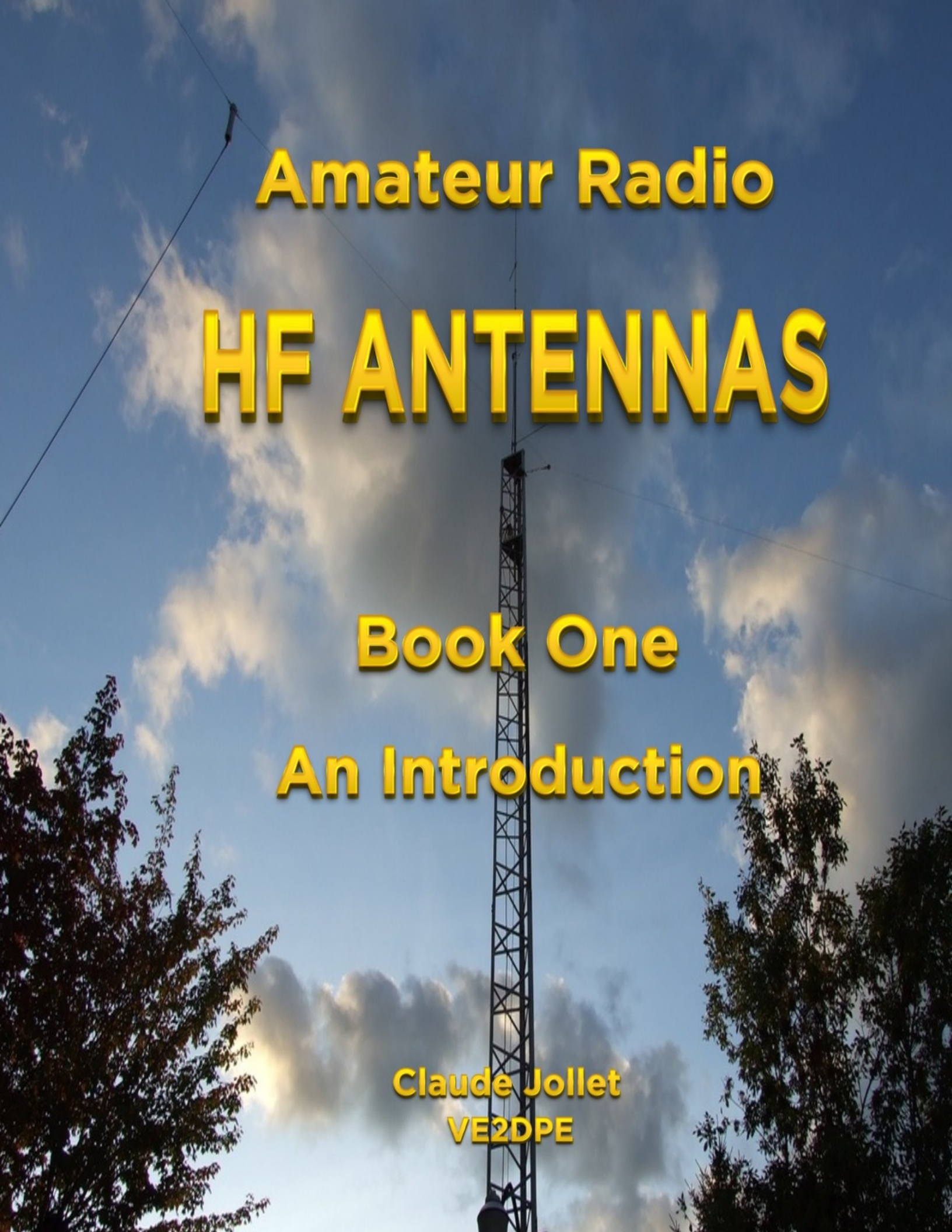

Amateur Radio
HF ANTENNAS
Book One
An Introduction
Claude Jollet
VE2DPE

Amateur Radio
HF ANTENNAS

Book One

An Introduction

by Claude Jollet VE2DPE
First edition published September 2015

MOBI ISBN: 978-0-9916968-2-6
EPUB ISBN: 978-0-9916968-1-9
PDF ISBN: 978-0-9916968-0-2

CIP Data on file with the National Library of Canada.

