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Modern Electronic Communication

(Ninth Edition)

现代电子通信

（第九版）

〔美〕Jeffrey S. Beasley
Gary M. Miller 著

（英文影印版）

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内 容 简 介

本书内容包括：幅度调制、单边带通信、频率调制、通信技术、编码技术、有线及无线数字通信、网络通信、波的传播、天线、波导与雷达、微波与激光、电视及光纤等，同时涉及通信领域很多新技术，如蓝牙、Wi-Max、DTV、DSP、HD-Radio 等。

本书可作为电子信息工程、通信工程专业本科生的双语教材或参考书，也可作为相关领域工程技术人员的参考书。

Original edition, entitled ***Modern Electronic Communication***, 9th Edition, 978-0-13-225113-6 by Jeffrey S. Beasley, published by Pearson Education, Inc, publishing as Pearson,Copyright © 2008 by Pearson Education.Inc.

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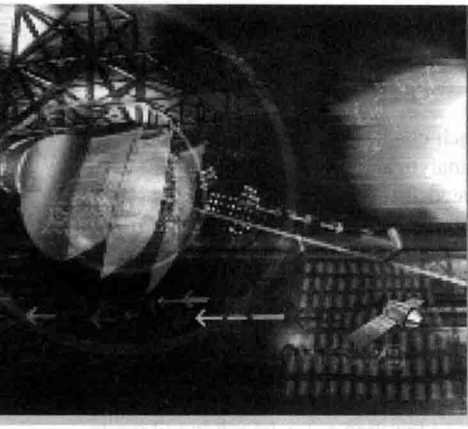
Dedicated to my family,
Kim, Damon, and Dana
Jeffrey S. Beasley

Dedicated to the youth of the world,
Especially my favorites,
Evan, Maia, Willo, Kevin, Richard, and Luca
Gary M. Miller



PREFACE

We are excited about the many improvements to this edition of *Modern Electronic Communication,* and we trust you will share in our enthusiasm as those improvements are briefly described. The 9th edition maintains the tradition of the 8th edition, including up-to-date coverage of the latest in electronic communication, readable text, and many features that will aid student comprehension.

This edition has greatly expanded the discussion on digital communications, focusing on the many changes and improvements in mobile communications, SS7 signaling, Bluetooth, Wi-Max, and DTV (digital television). Each chapter in the textbook includes Electronics Workbench™ Multisim simulations of the key components of the concepts presented. The 9th edition also includes new sections on wireless security, DSP (digital signal processing), radio frequency identification (RFID), and high-definition (HD) radio; an expanded discussion on satellite communications and parabolic reflectors; and an updated look at fiber optic communication.

We are also pleased to have incorporated a new section on high-frequency communication modules in the textbook. This section features the Mini-Circuits® modules with examples of the use of modular electronic systems to implement electronic communication circuitry. This section complements the updates made to the accompanying lab manual, with practical experiments that use the Mini-Circuits® modules.

We are also pleased to provide online "Operational Diagrams of Radio Transmitters and Receivers" prepared by Professors Lance Breger and Ken Markowitz, New York City College of Technology. This brochure provides an excellent look at radio frequency signals. The brochure can be downloaded at **www.prenhall.com/beasley.** Click on the *Modern Electronic Communication* text.

FEATURES

- The most up-to-date treatment of digital and data communications
- Updated treatment of digital television, from theory to application
- The use of Electronics Workbench™ Multisim in spread spectrum communications
- Extensive troubleshooting sections

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- Numerous questions and problems for each chapter, including "Questions for Critical Thinking" designed to sharpen analytical skills
- Many circuits from the book are simulated using Electronics Workbench™ Multisim; additional circuits provide interactive, hands-on troubleshooting exercises
- Key terms and definitions highlighted in the margins as they are introduced in the text
- Complete directory of acronyms and abbreviations at the end of the book
- Extensive problem sets
- Color photos of typical industrial equipment
- Chapter outlines, objectives, and key terms identified at the beginning of each chapter
- Summary of key points following each chapter
- Comprehensive glossary at the end of the book

