Summary

In Chapter 6 we discussed the basis of an FM receiver and showed the similarities and differences compared to an AM receiver. The major topics you should now understand include the following:

- the operation of an FM receiver using a block diagram as a guide, including complete descriptions of the discriminator, the deemphasis network, and the limiter functioning as AGC
- the benefits of RF amplifiers, including image frequency attenuation and local oscillator reradiation effects
- the detailed functioning of a transistor limiter circuit
- the description and comparison of slope detector, Foster–Seely discriminator, ratio detector, and quadrature detector circuits
- the description and operation of a phase-locked-loop (PLL) FM demodulator, including its three possible states
- the analysis of a stereo FM demodulation process using a block diagram
- the operation of the subsidiary communication authorization (SCA) decoder operation
- the operation of a complete 88–108-MHz stereo FM receiver by analysis of the schematic

Questions and Problems

Section 6-1

*1. What is the purpose of a discriminator in an FM broadcast receiver?
2. Explain why the automatic frequency control (AFC) function is usually not necessary in today's FM receivers.
*3. Draw a block diagram of a superheterodyne receiver designed for reception of FM signals.
4. The local FM stereo rock station is at 96.5 MHz. Calculate the local oscillator frequency and the image frequency for a 10.7-MHz IF receiver. (107.2 MHz, 117.9 MHz)

Section 6-2

5. Explain the desirability of an RF amplifier stage in FM receivers as compared to AM receivers. Why is this not generally true at frequencies over 1 GHz?
6. Describe the meaning of *local oscillator reradiation,* and explain how an RF stage helps to prevent it.
7. Why is a square-law device preferred over other devices as elements in an RF amplifier?
8. Why are FETs preferred over other devices as the active elements for RF amplifiers?
9. List two advantages of using a dual-gate MOSFET over a JFET in RF amplifiers.
10. Explain the need for the radio-frequency choke (RFC) in the RF amplifier shown in Figure 6-2.

Section 6-3

*11. What is the purpose of a limiter stage in an FM broadcast receiver?
*12. Draw a diagram of a limiter stage in an FM broadcast receiver.
13. Explain fully the circuit operation of the limiter shown in Figure 6-3.
14. What is the relationship among limiting, sensitivity, and quieting for an FM receiver?
15. An FM receiver provides 100 dB of voltage gain prior to the limiter. Calculate the receiver's sensitivity if the limiter's quieting voltage is 300 mV. (3 μV)

Section 6-4

16. Draw a schematic of an FM slope detector and explain its operation. Why is this method not often used in practice?
17. Draw a schematic of a Foster–Seely discriminator, and provide a step-by-step explanation of what happens when the input frequency is below the carrier frequency. Include a phase diagram in your explanation.
*18. Draw a diagram of an FM broadcast receiver detector circuit.
*19. Draw a diagram of a ratio detector and explain its operation.
20. Explain the relative merits of the Foster–Seely and ratio detector circuits.
*21. Draw a schematic diagram of each of the following stages of a superheterodyne FM receiver:
    (a) Mixer with injected oscillator frequency.
    (b) IF amplifier.
    (c) Limiter.
    (d) Discriminator.
    Explain the principles of operation. Label adjacent stages.
22. Describe the process of quadrature detection.

Section 6-5

23. Draw a block diagram of a phase-locked loop (PLL) and briefly explain its operation.
24. Explain in detail how a PLL is used as an FM demodulator.
25. List the three possible states of operation for a PLL and explain each one.
26. A PLL's VCO free-runs at 7 MHz. The VCO does not change frequency until the input is within 20 kHz of 7 MHz. After that condition, the VCO follows the input to ±150 kHz of 7 MHz before the VCO starts to free-run again. Determine the PLL's lock and capture ranges. (300 kHz, 40 kHz)

Section 6-6

27. Explain how separate left and right channels are obtained from the (L + R) and (L − R) signals.
*28. What is SCA? What are some possible uses of SCA?
29. Determine the maximum reproduced audio signal frequency in an SCA system. Why does SCA cause less FM carrier deviation, and why is it thus less noise resistant than standard FM? (*Hint:* Refer to Figure 6-17.) (7.5 kHz)
30. Explain the principle of operation for the CA3090 stereo decoder.

* An asterisk preceding a number indicates a question that has been provided by the FCC as a study aid for licensing examinations.

Section 6-7

31. The receiver front end in Figure 6-21 is rated to have noise below the signal by 30 dB in the output with a 1.75-μV input. Calculate its output *S/N* ratio with a 1.75-μV input signal. (31.6 to 1)
32. The LIC dual audio amplifiers in Figure 6-21 are rated to provide 70 dB of channel separation. If the left channel has 1 W of output power, calculate the wattage of the right channel that is included. (0.1 μW)

Section 6-8

33. Explain why you would wobble the IF signal fed into point A of Figure 6-22.
34. The quadrature detector troubleshooting circuit shown in Figure 6-24 includes a device labeled X_1. Explain the various options for circuitry at that point.
35. Describe the method for checking a diode with a DMM. Extend that description into a technique for testing a transistor.
36. Describe the operation of the quadrature detector in Figure 6-24 if C_1 is shorted.
37. Describe possible causes if the Foster–Seely discriminator of Figure 6-7 has a peak output voltage much less than calculated.
38. If L_2 is shorted in Figure 6-7, explain what happens to the output voltage.
39. Describe the demodulated signal of Figure 6-11 if C_3 is shorted.
40. Explain how a low beta (<40) on Q_4 in Figure 6-11 would affect the circuit's performance.

Questions for Critical Thinking

41. If you were concerned with the sensitivity rating of a communications system, would noise reduction capability be a major factor in your decision-making? Why or why not?
42. Explain why a limiter minimizes or eliminates the need for the AGC function.
43. Draw a schematic of the LM 565 PLL in Figure 6-14 if it is used as an FM demodulator. Pick C_o and R_o so that the free-running frequency is 455 kHz.
44. Draw a block diagram of an FM stereo demodulator. Explain the function of the AM demodulator and the matrix network so nontechnical users can understand. Add a circuit that energizes a light to indicate reception of a stereo station.