PRELIMINARY EXERCISES

P1

About: Physical channel structure, which is a very basic thing. Fundamentally related to error measures in P2.

Calculate the exact time duration (i.e. fraction) of the following structural units. Use the length of the traffic multiframe (26 frames) as the starting point. Notice that by remembering the length of the traffic multiframe, exactly 120ms, the length of all other structural units may be derived easily. Show your calculations on paper.

a)   normal burst
b)   a bit
c)   a frame (not the same as a burst!)
d)   signalling multiframe (51 frames)
e)   guard period
f)   superframe
g)   hyperframe

P2

About: Different error measures of the GSM system. Necessary knowledge in order to understand L5.

A GSM mobile station is receiving bits on the full rate speech channel. A total of 100 bit errors are detected after the equalizer during 24 bursts. After channel decoding, class I_a has 1 error bit and class I_b has 6 error bits. The frame erasure is performed next. Recall that each burst contains 114 encoded data bits.

a)   How many information (=speech) bits were sent during the 24 bursts? "Information bits" means the bits before channel coding.
b)   What is RXQUAL?
c)   What is $RBER_{II}$?
d)   What is $RBER_{Ib}$?
e)   What is FER?

Bit class	Errors after channel decoding, before frame erasure	Errors after frame erasure
I_a	1	-
I_b	6	4
II	12	11

P3

About: Training sequence has a small but essential role in the GSM system…

a)   What is the purpose of a training sequence?
b)   Why is it useful to place in the middle of the burst?
c)   What is the drawback of including a training sequence within a burst?
d)   Why is it necessary to have 8 different training sequences?

P4

About: Comparison of π/4 –DQPSK modulation to GMSK. These are the two dominant modulation methods in contemporary mobile communication systems. It is necessary to do this exercise before L8 can be completed.

a)   Draw the constellation diagram of π/4 –DQPSK.
b)   GMSK is a modulation method with constant envelope but π/4 –DQPSK is not. Compare these two methods from this point of view (what are the advantages and disadvantages?).
c)   Derive π/4 –DQPSK power spectrum S(f) after root raised cosine filtering and transmission. Root raised cosine with α=0,35 (D-AMPS) is used. Notice that the power spectrum at the input of the baseband filter $H(f)$ is white, since the autocorrelation function of the random impulse train is a delta function.

Root raised cosine (normalized) transfer function H(f) is

$$H(f) = \begin{cases} 1, & |f| \le 2W_0 - W \\ \cos\left[\dfrac{\pi}{4}\left(\dfrac{|f| + W - 2W_0}{W - W_0}\right)\right], & 2W_0 - W \le |f| \le W \\ 0, & |f| \ge W \end{cases}$$

and (R_s is the symbol rate)

$$W = (1+\alpha)W_0 = (1+\alpha)\frac{R_s}{2}.$$

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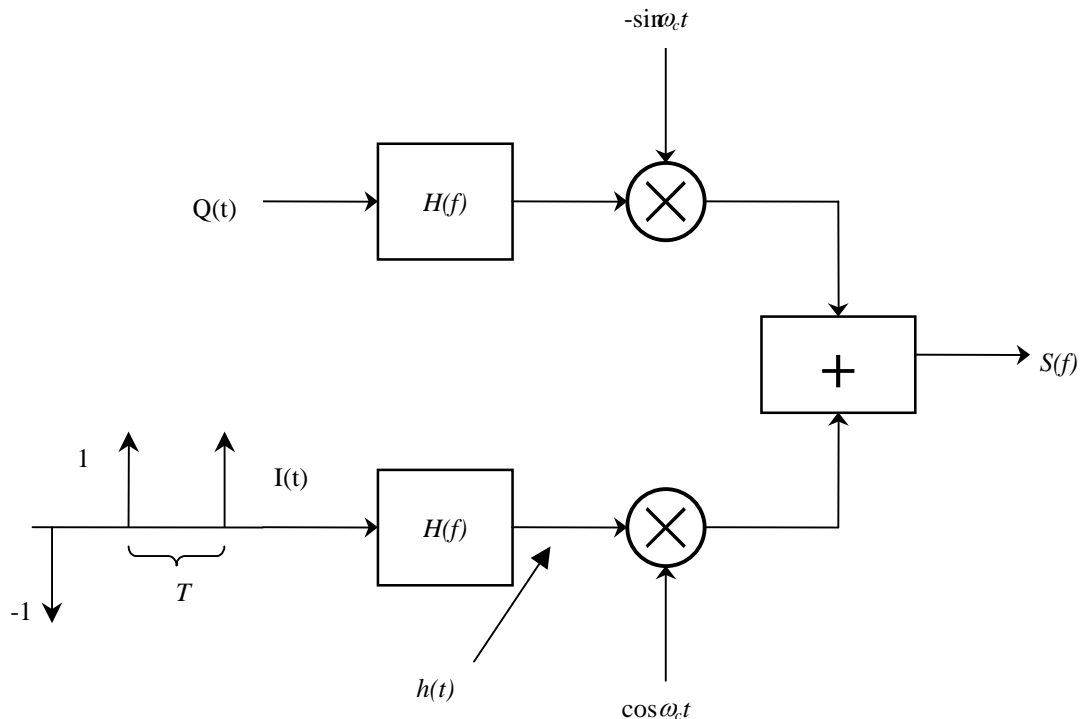
d)   271 kbit/s is transferred with π/4 –DQPSK modulation. How large is the –10dB RF bandwidth?

