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Preface

From the start of my radio amateur hobby (1960), I was interested in antennas and antenna constructions. Practically all the antennas I used till today were and are home built. I constructed and installed the antennas: multiband and single-band dipoles, off-center fed dipoles, verticals and ground planes, quads, delta loops, and Yagis. Most of them were only constructed with wire, and all did perform as presupposed. You do not have to be a professional handyman for those simple wire antennas, and it can be done with low cost and simple materials often found in the scrap box or at hamfests.

In those early years of the hobby, the only way to design antennas was by using the formulas mentioned in magazines and handbooks. With the computer entrance into the radio shack, lots of software makes it a lot easier. Antenna modeling programs are now available at low costs and have multiple tools to compute and display the modeled antenna properties as gain, feedpoint SWR, and radiation patterns. Practically from the first release of ELNEC and EZNEC from the author W7EL, Roy W. Lewallen, I started modeling antennas and built several according to the modeled dimensions. I must admit that the computed theoretical dimensions compared to the real-life measurements mainly did agree. When there was significant disagreement, the reason was that the antenna was relatively close to the ground (in fractions of wavelength) or nearby construction influences.

I often modeled and computed antennas for local club members, and more than often, they were pleased and satisfied with the results. For about 25 years, I also have an antenna analyzer, for the moment, an MFJ-269, and this is the best equipment I ever purchased. This analyzer quickly gives me all I want to know about the antenna feedpoint parameters. Adjusting or trimming the antenna to the desired resonant frequency is a much easier task with that tool than doing the necessary measurements and tests with the transmitter and the SWR meter. For those who like to build and experiment with antennas, I thoroughly recommend the purchase of such an antenna analyzer.

The Volumes of *“Practical Antenna Models”* are based on the 90 columns I wrote from 2009 to 2017 for AntenneX online magazine, which stopped since a few years with publishing. The columns become now completely rewritten where convenient. One of the significant additions is the use of the versatile AutoEZ model files. These model files allow you to use variables and equations to specify the coordinates of the wires and the definitions of insert objects, such as sources, loads, transmission lines, networks, etc. Using these options, you can easily optimize your antenna design until the maximum performances you have in mind are reached or even profoundly reorient and reshape your design. These AutoEZ options and features are fully explained in my book *“Advanced Antenna Modeling”* and where expedient, self-evidently in the new Volumes. **Important note:** The AutoEZ is a Microsoft Excel application that works in conjunction with EZNEC v 5.0 (5.0.60 update and higher) and with any release of EZNEC v 6.0. Thus, AutoEZ requires Excel 97 or later. AutoEZ will not operate correctly with other spreadsheet software such as Open Office Calc, Quattro Pro, Microsoft Works, Excel Starter, or Excel earlier than Excel 97. None of these other spreadsheet programs fully support the macros used in AutoEZ.

The use of AutoEZ from the author AC6LA, Dan Maguire, also allows to open not only EZNEC files (using suffix .ez) but many other models type files such as NEC, AO, NEC/Wires, MMANA-GAL, YM, YO, YW, ant, and the model files produced by the programs NEC-WIN+, NEC-WIN-SYNTH, and 4nec2. **Note:** AutoEZ model files have the suffix (.weq).

Acknowledgments

Experimenting, building, and writing about antennas is a time-consuming task. Lots of hours I am busy in my little workshop or backyard or reading magazines and books about antennas or sitting at the computer writing or collecting pieces of information and yes, also in the shack with QSO's. Hours off time I could spend with being together with the family. I know I neglected my family a bit when busy with the hobby and the many months (years) it took to write this book and the previous ones. Even though, without the understanding and encouragement of my family, I would never have finished the books.

I like to express my thanks and that I owe a lot to my family for how they supported me with my hobby. I dedicate this book to them.

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Practical Antenna Models

Introduction

The ionosphere plays a tricky but important role in our radio communications, and it is very little we can do about it. But there is plenty you can do about having a good and efficient antenna system. Yes, the antenna system is not the antenna itself but the whole part as a transmission line and adequately matching the transceiver and the antenna to the transmission line. It is a breath-taking concept that a simple length of wire or rod, or tube can transform electrical energy into invisible radio electromagnetic waves that can cross the space at the speed of light.

How does an antenna system work? Why does the antenna radiate electromagnetic waves? These questions I heard many times, and the answers are not given with few words. Nevertheless, many books and some of great weight and complexity have been written about antennas, and many antenna types have been developed and built. Often, it is not comprehensive to the layman to fully understand the whys and hows of antenna radiation capabilities. These counts even for the simplest ones like a dipole or a ground plane. Also, I often hear many times misconceptions about antenna properties and characteristics. To start with, understanding why and how a simple antenna effectively radiates will be explained in a clear view. The dipole is the best antenna to do that. Once the secrets of the dipole characteristics and properties are fully understood, it will be much easier to have a clear insight into the how's and why's of more complicated antennas.

