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Neil Edde
Publisher—Certification
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To my grandparents, parents, aunts, and uncles for sharing their knowledge and providing encouragement. And to my son Mike for all the encouragement, my son Brandon for taking care of the household and his sister when I couldn’t, and to my daughter, Kathryn, for being patient over the last seven months.
—Bill Woodward

For my parents, who always knew I’d get here. For Diane. Yes, I will now get back to working on the house. Thank you for your patience.
—Emile B. Husson
Foreword

This text is intended for students in fiber optics installation, design, and maintenance courses. The 16 chapters encompass the latest techniques, skills, and knowledge required of the technologists who are now rewiring the business and residential worlds with high-speed broadband optical fiber. While only months ago, some telecommunications industry observers were predicting that copper and fiber were soon to be replaced in the main by wireless technologies, that has proven not to be the case. Instead, the major telephone and communications companies have set in motion some of the industry’s largest and most expensive construction projects by initiating new fiber networks. The cable, telephone, and Internet technology companies have expanded their systems worldwide and have driven fiber cabling from the trunk lines to the curb, to the premises, and into the home. Local and wide area networks are heavily fibered. Ships, aircraft, and automobiles now include fiber transmission media.

The Electronics Technicians Association International began the FOI certification program in 1996. Nearly 20,000 workers now hold the Certified Fiber Optics Installer (CFOI) or Technician (CFOT) credential. It is a rare day when one hears of a certified fiber professional who does not hold a well-paying job. Telecommunications companies are hiring workers with fiber skills and knowledge and are training existing employees to handle the growing projected future needs.

During the last decade, the training schools have used one or more of the existing study textbooks in their courses. Suppliers, training institutions, and technical publishers have produced several fine books that have been critical in helping students understand the principles and skills needed to safely and correctly install cable infrastructure. This book is an outgrowth of previous efforts to produce a comprehensive study guide that includes virtually everything needed to become a fiber professional.

The primary author, William Woodward, P.E., CFOT, has taught fiber courses at commercial training schools as well as in industrial settings. Not only does he have a background in copper, coax, and fiber cabling, but his life’s work has been in electronics communications. This includes military and civilian research, development, and quality control experiences. He has served as the Cabling Division Committee Chairman for ETA-I for three years and has been a major part of the certification examination development teams in the Fiber, Copper, Telecommunications, FDR Line Sweeping, and Wireless Communications areas. Few others have the extensive background directly related to fiber, as well as related technologies, that Mr. Woodward has.

Both students and cabling instructors will find this guide invaluable. It not only covers the theoretical, but digs into the practical hands-on practices needed by fiber installers and technicians. It has the most extensive chapter ever written on the functions and usage of all the test equipment now being used by fiber technicians. It is heavy on standards recognition and is an excellent reference manual for cabling professionals. Yes, it is a lengthy textbook, but once you start your studies, you will quickly discover that the easy-to-understand style make it fun, rather than a chore, to learn all about fiber cabling.

Lastly, this text prepares you to pass the ETA CFOI and CFOT certification exams. As you reach the end of the book, the practice exams, and perhaps the end of your classroom training, you will know that you are ready to become a Certified Fiber Optics professional.

—Dick Glass, CETsr
President, Electronics Technicians Association, International
President, NCEE, National Coalition for Electronics Education
Acknowledgments

Writing a book is a team effort that takes a dedicated group of professionals. This is my first book and I am very fortunate to have been able to work with a team of talented and dedicated individuals. The talented staff at Sybex, my coworkers at the ECPI College of Technology and at WR Systems, and my friends and mentors have made this possible.

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Thank you, Lori Skowronski, for your significant contribution to Chapter 12. You spent many hours away from your family to write this chapter and to keep the book on track while I was recovering from surgery. You are a great friend.

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Thanks to the host of people behind-the-scenes that I did not mention for all your efforts to make this book the best that it can be.

