ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2017 SESSION

Open-book examination Programmable calculators, communicating calculators and personal computers are not allowed Duration : 3 hours

16-EL-A3 Signals and Communications

Question 1 : **(15 points)**

The following binary sequence $\mathbf{b} = [b_k]_{k=1,\ldots}$ is applied to the input of a DPSK (Differential Phase Shift Keying) modulator, where the initial differentially encoded symbol $d_0 = 0$.

$$\mathbf{b} = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 & 1 \end{bmatrix}.$$

a) Give the corresponding differentially encoded binary sequence $\mathbf{d} = [d_k]_{k=1,\ldots}$.

b) Give the corresponding phase sequence $\boldsymbol{\phi} = [\phi_k]_{k=1,\ldots}$.

c) Draw the resulting DSPK signal waveform. For this assume that the carrier frequency $f_c = \frac{1}{T_b}$ where T_b is the bit duration.

Question 2 : **(15 points)**

The antenna input terminals of an FM receiver have a 300 Ω impedance.

a) If the RMS voltage measured at these terminals is $V_{rms} = 65$ microvolts, what is the input signal power, P, (en Watts) ?

b) What is the corresponding P_{dBm} in dBm ?

c) What would be the RMS input voltage, if we were measuring the same input power but for an antenna input impedance of 50 Ω ?

Question 3 : **(20 points)**

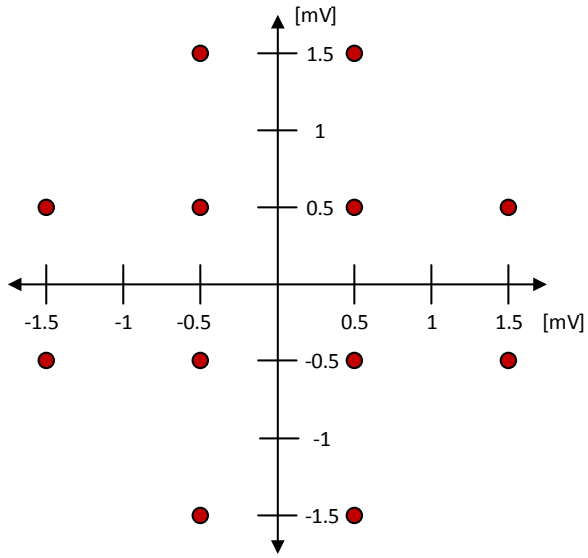
A receiver has 4 stages. The first stage is an low-noise amplifier with a gain of 30 dB and a noise figure of 3 dB. The second stage is an amplifier with a gain of 20 dB and a noise figure of 12 dB. The third stage consists of a 6-dB lossy network (assume the corresponding noise figure is 6 dB). The fourth stage is an amplifier with a gain of 40 dB and a noise figure of 15 dB.

a) Calculate the noise figure of the receiver.

b) What would be the noise figure, if we were to remove the second amplifier stage ?

Question 4 : **(20 points)**

Consider the signal constellation depicted below. The in-phase and quadrature signal components are : $\pm$ 0.5 [mV] and $\pm$ 1.5 [mV].



a) Write on a table the coordinates (in volts) and corresponding energy (in joules) of each symbol, assuming an impedance $Z = 50\Omega$ and symbol duration $T_s = 5$ [ms].

b) Compute the average energy per symbol E_s [J] for this signal constellation.

Question 5 : **(20 points)**

A source generates data at a rate of $R_b = 300$ Mbits/s. The data is bandpass modulated at carrier frequency $f_c = 3.7$ GHz using 256-QAM modulation with a raised-cosine filter.

a) Is it possible to transmit these 256-QAM symbols at carrier frequency within a $B_T = 48$ MHz bandwidth ? If so, what is the roll-off factor α ?

b) What is the minimum transmission bandwidth with the 256-QAM modulation if we can vary the roll-off factor α ?

Question 6 : **(10 points)**

a) Describe the principle of operation of an FM discriminator.

b) Explain the threshold effect in FM receiving systems.