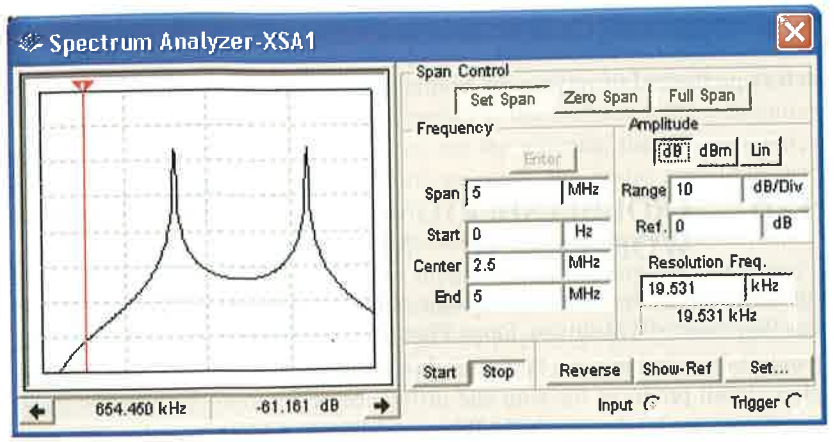

FIGURE 4-28 The double-sideband output spectrum for the multiplier circuit.

frequency of about 2.6 MHz. Therefore, frequencies below 2.6 MHz should be significantly attenuated. Connect the spectrum analyzer to the output of the filter and restart the simulation. Verify that the output contains only the upper-sideband component. The sideband at 2 MHz has been significantly reduced, but the upper sideband is still present. The result is shown in Figure 4-29.

The next part of this exercise provides you with the opportunity to troubleshoot a filter circuit. Open **FigE4-1** on your EWB CD. Start the simulation and use the spectrum analyzer to observe the output spectrum. Note that the spectrum analyzer is connected to the output of the filter. Is the circuit working as expected? If not, use the spectrum analyzer and the oscilloscope to check the waveform. Don't forget to perform a visual check of the circuit for potential problems. You will discover that both the upper and lower sidebands are present on the output. What circuit removes the lower sideband? Shouldn't the filter remove the lower sideband? Careful inspection of the filter shows that the ground is missing. Replace the ground and rerun the simulation. The circuit should be functioning properly.

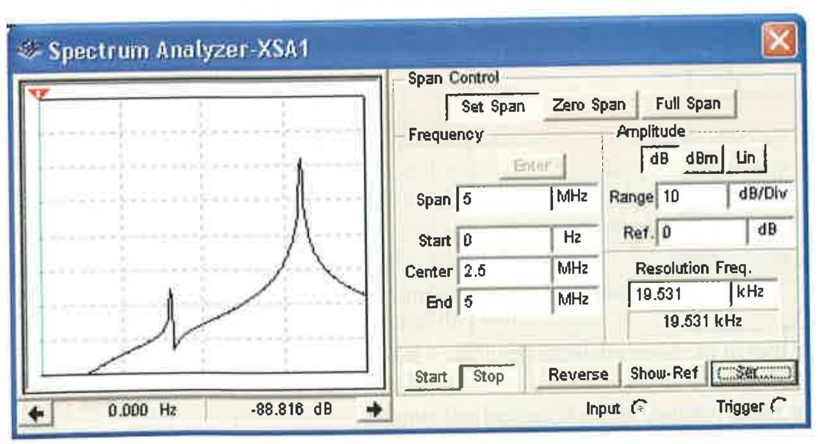

FIGURE 4-29 The multiplier circuit with the lower sideband removed.

