Name: _____
Section: Key

EE334 Homework PS7

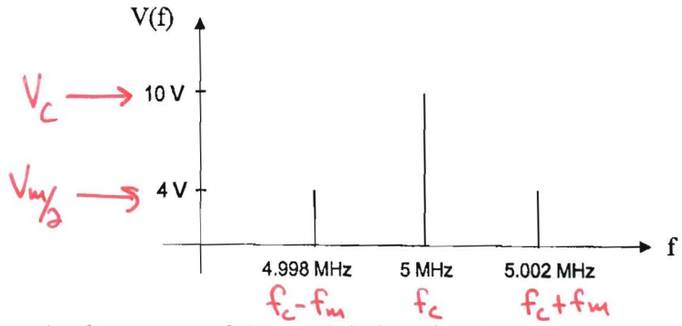
Problems from Supplement (Beige Book):

- 2.7, 2.9, 2.10. 2.11

Additional Problems (Instructor Option):

- Any as assigned by instructor
- 2.12

Problem 2.7 Given the spectrum of an AM signal shown below:



a. Determine the frequency of the modulating signal.
b. Determine the RF bandwidth required to transmit this signal.
c. Write the equation for this AM signal.
d. If this AM signal is applied to an antenna that has a radiation resistance of 200 Ω find the fraction of the total power in the information part of the signal.

a) $f_c + f_m = 5.002\,MHz$

$\boxed{f_m = 2\,KHz}$

b) $(f_c + f_m) - (f_c - f_m) = 5.002\,MHz - 4.998\,MHz = \boxed{4\,KHz}$

c) (2.9) $\boxed{v_{AM}(t) = 10\cos(2\pi \cdot 5 \cdot 10^6 t) + 4\left[\cos(2\pi \cdot 5.002 \cdot 10^6 t) + \cos(2\pi \cdot 4.998 \cdot 10^6 t)\right] V}$

d) (2.14)

- $m = V_m / V_c = \frac{8V}{10V} = 0.8$
- $P_{TOT} = \left(1 + \frac{m^2}{2}\right) P_c = \left(1 + \frac{(0.8)^2}{2}\right)\left(\frac{(10)^2}{2 \cdot 200\,\Omega}\right) = 0.33\,W$
- $P_c = \frac{V_c^2}{2R} = 0.25\,W$
- $P_{SBS} = 0.08\,W$

$\boxed{\%\ \text{Information Power} = \frac{0.08\,W}{0.33\,W} \cdot 100\% = 24.2\%}$

Problem 2.9

When a certain DSB-LC AM signal (pure tone modulating signal) is applied to an antenna,
400 W are transmitted at the carrier frequency and 80 W in each of the two sidebands.

a. Determine the modulation index.

b. If the amplitude of the un-modulated carrier remains the same but the modulation index is changed to 0.6 for the same antenna, find the power in the carrier and the two sidebands.

a) (2.14) $P_{TOT} = \left(1 + \frac{m^2}{2}\right) P_c$

$400w + 2 \cdot 80w = \left(1 + \frac{m^2}{2}\right) \cdot 400w$

$m = 0.89$

b) $P_c = 400w$ ← Same

$P_c = \frac{V_c^2}{2R} \therefore P_c$

$P_{TOT} = \left(1 + \frac{0.6^2}{2}\right) \cdot 400w = 472w$

$P_{SBS} = 72w$ ← vs. 160w total in Part a.)

Problem 2.10

Given the total transmitted power in a DSB-LC AM wave is 3 KW when the modulation index is 0.7, how much total power should a SSB-SC wave contain in order to have the same power content as that contained in the two sidebands together of the DSB-LC wave?

$$P_{TOT} = \left(1 + \frac{m^2}{2}\right) \cdot P_c = 3000\,W \qquad (m = 0.7)$$

