Chapter 4: Angle Modulation

MULTIPLE CHOICE

1. The FM modulation index:
   a. increases with both deviation and modulation frequency
   b. increases with deviation and decreases with modulation frequency
   c. decreases with deviation and increases with modulation frequency
   d. is equal to twice the deviation
   ANS: B

2. One way to derive FM from PM is:
   a. integrate the modulating signal before applying to the PM oscillator
   b. integrate the signal out of the PM oscillator
   c. differentiate the modulating signal before applying to the PM oscillator
   d. differentiate the signal out of the PM oscillator
   ANS: A

3. The bandwidth of an FM signal is considered to be limited because:
   a. there can only be a finite number of sidebands
   b. it is equal to the frequency deviation
   c. it is band-limited at the receiver
   d. the power in the outer sidebands is negligible
   ANS: D

4. Mathematically, the calculation of FM bandwidth requires the use of:
   a. ordinary trigonometry and algebra
   b. Bessel functions
   c. Taylor series
   d. fractals
   ANS: B

5. FM bandwidth can be approximated by:
   a. Armstrong's Rule
   b. Bessel's Rule
   c. Carson's Rule
   d. none of the above
   ANS: C

6. NBFM stands for:
   a. National Broadcast FM
   b. Non-Broadcast FM
   c. Near Band FM
   d. Narrowband FM
   ANS: D

7. When FM reception deteriorates abruptly due to noise, it is called:
   a. the capture effect
   b. the threshold effect
   c. the noise effect
   d. the limit effect
   ANS: B
8. An FM receiver switching suddenly between two stations on nearby frequencies is called:
   a. the capture effect          c. the "two-station" effect
   b. the threshold effect        d. none of the above

   ANS: A

9. Pre-emphasis is used to:
   a. increase the signal to noise ratio for higher audio frequencies
   b. increase the signal to noise ratio for lower audio frequencies
   c. increase the signal to noise ratio for all audio frequencies
   d. allow stereo audio to be carried by FM stations

   ANS: A

10. A pre-emphasis of 75 μs refers to:
    a. the time it takes for the circuit to work
    b. the "dead time" before de-emphasis occurs
    c. the time delay between the L and R channels
    d. the time-constant of the filter circuits used

    ANS: D

11. FM stereo:
    a. uses DSBSC AM modulation       c. has a higher S/N than mono FM
    b. is implemented using an SCA signal d. is not compatible with mono FM

    ANS: A

12. An SCA signal:
    a. can use amplitude modulation c. is monaural
    b. can use FM modulation        d. all of the above

    ANS: D

13. The modulation index of an FM signal can be determined readily:
    a. using measurements at points where $J_0$ equals one
    b. using measurements at points where $J_0$ equals zero
    c. using measurements at points where the deviation equals zero
    d. only by using Bessel functions

    ANS: B

**COMPLETION**

1. FM and PM are two forms of ________________ modulation.

   ANS: angle

2. PM is extensively used in ________________ communication.

   ANS: data
3. Compared to AM, the signal-to-noise ratio of FM is usually ________________.
   ANS: better

4. Compared to AM, the bandwidth of FM is usually ________________.
   ANS: wider
greater

5. FM transmitters can use Class ________________ amplifiers since amplitude linearity is not important.
   ANS: C

6. Both the power and amplitude of an FM signal ________________ as modulation is applied.
   ANS: stay constant

7. In FM, the frequency deviation is proportional to the instantaneous ________________ of the modulating signal.
   ANS: amplitude

8. The frequency deviation of an FM signal occurs at a rate equal to the ________________ of the modulating signal.
   ANS: frequency

9. Mathematically, the number of sidebands in an FM signal is ________________.
   ANS: infinite

10. As FM sidebands get farther from the center frequency, their power ________________.
    ANS: decreases

11. Mathematically, the value of an FM modulation index can be as high as ________________.
    ANS: any number

12. In FM, as the modulating frequency decreases, the modulation index ________________.
    ANS: increases

13. In FM, as the frequency deviation decreases, the modulation index ________________.
    ANS: decreases

14. As the FM modulation index increases, the number of significant sidebands ________________.
ANS: increases

15. For certain values of $m_f$, such as 2.4, the amplitude of the carrier frequency _________________.

ANS: disappears
goes to zero

16. The bandwidth of an FM signal can be approximated using ________________ rule.

ANS: Carson's

17. FM bandwidth can be calculated precisely using ________________ functions.

ANS: Bessel

18. The ________________ effect is characteristic of FM reception in a noisy environment.

ANS: threshold

19. The ________________ effect is seen when an FM receiver is exposed to two FM signals that are close to each other in frequency.

ANS: capture

20. Rest frequency is another name for an FM ________________ frequency.

ANS: carrier

SHORT ANSWER

1. If a 2-volt instantaneous value of modulating signal amplitude causes a 10-kHz deviation in carrier frequency, what is the deviation sensitivity of the modulator?

ANS: 5 kHz / volt

2. If a 2-kHz audio tone causes a frequency deviation of 4 kHz, what is the modulation index?

ANS: 2

3. What will be the deviation caused by a 3-kHz tone if the modulation index is 3?

ANS: 9 kHz

4. If the deviation sensitivity of an FM modulator is 2 kHz /V, what will be the modulation index caused by a 1-volt, 1-kHz audio signal?
5. At a modulation index of 2, how much power is in the carrier of a 1000-watt FM transmitter?

ANS:
48.4 watts

6. At a modulation index of 2, how much power is in the first pair of sidebands of a 1000-watt FM transmitter?

ANS:
673 watts

7. At a modulation index of 2, how much power is in the fifth pair of sidebands of a 1000-watt FM transmitter?

ANS:
200 mW (0.2 watt)

8. Using Carson's rule, what is the approximate bandwidth of an FM signal with a modulation index of 2 being modulated by a 5-kHz signal?

ANS:
30 kHz

9. Using the Bessel chart of Figure 4.1, what is the bandwidth of an FM signal with a modulation index of 2 being modulated by a 5-kHz signal if we ignore sidebands containing less than 1% of the total power?

ANS:
30 kHz

10. How would you use the fact that $J_0$ is zero for certain known values of $m_f$ (2.4, 5.5, etc) to measure the frequency deviation of an FM modulator?

ANS:
Use an audio frequency generator to modulate the FM carrier. Using a spectrum analyzer, adjust the audio frequency until the carrier amplitude vanishes. Record the audio frequency. Then do the calculation: $\delta = f_m \times m_f$ where $m_f$ will have one of the known values. For example, if $f_m$ is measured to be 2 kHz when $m_f$ is 5.5, then $\delta$ is 11 kHz.