HF Antennas for Beginners – 30 Meters and Below

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For a ham who is new to HF operation, there is a number of new things to learn. Among them are the propagation characteristics of the various ham bands, the correct operation of their radio gear, and what to do about antennas. This article will focus on that last item.

Why a discussion on antennas is appropriate is simply that new HF operators don't yet know how critical the subject is. There is a lot to think about when starting out. Setting up proper antennas often slips to the bottom of the priority list. After a few years of experience, that would never be the case.

The next time you hear one of those 40 dB over S9 signals, think about this: he may be running a kilowatt output to his antenna but if he turns his amplifier off and drops back to 100 watts, he will still be 30 dB over S9. How do these "big gun" guys do it? Simple, they put up good, efficient antennas. These are not huge installations. Most of these signals are coming from simple dipole antennas. It is the care and thought put into their installation that makes the difference.

The subject of antennas is a source of great confusion. There is a tremendous amount of information available on the subject. Some of which is accurate, some not so. Adding to that confusion are the performance claims made by commercial antenna manufacturers in their advertisements. One company even claims their 3 foot tall product will out perform a full size 65 foot tall vertical on 80 meters. That claim, of course, is false.

So where is a fellow to start? With the basics of course! Those are fairly simple:

1. *Full size antennas work better than smaller antennas. Full size antennas typically offer higher efficiency and wider operating bandwidth.*
2. *Higher antennas work better than lower antennas. That is true up to about 50 or 60 feet for most operation. The effect at greater heights varies from band to band and the distance to the station you wish to talk to.*
3. *Antenna gain depends upon efficiency and directivity. An efficient antenna can only achieve gain in one direction by reducing the signal strength in another. An inefficient antenna cannot be counted on to have any useful gain in any direction.*
4. *There is no single best antenna. What works best varies from band to band and from location to location.*

For folks just starting out, those are not often the most pleasant things to read. They say you need to put up something big and high if you want to operate HF. These rules can be ignored but only when the consequences are understood. It can be very frustrating for beginners when their expectations for HF operations are not met because of an inadequate antenna system.

What kind of antenna should you install?

What kind of antenna should you put up? Obviously that depends upon a number of site specific factors including how much room you have for installing antennas and how tolerant your wife and neighbors are. Oh yes, and how much money you are willing to spend. The sky is really is the limit when it comes to antenna systems.

It is probably best for an HF newcomer to start out modestly. Simple wire antennas work well on the 10 Mhz band and below. Ground mounted vertical antennas are also useable on these bands though they do require more effort during installation to obtain good performance. Concentrate first on achieving adequate performance with the simpler antennas before attempting more complex systems.

What kinds of antennas should the newcomer avoid? First off, avoid the shortened all-band antennas. Horizontal antennas less than a quarter wavelength long and verticals less than an eighth wavelength high are inefficient, narrow banded, or both. They can be made to work but usually not by a HF beginner.

The problem with the shortened all-band antennas is that they look good in magazine ads. The idea of a small, easily installed, do everything antenna is seductive. It can seem like the answer to a new HF ham's dreams. Unfortunately achieving the performance claimed in the magazine ads is possible only under special conditions. It is unlikely that those conditions can be met in an average backyard installation.

The Safest Bet – A Dipole or Inverted Vee

The safest bet for an antenna system for the bands below 20 meters is a simple half wave dipole. It should be resonant on the desired operating frequency, have a balun at its feed point, and be fed with RG-213 coax. Why a dipole? That is simple, it is among the most efficient antennas that can be built, its performance and directivity are well known, and it is so simple that it is nearly foolproof. Why an Inverted Vee? It is really just a dipole with its ends drooping down a bit. I'll explain more about the differences later.

Dipole wire

Let's discuss some of the dipole construction basics. It should be built with copper or aluminum wire, copper being the most common. The wire may be solid or stranded. It need not be bare wire. Antennas have traditionally been built with bare wires. That was the case because in the early half of the 20th century, wire insulation did not survive very well out in the weather. Modern insulation is much tougher. Use of insulated wire has become more common because of availability and reduced rain static.

Wire diameter is not critical but 12 and 14 seem to be the most common. Thinner wire is more fragile. Thicker wire provides wider operating bandwidth. Experienced HF operators will use thicker dipole conductors. It is not unusual for 80 meter dipoles to be made with old used RG-213 size coaxial cable. The shield and center conductor are tied together and treated as a large diameter conductor. The coax, with its plastic dielectric, is much lighter than copper wire of the same outer diameter. The coax jacket provides rain static reduction. The larger diameter provides a broad low SWR bandwidth with a high efficiency.

Balun

Though not required, it is best that a balun be used at the dipole feed point. Its purpose is to disconnect the shield of the feedline from the antenna. Without the balun, the coax shield is directly connected to one side of the dipole and thus is part of the antenna. Signals and noise picked up by the coax shield are heard in the receiver. They may not be the things you are intending to hear. Likewise, part of the transmitted RF is fed back down from the feed point along the coax shield and can interfere with equipment in your house. Some folks claim the coax shield radiation and pickup fills in any gaps in the dipole's radiation pattern. There is really no reason to expect this effect to be all that helpful. There have been many instances where it has cause noise and RFI problems.