Electronics Workbench™ Exercises

1. Open **FigE4-2** in your EWB CD. This circuit contains a tunable high-pass filter. Use the **(a/A)** and **(b/B) keys** to adjust the inductance values to optimize the performance of the filter. Record your settings and comment on the effect that changing the inductance values has on the output. (L_1 = 35%, L_2 = 55%)
2. Open **FigE4-3** in your EWB CD. This circuit contains a fault. In this exercise, assume that you have been told that the circuit does not appear to be working properly. You may need to refer back to the waveforms in **Fig4-27** for a properly functioning circuit to help guide you with your troubleshooting. Confirm that the circuit is not working properly and find the cause of the problem. Once you find the problem, record the fault and the circuit behavior generated by the fault. Correct the fault and rerun the simulation to verify that the problem has been corrected.
3. Open **FigE4-4** in your EWB CD. This circuit contains a fault. Use your troubleshooting techniques to find the problem. Once you find the problem, record the fault and the circuit behavior observed. Correct the fault and rerun the simulation to verify that the problem has been corrected.

Summary

In Chapter 4 we introduced single-sideband (SSB) systems and explained their various advantages over standard AM systems. The major topics you should now understand include the following:

- the advantages of SSB systems, including the utilization of available frequency bandwidth, noise reduction, power requirements, and selective fading effects
- the various SSB systems and their general characteristics
- an analysis of the function of a balanced modulator
- the operation of a balanced ring modulator
- the application of linear integrated circuit balanced modulators
- the need for high-Q bandpass filters and the description of mechanical, ceramic, and crystal varieties
- the analysis of SSB transmission systems, including the filter and phase methods
- an understanding of the need for amplitude compandoring and a method of implementation
- the description and operation of a class AB push-pull linear power amplifier
- the analysis of SSB demodulation techniques
- the analysis of a complete SSB receiver

Questions and Problems

Section 4-1

1. An AM transmission of 1000 W is fully modulated. Calculate the power transmitted if it is transmitted as an SSB signal. (167 W)
2. An SSB transmission drives 121 V peak into a 50-Ω antenna. Calculate the PEP. (146 W)

3. Explain the difference between rms and PEP designations.
4. Provide detail on the differences between ACSSB, SSB, SSBSC, and ISB transmissions.
5. List and explain the advantages of SSB over conventional AM transmissions. Are there any disadvantages?
6. A sideband technique called doubled sideband/suppressed carrier (DSBSC) is similar to a regular AM transmission, double sideband full carrier (DSBFC). Using your knowledge of SSBSC, explain the advantage DSBSC has over regular AM.

Section 4-2

7. What are the typical inputs and outputs for a balanced modulator?
8. Briefly describe the operation of a balanced ring modulator.
9. Explain the advantages of using an IC for the four diodes in a balanced ring modulator as compared with four discrete diodes.
10. Referring to the specifications for the AD630 LIC balanced modulator in Figure 4-2, determine the channel separation at 10 kHz, explain how a gain of +1 and +2 are provided.
11. Explain how to generate an SSBSC signal from the balanced modulator.

Section 4-3

12. Calculate a filter's required Q to convert DSB to SSB, given that the two sidebands are separated by 200 Hz. The suppressed carrier (40 dB) is 2.9 MHz. Explain how this required Q could be greatly reduced. (36,250)

*13. Draw the approximate equivalent circuit of a quartz crystal.

14. What are the undesired effects of the crystal holder capacitance in a crystal filter, and how are they overcome?

*15. What crystalline substance is widely used in crystal oscillators (and filters)?

16. Using your library or some other source, provide a schematic for a four-element crystal lattice filter and explain its operation.

*17. What are the principal advantages of crystal control over tuned circuit oscillators (or filters)?