$$P_c = 2409.6\,W$$

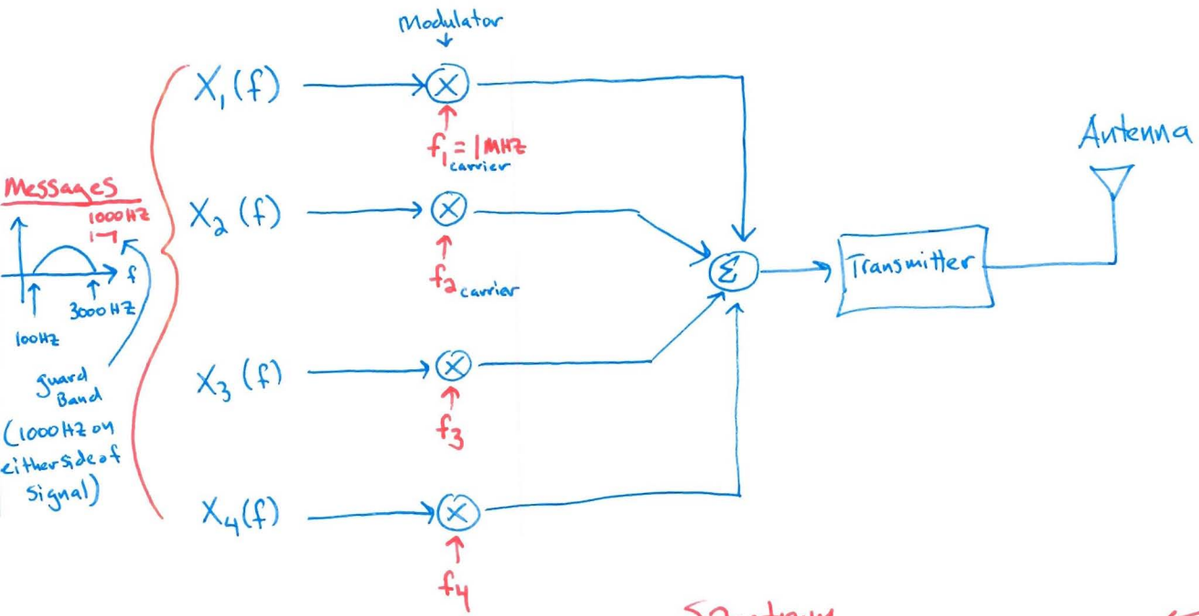
P_c: Carrier Power

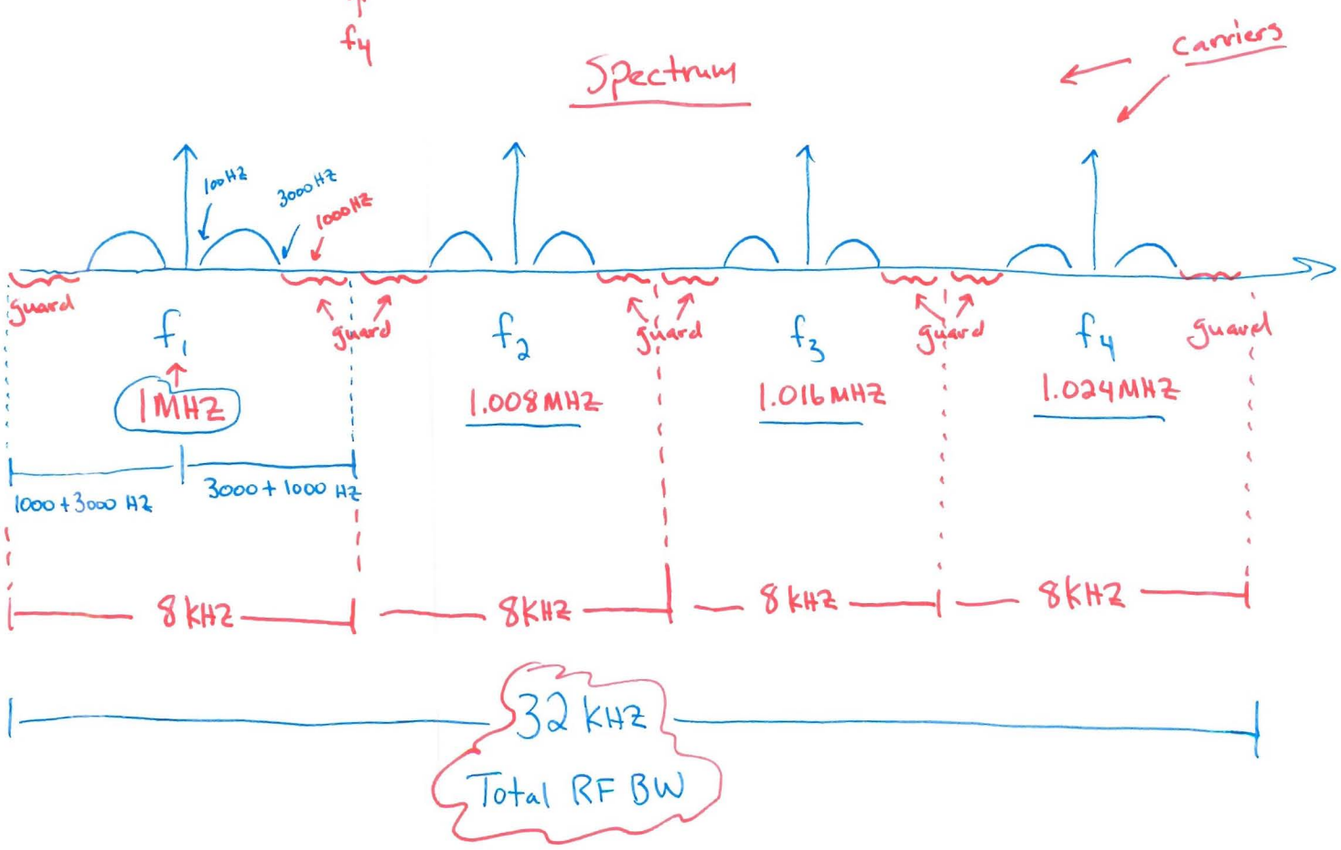
$$\therefore \; P_{SB's} = 590.4\,W \leftarrow \text{Both SideBands of DSB-LC}$$

