)	10 %	3 %	4 %	3,1 %	3 %
TCH/F9,6 & H4,8	(BER)	8 %	0,3 %	0,8 %	0,3 %	0,2 %
TCH/F4,8	(BER)	3 %	10^{-4}	10^{-4}	10^{-4}	10^{-4}
TCH/F2,4	(BER)	3 %	10^{-5}	10^{-5}	10^{-5}	10^{-5}
TCH/H2,4	(BER)	4 %	10^{-4}	10^{-4}	10^{-4}	10^{-4}
TCH/FS	(FER)	21α %	3α %	3α %	3α %	3α %
	class Ib (RBER)	2/α %	0,2/α %	0,25/α %	0,25/α %	0,2/α %
	class II (RBER)	4 %	8 %	8,1 %	8,1 %	8 %
TCH/EFS	(FER)	23 %	3 %	3 %	3 %	4 %
	(RBER Ib)	0,20 %	0,10 %	0,10 %	0,10 %	0,13 %
	(RBER II)	3 %	8 %	8 %	8 %	8 %

(continued)

Appendix 2: Reference Sensitivity and Interference Sensitivity Performance Requirements [GSM0505]

Table 2 (concluded): Reference <u>interference</u> performance

DCS 1 800					
TCH/HS (FER)	19,1 %	5,0 %	5,0 %	5,0 %	4,7 %
class Ib (RBER, BFI=0)	0,52 %	0,27 %	0,29 %	0,29 %	0,21 %
class II (RBER, BFI=0)	2,8 %	7,1 %	7,2 %	7,2 %	7,0 %
(UFR)	20,7 %	6,2 %	6,1 %	6,1 %	5,6 %
class Ib (RBER, (BFI or UFI)=0)	0,29 %	0,20 %	0,21 %	0,21 %	0,17 %
(EVSIDR)	21,9 %	7,1 %	7,0 %	7,0 %	6,3 %
(RBER, SID=2 and (BFI or UFI)=0)	0,02 %	0,01 %	0,01 %	0,01 %	0,01 %
(ESIDR)	17,1 %	3,6 %	3,6 %	3,6 %	3,4 %
(RBER, SID=1 or SID=2)	0,5 %	0,27 %	0,26 %	0,26 %	0,20 %

NOTE 1: The specification for SDCCH applies also for BCCH, AGCH, PCH, SACCH. The actual performance of SACCH, particularly for the C/I TU3 (no FH) and TU 1.5 (no FH) cases should be better.

NOTE 2: Definitions:
FER: Frame erasure rate (frames marked with BFI=1)
UFR: Unreliable frame rate (frames marked with (BFI or UFI)=1)
EVSIDR: Erased Valid SID frame rate (frames marked with (SID=0) or (SID=1) or ((BFI or UFI)=1) if a valid SID frame was transmitted)
ESIDR: Erased SID frame rate (frames marked with SID=0 if a valid SID frame was transmitted)
BER: Bit error rate
RBER, BFI=0: Residual bit error rate (defined as the ratio of the number of errors detected over the frames defined as "good" to the number of transmitted bits in the "good" frames).
RBER, (BFI or UFI)=0: Residual bit error rate (defined as the ratio of the number of errors detected over the frames defined as "reliable" to the number of transmitted bits in the "reliable" frames).
RBER, SID=2 and (BFI or UFI)=0: Residual bit error rate of those bits in class I which do not belong to the SID codeword (defined as the ratio of the number of errors detected over the frames that are defined as "valid SID frames" to the number of transmitted bits in these frames, under the condition that a valid SID frame was sent).
RBER, SID=1 or SID=2: Residual bit error rate of those bits in class I which do not belong to the SID codeword (defined as the ratio of the number of errors detected over the frames that are defined as "valid SID frames" or as "invalid SID frames" to the number of transmitted bits in these frames, under the condition that a valid SID frame was sent).

NOTE 3: $1 \leq \alpha \leq 1.6$. The value of α can be different for each channel condition but must remain the same for FER and class Ib RBER measurements for the same channel condition.

NOTE 4: FER for CCHs takes into account frames which are signalled as being erroneous (by the FIRE code, parity bits, or other means) or where the stealing flags are wrongly interpreted.

NOTE 5: Ideal FH case assumes perfect decorrelation between bursts. This case may only be tested if such a decorrelation is ensured in the test. For TU50 (ideal FH), sufficient decorrelation may be achieved with 4 frequencies spaced over 5 MHz. The TU3 (ideal FH) and TU1.5 (ideal FH), sufficient decorrelation cannot easily be achieved. These performance requirements are given for information purposes and need not be tested.

