

## Table of Contents

Preface and Acknowledgments	-	-	-	-	-	1
Introduction	-	-	-	-	-	3

### Chapter 4: Loop Antennas

Episode 1: Square Loop antennas	-	-	-	-	-	5
Episode 2: Delta Loop Antennas	-	-	-	-	-	15
Episode 3: More Delta Loop Antennas	-	-	-	-	-	26
Episode 4: Half Loop Antennas	-	-	-	-	-	44
Episode 5: Multiband Delta Loops	-	-	-	-	-	74
Episode 6: Horizontally Oriented Loop Antennas	-	-	-	-	-	99
Episode 7: Star-Shape Loop	-	-	-	-	-	119
Episode 8: The IL-ZX Loop	-	-	-	-	-	126
Episode 9: The Hentenna	-	-	-	-	-	136
Episode 10: Magnetic Loops	-	-	-	-	-	142

### Chapter 5: Matching

Episode 1: Some Matching Methods	-	-	-	-	-	174
Accompanying download files	-	-	-	-	--	204
Tables and conversions	-	-	-	-	-	213
Index	-	-	-	-	-	215
Postscript	-	-	-	-	-	218
Other Publications	-	-	-	-	-	218

## 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 built. The antennas I constructed and installed were dipoles, off-center fed dipoles, verticals, ground planes, quads, delta loops, and Yagis. Many of them only used wires, and all performed 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. Today, with the computer's entrance 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, such as gain, feedpoint SWR, and radiation patterns. 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 comparatively close to the ground (in fractions of wavelength) or nearby construction influences.

Often, I modeled and computed antennas for local club members, and more than usual, they were pleased and satisfied with the results. For about 25 years, I have owned an antenna analyzer, for the moment, an MFJ-269, and this is the best equipment I have ever purchased. This analyzer effortlessly 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. I recommend purchasing such an antenna analyzer for those who like to build and experiment with antennas.

The Volumes of "Practical Antenna Models" are based on the ninety columns I wrote from 2009 to 2017 for AntenneX online magazine, which stopped publishing. The columns are now totally rewritten where convenient. One of the significant additions is using the versatile AutoEZ model files. These model files allow you to use variables and equations to specify the coordinates of the wires. Also, the definitions of insert objects, such as sources, loads, transmission lines, networks, etc. Using these options allows efficiently optimizing your antenna design until the maximum performances you have in mind are reached, or even profoundly reorient and reshape your model design. These AutoEZ options and features are described in detail in my book "**Advanced Antenna Modeling**" and, when needed, in the new Volumes, "**Practical Antenna Models.**"

**Important note:** The AutoEZ is an application using Microsoft Excel that calculates in conjunction with EZNEC v 7.0. Now, since January, public domain freeware. 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 Dan Maguire, AC6LA, 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. For many hours daily, I am busy in my little workshop or backyard, reading magazines and books about antennas, sitting at the computer writing or collecting pieces of information, and yes, in the shack with QSOs. Hours off time I could spend being together with the family. I realize 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 I owe a lot to my family for supporting me with my hobby.

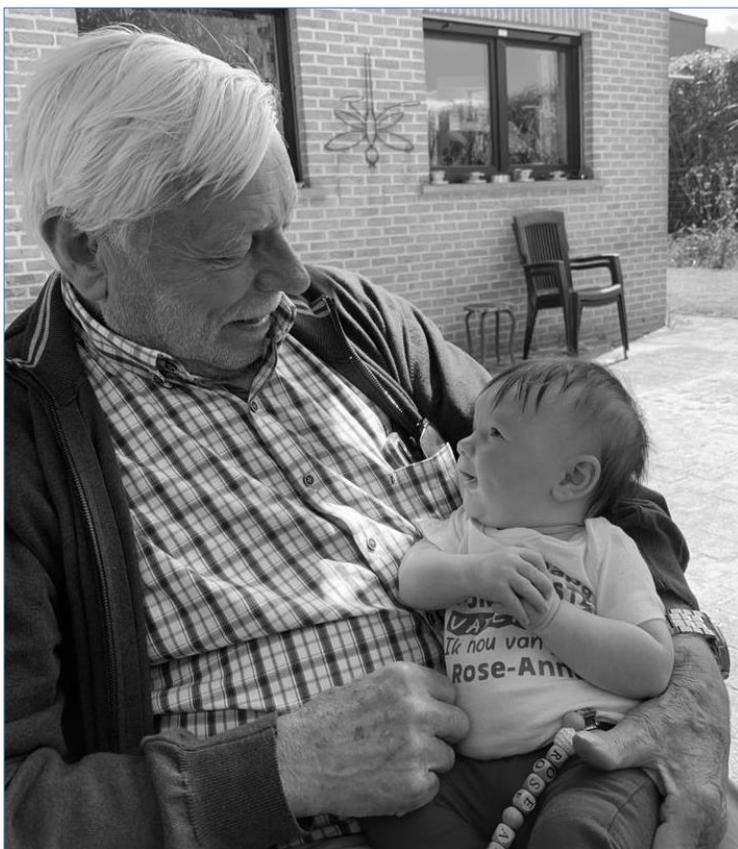
**To Roy Lewallen W7EL**, who released EZNEC Pro2 v7.0 in February 2022 and is available for free. Many thanks, Roy, from everyone who used and was planning to use EZNEC.

