

# Simple and Effective Antennas for Amateur Radio Operators

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This paper will cover the following points:

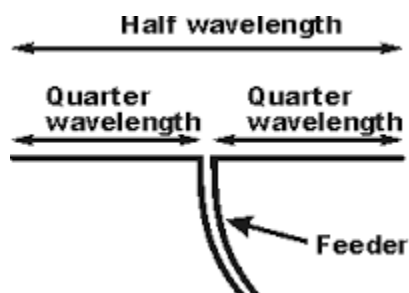
- What is an antenna?
- Resonant antennas
- Non-resonant antennas
- Balanced versus unbalanced antennas
- Antenna Directivity
- Antenna Couplers
- Polarisation
- Basic constructional Techniques

## What is an antenna?

Antennas are radiators. Good ones radiate electromagnetic energy enabling communications over varying distances. Here is a definition from the ARRL. 'Antennas belong to a class of devices called "transducers". This term is derived from two Latin words, meaning to "lead across" or "to transfer". Thus, a transducer is a device that transfers, or converts, energy from one form to another. The purpose of an antenna is to convert radio-frequency electric current to electromagnetic waves, which are then radiated into space' (The ARRL Antenna Book, 2000, p. 2.1).

## Resonant Antennas

The most common and proven performer in basic antennas is the half wave dipole ( $\lambda/2$ ). Lambda, the 11<sup>th</sup> letter of the Greek alphabet is the symbol used for dipole, so  $\lambda/2$  means a half-wave dipole. We refer to our band from 7.000 MHz to 7.300 MHz as the 40 metre amateur band. In US books the band is also referred to as the 40 metre amateur band, but construction details for such an antenna are usually given in the Imperial measurement of feet and inches. A 40 metre dipole, cut for, that is, resonant at 7.150 MHz will only be resonant at one point.



If you decided to make such an antenna where would you make it resonant? I would choose 7.100 MHz approximately. I indicated earlier that this antenna is assumed to have a nominal

impedance of 50 ohms, so it can be fed with a light-weight coaxial feed-line with a characteristic impedance of 50 ohms. If you expect to use a transceiver generating 100 watts in a suburban block I would use RG58 (the best quality I could afford – double shielded is the best). I would also balance the antenna by adding a balun at the feed-point. I will say more about this later. A half-wave dipole antenna is easy to construct as a single band antenna.

A full-wave length antenna can be calculated in feet by the formula  $984/F$  (MHz) and a  $\lambda/2$  is obtained by dividing the figure above the line by two (2). So a half-wave length antenna in feet will be  $492/F$  (MHz).

$492/7.1 = 69.29$  feet or 35 feet either side of the centre. If you want to compute the length in metres it is done this way:

$142.6464/7.1 = 20.09$  metres.

However, if you get to work and construct the antenna to this formula it will be *too* long and it will not work on 7.1 with a vswr of 2:1 or below. The formula only applies in space and with perfect conditions. So you need to use a modified formula:

$468/F$  (MHz) or  $468/7.1 = 65.9155$  or 65.92 feet or 66 feet will be fine. So if you cut your antenna 66 feet long, that is, 33 feet each side of feed point or centre and located above ground somewhere between seven and 10 metres, away from metal objects (cars, sheds, clothes-lines etc.), it will work. Other relevant factors in determining where the resonant point is, are: diameter of the wire, insulated or not, geometry of the antenna (horizontal or inverted-vee or a combination of these two) and whether the antenna is balanced or not and the nature of the ground. The rule of thumb is, cut your antenna to a length a few centimetres (inches) longer and trim each leg equally in small lengths using your antenna analyser to check the frequency as you go. Now I know we adopted decimal measurements in the 1960's and I use the metric measures of length *most* of the time, but for making antennas I prefer to work in inches and feet. For me it is easier than metres, centimetres and millimetres!

## **Non-Resonant Antennas**

### *Universal Antenna*

An old favourite and a very useful antenna is a centre-fed dipole fed with an open wire feeder. This antenna is commonly referred to as a Universal Antenna (Orr & Cowan, 1972, pp. 157 - 166). It is *not* a G5RV. One hundred feet across the top and a feeder of a quarter-wave length long, or multiples of a quarter wavelength, will allow you to operate on all bands from 3.5 to 28 MHz. You can use 300 ohm ribbon, commercially available 450 ohm twin lead or home-brewed 450 ohm line using appropriate spreaders (<http://www.tetemtron.com.au>), or wider still to make 600 ohm feeder. To operate this antenna you need a balanced tuner or a standard tuner, e.g. a T-match and a 4:1 balun. A better approach than bringing balanced feed-line into the shack is to use a standard tuner and a 4:1 balun mounted under the eaves. The transition to coaxial line occurs here.

