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Preface

From the start of my radio amateur hobby, (1960), I was interested in antennas and antenna constructions. Practical all the antennas I used till today were and are home build. Among the antennas, I constructed and installed are multiband and single-band dipoles, off-center fed dipoles, verticals and ground planes, quads, delta loops, and Yagis. Most of them were constructed with wire only and all did perform as presupposed. For those simple wire antennas, you do not have to be a professional handyman and can be done with low cost and simple materials often find 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 as mentioned in magazines and handbooks. Today with the entrance of the computer into the radio shack, lots of software make 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 build several according to the modeled dimensions. I must admit that the computed theoretical dimensions compared to the real-life dimensions did mostly agree. When there was significant disagreement, the reason was that the antenna was rather close to the ground (in fractions of wavelength) or nearby construction influences.

More than often I 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 gives me in an easy manner all I want to know about the antenna feedpoint parameters. Adjusting or trimming the antenna to the desired resonant frequency is with that tool a much easier task, 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 fully 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 major 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. By 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, allows also 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 being busy with the hobby and the many months (years) it did take 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 the way 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, antenna system, it is not the antenna itself but the whole part as a transmission line and matching properly 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 electro-magnetic 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. Never-the-less, many books and some of great weight and complexity have been written about antennas and many antenna types have been developed and build. Often it is not comprehensive to the layman to fully understand the why's and how's of the radiation capabilities of an antenna and 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 effective radiates will be explained in a clear view. The dipole is the best antenna to do that and once the secrets of the dipole characteristics and properties are fully understood it will be much easier to have a clear insight of the how's and why's of more complicated antennas.

The first chapter will handle completely about antenna fundamentals mostly 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 transmitting or receiving antenna and its many practical installations and shapes will be fully 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 properly 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 on these important matching requirements.

Your antenna is a very important part of your amateur station. The finest transmitter equipment is useless if it is connected to an inadequate antenna and leading to great 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 own antennas and I feel a bit pity about this. Pity because of the many dollars, euros, or whatever your currency might be, that is spent to buy instead of building the simplest and easy to construct antennas. Decent home brewing an antenna is to my modest opinion too little done these days. Why is often the question I put to myself, does a radio ham buy a most simple and easy to construct antenna when he could build it for only 10% of its purchase price and with at the least 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 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 where they are necessary to explain a concept or to calculate the length of an antenna element or a matching section. Explicit drawings, graphs, photos, and tables will be used to clarify matters to the fullest measure. Where convenient, animation wizards will be presented to show properties in slow motion. The **EZNEC** antenna modeling program will also be used more than 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 the use variables and formulas to define wire(s) coordinates in a variable manner and to optimize the design. It is also recommended to read my book "**Advanced Antenna Modeling**" which explains thoroughly the use of EZNEC and AutoEZ. Many modeling tips and the proper use of such a program were found at the L.B. Cebik (SK) webpage. His series about this subject was the best I ever found 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

Throughout the material of this book involves operating the software. Such as: selecting from menus, activating calculations and so forth. Often your attention is needed to a part of the text or an illustration, etc. To help references and directions clear, 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 such as **Note:** or **Remember:** or needs an **odd number** of segments, etc. In the latter, the attention is asked to the text "**odd number**". Also, such as variable **A** and **B** define the element length coordinates and **S** the segmentation number.

A reference to an EZNEC model file is highlighted 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**, whereof 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 indicated 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 us start the "**Practical Antenna Models**" **Volume 1**.