Last but not least, thank you to my children, Mike, Brandon, and Kathryn; the love of my life, Susan; and her sons, Eric and Nathan, for your patience, inspiration, encouragement, and prayers. I am the luckiest man alive to have all of you in my life.

—Bill Woodward
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Introduction

This book focuses on building a solid foundation in fiber optic theory. In addition, it describes in great detail fiber optic cable technology, connectorization, splicing, and passive devices. It examines the electronic technology built into fiber optic receivers, transmitters, and test equipment. It also incorporates many of the current industry standards pertaining to optical fiber, connector, splice, and network performance.

This book is an excellent reference for anyone currently working in fiber optics or for the person who just wants to start learning about fiber optics. The book covers in detail all of the competencies of the Electronics Technicians Association International (ETA) fiber optic installer (FOI) and fiber optic technician (FOT) certification.

ETA’s FOI and FOT Programs

The ETA's FOI and FOT programs are the most comprehensive in the industry. Each program requires the student to attend an ETA-approved training school. Each student must achieve a score of 75% or greater on the written exam and satisfactorily complete all the hands-on requirements. Persons interested in obtaining ETA FOI or FOT certification can visit the ETA’s website at www.eta-i.org and get the most up-to-date information on the program and a list of approved training schools.

The ETA FOI certification requires no prerequisite. The FOI program is designed for anyone who is interested in learning how to become a fiber optic installer. The FOI certification is recommended as a prerequisite for the FOT certification. The FOT certification is recommended for anyone who wants to learn how to test a fiber optic link to the current industry standards and how to troubleshoot. Fiber optic certification demonstrates to your employer that you have the knowledge and hands-on skills required to install, test, and troubleshoot fiber optic links and systems. With the push to bring fiber optics to every home, these skills are highly sought after.

What Does This Book Cover?

We’ve put this book together to provide you with a solid foundation in fiber optic technologies and practices. The book is loaded with valuable information, including the following elements:

Assessment test  Directly following this introduction is an assessment test that you should take. It is designed to help you determine how much you already know. Each question is tied to a topic discussed in the book. Using the results of the assessment test, you can figure out the areas where you need to focus your study. Of course, we do recommend that you read the entire book.

Objective-by-objective coverage of the topics you need to know  Each chapter lists the exam objectives covered in that chapter, followed by detailed discussion of each objective. Each objective meets or exceeds an ETA FOI or FOT competency.
Chapter exercises  In each chapter, you’ll find exercises designed to give you the important hands-on experience that is critical for your exam preparation. The exercises support the topics of the chapter, and they walk you through the steps necessary to perform a particular function.

Real World Scenarios  Because reading a book isn’t enough for you to learn how to apply these topics in your everyday duties, we have provided Real World Scenarios in special sidebars. These explain when and why a particular solution would make sense, in a working environment that you’d actually encounter.

Exam Essentials  To highlight what you learn, you’ll find a list of Exam Essentials at the end of each chapter. The Exam Essentials section briefly highlights the topics that need your particular attention as you prepare for the FOI or FOT exam.

Review questions, complete with detailed explanations  Each chapter is followed by a set of review questions that test what you learned in the chapter. The questions are written with the exam in mind, meaning that they are designed to have the same look and feel as what you’ll see on the exam.

Glossary  Throughout each chapter, you will be introduced to important terms and concepts that you will need to know for the FOI or FOT exam. These terms appear in italics within the chapters. At the end of the book, a detailed glossary gives definitions for these terms, as well as other general terms you should know.

How Do You Use This Book?