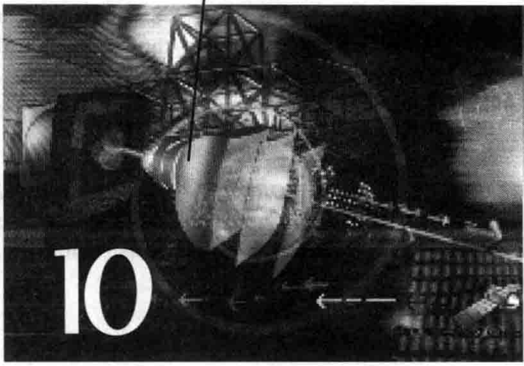
Partial Listing of New Material in the 9th Edition

- Expanded coverage mobile (cell phone) communications
- SS7 and telephone signaling systems
- Wireless security
- Digital signal processing
- Monitoring the digital television signal
- High-frequency communication sections featuring the Mini-Circuits® modules
- Expanded fiber optics discussion
- High-definition (HD) Radio
- Radio Frequency Identification (RFID)
- Wi-Max
- Bluetooth (update)
- Fiber optics (update)
- Satellite communications (update)
- Figure of merit and satellite link budget analysis, plus a link to an online calculator for use in a satellite link budget analysis that has been developed specifically for this textbook
- Updated lab manual, incorporating traditional communication integrated circuits, Electronics Workbench™ Multisim exercises, and exercises featuring the Mini-Circuits® modules.

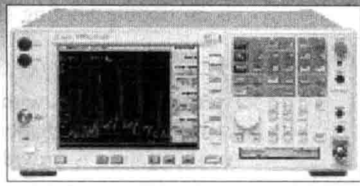
Illustration of Features

CHAPTER OPENER—Each chapter begins with a color photo related to content, a chapter outline, a list of objectives, and key terms being introduced. An example is shown on page vii.

Chapter Opener photo



WIRELESS DIGITAL COMMUNICATIONS



The Agilent E4440A PSA Series Spectrum Analyzer. (© Agilent Technologies, Inc. 2007 Reproduced with Permission, Courtesy of Agilent Technologies, Inc.)

Chapter Outline

10-1 Introduction
10-2 Digital Modulation Techniques
10-3 Spread-Spectrum Techniques
10-4 Orthogonal Frequency Division Multiplexing (OFDM)
10-5 Telemetry
10-6 Troubleshooting
10-7 Troubleshooting with Electronics Workbench™ Multisim

Objectives

- Describe the basics of a wireless digital communications link
- Provide detail on the various schemes used to transmit digital signals, including FSK, PSK, BPSK, QPSK, DPSK, and QAM
- Describe the generation of eye patterns and explain their use
- Describe the OFDM technique and explain why it is used
- Detail the operation of a complete radio-telemetry system
- Understand the basic steps for troubleshooting cell phone problems

Key Terms

wireless digital communications	pseudonoise (PN) codes	hit	hybrid AM, FM
wireless	spread	signature sequence	COFDM
frequency shift keying	PN sequence length	despread	flash OFDM
phase shift keying	maximal length	orthogonal frequency division multiplexing (OFDM)	telemetry
data bandwidth compression	frequency hopping spread spectrum	multitone modulation	radio telemetry
quadrature amplitude modulation	dwell time	orthogonal	water mark sticker
constellation pattern	DSSS	cyclic prefix	preferred roaming list (PRL)
loopback	chips	HD radio	OTA
eye patterns	code division multiple access (CDMA)	in-band on-channel (IBOC)	RF shield box
	multiple access		

Chapter Outline

Chapter Objectives

Key Terms for this chapter

WORKED EXAMPLES—Numerous worked-out examples are included in every chapter, as shown below. These examples reinforce key concepts and aid in subject mastery.

Every chapter contains a Troubleshooting section

Numerous worked-out examples aid in subject mastery

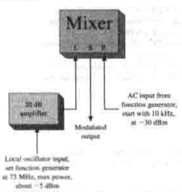


FIGURE 7-31 The suggested connection diagram for the ZP-3.

the input frequency (terminal L) needs to be less than or equal to −20 dBm. The theoretical mixer conversion loss is 6 dB. This means that if the input power is −20 dBm, the output power will be −26 dBm.

7-8 TROUBLESHOOTING

Transceivers, or two-way radios, are found in many commercial applications. In this section we will look at troubleshooting the transmitter portion of a mobile transceiver. General troubleshooting techniques are presented in this section. You should always consult the service manual before disassembling a transceiver and making any adjustments or repairs on it.

