ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2013 SESSION

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

07-ÉLEC-B3 Digital Communications Systems

Question 1 : **(20 points)**

The parity equations of a $\mathcal{C}(8,4)$ systematic linear block code are given by :

$$\begin{aligned} c_0 &= m_1 \oplus m_2 \oplus m_3 \\ c_1 &= m_0 \oplus m_1 \oplus m_2 \\ c_2 &= m_0 \oplus m_1 \oplus m_3 \\ c_3 &= m_0 \oplus m_2 \oplus m_3 \end{aligned}$$

a) Give the code's generator matrix $\mathbf{G}$. (4 points)

b) Find its parity-check matrix $\mathbf{H}$. (4 points)

c) Write the list of codewords. (8 points)

d) What is the minimum distance of the code ? (2 points)

e) What is the error correction capacity of the code ? (2 points)

Question 2 : **(15 points)**

We want to multiplex 6 audio signals sampled at 192 kHz each using PCM modulation.

a) These 6 signals are time division multiplexed (TDM). Draw the TDM signal as a function of time, indicating clearly the location and the duration of the multiplexed samples. (5 points)

b) 24-bit PCM codewords are produced using a uniform quantizer. What is the number of quantizing levels L ? (5 points)

c) What is the bit rate, R_b, of the multiplexed PCM signal ? (5 points)

Question 3 : **(20 points)**

An information source generate data at a $R_b = 750$ Mbits/s bitrate. The binary sequenxe is passband modulated at a carrier frequency $f_c = 38$ GHz using 64QAM modulation and filtered with a raised-cosine filter.

a) Is it possible to transmit these 64QAM symbols within a $B_T = 200$ MHz bandwidth in the passband ? Justify your answer. If so, what is the roll-off factor α ? (10 points)

b) What is the minimum passband transmission bandwidth, still with 64QAM modulation, if we can change α ? (10 points)

Question 4 : **(20 points)**

An information source generates random bits at a rate $R_b = 1.2$ Mbits per second.

a) Compute the autocorrelation function $R_{NRZ-bi}(k)$ and the power spectral density $\mathcal{P}_{NRZ-bi}(f)$ for a bipolar NRZ line code with $A = 8$ V. (10 points)

b) Compute $R_{RZ-uni}(k)$ and $\mathcal{P}_{RZ-uni}(f)$ for an unipolar NRZ line code with $A = 8$ V and a pulse duration $\tau = 0.35T_b$. (10 points)

Question 5 : **(25 points)**

The thermal noise power spectral density at the input of a receiver $\mathcal{P}_{as}(f) = \frac{k}{2}T_i$ [Watt/Hz] over the receiver's bandwidth $B = 20$ [MHz]. The ambient temperature $T_i = 290$ [Kelvin] and the Boltzmann's constant is $k = 1.38 \times 10^{-23}$ [Joule/Kelvin].

a) What is the thermal noise power, P_{as} [Watt], at the input of the receiver ? (5 points)

b) The receiver power gain $G_a(f) = 100$ over the 20 MHz bandwidth. What would be the noise power spectral density at the output of the receiver, $\mathcal{P}_{ao}(f)$ [Watt/Hz], if we assume an ideal receiver that does not introduce additionnal noise ? (5 points)

c) What would then be the noise power P_{ao} [Watt] at the receiver output ? (5 points)

d) Now, if the noise power measured at the receiver's output is instead $P_{ao} = 10^{-10}$ [Watt], what if the effective noise temperature, T_e [Kelvin], of the receiver ? (5 points)

e) Again, for a measured noise power $P_{ao} = 10^{-10}$ [Watt], what is the noise figure, F_{dB} [dB] (in decibels), of the receiver ? (5 points)