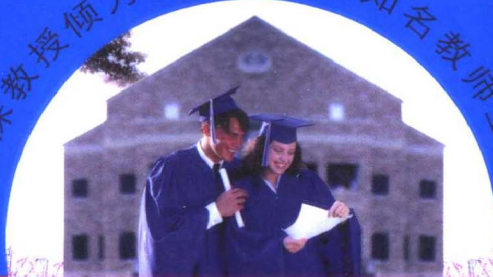


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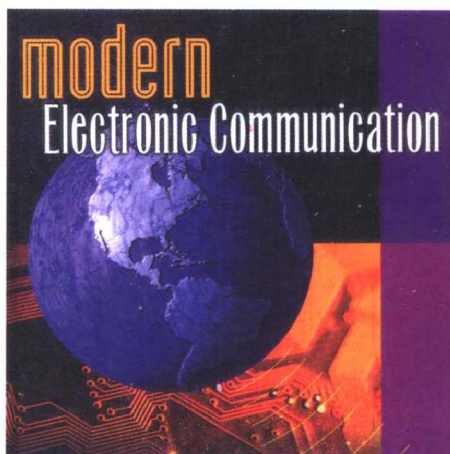
现代电子通信

(第七版)

Modern Electronic Communication

(Seventh Edition)

(英文影印版)



Gary M. Miller Jeffrey S. Beasley 著



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北 京

内 容 简 介

本书为国外高校电子信息类优秀教材(英文影印版)之一。

本书在每一章结合 Electronic Workbench Multisim 阐述了电子通信的关键概念。内容包括:幅度调制,单边带通信,频率调制,通信方法,数字通信,网络通信,传输线,波的传播,天线,波导与雷达,微波与激光,电视,光纤等。

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

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国外高校电子信息类优秀教材(英文影印版)

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Dedicated to the youth of the world,
especially my favorites,
Evan and Maia
Gary M. Miller

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

Preface

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

This edition has expanded the Troubleshooting section by including *Troubleshooting with Electronics Workbench™ Multisim*. This is accompanied by an Electronics Workbench Multisim CD-ROM, which is packaged with the text. The CD now contains all circuits from the text based on the latest version of Electronics Workbench Multisim. These valuable tools enable the student to simulate laboratory conditions at any convenient time and to stimulate the learning process.

FEATURES

- The most up-to-date treatment of digital and data communications
- The addition of “Troubleshooting with Electronics Workbench™ Multisim” in each chapter
- Extensive troubleshooting sections
- Numerous questions and problems, including a section for each chapter entitled “Questions for Critical Thinking” designed to sharpen analytical skills
- All circuits from the book are simulated on a full-function Electronics Workbench (EWB) Multisim CD. 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
- Numerous worked-out examples
- 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 SEVENTH EDITION

- The dB in communications
- Understanding the frequency spectra
- Explanation and examples of the FFT (fast Fourier transform)
- Digital sampling oscilloscope waveforms
- Updated review of single-sideband communications
- CRC coding
- Hamming distance
- Expanded digital communications coverage
- Time-division multiple access
- Data transmission
- Updated section on modern telephone networks
- PCS (personal communication services)
- Updated coverage of local area networks
- xDSL (digital subscriber line services)
- Voiceover IP (Internet telephony)
- WAP (wireless application protocol)
- Updated discussion of UTP (unshielded twisted pair)
- Introduction to the basics of DTV (digital television)
- Significantly updated fiber-optics chapter
- System design of a fiber installation
- Optical networking
- OTDR measurements and trace analysis
- Appendix A: Electronics Workbench™ Multisim Tutorial

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 in Figure P-1.

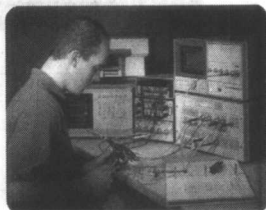
WORKED EXAMPLES—Numerous worked-out examples are included in every chapter, as shown in Figure P-2. These examples serve to reinforce key concepts and aid in subject mastery.

TROUBLESHOOTING—Every chapter contains an extensive troubleshooting section. An illustration is provided in Figure P-2. 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.

8 CHAPTER

Digital Communications: Coding Techniques

A digital test set using the Agilent 71612A 12 Gbps pattern generator and detector. (Courtesy of Agilent Technologies.)



