Pasadena Radio Club
Pasadena, CA

Crown City HF

A compilation of articles covering the broad technical elements of Amateur Radio

By

Dr. Tom Berne W6TAG

Edited by Bob Ross WA6JLP

PASADENA
W6KA
RADIO CLUB

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Dr. Tom Berne W6TAG

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Dedicated to the founders and the leaders
over time, of the Pasadena Radio Club

Contents

Foreword

Tom Berne, W6TAG, followed in the footsteps of his father, Dr. Clarence J. Berne, becoming a surgeon. He was also a researcher and a professor at USC. He was noted as a pioneer in the field of kidney transplantation and was widely respected and loved by many. However he chose to be just Tom to his many ham radio friends.

In his teens, he had discovered his affinity for amateur radio and pursued it happily for the rest of his life. It was his nature to share experience he found fulfillment in. He was especially motivated to reach out to younger people, guiding them ever so patiently and gently.

Tom was a member of the Pasadena Radio Club for many years, sometimes as a club officer, taking an active role in contests, field days, and other events. As always, he was supported by his beloved wife Cynthia.

In the fall of 2007 Peter Fogg, KA6RJF, then club president-elect, suggested that Tom might consider writing a column for the monthly newsletter, *The Pasadena Radio Club Bulletin*, especially for our club's technicians, to encourage upgrading and for new generals, to help them build HF equipped shacks.

Tom was modest about his experience, but Peter persuaded him to create the *Crown City HF* column, which he wrote every month for eight years. Ten months after the column ended, Tom became a Silent Key at age 81. We were all blessed to have had Tom with us for those many years.

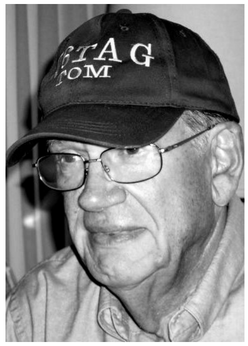
Since then, Bob Ross, WA6JLP, volunteered to collect Tom's work in a single document. We are pleased to present for you that collection of all of the Crown City HF columns.

John Minger AC6VV

Editor - *The Pasadena Radio Club Bulletin*,
Past President - Pasadena Radio Club

Crown City HF

The Beginning



At our recent PRC holiday dinner our new president Peter Fogg, KA6RJF, suggested that there should be a column in the PRC Bulletin to encourage the club's involvement in "HF". The idea was discussed again at the December board meeting, and the idea is for the content of the column to support an effort to try and involve those members who would like to learn more and have more opportunities to participate in High Frequency activities within the PRC. More specifically to help and encourage members who have recently upgraded or are considering upgrading. Some of the suggestions were for our club to participate in more organized (ARRL, CQ, etc.) contests other than just Field Day, and/or have our own "winter Field Day" or club "HF Day(s) in the Park" (locally setting up one or two HF rigs and antennas then making a few hours worth of contacts).

I am not sure why Peter encouraged me to write this column (come to think of it, there is always the possibility that he may have had a drink or so while waiting at the Shogun restaurant before the fire chased us out, and a few more after we settled at Robin's BBQ). My only qualifications are that for a long time (first HF contact 1952, 10 meters, 5 watts AM, Los Angeles to Shreveport, LA) I have enjoyed the special challenges and joys of "HFing": propagation, DX/award chasing, contests, rig/antenna selection, construction and tinkering, DXpeditions, CW, mobile HF, maritime amateur radio HF, and its other aspects, many of which differ significantly from VHF and UHF.

Although the sun spot activity is low now, with a little effort and finesse, there are always interesting HF QSOs to be made!

I will need help with this column from the many PRC hams with HF expertise, so please let me know what you can contribute. We are about to (or have just) entered a new solar cycle. We might as well get started now gearing up to enjoy that exciting ride to its peak.

Crown City HF

What is High Frequency?

In order to get this column off on the right foot let's look at what "HF" actually means. The abbreviation stands for "high frequency" which indicates the frequencies between 3 and 30 MHz and includes the bands with wavelengths between 80 and 10 meters. These bands are the ones hams most often use to get beyond-the-horizon long distance contacts using the refraction characteristics on the ionosphere. That layer of our earth's atmosphere contains a high concentration of free electrons and positive ions the number of which is dependent on the level of solar activity. This region contains layers that may bend HF electromagnetic radio waves back to earth if the ionization is sufficient. In general the higher the sunspot activity the greater the ionization and the more these layers help us particularly at the higher HF frequencies. Ionization of the ionosphere depends on many variables such as sunspot activity, the position of the earth (seasons), time of day, location on the earth, etc. The sun also is responsible for the geomagnetic activity of the earth, and at times of solar storms it can disrupt radio communication.

Part of the thrill of HF communication is contacting radio amateurs around the world (so called “DX”), but there is much more to it! When I explain my hobby to new friends they often ask “Can’t that be done much more easily on the internet?” I usually answer by pointing out that dropping dynamite into a lake usually yields lots of fish, but it isn’t as much fun as using fishing tackle! It is the many challenges of understanding radio propagation and using that knowledge to select the right band, pick the time of day, assemble an effective antenna-feed line, and (most importantly know) how to operate your equipment which allows you to bag a really exciting transcontinental or international contact.

In the next few columns we will look at the ionosphere in more detail (its various layers and what they do), expand on the fascinating role the sun plays (sunspots, solar storms), see how all that is measured (the “indices and fluxes”) and learn how those observations can help us.