P5

About: 0.3GMSK modulation. This problem should be completed fully in order to understand L6.

GMSK modulation where the Gaussian filter BT=0.3 is used in GSM. Here B equals the -3dB bandwidth of the filter and T is the symbol duration.

    a)   What is the –3 dB bandwidth of the Gaussian filter in GSM?
    b)   The bandwidth of the Gaussian filter is not the same as the bandwidth of the GMSK modulation. Explain why.
    c)   What are the disadvantages of Gaussian filtering?
    d)   Calculate the frequency offset of frequency correction burst compared to the carrier frequency f_c. The f-burst is a stream of 148 zero bits.
    e)   What is the bandwidth efficiency in GSM (assume the bandwidth to be equal to channel spacing)?
    f)   Sketch transitions in phase (phase trellis) in a function of time when the modulator is fed the following line of bits: 110110010.
    g)   Sketch how the signal trajectory behaves in the IQ plane when modulator is fed with bit sequence 11011.
    h)   Draw the ideal constellation diagram and transitions for the GMSK modulation.

P6

About: IQ diagram and modulation errors. This problem should be completed to understand L6.

Data is being received using the standard QPSK modulation, where the constellation points lie on a circle in angles of ±45, ±135. Assume that the circle has unit radius.

a)   A sample of the received complex baseband signal has value $0.6 + j0.7$. What is the phase error? What is amplitude error? Assume that SNR is very high, and that symbol timing and carrier synchronization are perfect.
b)   Suppose we know that for the same signal both phase and amplitude error are zero. Calculate DC offset.

Hint: For information on modulation errors, see the application note "Digital Modulation in Communication Systems - An Introduction", available through the lab home page.

P7

About: The effect of modulator imperfections to modulated signal. Formulas derived in this problem are needed in L7.

The most common non-idealities of an IQ modulator are that the LO signals are not completely orthogonal, the LO signals have different amplitude, or that there is DC offset in the modulating I and Q signals.

a)   Suppose that the input signals in the I and Q branches are $I(t) = \sin(\omega_m t)$ and $Q(t) = \cos(\omega_m t)$, and the phase error in the LO signal of the Q branch is θ and the difference in the LO signal amplitudes is ΔA. Derive an expression for the IQ modulator output signal and show that the amplitude ratio of the spurious output α to the desired output β equals

$$\frac{\alpha}{\beta} = \sqrt{\frac{\left[1 - (1 + \Delta A)\cos(\theta)\right]^2 + \left[(1 + \Delta A)\sin(\theta)\right]^2}{\left[1 + (1 + \Delta A)\cos(\theta)\right]^2 + \left[(1 + \Delta A)\sin(\theta)\right]^2}} \; .$$

Sketch the spectrum of the IQ modulator output.
b)   Calculate the output time signal of IQ modulator when the modulating signals are $I(t) = A + \cos(\omega_m t)$ and $Q(t) = B + \sin(\omega_m t)$ i.e. the branches have DC offsets A and B. Otherwise, assume the modulator to be

ideal. Draw the spectrum of the output. Indicate the ideal output signal and the spurious output signal caused by DC offset.

c) How many dB lower is the spurious sideband level compared to the wanted sideband when the phase error in LO signals is 5° and the amplitude ratio of the quadrature branch LO signal to the in-phase LO signal is $\Delta A = 0.5 \text{dB}$? Use the formula you derived in part a.

d) How many dB lower is the carrier frequency compared to the wanted side band if the DC offset in both modulating signals is $A = B = 0.5$. Use the formula you derived in part b.

P8

About: Phase and frequency error.

The phase error of modulator in a GSM1800 MS changed linearly from –1 degrees to +3 degrees during one burst.

a) What was the frequency error during the burst?
b) Specifications allow a frequency error of 0.1 ppm (parts per million). Is the calculated frequency error acceptable?

P9

About: To save time during lab shift.

Examine the laboratory exercises. At the minimum clear up the following questions:

a) How is the sensitivity of a GSM MS defined?
b) How are CCI and ACI defined? You'll find information in appendices.
c) Sketch the RF connections for measuring co-channel interference. You'll have a power splitter/combiner, interference generator (base station), GSM tester and necessary cables and connectors.
d) What information is needed concerning the base station signal in order to calculate CCI and ACI?
e) How can you calculate CCI and ACI in the laboratory?

P10

About: Spectrum analyzer basics. Important to know in L6-L8.

Unless you are familiar with superheterodyne spectrum analyzers, you should find out the following:

a) How does a superheterodyne spectrum analyzer work?
b) What does resolution bandwidth mean? How does it relate to sweep time and frequency span?
c) What is the dynamic range of a typical spectrum analyzer?