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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)

科学出版社

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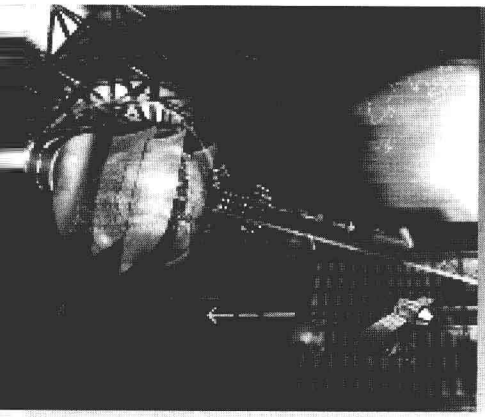
Dedicated to my family,
Kim, Damon, and Dana
Jeffrey S. Beasley

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 featurs 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

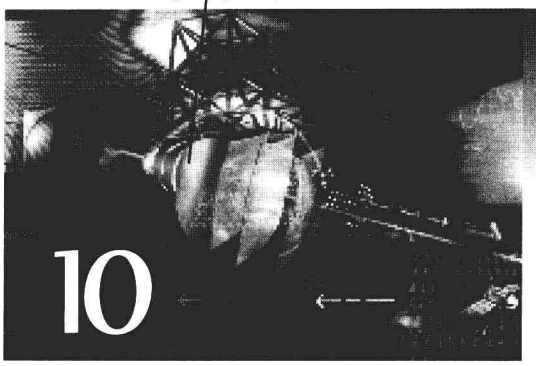
Partial Listing of New Material in the 9th Edition

- 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

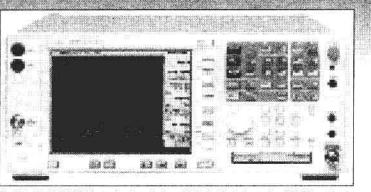
CHAPTER OPENER—Each chapter begins with a color photo related to content, a chapter outline, a list of objectives, and key terms being introduced. An example is shown on page vii.

Chapter Opener photo



10

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

Chapter Outline

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

Chapter Objectives

Key Terms

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

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

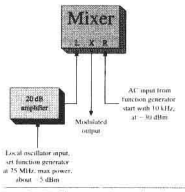


FIGURE 7-31 The suggested connection diagram for the ZP-3.

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

Numerous worked-out examples aid in subject mastery

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,

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

$$= 59.7\text{ dB}$$

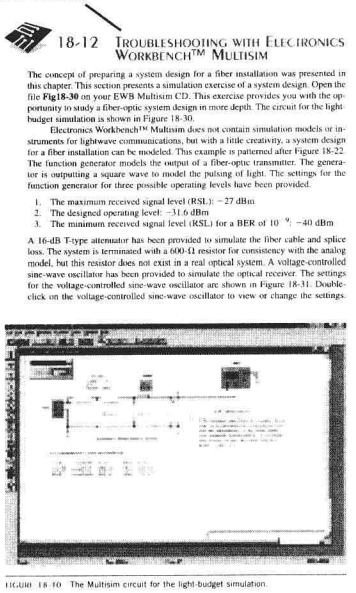
EXAMPLE 7-9

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?

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.

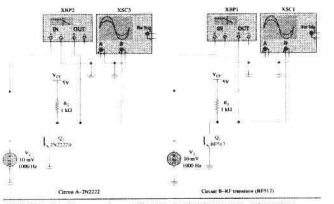


FIGURE 16-41 The example amplifier circuits that incorporate either a low-frequency or a high-frequency RF transistor.

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.

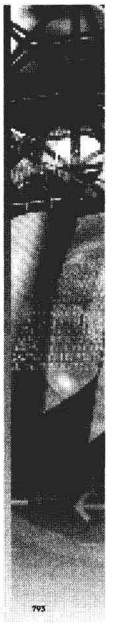
ELECTRONICS WORKBENCH™ EXERCISES

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

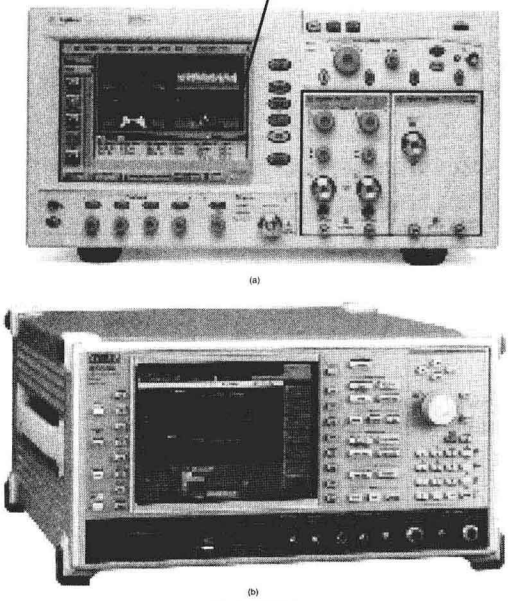


Each chapter contains Electronics Workbench™ exercises

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) 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.)