Crown City HF #1

Radio Propagation

Let’s look at the ways that radio frequency transmissions travel. They are: ground wave, line-of-sight, troposphere and sky waves assisted by skip. Because we are particularly interested here in really long distance HF transmissions, for now we will focus on sky waves. They work for us because of the bending, or refractive property, of the ionosphere, otherwise all the HF radio waves leaving the earth’s surface at more than a few degrees upward would pass into space and go on forever. As a ham that only works if you are using a satellite or talking to a spacecraft!

This refraction depends on the amount of ionization of those free electrons and positive ions we heard about last month. The ionization largely occurs due to ultraviolet radiation coming from the sun.

The presence of the ionosphere was first suspected as far back as 1902, when Arthur Kennelly (USA) and Oliver Heaviside (UK) independently figured out that there must be such a phenomenon (existence was actually detected in 1924). As more was learned at least four layers have been characterized. The lowest, the D layer at 40-60 miles, is not our friend because during daylight it is ionized and absorbs much of the energy of our amateur radio bands at or below 7 MHz. This limits these lower HF frequencies to short range communications during the daytime. We all have observed this effect when visiting somewhere like Colorado; at night you can often hear KNX’s AM broadcasts from here, but not during the day. Fortunately the D layer only degrades the lower HF frequencies and it also disappears quickly at sundown due to rapid recombination of the ions in this layer. Solar events can also activate the D layer occasionally.

The next ionospheric layer is 60-100 miles up. This E layer is sometimes (midday when sunspot activity is good) gives some long distance communications on the highest HF frequencies but it is also degrades HF communications because of its effect on frequencies above 10 MHz due to partial absorption.

Now we come to HF's best friend, the F region. During the mid-daylight hours it sometimes splits into two layers, F1 and F2, but for the sake of simplicity we can consider this as a single layer since the F2 layer is the highest and is responsible for most very long distance amateur radio communication (often called "DX"). Although less ionized at night, it persists all day, and to some degree, all night because it recombines slowly. The F region extends from100 to 250 miles up. This is the layer that allows, in the best of times, roundthe-world communications on low power with a simple antenna but at other times frustrates even the most experienced HF operator.

Next month we will look at how radio waves and the ionosphere interact and what influences each of these factors in our quest to reach way beyond the horizon.

Crown City HF #2

More on the Ionosphere

Last month we introduced the layers of the ionosphere and learned which of them help us (by refracting) and those that make radio communication more difficult (attenuate). You heard that the lower the frequency used and the greater the ionization of the ionosphere the more the refraction (bending) by the ionosphere. Together these determine the highest frequency that can reliably be bent back to earth and therefore give long distance HF communication, called the "maximum usable frequency" or "MUF".

Put in practical terms, if we have an F-layer that suffers from low ionization due to poor solar radiation (as we do now), or at nighttime and/or seasonal variation the higher HF frequencies like 28, 24 and 21 MHz (10, 12 & 15 meters) will most often be above the "MUF" and are of little use for DX. However, the lower frequency amateur radio allocated bands at the other end of the HF spectrum such as 3.5 and 7 MHz (80 & 40 meters) probably will refract and yield reasonable DX, particularly at night when the D-layer (which absorbs) rapidly fades. On the other hand as ionization levels rise up a few short years from now and/or during the daylight (longer in summer) the higher HF frequencies open up and the mid-range ones, particularly 14 (20 meters, the DX workhorse), will regularly work very well during daylight and well on into the night. Although propagation can get rather complicated, these basics are the keys to understanding what bands to use when and help you to understand what you observe when you are "on the air" using HF.

An old adage in amongst experienced hams is the importance of spending time listening to your radio and when you do, use what you have read in this column to see if you can explain what you are hearing in the HF bands.

Next month this column will take a holiday from the topic of "Propagation". Because Field Day will be here soon I thought it would be a good time to have a guest authored contribution by Ray Overman, KJ6NO, on "Contesting".

Crown City HF #3

Ray Overman, KJ6NO,
guest author

Contesting Pasadena Style

Or How Did I Get Started in This?

A basic contest is where you exchange some information and log it in order to have the contact count for points where points are the name of the game. Just like baseball the more points the better. I have worked contests for only a few hours in the weekend and won my class and ARRL section with less than 50 contacts in the log.

There are contests in which every ham can be a part of and these include the major VHF contests through the year, 10 meter contest in December, and for those that can send Morse code, Straight Key Night in December. Also many HF contests have a category for single band and those of you with Technician or Novice licenses can compete on 10 Meters.

Where to find contests and their rules:

http://www.arrl.org/contest-calendar

http://www.cq-amateur-radio.com/cq_contests/index_cq_contests.html

http://www.cqp.org/index.htm

http://www.hornucopia.com/contestcal/contestcal.html

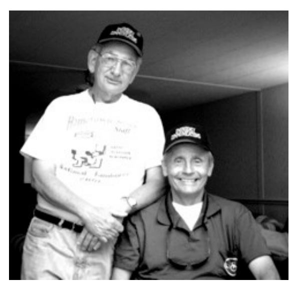
You can try an HF contest, operating on bands from 160 meters to 10 meters. As the sun moves across the sky your operating frequency will change with it. The higher frequencies are in the daytime and lower frequencies, 40 Meters and down, in the evening.

