

Name: _____
Section: _____

Key

EE334 Homework PS6

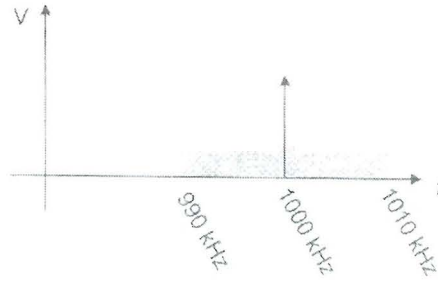
Problems from Supplement (Beige Book):

- 2.1, 2.2, 2.3, 2.4

Additional Problems (Instructor Option):

- Any as assigned by instructor

Problem 2.1: An AM signal has a frequency spectrum shown below



- What is the bandwidth of the audio signal which was modulated onto the carrier?
- What is the RF bandwidth of the signal being transmitted?
- What type of AM modulation produces the signal?

a) This is AM DSB-LC

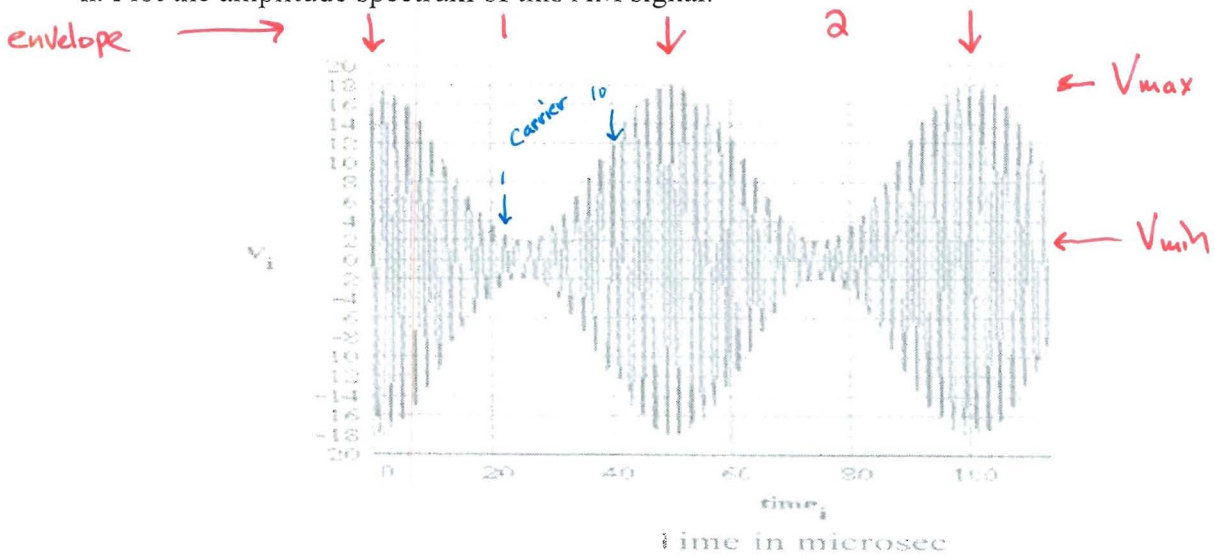
• Audio BW = $\underbrace{1010 \text{ kHz}}_{\text{max. of USB}} - \underbrace{1000 \text{ kHz}}_{\text{Carrier}} = \boxed{10 \text{ kHz}}$ (Pg. 12-13)

b) RF BW = $\underbrace{1010 \text{ kHz} - 990 \text{ kHz}}_{\text{Includes USB \& LSB}} = \boxed{20 \text{ kHz}}$

c) DSB-LC
Double Side Band Large Carrier (Pg. 8)

Problem 2.2: For the signal shown below, determine:

- the type of modulation used to produce the signal,
- the modulation index,
- the carrier frequency,
- the modulating frequency,
- the amplitude of the carrier if the modulating signal were reduced to zero,
- the amplitude of the USB and LSB components,
- write the equation for the above waveform,
- Plot the amplitude spectrum of this AM signal.



a) **AM DSB-LC** (Fig. 2.1)

b)
$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{18 - 2}{18 + 2} = 0.8 \leftarrow 80\% \text{ modulation}$$

c) EYE Test ON THIS ONE

- Count Peaks Starting just to the right of 20 μsec , Stop at 40 μsec
10 cycles in 20 μsec

$$f_c = \frac{10}{20 \mu\text{sec}} = 500 \text{ kHz}$$

d) This is the envelope \rightarrow $\frac{2 \text{ cycles}}{100 \mu\text{sec}} = 20 \text{ kHz}$

e) This means no change in the Carrier Amplitude V_c \leftarrow No longer being modulated