Appendix 2: Reference Sensitivity and Interference Sensitivity Performance Requirements [GSM0505]

The reference interference performance (for cochannel, C/Ic, or adjacent channel, C/Ia) in terms of frame erasure, bit error or residual bit error rates (whichever appropriate) is specified in table 2, according to the type of channel and the propagation condition. The actual interference ratio is defined as the interference ratio for which this performance is met. The actual interference ratio shall be less than a specified limit, called the reference interference ratio. The reference interference ratio shall be, for BTS and all types of MS:

-	for cochannel interference	:	C/Ic	=	9 dB
-	for adjacent (200 kHz) interference	:	C/Ia1	=	-9 dB
-	for adjacent (400 kHz) interference	:	C/Ia2	=	-41 dB
-	for adjacent (600 kHz) interference	:	C/Ia3	=	-49 dB

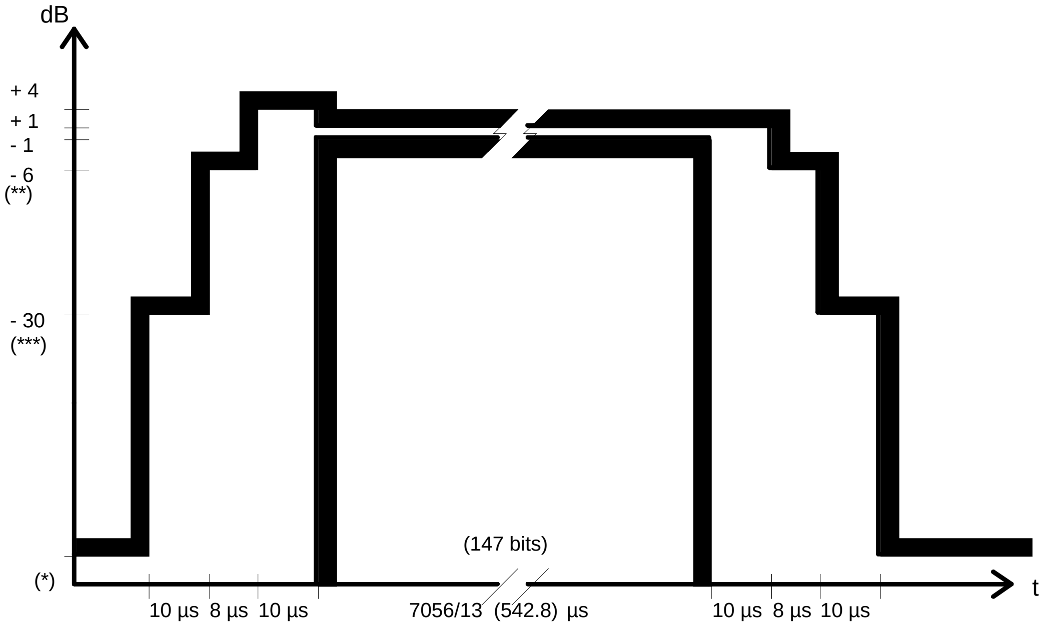
For packet switched channels, the minimum interference ratio for which the reference performance for cochannel interference (C/Ic) shall be met is specified in table 2a, according to the type of channel and the propagation condition. The reference performance is the same as defined in subclause 6.2. The corresponding interference ratio for adjacent channel interference shall be:

-	for adjacent (200 kHz) interference	:	C/Ia1	=	C/Ic - 18 dB
-	for adjacent (400 kHz) interference	:	C/Ia2	=	C/Ic - 50 dB
-	for adjacent (600 kHz) interference	:	C/Ia3	=	C/Ic - 58 dB

NOTE: The C/Ia3 figure is given for information purposes and will not require testing. It was calculated for the case of an equipment with an antenna connector, operating at output power levels of +33 dBm and below. Rejection of signals at 600 kHz is specified in subclause 5.1.

These specifications apply for a wanted signal input level of 20 dB above the reference sensitivity level, and for a random, continuous, GSM-modulated interfering signal. In case of frequency hopping, the interference and the wanted signals shall have the same frequency hopping sequence. In any case the wanted and interfering signals shall be subject to the same propagation profiles (see annex C), independent on the two channels.

Appendix 3: Time Mask for a Normal Burst [GSM0505]



Time mask for normal duration bursts (NB, FB, dB and SB)

(*)	For GSM 900 MS	:	see 4.5.2.
	For DCS 1 800 MS	:	-48 dBc or -48 dBm, whichever is the higher.
	For GSM 900 BTS and DCS 1 800 BTS	:	no requirement below -30 dBc (see 4.5.1).
(**)	For GSM 900 MS	:	-4 dBc for power control level 16; -2 dBc for power level 17; -1 dBc for power level controls levels 18 and 19.
	For DCS 1 800 MS		-4dBc for power control level 11, -2dBc for power level 12, -1dBc for power control levels 13,14 and 15
(***)	For GSM 900 MS	:	-30 dBc or -17 dBm, whichever is the higher.
	For DCS 1 800 MS		-30dBc or -20dBm, whichever is the higher.