There are other practical issues to sort out if you choose this approach, e.g. keeping your open wire feeder free of kinks, from twisting and flapping in the wind and away from metal objects and avoiding sharp bends (ARRL, 1974, pp. 264 ff).

### G5RV

Louis Varney, G5RV, died on June 28<sup>th</sup> 2000. He was 89 years of age.

(<http://www.g0mwt.org.uk/society/g5rvfold/g5rv.htm>)

He developed the popular non-resonant, multi-band antenna, now known by his call-sign G5RV. This antenna is a dipole 102 feet long along the top fed by 29 feet six inches of 300 ohm ribbon (or 34 feet of open wire feeder) and then coaxial cable to the antenna coupler. The theory of operation of this antenna is too complex and detailed to discuss here (see Moxon, 1977, pp. 185 ff) for a detailed explanation band by band.

### Random Wire

The Marconi or random wire can also work, satisfactorily, for a home station. I do not recommend this antenna for portable use. It is just too difficult to obtain a satisfactory ground without an extensive counterpoise, made even more difficult, if you are operating over rock.

But at a home station a random wire can be useful. The challenge is defining the word 'random' (see Bertrand & Wait, 2005, p.82). If you make your random wire 33 feet long and use a counterpoise 33 feet long, the same handbook defines it as '30 Up and Out' (p. 83), but Kleinschmidt (1999- 2001, p. 4.12) describes it as 33 feet vertical turned on its side. But because of the length, 33 feet, it is effectively a single band antenna (40m) and becomes a half wave-length on 20 metres. Random means avoiding a length where the antenna becomes a half-wave length long on any of your bands of interest. I have an Alinco EDX-2 automatic antenna tuner and I have included Alinco's formula for calculating *undesirable* antenna lengths for amateur bands. I did the arithmetic and settled on 43 feet as a useful antenna length for a random wire. Some antenna manufacturers build vertical antennas to this length.

#### ■ CALCULATION OF UNDESIRABLE ANTENNA LENGTH

Certain length of antenna element could be extremely difficult to tune with EDX-2, besides causing high-voltage on the radio chassis.  
Such lengths are dependent on your operating frequency, and can be calculated as follows.

$$\text{Length of half-wave and its multiples } (1/2 \lambda) = \frac{300}{\text{Operating frequency ( MHz )}} \times \frac{1}{2} \times n$$

[ EXAMPLE ] Undesirable antenna length with an operating frequency of 29.00MHz

$$\text{Multiple of } 1/2 \lambda = \frac{300}{29} \times \frac{1}{2} \times ( 1, 2, 3, 4, \dots ) = 5.2, 10.3, 15.5 \text{ m etc.}$$

## Balanced versus Un-balanced Antennas

Kleinschmidt (1999 – 2001, p. 4.5 ff.) provided a simple explanation of why balanced antennas perform better than unbalanced. Essentially it is to do with current flow. You want your antenna to radiate effectively. I use un-balanced antennas when operating QRP in the field. I only use five watts. Current flowing on the coax shield, interference to others and skewed pattern are not really issues, but at home with 100 watt transceivers, I always use balanced antennas. If you want both sides of your antenna to radiate equally and avoid currents flowing on the outside of the coax (making it RF hot) use a balun.

Baluns with a 1:1 or 4:1 ratio can be purchased for as little as \$50 from Australian suppliers. These baluns are made by LDG and need water-proofing if you mount them outside. You can make your own: I have two home-brewed models here today on display. You can also purchase a balun kit from Tet-Emtron. If you decide to have a balun in place permanently on your antenna you need to make it waterproof, which can be a difficult task. I used my 'sewer pipe' balun, which is a 4:1 balun, mounted under the eaves. I used this to feed a flat-top dipole with 450 ohm open wire feeder.