For those who would like to run a net, a contest is good practice. You must be fast and accurate with the exchanges. Your listening skills will improve with each contest as you begin to pull out the difficult to copy stations. Although not necessary, a computer logging system will help you a lot by keeping your log neat and orderly, checking for duplicates and, as a side bonus, many get your log ready to submit to the contest officials. Just attach the Cabrillo format log to an email and send it to the proper address. My logs of choice are from N3FJP at

http://n3fjp.com/

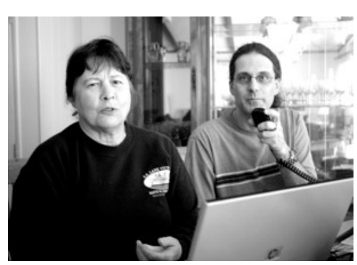
He has a great set logging programs and the price for the complete set is quite reasonable compared to some of the more famous logging programs.

Contesting can be a solo experience or a group get-together. Ask Paul Gordon to use



the club call and do not forget to send him a copy of the log and you can operate with a call that many are familiar with. Just remember that you can only use the privileges that control operator has. Some of you may know

that last October four of us went to Palm Desert to operate the California QSO Party and in November three of us went back to the desert for the ARRL SSB Sweepstakes. In the



Sweepstakes we made over 100 contacts and for efforts we were able to get a pin for 2007's contest.

For those you that want to upgrade to more active contesting, how about roving in VHF and UHF contests. You have probably heard about Eli and myself going out on a contesting weekend and driving from grid square to grid square, trying to make as many contacts as possible. If you want to do this type of contesting, here are sites to look at:

http://users.adelphia.net/~w3iy/Rove.htm <link deleted> or

http:// www.qsl.net/k9cu/vhflink.html

or you can talk to Eli or myself at one of the club meetings. We always encourage participation in these contests as there are just a small percentage of hams in Southern California that operate during these contests.

Roving in a VHF Contest

Until this year, when you went out in a rover you could only have a maximum two people in a vehicle. With the rule change this year, more people can come along and operate or just observe. We hope to have a few of you come along to enjoy the fun.

One last word about equipment you will need. I have worked contesters that were using just a hand held to contesters that had mega stations. One thing to remember is the little station usually has more fun. If you have a multi mode rig put it to good use, as many use them in all types of contests. Just a reminder, for VHF and up, SSB horizontal, FM vertical.

So dig out your radio and come and join us in our Club's Field Day effort on June 28-29. It is the perfect opportunity to get some real experience at hands-on contesting!

I was asked to write an article on contesting for the bulletin. This was difficult to do as there is so much that can be said on the subject. What I tried to do was give a broad overlay on the subject from my perspective and if you want more information, feel free to contact me at kj6no@arrl.net

73, Ray

Next month **Crown City HF** *will feature another Field Day related article about the use of propagation prediction software by guest author Randy Graham, KG6OTE. We will be using the software he describes to improve our Field Day performance.*

Crown City HF #4

Randy Graham, KG6OTE
guest author

Propagation Prediction

or

It is 1700 hours on June 28th 2008. Do you know where your HF signals are?

After the May exploration of contesting we return to the subject of propagation. In prior articles Tom Berne has explained the various ionospheric layers and how they affect HF signals. We learned that propagation of an HF signal will vary depending on the frequency, time of day, season of the year, solar activity and position of the transmitter on the earth.

Given all of these variables, how can we predict what time of day and which frequency will be best to support a QSO between any two points on the earth?

Listening to propagation beacons can give us an idea of how signals are propagating at the moment but bands can open and close in a matter of minutes. Listening across the bands and keeping a log of stations contacted is the time honored way amateurs have gained experience and knowledge of propagation. For fun and excitement there is no substitute for listening and operating. However, band scanning can be frustrating and time consuming when conditions are poor.

To avoid the frustration and loss of time, propagation can be forecasted so that one may choose the best frequency and time of day to make contact with a particular region or station. You don't have to be a "rocket scientist" to make reasonable predictions as long as you know the location (latitude and longitude of two stations) and the solar weather forecast (Radio Flux and Kp index prediction) for the day you are interested in. Radio Flux and the A and K index will be covered in a future edition of Crown City HF.

PC based propagation prediction programs usually written by HAMs and made available for little or no cost to others are readily available. One such program named W6ELProp was written by LA Amateur Sheldon Shallon W6EL. It is a free download from the web site (http://www.qsl.net/w6elprop/) Given the inputs of location and solar weather, W6ELProp returns a one page report listing the MUF (maximum usable frequency) the signal strength or signal to noise ratio and the probability of receiving a signal on each of the major ham bands for every ½ hour period of the day. The program will also calculate great circle and rectangular maps showing the path of the signal and the parts of the earth lit by the sun at the time selected.

The algorithms and mathematics inside the programs are way beyond the scope of this series of articles, however one can imagine that the program calculates the path of an RF signal from a transmitter and antenna as it travels up through the ionosphere bending back down again toward earth then skipping back through the ionosphere and so on until it reaches the receiving station, taking into consideration all of the variables mentioned above. Of course the predictions are general and approximate in nature and only as accurate as the solar forecast provided by NOAA. Accuracy is also affected by the similarity of the actual transmitter and antenna to the standards assumed (defult) by the program.

