Solutions to Mid-Term Exam

Question 1

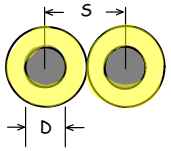
(a) **Optical Fibers** are only 125 μm thick – the thinnest of the media we studied – and many will fit into a cable that will fit a small conduit. Because they use signals at optical frequencies they are not affected by lower-frequency electromagnetic fields.

(b) **Wireless Communications** (through free-space channels) allows communication with portable or mobile devices such as battery-powered robots moving products around a warehouse

(c) **Co-Axial Cables** can carry Radio Frequency (RF) signals with frequencies of 900 MHz such as from a cellular radio transmitter at the bottom of a cell tower to an antenna at the top. Twisted pair cable would have too high a loss at this frequency and optical fiber signals cannot carry RF power.

Question 2

If we treat "open wire" transmission line as an example of twisted pair:



with an air dielectric the equation for the characteristic impedance is:

$$Z_0 \approx \frac{120}{\sqrt{\varepsilon_r}} \ln\left(\frac{2S}{D}\right)$$

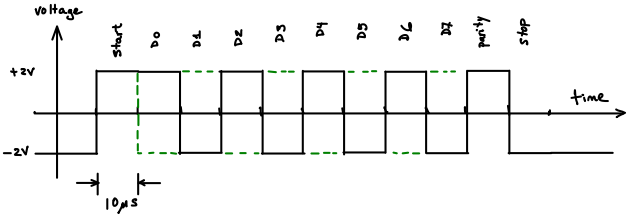
For free space $\varepsilon_r \approx 1.0$. The spacing between wire centers is $S = 75$ mm. For $D = 6$ gauge, the wire diameter is increased from that of 24-gauge ($D = 0.5$ mm) by 18 (3 steps of 6) resulting in a diameter of $0.5 \times 2^3 = 4$ mm. For $D = 8$ gauge, the wire diameters is increased from that of 24-gauge by 16 (2.66 steps of 6) resulting in a diameter of about $0.5 \times 2^{2.66} = 3.2$ mm. You could also have used the equation derived in Assignment 2. The characteristic impedances are approximately 460 Ω and 430 Ω for 8- and 6-AWG conductors respectively.

Question 3

The RS-232 waveform required to transmit an 8-bit value with even parity consists of one start bit, 8 data bits, a parity bit that makes the number of '1's an even number, and a stop bit. Each bit has a duration of $\frac{1}{100\times10^3} = 10$ μs and the voltage are $\pm$2V.

Data bits are sent in order from LS to MS bit. For a value of 0xAA (binary 1010 1010) there are four '1' bits which is already an even number so the parity bit should be '0'. The initial (LS) data bit is a '0' which is transmitted as a high voltage level (+2V). The subsequent bits alternate in value and voltage level except the parity bit which is set to '0' (H). For a value of 0x55 (binary 0101 0101) the data bit are the complement of the above but the parity bit is the same since the number of '1's is still an even number (4).

The diagram below shows the waveform for a value of 0xAA in solid black line. The portions of the waveform that would be different for a value of 0x55 are shown with a dashed green line.



These voltage levels *do not* conform to the RS-232 standard which requires that the signal levels be less than -3 V or greater than +3 V.

Question 4

(a) The throughput is the average number of data bits received by the data sink per unit time, not including overhead such as bits used for framing or error-detection or data that contains errors. This overhead or unusable data is not delivered to the data sink and is not counted in throughput.

In this example each packet takes the same amount of time to be received. A packet is composed of 100 data symbols plus either 6 or 8 checksum symbols. The symbol rate is 1000 symbols per second. So each packet takes 108/1000 or 106/1000 seconds to be received. Each packet carries $100 \times 3 = 300$ data bits. The throughput is thus $\frac{3\times100}{108/1000} = 2778$ bps or $\frac{3\times100}{106/1000} = 2830$ bps.

Some students interpreted the wording that the checksum symbols were "added to each packet" as that the checksum symbols were "included in each packet". In that case the throughputs would be $\frac{3\times(100-8)}{100/1000} = 2760$ bps or $\frac{3\times(100-6)}{100/1000} = 2820$ bps. These answers were also marked as correct.

(b) The "Latin Small Character Sharp S" has a Unicode code point of U+00DF which has a binary encoding of 0000 0000 1011 1111. This bit pattern matches the second row of Table 3-6 of the Unicode standard (see Lecture 1, page 4) and so the UTF-8 encoding will use two bytes.

(c) Co-axial cable does not require balanced signals to provide shielding of the signal so it would be more appropriate for RS-232 which uses unbalanced signalling. However, in practice the distances over which RS-232 is used are short and twisted-pair is less expensive so this was also accepted as a valid answer if an explanation was given.

RS-422 uses balanced signalling so for best noise immunity it should be used with a balanced transmission line such as twisted pair. This will result in equal noise and interference voltages being induced on both conductors. A differential receiver will be immune to this common-mode noise. The currents and voltages on co-axial cable will typically not be balanced and so a differential receiver will "see" the common-mode noise.