ELEX 4340 : Data Communications
2015 Fall Session

Solutions to Final Exam

Question 1

(a) The probability of each message is the fraction of messages of each type. In one version of the exam these are $\frac{30}{60} = 0.5$, $\frac{18}{60} = 0.3$, $\frac{6}{60} = 0.1$. In the other they are $\frac{30}{60} = 0.5$, $\frac{20}{60} = 0.333$, $\frac{5}{60} = 0.083$.

(b) The entropy of a source is given by:

$$H = \sum_i (-\log_2(P_i) \times P_i) \quad \text{bits/message}$$

Where the probabilities are as given above. The result in both cases is ≈ 1.6 bit/smessage.

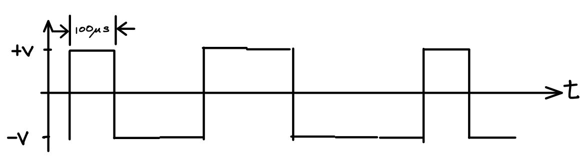
(c) The information rate is the amount of information transmitted per second. In this case since one message is generated per second the information rate is also ≈ 1.6 bits/second.

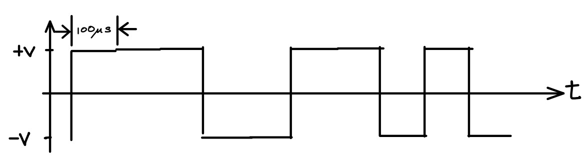
Question 2

The bits are transmitted in little-endian order. There were two versions of the question. One was for the character 's' (0x73, binary 0111 0011) and one for the character 'L' (0x4c, binary 0100 1100).

The differential voltage is the difference between the two voltages (in this case labelled `V+` and `V-`). These must have opposite values for differential signalling. If the two voltages are 0 and 3 V then the differential voltages must be $0-3 = -3$ V and $3-0 = 3$ V. Similarly for 0 and 5 V levels. The duration of each symbol is the bit period, $\frac{1}{10\times10^3} = 100\ \mu$s.

The waveforms are:





Question 3

(a) If the propagation delay through a 100 m section of co-ax cable is found to be 1 μs then the velocity factor is:

$$VF = \frac{v}{c} = \frac{\frac{100}{1\times10^{-6}}}{3\times10^8} = \frac{1}{3}$$

from the velocity factor we can obtain the dielectric constant:

$$\varepsilon_r = \frac{1}{VF^2} = 9$$

(b) We also know the relationship between characteristic impedance and the product of distributed inductance and capacitance, LC, ($Z_0 = \sqrt{\frac{L}{C}}$) and between LC and velocity of propagation ($v = \frac{1}{\sqrt{LC}}$) from which we can derive:

$$C = \frac{1}{vZ_0} = 200 \text{ pF}$$

for $Z_0 = 50\ \Omega$ and 133 pF for $Z_0 = 75\ \Omega$.

Question 4

To achieve error-free communication over an AWGN channel requires that we meet the Shannon capacity limit. This is:

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

We are given the SNR (-10 dB or 0.1) and the bit rate which must be less than the capacity. Thus we can compute the required bandwidth, B:

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

and for a capacity (bit rate) of 1 kb/s this is ≈ 7.3 kHz and for a bit rate of 2 kb/s it is ≈ 14.6 kHz.

Question 5

HDLC framing requires adding a start flag, an end flag, bit-stuffing within the frame after 5 consecutive 1's.

For the bit sequence `1 1 0 1 1 1 1 1 0 1` the transmitted bits would be:

01111110 1 1 0 1 1 1 1 1 0 0 1 01111110

and for `0 0 1 1 1 1 1 1 0 1` it would be:

01111110 0 0 1 1 1 1 1 0 1 0 1 01111110

Question 6

To compute the IP checksum we add up the bytes arranged as 16 bit words in big-endian byte order. Then add the MS 16 bits to the LS 16 bits and invert the bits of the result.

Both versions of the question give the same result: the sum is 0x13c7e and the IP checksum is 0xc380.

Question 7

For the routing table:

Destination	Netmask	Interface
127.0.0.0	255.255.0.0	lo
10.0.3.0	255.255.255.0	eth0
0.0.0.0	0.0.0.0	eth1

We can determine the interface by AND'ing the destination IP address and the Netmask column and comparing the result to the Destination column. The first match is used to select the interface. The last row matches all addresses and is thus the default route.

There were two versions of the question with the same IP addresses arranged in different orders. The results are:

IP address	selected interface
74.125.25.104	eth1
10.0.3.255	eth0
127.0.0.1	lo
10.0.5.1	eth1