The exam is closed book. Please, answer the questions as short as possible, but completely. Don't hesitate to present a drawing if this can elucidate the answer. The answers can be given in Dutch or English.

Problem 1

A GSM "hand-held" transmits with a power of 1 Watt at a frequency of 900 MHz. The distance between the "hand-held" and the base station is 3 km.

a. Calculate the free space path loss in dB between the transmit and the receive antenna.

b. Calculate the received power in dBm in the ideal case where isotropic (omni directional) antennas are used.

Beside the direct wave the base station also receives a second reflected wave, which is due to the path length difference shifted in phase. The field strength of this reflected wave is 90% of the direct wave.

c. Between what values does the received power vary? Calculate the fluctuation in dB.

Direction-sensitive antennas are used to reduce this fluctuation. In the direction of the direct wave the power is increased by 3 dB and in the direction of the reflected wave the power is decreased by 3 dB.

d. Again calculate the fluctuation.

e. Are direction-sensitive antennas used in real GSM-systems? Explain your answer.

Problem 2

A voltage pulse with magnitude of 1 volt is applied to the input of a lossless coaxial cable. The source has an internal impedance equal to the characteristic impedance of the cable. The response of the cable is measured by an oscilloscope (see figure below) at the input. This picture presents the voltage response on a limited time scale.

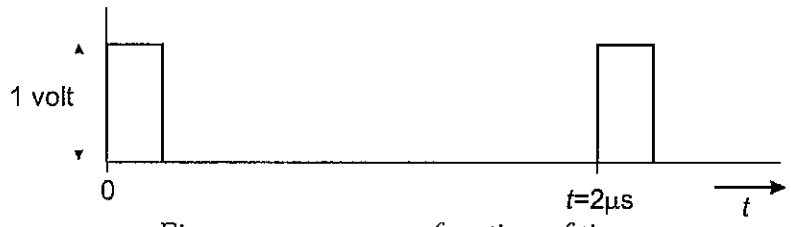

Figure : response as function of time.

a. Calculate the length of the cable, if it is given that the relative permittivity of the dielectric has the value ε_r=2.25.

b. Is the cable characteristic terminated, open-ended or short-circuited? Explain your answer.

c. If the time scale is extended, will then more pulses be observed?

Now the same pulse is applied to a lossy cable with the same dielectric. The loss amounts to 5 dB/100m.

d. Make a sketch of the cable's response in this case. Indicate the position on the time axis and calculate the magnitude of the reflected pulse.

e. What are the technical advantages of coaxial cable compared to twisted pair? Why are nevertheless twisted pairs more used in practice?

NOTE The pulse broadening on transmission may be neglected.

Problem 3

a. Define amplitude modulation and describe the basic operation of an amplitude modulator.

b. In an AM communication system, what is meant by the terms: modulating signal, carrier, modulated wave and AM envelope? (Make a sketch of an AM signal)

c. Describe upper and lower sidebands and the upper and lower side frequencies and what is the relationship between modulation signal frequency and the bandwidth in an AM system.

d. What is the highest modulation coefficient possible with a conventional AM system without causing excessive distortion?

e. What is the predominant advantage and disadvantage of AM Double Sidebanded Full Carrier (DSBFC)?

f. Describe the operation of a peak (envelope) detector.

Problem 4

A PCM system uses uniform quantization followed by 8 bits encoding. The channel bit rate amounts to 100 Mb/s.

a. Calculate the maximum information bandwidth that this system can accommodate.

b. Calculate the maximum signal-to-quantization noise ratio if a sinusoidal signal of frequency 5 MHz is applied to the input of this system.

Problem 5

A carrier is modulated by a binary data sequence in bipolar form using Quadri-phase Shift Keying (QPSK). The data rate is 100 Mbit/sec and the oscillator frequency is 500 MHz.

A schematic drawing of the transmitter is shown below.

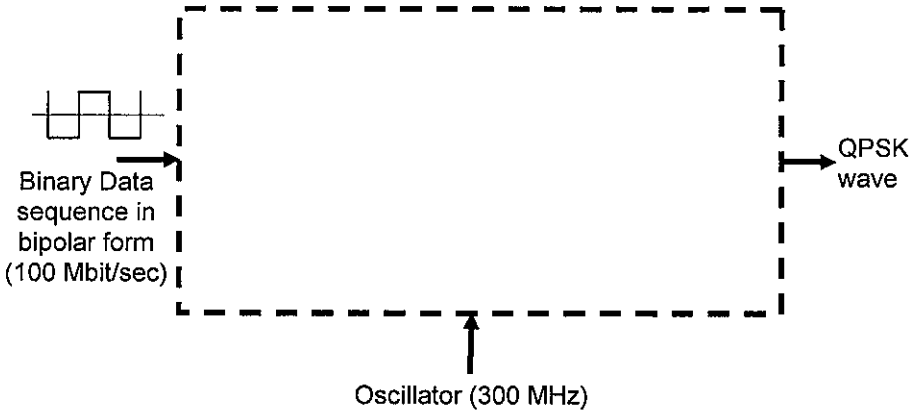

Figure: QPSK transmitter

a. Complete the transmitter scheme and describe its operation.

b. Make a drawing of the generated QPSK signal (as a function of time).

c. Explain the relationship between bits per second and baud for a QPSK system.

d. Make a sketch (power spectral density) of the input and output signal of the transmitter.

The QPSK wave is applied to a coherent receiver. A schematic drawing of the receiver is shown below.

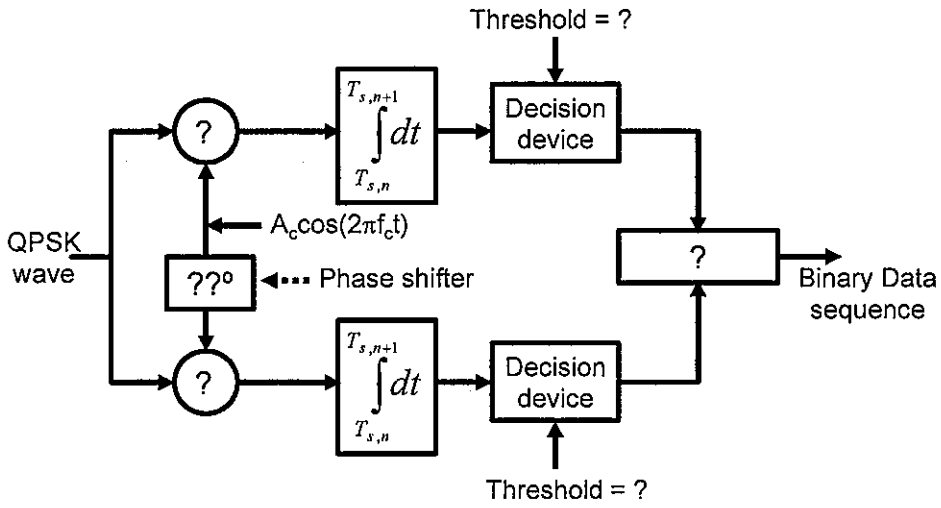

Figure: Coherent QPSK receiver

e. Complete the receiver scheme (fill question marks) and explain the operation.

f. What is the optimal threshold value for the decision device? Explain.

g. What is meant with **coherent** in coherent QPSK receiver?

h. Explain the relationship between the minimum bandwidth required for a QPSK system and the bit rate.

END