Electronics Workbench™ Exercises

1. Open the file **FigE7-1** in your EWB CD. You have discovered that this squelch circuit is not working. Troubleshoot the squelch circuit to determine the cause of the failure. Correct the fault and rerun the simulation. Report on your findings.
2. Open the file **FigE7-2** in your EWB CD. You have been told that this squelch circuit is working but does not have the range of control that it previously had. Troubleshoot the squelch circuit to determine the cause of the failure. Correct the fault and rerun the simulation. Report on your findings.
3. Open the file **FigE7-3** in your EWB CD. You discovered that the squelch circuit is not working. You suspect that an employee at the facility dropped a screwdriver into the receiver cabinet while power was on. Troubleshoot the squelch circuit to determine the cause of the failure. Correct the fault(s) and rerun the simulation. Report on your findings.

Summary

In Chapter 7 we described various improvements to receiver design and discussed some of the more complicated specifications used in high-quality receivers. The concept of spread-spectrum communications was also introduced. The major topics you should now understand include the following:

- the analysis of advanced techniques for image frequency reduction, including double conversion and up-conversion
- the description and explanation of special techniques for improving receiver operation, including delayed AGC, auxiliary AGC, manual sensitivity control, variable notch filters, ANL circuits, and squelch control
- the analysis of the relationship among noise, sensitivity, and dynamic range in a high-quality receiver
- the analysis of intermodulation distortion (IMD) testing
- the description and analysis of various frequency synthesizers
- the method used to obtain direct digital synthesis (DDS) systems
- the analysis of spread-spectrum techniques, including description of CDMA, frequency hopping, time hopping, and direct sequence

Questions and Problems

Section 7-2

1. Explain the difference between an FM stereo receiver and a communications transceiver.
2. Draw a block diagram for a double-conversion receiver when tuned to a 27-MHz broadcast using a 10.7-MHz first IF and 1-MHz second IF. List all pertinent frequencies for each block. Explain the superior image frequency characteristics as compared to a single-conversion receiver with a 1-MHz IF, and provide the image frequency in both cases.
3. Draw block diagrams and label pertinent frequencies for a double-conversion *and* up-conversion system for receiving a 40-MHz signal. Discuss the economic merits of each system and the effectiveness of image frequency rejection.
4. A receiver tunes the HF band (3 to 30 MHz), utilizes up-conversion with an intermediate frequency of 40.525 MHz, and uses high-side injection. Calculate the required range of local oscillator frequencies. (43.5 to 70.5 MHz)
5. An AM broadcast receiver's preselector has a total effective Q of 90 to a received signal at 1180 kHz and uses an IF of 455 kHz. Calculate the image frequency and its dB of suppression. (2090 kHz, 40.7 dB)

Section 7-3

6. Discuss the advantages of delayed AGC over normal AGC and explain how it may be attained.
7. Explain the function of auxiliary AGC and give a means of providing it.
8. Explain the need for variable sensitivity and show with a schematic how it could be provided.
9. Explain the need for variable selectivity. Describe how VBT is accomplished if the oscillator in Figure 7-8 is changed to 2650 Hz.
10. What is the need for a noise limiter circuit? Explain the circuit operation of the noise limiter shown in Figure 7-9.
11. List some possible applications for *metering* on a communications transceiver.

*12. What is the purpose of a squelch circuit in a radio communications receiver?

13. List two other names for a squelch circuit. Provide a schematic of a squelch circuit and explain its operation. List five different squelch methods.
14. Describe the effects of EMI on a receiver.
15. Describe the operation of an automatic noise limiter (ANL).

Section 7-4

16. We want to operate a receiver with NF = 8 dB at S/N = 15 dB over a 200-kHz bandwidth at ambient temperature. Calculate the receiver's sensitivity. (−98 dBm)
17. Explain the significance of a receiver's 1-dB compression point. For the receiver represented in Figure 7-11, determine the 1-dB compression point. (≅10 dBm)
18. Determine the third-order intercept for the receiver illustrated in Figure 7-11. (≅ +20 dBm)
19. The receiver described in Problem 16 has the input/output relationship shown in Figure 7-11. Calculate its dynamic range. (78.7 dB)
20. A receiver with a 10-MHz bandwidth has an S/N of 5 dB and a sensitivity of −96 dBm. Find the required NF. (3 dB)

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

Section 7-5

21. Explain the operation of a basic frequency synthesizer as illustrated in Figure 7-14. Calculate f_0 if $f_R = 1$ MHz and $N = 61$. (61 MHz)
22. Discuss the relative merits of the synthesizers shown in Figures 7-16(a), (b), and (c) as compared to the one in Figure 7-14.
23. Describe the operation of the synthesizer divider in Figure 7-17. What basic problem does it overcome with respect to the varieties shown in Figures 7-14 and 7-16?
24. Calculate the output frequency of a synthesizer using the divider technique shown in Figure 7-17 when the reference frequency is 1 MHz, $A = 26$, $M = 28$, and $N = 4$. (138 MHz)
25. Determine the output frequency for the synthesizer of Figure 7-19 when the input code is 100011. (27.245 MHz)
26. Explain the operation of the UHF multifrequency receiver of Figure 7-22.

Section 7-6

27. Briefly explain DDS operation based on the block diagram shown in Figure 7-23.
28. A DDS system has $f_{\text{CLK MAX}} = 60$ MHz and a 28-bit phase accumulator. Calculate its approximate maximum output frequency and frequency resolution when operated at $f_{\text{CLK MAX}}$. (24 MHz, 0.223 Hz)

Section 7-7

29. Define parasitics.
30. What are the five basic issues to consider when assembling a printed circuit board for use at high frequency?
31. Why are sharp turns an issue when laying out printed circuit board traces?
32. What should be the spacing for parallel lines on the printed circuit board if the printed circuit board is 0.08″ thick?
33. What is the purpose of an RF choke?

Section 7-8

34. Explain how the technician would know that the AF amplifier in Figure 7-32 lost its gain.
35. Describe a possible output that leads the technician to suspect that the problem is in the frequency multipliers of Figure 7-32.
36. What are some of the problems that can occur in the FM transceiver of Figure 7-32 from a bad oscillator?
37. Describe the output if the harmonic filter in Figure 7-32 was leaky.

Questions for Critical Thinking

38. Describe the process of up-conversion. Explain its advantages and disadvantages compared to double conversion.

39. You have been asked to extend the dynamic range of a receiver. Can this be done? What factors determine the limits of dynamic range? Can they be changed? Explain.
40. In evaluating a receiver, how important is its ability to handle intermodulation distortion? Explain the process you would use to analyze a receiver's ability to handle this distortion. Include the concept of third-order intercept point in your explanation.
41. The receiver in Problem 19 has a 6-dB NF preamp (gain = 20 dB) added to its input. Calculate the system's sensitivity and dynamic range. (−99.94 dBm, 66.96 dB)