18. Explain the operation of a ceramic filter. What is the significance of a filter's shape factor?
19. Define *shape factor*. Explain its use.
20. A bandpass filter has a 3-dB ripple amplitude. Explain this specification.
21. Explain the operation and use of mechanical filters.
22. Why are SAW filters not often used in SSB equipment?
23. An SSB signal is generated around a 200-kHz carrier. Before filtering, the upper and lower sidebands are separated by 200 Hz. Calculate the filter Q required to obtain 40-dB suppression. (2500)

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

Section 4-4

24. Determine the carrier frequency for the transmitter shown in Figure 4-8. (It is *not* 3 MHz).
25. Draw a detailed block diagram of the SSB generator shown in Figure 4-9. Label frequencies involved at each stage if the intelligence is a 2-kHz tone and the usb is utilized.
26. The sideband filter (FL_1) in Figure 4-9 has a 5-dB *insertion loss* (i.e., a 5-dB signal loss from input to output). Calculate the filter's output voltage assuming equal impedances at its input and output. (0.45 V p-p)
27. Calculate the total impedance in the collector of Q_3 in Figure 4-9. (54.3 Ω)
28. List the advantages of the phase versus filter method of SSB generation. Why isn't the phase method more popular than the filter method?
29. Explain the operation of the phase-shift SSB generator illustrated in Figure 4-10. Why is the carrier phase shift of 90° not a problem, whereas that for the audio signal is?
30. Explain the operation and need for the control circuitry (K_1, Q_1, Q_2) in the linear power amplifier shown in Figure 4-13.
31. The PEP transmitted by an ACSSB system is 140 W. It uses an NE571N compandor LIC. Calculate the power transmitted under the no-modulation condition. The audio signal ranges from −28 dBm to +34 dBm before compression. Determine the compressor's output range. (14 W, −14 dBm to +17 dBm)
32. Explain how an ACSSB system can provide improved noise performance compared to a regular SSB system.

Section 4-5

33. List the components of an AM signal at 1 MHz when modulated by a 1-kHz sine wave. What is the component(s) if it is converted to a usb transmission? If the carrier is redundant, why must it be "reinserted" at the receiver?
34. Explain why the BFO in an SSB demodulator has such stringent accuracy requirements.
35. Suppose the modulated signal of an SSBSC transmitter is 5 kHz and the carrier is 400 kHz. At what frequency must the BFO be set?
36. What is a product detector? Explain the need for a low-pass filter at the output of a balanced modulator used as a product detector.
37. Calculate the frequency of a product detector that is fed an SSB signal modulated by 400 Hz and 2 kHz sine waves. The BFO is 1 MHz.

Section 4-6

38. Draw a block diagram for the receiver shown schematically in Figure 4-18. Suggest a change to the schematic that you feel would improve its performance and explain why.

Section 4-7

39. Describe the output of the modulator in Figure 4-1 if the L_1 winding was open circuited.
40. When troubleshooting the balanced modulator in Figure 4-19, provide a detailed procedure to check diode matching by using an ohmmeter. Describe the problem caused with this circuit if the diodes are not matched.

41. Explain the concept of carrier leakthrough and its causes, and provide two methods of testing for it.
42. The two-tone test is used to check amplifier linearity. Explain why a single-tone test will not be as effective as a two-tone test.
43. Explain the effect of injecting a modulated IF signal at point D in Figure 4-26.
44. Suppose it was determined that there was an output from test point B in Figure 4-26 and no output from test point A. Explain the possible causes of no output.
45. Describe how signal tracing and signal injection can be used to troubleshoot the SSB receiver in Figure 4-26.
46. With reference to Table 4-1, explain why doing test 5 before tests 1 through 4 invalidates the analysis.

Questions for Critical Thinking

47. If a carrier and one sideband were eliminated from an AM signal, would the transmission still be usable? Why or why not?
48. Explain the principles involved in a single-sideband, suppressed-carrier (SSBSC) emission. How does its bandwidth of emission and required power compare with that of full carrier and sidebands?
49. You have been asked to provide SSB using a DSB signal, cos $\omega_i t$, cos $\omega_c t$. Can this be done? Provide mathematical proof of your judgment.
50. If, in an emergency, you had to use an AM receiver to receive an SSB broadcast, what modifications to the receiver would you need to make?