Today's communication equipment usually includes digital logic circuits to control various functions. We will learn to troubleshoot some basic logic circuits. We'll also consider troubleshooting a frequency synthesizer.

After completing this section you should be able to

- Describe the signal flow in a mobile FM transmitter circuit
- Describe common mobile transmitter failures
- Troubleshoot basic logic circuits
- Troubleshoot a frequency synthesizer

TRANSCEIVER TRANSMITTER

The block diagram in Figure 7-32 depicts the transmitter portion of a mobile transceiver. Mobile transmitters may differ somewhat in design. For example, this particular transmitter uses several frequency multiplier circuits in the exciter stage to step up the frequency to the necessary operating frequency. A press-to-talk microphone feeds the voice signal into an audio amplifier. The voice signal is amplified

Section 7-8 • Troubleshooting 335

EXAMPLE 7-8

The receiver from Example 7-7 has a preamplifier at its input. The preamp has a 24-dB gain and a 5-dB NF. Calculate the new sensitivity and dynamic range.

Solution

The first step is to determine the overall system noise ratio (NR). Recall from Chapter 1 that

$$NR = \log^{-1}\frac{NF}{10}$$

Letting NR_1 represent the preamp and NR_2 the receiver, we have

$$NR_1 = \log^{-1}\frac{5\text{ dB}}{10} = 3.16$$
$$NR_2 = \log^{-1}\frac{20\text{ dB}}{10} = 100$$

The overall NR is

$$NR = NR_1 + \frac{NR_2 - 1}{P_{G_1}} \qquad (1\text{-}16)$$

and

$$P_{G1} = \log^{-1}\frac{24\text{ dB}}{10} = 251$$
$$NR = 3.16 + \frac{100 - 1}{251} = 3.55$$
$$NF = 10\log_{10} 3.55 = 5.5\text{ dB}$$
$$= \text{total system NF}$$
$$S = -174\text{ dBm} + 5.5\text{ dB} + 60\text{ dB} = -108.5\text{ dBm}$$

The third-order intercept point of the receiver alone had been +5 dBm but is now preceded by the preamp with 24-dB gain. Assuming that the preamp can deliver 5 dBm to the receiver without any appreciable intermodulation distortion, the system's third-order intercept point is +5 dBm − 24 dB = −19 dBm. Thus,

$$\text{dynamic range} = \frac{2}{3}[-19\text{ dBm} - (-108.5\text{ dBm})]$$
$$= 59.7\text{ dB}$$

EXAMPLE 7-9

The 24-dB gain preamp in Example 7-8 is replaced with a 10-dB gain preamp with the same 5-dB NF. What are the system's sensitivity and dynamic range?

Section 7-4 • Receiver Noise, Sensitivity, and Dynamic Range Relationships 315

TROUBLESHOOTING—Every chapter contains an extensive troubleshooting section. An illustration is provided on page vii. Notice that areas of expected student mastery are highlighted. Students are very interested in applying knowledge gained by "fixing" real-world systems. Their comprehension is improved in this process. Equally important, employers and accrediting agencies strongly encourage emphasis on troubleshooting skills.

TROUBLESHOOTING—WITH ELECTRONICS WORKBENCH™ MULTISIM Every chapter ends with a Multisim circuit simulation and troubleshooting exercise as well as end-of-chapter exercises incorporating Electronics Workbench Multisim. An illustration is provided below.

Troubleshooting with Electronics Workbench™ Multisim is featured in this edition

18-12 TROUBLESHOOTING WITH ELECTRONICS WORKBENCH™ MULTISIM

The concept of preparing a system design for a fiber installation was presented in this chapter. This section presents a simulation exercise of a system design. Open the file **Fig18-30** on your EWB Multisim CD. This exercise provides you with the opportunity to study a fiber-optic system design in more depth. The circuit for the light-budget simulation is shown in Figure 18-30.

Electronics Workbench™ Multisim does not contain simulation models or instruments for lightwave communications, but with a little creativity, a system design for a fiber installation can be modeled. This example is patterned after Figure 18-22. The function generator models the output of a fiber-optic transmitter. The generator is outputting a square wave to model the pulsing of light. The settings for the function generator for three possible operating levels have been provided.