Chapter Opener photo

Chapter Outline

Chapter Objectives

CHAPTER OUTLINE

- 8-1 Introduction
- 8-2 Alphanumeric Codes
- 8-3 Pulse-Code Modulation
- 8-4 Digital Signal Encoding Formats
- 8-5 Coding Principles
- 8-6 Code Error Detection and Correction
- 8-7 Troubleshooting
- 8-8 Troubleshooting with Electronics Workbench™ Multisim
- SUMMARY

OBJECTIVES

- Describe the quantization process in a PCM system in terms of how it is created, how to determine the Nyquist sampling frequency, and how to define quantization levels
- Determine the dynamic range and signal-to-noise ratio of a PCM system
- Describe the common digital signal encoding formats
- Understand the concept of Hamming distance as applied to the technique of error detection and correction
- Describe the various techniques for code error detection and correction, including parity, block check character, cyclic redundancy check, Hamming code, and Reed-Solomon codes.

KEY TERMS

representation	quantization	minimum distance (d_{min})
digital signal processing	quantile	symbol substitution
algorithms	quantile interval	block check character (BCC)
ASCII	quantization levels	longitudinal redundancy
parity	quantization error	check (LRC)
EBSDIC	quantization noise	cyclic redundancy check
bandwidth	dynamic range	BCC
Gray code	uniform quantization level	systematic code
acquisition time	linear quantization level	(n, k) cyclic code
aperture time	nonlinear coding	generating polynomial
natural sampling	nonuniform coding	syndrome
flat-top sampling	like channel noise	polynomial (PM) codes
Nyquist rate	amplitude companding	forward error-correcting
aliasing, or foldover	code	Hamming code
distortion	multilevel binary	interleaving
antialiasing filter	Hamming distance	

Key Terms for this chapter

FIGURE P-1

$$1 + \frac{m^2}{2} = \left(\frac{10}{10} \right)^2$$

$$m^2 = 2 \left[\left(\frac{10}{10} \right)^2 - 1 \right] = 0.34$$

$$m = 0.59$$

$$\%m = 0.59 \times 100\% = 59\%$$

Example 2-7

An intelligence signal is amplified by a 70% efficient amplifier before being combined with a 10-W carrier to generate the AM signal. If it is desired to operate at 100% modulation, what is the dc input power to the final intelligence amplifier?

Solution

You may recall that the efficiency of an amplifier is the ratio of ac output power to its input power. To fully modulate a 10-W carrier requires 5 kW of intelligence. Therefore, to provide 5 kW of sideband (intelligence) power through a 70% efficient amplifier requires a dc input of

$$\frac{5 \text{ kW}}{0.70} = 7.14 \text{ kW}$$

If a carrier is modulated by more than a single sine wave, the effective modulation index is given by

$$m_{eff} = \sqrt{m_1^2 + m_2^2 + m_3^2 + \dots} \quad (2-9)$$

The total effective modulation index must not exceed 1 or distortion (as with a single sine wave) will result. The term m_{eff} can be used in all previously developed equations using m .

Example 2-8

A transmitter with a 10-W carrier transmits 11.2 kW when modulated with a single sine wave. Calculate the modulation index. If the carrier is simultaneously modulated with another sine wave at 50% modulation, calculate the total transmitted power.

Solution

$$P_t = P_c \left(1 + \frac{m^2}{2} \right) \quad (2-7)$$

$$11.2 \text{ kW} = 10 \text{ kW} \left(1 + \frac{m^2}{2} \right)$$

$$m = 0.49$$

$$m_{eff} = \sqrt{m^2 + m_2^2} \quad (2-9)$$

3-8 TROUBLESHOOTING

In this section we are going to analyze and troubleshoot the AM mixer circuit. The mixer circuit, also known as an autodyne circuit, is a combination of the local oscillator and the mixer in a single stage. We're also going to discuss power supply and audio amplifier problems in this section.

Upon completing this section you should be able to

- Troubleshoot an AM mixer circuit
- Identify an open input circuit
- Identify a dead or intermittent local oscillator circuit
- Identify causes for a dead or intermittent local oscillator
- Troubleshoot the receiver's power supply
- Troubleshoot the receiver's audio amplifier

The Mixer Circuit

In Sec. 3-3 it was shown that the local oscillator and the mixer play a very important part in AM reception. Figure 3-27 shows the mixer stage (autodyne circuit) of an AM radio. The received RF input signal is fed into the base of Q₁ from coils L₁ and L₂. The input AM radio signal is selected by tuning C₁; notice also that C₁ and C₂ are ganged. When C₁ is adjusted, C₂ will be adjusted by the same amount. The

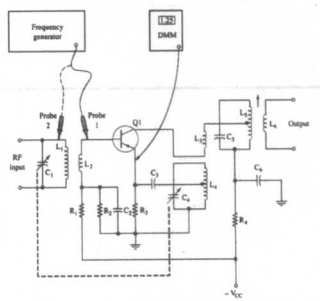


FIGURE 3-27 Troubleshooting a self-excited mixer.