This book provides a solid foundation for the serious effort of preparing for the ETA FOI or FOT certification exam. To best benefit from this book, you might want to use the following study method:

1. Take the assessment test to identify your weak areas.
2. Study each chapter carefully. Do your best to fully understand the information.
3. Read over the Real World Scenarios to improve your understanding of how to use what you learn in the book.
4. Study the Exam Essentials to make sure that you are familiar with the areas you need to focus on.
5. Answer the review questions at the end of each chapter. If you prefer to answer the questions in a timed and graded format, install the test engine from the book’s companion CD and answer the chapter questions there instead of from the book.
6. Take note of the questions you did not understand, and study the corresponding sections of the book again.
7. Go back over the Exam Essentials.
8. Go through this book’s other training resources, which are included on the book’s accompanying CD. These include electronic flashcards, the electronic version of the assessment test and chapter review questions (try taking them by objective), and two bonus exams.

To learn all the material required to pass the exam, you will need to study regularly and with discipline before and while attending an ETA-approved training course. Try to set aside the
same time every day to study, and select a comfortable and quiet place in which to do it. Do not wait until the break before the exam to start studying. Remember: if you have any questions about the material you are learning, ask your instructor.

**What’s on the CD?**

This book’s companion CD includes numerous simulations, bonus exams, and flashcards to help you study for the exam. We have also included the complete contents of the book in electronic form. The CD’s resources are described here:

**The Sybex test engine preparation software**  These are a collection of multiple-choice questions that will help you prepare for your FOI and FOT exams. You’ll find the following:

- Two bonus exams designed to simulate the actual live exam.
- All the chapter review questions from the book. You can review questions by chapter or by objective, or you can take a random test.
- The assessment test.

**Electronic flashcards for PCs and Palm devices**  The “flashcard” style of question is an effective way to quickly and efficiently test your understanding of the fundamental concepts covered in the exam. The Sybex flashcards set consists of 150 questions presented in a special engine that can run either on your PC or on your hand-held device.

**Fiber Optics Installer and Technician Guide in PDF**  Many people like the convenience of being able to carry their book on a CD. They also like being able to search the text via computer to find specific information quickly and easily. For these reasons, the entire contents of this book are supplied on the companion CD in PDF. We’ve also included Adobe Acrobat Reader, which provides the interface for the PDF contents as well as the search capabilities.

**ETA-Approved Certified Fiber Optics Installer Training Schools**

These training schools are listed in ZIP code order.

- **Telecommunications Training Academy of New England**
  32 Boulevard Road
  Wellesley, MA 02481
  617-784-1844
  Barry McLaughlin, RCDD: barry@barrymclaughlin.com
  www.ttane.com

- **Briarcliffe College**
  1055 Stewart Avenue
  Bethpage, NY 11714
  516-918-3700
  Nancy Klein: nklein@bcl.edu
New Horizons Computer Learning Center of Long Island
6080 Jericho Turnpike
Commack, NY 11725
631-499-7929, ext. 127
Stuart Tenzer: stuart@nhli.com
www.nhli.com

Computer Education Services Corp.
920 Albany Shaker Road
Latham, NY 12110
860-243-1000, ext. 191
Ralph Fraley: rfraley@computeredservices.com
860-243-1000, ext. 174
Holly Banak: hbanak@computeredservices.com

Pittsburgh Job Corps Center
341 Third Street
Pitcairn, PA 15140
412-401-0846
Edward Parady, CET: eepar@aol.com

TBK Technologies
RD#1, Box 546
Adrian, PA 16210
412-600-8185
Robert Keys, FOI: rkeys@teksystems.com

Philadelphia Wireless Technical Institute
1533 Pine Street
Philadelphia, PA 19102
215-928-9960
Richard Agard, FOI: ragard@aol.com

Quality Telecommunications Services, Inc.
5410 Indianhead Highway
Oxon Hill, MD 20745-2021
301-686-0500
Bennie Davis: info@hqtsi.com
Howard Community College
10901 Little Patuxent Parkway
Columbia, MD 21044
410-772-4123 (Dave Rader)
410-772-4856 (Admissions)
Dave Rader: drader@howardcc.edu

Honeywell Technology Solutions, Inc.
7000 Columbia Gateway Drive
P.O. Box 5555
Columbia, MD 21046
410-964-7274
Jeffry Miller, FOI

