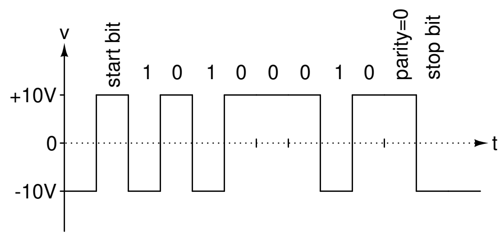
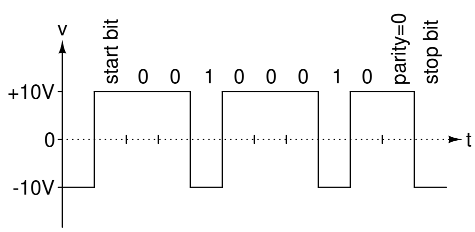
Solutions to Final Exam

Question 1

In the "RS-232" standard a high level represents a '0' and a low level represents a '1'. The following waveforms show the eight data bits and one parity bit:





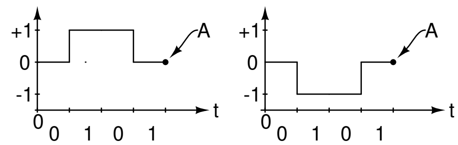
(a) Bits are transmitted in bit-reversed order so the values in binary are 0100 0101 and 0100 0100 which are 0x45 and 0x44 respectively.

(b) From the ASCII (Unicode) table in Lecture 1, these are the upper-case 'E' and upper-case 'D' characters respectively.

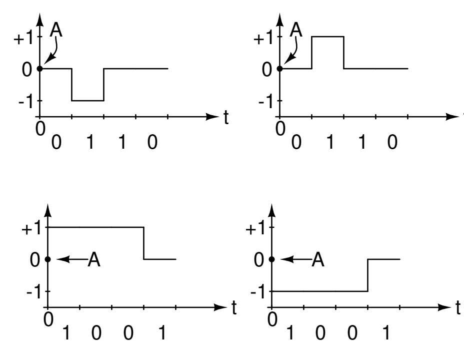
(c) The signal is high after the final (eight) data bit, so it cannot be a stop bit and there must be a parity bit. In both cases the value of the parity bit is 0. For a data value of 0x45 a '0' parity bit makes the number of ones 3, an odd number (odd parity) and for a data value of 0x44 a '1' parity bit makes the number of of ones 2, an even number (even parity).

Question 2

(a) The following diagram shows the bits transmitted between time 0 and point `A` as encoded using the MLT-3 line code assuming the previous signal level was 0 (zero). A '1' corresponds to a change in level and a '0' to no change:



(b) The waveforms that would be used to transmit the additional bits 0,1,1,0 or 1,0,0,1 are shown in the following diagrams. The sequence transmitted is the one where the next non-zero value has the opposite polarity as the previous one.



Question 3

(a) The length of the CRC in bits is the same as the order of the generator polynomial, 2 (bits).

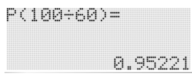
(b) The value of the CRC is computed by dividing the message polynomial, with two (CRC length) zeros appended, by the generator polynomial as follows:

```
        --------            --------
101 | 111000        101 | 110000
      101                 101
      ---                 ---
       100                 110
       101                 101
       ---                 ---
        010                 110
        ---                 101
         100                 ---
         101                  110
         ---                  101
          01                  ---
                               11
```

resulting in CRC's of 01 and 11 respectively.

Question 4

The normalized threshold corresponding to a voltage threshold of $v = 100$ or $v = 200$ mV with a mean of $\mu = 0$ V and and RMS voltage of $\sigma = 60$ or $\sigma = 120$ mV is $(v-\mu)/\sigma = (100-0)/60 = (200-0)/120 \approx 1.66$. Using a graph or a calculator the probability that the noise is less than the threshold is found to be $P(1.66) \approx 0.952$:



and the probability (fraction of time) that it's greather than the thresholdis $1 - P(1.66) \approx 4.8\%$.

Question 5

The values of the bits included in the frame can be obtained by removing the bits before and after the HDLC flag sequences (shown struck out below), the flag sequcences (also struck out) and any bit-stuffing within a frame (the zero after five consecutive '1' bits, crossed out and labeled):

~~0 0 0~~ ~~0 1 1 1 1 1 1 0~~ 1 0 1 1 1 1 1
stuffed
~~0~~ 0 1 0 ~~0 1 1 1 1 1 1 0~~

and

~~0 0 0~~ ~~0 1 1 1 1 1 1 0~~ 1 0 1 1 1 1 1
stuffed
~~0~~ 1 0 0 ~~0 1 1 1 1 1 1 0~~

Question 6

(a) For an FEC cod using the three six-bit codewords: `110000`, `001100` and `000011`, the Hamming distances between codewords are shown in the following table. The minimum distance of these distances is $D_{\text{min}} = t = 4$.

	110000	001100	000011
110000	0	4	4
001100		0	4
000011			0

(b) The maximum number of errors per codeword that this code guaranteed to detect is $t - 1 = 3$.

(c) The maximum number of errors per codeword that this code guaranteed to correct is $\lfloor \frac{t-1}{2} \rfloor = \lfloor \frac{4-1}{2} \rfloor = \lfloor \frac{3}{2} \rfloor = 1$?

Question 7

(a) If the signal power at the output of an AWGN (Additive White Gaussian Noise) channel is 40 (or 50) dBm and the noise power is 30 (or 40) dBm the SNR is $40 - 30 = 50 - 40 = 10$ dB= 10.

(b) If the bandwidth of this channel is $B = 10$ (or $B = 20$) MHz, the maximum information rate that can be transmitted over this channel with an arbitrarily low error rate is the Shannon Capacity for an AWGN channel: $C = B \log_2(1 + S/N) = 10 \times 10^6 \log_2(1 + 10) \approx 34.6$ Mb/s (or 69.2 Mb/s for a $B = 20$ MHz channel).

Question 8

(a) (i) DTR is an output on a DTE and DSR is an output on a DCE.

(ii) Handshaking signals are asserted when high, so this signal is asserted (i.e. the Data Terminal (or Set) is Ready.

(b) A signal going from -5 V to $+5$ V in 400 ns (at a constant rate) is increasing at a rate of $\frac{5--5}{400\times10^{-9}} = 25$ V/µs. The same increase in 600 ns is a slew rate of $\frac{5--5}{600\times10^{-9}} \approx 16.6$ V/µs.

(c) The common-mode voltage is the average of the two voltages:

$(\text{TD+} + \text{TD}-)/2 = (9+5)/2 = 7\,\text{V}$

or

$(\text{TD+} + \text{TD}-)/2 = (7+3)/2 = 5\,\text{V}$.

The absolute value of the differential voltages is:

$|\text{TD+} - \text{TD}-| = |9 - 5| = 4\,\text{V}$

or

$|\text{TD+} - \text{TD}-| = |7 - 3| = 4\,\text{V}$.

(d) The period of a maximal-length pseudo-random bit sequence (ML PRBS) that contains 1024 (or 512) '1' bits and 1023 (or 511) '0' bits is the sum of the two, 2047 (or 1023).