LABORATORY EXERCISES

You can write the answers on this sheet, or use a separate sheet if necessary. The deadline for returning these exercises can be seen on the course web page. If you run into problems, please consult the assistant well before the deadline.

NOTE 1: Sources of measurement errors should be considered in (almost) all the measurements even if this is not specifically required in the exercise. In some cases the schematic of the measurement set-up should be presented. The key point is that the laboratory report should contain enough information so that whoever reads it *should be able to repeat* the measurement (and get the same result).

NOTE 2: RF cables and connectors used in the measurements are very susceptible to any rough or careless treatment. More than that, they are extremely expensive! Treat them with care and avoid unnecessary cable switching.

L1

Measure Erkki GSM900 with Auto Test mode of the GSM tester. Print the test reports. Are the mobiles OK? What kind of errors did you find?

Settings: coupler *on*, mode *continuous*, MS type *default.*

L2

Use Manual Test mode and measure the receiver sensitivity of a GSM1800 MS. Use the automated BER sensitivity test (Manual → BER → BER Sens.). Perform the measurements on channels 512, 700, 885. During the sensitivity search observe the accuracy of the RXLEV measurement done by the MS.

Settings: coupler *on*, MS type *default*, MS transmission power (ctrl level) *30 dBm*.

a) What is the sensitivity of the phone on different channels? Are there differences between frequency channels?

Avoid unnecessary cable switching!

b) Comment on the accuracy of the RXLEV measurement? What are the disadvantages of inaccuracy of the RXLEV measurement?

c) What kind of propagation environment does the measurement situation correspond to? Can the sensitivity measurement results be compared with the sensitivity requirements given in the specifications?

L3

Power ramp: Use Manual Test mode (Manual → Ramp) and measure if the power ramp fits the power mask defined in the specifications?

Settings: channel *516*, MS transmission power *30 dBm*.

a) What is the power-rise-speed in the beginning of the ramp (dBm/s)? Careful with the units! Show calculations.

b) What is the timing error of the phone (in bits)? What is the first bit sent on full power at the beginning of the burst?

c) Observe the middle section of the burst. Is the amplitude constant? Comment. GMSK should have constant envelope (≈amplitude).

d) Why should the power ramp not be too gently sloping? Why shouldn't it be too steep?

e) Measure the accuracy of the MS transmission power on the lowest (0 dBm) and highest (30 dBm) transmission power of the MS. You can do this by giving power commands to the MS, and observing the actual transmitted power measured by the tester. Repeat for channels 512, 700, and 885. Comment on differences. Information about the required accuracy of the MS transmission power is given Appendix 5.

L4

Phase and frequency error: Use Manual Test mode (Manual → PhaseFreq) and measure the phase and frequency error of the GSM1800 MS on channel 700.

Settings: coupler *on*, MS transmission power *30 dBm*.

a) What are the rms errors and peak errors?

b) Observe the behavior of the phase error during the burst. How does the frequency error change? Does the phase error change linearly during the burst as in P8? Comment on the difference of the measurement and the preliminary exercise.

L5

BER curve exercise: Using Manual Test mode, measure and draw FER, $RBER_{Ib}$, $RBER_{II}$ of the MS as a function of received power at the MS input. (Manual → BER → BER Cont.). Start from MS receiving power level at –100dBm, and then drop downlink transmission power gradually. Notice that you will have to use an attenuator between MS and the GSM tester to be able to measure levels lower than –110dBm which is the lowest transmission power of the tester. The attenuation of the measurement cable is about 0.5dB.

Settings: coupler *on* (0.5 dB), channel *620*, MS transmission power *30 dBm*, averaging window *499 frames* (10 sec, BER Cont. → Config), measurement mode *RBER* (BER Cont. → Config).

Hints: You may first decrease the tx power in steps of 1 dB. When the error rates begin to rise faster, use a smaller step, like 0.5 dB, or less. You should aim for a smooth FER curve. You must wait 10 sec after each power drop because of the averaging window. If the FER value is stable you can read the measurement result from the screen of the GSM tester. If FER fluctuates a lot you can use the *cts_ber2.exe* program to read several values to a file and average the results.

Present all three curves in the same graph (eg. Excel).

a) Comment on the behavior of the $RBER_{Ib}$, $RBER_{II}$ and FER. Why does FER suddenly rocket up?

b) Explain how you can estimate coding improvement and coding gain from the measured curves? Estimate coding improvement and coding gain for some suitable point in the curve. Comment on the accuracy of the results and the estimation method.

c) What is the downlink transmission power when the connection is lost?

L6

Examine the constellation diagram and vector transition diagram in the IQ plane using the vector signal analyzer. Erkki phone, without SIM card, is used in this experiment. You can tune the modulator parameters using the WinTesla program. You can put the right settings by choosing Testing → Quick Testing (RF).

Settings for WinTesla: active unit *tx*, tx power level *15*, tx data type *random.*

In order to locate the modulator signal in the spectrum analyzer, use the frequency span 1 MHz centered at the carrier frequency (902 MHz), 1 kHz resolution bandwidth and reference level 10 dBm. Now you should be able to see the signal in the constellation and vector transition diagrams.

a) How does the DC error show in the constellation diagram (Mode → Vector Analyzer → Meas Result → Meas Signal → Polar [IQ] Constell)? Is there any DC error visible in the constellation diagram? How does the phase error show in the constellation diagram? Is there any phase error visible in the constellation diagram? Is the phase error systematic or random?

b) Examine the vector transition diagram (Mode → Vector Analyzer → Meas Result → Meas Signal → Polar [IQ] Vector). Does the signal have constant envelope? What anomalies are there in the vector transition diagram? What is the cause of these anomalies?

L7

Modulation errors.

a) Feed the modulator with a continuous line of zero bits. Measure the output spectrum using 200 kHz frequency span centered at the carrier frequency, and 1 kHz resolution bandwidth. The reference level can be set to 20 dBm. Calculate phase error from the spectrum. Assume that there is no amplitude error. What is the DC offset that the output spectrum corresponds to? Show calculations. You will need formulas you derived in P7.

Use delta markers!

b) Check the measured phase error and DC offset with the vector analyzer, display Symbol Table/Errors (Mode → Vector Analyzer → Meas Result → Symb Table/Errors). Do the results correspond to values of the previous part?

c) Tune the IQ modulator with the WinTesla program by choosing Tuning → Tx I/Q. You can observe how the phase error and DC offset change while at the same time. Try to eliminate the modulation errors completely. What settings did you use?

d) Pedagogical demo: Now that you have almost completely eliminated modulation errors, go back to the spectrum analyzer. Increase phase error to the maximum allowed, and *at the same time* observe what happens to the output spectrum. After that, increase the DC offset of either branch to the maximum, and *at the same time* observe what happens to the output spectrum. Does this comply with the formulas you derived in P7?

L8

Measure the power spectrum of GSM modulation by using the output signal of one of the base stations. Set the resolution bandwidth to 30 kHz. As a base station use the vector signal generator SMJ 100A.

a) Does the power spectrum correspond to GMSK modulation value of BT=0.3? Compare with the graphs given in the literature. Compare the power spectrum also with the frequency mask given in the specifications (appendix).

b) Compare the -10 dB bandwidth of the measured GMSK spectrum with the bandwidth you calculated for $\pi/4$ -DQPSK in P4.