Feedline

With coaxial cable, size matters. Some RF is always lost as it runs through coax. There is resistive loss from the RF current in the coax conductors. There is dielectric loss from the RF voltage between the coax center conductor and its shield. The thicker the coax, the lower these losses are.

RG-58	50 ft.
RG-8X	75 ft.
RG-213	100 ft.
RG-8 Foam	200 ft.

The above table provides a rough approximation of recommended maximum lengths of the various kinds of coax hams typically use for HF operation. There are lower loss but more expensive kinds of coax available for even longer runs. Generally speaking though, exceeding the above listed lengths by a factor of two is OK as long as it is understood that coax feedline loss will be around 3 dB on the 10 and 12 meter bands.

Each kind of coax has a power limit that is determined by heating and voltage breakdown limits. RG-58 and RG-8X should be used at power levels less than about 500 watts. RG-58 can overheat. RG-8X's foam dielectric has a low breakdown voltage. RG-213 and other coax of the 0.405 inch diameter easily handle the full 1500 watt legal ham power limit.

Building a dipole

Dipole construction is simple. Two quarter-wave wires are connected to each side of the balun or center insulator. Insulated support ropes or wires are attached to the ends of the wires. Most dipoles are installed with center support for the balun or center insulator. That simplifies installation since only one tall support is needed. The weight of the feedline is carried by the center support, not by tension on the the dipole elements. The element ends are simply pulled outward to convenient tie off points. When the element ends angle down more than a few degrees, the antenna is known as an Inverted Vee.

The connections between the feedline and the antenna wires must be both electrically and mechanically solid. A problem to solve is how to achieve this while allowing for the flexing that will no doubt occur from wind blowing the dipole elements around. Another big problem to solve is sealing the end of the coax cable to keep rainwater out. Any moisture that gets into coax will corrode conductors and contaminate the dielectric, increasing power loss and the reducing breakdown voltage.

As a general rule, insulators should be used at the outer ends of the dipole wires. High RF voltages occur at the ends of the dipole wires. When synthetic material string or rope is used, however, the support material itself is often sufficient insulation.

Installing a dipole

Dipole installation is straightforward. Connect the antenna wires and the feedline to the balun or center insulator. Waterproof the connections. Raise the balun or center conductor to operating height, preferably pulling it with a lanyard running through a pulley or eyebolt. Pull the ends of the antenna wires outward and temporarily attach their ropes to your predetermined tie-off points. I say temporarily advisedly.

Hanging a dipole is only the first step of installation. The next part is to carefully adjust the wire lengths to resonate the dipole at some desired frequency. That is usually the middle of the band. Occasionally a specific spot in a band is chosen when frequent operation on a single frequency is expected.

Dipoles can usually be made to work if they are simply cut to the 468 over frequency in MHz formula, provided your transmitter has sufficient output tuning capability. There are couple good reasons for not stopping there. Correctly adjusting the antenna will provide maximum transmitted efficiency and typically provide the best receive signal strength. It will also allow you to tell if the antenna has been damaged should the SWR suddenly rise.

The SWR on a resonant dipole is typically less than 1.5 to 1. What you want to see is a SWR reading of less than 3 to 1 throughout the frequency range you plan to operate, preferably with the lowest SWR frequency near the center of that range. Dipoles with SWR readings higher than 3 to 1 are useable but will suffer additional feedline and antenna tuner losses, sometimes very high losses.

Take the time to get the resonance exactly right. It will probably take several trips from your shack out to the antenna and back shortening or lengthening the elements. Keep the lengths of the dipole legs the same as you are adjusting their lengths. Adjust both legs each time you make an adjustment. You will be using that dipole for many, many hours. A couple extra hours to fine tune it will pay off in both performance and piece of mind.

What about a G5RV?

The G5RV dipole has a mystique that is, for the most part, undeserved. This antenna is simply a 102 foot long dipole feed with 30 feet or so of twin lead with a length of 50 ohm coax added on. It was originally designed as a 20 meter antenna with radiation lobes in desirable DX directions from G5RV's back yard. The twin lead feed matched the high impedance found at the feed point on this band reasonably well to 50 ohm coax. It was never designed as a multiband antenna.

A properly installed G5RV will perform nearly as well as a single band dipole on 80 and 40 meters. The SWR is relatively high but most ham antenna tuners match the feedline impedance to 50 ohms as needed by our transceivers. Performance on other bands is not as reliable. The problem is that properly installing a G5RV is more difficult than properly installing a simple dipole.

First of all, the twin lead feedline must be kept away from metal. In general, twin lead should be kept at least twice its conductor spacing from other conductors, including antenna support poles. Also, the twin lead must not lie on the ground or be coiled. Failure to observe these limitations can reduce G5RV performance by 10 dB or more.