Every chapter contains a Troubleshooting section

FIGURE P-2

TROUBLESHOOTING WITH ELECTRONICS WORKBENCH™ MULTISIM— Every chapter ends with an EWB circuit simulation and troubleshooting exercise as well as end-of-chapter exercises incorporating Electronics Workbench Multisim (Figure P-3).

Troubleshooting with Electronics Workbench™ Multisim is a new feature in this edition

17-12 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 **Fig17-33.ms10** 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 Fig. 17-33.

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 Fig. 17-24. 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) -40 dBm for a BER of 10^{-9}

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

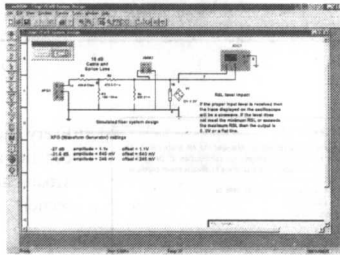


FIGURE 17-33 The Multisim circuit for the light-budget simulation.

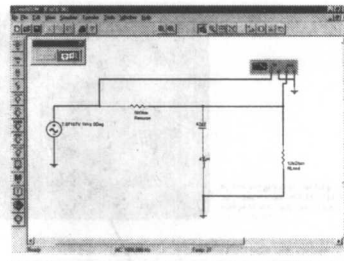


FIGURE 16-36 The Electronics Workbench Multisim circuit of a high-Q bandstop circuit, or wavestop.

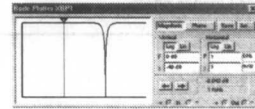


FIGURE 16-37 The Bode plotter output for the wave-stop filter.

Electronics Workbench Exercises

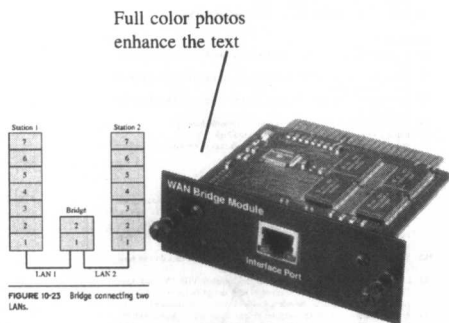
1. Open the file **FigE16-2.ms10** in your EWB CD. Determine the center frequencies for the visual and aural carriers. Verify your results with the spectrum analyzer. What frequency band and television channel is this? (67.25 MHz, 71.75 MHz, VHF, Channel 4)
2. Open the file **FigE16-3.ms10** in your EWB CD. Determine if the filter circuit is working properly. If the circuit is not working, troubleshoot it and correct the problem.
3. Open the file **FigE16-4.ms10** in your EWB CD. Determine if the filter circuit is working properly. If the circuit is not working, troubleshoot it and correct the problem. Explain why this type of failure might cause the problem.

Each chapter contains Electronics Workbench™ exercises

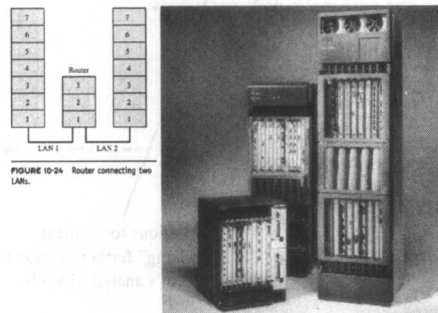
FIGURE P-3

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 in Figure P-4.

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 in Figure P-4. Having the key terms presented in this way allows the student to quickly access, review, and understand new concepts and terminology.



A WAN bridge module. (Courtesy of Black Box Corporation.)



The Cisco 12000 series gigabit switch router. (Courtesy of Cisco Systems.)

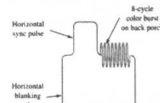


FIGURE 10-24 Color burst.

no color burst, and thus the phase detector has a large dc output that the color killer circuit uses to "kill" the 2- to 4.2-MHz bandpass amplifier. The purpose is to prevent any signals out of the chroma circuits during a monochrome broadcast. A defective color killer results in colored noise, called *confetti*, on the screen of a color receiver during a black-and-white transmission. The confetti looks like snow but with larger spots, in color. Additionally, the color killer also kills the color if a weak RF signal is received.

