Solutions to Final Exam

Question 1

Using the UTF-8 decoding tables, the value 0xd0 (1101 0000) begins a 2-byte encoding with the values yyyyy = 10000 and the next byte, 0x92 (1001 0010) supplying xxxxxx = 010010. The code point scalar value is thus 00000 1000 0 01 0010 or 0000 0100 0001 0010 which is 0x0412.

The value 0xe3 (1110 0011) begins a 3-byte encoding with the values zzzz=0011, the next byte, 0x81 (1000 0001) supplying yyyyyy = 00 0001 and the next byte, 0x99 (1001 1001) supplying xxxxxx = 01 1001. The code point scalar value is thus 0011 00 0001 01 1001 or 0011 0000 0101 1001 which is 0x3059.

The values 0x38 or 0x33 are single-byte UTF-8 encodings with themselves as the code point values.

There two versions of this question with two different sequences of three code points. The answers were:

(a) Three Unicode code points can be decoded.

(b) The values of the code points are: U+0412, U+3059 and U+33 (one answer) or U+38, U+3059 and U+0412 (second answer).

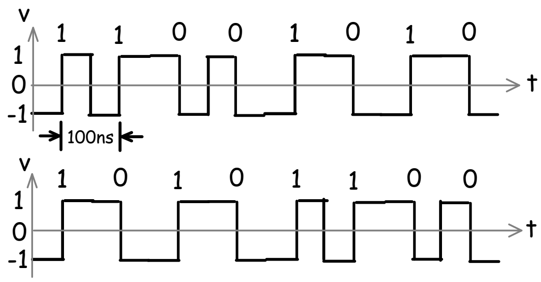
(c) The single-byte code point is also an ASCII character (0x33 or 0x38 depending on the version of the exam).

Question 2

The waveform required to transmit the byte values using 10 Mb/s Ethernet (Manchester encoding, little-endian bit order) are shown below. There were two versions of this question: 0x53 (0101 0011) and 0x35 (0011 0101). The bits are transmitted in little-endian bit order (1100 1010 and 1010 1100). A ’1’ is transmitted as a low-to-high transition and a ’0’ as a high-to-low transition.

The differential voltage is the difference between the two voltages (in this case labelled `TD+` and `TD-`). These must have opposite values for differential signalling. If the two voltages are 0 and 1 V then the differential voltages must be $0 - 1 = -1$ V and $1 - 0 = 1$ V. The duration of each symbol (H-L or L-H pair) is the bit period, $\frac{1}{10 \times 10^6} = 100$ ns.

The waveforms are:



Question 3

(a) The received power is −40 dBm which is $10^{-40/10} = 10^{-4}$ mW. This is $10^{-4} \times 10^{-3}$W/mW $= 10^{-7}$ W or 100 nW.

(b) We can solve the Friis equation:

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

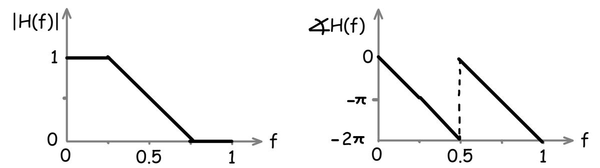
for the distance d:

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

where $P_T = 10 \times 10^3$, $G_T = 10^{10/10} = 10$, $G_R = 10^0 = 1$ and $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{300} = 1$ m for $f = 300$ MHz or 0.5 m for $f = 600$ MHz. The resulting value for $d \approx 79.6$ km for $f = 300$ MHz and 39.8 km for $f = 600$ MHz.

Question 4

For the channel not to cause ISI the magnitude of the transfer function must be constant or be symmetrical about half of the symbol rate. The phase response must be linear. There are many possible such transfer functions. Two examples are shown below:



Question 5

PPP framing requires a flag character (0x7e) at the start and end of the frame and escaping the flag and escape characters by prefixing them with the escape character (0x7d). There were two version of this question:

`0x5f 0x7d 0x1b 0xc4 0x3d 0x7e`

which is framed as:

`0x7e 0x5f 0x7d 0x7d 0x1b 0xc4 0x3d 0x7d 0x7e 0x7e`

and

`0x38 0x7d 0x1b 0xf0 0x50 0x7e`

which is framed as:

`0x7e 0x38 0x7d 0x7d 0x1b 0xf0 0x50 0x7d 0x7e 0x7e`

Question 6

To compute the CRC we must append the appropriate number of zero bits (one less than the order of the polynomial) and divide by the generator polynomial.

For both generator polynomials ($x^3 + x^1 + 1$ and $x^3 + x^2 + 1$) the CRC is 110:

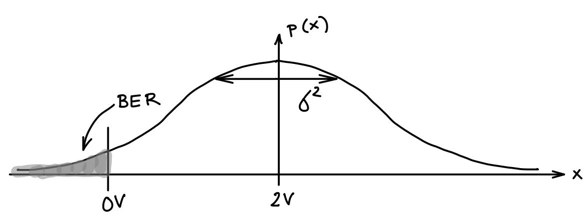
```
      ---------
1011 |11111000
      1011
      ----
       1001
       1011
       ----
        0100
        ----
         1000
         1011
         ----
          0110
          ----
           110
```

```
      ---------
1101 |11111000
      1101
      ----
       0101
       ----
        1010
        1101
        ----
         1110
         1101
         ----
          0110
          ----
           110
```

Question 7

For bipolar NRZ signalling the decision threshold is at 0 V and an error happens when the noise level is less than (more negative) than the (negative of the) signal voltage. Because of symmetry the BER is the same for the positive or negative transmitted levels.

When computing the normalized threshold t, the mean (μ) is the signal level (e.g. 2 V), the unnormalized threshold voltage (v) is the decision threshold (0 V) and the standard deviation (σ) is the square root of the noise variance (σ^2) as given in the problem (e.g. 0.64):



There were two versions of the question, both give $t \approx -2.5$:

$$t = \frac{0-2}{\sqrt{0.64}} = -2.5 \text{ and } t = \frac{0-4}{\sqrt{2.5}} = -2.53$$

and $P(t)$ can be found using a calculator, graph or approximation formula to be approximately 1%.