IES Training Facility
220 8th Avenue N.W.
Glen Burnie, MD 21061
410-760-2990
Craig Jones: cjones@iestraining.com

Northern Virginia Community College
7630 Little River Turnpike, Suite 600
Annandale, VA 22003
703-323-3102
Rickie Harris: riharris@nvcc.edu

Priest Electronics, Inc.
1525 Technology Drive
Chesapeake, VA 23320
800-777-3532
John Hogan: Haggard23434@yahoo.com
Ted Green, FOI: ted@priestelectronics.com

Advanced Technology Center
1800 College Crescent
Virginia Beach, VA 23453
757-468-8960
Robert Stover, FOI: rstover@vbcps.k12.va.us
www.vbatc.com
ECPI
5555 Greenwich Road
Virginia Beach, VA 23462
757-858-6000
Chuck Casbeer, FOI: ccasbeer@ecpi.edu
Bill Woodward, FOI: wwoodwar@wrsystems.com

KITCO Fiber Optics
5269 Cleveland Street, Suite 109
Virginia Beach, VA 23462
888-548-2636
Dan Morris: dmorris@kitcofo.com

WR Systems
2500 Alameda Avenue, Suite 214
Norfolk, VA 23513
757-858-6000, ext. 606
William Woodward, FOI: wwoodwar@wrsystems.com

Yeager Career Center
10 Marland Avenue
Hamlin, WV 25523
304-824-5449
Gregory A Gosnay: ggosnay@access.k12.wv.us

Calhoun Community College
6250 U.S. 31 N.
Tanner, AL 35671
256-306-2972
Sherman Banks: smb@calhoun.edu

Communications Apprenticeship & Training
1400 E. Schaaf Road
Cleveland, OH 44131
216-635-1313
Richard Bowers: rickcatcwa@hotmail.com

Midwest Telecom Training, FiberCamp
2518 Waller Drive
Washington, IN 47501
812-254-3488
Kent Norris: kent@fibercamp.com
Diversified Wiring and Cable, Inc.
6250 Fifteen Mile Road
Sterling Heights, MI 48312
586-264-6500, ext. 245
Al Jankowski, FOI: a.jankowski@dw-c.com

Breakthru Training Solutions
8608 N. Richmond Avenue, 1st Floor
Kansas City, MO 64157
816-584-8177
Christopher Kehoe: ckehoe@btstraining.com
www.BTStraining.com

Central Community College
3134 W. Highway, Suite 34
Grand Island, NE 68802-4903
308-398-7490
Tim Ziller: tziller@cccneb.edu

Louisiana Technical College: Slidell Campus
1000 Canulette Road
Slidell, LA 70458
985-646-6430, ext. 128
William L. Little, FOI: wlittle@theltc.net

Elayn Hunt Correctional Center
Education Department
P.O. Box 174
St. Gabriel, LA 70776-0174
225-319-4266
Madeline McCaleb: eeducation@corrections.state.la.us

Texas State Technical College
3801 Campus Drive
Waco, TX 76705
Sandra Herinckx, FOI: sherinckx@tstc.edu

Cricket Institute of Technology
3727 Pinemont Drive
Houston, TX 77018
713-682-7352
Michael Brittain, FOI: Michael@cricketfiber.com
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The Institute of Robotics
957 NASA Road 1, Suite 261
Houston, TX 77058
281-535-3030
Scarlet Black: rov@irov.com

Montgomery College
102 Longview Drive
Conroe, TX 77301
936-271-6033
David Boden, FOI: boden@nhmccd.edu
www.mc.nhmccd.edu

Texas A&M Riverside Campus
Telecom Training Division
301 Tarrow, Suite 119
College Station, TX 77843-8000
800-645-0686
Joe Smith, FOI: joesmith@tamu.edu

Rocky Mountain Technical Institute
6229 S. Krameria
Greenwood Village, CO 80111
720-200-0784
Tom Janca, CETsr, FOI: trjanca@lucent.com

