Mid-Term Exam Solutions

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Question 1

(a) The bit rate is the inverse of the bit duration. Since the waveform is Manchester encoded, each bit is encoded as a pair of voltage levels: H,L for a zero and L,H for a one. From the diagram, the duration of each pair of voltage levels is 0.5 ms so the bit rate is $\frac{1}{0.5\times10^{-3}}$ =2 kb/s.

(b) The baud rate (according to the IEEE) is the maximum number of voltage waveform transitions per second. For Manchester encoding this is two transistions per bit when consecutive 0's or consecutive 1's are transmitted. Thus the baud rate is $2\times$ the bit rate, or 4 kHz.

(c) For Manchester line code the transmitted bits can be decoded by deciding if the sequence in each bit period is H,L (for a zero) or L,H (for a one). For the waveform given in the exam, the values are: 1100 1010.

(d) If these bits represent the bits in order from LS to MS, the value in conventional numerical order (MS to LS) is 0101 0011. This is hex 53. From an ASCII table this corresponds to the character "S" (upper-case "ess").

Question 2

The Shanon channel capacity sets an upper bound on the achievable *error-free* bit rate:

$$C = B\log_2(1+\frac{S}{N})$$

In this case the bandwidth $B = 9$ kHz, $S/N = 10$dB (which is also 10 in linear units) so the capacity is

$$C = 9\times10^3\log_2(1+10)$$

$$= 9\times10^3\frac{\log(11)}{\log(2)} = 31 \text{ kb/s}$$

Becaues the channels Shannon capacity is less than the required bit rate it will not be possible to communicate over this channel at the required data rate with an arbitrarily low error rate.

Question 3

(a) The wavelength is:

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{2.4\times10^9} = 0.125 \text{ m}$$

(b) The received power for free-space propagation is given by the Friis equation:

$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2$$

All of the values are given in the problem except for the distance d. Solving for d,

$$d = \frac{\lambda}{4\pi}\sqrt{\frac{P_T G_T G_R}{P_R}}$$

from the problem, the transmit power, $P_T = 0.1$ W, $G_T = G_R = 100$, and $P_R = 0.1\times10^{-6}$ so

$$d = \frac{0.125}{4\pi}\sqrt{\frac{100\times100\times100}{10^{-4}}} \approx 1 \text{ km}$$

Question 4

(a) Velocity is:

$$v = \frac{\text{distance}}{\text{time}} = \frac{100}{0.5\times10^{-6}} = 200 \text{ m}/\mu\text{ s}$$

(b) The velocity factor is the ratio of the propagation velocity to the speed of light:

$$VF = \frac{v}{c} = \frac{200}{3\times10^8} = 0.666$$

(c) The velocity factor is also a function of the dielectric constant, $VF = 1/\sqrt{\varepsilon_r}$ so

$$\varepsilon_r = \frac{1}{VF^2} = \frac{1}{0.666^2} = 2.25$$

(d) For co-ax transmission line the characteristic impedance can be calculated from the dielectric constant and the inner and shield diameters:

$$Z_0 = \frac{138}{\sqrt{\varepsilon_r}} \log_{10}(\frac{D}{d})$$

$$= \frac{138}{\sqrt{2.25}} \log_{10}(\frac{10}{1}) \approx 92\Omega$$