The first chapter will completely handle antenna fundamentals, mainly with the half-wavelength dipole as a study example. The dipole is also often a part element of more complicated antennas such as a Yagi and others. In particular, for the low-frequency bands, the dipole is used by many radio amateurs as a transmitting or receiving antenna. Its many practical installations and shapes will be thoroughly studied and explained in a chapter later on. In fact, many other antenna types will become subject to an explanation as the antenna story develops.

As mentioned above, it is better to speak about an antenna system consisting of the feedline and matching devices or circuits. If the matching is not correctly done, then the energy of your transmitter or received signal is not fully transferred to your antenna or vice-versa to your receiver. So, also great attention will be taken to these essential matching requirements.

Your antenna is a significant part of your amateur station. The most delicate transmitter equipment is useless if connected to an inadequate antenna. It leads to incredible frustration, while simple gear used in conjunction with a well-engineered antenna system can provide great satisfaction. Amateurs have been using HF antennas for 80 years or more, and some of the best antennas in use today were designed and developed 60 to 70 years ago.

In the decade I got my radio ham license (1961), only a few amateurs used factory-built equipment and antennas. Most were homebrewed or modified Army surplus. Today I believe it is the other way, and only a few build their antennas, and I feel a bit pity about this. Pity because of the many dollars, euros, or whatever your currency might be, spent to buy instead of building the simplest and easy-to-construction antennas. Decent home brewing an antenna is, in my modest opinion, too little done these days. Why is often the question I ask myself, does a radio ham buy a most easy-to-construction and straightforward antenna when he could build it for only 10% of its purchase price and equal working ability? Is it a shortage of time, lack of tinker skill, or lack of necessary know-how or willingness to follow construction tips or examples? Whatever the answers might be, I like to contribute my part of my experience toward more home-building of antennas.

If a fellow radio amateur of my local club decided to give it a try to build and install an antenna, I often got questions as: "How high to install, how long the wire or tube to be made, which wire or other material to use?" These are absolutely not silly or meaningless questions at all, but not also answered with just a few simple words. It is my goal to answer these and many other questions in a not too theoretical

way. However, sometimes the theory is inevitably necessary to provide a good insight into the antenna's workings and properties. High-level math will not be used, only simple equations essential to explain a concept or calculate the length of an antenna element or a matching section. Detailed drawings, graphs, photos, and tables will be used to clarify matters to the whole measure. Where convenient, animation wizards will be presented to show properties in slow motion. The **EZNEC** antenna modeling program will also be used often to compute and illustrate the antenna properties. Such a program is the best a radio amateur who likes to design his antenna(s) can have. In addition, the **AutoEZ** Excel application by Dan Maguire, AC6LA, is strongly recommended. It allows you to use variables and formulas to define wire(s) coordinates variably and optimize the design. I also recommend reading my book "**Advanced Antenna Modeling**" which explains the use of EZNEC and AutoEZ thoroughly. Many modeling tips and the proper use of such a program were found on the L.B. Cebik (SK) webpage. His series about this subject was the best I ever saw and the most revealing to potential pitfalls. Nearly all Cebik's columns, documents, and eBooks are available on my website: <http://www.on5au.be>

Conventions for Text Markers

This book's material involves operating the software, such as selecting from menus, activating calculations, etc. Often your attention is needed to a part of the text or an illustration, etc. to help make references and directions clearly, the following conventions are used:

Bold Characters

A word or words in bold characters is to highlight them or to pull your attention. It might be **Note**, **Remember**, or needs an **odd number** of segments, etc. In the latter, the attention is asked to the text "**odd number**." Also, such as variables **A** and **B** define the element length coordinates and **S** the segmentation number.

A reference to an EZNEC model file is given between square brackets and bold characters as: **[20m dipole.EZ]**. In fact, any reference to a file is highlighted between square brackets and bold characters as **[Ratio-dB.xlsx]** or **[Wizard 1-2.exe]** or **[20m dipole.weq]**.

A reference to a Figure, a Table is highlighted with bold characters as **Figure 2.7** or **Table 5.2**, of which the number ahead the dot refers to the chapter number.

A reference to another Chapter is between double quotes " " and bold characters as: "**Chapter 1: Episode 2**" or "**Chapter 2: Dipoles**", etc.

Activating Menu options or an Action Button or a Selection button or a Checkbox or a Radio button or a series of these are highlighted with bold characters and additionally underlined. Consecutive clicking is separated by > character. Some examples are: **Variables** or **Calculate** or **Src Dat**, or a series of them as **Calculate > Resonate on Selected Cell**.

An entry via the keyboard is marked with bold characters and between angled brackets. For example, when it is required to push the Enter key, this is indicated by **<Enter>**. If necessary, to type the number 12; this is marked as **<12>**.

Italic Characters

Are used for the reference info-text and reference titles as:

From QST November 2000, pp. 34 – 38 "*A Beginner's Guide to Modeling with NEC, Part 1*" or ARRL "***Antenna Book***," Edition 22; Chapter 11 – Page 38 "*A Two Element, 8-Foot Boom Pentaband Quad*".

So, let start with the "***Practical Antenna Models***" **Volume 1**.