The resulting predictions can be very handy for field day, contesting, scheduling nets or QSOs or just to understand what you may be hearing on any give day while band scanning.

I will be demonstrating the W6ELProp program, its inputs, interfaces and outputs at the June 24th PRC meeting, so download it now and give it a try before the meeting. It will be fun to compare our W6EL predictions to our actual contacts during field day.

Randy Graham first became interested in HAM radio when his parents replaced the old Philco world band radio with a new TV in 1955. Randy was given the radio and he set up a receiving station in the coal bin in his basement. School, the military, a family and a career kept him too busy to get licensed until he retired in 2003 and became a Technician. A general license followed in 2006 and an Extra in 2007. He combines yachting and HAM radio and says he can't wait until the new solar cycle opens the bands for great HF QSOs around the world.

May 25th tower setup test

Crown City HF #5

Solar Indices

Prior to the two articles highlighting our Field Day activities, we have been studying how HF radio waves can be sent far beyond the horizon utilizing the refracting properties of our ionosphere. Several times there has been mention of how the sun affects the propagation of these transmissions. Now we are going to look at what measurements of the sun's emissions are most helpful to amateur radio operators, what they mean and how we can use them as mentioned by Randy in his article last month.

Most of us have heard of sunspots and know that the more of them that there are, the more "active" the sun is. These sunspot numbers (SSNs) range from a low of zero to a maximum rising as high as 200. Somewhere about SSNs up to 34-50 the HF bands get good with 20 meters consistently open and 15 meters starting to get active. This sun spot number rise and fall repeats about once every 11 years and is called the "sun spot cycle". The counting of sunspots is an old and traditional way of looking at the amount of solar activity. The reported number is not the actual numbers of spots seen, rather the calculation considers the number of sunspot groups and the size of each group. The count gets 10 points for each sunspot group, and one point for each spot within the groups. There are also problems with accurately counting them and large day-to-day variations that make it necessary to use monthly averages or "smooth" the values over several months (up to13). If you are, for instance, using a propagation computer program and you want to use today's 13 month smoothed SSN, you will need to find the last six and one-half months SSN back data and estimate the next six and one-half months. You don't really have to do all that work yourself…we will learn in later columns where to find all these things already collected for you.

Because of these problems with SSNs it is common to use a different measurement called the "solar flux". This is calculated using the radio noise emitted from the sun at a wavelength of 10.7 cm (~2800MHz). The values in Solar Flux Units (SFU's) can get down below 50 during the lowest part of the sunspot cycle and 300 during the best (sunspot maximum). Although this index is widely used because it is the most convenient easily measured guide to the ionization of the ionosphere's F region. Roughly, when the Solar Flux is at the bottom (as it is now) around 50-70 SFUs it is tough to find openings for DX above 40 meters (7 MHz). Don't despair; there is always the chance of some amazing contacts if you work at it! Also, just wait a while until we get SFUs of 100 when some easy contacts appear on 20 meters (14 MHz), and then (even better) on the way to 120 SFUs 15 meters (21 MHz) opens up. Now things get hot! As we move from there to 150 and 200 SFUs there will be the really good and reliable HF openings even on 10 meters (28 MHz) and now we can even use our new "HF" radios that include 6 meters for some reliable DX.

Next month we will look at solar events that give rise to geomagnetic and ionospheric storms that can cause real problems for radio communications here on earth.

Crown City HF #6

The Geomagnetic Indices

Last month I mentioned that we will be looking at the sun's other emissions, such as the geomagnetic and ionospheric storms, that come to our planet from deep within the sun. The space available in this column does not allow a full exploration of the fascinating disturbances which are due to massive energy releasing events on the sun such as solar flares, coronal mass ejections, and coronal holes that cause "storms", "winds", "rays" and "particles" that travel largely to the sunlit side of earth in from 8.3 minutes to 3 days. However, it is useful to know something about these phenomena because they can alter the earth's geomagnetic field and, to a lesser degree, our ionosphere. Such changes can cause radio communications mischief on our planet that can last from hours to several days. These problems often manifest themselves by increases in what we hear as HF radio noise but occasionally can progress all the way to total radio communication blackouts. These disturbances are independent from the more predictable propagation influences due to seasons, time of day, our location on the planet, and the sunspot cycle that we have been talking about up to now.

For these effects there are two magnetism measurements that are most commonly used; they are reported as the "K" and "A" indices. The K index comes from measurements of the earth's geomagnetic field at Boulder, Colorado which are most often express as a three hour index. It's scale ranges from low K index levels with little negative effect on radio transmission up to about 3 where HF noise starts to be noticeable at S3, at 5 to S6, at 7 to S9, and at 8+ complete failure of radio communications. The A index is mathematically derived from the K index (to make it linear) and most often reported as a "daily index" (really an average of eight 3 hour indices). For comparison a K index of 3 approximates an A index of 12-18, K of 5 is like an A of 39-56, a K of 7 is like an A of 111-154 and the top K index of 9 comes in at 300-400. To avoid confusion I should mention that sometimes these are given as Kp and Ap for planetary (measurements are averaged from around the world) and they may even be averaged or "smoothed", like sunspots and solar flux. So for now just remember that, as a general rule, ***the higher the numbers that tell us about solar activity (sunspot numbers and solar flux) the better, but it is the opposite with geomagnetic disturbances (K and A indices). For a reference point remember a sunspot number above 5, a solar flux above 100, an K index at or below 3 and a A index at or below 15 are the targets we would like in order to get very good HF propagation***.