Legal deposit: third quarter 2015
Quebec National Library And Archives

About This e-Book

What stands between you, the amateur radio operator, and all the other amateur radio operators in the world? Antennas. Yours, theirs…and propagation conditions between. In other words, you can have the most advanced transceiver, coupled with the most powerful amplifier on the market, if you know too little about how antenna systems work and about radio wave propagation, you risk spending your time and money for naught. This e-book is the first of a series on HF antennas. Together, they will help ensure that you turn the situation around to your advantage.

About VE2DPE

Claude Jollet obtained his amateur radio *Basic Certificate* with his operator's license in 1973 and his *Advanced Certificate* in 1974. He has been operating under the call sign VE2DPE from day one. He loves everything about ham radio, but he especially loves to experiment with antennas. Hence his decision to share the fruits of his more than 40 years experience in this e-book and the others in the series. As the call sign reveals, Claude lives in the predominantly French speaking Canadian Province of Québec, in a small town called Notre-Dame-des-Prairies.

Dear Reader

INTRODUCTION
HAM RADIO HF ANTENNAS

All ham radio antennas involve compromises. There are no exceptions. This e-book will show you how to choose the set of compromises that will best fit your particular situation and requirements.

Most ham radio operators use the same antenna for receiving and transmitting on a given amateur radio band. That is the first compromise of many!

The greater the number of frequency bands you want to work with the same antenna system, the greater the number of compromises you will have to live with. The high-performance yagi type antenna in the picture (below) is one of the best set of compromises available for a multi-band operation on HF.

But few of us have the money for a multi-element directional antenna (a yagi or quad) covering all HF bands from 20 to 10 meters, not to mention the tower to support it. Fewer still have the space or the money to have individual antennas for each band!

A Setup To Avoid!

Here is a typical example of the worst possible setup, all too often encountered on the HF bands:

You should avoid being the amateur radio operator calling "CQ" while feeding maximum legal power into a multi-band trap dipole or, worse, a multi-band trap vertical!

If you **are** such an operator, you will often not "hear" the hams answering your calls! Why? Because of the poor receiving efficiency of such multi-band antennas. Even when installed properly, they may "appear" to be "effective" radiators, but be advised that they are very inefficient. Under full legal transmitting power, the signal from such "inefficient" antennas can be detected so far away that the same antenna cannot detect the signal of the DX (far distant) station responding to the call!

What is the point of operating with an antenna system that does not let you hear those who can hear you and are answering your call?

The Ideal Setup

You can easily avoid unbalanced operating conditions such as I described above.

- Reduce transmitting power to correspond to the receiving capabilities of the amateur radio antenna you are using. Remember that a full length half-wave dipole will capture much more RF energy (on receive) than a shortened trap dipole on the same frequency band. Traps introduce resistance and reactance. Part of the RF energy is transformed into heat by the traps. Whatever is left will flow down the transmission line to your receiver or transceiver.

- If you can, use a separate, high performance receiving antenna on each HF band you want to work.

- Or, use a beam-type directional antenna, on your ham radio tower, for both transmitting and receiving (as in the picture shown previously).

If you like to experiment, you can even design your own "dream antenna" that will fit your operating conditions and preferences. You will find all you need to know in the ARRL Antenna Book, including how to use an antenna design program to build your next high-performance homemade ham radio antenna.

