

# The ARRL Antenna Book

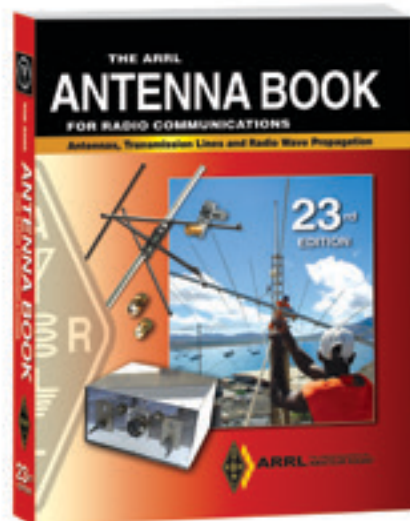
**FOR RADIO COMMUNICATIONS**



Twenty-Third Edition

**Published by:**  
**ARRL**

the national association for Amateur Radio™  
Newington, CT 06111 USA



## Front Cover

Locals on Cape Verde Island assist with the construction of a new antenna at the home of Carlos Pulu, D44AC. Photo by Henryk Kotowski, SM0JHF

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ISBN: 978-1-62595-044-4 Softcover  
978-1-62595-039-0 Hardcover

Twenty-third Edition

# Foreword

This 23rd edition of the *ARRL Antenna Book* carries forward the amateur's relationship with antennas and transmission lines, a common element of Amateur Radio, no matter in what era or on what band or mode. Transmitters and receivers may change, computers may give us an entirely new view of the spectrum and signals, but at the end of the feed line there will always be an antenna to launch our electromagnetic waves into the aether and receive them from others. There literally is no more important part of an amateur's station than the antenna.

Approaching the subject of antennas takes on aspects of both a teaching text and a practical how-to guide. Amateurs may duplicate a project or build from design tables to satisfy an immediate need. Then they can explore the technical aspects of why that particular design works the way it does. Knowing not only that a particular design works, but why, makes an amateur more flexible and robust in pursuit of our service's goals.

Antenna design and construction is also an area in which amateurs make contributions to the state of the art on a regular basis. This book is full of antenna designs pioneered by amateurs from the venerable W8JK array to the high-performance VHF/UHF Yagis making their appearance in this edition. The tools we have available to design and test antennas have grown in sophistication and power by leaps and bounds over the past years and this is reflected in the new designs springing up in every niche of Amateur Radio.

Antenna modeling has fundamentally changed antenna design and development with low-cost or free programs available to amateurs such as *EZNEC* and *4nec2*. A large set of antenna models designed for use with the *EZNEC 6.0* demo software is provided on the CD-ROM that comes with this book. For those of you just getting started with modeling, there is an extensive *EZNEC* tutorial by Greg Ord, W8WWV, also included on the 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).

Building from the previous edition's reorganization, there is a great deal of new material in areas of progress in design and understanding. Justin Johnson, GØKSC, contributed discussion and designs for brand-new VHF and UHF antennas that are changing the game in terrestrial and EME weak-signal operating. Rudy Severns, N6LF, continues to refine our understanding of short vertical antennas and how ground affects the performance of our antenna systems. Meanwhile, Carl Luetzelschwab, K9LA, has not only updated the Propagation chapter but has begun a discussion of MF and LF propagation in anticipation of amateur access to the 630 and 2200 meter bands. Receiving antennas get some attention, too, with both a discussion of metrics and articles on new designs. Grounding and bonding, both key to effective station design and protection, now have their own section that will surely grow with time.

Like those before it, this edition of the *ARRL Antenna Book* adds new and useful antenna projects.

- Multiband HF antennas from 160 through 10 meters
- A simple omnidirectional satellite antenna system
- More of the popular Moxon antennas
- Updated instructions and data services for using *HFTA*
- Stealthy and portable antenna designs for home and away

There are dozens of new supporting PDF files on the CD-ROM and supplementary material on the book's website, [www.arrl.org/arrl-antenna-book-reference](http://www.arrl.org/arrl-antenna-book-reference). Every project includes the complete construction details. Numerous *QST* articles supplementing or supporting the book's contents are included. The time-tested antenna projects from previous editions are included, too. New CD-ROM-only material includes:

- Maximizing the effectiveness of radial systems by Al Christman, K3LC

- The classic Yagi designs of Steve Powlishen, K1FO (SK), long a centerpiece of high-performance Yagi design
- The series of *QST* articles on lightning protection by Ron Block, KB2UYT
- A do-it-yourself satellite azimuth-elevation rotator system by Mark Spencer, WA8SME
- Reference and classic articles on antennas supporting and extending material in the book

There is so much going on in the world of Amateur Radio antennas that just keeping up with developments is almost impossible for an individual. The *ARRL Antenna Book* is the amateur's reference source for a balance of practical designs supplemented with theory and rationale.

David Sumner, K1ZZ  
Chief Executive Officer  
Newington, Connecticut  
September 2015

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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:



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