Next month this column will cover where to find reports containing the propagation numbers you need, expand on what they mean, and go over how you can use them and other aids to get the big DX.

Crown City HF #7

Where to find the Data for Propagation Programs and Other DX Tools

Two months ago Randy Graham, KG6OTE, covered propagation forecasting software. And then last month we learned about sunspot numbers, solar flux, and the A and K indices and got some ideas about what different values meant for HF propagation. Well, to use these tools you need to get your hands on them. So let's find out where to find them.

One source that many of you already know about is the broadcasts of stations WWV and WWVH which contain geophysical messages that provide information about solar terrestrial conditions. WWV and WWVH broadcast time and frequency information 24 hours per day, 7 days per week. WWV is located in Fort Collins, Colorado and WWVH is located on the Island of Kauai, Hawaii. WWV radiates 10,000 W on 5, 10, and 15 MHz; and 2500 W on 2.5 and 20 MHz while WWVH radiates 10,000 W on 5, 10, and 15 MHz, and 5000 W on 2.5 MHz. Geophysical information is broadcast from WWV at 18 minutes after the hour and from WWVH at 45 minutes after the hour. The messages are updated every 3 hours. Of interest to amateur radio operators is that the broadcast includes time announcements (in Zulu), standard frequencies for calibration, solar flux, and the mid-latitude A and K indices. Their recent and expected space weather condition reports can also be helpful.

One of the easiest to understand websites for finding solar and geomagnetic data is http://dx.qsl.net/propagation/. This gives you the Solar and K indices that you need for the “W6ELProp” software that Randy told us about. Also try “ARLP023 Propagation de K7RA” which is free to ARRL members each week via E-mail. Some other helpful sites are

http://www.spacew.com/www/realtime.php that provides high-resolution maps of Maximum Usable Frequencies (MUFs) for 3,000 kilometer radio signal paths and https://www.swpc.noaa.gov/products/3-day-geomagnetic-forecast , which gives the NOAA Space Weather Prediction Center 3-day report of solar and geophysical activity.

One additional tool that some hams use is to listen to beacons around the world. These are stations, on permanent amateur radio frequencies, are scattered around the world and can be listened for to see if there is a path open on that band. A useful website sponsored by the Northern California DX Foundation is http://www.ncdxf.org/Beacons.html . It has a long list of beacons and information on programs which help find and use these beacons.

Another helpful website is QRZ.com’s “Last 100 DX Spotting Reports”

https://www.qrz.com/dxcluster

which is updated every 10 minutes and lists QSOs reported to them by QRZ members from around the world. By looking at this, you can also quickly identify DX opportunities. Another useful “spotting” website is http://www.dxsummit.fi .

Up to this point, we have been dealing with what affects the received signal strength of our transmissions. But that is only one side of the equation. The other, “noise”, is often lost sight of. It is the balance between these two, signal strength and noise, that allows us to understand what we hear. So next month we will look at the many sources of interference that make up “noise” and explore some ways to minimize it.

Crown City HF #8

Noise

So this month we look at “noise”. I guess everyone has some idea of what that is: that annoying interference that you hear when listening on an unoccupied HF frequency and which sometimes makes it hard to copy radio transmissions. The background constant hissing (usually from lightning around the world plus some small addition from outer space) is called “white noise”. There are also spikes or crashes (usually nearby lightning strikes). Some noise elements are easily recognized as mankind’s activities, particularly if you are in an urban environment.

Noise is usually divided, by source, into internal and external (to your radio). We will not spend any time on internal noise because the moderately priced modern HF receiver input circuits that we have today are quite good at keeping the internal contribution of noise to a minimum. A discussion of receiver design and filtering (triple conversion, multifunction 32-bit floating point digital signal processing with adjustable IF width, IF shift, notch filter, etc.) at this time will lead us too far off the propagation track. Also, shelling out a lot more money for your rig may not be your best move because it is the (external) noise that is picked up by your antenna which causes most of the trouble. Fortunately, that is the part most amenable to correction.

There are two types of external noise: natural and man-made. Man-made noise comes from many sources. When we use the Q-sign “QRM” on the air we usually mean intentional radio transmissions from another amateur radio station on the same or nearby frequency or, in some instances, commercial stations in different parts of the world. Some of this can be reduced by using narrower band modes like CW or digital and directional antennas. We can prevent contributing to QRM by limiting on-the-air tuning up, using the least power necessary to make a readable contact and listening carefully and asking if the frequency is clear (QRL?) before settling down to call CQ.

But modern civilization creates lots of other electromagnetic interference. Some of the most common offenders are: overhead high tension power lines, automotive ignition systems, fluorescent and neon lighting, dimmer switches, welding machines, computers, electrical motors, TV sets, satellite receivers, cordless phones, etc. Some of these sources can be identified and suppressed or avoided. When you have the option, locate your station and its antennas as far as possible away from high power lines, neon lights and large electric motors (on field day for instance). Also, try and get rid of fluorescent lights, dimmers, motors, and other sources of interference in or near your shack. Finally, this manmade noise tends to be vertically polarized (probably because it travels by ground wave propagation) and is somewhat suppressed by using a horizontally polarized antenna.