**To ON4UN John (SK)**, my dearest friend who passed away in November 2020. I will remember our 60 years of friendship forever.

**To AC6LA Dan Maguire**, the author of the AutoEZ application, who always had a solution for any problem or question I had, and mostly within 24 hours spontaneously. I am sure no one has more knowledge and experience with EZNEC.

### Dedicated To

I dedicate this book to my beloved great-granddaughter **Rose-Anna**, born on the palindrome date **22/02/2022**. You are so unique! Love you!



**Rose-Anna**  
3 ½ month young

Marcel De Canck, ON5AU,  
**79 years young.**  
Rollegem-Kapelle, Belgium.  
August 2022. CUAGN.

# Practical Antenna Models

## Introduction

Your antenna is an essential part of your amateur station. The most delicate transmitter equipment is useless if connected to an inadequate antenna, leading to incredible frustration. In contrast, simple gear 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 pity about this. Pity because of the many spent dollars, euros, or whatever your currency might be to buy, instead of building the most uncomplicated 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, 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 such as: "How high to install, how long the wire or tube to be made, which wire or other material to use?" These are not silly or meaningless questions but are not answered with just a few simple words. I aim to answer these and many other questions in a not too theoretical way. However, sometimes the theory is 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. Expressive drawings, graphs, photos, and tables shall clarify matters to the full measure. The EZNEC antenna modeling program will also be used 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 and optimize the design. I also recommend consulting my book *"Advanced Antenna Modeling,"* explaining the use of EZNEC and AutoEZ thoroughly. Many modeling tips and the proper use of a modeling 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 of 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, an illustration, etc. To make 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 as **Note:** or **Remember:** or needs an **odd number** of segments, etc. In the latter, 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 highlighted between square brackets and bold characters as: **[3.2.1a.EZ]**. In fact, any reference to a file is highlighted between square brackets and bold characters as **[conversions.xlsx]** or **[Wizard 3.1.exe]** or **[3.2.1a.weq]**.

## Introduction

A reference to a Figure, a Table is highlighted with bold characters as **Figure 3.2b** or **Table 3.2**, of which the number ahead the dot refers to the chapter number.

A reference to another Chapter is between double quotes “ ” and bold characters such as: **“Chapter 2: Episode 4”** or **“Chapter 3: Episode 2: Verticals”**, etc.

Activating Menu options, an Action Button, a Selection button, a Checkbox, a Radio button, or a series of these are highlighted with bold characters and underlined. The > symbol indicates consecutive clicking. Some examples are: **Variables**, **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, typing a number (12 as an example); it is stated 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*”.

Meanwhile, EZNEC Pro2+ v. 7.0 is available for free and became public domain in January 2022. Owners of EZNEC Pro4+ v. 6.0 can also update for free to EZNEC Pro4+ v. 7.0. However, EZNEC Pro2+ v. 7.0 allows the use of external engines NEC4 and NEC5. See the table below from Dan Maguire, AC6LA.

Feature Availability vs Engine Choice for EZNEC Pro/2+ and EZNEC Pro/4+				
Feature	Calculating Engine			
	EZCalcD (NEC-2D)	EZCalc4D (NEC-4D)	External NEC-4.2	External NEC-5
Insulated wires	✓	✓	✓	
Buried wires		✓	✓	✓
Unconnected 1-seg wires with insertion objects	✓	✓	✓	
Split sources	✓	✓	✓	
Two ground media	✓	✓	✓	
Two ground media with MININEC ground	✓	✓		
Ground Wave calculation with MININEC ground	✓	✓		✓
Near Field calculation with MININEC ground	✓	✓		✓
Real/High Accuracy (GN2) ground	✓	✓	✓	
Real/Extended Accuracy (GN3) ground		✓	✓	✓
Notes:				
1) Features not listed such as lossy transmission lines, L networks, and transformers are available with all engines.				
2) The EZCalc4D engine is available only to existing EZNEC Pro/4 users.				
3) External NEC-4.2 and/or NEC-5 engines must be purchased from LLNL.				

So, let us start with the **“Practical Antenna Models – Volume 3”**.

**Introduction**