1. The maximum received signal level (RSL): −27 dBm
2. The designed operating level: −31.6 dBm
3. The minimum received signal level (RSL) for a BER of 10^{-9}: −40 dBm

A 16-dB T-type attenuator has been provided to simulate the fiber cable and splice loss. The system is terminated with a 600-Ω resistor for consistency with the analog model, but this resistor does not exist in a real optical system. A voltage-controlled sine-wave oscillator has been provided to simulate the optical receiver. The settings for the voltage-controlled sine-wave oscillator are shown in Figure 18-31. Double-click on the voltage-controlled sine-wave oscillator to view or change the settings.

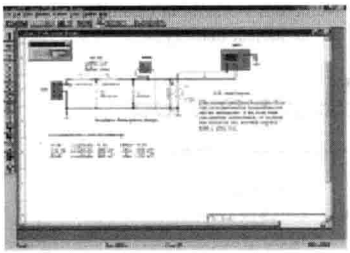


FIGURE 18-30 The Multisim circuit for the light-budget simulation.

904 Chapter 18 • Fiber Optics

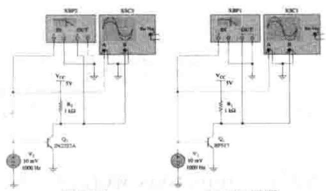


FIGURE 16-41 The example amplifier circuits that incorporate either a low-frequency or a high-frequency RF transistor.

upper cutoff frequency of about 240 MHz. This demonstrates the vast improvement in the frequency response of an amplifier with the use of an RF circuit.

The following exercises provide you with an opportunity to explore the characteristics of an RF inductor and troubleshoot an RF amplifier.

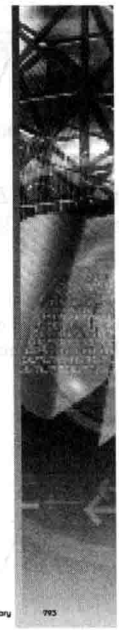
Electronics Workbench™ Exercises

1. Open the file **FigE16-1.ms7 (.msm)** in your EWB CD. This circuit provides a comparison of an ideal and an RF inductor. Determine the upper 3-dB cutoff frequencies for the inductors. (160 kHz, approx. 1.5 GHz)
2. Open the file **FigE16-2.ms7 (.msm)** in your EWB CD. Determine the resonant frequency of this dipole antenna. (f = 1.071 GHz).
3. Open the file **FigE16-3.ms7 (.msm)** in your EWB CD. Determine if the RF amplifier is working properly. If it isn't, locate and correct the fault and retry the simulation. Report on your findings.

SUMMARY

In Chapter 16 we studied microwaves and lasers. We learned that microwaves share many properties with light waves. The major topics you should now understand include:

- the description and analysis of microwave antennas, including parabolic, horn, and lens varieties
- the calculation of power gain and beamwidth for parabolic antennas



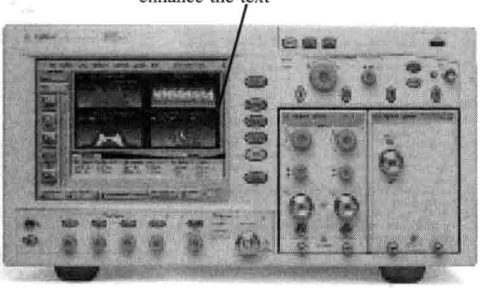
Summary 793

Each chapter contains Electronics Workbench™ exercises

FULL-COLOR FORMAT—Color is used throughout as an aid to comprehension and to make the material more visually stimulating. A representative use of color is shown below.

KEY TERMS DEFINED—The important new terms and concepts are defined in the margins near where they are introduced in the text. An illustration is shown below. Having the key terms presented in this way allows the student to quickly access, review, and understand new concepts and terminology.

Full-color photos enhance the text



(a)

(b)

(a) The 86100C digital communications analyzer with jitter analysis offers breakthrough speed, accuracy, and affordability. (Courtesy of Agilent Technologies. Reprinted with permission.) (b) The MT8820B radio communications analyzer was designed to support the test needs of the manufacturing, R&D, and maintenance markets. (Courtesy of Anritsu Company.)

