

# The ARRL Antenna Book

## FOR RADIO COMMUNICATIONS



Twenty-Second Edition

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the national association for Amateur Radio™  
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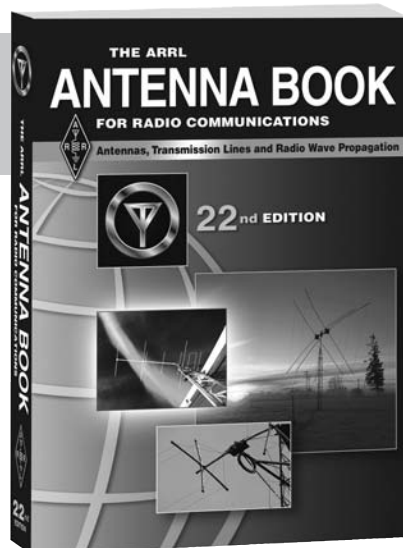
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### Front Cover

*Bottom:* A portion of the cage dipole antenna used at ARRL Headquarters station W1AW in Newington, Connecticut. Photo by Steve Ford, WB8IMY

*Middle:* An aurora display in the Norwegian city of Tromso highlights an Optibeam OB6-6 six element LFA Yagi for 6 meters below a five-element LFA Yagi for 4 meters. Photo by Hans Christian Larssen, LA9AKA.

*Top:* A 20-meter quad antenna and an icy sunrise in Spokane, Washington. Photo by Gordon Grove, WA7LNC.

### Back Cover

A multiband horizontal delta array.

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Twenty-second Edition

# Foreword

As the Amateur Service grew during the pre-World War II era, technology began to outgrow the all-encompassing technical reference of the times, *The ARRL Handbook*. It is a telling observation that the first additional reference text was devoted to antennas and transmission lines and radio wave propagation. That first edition of *The ARRL Antenna Book*, published in 1939, addressed what today's amateurs know well — that antennas and their associated technical concepts and systems are key to success in Amateur Radio. That focus continues in this latest 22nd edition of the book.

Not only are antennas fundamental to Amateur Radio but amateurs are encouraged, even expected, to experiment with the development and construction of an ever-improving array of designs and configurations. Even in a time of electronic miniaturization and sophisticated software, the antenna system remains an element of the service accessible to every amateur. FCC Part 97.1, the Basis and Purpose for the Amateur Service, is clear when it refers to the “Continuation and extension of the amateur’s proven ability to contribute to the advancement of the radio art.” Antennas are at the forefront of fulfilling that purpose.

This edition continues the tradition established more than 70 years ago as it summarizes a broad swath of antenna technology of interest to the amateur community. The book is intended to serve as both a means of education and as a source of design instruction and information. In these pages you will find theoretical material and practical, hands-on advice from knowledgeable and experienced amateurs — there are 213 different listed or referenced authors in the text alone. We have rearranged the new contributions and material from previous editions to provide a more effective learning experience that couples directly to practical designs.

In particular, we are fortunate to include with the book *EZNEC ARRL 5.0* antenna modeling software, contributed by Roy Lewallen, W7EL, recipient of the 2011 Technical Excellence Award from the Dayton Hamvention. Antenna modeling has fundamentally changed antenna design and development and *EZNEC* software sets the amateur standard. An entire chapter is devoted to antenna modeling and an extensive *EZNEC* tutorial by Greg Ordy, W8WWV, is also included on the book’s CD-ROM. Popular software written by this book’s previous editor, Dean Straw, N6BV, is again included in this edition: *HFTA* (HF Terrain Analysis), *TLW* (Transmission Line for Windows), and *YW* (Yagi for Windows).

You’ll also notice that we have made more use of material from our sibling organization, the Radio Society of Great Britain (RSGB). RSGB publications are renowned for their quality and provide alternative perspectives and treatment of antenna topics. Articles from the Wireless Institute of Australia (WIA) also make appearances. We are grateful for their support in this new edition.

Antenna system design takes a new emphasis in this edition. Material previously distributed throughout the book has been collected into a single chapter, **HF Antenna Systems Design** dealing with the effects of local terrain, antenna height, ground conductivity, desired coverage “footprint” and other similar topics. The goal is to help the amateur make better choices to achieve the desired communications objectives by considering “the big picture” as the antenna system components are selected.

