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The ARRL

ANTENNA BOOK

21st Edition

The *ultimate* reference for Amateur Radio antennas, transmission lines and propagation

INSIDE: Includes the fully searchable book on CD-ROM

The ARRL Antenna Book

All the information you need to design your own complete antenna system.

Since the first edition in September 1939, radio amateurs and professional engineers have turned to **The ARRL Antenna Book** as THE source of current antenna theory and a wealth of practical how-to construction projects. Use this book to discover even the most basic antenna designs— wire and loop antennas, verticals, and Yagis—and for advanced antenna theory and applications. Many of the antennas in this edition benefit directly from advances in sophisticated computer modeling.

This 21st edition has been extensively revised to include information you can use to build highly optimized or specialized antennas. The book includes new content on Near Vertical Incidence Skywave (NVIS) techniques, phased arrays, S-parameters as used in modern vector network analyzers (VNA), Beverage receiving antennas, mobile "screwdriver" antennas, ionospheric area-coverage maps, *and much…much more*.

Fully searchable CD-ROM included!
Bundled with this book is a CD-ROM containing **The ARRL Antenna Book** in its entirety, using the popular Adobe® Reader® software for Microsoft® Windows® and Macintosh® systems. View, search and print from the entire text, including images, photographs, drawings…**everything!**

The CD-ROM contains additional utility programs, including:

- **YW**—Yagi for Windows
- **TLW**—Transmission Line for Windows
- **HFTA**—HF Terrain Assessment for Windows
- **Range-Bearing**— compute range/bearing or latitude/longitude
- **Arrayfeed1**— designing phased-array feed systems
- **EZNEC-ARRL**— antenna modeling for Windows

PLUS propagation forecast tables for more than 170 locations around the world for all portions of the solar cycle!

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Includes a comprehensive glossary and index

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21st Edition

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Tower photo at sunset (front and back): Tower and beam at the station of Francisco R.F. Aragao, PT2TD, in Brasilia, Brazil.

Center image: Kurt Andress, K7NV, working on 40-meter Yagi at N6RO in Oakley, CA. Photo by Dean Straw, N6BV.

Upper right image: UHF antenna. Photo credit: ShutterStock.com.

Lower right image: Some of the members of the C5Z contest DXpedition near Banjul, The Gambia. Photo by Henryk Kotowski, SMØJHF.

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We strive to produce books without errors. Sometimes mistakes do occur, however. When we become aware of problems in our books (other than obvious typographical errors that should not cause our readers any problems) we post an Adobe Portable Document Format (PDF) file on ARRLWeb. If you think you have found an error, please check **www.arrl.org/notes** for corrections. If you don't find a correction there, please let us know, either using the Feedback Form in the back of this book or by sending an e-mail to **pubsfdbk@arrl.org**.

Foreword

We are pleased to offer the 21st edition of *The ARRL Antenna Book*. Since the first edition in September 1939, each new *Antenna Book* has provided more and better information about the fascinating subject of radio antennas. We've sold more than a million *Antenna Books* over the years to amateurs and professionals alike, making it one of the most successful books in our extensive lineup of publications.

Fundamentals about antennas rarely change from edition to edition, but modern application of these fundamentals can result in more highly optimized or specialized antennas. For example, many of the antennas in this new edition benefit directly from advances in sophisticated computer modeling.

We usually update at least 20% of the material in a new edition, and this book is no exception. There have been major revisions in the following chapters:

- Chapter 2: Updated information the concept of "gain."
- Chapter 6: Further insights into the importance of low elevation angles for the lower frequencies, plus a whole new section on NVIS (Near Vertical Incidence Skywave) operation.
- Chapter 8: Completely new section on feeding of phased arrays by W7EL.
- Chapter 13: Updates on Beverage receiving antennas.
- Chapter 14: New "tape-measure" portable Yagi for fox hunting.
- Chapter 16: New information on mobile "screwdriver" antennas.
- Chapter 23: Expanded section on ionospheric area-coverage maps.
- Chapter 27: New section on S-parameters, as used in Vector Network Analyzers (VNAs)

We are fortunate to have the expertise of some well-known and highly talented authorities, who either wrote or reviewed a number of chapters for technical accuracy:

- Rudy Severns, N6LF, and Roy Lewallen, W7EL—low-frequency antennas.
- LB Cebik, W4RNL—Modeling antennas.
- Dick Jansson, WD4FAB—satellite antennas.
- Dave Hallidy, K2DH—EME arrays.
- Bob Hunsucker, AB7VP, and Carl Luetzelschwab, K9LA—HF propagation.