The Color CRT and Convergence

Color receiver CRTs are a marvel of engineering precision. As previously mentioned, they are made up of triads of red, blue, and green phosphor dots. The trick is to get the proper electron beam to strike its respective colored phosphor dot. This is accomplished by passing the three beams through a single hole in the *shadow mask*, as shown in Fig. 10-25. The shadow mask prevents the "red" beam from spilling over onto an adjacent blue or green phosphor dot, which would certainly destroy the color rendition. A typical color CRT has over 200,000 holes in the

Confetti colored noise on the screen of a color receiver during a black-and-white transmission

Shadow Mask screen used in a color CRT to prevent electron beam from striking wrong color phosphor triad

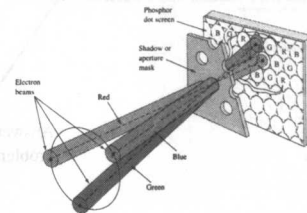


FIGURE 10-25 Color CRT construction.

FIGURE P-4

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. An illustration of how this material is presented can be seen in Figure P-5. 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.

Summary of key concepts

Questions and problems are organized by section, including troubleshooting

Summary

In Chapter 12 we studied various considerations of wave propagation. It was discovered that electrical energy can be converted to wave energy with many properties in common with light wave propagation. The major topics the student should now understand include:

- the definition of an electromagnetic wave, isotropic point source, wavefront, and characteristic impedance of free space
- the understanding of environmental effects on wave propagation, including reflection, refraction, and diffraction
- the explanation of ground- and space-wave propagation
- the description of ionospheric layers and their effects on sky-wave propagation
- the definition of skipping, critical frequency, critical angle, maximum usable frequency (MUF), skip zone, fading, and tropospheric scatter
- the description and usage of satellite communications
- the explanation of multiplexing techniques used in satellite communications, including FDMA, TDMA, and CDMA
- the description of very small aperture terminal (VSAT) and ultrasmall aperture terminal mobile satellite (MSAT) communication
- the power-loss calculations used in satellite communications analysis

Questions and Problems

Section 1

1. Explain why an antenna can be thought of as a transducer.
2. List the similarities and dissimilarities between light waves and radio waves.

Section 2

3. What are the two components of an electromagnetic wave? How are they created? Explain the two possible things that can happen to the energy in an electromagnetic wave near a conductor.
4. What is horizontal and vertical polarization of a radio wave?
5. What kinds of fields emanate from a transmitting antenna, and what relationships do they have to each other?
6. Define wavefront.
7. Calculate the power density in watts per square meter (on earth) from a 10-W satellite source that is 22,000 mi from earth. (6.35×10^{16} W/m²)
8. Calculate the power received from a 20-W transmitter, 22,000 mi from earth, if the receiving antenna has an effective area of 1600 m². (2.03×10^{-15} W)
9. Calculate the electric field intensity, in volts per meter, 20 km from a 1.4-W source. How many decibels down will that field intensity be an additional 30 km from the source? (8.66 mV/m, 7.96 dB)
10. Calculate the characteristic impedance of free space using two different methods.

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

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 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 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 μ V/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 (r) 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 signal 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 signal 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 sketch.)

Asterisked questions are provided by the FCC as study aids for licensing exams

Answers to quantitative problems are in parentheses

"Questions for Critical Thinking" further develop the student's analytical skills

FIGURE P-5

GLOSSARY AND ACRONYMS—The end-of-book material includes an extensive glossary and list of acronyms. These important tools are illustrated in Figure P-6. 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.

Complete glossary of terms
provides quick reference

Glossary

acoustic coupler supports a telephone handset and uses sound transducers to send and receive audio tones

acquisition time amount of time it takes for the hold circuit to reach its final value

AC3 the Dolby Laboratories audio compression technique for digital television

ACR manufacturer combined measurement of attenuation and crosstalk. A large ACR indicates greater bandwidth

ADSL provision of up to 1.544 Mbps from the user to the service provider and up to 8 Mbps back to the user from the service provider

advanced mobile phone service (AMPS) cellular mobile radio that uses 12-kHz peak deviation channels, which are spaced 30-kHz apart in the 800-900-MHz band