(2.6)
$$V_c = \frac{V_{max} + V_{min}}{2} = \frac{18 + 2}{2} = 10 \text{ V}$$

Note - This is Half-way between the maximum & minimum Amplitudes

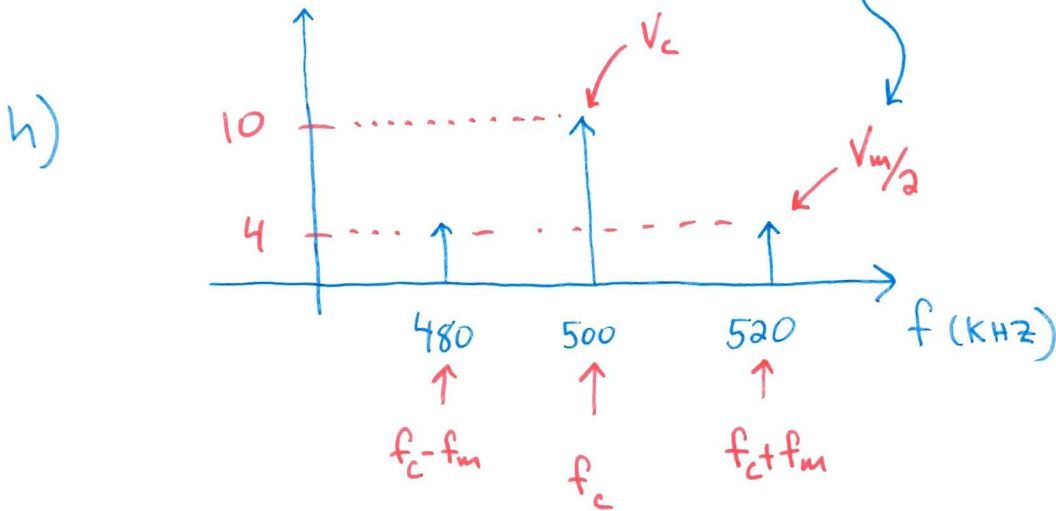
2.2 cont.

f) ^(2.6) $V_m = \frac{V_{max} - V_{min}}{2} = \frac{18 - 2}{2} = 8V$

Modulating Amplitude (USB & LSB)

$m \cdot V_c = V_m$ (2.7)

g) ^(2.9) $V_{AM}(t) = 10 \cos(2\pi \cdot 500t) + \frac{0.8 \cdot 10}{2} [\cos(500\text{kHz} + 20\text{kHz})2\pi t + \cos(500\text{kHz} - 20\text{kHz})2\pi t]$ V

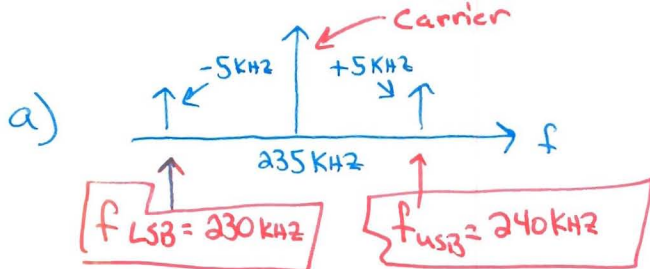


(Fig. 2.3)

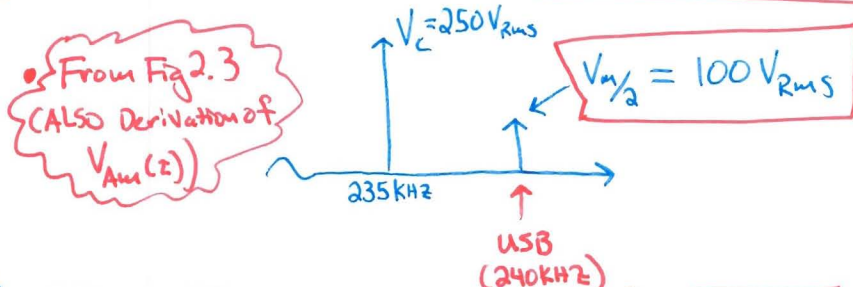
Problem 2.3

A 235 KHz carrier is amplitude modulated (DSB-LC) by a 5 KHz pure tone. The unmodulated amplitude of the output was $250V_{RMS}$ and the modulation index is 80%.

- What are the lower and upper sideband frequencies?
- What is the amplitude of the upper sideband component in the frequency spectrum?
- If this AM signal is applied to an antenna which has a radiation resistance of 80Ω , determine the total power in the two side bands together and the power in the carrier.
- How much radio frequency bandwidth does this AM signal occupy?



b) (2.7) $V_m = V_c m = (\sqrt{2} \cdot 250 V_{RMS}) \cdot 0.8 = 282.8 V_{Peak} \text{ or } 200 V_{RMS}$



c) (2.14) $P_c = \frac{(V_{RMS})^2}{R} = 781.25 W$, $P_{SB} = \frac{m^2 V_c^2}{4R} = \frac{V_m^2}{4R} = 125 W$

Note - No 1/2 as in RMS already

One Side Band

$P_{TOT} = 781.25 W + 125 W + 125 W = 1031.25 W$

* Note - Power of sidebands ~ 24% of total and only ~ 12% for 1!

d) $240 kHz - 230 kHz = 10 kHz$

RF BW occupied

Problem 2.4: An amplitude modulated waveform is given by the equation:

(2.9)
$$v_{AM}(t) = \underbrace{100}_{V_c} \cos(\underbrace{1.130 \times 10^6 t}_{\omega_c}) + \underbrace{45}_{V_m/2} \cos(\underbrace{1.0986 \times 10^6 t}_{\omega_c - \omega_m}) + \underbrace{45}_{V_m/2} \cos(\underbrace{1.16 \times 10^6 t}_{\omega_c + \omega_m})$$
 ✓

- What is the percentage of modulation?
- For an RF filter to pass the waveform, what must its minimum bandwidth be?
- Sketch the envelope of the waveform.

a) (2.7)
$$m \cdot 100\% = \frac{V_m}{V_c} \cdot 100\% = \frac{90}{100} \cdot 100\% = \boxed{90\%}$$

b) (Sect. 2.3) (2.12)
$$\underbrace{(\omega_c + \omega_m) - (\omega_c - \omega_m)}_{BW} = \boxed{61.4 \frac{\text{krad}}{s} \text{ or } 9.77 \text{ kHz}}$$

 $2\omega_m = 2(2\pi f_m)$ $2 \cdot f_m = BW$