In addition, some exceptional software writers have contributed programs and data for the *Antenna Book*.

- Roy Lewallen, the author of *EZNEC*, has created a special *EZNEC ARRL* program, just for the *Antenna Book*. *EZNEC ARRL* uses the multitude of specialized modeling files also included on the CD-ROM. These models were used in almost every chapter in the book.
- W7EL has also supplied *Arrayfeed1.exe*, a program to design feed systems for phased-arrays.
- Dr Peter Guth and the US Naval Academy have again graciously allowed ARRL to include the versatile *MicroDEM* mapping program on the CD-ROM. *MicroDEM* can easily and quickly generate customized terrain files for the *HFTA* terrain-assessment program, as well as map terrain all around the country using free US topographic data files from the Internet.
- Jim Tabor, NU5S, wrote *GeoAlert-ARRL*, a wonderful freeware program to track propagation trends and to keep tabs on the latest Internet propagation bulletins.
- Dean Straw, N6BV, editor of *The ARRL Antenna Book* has updated and upgraded his *YW* (Yagi for Windows), *TLW* (Transmission Line for Windows) and *HFTA* (HF Terrain Assessment) programs from the 20th edition. A large number of statistical elevation-angle files for QTHs all around the world are included as well. N6BV has also written a new *Range-Bearing* program that is included on the CD-ROM.
- Also included on the CD-ROM are DOS-based utility programs by several authors that analyze antenna tuners, design mobile antennas and LPDAs, and that scale Yagis for *YW*.
- Are you planning on going on a DXpedition to somewhere you've never been before? The CD-ROM now includes both Simplified and Detailed propagation prediction tables for more than 150 QTHs all around the world. Even if you don't journey to distant lands, these tables will give you plenty of insight on planning contesting or DXing strategies—They can also help you set up that Saturday afternoon schedule with your uncle Harry in Cleveland!

You now have in one place the information you need to design your own complete antenna system scientifically—the elevation angles to aim for from your part of the world and the effects of your own local terrain.

As usual, in a publishing effort of this magnitude, errors creep into the process, despite our best efforts. We appreciate hearing from you, our readers, about errors or about suggestions on how future editions might be made even more useful to you. A form for mailing your comments is included at the back of the book, or you can e-mail us at: **pubsfdbk@arrl.org**.

