EEEN 20060 – Communication Systems

Problem Set 1

Each of these problems is based on one area of the module. Exam questions may require understanding of more than one area of the module, and an ability to apply this to new problems. Also, these problems only cover the first sections of the module.

1. Explain the terms *noise*, *interference* and *distortion*, in the context of the physical layer of a communication system. Show that you understand the difference between these terms.

2. You want to transmit data at 10 Mbit/s along a cable, using NRZ signals with average value 0 V. The voltage range at the transmitter is limited to ±8 V (you do not have to use all of this range, but you should aim to use most of it). From the viewpoint of the transmitter, the channel looks like a resistance of 600 Ω. The bandwidth is limited to 2.5 MHz.

   Design a suitable set of signals. Define the mapping from bits to signals. Calculate the average power sent into the channel by the transmitter, assuming a random sequence of 1s and 0s is being transmitted.

3. Write a function to transmit data at 100 kbit/s using Manchester coding with signal values of ±2.5 V. The function should have two arguments:

int *data	pointer to array of bits to be sent (all values either 0 or 1)
int nBit	number of bits to be sent

   You can use a function void output (float v, float t)
   where v is the voltage to be transmitted, in volts,
   and t is the time for which it is to be transmitted, in microseconds.

4. A simple error detecting code adds one check bit at the end of a group of 18 data bits, so that the number of 1 bits in the new group of 19 bits is always an even number. The physical layer is such that each received bit has probability of error 5×10^{-3}. The receiver checks for an even number of 1 bits in each group of 19. If this test is passed, it removes the check bit and delivers the 18 data bits. What is the probability of these delivered data bits being incorrect? You may make approximations to simplify the calculation, but you must show clearly that you are doing this deliberately!

5. To improve the reliability of the system in problem 4, it is proposed to add 3 check bits to each group of 18 data bits. Propose a method of doing this, based on the same parity check idea as in problem 4. Calculate the probability of an un-detected error.

6. A cyclic redundancy check (CRC), with divisor 1101, is used to add check bits to the end of a group of 18 data bits. For the example data bits 101001110011010011 (leftmost bit sent first), calculate the transmitted bits.

7. A link layer protocol uses a flag consisting of exactly 6 consecutive 0 bits to mark the start and end of a frame. The frame header includes a 4-bit type code (to identify data, ACK, NAK, etc.), a 4-bit sequence number and an 8-bit address. This is followed by a variable number of data bits, up to a maximum of 1500 bits. The trailer includes a 16-bit CRC, calculated over all the data bits and the header bits (excluding the flag). Bit stuffing is used on all the bits between the flags, and is applied after the CRC is calculated. Explain clearly how the receiver operates: How does it detect the start and end of the frame? How does it know if the frame has errors? How does it know how many data bits it has received?

8. A link layer protocol uses the data frame described in problem 7, and transfers data using a simple stop and wait mechanism with both positive and negative acknowledgements, but without enquiries or flow control. Design the response frame (ACK or NAK). Calculate the throughput that could be achieved using frames of maximum size on a link operating at 100 kbit/s, with probability of bit error 2×10^{-5} and propagation delay 30 ms.

9. Find the optimum number of data bits per frame for the protocol in problems 7 and 8. Calculate the maximum throughput that could be achieved.

10. Re-design the protocol in problems 7 and 8 to allow almost continuous transmission. Increase the number of bits used to represent the sequence number if necessary. Find the throughput that your new design can provide, using 1500 data bits per frame.