Advanced Television Systems Committee (ATSC) developed to make recommendations for advanced television in the United States

air interface used by PCS systems to manage the transfer of information

algorithm a plan or set of instructions to achieve a specific goal

alias frequency an undesired frequency produced when the Nyquist sampling rate is not attained

aliasing errors that occur when the input frequency exceeds one-half the sample rate

aliasing distortion the distortion that results if Nyquist criteria are not met in a digital communication system using sampling of the information signal; the resulting alias frequency equals the difference between the input, intelligence frequency and the sampling frequency

amplitude companding process of volume compression before transmission and volume expansion after detection

amplitude companded single sideband (ACSSB) sideband transmission with speech compression in the transmitter and speech expansion in the receiver

amplitude modulation (AM) the process of impressing low-frequency intelligence onto a high-frequency carrier so that the instantaneous changes in the amplitude of the intelligence produce corresponding changes in the amplitude of the high-frequency carrier

anechoic chamber a large enclosed room that prevents reflected electromagnetic waves and shields out interfering waves from the outside world; used for radiation measurements

angle modulation superimposing the intelligence signal on a high-frequency carrier so that its phase angle or frequency is altered as a function of the intelligence amplitude

antenna a device that generates and/or collects electromagnetic energy

antenna array group of antennas or antenna elements arranged to provide the desired directional characteristics

antenna coupler an impedance matching network in the output stage of an RF amplifier or transmitter that ensures maximum power is transferred to the antenna by matching the input impedance of the antenna to the output impedance of the transmitter

antenna gain a measure of how much more power in dB an antenna will radiate in a certain direction with respect to that which would be radiated by a reference antenna, i.e., an isotropic point source or dipole

antialiasing filter a sharp-cutoff low-pass filter used to make sure no frequencies above one-half the sampling rate reach the ADC converter

aperture the time that the 50 Ω circuit must hold the sampled voltage

Acronyms and Abbreviations

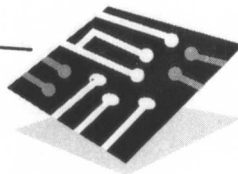
2D	two-dimensional	AP-S	Antennas and Propagation Society
3D	three-dimensional	ARPA	Advanced Research Projects Agency (now DARPA)
4FSK	four-level frequency shift keying	ARQ	automatic repeat request
A		ARL	American Radio Relay League
AAL	ATM adaptation layer	ASCII	American Standard Code for Information Interchange
AC	alternating current	ASIC	application-specific integrated circuit
ACA	adaptive channel allocation	ASK	amplitude-shift keying
ACIL	trade association (formerly the American Council of Independent Laboratories)	ASSP	application-specific standard products
ACK	acknowledgment	ATC	adaptive transform coding
ACL	advanced CMOS logic	ATE	automatic test equipment
ACR	attenuation and crosstalk measurement	ATG	asynchronous transfer mode
AD	analog-to-digital converter	ATM	Advanced Television Systems Committee
ADC	advanced digital communications control protocol	ATSC	Advanced Television Systems Committee
ADCCP	asymmetric digital subscriber line	ATV	additive white Gaussian noise
ADSL	audio frequency	AWGN	
AF	automatic frequency control	B	byte
AFSK	audio-frequency shift keying	BAW	bulk acoustic wave
AGC	automatic gain control	BBNS	broadband network services
AIAA	American Institute of Aeronautics and Astronautics	BCC	block check character
AlGaAs	aluminum gallium arsenide	BCH	broadcast control channel
ALC	automatic level control	BCD	binary-coded decimal
ALU	arithmetic logic unit	B-CDMA	broadband CDMA
AM	amplitude modulation	BCI	broadcast interference
AML	automatic modulation limiting	BeCu	beryllium copper
AMPS	Advanced Mobile Phone Service	BER	bit-error rate
ANSI	American National Standards Institute	BERT	bit-error-rate tester
APC	angle-polished connector	BFO	beat-frequency oscillator
APD	avalanche photodiode	BiCMOS	bipolar/CMOS
		BIOS	basic input/output system

Comprehensive listing of
commonly used acronyms

FIGURE P-6

CD-ROM INCLUDED—Over 90 percent of the circuits from the text plus additional circuits for troubleshooting are provided on this EWB Multisim software, available free of charge.

Over 90 percent of
the circuits are simulated on a CD-ROM



ANCILLARY PACKAGE

- *Laboratory Manual with System Projects* and accompanying CD-ROM, by Jeffrey S. Beasley and Michael Fairbanks
- *Laboratory Manual* with accompanying CD-ROM, by Mark E. Oliver
- *Learning Electronics Communications Through Experimentation Using Electronics Workbench™ Multisim* with accompanying CD-ROM, by Richard H. Berube
- Companion Website (www.prenhall.com/miller) featuring simulation circuits using EWB Multisim and practice test questions
- Instructor's Manual featuring:
 - Chapter Overviews
 - Test Item File
 - Worked-out solutions to quantitative problems appearing in the text
 - Laboratory Manual experiment results
 - CD-ROM containing PowerPoint slides of all figures in the text
- Prentice Hall Test Manager

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