David Sumner, K1ZZ
Executive Vice President
Newington, Connecticut
February 2007

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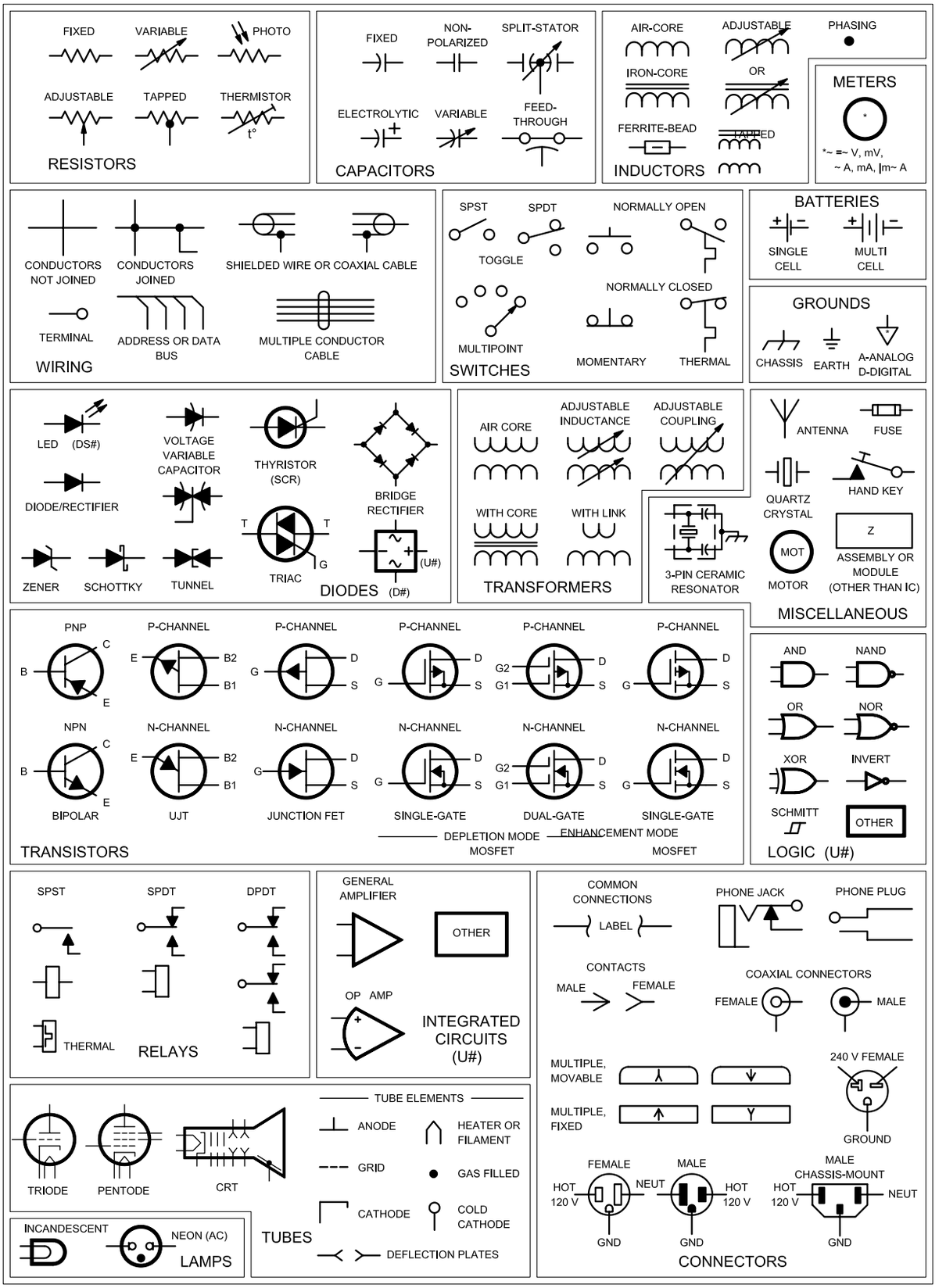

About the ARRL

The seed for Amateur Radio was planted in the 1890s, when Guglielmo Marconi began his experiments in wireless telegraphy. Soon he was joined by dozens, then hundreds, of others who were enthusiastic about sending and receiving messages through the air—some with a commercial interest, but others solely out of a love for this new communications medium. The United States government began licensing Amateur Radio operators in 1912.

By 1914, there were thousands of Amateur Radio operators—hams—in the United States. Hiram Percy Maxim, a leading Hartford, Connecticut inventor and industrialist, saw the need for an organization to band together this fledgling group of radio experimenters. In May 1914 he founded the American Radio Relay League (ARRL) to meet that need.

Today ARRL, with approximately 150,000 members, is the largest organization of radio amateurs in the United States. The ARRL is a not-for-profit organization that:

- promotes interest in Amateur Radio communications and experimentation
- represents US radio amateurs in legislative matters, and
- maintains fraternalism and a high standard of conduct among Amateur Radio operators.

At ARRL headquarters in the Hartford suburb of Newington, the staff helps serve the needs of members. ARRL is also International Secretariat for the International Amateur Radio Union, which is made up of similar societies in 150 countries around the world.

ARRL publishes the monthly journal *QST*, as well as newsletters and many publications covering all aspects of Amateur Radio. Its headquarters station, W1AW, transmits bulletins of interest to radio amateurs and Morse code practice sessions. The ARRL also coordinates an extensive field organization, which includes volunteers who provide technical information and other support services for radio amateurs as well as communications for public-service activities. In addition, ARRL represents US amateurs with the Federal Communications Commission and other government agencies in the US and abroad.

Membership in ARRL means much more than receiving *QST* each month. In addition to the services already described, ARRL offers membership services on a personal level, such as the ARRL Volunteer Examiner Coordinator Program and a QSL bureau.

Full ARRL membership (available only to licensed radio amateurs) gives you a voice in how the affairs of the organization are governed. ARRL policy is set by a Board of Directors (one from each of 15 Divisions). Each year, one-third of the ARRL Board of Directors stands for election by the full members they represent. The day-to-day operation of ARRL HQ is managed by a Chief Executive Officer.

No matter what aspect of Amateur Radio attracts you, ARRL membership is relevant and important. There would be no Amateur Radio as we know it today were it not for the ARRL. We would be happy to welcome you as a member! (An Amateur Radio license is not required for Associate Membership.) For more information about ARRL and answers to any questions you may have about Amateur Radio, write or call:

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