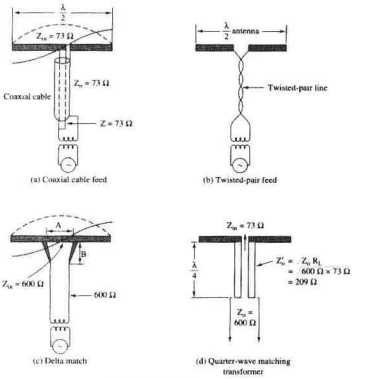


FIGURE 14-10 Feeding antennas with nonresonant lines.

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.

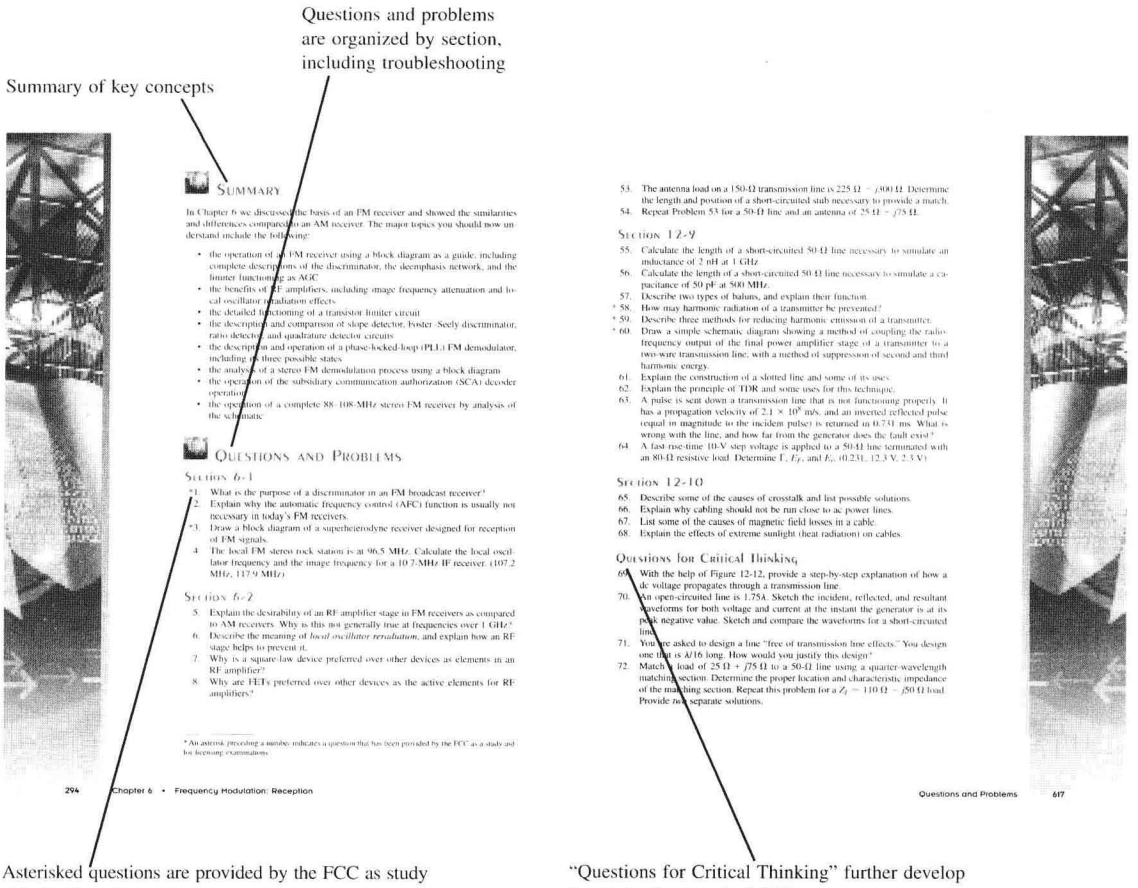
Another method of transferring energy to the antenna is through the use of a twisted-pair line, as shown in Figure 14-10(b). It is used as an untuned line for low frequencies. Due to excessive losses occurring in the insulation, the twisted pair is not used at higher frequencies. The characteristic impedance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

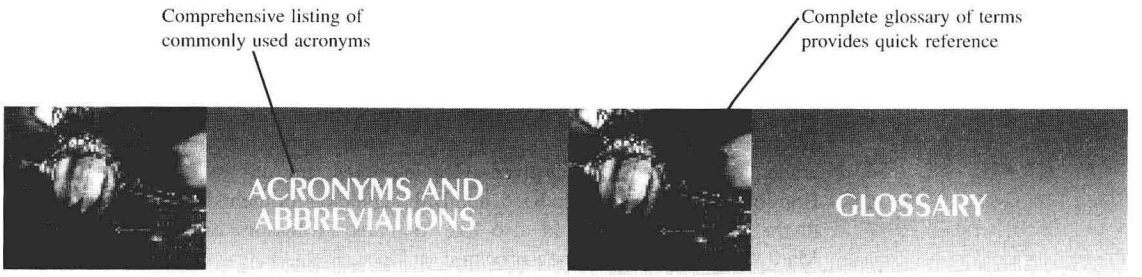
Delta Match
an impedance matching device that spreads the transmission line as it approaches the antenna

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



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.