Appendix 4: Frequency Mask of the Modulation Spectrum [GSM0505]

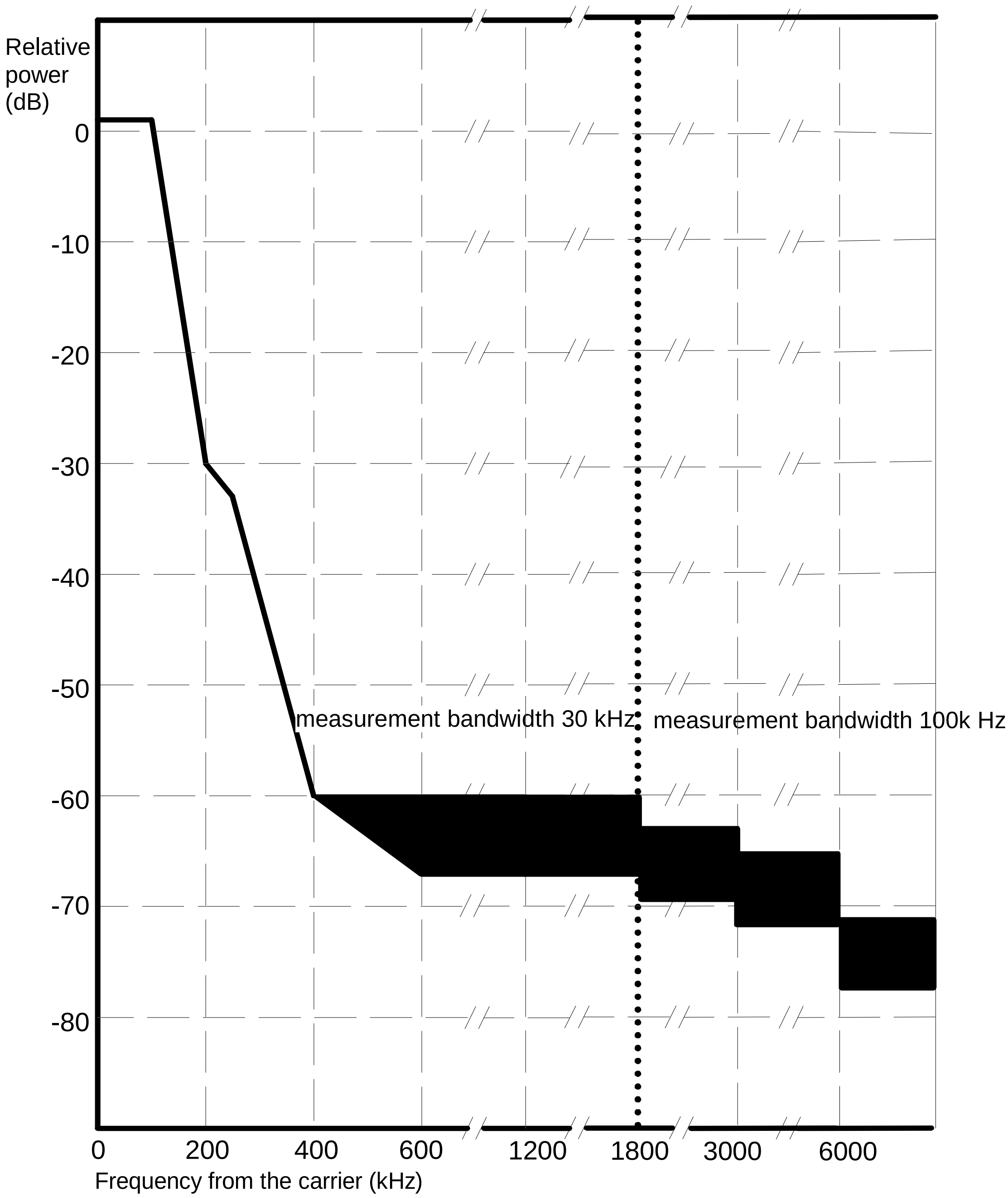


Figure A.1: GSM 900 MS spectrum due to modulation

Appendix 5: Accuracy Requirements of MS Transmission Power [GSM0505].

GSM 900

Power control level	Nominal Output power (dBm)	Tolerance (dB) for conditions	
		normal	extreme
0-2	39	±2	±2.5
3	37	±3	±4
4	35	±3	±4
5	33	±3	±4
6	31	±3	±4
7	29	±3	±4
8	27	±3	±4
9	25	±3	±4
10	23	±3	±4
11	21	±3	±4
12	19	±3	±4
13	17	±3	±4
14	15	±3	±4
15	13	±3	±4
16	11	±5	±6
17	9	±5	±6
18	7	±5	±6
19-31	5	±5	±6

DCS 1 800

Power control level	Nominal Output power (dBm)	Tolerance (dB) for conditions	
		Normal	extreme
29	36	±2	±2.5
30	34	±3	±4
31	32	±3	±4
0	30	±3	±4
1	28	±3	±4
2	26	±3	±4
3	24	±3	±4
4	22	±3	±4
5	20	±3	±4
6	18	±3	±4
7	16	±3	±4
8	14	±3	±4
9	12	±4	±5
10	10	±4	±5
11	8	±4	±5
12	6	±4	±5
13	4	±4	±5
14	2	±5	±6
15-28	0	±5	±6