CHAPTER ONE

ANTENNA SELECTION TIPS

Every ham radio antenna is full of inevitable compromises. Some antennas have more than others as we will see here. When choosing or building an amateur radio antenna, the most common compromises you have to make will fall in the following categories:

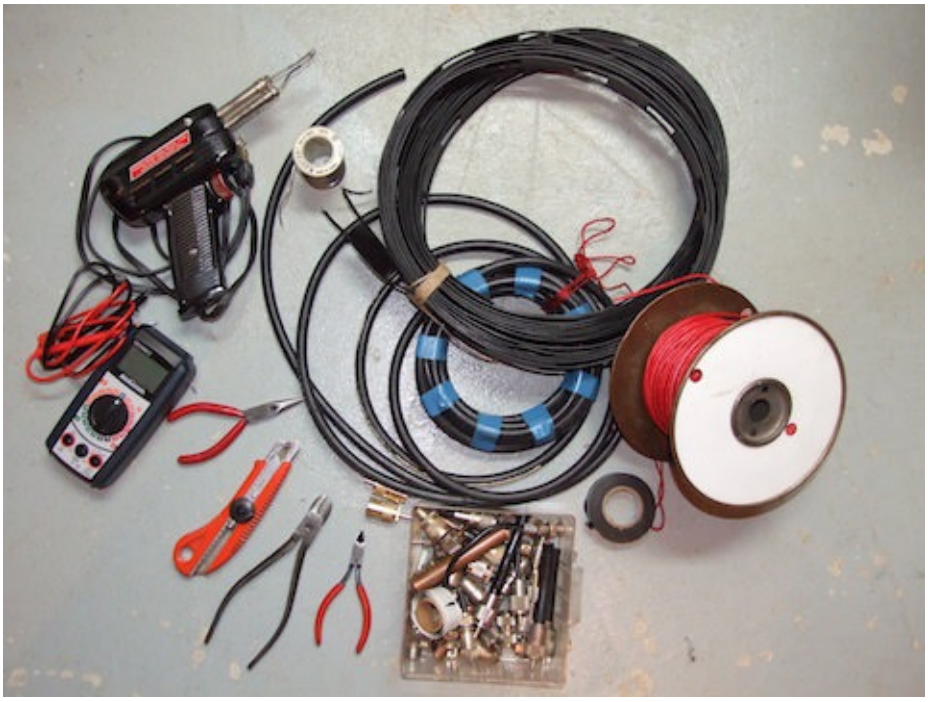
- Cost (for a commercially made antenna or cost of parts if homemade).
- Available space (both horizontal and vertical).
- Durability.
- Performance (of course!).
- City bylaws (increasingly…sigh!).

The above are by no means the only compromises one must make, but addressing them, and finding the best solution for my own needs constitute the kind of challenge I enjoy.

In Search Of The "Perfect" Antenna

If perfect antennas were possible I would make them and become a millionaire! The bad news is that the perfect antenna does not exist, even in theory! The theoretically perfect antenna can never be built… because theory itself is not perfect! However, the good news is that experimenting with homemade antennas is one of the most accessible and enjoyable aspects of amateur radio.

Homemade Ham Radio Antenna



Nothing is more satisfying than building a few antenna prototypes and getting better results with each new one. Trust me. I know because experimenting with homemade antennas is the part of the ham radio hobby that I love the most. I have been tinkering with antennas since 1973.

The aspects I love best are:

1. Studying (learning) antenna theory.
2. Researching and studying experiments made by other hams.
3. Designing my own ham radio wire antenna with its own optimized set of compromises.
4. Building, erecting and testing it on the air.
5. Then starting all over on a new antenna project!

I especially love experimenting with wire antennas of various configurations, including so-called "stealth" (relatively invisible) antennas. In fact, when you hear me on the HF bands, it is likely because I am testing the performance of my latest "baby". I will give you an example, in my soon to be released **Antenna Book Three**, of one of my experimental antennas, the "*VE2DPE 160M Special*".

What if you do not have the necessary horizontal space to put up a full size 160 meter ham radio dipole? Then try your hand at building a much smaller…

- ham radio dipole for 10 meters
- or a folded dipole for 6 meters.

These are easy and fun to build and use on the air!

If you do not have the real estate to put up a "classic" half-wave horizontal dipole, do not despair! I will give you some space-saving configurations of ham radio HF antennas that might do the trick in my soon to be released **Antenna Book Two**.