We have already spoken about HF noise from geomagnetic sources when this column covered the A and K indices. Atmospheric or natural noise (QRN) comes largely from electrical storms, which thankfully are not as common in Southern California as in much of the rest of our country. QRN tends to be troublesome during times (like this) when solar activity is low and we use lower frequencies, particularly at night when we tend to use those bands. A small amount natural noise also comes from outer space. This galactic (or cosmic) noise is coming largely from our own galaxy.

One last thing is the concept of the Signal to Noise ratio (S/N or SNR). This equation expresses the fact that as the strength of the signal goes up and the noise goes down your can understand the intelligence on the transmission better (and of course visa versa). That is sometimes called “readability”. Creating a favorable S/N is critical, so lowering the received noise is just as important as raising the signal strength and often underappreciated. A rough measurer is to look at your SSB HF radio’s S-meter when it is receiving a strong radio signal (maybe S 9) and when it is not (lets say S 4.5). That ratio (2/1) gives you an idea of the relative contributions of the received signal and the noise on that band, with that path, at that time, using your location and equipment.

Now we need to turn to some other details about what radio waves really are. That is, their characteristics, such as polarization (already mentioned above) and the effects of the angle at which they are sent skyward. That will come next month

Crown City HF #9

Polarity and Radiation Angle

This month we will look more closely at "radio waves" in order to help us make our transmitted and received signals as strong as possible. So here goes some of the background information first. While an alternating radio frequency current is being sent to a correctly constructed antenna by a radio transmitter, electromagnetic energy is radiated. These "radio waves" are made up of two elements, electrical and magnetic. Explaining what actually makes up these traveling waves would get us into subatomic particle physics which, although interesting, is not of much practical use to us. However, knowing about some characteristics of this electromagnetic radiation is helpful.

Since the speed at which they propagate is that of light, and the waves have positive and negative polarity which alternate, in the case of HF signals at thousand to millions of times a second, we can also characterize their "wave lengths". That is how far the wave front travels while going one full cycle: from baseline to fully positive, then back to baseline, then to fully negative and finally back to baseline to start over again. Because when the cycle is repeating more often per unit time while traveling at the same speed *the higher the frequency the shorter the wave length* (and visa versa). So what happens when this wave of electromagnetic radiation travels from a transmitting antenna and encounters a receiving antenna? Magically the magnetic lines of force cutting through the receiving antenna's elements cause electron movement which results in a tiny alternating electrical current in the antenna and feed line which a radio receiver can detect.

Now let's look at another characteristic of radio waves: "polarization". It just so happens that the two components of electromagnetic waves actually travel together but at right angles to each other. By convention the direction of polarization of the wave has been chosen to be the direction of the electric field. In practical terms, when radio waves are launched by an antenna they will be *horizontally polarized if its elements are parallel the earth's surface and vertical if the antenna is perpendicular to the ground*. This is important because reception is generally better if the elements of the antenna receiving the transmission are also horizontal allowing its magnetic radiation component the greatest opportunity to induce an antenna current. Similarly a vertical transmitting antenna induces a better signal in a receiving antenna if its elements are also oriented in the same vertical direction. Another difference, previously mentioned, is that man made noise is vertically polarized and therefore less of a problem when using a horizontal antenna.

In last month's article I said I would also cover the "angle of radiation". It is the angle from the earth's surface at which the major part of the RF energy is radiated from an antenna. For the long distance transmission of HF signals, the lower the antenna's angle of radiation the better, because the radio waves stay in the refracting layer (usually F region) longer. Hence they encounter more ionized particles and are more likely to be bent back to earth. In general, the higher the antenna the lower the angle of radiation will be (ideal is around 20 degrees). Also, the type of antenna matters, for instance quads and verticals give lower angles of radiation than Yagis. Later when Crown City HF gets into antennas, we can go into more detail about these kinds of antennas and the practical value of these concepts.

However, we still need to round up some “loose ends” to give a reasonably complete understanding of HF propagation. So next month we will look at several important additional “variations” such as those that are seasonal or that occur throughout the day.

Crown City HF #10

Seasonal, Intraday and Latitudinal Variations

It is very helpful to have clearly in mind the variations of HF propagation which occur depending on what season it is, what time of day it is, and what are latitudes of at the transmitting and receiving stations.

Seasonal Variations

I guess we all know that when we are experiencing a summer in the Northern Hemisphere (North America, Europe, Near East and Asia) the Southern hemisphere (Australasia, Africa and South America) is in winter. This is because as a result of the tilt of the earth’s axis relative to the sun the seasons change. This is because north of the equator we go from equal hemispheric radiation due to the sun striking directly on the equator in spring and fall to more direct sunshine during summer with longer daylight and less direct with shorted daylight in winter. This is important because, in general, you would think that the warm summer months enhance upper frequency band communications more than cold winter months and the opposite would hold for the lower frequencies. Longer days and more direct solar radiation should increase the F (good for higher HF frequencies) layer ionization and increase D layer adsorption (bad for lower frequencies HF).

You may remember that sometimes at midday when sunspot activity is high the E layer gives long distance communications on the higher HF frequencies. As you would expect in summer for this layer the ionization regularly rises to its highest yearly level. But we know that it is the highest layer of the ionosphere, the F layer, that is most responsible for really good or really bad DX. For this zone things are not what you might think. Instead of peaking in summer, ***the ionization of the F layer peaks for a month or so before and after the equinoxes (late March and late September), and falls around the solstices (late June and late December)***. Also, during periods of low sunspot activity summer the F layer ionization levels are higher than in winter. But strangely, in periods of high sunspot activity, the winter upper layer ionization can exceed that during the summer, a phenomenon called seasonal anomaly. The reason for these several variations is apparently very complicated and not well understood.

