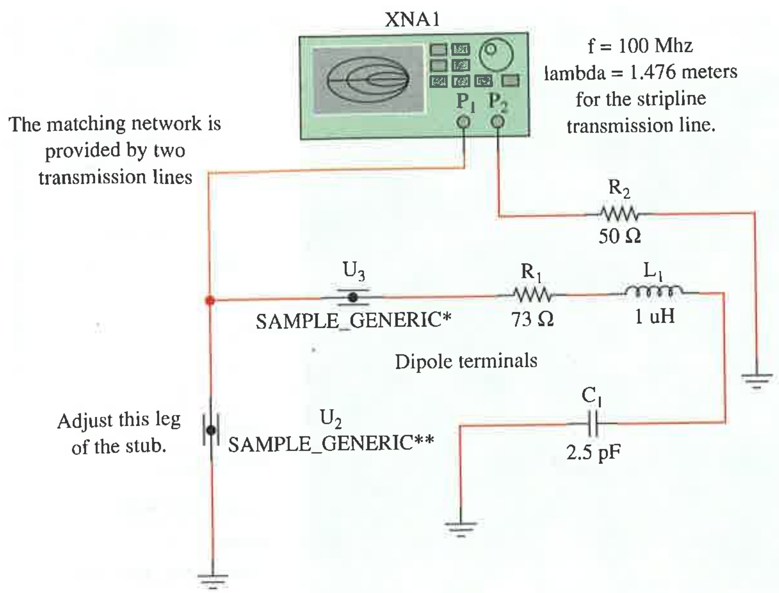
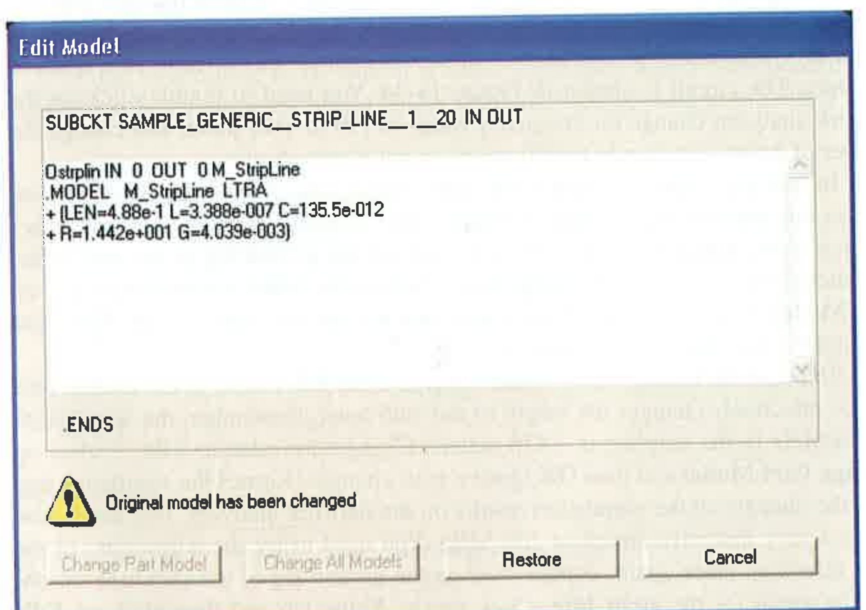


FIGURE 14-34 The model of a single stub tuner using the Multisim stripline transmission-line elements.

results show that we are getting closer to matching the antenna to a 50-Ω load. The tuning requires that this adjustment process be repeated several times until a satisfactory result is obtained. A LEN setting of $4.0e^{-1}$ for the ground leg provides a good match for the antenna. The exercises provide additional opportunities for you to experiment with dipole antennas.



Electronics Workbench™ Exercises

1. Design a half-wave 92-MHz dipole antenna. Use the file **Fig14-32.ms7 (.msm)** as a sample. This file is for a 100-MHz half-wave dipole. Modify the values for L1 and C1 so that the resonant frequency is 92 MHz. (L1 = 1.198 μH, C1 = 2.5 pF)
2. Design a half-wave 450-MHz dipole antenna. Use the file **Fig14-32.ms7 (.msm)** as a sample. This file is for a 100-MHz half-wave dipole. You must modify the values for L1 and C1 in this file so that the resonant frequency is 450 MHz. (L1 = 50 nH, C1 = 2.5 pF)
3. Open the Multisim simulation of a single stub tuner found in the **FigE14-1.ms7 (.msm)** file found in your EWB CD. Use the technique presented in the text to provide a match for this 100-MHz dipole antenna.

Summary

In Chapter 14 we examined antenna operation and many of the possible configurations. Be sure to keep in mind that antenna properties apply identically when both transmitting and receiving—the principle of reciprocity. The major topics you should now understand include:

- the analysis of the half-wave dipole antenna, including its impedance, radiation field, radiation pattern, and gain
- the definition of radiation resistance and related calculations
- the description of antenna feed lines, including resonant and nonresonant
- the operation of impedance matching devices, including the delta match and quarter-wave matching transformer
- the analysis of monopole antennas, including ground effects, counterpoise effects, radiation pattern, and loading effects
- the effects of parasitic elements, including discussion of the Yagi–Uda antenna, driven collinear array, broadside array, and vertical array
- the description and operation of various special-purpose antennas, including the log-periodic, loop, ferrite loop, folding dipole, and slot antennas

Questions and Problems

Section 14-1

*1. How should a transmitting antenna be designed if a vertically polarized wave is to be radiated, and how should the receiving antenna be designed for best performance in receiving the ground wave from this transmitting antenna?