## Antenna Directivity

Nearly all antennas have some tendency to radiate better in some directions than in others. Here is my definition. If an antenna produces *a radiated signal in one direction stronger than another when compared with an antenna which radiates in all directions equally, such an antenna is said to have gain* (my emphasis). Gain is a quality usually attributed to beam antennas and collinear vertical antennas. It is beyond the scope of the presentation to discuss this any further today.

## Antenna Couplers

'(An) antenna tuner is a variable impedance transforming device that can transform the impedance of an antenna system to that it appears to the transmitter as a 50 ohm load' (Hallas, 2010, 1.4). I thoroughly recommend Joel Hallas's 2010 book if you are interested in antenna couplers, to use a more precise term. He describes the various circuits used, discusses the pros and cons of manual and auto tuners, reviews a number of recent commercial products and describes home brewing techniques. He states that a home-made tuner is within the capability of most amateurs and describes and gives circuit values for a T-network, a Pi-network and a Low-pass L network (Hallas, 2010, p. 15.12). I have brought along two on my home brew devices to show you how easy it is to build attractive and useful accessories for your shack. The first coupler on display is an L-Network for 160 metres and above. This coupler enabled me to load my home brew 160 metre am/cw transmitter into a quarter wave antenna cut for 160 metres and work cw on, say 1815 KHz and also the ssb/(am 1843 KHz) portions of the band. It is capable of handling 100 watts pep. I used a transmitter of 13 watts DC input to the final; almost QRP!



Photo 1

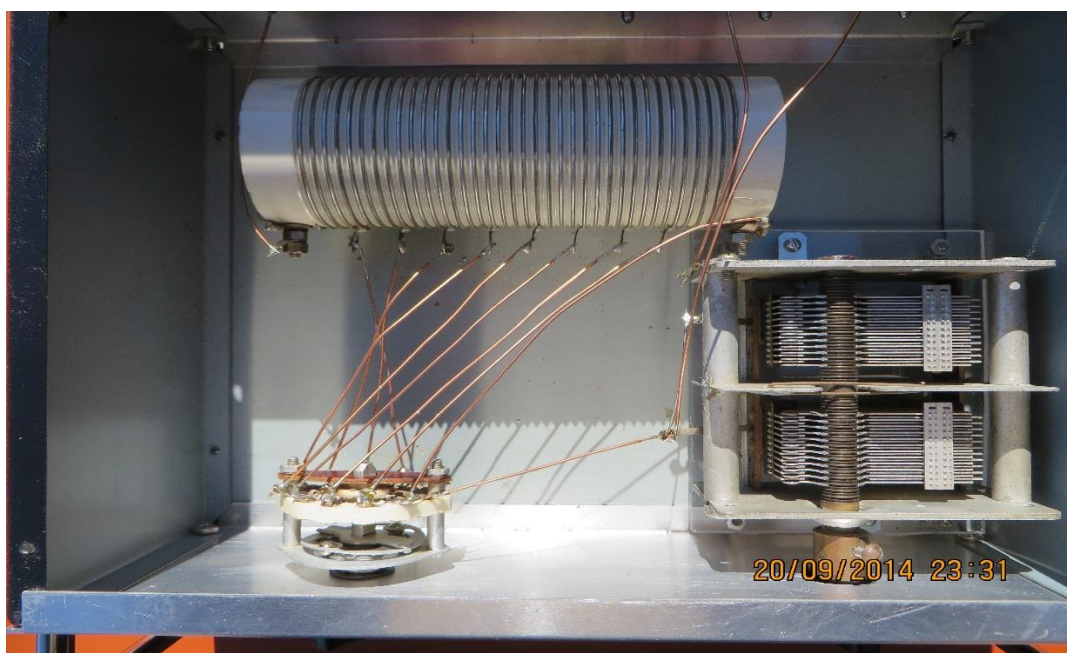


Photo 2

You will notice (photo 2) that the dual-gang capacitor is not directly bolted to the case. It sits above RF ground and that is achieved by fixing the capacitor to a polycarbonate sheet and then bolting that on spacers above the bottom of the case.

The circuit for this coupler came from Orr & Cowan (1972, p. 99). Photo 1 shows the front of the coupler and photo 2 the interior and circuit components. The most difficult components to find were the coils. They came from the AHARS buy and sell. The capacitor is a standard broadcast type of about 425 pf. If more C is needed just add a high voltage good quality fixed capacitor across the variable C and make it switchable. If you look at Orr & Cowan

(1972) you will see I took a very different approach to constructing my device, as I used a closed box.