Intraday Variations

There are also variations (called diurnal or intraday) in propagation which occur depending on what time of day it is. As noted above the highest usable DX frequencies are generally greatest during the day, peaking about noon, and dropping down modestly with time in the dark. The D layer ionization, thankfully, drops more rapidly as dusk fades. Based on what was covered earlier in these articles, that means that in ***the higher frequency/shorter wavelength bands (15 meters and up) are “daytime bands” and the lower frequency/longer wavelength bands (30 meters and below) are “nighttime bands”***. What about 20 meters?

It shares characteristics of the low and high frequency bands, particularly some good daytime DX openings even in periods of low solar activity and with just modest sunsport numbers the ability to still be refracted well into the night with only modest F layer ionization. Consequently it has a reputation as the premier DX band.

Latitudinal Variations

Finally we need to consider station latitude. During daylight the further a station is from the equator the less ionization of the nearby ionosphere will occur (sunshine is less direct). However, those of you planning to sail around the earth need to know that that F region ionization peaks do not actually occur on the equator, rather at about 15-20 degrees north and south latitudes (equatorial anomaly). For both intraday and latitudinal variations it is important to consider the locations of both stations and the state of the ionosphere between them, rather than just where you are operating. Next month we can wrap up the coverage of propagation with a look at “Fading and the Grey Line”.

Crown City HF #11

Fading and the Grey Line

“QSB got the last part of your transmission, could your please repeat everything after my signal report?” I hate that! Having just made a nice solid contact, then for no apparent reason, the signal becomes very weak or unreadable. That is “fading” and to explain it we will have to go back a ways. We have covered the ionospheric refraction of HF radio waves in previous Crown City HF installments, but we never quite got specific about what actually happens after the signal has been bent and heads back to earth. So, we need to return to our study of the “ionosphere” in order to explain “fading”

For the DXer using the F layer the longest distance from the transmitter to where the signal returns to earth is about 2000 miles. That distance is called the “skip distance”. We know that DX transmissions can often go several times that far, so how can that happen? The answer is that usually the surface of the earth is a pretty good reflector of radio waves, so back up they go. Soon they hit the F layer a second time and are bent back down about another 2000 miles away, and so on. They do weaken as they travel on, but some times they can make several “hops” and go nearly all the way around the world on something called “long path”. But that is not the only path your signal can take. Depending on many factors, particularly the frequency, radiation angle and the ionosphere’s ionization, your transmission’s energy might enter the F layer and be refracted slowly so that it travels a long way before emerging to return to earth. Other paths, like bouncing back and forth between the F and E layers before returning to earth, called “ducting”, can also occur. So you can see that with many paths possible, the energy from an HF transmitter may arrive after considerably different travel times to any given receiver. So, what? Well, such signals will usually be out of phase with each other (like those noise canceling earphones) that can severely depress the strength and distort the intelligence. We call this “multipath fading”. Other less common forms of fading occur due to changes in signal polarity and areas of greater radio wave absorption occurring along the transmission path.

Another important propagation phenomenon to understand is the special properties of the "grey line". If you connect all the places on earth where daylight is turning to darkness, or visa versa, you have the grey line. There is often unusually good HF communication along this line, largely due to the rapid disappearance of the rf energy absorbing D layer on the darkening side of the line. This occurs faster than the F layer de-ionizes on the sunlit side, in part because it is higher up and receives solar energy longer. Although running exactly north and south on September 21st and March 21st, the rest of the time there is a tilt (as much as 23 degrees) to this line. To see the location of the "grey line" at the present time you can always go to

http://dx.qsl.net/propagation/greyline.html .

This map can be a big help in finding DX possibilities in the southern hemisphere and even in Europe over the pole. For a more detailed explanation of the possibilities see

www.astrosurf.com/luxorion/qsl-propa5.htm

So over approximately the past year we have been looking at HF propagation. Next month we will begin to look at HF antennas and all that goes with them.

Crown City HF #12

Antennas and Things that Make them Work

This topic is potentially huge! There are tons of books and articles written every year about antennas covering feed lines, tuners, towers, grounding, and the many different configurations and accessories available to an amateur radio operator. So, I need to remind you that these "Crown City HF" articles are being written largely for hams who are new to HF activity. Hence we will stick with the basics. I will avoid any complicated charts or math and try to talk about equipment that is simple and "affordable". Hopefully you will try to put together your own antenna system(s). Making antennas is one of things which most hams can do to feel the thrill that comes with building and successfully using your own equipment.

It seems logical to start this new direction with a look at how we connect our transceiver to our antenna. Until later in this series, when we cover mobile antennas, we will assume that you have a corner of your bedroom or a closet or, best of all, a room in your home devoted to amateur radio which I will refer to as your "shack". Your HF transceiver (we will call it your "rig") is 100 feet from where it will connect to your antenna (its "feedpoint") so you need some efficient and safe way to get RF energy from one to the other. So you need to connect them together using a "feed line" ("transmission line" or "feeder"). For the vast majority of amateur radio applications we use coaxial cable ("coax") for that purpose. OK, there are other kinds of transmission lines; the second most often used in HF work being balanced open (twin) wire lines. But the vast majority of hams use coax. We will come back to the other options later and for now we will focus on coax while we go through the steps to get up a few relatively simple antenna systems.

