ES 442 Homework 6
(Spring 2020 – March 11, 2020)
Write all answers on this examination – show your work and state all assumptions.
A total of 100 points are possible.

Question 1  Shannon-Weaver Model  (5 points)
According to the Shannon-Weaver model what elements or components (i.e., represented in a block diagram) must a communication system have?

Question 2  Analog & Digital Signal Properties  (6 points)
List the principle properties for both physically realizable analog and digital signals.

Analog:
(1)
(2)
(3)

Digital
(1)
(2)
(3)
Question 3 Adding Phasors  (10 points)

You are given two sinusoidal signals: $\varphi_1(t) = 2 \cdot \cos(\omega_1 t + \pi)$ and $\varphi_2(t) = \sin(\omega_2 t)$. Show how you would add these signals using phasors. But do not do the mathematics to find a value – show the basic principle you use in combining the two signals on the polar graph. You will want to assume a value for time $t$ to do the drawing. (State your assumption for time.)

Does linearity hold when combining signals?

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Question 4 Using Single Tone for Analysis  (5 points)

In EE442 we have used tone modulation to discuss the operation of communication components and systems. Of course, a tone modulation message signal carries no information. So why is tone modulation useful for analyzing communication components and systems?
Question 5  Group Delay Interpretation  (5 points)

What is the physical meaning of the group delay of a two-port network (such as a transmission line of a filter)? Hint: Not the equation.

Question 6  Channel Distortion  (5 points)

To avoid signal distortion over a channel or transmission medium, what two properties are required of the channel?

1.

2.

Question 7  Signal Power in a Receiver  (10 points)

The receiver shown below has the following features: (1) An antenna for receiving the input RF signal, (2) a preselect filter with an attenuation loss of 5 dB, (3) a mixer with a 7.5 dB conversion loss (defined as the IF output
power to the RF input power), (4) an IF filter with a 3.5 dB nominal loss (as defined as the ratio of the power at point B relative to the power at point A), (5) an IF amplifier with 26 dB gain, and a local oscillator (LO) delivering a power of +12 dBm to the mixer’s LO port.

If the power delivered to the input of the detector (at point C) must be at least –20 dBm to reliably detect the message signal, what is the lowest power in dBm that must be received by the antenna for the receiver to operate?

**Question 8  Signal Duration vs. Bandwidth  (5 points)**

Explain the “signal duration versus bandwidth” tradeoff which arises when comparing the time domain viewpoint and the frequency domain viewpoint.
associated with a signal. Hint: What Fourier transform property would apply here?

**Question 9  AM Crystal Radio Operation  (9 points)**

You are given a crystal radio schematic (shown below) like the foxhole radio we discussed in class. Here a germanium diode replaced the razor blade/safety pin “point contact” and a high impedance earphone is used. Explain how this radio works to (a) select a radio signal, (b) how the detector works (Hint: Is this an envelope detector or rectifier detector?), and (c) why can’t a person hear the carrier frequency?

https://www.n6cc.com/crystal-radios-it-started-here

**Question 10  DSB-SC Modulator  (10 points)**
You are given a balanced modulator as shown below. It is used to generate a “double sideband-suppressed carrier “ (DSB-SC) signal. Assume both AM modulators are identical. The information signal is denoted by $m(t)$ with the upper branch’s input being $m(t)$ and the lower branch’s input being $-m(t)$. The upper branch AM modulator is driven by an oscillator supplying $A\cos(\omega_{ct})$. The lower branch’s AM modulator is driven from the same oscillator, but with an appropriate phase shift $\phi$. Be careful to note that the summing node sums the positive values of both branches (upper and lower).

(a) What must the phase shift $\phi$ be to generate the output DSB-SC signal as indicated in the diagram?

(b) If the summing node subtracted the lower branch’s modulated signal from the upper branch’s modulated signal, then what must the phase shift angle $\phi$ be to generate DSB-SC?

Question 11 Advantages of Superheterodyne Receiver (14 points)
Explain the advantages in using a superheterodyne receiver. List the advantages (at least three) and draw a block diagram of a single-mixer superheterodyne receiver able to tune among multiple channels or stations.

**Question 12  Switching Modulator**  (16 points)

Explain the basic principle behind the operation of a switching modulator (i.e., why does a switching modulator work?). You can explain by showing a circuit diagram and explain it from the circuit schematic or give a generic explanation.