Another coupler I have used a great deal is a parallel tuned circuit. These have only commonly become available very recently. Here is my very small SOTABEAMS Mountain Tuner for 40 – 17 metre half wave length antennas (<http://www.sotabeams.co.uk/antenna-tuners/>). Matching a half wave length antenna to a 50 ohm radio requires a parallel-tuned circuit, that is, a coil and capacitor in parallel. But here are pictures of my home brew parallel tuned coupler which does a great job, but a bit too heavy and large for mountain topping!

Photo 3 shows the front of the box.



Photo 3

Photo 4 shows the circuit components. Again I was fortunate in obtaining a coil and capacitor at the AHARS buy and sell. Amateurs a generation or two before me knew where these components came from, usually war service equipment that became available to amateurs in the 1950's. You will see I used good quality tinned copper wire for the links to the switch. Heavy duty switches are hard to obtain. You should not hot-switch any tuner. You will burn the contacts and destroy the switch if you do! This coupler enabled me to use a quarter wave long wire, cut for 1843 KHz on the 80 metre band: a half wave length end-fed antenna having a little more gain than a quarter wave length long-wire.



**Photo 4**

I recommend building and using manual antenna tuners. These projects are within the range of most amateurs as home brew projects. I have auto-tuners but prefer using the manual ones. You will achieve worthwhile and attractive components for your radio shack.

### **Polarisation**

The polarisation of a radio wave is determined by the position of the radiated field leaving the antenna. If it is horizontal to the ground it is said to be horizontally polarised. If it is vertical to the ground it is said to be vertically polarised. The definition applies to the radio wave but amateurs also refer to the antenna as being polarised as well: vertical, horizontal or circular.

In amateur operations conventions apply. FM is usually vertically polarised. Weak signal VHF/UHF and microwave work is usually conducted using horizontally polarised signals. On high frequency signals polarisation is usually not as critical and therefore both horizontal and vertical polarisation are used.

### **Basic Constructional Techniques**

When you read most constructional articles from the well-known publishers they give you the basics. However, translating the basics into practical approaches is left to the constructor. Great ideas and basic techniques can be found in Drew Diamond's books (see references). If you are looking to build HF antennas for portable use a read through the

blogs of amateurs such as VK3ZPF, VK3PF, VK3YY and VK1NAM (just a few examples) will reward you with practical approaches (<http://www.parksnpeaks.org/>). Here are just a few ideas: soldering versus crimping when building antennas. There is a wealth of evidence that crimping conductors onto antenna wire is a more satisfactory approach when building a linked dipole than soldering. The proponents of crimping suggest that such joints are less likely to fracture though many cycles of use and with wind loading, stretching and packing up compared with soldered joints. I found it hard to give up soldering. It took quite a bit of reading to convince me, but in the end I crimp Anderson Power Poles to make and break linked dipoles. I usually just dab a bit of solder at the very tip of the cleared wire to hold the strands together after I twist the wire and then I crimp using the Anderson PP crimping tool. But any wire crimping tool will do a good job. If you look at some advertisements for antennas in QST, for example, you will see uninsulated wire is used. Don't use uninsulated wire, especially if you live near the sea!

In 'chassis-bashing', for example, for many years I used a hand drill and a nibbler. The two couplers on display were made this way. I have only owned a drill press for the last four or five years.

Whenever you get a chance to see other people's home brewed gear take a look. You will always learn something: sometimes reinforcing your views about how things should be done!

## References

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Internet Resources



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<http://www.sotabeams.co.uk/antenna-tuners/> (accessed on 21 Sept. 2014)

<http://www.parksnpeaks.org/> (accessed on 21 Sept. 2014)

<http://vk5bjc.com>

Books listed as references may be obtained from the Wireless Institute of Australia, Book Shop. I suspect that Orr & Cowan may be out of print. While I am a member of the WIA and ARRL, I have no financial interest in any of the publications or suppliers mentioned.

### **About the Author**

John Dawes PhD has been a radio amateur since December 1976. He has explored many facets of the hobby, including analogue ATV on 70 centimetres and, in addition to portable and weak-signal communications on HF, VHF and UHF, he is active in digital modes, such as JT65hf and Digital Voice (DStar). When he is in the shack he operates a DStar hot-spot on 438.925 MHz.

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