242 Chapter 5 • Frequency Modulation: Transmission

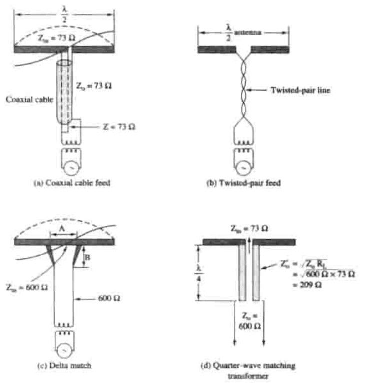


FIGURE 14-10 Feeding antennas with nonresonant lines.

of the antenna. This method of connection produces no standing waves on the line when the line is matched to a generator. Coupling to a generator is often made through a simple untuned transformer secondary.

Another method of transferring energy to the antenna is through the use of a twisted-pair line, as shown in Figure 14-10(b). It is used as an untuned line for low frequencies. Due to excessive losses occurring in the insulation, the twisted pair is not used at higher frequencies. The characteristic impedance of such lines is about 70 Ω.

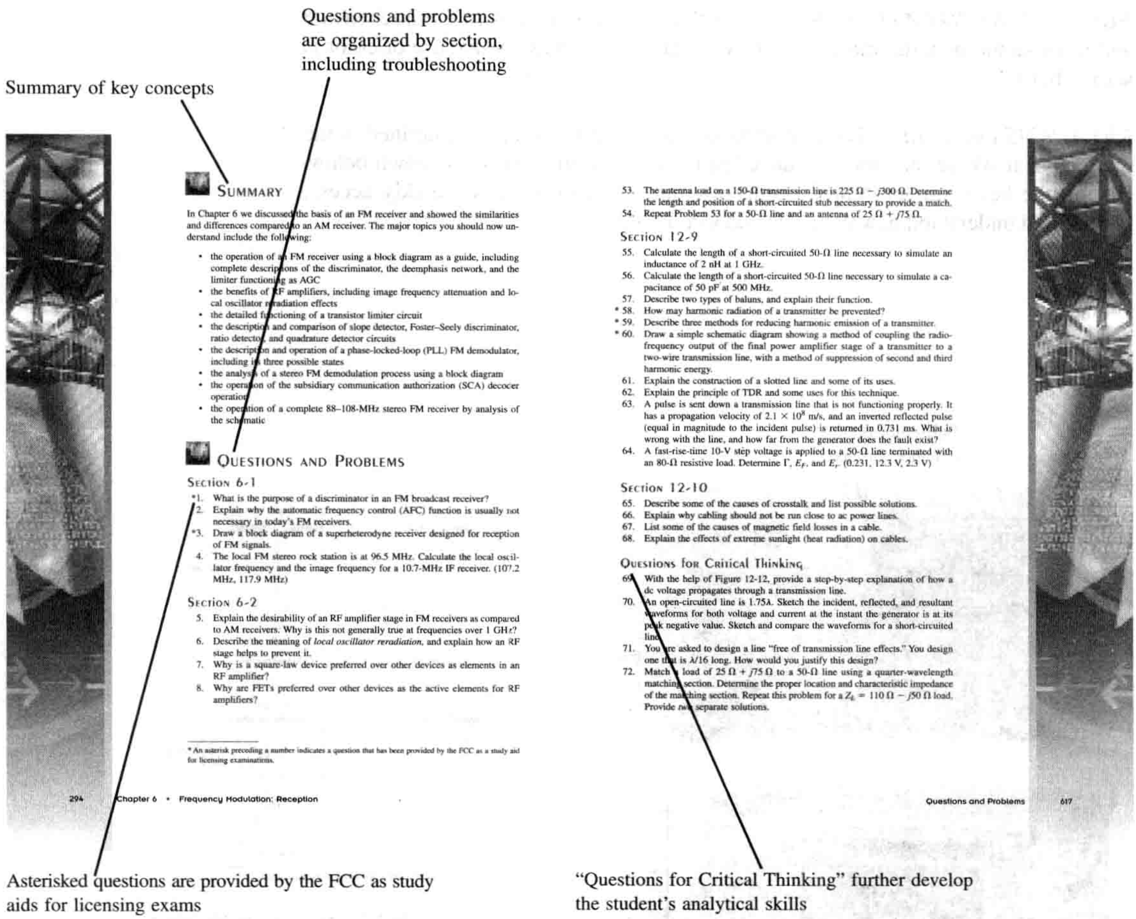
DELTA MATCH

When a line does not match the impedance of the antenna, it is necessary to use special impedance matching techniques such as those discussed with Smith chart applications in Chapter 12. An example of an additional type of impedance matching device is the **delta match**, shown in Figure 14-10(c). Due to inherent characteristics, the open, two-wire transmission line does not have a characteristic impedance

Delta Match an impedance matching device that spreads the transmission line as it approaches the antenna

Section 14-4 • Antenna Feed Lines 677

Full-color format is used throughout, enhancing illustrations and highlighting key terms



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?