CHAPTER TWO

THE CLASSIC DIPOLE

The ham radio dipole is called a half-wave antenna because its length corresponds to an electrical half wave at the frequency for which it is intended. The dipole will always be physically shorter than its “free space” length. Why? First, the resistance in the antenna wire slightly impedes the flow of RF energy. Second, impedance and reactance also slowdown the flow of RF current. These are introduced by:

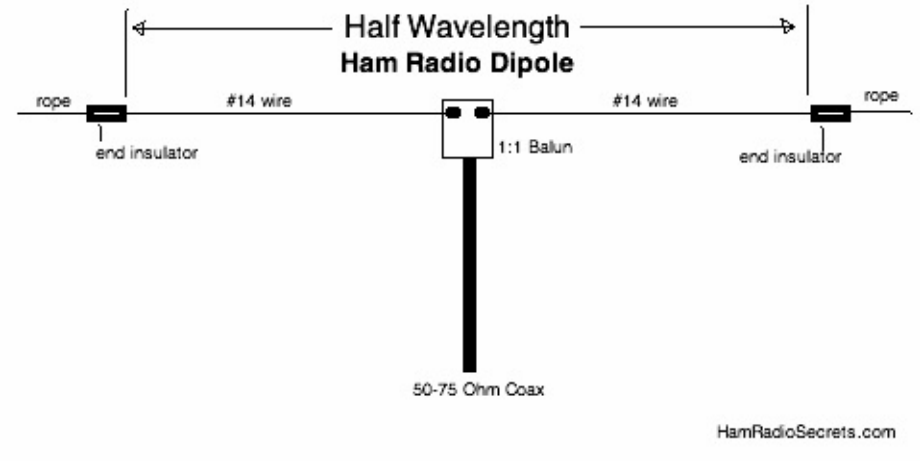
- ground conductivity below the antenna,
- its height above ground,
- and the presence of buildings and trees in the vicinity.

The dipole is called a balanced antenna because it is “fed” at its exact center. In other words, the transmission line is connected at the center. The majority of amateur radio operators throughout the world choose this antenna over other types, at least, to start.

Why Is The Dipole So Popular?

Because it is an inexpensive, yet effective, antenna. Hams can cut costs further by building it themselves using wire, insulators and rope that they already have in their (or a friend's) “junk box” of spare parts!

A Picture Is Worth…



In "free space", the characteristic impedance of a half wave dipole is around 73 ohms and it's length, in meters, is obtained by this formula:

length in meters = (299.7925 / frequency in MHz) / 2

Thus a dipole on the 20 meter band would measure (in free space): (299.7925 / 14) / 2 = 10.706875 meters or 35.127543 feet long.

However, if the horizontal dipole is between 0.1 and 0.2 wavelength above ground, its impedance will be somewhat lower and closer to 50 ohms, which is the characteristic impedance of commonly used coaxial transmission line such as RG-8, RG-8X and RG-58.

As a bonus, the impedance will remain low at odd harmonic multiples of the basic frequency! Yes, you can operate a 40 meter (7 MHz) dipole on 15 meters (21 MHz) too. A two-for-one antenna!

The Antenna "System"

Bear in mind that the antenna is only part of a coherent system! An antenna system is composed of:

- The antenna (the radiating and receiving portion).
- The transmission line (carrying the RF energy between the antenna and the transceiver).
- The impedance matching unit between the transceiver and the transmission line (if one is used).

The transceiver or receiver will "see" the above three components as a whole.

Dipole Formula

The formula to calculate the (approximate) overall **physical length** of a dipole is:

Length (meters) = 142.58 / frequency (MHz)

Length (feet) = 468 / frequency (MHz)

Thus, the operating length of a half wave dipole on the 20 meter band (14 MHz) would be:

468 / 14 = 33.4286 feet (1.7 feet *shorter* than in free space)

The length of wire obtained by the formula is cut in half. The transmission line connects between each half of wire, which becomes the dipole's feed point.

