TCOM 370

May 6, 1998 — Final Exam — 1:30 - 3:30

Closed Book — Summary Sheets Allowed

(Where descriptive answers are required, be precise.)

Problem 1

We want to transmit user data at 14400 bits/sec, using baseband signaling pulses at a rate of R_S baud (pulses/second).

(a) What is the absolutely minimum bandwidth needed for R_S=2400 baud?

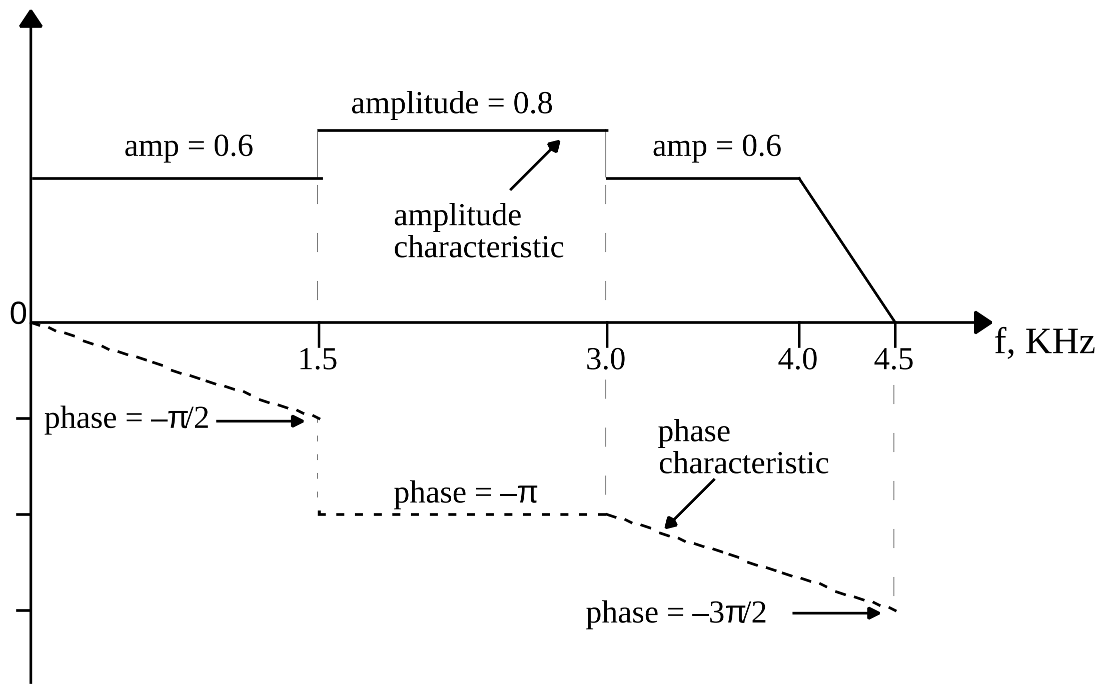
(b) In a telephone modem, the baseband pulses are modulated using QAM at a carrier frequency f_c. The available frequency band is between 300 and 3300 Hz. What maximum baud rate is achievable? What f_c should we use for this? (Justify answers).

(c) At R_S=2400 baud, what is the size of the QAM constellation? How does your answer change if we also transmit one error control bit for every 6 user data bits?

Problem 2

The frequency response of a channel is shown below:

Frequency Response



(a) *Identify* the frequency bands or combinations of bands, if any, over which

(i) there is no amplitude distortion;
(ii) over which *distortionless transmission* is possible.

(b) The waveform $x(t) = 10\cos(2\pi\cdot 750\cdot t) + 10\cos(2\pi\cdot 3750\cdot t)$ is input to this channel. Describe, and write an equation for, the signal y(t) at the output of this channel.

Problem 3

(a) Standard facsimile transmission makes use of two techniques to achieve data compression in the representation of scanned pages. Explain briefly what these are and how they work together to achieve significant compression in fax transmission.

(b) Explain briefly the principle of *differential encoding* as it is applied to compression of a video sequence of gray scale (intensity-only) images. What is the basic reason why differential encoding allows compression to be achieved?

Problem 4

Consider the systematic Hamming (7,4) linear block code for which $d_{min}=3$.
A (9,4) block code may be generated from this as follows:
If [**d**, **p**] = [d_3, d_2, d_1, d_0, p_2, p_1, p_0] is a codeword of the (7,4) code for message word **d**, then the codeword of the (9,4) code is [**d**, **p**, b_1, b_0], formed by appending bits b_1 and b_0. These bits are such as to make [**d**, b_1] and [**p**, b_0] both have even parity.

(a) Is the (9,4) code a linear block code? (Justify your answer.)

(b) What is d_{min} for this (9,4) code? (Justify your answer.)

(c) Suppose we define a (7,3) block code as follows. Each codeword [**d**, **p**] of the Hamming (7,4) code for which d_3=0 is used; the d_3 bit is converted into a parity check bit p_3 for the other 6 bits. The codeword is now [p_3, d_2, d_1, d_0, p_2, p_1, p_0] corresponding to message [d_2, d_1, d_0].
What is d_{min} for this code? Is the (9,4) code better than the (7,3) code? (Explain your answers).

Problem 5

(a) The formula for the efficiency of an Ethernet LAN is $\eta = \frac{1}{1+5a}$ where "a" is the ratio {maximum propagation delay T_p between nodes}/{frame duration T_{ix}}.
Explain why in a coaxial cable Ethernet LAN there is a limit on the *shortest frame* length as well as *longest frame* length that can be used, and also on the *maximum length of each cable segment* as well as *number of repeater-connected cable-segments*.

(b) Suppose you have an ethernet LAN with several hundred nodes. You want to add a new cable segment with a 100 nodes to this LAN. Explain the difference between a *bridge* and a *repeater* in connecting the new segment to the existing LAN, stating the advantage and disadvantage of each.

Problem 6

A number N of PC's and one printer station share a common cable bus. The transmission rate for PC's on the bus is 40 Kbps. The printer station completes printing a page within 2 seconds after getting a complete page of bits from a PC. Each page has 100,000 bits.

A slotted ALOHA multiple-access protocol is used, with a frame length of 100,000 bits. (Short ACKs put by the printer on the bus do not add significant overhead.) If the assumptions for slotted ALOHA analysis remain valid then the probability of a slot carrying a single uncorrupted frame is $G e^{-G}$, and the probability of a slot going empty is e^{-G}, where G is the average rate at which all the PC's together are attempting to use each slot.

(a) What is the average number of pages per minute (ppm) printed in the best case, if the assumptions of the ALOHA analysis are valid?
For this case, if N=20, on average how many ppm will each PC be able to print?

(b) An engineer suggests that adding a second printer on this bus will allow each PC to print a larger number of pages per minute. Decide how much improvement, if any, this will produce.

(c) Suppose one rogue PC does not adhere to the ALOHA etiquette, and attempts to transmit a page in every slot with probability 0 5. The other PC's do not know this, and attempt to transmit in any slot with a probability 1/N. How many ppm will the rogue PC be able to print? How many pages per minute will any of the other N-1 PC's be able to print? (Assume that N=20 and that this can be assumed to be large in the analysis).