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

53. The antenna load on a 150-Ω transmission line is 225 Ω − j300 Ω. Determine the length and position of a short-circuited stub necessary to provide a match.
54. Repeat Problem 53 for a 50-Ω line and an antenna of 25 Ω + j75 Ω.

SECTION 12-9

55. Calculate the length of a short-circuited 50-Ω line necessary to simulate an inductance of 2 nH at 1 GHz.
56. Calculate the length of a short-circuited 50-Ω line necessary to simulate a capacitance of 50 pF at 500 MHz.
57. Describe two types of baluns, and explain their function.
*58. How may harmonic radiation of a transmitter be prevented?
*59. Describe three methods for reducing harmonic emission of a transmitter.
*60. Draw a simple schematic diagram showing a method of coupling the radio-frequency output of the final power amplifier stage of a transmitter to a two-wire transmission line, with a method of suppression of second and third harmonic energy.
61. Explain the construction of a slotted line and some of its uses.
62. Explain the principle of TDR and some uses for this technique.
63. A pulse is sent down a transmission line that is not functioning properly. It has a propagation velocity of 2.1 × 10⁸ m/s, and an inverted reflected pulse (equal in magnitude to the incident pulse) is returned in 0.731 ms. What is wrong with the line, and how far from the generator does the fault exist?
64. A fast-rise-time 10-V step voltage is applied to a 50-Ω line terminated with an 80-Ω resistive load. Determine Γ, E_r, and E_r. (0.231, 12.3 V, 2.3 V)

SECTION 12-10

65. Describe some of the causes of crosstalk and list possible solutions.
66. Explain why cabling should not be run close to ac power lines.
67. List some of the causes of magnetic field losses in a cable.
68. Explain the effects of extreme sunlight (heat radiation) on cables.

QUESTIONS FOR CRITICAL THINKING

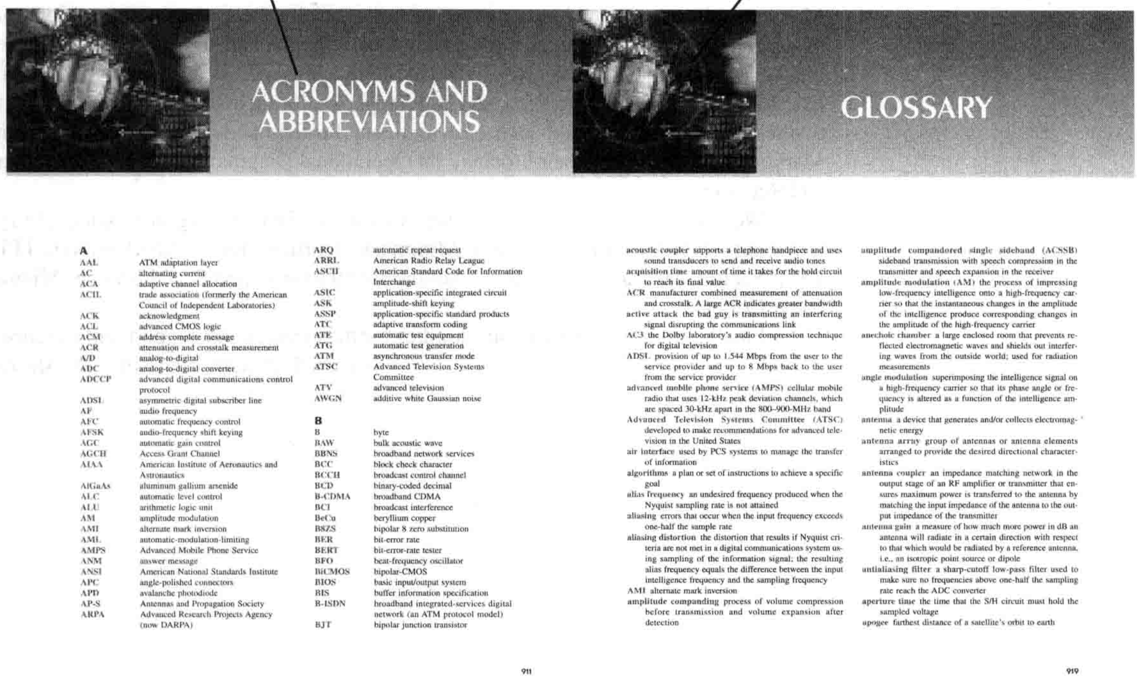
69. With the help of Figure 12-12, provide a step-by-step explanation of how a dc voltage propagates through a transmission line.
70. An open-circuited line is 1.75λ. Sketch the incident, reflected, and resultant waveforms for both voltage and current at the instant the generator is at its peak negative value. Sketch and compare the waveforms for a short-circuited line.
71. You are asked to design a line "free of transmission line effects." You design one that is λ/16 long. How would you justify this design?
72. Match a load of 25 Ω + j75 Ω to a 50-Ω line using a quarter-wavelength matching section. Determine the proper location and characteristic impedance of the matching section. Repeat this problem for a Z_L = 110 Ω − j50 Ω load. Provide two separate solutions.