It is worth repeating here that the above formula gives an approximate result because the length at the desired resonant frequency is affected by its operating environment conditions, such as:

- the antenna height above ground,
- the conductivity of the ground itself,
- the proximity of metal structures and other objects such as trees and power lines.

Dipole *Resonant* Length

Most dipoles will require a little “pruning” (on site) to resonate at the desired frequency. I recommend that you:

1. Cut your dipole wire some 2-3% longer than the length given by the formula.
2. Make a note of the length obtained in step 1.
3. Raise the dipole to its operating height.
4. Measure the SWR at several frequencies within the intended frequency band. (Use only a few watts and pick a quiet time on the band to make your tests).
5. Note the frequency (F_min) at which minimum SWR is obtained.
6. Multiply (F_min) by the antenna length recorded in step 2.
7. Divide the result of the above multiplication by the desired frequency of operation, to obtain the final length.
8. Trim both ends of the dipole down to the final length obtained in step 7.

Transmission Line

You can feed your dipole with coax, as already mentioned above. However, coaxial cable is unbalanced! When feeding a balanced load, such as a dipole, with an unbalanced transmission line, the antenna will induce RF currents on the outer shield of the coax during transmission.

These unwanted RF currents spell nothing but trouble, not the least of which are RFI (radio frequency interference) caused by stray RF energy being radiated back in the shack to wreak havoc with your computer or other delicate electronic devices!

Fortunately, you can prevent these unwanted RF currents from traveling back on the outer shield of your coaxial transmission line with a RF choke.

RF Choke Balun

To make a choke balun, all you need to do is wind a portion of the coaxial transmission line to form a coil. A choke balun made of coax is most effective when a single layer is close-wound on a form, such as 4 inch plastic drainpipe or 6 inch “schedule 40” PVC pipe. The tables below list values for each HF amateur band. Form size and number of turns are optimized for each band.

Single Band RF Chokes
(most effective)

Band (meters)	**Form** (inches)	**Coax RG-213 RG-8**	**Coax RG-8X RG-58**
160	6 in.	8 turns	5-6 turns
80	6 in.	8 turns	5-6 turns
40	6 in.	8 turns	5-6 turns
30	6 in.	8 turns	5-6 turns
20	4 in.	12 turns	7-8 turns
17	4 in.	12 turns	7-8 turns
15	4 in.	6 turns	4-5 turns
12	4 in.	6 turns	4-5 turns
10	4 in.	6 turns	4 turns

Multi-Band RF Chokes

Freq. Range (MHz)	**COAX**: RG-8, RG-58, RG-59, RG-8X, RG-213
3.5 - 30	3.05 m. (10 ft.), 7 turns
3.5 - 10	5.49 m. (18 ft.), 9-10 turns
14 - 30	2.44 m. (8 ft.), 6-7 turns

Alternatively, you could use Amidon(TM) *31 material* cable clamp ons. These molded ferrite clamp ons come in different sizes and shapes to fit over RG-58, RG-59, RG-8 coax cables. The *31 material* ferrite formula is designed to stop RF, in the range between 1 to 300 MHz, from travelling back in the shack along the outer shield of the coaxial transmission line. I install two to four of these (as needed) on the coax, outdoors, just before the cable enters the outside wall to my radio room.

Dipole Hardware

Many types of wire, insulators and rope can be pressed into service for a temporary installation. But for a permanent and safe all-weather installation, here is what I recommend.

Wire

I use either 14 gauge stranded (7x22) hard-drawn copper wire, for spans less than 45 meters (150 ft.) between **stable** supports. But when a dipole antenna needs to be strung between trees, I recommend the very strong VariFlex(TM) 13 gauge, 19 strand, copper-clad steel wire. I use the latter for 80 meter dipoles that I install between the maple trees that I'm fortunate to have on either side of my house.

Insulators

You can use a ceramic "*dog bone*" as center insulator, but you will have to wrap your coax around it, tie it securely with tie-wraps, then split the center conductor and braid to connect to each side of your ham radio dipole, then seal to prevent water from seeping in the coax! Not exactly the best setup.