A

AAL ATM adaptation layer
AC alternating current
ACA adaptive channel allocation
ACH trade association (formerly the American Council of Independent Laboratories)
ACK acknowledgment
ACL advanced CMOS logic
ACM address complete message
ACR attenuation and crosstalk measurement
A/D analog-to-digital
ADC analog-to-digital converter
ADCCP advanced digital communications control protocol
ADSL asymmetric digital subscriber line
AF audio frequency
AFC automatic frequency control
AFSK audio-frequency shift keying
AGC automatic gain control
AGCH Access Grant Channel
AIAA American Institute of Aeronautics and Astronautics
AlGaAs aluminum gallium arsenide
ALC automatic level control
ALU arithmetic logic unit
AM amplitude modulation
AMI alternate mark inversion
AML automatic modulation limiting
AMPS Advanced Mobile Phone Service
ANM answer message
ANSI American National Standards Institute
APC angle-polished connectors
APD avalanche photodiode
APS Antennas and Propagation Society
ARPA Advanced Research Projects Agency (now DARPA)
ARQ automatic repeat request
ARRL American Radio Relay League
ASCII American Standard Code for Information Interchange
ASIC application-specific integrated circuit
ASK amplitude-shift keying
ASSP application-specific standard products
ATC adaptive transform coding
ATE automatic test equipment
ATG automatic test generation
ATM asynchronous transfer mode
ATSC Advanced Television Systems Committee
ATV advanced television
AWGN additive white Gaussian noise

B

B byte
BAW bulk acoustic wave
BBNS broadband network services
BCC block check character
BCCH broadcast control channel
BCD binary-coded decimal
B-CDMA broadband CDMA
BCI broadcast interference
BeCu beryllium copper
BNZS bipolar 8 zero substitution
BER bit error rate
BERT bit error rate tester
BFO beat-frequency oscillator
BiCMOS bipolar CMOS
BIOS basic input/output system
BIS buffer information specification
B-ISDN broadband integrated-services digital network (an ATM protocol model)
BJT bipolar junction transistor

acoustic coupler supports a telephone handpiece 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
ACR manufacturer combined measurement of attenuation and crosstalk. A large ACR indicates greater bandwidth
active attack the bad guy is transmitting an interfering signal disrupting the communications link
AC-3 the Dolby laboratory's audio compression technique for digital television
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
algorithms 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 communications system using sampling of the information signal; the resulting alias frequency equals the difference between the input intelligence frequency and the sampling frequency
AMI alternate mark inversion
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 A/D converter
aperture time the time that the S/H circuit must hold the sampled voltage
apogee farthest distance of a satellite's orbit to earth

Supplement Package

- *Laboratory Manual,* by Mark E. Oliver, Jeffrey S. Beasley, and David Shores ISBN 0-13-156855-8
- Online Instructor's Resource Manual (ISBN: 0-13-225080-2) featuring:
  Chapter Overviews
  Worked-out solutions to problems in the text
  Test item file
  Laboratory solutions
  PowerPoint slides of all figures in the text
- Online TestGen (ISBN: 0-13-225081-0)
- Companion Website: www.prenhall.com/beasley

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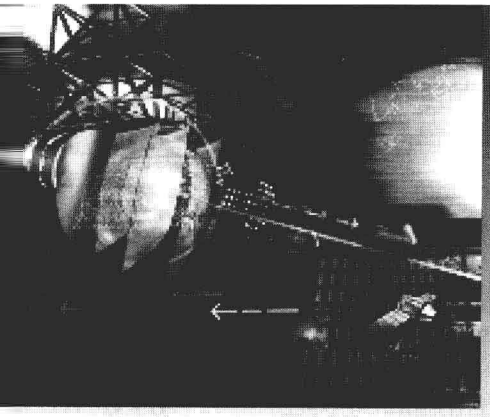
Jeffrey S. Beasley and Gary M. Miller



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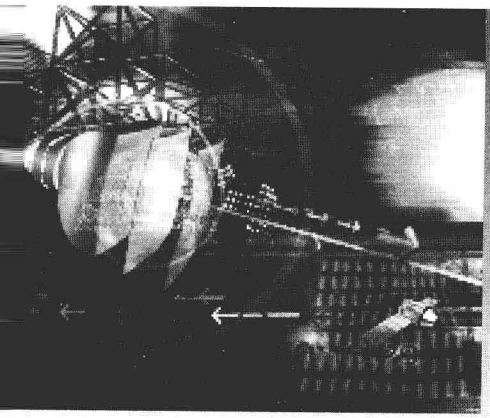

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