ELEX 4340 Midterm Solutions (201330)

Question 1 (5 marks)

Consider the last two digits of your student number as a decimal number between 0 and 99. Convert this number to an 8-bit binary number written in MS-bit-first order.

Sketch the waveform showing how this number would be transmitted in network order (MS bit first) using the *differential* Manchester line code described in the course. Assume the previously transmitted symbol was a high-to-low transition.

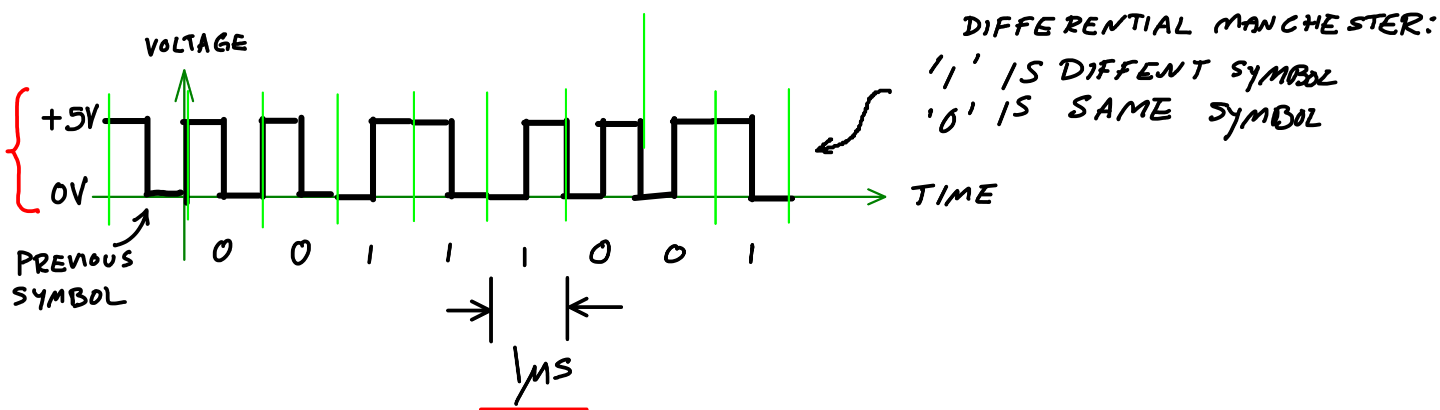
Assume a date rate of 1 Mb/s and unipolar signaling using 0 and 5V voltage levels. Show the voltage levels (in volts) and the duration of one bit period (in microseconds) on your sketch.

EACH ANSWER WILL BE DIFFERENT.

EXAMPLE: $57_{10} = 32+16+8+1 = 2^5+2^4+2^3+2^0$

$$\begin{array}{cccccccc} 7 & 6 & 5 & 4 & 3 & 2 & 1 & 0 \end{array} \leftarrow \text{POWER OF 2}$$

$$= \begin{array}{cccccccc} 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{array} \leftarrow \text{VALUE OF EACH BIT}$$



MARKS WERE ASSIGNED AS FOLLOWS:

One mark for each of the following:

- converting student number to binary
- bit order
- Manchester coding
- differential encoding
- voltage and time scales

Question 2 (4 marks)

You measure the capacitance of one meter of 50 ohm co-ax cable as 50 pF. What is the inductance of the cable per meter? If the cable uses air as the dielectric and the inner conductor diameter is 1 mm, what is the shield diameter?

$$Z_0 = \sqrt{\frac{L}{C}}$$ (lossless cable assumed, L & C per unit length)

Solve for L:

$$L = C Z_0^2 = 50 \times 10^{-12} \cdot 50^2 = 125\,nH/m$$

for air VF = 1, $\varepsilon_r = 1$

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

Solve for D:

$$D = d\,10^{\left(\frac{Z_0\sqrt{\varepsilon_r}}{138}\right)} = 1 \cdot 10^{\left(\frac{50 \cdot 1}{138}\right)} = 2.3\,mm$$

MARKS WERE ASSIGNED AS FOLLOWS:

Two marks each for inductance and diameter (one for method, one for value).

Question 3 (4 marks)

The magnitude of the transfer function of a channel (including all transmit filters, channel, and receive filters) has a loss of ~~3 dB~~ 6dB at 250 kHz, and 1 dB at 100 kHz. The channel does not cause ISI to a data waveform. What is the (maximum) symbol rate of this waveform? Why? What is the loss at 400 kHz? Why?

If no ISI the channel must meet Nyquist no-ISI criteria: transfer function must be symmetrical about $\frac{f_{symbol}}{2}$ and have gain of $\frac{1}{2}$ (−6dB) at $\frac{f_{symbol}}{2}$.

$\therefore \frac{f_{symbol}}{2} = 250\ kHz \qquad f_{symbol} = 500\ kHz.$

From symmetry condition

$$H\left(\frac{f_s}{2} - \Delta\right) = H\left(\frac{f_s}{2} + \Delta\right)$$

given: $H(100kHz) = -1\,dB = 10^{\frac{-1}{20}} = 0.89 \qquad 100\ kHz = \frac{f_{symbol}}{2} - \Delta = 250\ kHz - \Delta$

$\Delta = 150\ kHz$

$$H\left(\frac{f_{symbol}}{2} + \Delta\right) = H(400\ kHz) = 1 - H(100\ kHz) = 1 - 0.89 = 0.11$$

$$H(400\ kHz) = 0.11 = -19\ dB$$

MARKS WERE ASSIGNED AS FOLLOWS:

- for the symbol rate: 1 mark for correct value, 1 for the explanation
- for gain at 400 kHz: 1 mark for correct value, 1 for the explanation

Question 4 (4 marks)

An FM radio station transmits with a power of 50 kW at a frequency of 100 MHz. The transmit antenna has a gain of 10 dB. Assuming a direct line of sight distance of 1 km between the transmitting and receiving antennas, what power is received by a receiving antenna with a gain of 0 dB? Give your answer in dBm.

$$P_T = 50\,kW = 50\times10^3\,W = 50\times10^6\,mW = 77\ dBm \quad (10\log(50\times10^6))$$

$$G_T = 10\,dB = 10 \qquad G_R = 0\,dB = 1 \qquad d = 1\,km = 10^3\,m$$

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{100\times10^6} = 3\ m$$

calculation in linear units:

$$P_R = P_T\, G_T\, G_R \left(\frac{\lambda}{4\pi d}\right)^2 = 50\times10^6\cdot 10\cdot 1\cdot\left(\frac{3}{4\pi\cdot10^3}\right)^2 = 28.5\ mW$$

$$\simeq 15\ dBm.$$

in log units:

$$P_R = P_T + G_T + G_R + 20\log\left(\frac{\lambda}{4\pi d}\right) = 77 + 10 + 0 + 20\log\left(\frac{3}{4\pi\,10^3}\right)$$

$$\approx 77 + 10 - 72 = 15\ dBm.$$

MARKS WERE ASSIGNED AS FOLLOWS:

One mark for each of the following:

- for using the correct equation
- for converting frequency to wavelength
- for conversion to/from dB(m)
- for the correct answer