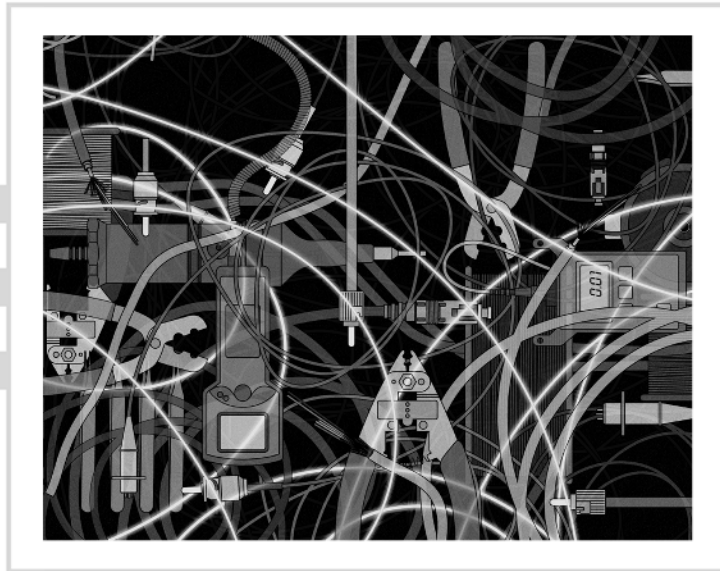


# Fiber Optics Installer and Technician Guide

*Bill Woodward*  
*Emile B. Husson*

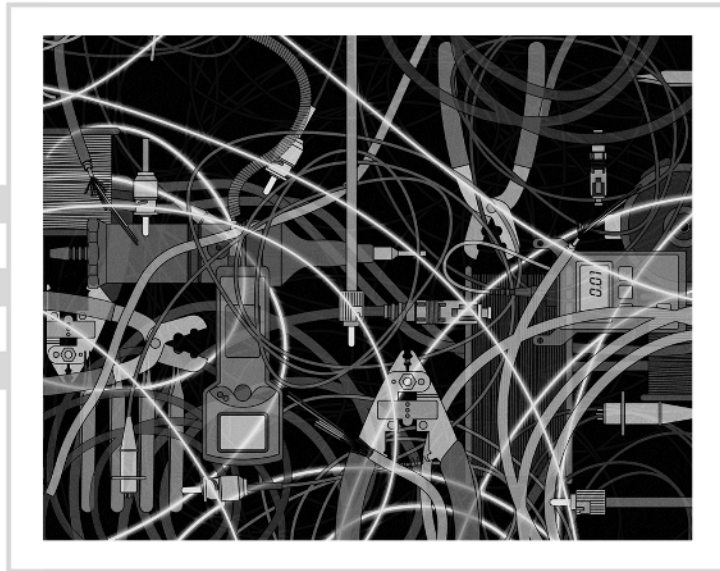
**SYBEX®**

# Fiber Optics Installer and Technician Guide





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Bill Woodward  
Emile B. Husson

San Francisco • London



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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

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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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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](http://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](mailto:barry@barrymclaughlin.com)  
[www.ttane.com](http://www.ttane.com)

Briarcliffe College  
 1055 Stewart Avenue  
 Bethpage, NY 11714  
 516-918-3700  
 Nancy Klein: [nklein@bc1.edu](mailto:nklein@bc1.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](mailto:stuart@nhli.com)  
[www.nhli.com](http://www.nhli.com)

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

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

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

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

Quality Telecommunications Services, Inc.  
5410 Indianhead Highway  
Oxon Hill, MD 20745-2021  
301-686-0500  
Bennie Davis: [info@hqtsi.com](mailto: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  
Jeffrey 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](mailto:ccasbeer@ecpi.edu)  
Bill Woodward, FOI: [wwoodwar@wrsystems.com](mailto:wwoodwar@wrsystems.com)

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

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

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

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

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

Midwest Telecom Training, FiberCamp  
2518 Waller Drive  
Washington, IN 47501  
812-254-3488  
Kent Norris: [kent@fibercamp.com](mailto: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

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](mailto:eneilsen@aesa.com)

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

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

The Light Brigade  
7691 S. 180th Street  
Kent, WA 98032  
800-451-7128  
Larry Johnson: [larry@lightbrigade.com](mailto:larry@lightbrigade.com)  
[www.lightbrigade.com](http://www.lightbrigade.com)

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

Vector Technology Institute  
35a Eastwood Park Road  
Kingston, Jamaica KGN10  
876-929-3434  
Rohan Morris: [rohmor@cwjamaica.com](mailto:rohmor@cwjamaica.com)  
[www.vti-institute.com](http://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  
 MSgt. 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