*2. If a field intensity of 25 mV/m develops 2.7 V in a certain antenna, what is its effective height? (108 m)

*3. If the power of a 500-kHz transmitter is increased from 150 W to 300 W, what would be the percentage change in field intensity at a given distance from the transmitter? What would be the decibel change in field intensity? (141%, 3 dB)

*4. If a 500-kHz transmitter of constant power produces a field strength of 100 μV/m at a distance of 100 mi from the transmitter, what would be the theoretical field strength at a distance of 200 mi from the transmitter? (50 μV/m)

*5. If the antenna current at a 500-kHz transmitter is reduced 50 percent, what would be the percentage change in the field intensity at the receiving point? (50%)

*6. Define *field intensity*. Explain how it is measured.

*7. Define *polarization* as it refers to broadcast antennas.

8. Explain how antenna reciprocity occurs.

Section 14-2

9. Explain the development of a half-wave dipole antenna from a quarter-wavelength, open-circuited transmission line.

*10. Draw a diagram showing how current varies along a half-wavelength dipole antenna.

*11. Explain the voltage and current relationships in a one-wavelength antenna, one half-wavelength (dipole) antenna, and one quarter-wavelength *grounded* antenna.

*12. What effect does the magnitude of the voltage and current at a point on a half-wave antenna in *free space* (a dipole) have on the impedance at that point?

*13. Can either of the two fields that emanate from an antenna produce an EMF in a receiving antenna? If so, how?

14. Draw the three-dimensional radiation pattern for the half-wave dipole antenna, and explain how it is developed.

15. Define antenna *beamwidth*.

*16. What is the effective radiated power of a television broadcast station if the output of the transmitter is 1000 W, antenna transmission line loss is 50 W, and the antenna power gain is 3? (2850 W)

17. A $\lambda/2$ dipole is driven with a 5-W signal at 225 MHz. A receiving dipole 100 km away is aligned so that its gain is cut in half. Calculate the received power and voltage into a 73-Ω receiver. (7.57 pW, 23.5 μV)

18. An antenna with a gain of 4.7 dBi is being compared with one having a gain of 2.6 dBd. Which has the greater gain?

19. Explain why a monopole antenna is used below 2 MHz.

20. Explain what is meant by half-wave dipole. Calculate the length of a 100-MHz $\frac{2}{3}\lambda$ antenna.

21. Determine the distance from a $\lambda/2$ dipole to the boundary of the far-field region if the $\lambda/2$ dipole is being used in the transmission of a 90.7-MHz FM broadcast band signal. (R = 1.653 m)

22. Determine the distance from a parabolic reflector of diameter D = 10 m to the boundary of the far-field region. The antenna is being used to transmit a 4.1-GHz signal. (R = 2733.3 m)

23. Define *near* and *far fields*.

Section 14-3

24. Define *radiation resistance* and explain its significance.

*25. The ammeter connected at the base of a vertical antenna has a certain reading. If this reading is increased 2.77 times, what is the increase in output power? (7.67)

27. Explain what happens to an antenna's radiation resistance as its length is continuously increased.

28. Explain the effect that ground has on an antenna.

29. Calculate the efficiency of an antenna that has a radiation resistance of 73 Ω and an effective dissipation resistance of 5 Ω. What factors could enter into the dissipation resistance? (93.6%)

*30. Explain the following terms with respect to antennas (transmission or reception):
(a) Physical length.
(b) Electrical length.
(c) Polarization.
(d) Diversity reception.
(e) Corona discharge.

31. What is the relationship between the electrical and physical length of a half-wave dipole antenna?

*32. What factors determine the resonant frequency of any particular antenna?

*33. If a vertical antenna is 405 ft high and is operated at 1250 kHz, what is its physical height expressed in wavelengths? (0.54λ)

*34. What must be the height of a vertical radiator one half-wavelength high if the operating frequency is 1100 kHz? (136 m)

Section 14-4

35. What is an antenna feed line? Explain the use of resonant antenna feed lines, including advantages and disadvantages.

36. What is a nonresonant antenna feed line? Explain its advantages and disadvantages.

37. Explain the operation of a delta match. Under what conditions is it a convenient matching system?

*38. Draw a simple schematic diagram of a push-pull, neutralized radio-frequency amplifier stage, coupled to a vertical antenna system.

*39. Show by a diagram how a two-wire radio-frequency transmission line may be connected to feed a half-wave dipole antenna.

*40. Calculate the characteristic impedance of a quarter-wavelength section used to connect a 300-Ω antenna to a 75-Ω line. (150 Ω)

41. Explain how delta matching is accomplished.

Section 14-5

*42. Which type of antenna has a minimum of directional characteristics in the horizontal plane?