Casper College
125 College Drive
Casper, WY 82601
307-268-2521
David Arndt, FOI: darndt@caspercollege.edu

FNT Fiber Network Training
3908 E. Broadway, Suite 100
Phoenix, AZ 85040
866-818-8050
Jeffrey Dominique: jeff@f-n-t.com
www.f-n-t.com
Southern Arizona Institute for Advanced Technology
3000 East Valencia, Suite 190
Tucson, AZ 85706
520-573-7399 ext. 109
Kimberly Nichols: knichols@saiat.org
www.saiat.org

Integrated Training Center
4801 Hardware Avenue N.E.
Albuquerque, NM 87109
877-883-4130
Melody Dudley: Melodyd@itc4u.com
www.itc4u.com

JM Fiber Optics, Inc.
6251 Schaefer Avenue, Suite D
Chino, CA 91710-9065
909-628-3445
Kenneth Rivera: krivera@jmfiberoptics.com
www.jmfiberoptics.com

Advanced Training Associates
1900 Joe Crosson Drive, Suite C
El Cajon, CA 92020-1236
619-596-2766
Jose Villaman: tony@advancedtraining.edu

Cable Links Consulting/West Hills College
5100 N. 6th Street, Suite 174
Fresno, CA 93710
877-995-2555
559-225-2555
Sandy Slumberger: slummyclc02@sc.com

Technical Training Seminars
P.O. Box 596
Concord, CA 94522
510-331-1124
Joseph I. Pappaly, FOI: molu@attbi.com
Aviation and Electronic Schools of America  
P.O. Box 1810  
201 South Railroad Street  
Colfax, CA 95713  
800-345-8466  
Evan Neilsen: eneilsen@aesa.com

CORADI Telecom Training Center  
184 Lizama Street  
Barrigada, Guam 96913  
671-734-6897  
Al Alicto, FOI: coradia@netpci.com

Guam Community College  
P.O. Box 23069  
Barrigada, Guam 96921  
671-735-5610  
John Limtiaco, FOI: jlimtiaco@guamcc.net

The Light Brigade  
7691 S. 180th Street  
Kent, WA 98032  
800-451-7128  
Larry Johnson: larry@lightbrigade.com  
www.lightbrigade.com

Renton Technical College  
3701 N.E. 10th Street  
Renton, WA 98056  
425-235-2352  
John Cambroto: jcambroto@rtc.ctc.edu

Vector Technology Institute  
35a Eastwood Park Road  
Kingston, Jamaica KGN10  
876-929-3434  
Rohan Morris: rohmor@cwjamaica.com  
www.vti-institute.com
Approved Military Schools

These training schools are listed in ZIP code order.

Fleet Training Center Norfolk
9459 Bainbridge
CCMM/N752/Fiber Optics
Norfolk, VA 23511
757-444-1262 ext. 3041
Anthony Corey, FOI: ET2-anthony.m.corey@cnet.navy.mil

Sheppard Air Force Base
364th TRS (Fiber Optics)
Building 1950
Wichita Falls, TX 76311
940-676-5541
Ronald Cook: Ronald.Cook@Sheppard.AF.Mil
M Sgt. Wayne Siverling: Wayne.Siverling@Sheppard.AF.Mil

Goodfellow AFB Air Education and Training Command
316th TRS/DOBB
17th Training Wing
156 Marauder Street
Goodfellow AFB, TX 76908-5000
325-654-4535
James Beam, FOI: james.beam@goodfellow.af.mil

Fleet Training Center San Diego
3975 Norman Scott Road, Suite 1
Code N7623/Fiber Optics
San Diego, CA 92136-5588
619-556-7059

Marine Corps/Communications–Electronics
Marine Corps Air Ground
Combat Center
Box 788251
29 Palms, CA 92278-8251
760-830-5028
760-830-6831
John A. Walters: waltersja@29palms.usmc.mil