I prefer using a center insulator with a SO-239 which makes it much easier to seal against water infiltration. I like to use Coax-Seal(TM) for this purpose.

Of course, you could use a commercially made 1:1 balun at the dipole feed point. It will serve as center insulator and coax connector. The balun will improve the radiation pattern somewhat ... if your dipole is at least 1/4 wavelength above ground.

Finally, I use Delta CIN ceramic end insulators by Alpha Delta Communications, at each end of a dipole, for their resistance to RF and long leakage path. Remember that high voltage is present at each end of a dipole while transmitting!

Rope

I have had a dipole strung between two large trees for years with (3/16 in.) Mil Spec Dacron® rope. My antenna is still up there! This rope is very strong, abrasion and UV resistant.

A Reminder

Take your ham radio dipole down at least once a year to check for damage (frayed ropes, damaged coaxial shield or connection, etc). Repeat this inspection more than once a year if you have had severe weather.

— 73 —

More About The Author

Claude Jollet is a self-proclaimed *incorrigible eclectic*. His day job was in operational meteorology for 31 years. He also has a degree in Management Information Systems and Computer Programming.

He had been sharing his passion, knowledge and know-how on websites since 2005, and decided in 2015 to become a self-publisher of e-books.

His website focusing on **amateur radio** is: HamRadioSecrets.com.

His Other Websites

He is also the author and webmaster of the following websites:

www.Meteo-NDP.info (French)

www.Claude-Jollet-Ecrivain.info (French)

www.ClaudeJollet.com where he "bloomed out of anonymity" (his words).

You can follow Claude on Twitter, get in touch on Facebook, connect with him on LinkedIn, or e-mail him at ve2dpe@hamradiosecrets.com.

Other Books In This Series

This e-book is the first of a series on HF antennas. It is available in these three (3) popular formats: PDF, Kindle, ePub.

The other e-books in the series are:

BOOK TWO - Space Saving HF Antennas for Amateur Radio

BOOK THREE - Homemade Amateur Radio HF Antennas

BOOK FOUR - Amateur Radio HF Antenna Accessories

BOOK FIVE - Four-Book Compendium

All his e-books on antennas are deliberately short and to the point. They are devoid of unnecessary prose that would only distract and prevent the reader from acquiring practical and immediately useful knowledge.

If you would like to be automatically informed when the next e-books in the series and their updates are released, visit his Ham Radio Blog and subscribe to its RSS feed.

May I Ask?

Have you found this e-book helpful? Please spread the word on your favorite social media channel. Share your opinion of this book. Have you found it to be of no particular use to you? Spread the word anyway! Others may not possess your level of knowledge and know-how. Let them know of this e-book. They might thank you for the tip.

Dedication

This e-book is dedicated to all amateur radio operators who love and long to share their knowledge and know-how about the *King of Hobbies*.

Acknowledgments

My many websites testify to my love of writing about my various passions, and areas of expertise. But my decision to publish e-books — and eventually their printed versions — comes from my exposure to the exceptional community of fellow website owners on the SBI! Forums. Among them, Harvey Chapman has influenced me the most. I thank him for his continuous contributions of priceless information which gave me the tools to develop the patience needed to undertake the painstaking work required to become a successful self-published author.

I learned how to promote my services and my writings, online and successfully, from a man named Ken Evoy. I will be forever in his debt.

I have to tip my hat to the people at Serenity Software for their exceptional *Editor*. This software forces me to think how best to say what I want to communicate by making me go through a rigorous multi-step self-editing process with each of my texts. The result is *near perfect* and saves me hundreds of dollars in professional editing services. I may eventually hire a professional editor anyway — after my self-edited e-books have generated enough income — because, honestly, it requires a great deal of tedious work!

Finally, I need to thank my wife for humoring me while I toil behind closed doors on these e-books, with strict orders not to be disturbed, barring a fire or an earthquake. It works…often enough.

Table of Contents