*43. If the resistance and the current at the base of a monopole antenna are known, what formula can be used to determine the power in the antenna?

*44. What is the difference between a half-wave dipole and a monopole antenna?

*45. Draw a sketch and discuss the horizontal and vertical radiation patterns of a quarter-wave monopole antenna. Would this also apply to a similar type of receiving antenna?

46. What is an image antenna? Explain its relationship to the monopole antenna.

*47. What would constitute the ground plane if a quarter-wave grounded (whip)

*48. What is the importance of the ground radials associated with standard broadcast antennas? What is likely to be the result of a large number of such radials becoming broken or seriously corroded?

*49. What is the effect on the resonant frequency of connecting an inductor in series with an antenna?

*50. What is the effect on the resonant frequency of adding a capacitor in series with an antenna?

*51. If you desire to operate on a frequency lower than the resonant frequency of an available monopole antenna, how may this be accomplished?

*52. What is the effect on the resonant frequency if the physical length of a $\lambda/2$ dipole antenna is reduced?

*53. Why do some standard broadcast stations use top-loaded antennas?

*54. Explain why a *loading coil* is sometimes associated with an antenna. Under this condition, would absence of the coil mean a capacitive antenna impedance?

Section 14-6

55. Explain how the directional capabilities of the elementary antenna array shown in Figure 14-16 are developed.

56. Define the following terms:
    (a) Driven elements.
    (b) Parasitic elements.
    (c) Reflector.
    (d) Director.

57. Calculate the ERP from a Yagi–Uda antenna (illustrated in Figure 14-17) driven with 500 W. (2500 W)

58. Calculate the *F/B* ratio for an antenna with
    (a) Forward gain of 7 dB and reverse gain of −3 dB.
    (b) Forward gain of 18 dB and reverse gain of 5 dB.

59. Sketch a Yagi–Uda configuration.

60. Describe the physical configuration of a collinear array. What is the effect of adding more elements to this antenna?

61. Describe the physical configuration of a broadside array. Explain the major advantage they have compared to collinear arrays.

*62. What is the direction of maximum radiation from two vertical antennas spaced $\lambda/2$ and having equal currents in phase?

*63. How does a directional antenna array at an AM broadcast station reduce radiation in some directions and increase it in other directions?

*64. What factors can cause the directional pattern of an AM station to change?

65. Define *phased array*.

66. Explain how a parasitic array can be developed.

Section 14-7

67. Describe the major characteristics of a log-periodic antenna. What explains its widespread use? Explain the significance of its shortest and longest elements.

*68. Describe the directional characteristics of the following types of antennas:
    (d) Horizontal loop antenna.
    (e) Monopole antenna.

*69. What is the directional reception pattern of a loop antenna?

70. What is a ferrite loop antenna? Explain its application and advantages.

71. What is the radiation resistance of a standard folded dipole? What are its advantages over a standard dipole? Why is it usually used as the driven element for Yagi–Uda antennas instead of the half-wave dipole antenna?

72. Describe the operation of a slot antenna and its application with aircraft in a driven array format.

73. An antenna has a maximum forward gain of 14 dB at its 108-MHz center frequency. Its reverse gain is −8 dB. Its beamwidth is 36° and the bandwidth extends from 55 to 185 MHz. Calculate:
    (a) Gain at 18° from maximum forward gain. (11 dB)
    (b) Bandwidth. (130 MHz)
    (c) *F/B* ratio. (22 dB)
    (d) Maximum gain at 185 MHz. (11 dB)

74. Explain the difference between antenna beamwidth and bandwidth.

Section 14-8

75. Explain VSWR and tell why it is important in troubleshooting antenna problems.

76. Explain how to proceed in troubleshooting the antenna to determine causes of transmission problems.

77. Describe how to use a grid-dip meter, and give examples of where it is most commonly used.

78. What is an SWR meter and how is it used in troubleshooting?

79. Explain what happens when the VSWR is too high.

80. What is an anechoic chamber? Explain what factors to consider with respect to its size requirements.

Questions for Critical Thinking

*81. A ship radio-telephone transmitter operates on 2738 kHz. At a distant point from the transmitter, the 2738-kHz signal has a measured field of 147 mV/m. The second harmonic field at the same point is measured as 405 μV/m. How much has the harmonic emission been attenuated below the 2738-kHz fundamental? (51.2 dB)

*82. You are asked to calculate effective radiated power. What data do you need to collect and how do you perform the calculation?

83. Design a log-periodic antenna to cover the complete VHF TV band. (See Chapter 7 for the frequencies involved.) Use a design factor (τ) of 0.7, and provide a scaled sketch of the antenna with all dimensions indicated.

84. A loop antenna used for DF purposes detects a null from a signal with the loop rotated 35° CCW from a line of latitude. When the antenna is moved 3 mi west along the same line of latitude, it detects a null from the same signal source when rotated 45° CW from the line of latitude. You have been asked to identify the exact location of the signal source with respect to the two points when readings were taken. Provide this information. (You may use a