But Note - P_{SB} (single) $= 295.2\,W$ Compare w/ 3000 W !

Problem 2.11

Four different messages are to be transmitted simultaneously by the same antenna by using frequency division multiplexing with four different carriers. Each message has a frequency range from 100 Hz to 3 KHz and a guard-band of 2 KHz is to be inserted between adjacent channels to help prevent interference and make demultiplexing easier. If the lowest frequency carrier is 1 MHz, sketch the total magnitude spectrum transmitted by the antenna and find the total RF bandwidth for the Transmitter/Antenna. Assume DSB- LC modulation for each channel.





Problem 2.12

Frequency division multiplexing is used in the communications system shown below in block diagram form.

(a) Determine the highest frequency present at point A.

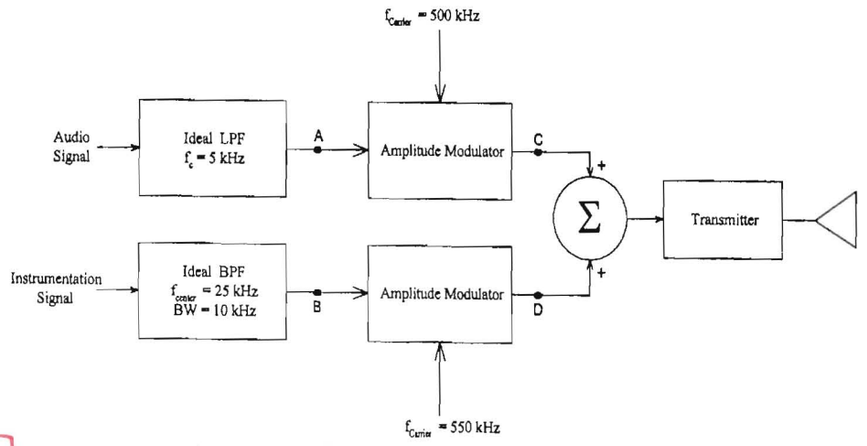
(b) Determine the lowest frequency present at point B.

(c) Find the range of frequencies present at points C and D.

(d) This system provides how much guard-band between the audio and instrumentation channels?

(e) Sketch the frequency spectrum at the output of the transmitter, using nominal amplitudes.

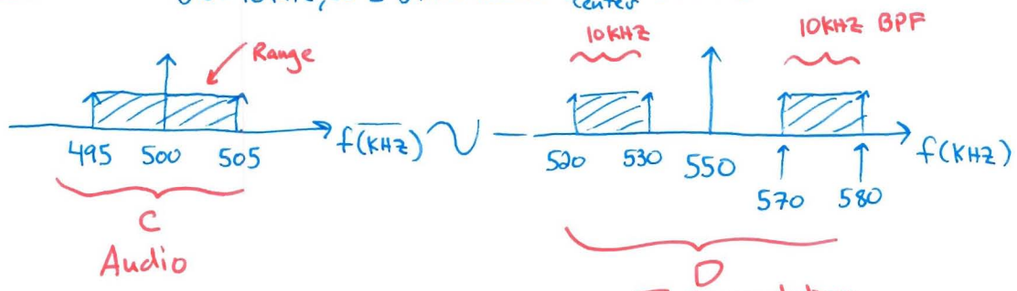
(f) What is the minimum bandwidth required for the amplifiers in the transmitter?



a) 5 KHZ ← Ideal Low Pass Filter
← Highest Frequency allowed to pass

b) 20 KHZ ← Ideal Band Pass Filter
BW = 10KHZ, so ± 5KHZ around f_{center} = 25KHZ

c)



d) Guard Band = 15 KHZ

e) See Above (Part C.)

f) Minimum BW = 580 - 495 = 85 KHZ