

EE 302 PS 10 - SOLUTIONS

Chapter 5

Questions: 2, 4, 14

Problems: None

Critical Thinking: None

Additional Problems: 1-3

Question 2

FM and PM have no effect on the amplitude of the carrier.

Question 4

Changing the **modulating signal's amplitude** causes a proportional change in **how far** the FM signal's instantaneous frequency deviates from the carrier frequency. Changing the **modulating signal's frequency** changes **how fast** the FM signal's instantaneous frequency deviates from the carrier frequency.

Question 14

Narrowband FM is a special case where $m_f < \pi/2$ (or $m_f < 0.25$ from the course presentation) and only one significant side band exists, resulting in a signal with the **same bandwidth** as a similar AM waveform.

Additional Problem 1

1.a. The frequency swings are centered about **72.000 MHz**. This is the carrier frequency.

1.b. The modulating frequency corresponds to the deviation rate. "2000 times per second" means that $f_m = 2$ kHz.

1.c. The signal deviates a maximum of 0.020 MHz (or 20 kHz) from the carrier.

1.d.

$$m_f = \frac{f_d}{f_m} = \frac{20 \text{ kHz}}{2 \text{ kHz}} = 10$$

1.e. For $m_f = 10$, the number of significant sidebands is $N = 14$.

1.f.

$$BW = 2f_m N = 2 \times 2 \text{ kHz} \times 14 = 56 \text{ kHz}$$

Additional Problem 2

2.a. Cutting the modulating signal's amplitude in half reduces the carrier signal's swing in frequency by one half. The signal is now contained within 71.990 MHz and 72.010 MHz.

2.b. 0.010 MHz (or 10 kHz).

2.c.

$$m_f = \frac{f_d}{f_m} = \frac{10 \text{ kHz}}{2 \text{ kHz}} = 5$$

2.d. $N = 8$.

2.e.

$$BW = 2f_m N = 2 \times 2 \text{ kHz} \times 8 = 32 \text{ kHz}$$

Additional Problem 3

3.a.

$$m_f = \frac{f_d}{f_m} = \frac{75 \text{ kHz}}{15 \text{ kHz}} = 5$$

3.b.

$$BW = 2f_m N = 2 \times 15 \text{ kHz} \times 8 = 240 \text{ kHz}$$

3.c.

$$BW = 2[f_{d,max} + f_{m,max}] = 2[75 \text{ kHz} + 15 \text{ kHz}] = 180 \text{ kHz}$$