EE 302 PS 11 - SOLUTIONS

Chapter 5

Questions: 18, 19, 26, 28
Problems: 1, 4
Critical Thinking: None

Additional Problems: 1

Question 18

AM signals are more susceptible to noise because it is additive and directly distorts the message conveyed in the amplitude of the AM wave. FM signals, however, have much lower noise levels because although additive static noise directly affects the amplitude of the FM wave, it does not directly affect the FM wave's frequency. Thus, in FM, additive noise has no direct effect on the message.
The book's answer is that "noise is minimized by clipping off the amplitude variations so that the FM signal is a constant amplitude before demodulation."

Question 19

The primary advantage of FM over AM is a much higher noise immunity.

Question 26

The capture effect is an FM is a phenomenon that occurs when two FM signals are present at the same frequency, and the stronger "captures" the the channel, thereby eliminating the other. This is caused by the limiting and demodulation action in the receiver.

Question 28

Preemphasis is the process of amplifying higher-frequency content in a signal prior to transmission. It boosts performance because high-frequency components in signals tend to have smaller amplitudes, so they suffer lower SNRs than do lower-frequency components. Preemphasis is done in the transmitter.

Problem 1

Note: "deviation ratio" is simply the modulation index m_f when the maximum frequency deviation $f_{d,max}$ and maximum modulating frequency $f_{m,max}$ are used to compute m_f.

$$m_f = \frac{f_{d,max}}{f_{m,max}} = \frac{12 \text{ kHz}}{2 \text{ kHz}} = 6$$

Problem 4

For a modulating signal that is a single tone (a pure sinusoid), spacing between the sidebands is the frequency of the modulating signal f_m. In this case, sideband spacing is equal to $f_m = 3$ kHz.

Additional Problem 1

$$BW = 2\left(f_{d,max} + f_{m,max}\right) = 2\left(9 \text{ kHz} + 3 \text{ kHz}\right) = 24 \text{ kHz}$$

To plot the frequency domain plot of the FM wave, go through the following process:

(1) Calculate modulation index m_f. Use this value as the entering argument for the Table 5-8 on page 161 of your textbook to determine:
  (a) The number N of significant sideband pairs
  (b) Relative amplitudes of the various frequency components

(2) Plot the carrier with its relative amplitude

(3) Plot the sidebands with their relative amplitudes. Sidebands are spaced by f_m.

In accordance with the process outlined above,

$$m_f = \frac{9 \text{ kHz}}{3 \text{ kHz}} = 3$$

From Table 5-8 on page 161, for $m_f = 3.0$, there are six significant sidebands, and the relative carrier amplitude is -0.26. Relative sideband amplitudes (from lowest-order to highest-order) are 0.34, 0.49, 0.31, 0.13, 0.04, and 0.01. Since no carrier amplitude is specified, either assume a value (a nice value is $V_c = 1$ V), or do it symbolically. In this solution, I do it symbolically. Note: carrier frequency f_c is unspecified, so this further requires a solution with a symbolic answer. See Figure 1 for the sketch of the frequency spectrum.

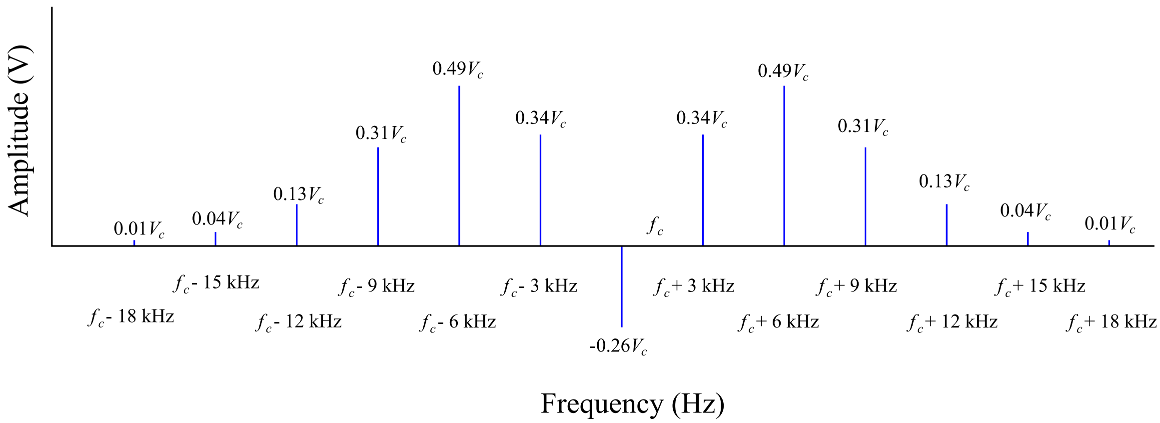

FIGURE 1. Frequency spectrum for FM signal of Additional Problem 1.