

Professional Engineers of Ontario

Annual Examinations - May 2003

98-Elec-B4

Communications Systems

3 hours duration

Notes:

- 1) If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumption made.
- 2) Open book exam - any non-communicating calculator is permitted.
- 3) Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
- 4) All questions are of equal value.

- 1) A digital radio communication link uses a 64QAM modulation scheme. The channel has a bandwidth of 1.5 MHz.
 - a) Plot the signaling constellation diagram for this modulation scheme.
 - b) Give an expression for the waveform of the signal (i.e. the modulated signal).
 - c) Determine the maximum bit rate that can be transmitted if transmitter pulse shaping filters with 40% excess bandwidth (over the minimum possible pulse bandwidth for zero ISI) are used.
 - d) If a 2/3 rate convolutional code is used for error correction, determine the information bit rate for this system.

- 2)
 - a) In a communication system designed according to protocol layering principles an upper layer message is split into 10 frames for transmission across a noisy channel. Each frame has an 80 percent chance of arriving at the receiver undamaged for a given transmission. If no error control is done by the data link protocol, how many times must the message be sent on the average to get it completely across?
 - b) A CRC code in a data link protocol uses the generator polynomial $g(x) = x^5 + x^4 + x^3 + 1$. Determine the CRC check bits if the message part of the frame (data + all headers) is 1100001011100001. Give the complete transmitted frame.
 - c) A channel has a bit rate of 4 kbits/s and a propagation delay of 10 msec. For what range of frame sizes does the stop and wait protocol give an efficiency (throughput) of a least 80 percent? Assume that the number of overhead bits is negligible and that the time-out period for the stop and wait protocol is set equal to the propagation delay.

- 3)
 - a) A communication channel has a peak transmission rate of 5 Mbps. Assume a population of 50 users and a total offered traffic of 0.8 packets per packet time. What is the average bit rate per user for the cases of each of the following channel access protocols: ALOHA, slotted ALOHA, non-persistent CSMA (give approximate value)?
 - b) Consider building a CSMA/CD network running at 1 Gbps over a 1 Km cable with no repeaters. The signal propagation speed on the cable is 200,000 Km/sec. What is the minimum transmission frame size that can be utilized?
 - c) Why is CSMA/CD unsuitable for a wireless LAN?
 - d) Describe the channel access protocol used in the 802.11 wireless LAN.

- 4) A typical cellular system in North America utilizes two frequency bands with 12.5 MHz bandwidth each. One of these is for transmissions from base stations to mobile terminals and the other is for transmissions from mobile terminals to base stations.
- What is the difference in carrier frequency between the transmitting and receiving frequencies for a terminal. What factor determines this difference.
 - What is the total number of calls that can be set up if the system is AMPS and is based on a single cell.
 - If the system is a GSM system, what is the total number of voice circuits that can be set up if the system consists of a single cell?
 - If the system is AMPS and the frequency re-use cluster size is 7 and in each cell two channels are used for system control, what is the capacity of the system in terms of the number of voice calls per cell?
- 5)
- A certain information source produces a random sequence of characters from a 4 symbol alphabet {A, B, C, D}. The symbols occur with the following probabilities: $P\{a\}=1/2$, $P\{B\}= 1/4$, $P\{C\} = 3/16$, and $P\{D\} = 1/16$. Devise a binary code for the transmission of these symbols that will result in the average bit rate being minimized. Determine the average bit rate for this code if the source produces 10,000 symbols per second.
 - A colour video signal uses a PCM encoding scheme with an 8 bit A/D quantizer for each of the three colour components. The signal has the same number of pixels and frame rate as an NTSC signal. Determine the bit rate of the resulting digital video signal.
 - Describe the reason for interlacing as used in the NTSC transmission system.
 - What is the approximate bit rate for the following signals:
 - PCM as used in telephony
 - voice coder for 2nd generation cellular systems
 - bit rate in MPEG2 video coding
 - bit rate in a T1 link in the telephone network
- 6) Describe the 7 layers of the ISO/OSI protocol. Give a brief description of the following protocols and state the layer that each belongs to:
- equalization of a signal to remove intersymbol interference
 - forward error correction with a convolutional code
 - encryption for privacy
 - the TCP protocol (used in the Internet)
 - CDMA as in IS-95 (a cellular system)
 - the CSMA/CD protocol used in the Ethernet
 - HDLC
 - HTML
 - The FTP protocol
 - The IP protocol