END-OF-CHAPTER MATERIAL—Each chapter concludes with a summary of key concepts, an extensive problem set, a section entitled "Questions for Critical Thinking," and chapter exercises incorporating Electronics Workbench™ Multisim. See above for an illustration of how this material is presented. The questions and problems are very comprehensive and are keyed to the appropriate chapter section. An asterisk next to the question number indicates that a particular question has been provided by the FCC as a study aid for licensing examinations. In addition, the answer to quantitative problems is provided in parentheses following the question. Worked-out solutions to selected problems are available in the Instructor's Manual.

GLOSSARY AND ACRONYMS—The end-of-book material includes an extensive glossary and list of acronyms. These important tools are illustrated on page xi. Acronyms are widely used in electronic communications and are often a source of confusion for students. This listing solves the problem by offering a quickly accessible description.

Comprehensive listing of commonly used acronyms

Complete glossary of terms provides quick reference



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Acknowledgments

Many people have provided constructive criticism for the earlier eight editions of *Modern Electronic Communication,* and we truly appreciate the input that all have made. A special thank you is given to David Shores, Jim Andress, Dr. Russ Jedlicka, Dr. Eric Johnson, Dr. Guillermo Rico, and Bill Saggerson for their significant contributions to the 9th edition. I would also like to thank Professors Lance Breger and Ken Markowitz for providing their brochure on Operational Diagrams of Radio Transmitter and Receivers.

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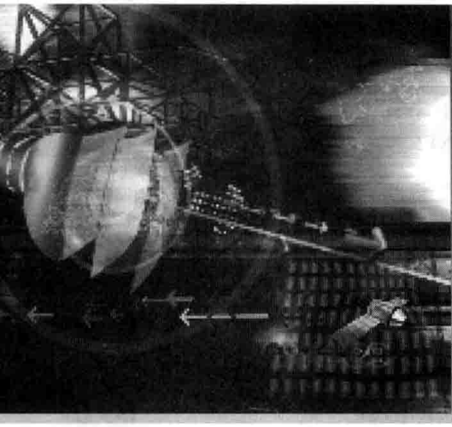
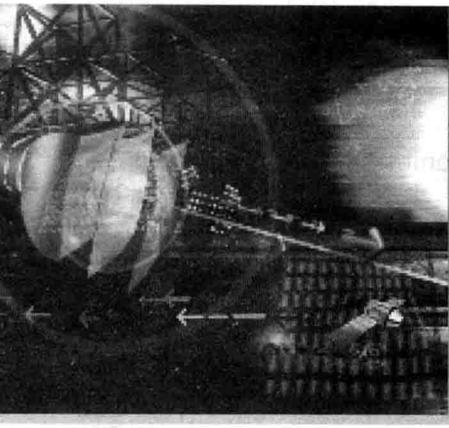
Finally, we'd like to thank our families for their continuing support and patience.

Jeffrey S. Beasley and Gary M. Miller



BRIEF CONTENTS



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