Second, many of the commercially manufactured G5RV antennas are supplied with 50 or 100 feet of small diameter coax connected to the twin lead. The loss introduced by this length of coax masks high SWR at the antenna. A relatively mild 3 to 1 SWR reading at the transceiver may actually correspond to an SWR of 10 to 1 or greater at the antenna. Having a low SWR reading makes the antenna look good to the buyer. The high loss means that only a small part of the 100 watts your transceiver is generating is reaching the 102 foot dipole wire to be radiated.

For use on 20 meters and above, the G5RV must be installed in a flat-top dipole configuration. Inverted Vee configuration for this antenna should be used only for 30 meters and below.

So, is a G5RV a good antenna? Sure, if you are careful when you install it. Will it work as an effective all-band antenna? Nope. It can work well on some bands but probably not all of them. The G5RV is a compromise antenna.

What about a Butternut or Gap vertical?

There are several multiband vertical antennas that work reasonably well. Just remember rule number 1 from the first page. Antennas shorter than a quarter wavelength long physically are either inefficient or cover very narrow frequency ranges on the bands they operate on.

Though they appear simpler to install than horizontal dipoles, that is seldom the case. They must be installed away from other structures. The vertical antenna itself is really only half of an antenna. You must create the other half by stringing or burying wire radials around its base. For maximum efficiency, 24 or more radial are needed for ground-mounted verticals. Fewer radials are needed if the base of the vertical is a few feet or more above the ground but a minimum of two for each operating band is needed.

Tuning one of these multiband verticals can be tricky due to interaction between bands. As long as the tuning approached as a challenge to be worked through over the course of a few days or weeks, you will do fine.

Will a 30 foot Butternut perform as well as a 30 foot high horizontal dipole on 80 meters? It probably won't for contacts out to 500 miles or so. It may not compete well with a dipole mounted at 60 feet out to 1000 miles. At greater distances, the vertical may win out… But not always.

Multiband vertical antennas are typically much shorter than a full quarter wavelength high on 30 meters and below. That obviously impacts their efficiency and SWR bandwidth on each band. With careful installation, they can perform adequately. Just make sure you understand how much work this takes.

What about the no-ground verticals?

There are vertical antennas available from several vendors claiming that no ground radials are needed. The trick employed is that of resonating these verticals as electrical half-wave radiators. The feed point impedance for a half-wave vertical is very high so a relatively small cluster of springy rods provides an adequate counterpoise. The physically larger products work well on 20 meters and above. On 30 meters and below, they are too short for efficient operation.

What about the……?

Let's face it. There are hundreds of different kinds of antennas that can be placed into service on the ham bands. Many of them work very well if installed properly. Part of the fun of ham radio is trying different antenna ideas. Most of us are constantly changing and adjusting our antenna systems. There really is no perfect final antenna installation.

Ok, what should I be shooting for?

There are two basic paths in HF operation: local and DX. Local includes net and rag chew operation with stations within about 1500 miles or so. DX operators often choose antennas that do not perform well inside that 1500 mile range. HF beginners should probably start with antennas better suited for local operation.

What would an ideal starting point be for operation on the 30 meters and below? That would be individual half wave dipoles at 30 feet or more above the ground for each band, center fed with a separate coax feedlines. These dipoles can be in an Inverted Vee configuration. The center half of the dipoles should be 10 feet or more from any structures, except their support mast of course.

Properly constructed dipoles, in the clear and up at least 30 feet, will equal the performance of 80% of the stations on the air. Raising the height to more than 50 or 60 feet is unnecessary for any but the most avid Dxer. If 30 feet proves difficult to start with, dipoles as low as 15 feet and clear of nearby structures will work adequately for communications out to several hundred miles. This is called NVIS operation.

But I don't have room for all those dipoles!

Welcome to the world of 90% of the ham population. This is where your individual inventiveness and technical skill comes into play. You will eventually find an antenna configuration to match your operating needs. The first step is to simply put an antenna up and give it a try.

There is a simple solution to the space problem. That is to put up a flat-top dipole of whatever length is available between two convenient supports. Feed the antenna in the center with open wire transmission line and a wide range antenna tuner. Losses in the feedline and the antenna will usually be insignificant as long as the dipole is longer than about three-eighths of a wavelength at your operating frequency. Efficiency drops off rapidly as the antenna length gets below about one quarter wavelength long.

As with most of the horizontal polarized multiband antennas, it is best if this random length dipole is installed in a flat-top configuration. That is, the entire length of the dipole should be run at roughly the same height. If necessary, the wires can be run at a horizontal angle from each other. That angle should be 90 degrees or greater. There will be some directivity and even perhaps a little gain on higher bands along a line bisecting the angle between the wires.

In general, multiband dipoles including G5RVs and ground mounted multiband verticals are compromise antennas but can be made work. They require care in installation and tuning to achieve adequate performance. Keep that in mind when you are choosing an antenna for your beginning HF operation.

The most important point about antenna work is to enjoy yourself. Some antennas work better than others but no antenna is best for all situations. The fun is in figuring out which will work best for your property, soil, neighbor, spouse, and financial situation. Hopefully this article will help you avoid some of the failures the rest of us have experienced. Even with this advice, you will, no doubt, create some less successful antenna configurations. We all do. Those experiences always make for good stories at ham breakfasts.