New and completely rewritten material includes:

- “Building Antenna Systems and Towers” by Steve Morris, K7LXC
- “Effects of Ground” by Rudy Severns N6LF, including a major update on radial systems and elevated radials
- “Mobile VHF and UHF Antennas” by Alan Applegate KØBG
- The chapter “Mobile and Maritime HF Antennas” has been rewritten by Alan Applegate KØBG and Rudy Severns N6LF, as well.
- The tables listing vendors of Antenna System Materials and Services have been updated and will be maintained as a downloadable spreadsheet on the book’s new website, [www.arrl.org/antenna-book](http://www.arrl.org/antenna-book).

Recognizing the new ways in which antennas are being used and installed, there are new chapters on **Portable Antennas** and **Stealth and Limited-Space Antennas**. These will surely expand in future editions. An area long unaddressed but of value to all amateurs now has its own chapter, **Antenna System Troubleshooting**.

Every edition of the *ARRL Antenna Book* features some exciting new antenna projects. This edition includes the C-pole ground-independent HF antenna by Brian Cake, KF2YN; Patch and Vivaldi Antennas for microwave applications; Kent Britain, WA5VJB's famous "Cheap Yagis" for VHF and UHF use; a 40 Meter Moxon beam by Dave Leeson, W6NL; a TV-to-ham Log-Periodic Conversion by John Stanley, K4ERO; a detailed treatment of his receiving loop antenna design by Gary Breed, K9AY; and a new set of Half-Element Designs for Yagis by Stan Stockton, K5GO.

There are dozens of new supporting PDF files on the CD-ROM. Every project includes the complete construction details. Numerous *QST* articles supplementing or supporting the book's contents are included. You'll find some familiar antenna projects from previous editions included, too. New CD-ROM-only material includes:

- Antenna tuner comparisons and analysis by Bob Neese, KØKR
- Spreadsheets for calculating ground effects by Rudy Severns, N6LF
- "Active Antennas" by Ulrich Rohde, N1UL

The indexes have all been redone to make it easier for the reader to find specific topics. Separate Author and Project Indexes are now included. The structure of the book follows the improved layout of the 2011 *ARRL Handbook* — there is a more detailed master Table of Contents and one at the beginning of each chapter, numbered to three levels, making the book far easier to navigate.

We hope you'll agree that this new edition of *The ARRL Antenna Book* does more than just keep pace with antennas in Amateur Radio. The new material and software, reorganization for better learning and application, expanded use of the CD-ROM and the ARRL website, all make for a more useful reference and learning tool. Wherever there is Amateur Radio, there will surely be an antenna and just as surely, *The ARRL Antenna Book* will be there, too.

David Sumner, K1ZZ  
Chief Executive Officer  
Newington, Connecticut  
September 2011

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## The American Radio Relay League, Inc.

The American Radio Relay League, Inc. is a noncommercial association of radio amateurs, organized for the promotion of interest in Amateur Radio communication and experimentation, for the establishment of networks to provide communication in the event of disasters or other emergencies, for the advancement of the radio art and of the public welfare, for the representation of the radio amateur in legislative matters, and for the maintenance of fraternalism and a high standard of conduct.

ARRL is an incorporated association without capital stock chartered under the laws of the State of Connecticut, and is an exempt organization under Section 501(c)(3) of the Internal Revenue Code of 1986. Its affairs are governed by a Board of Directors, whose voting members are elected every three years by the general membership. The officers are elected or appointed by the directors. The League is noncommercial, and no one

with a pervasive and continuing conflict of interest is eligible for membership on its Board.

"Of, by, and for the radio amateur," the ARRL numbers within its ranks the vast majority of active amateurs in the nation and has a proud history of achievement as the standard-bearer in amateur affairs.

A *bona fide* interest in Amateur Radio is the only essential qualification of membership; an Amateur Radio license is not a prerequisite, although full voting membership is granted only to licensed amateurs in the US.

Membership inquiries and general correspondence should be addressed to the administrative headquarters: ARRL, 225 Main Street, Newington, Connecticut 06111-1494.



## 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:



ARRL — The national association for Amateur Radio

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Fax: 860-594-0259

E-mail: [hq@arrl.org](mailto:hq@arrl.org)

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Prospective new amateurs call (toll-free):

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You can also contact us via e-mail at [newham@arrl.org](mailto:newham@arrl.org)

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# Common Schematic Symbols Used in Circuit Diagrams

