TCOM 370

1 Hr. 30 Min. **Exam 1** **Feb. 10, 1999**

Closed Book **One Summary Sheet Allowed**

All problems approximately equally weighted

Problem 1

A communication link has a bandwidth of 800 KHz and a power attenuation of 20 dB. The transmitted signal power is 10^{-5} watts.

(a) What is the signal power *at the receiver?*

(b) A reliable (error-free) data transmission rate of 1.6 Mbps is required. What is the *maximum noise power* (watts) that, in theory, can be tolerated at the receiver?

Problem 2

Consider a channel (linear system) with frequency response shown in the Figure.
The channel input x(t) is a *sum* of *an amplitude modulated carrier* and *a sinusoid:*

$$x(t) = s(t)\cos(2\pi f_c t) + \cos(2\pi 1000 t) \quad ,$$

where $s(t) = \cos(2\pi 350 t)$ and f_c=1150 Hz.

(a) Sketch the *amplitude spectrum* of the input signal.

(b) What is the output y(t)? (Write the expression for y(t)).

Problem 3

A channel has frequency response shown in the Figure. The transmitter produces almost rectangular pulses, and uses amplitude shift keying (ASK) of a carrier. Note that ASK is a two-level scheme. (The noise is negligible. Equalization is not used.)

(a) Identify *a carrier frequency* that will allow a data rate of R= 200 bps.

(b) What is the *maximum data rate,* given freedom to choose *a carrier frequency*?

(c) Is it possible to attain a bit-rate of 1600 bps on this channel, if ideal (Nyquist) pulses are used, with ASK of a carrier or carriers? Explain your answer.

Problem 4

A two-wire link with total bandwidth 6 KHz is used to transmit data in both directions, using FSK. Separate frequency bands are used for the two directions. A minimum spacing of 600 Hz is needed between carrier frequencies in any one direction. The baseband pulse shape is almost rectangular.

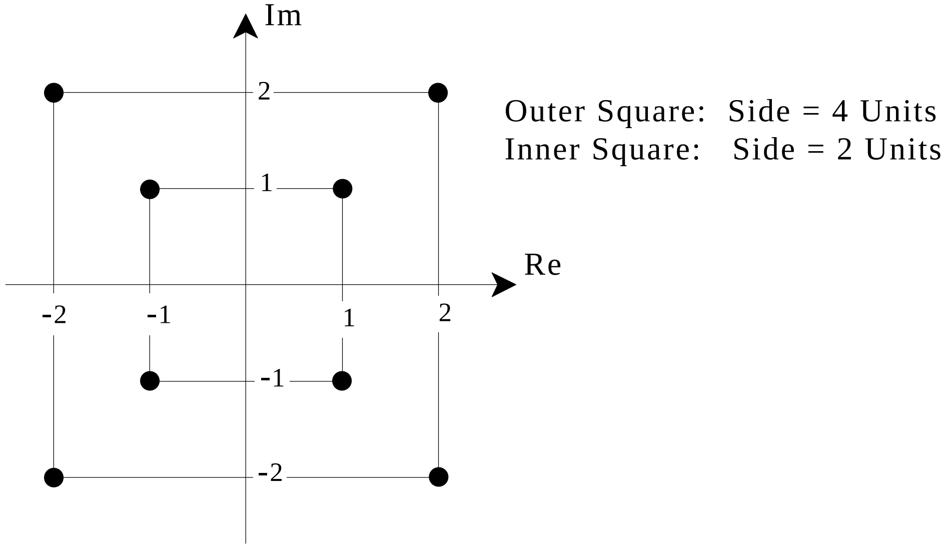
(a) Is this a *full-duplex* or a *half-duplex* scheme?

(b) What is the *maximum data rate* R bps that can be achieved in each direction?

(c) What is the *bandwidth efficiency* of the link?

Problem 5

Consider the symmetric 8-point signaling constellation given below:



(a) How many different *amplitudes* are produced in this constellation?

(b) How many *binary digits* can be encoded onto each symbol?

(a) Suppose we *rotate* the inner square of 4 points, by $\pi/4$ (45 deg.). Is the modified constellation any better than the original one? Explain.

(d) What would the *radius* be of an 8-point PSK constellation with the same average power as the given one? (All constellation points equally likely).

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Given Information:

(i) Shannon's formula for the capacity C of a communication link with bandwidth W Hz is $C = W \log_2(1 + \frac{S}{N})$ bps, where $\frac{S}{N}$ is the ratio of signal power S to noise power N at the receiver.

(ii) Power attenuation in dB of a link is $10 \log_{10}(P_{input}/P_{output})$

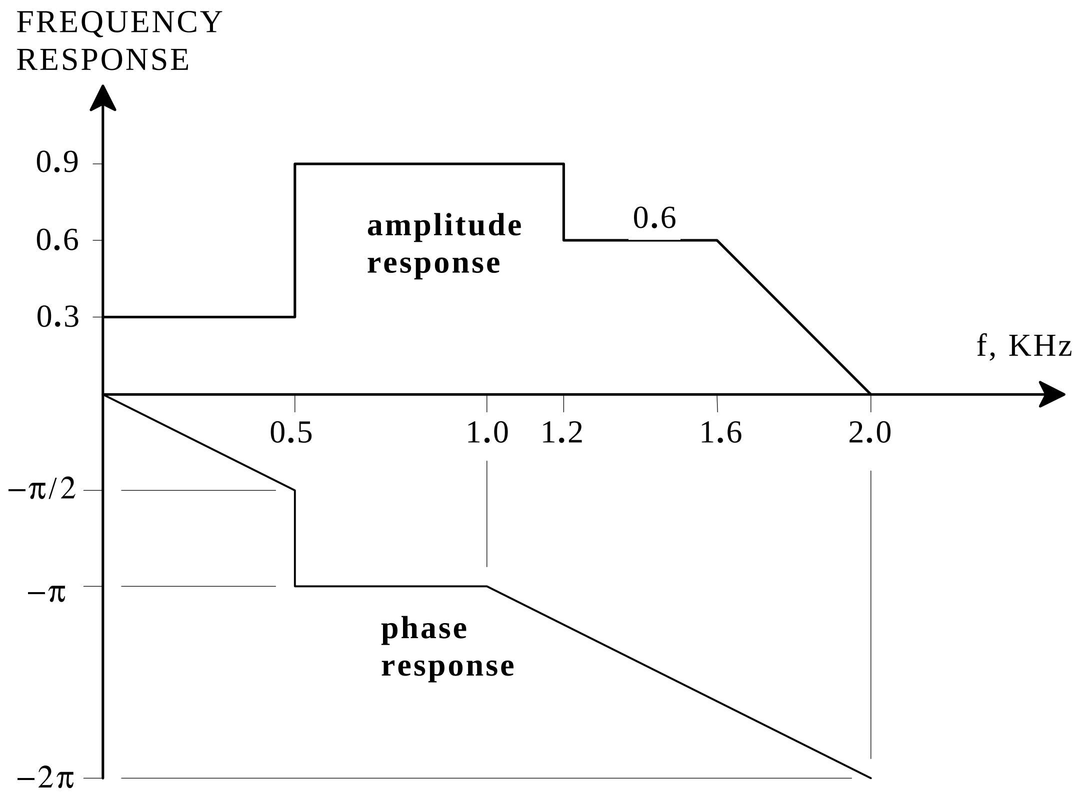

Figure for Problems 2 and 3