You all know what coax is. Typically it is round black cable, about ¼ to ½ inch in diameter with a vinyl jacket and reasonably flexible. Just inside the jacket is what is variously called either the "shield" or "outer conductor" (often braided copper). Inside that is usually a center conductor made of wire and separating the two conductors is most often an insulating thick layer of polyethylene. An important advantage of coax is that it can be coiled and placed close to metal objects without degrading its performance. Coax may have slightly more power “loss” than, for instance an open parallel conductor, but at HF frequencies it is a minor problem. Coax is not only easy to put up, it is also readily available in various configurations, commonly “matches” both your transceiver and antenna, and is reasonably priced for HF applications.

Next we will expand on feed line “losses”, the importance of “matching” and why power and frequency matter. Then we will then pick the right coax for our hypothetical “Crown City HF shack”.

Crown City HF #13

Transmission Lines: Characteristic Impedance

Last month I mentioned the importance of “matching”, “power” and “frequency” in regard to transmission lines. I suppose it is obvious that if its job is carrying an RF signal from your transmitter to your antenna, then the less power wasted in that transfer the better. So let’s start looking at some things we can do to make our antenna system as efficient as possible.

Getting started on this subject will require explaining “characteristic impedance”. I will spare you the detailed explanation that includes imagining your coax as a whole series of capacitors and inductors with little ammeters and voltmeters attached. What you need to know is that each kind of coaxial cable comes with a stated “characteristic impedance”, referred to as “Zo”. That value is determined by the size of conductor and the space between the two conductors. Again, to keep this relatively uncomplicated, let’s stick to what is the most common Zo for amateur radio use, 50 ohm coax, for our theoretical Crown City HF shack.

So why is it important what the coax’s impedance is? Well it just so happens that if the output circuit of your transmitter is made to drive a 50 ohm load (in this case the coax) and our 50 ohm coax is terminated in an antenna with 50 ohm feed point impedance the antenna will receive the most power possible! It is only limited by something called “attenuation” which we will deal with soon. The good news here is that not only does the coax come made to a standard Zo of 50 ohms, essentially all amateur radio transceivers today come with transmitters that “match” that same impedance. There is that word “match again”, so you should know that it pretty much means what it says: the impedances match up…the closer they are to each other the better the transfer of power from rig to antenna.

So how do you know what the Zo is of coax you are purchasing? Well that is pretty easy. Remember that we are trying to put together a low cost, easy to understand station. So I suggest we look at only three candidates for the coax that go by the codes RG-58, RG-8X and RG-213. They all fit the maximum power transferring of 50 ohm impedance and all are commonly available. But they are different in regard to other characteristics that you need to be familiar with.

Next month we will see just how much difference there is between the each of these types of coax and then, mostly taking power loss and cost into consideration, we will choose our transmission line.

Crown City HF #14

Coax Attenuation

Last month we began looking at the causes of power losses (attenuation) in transmission lines, and more specifically coaxial cable. In coax the greater the diameter of the center conductor and the greater the bulk of the outer conductor (shield) the less resistive loss occurs. Also, the dielectric (the plastic stuff that separates the center conductor and shield) causes losses. These latter losses become a problem as frequency rises, and represent a significant consideration when buying coax for our theoretical shack because it is 100 feet from the antenna feed point and coax characteristics can make a lot of difference, particularly if you are using the higher HF frequencies and chasing rare DX.

First we need to agree on a way to measure the power loss. The amateur radio literature has for years used “decibels (dBs) loss” for this. We will see it used a lot later on when we talk about antenna gain. But the concept is cumbersome because it works on a non-linear scale…and I don’t think our brains were meant to. For instance a 3dB loss would cause a 50% loss in power, and a 10 dB loss would be a 90% loss. Fortunately for our purposes we can use a different approach which is more intuitive in order to make our decisions. We will use “power loss” instead.

So the next fact we need to consider is that as the frequency of a transmitted signal goes up the more loss (attenuation) occurs. But not all coaxes are created equal! The physically larger coax cables with heavier conductors and better dielectrics exhibit less power loss. Luckily for us, living in the information age lets us just go to our trusty on-line computer and figure out these effects on almost any coax rather quickly at

http://www.qsl.net/co8tw/
Coax_Calculator.htm

(or Google: coax loss calculator). We will look at the same three coaxes we have been talking about (RG-58, RG-8X and RG-213) and assume that we will soon put together a good antenna to match our coax. That lets us use a low SWR (standing wave ratio) of say 1:1.2 in our calculations (so we don’t lose our way here we will defer an explanation of SWR until we get to antennas). Now go to your computer with the coax loss calculator webpage that I mentioned above displayed. Scroll down past the first big box to the two side-by-side boxes. In the “Set Parameters as Desired” boxes enter the type of coax from the “Line Type” drop down box as “Belden 9201 (RG-58)”. Next enter 100 feet for our theoretical shack’s coax length in the next line down, then enter 3.8 MHz (80 meter phone band) and finally enter the power output of our virtual HF transceiver as 100 watts. Click on the “Calculate” button and read the “Results”. We would get 84.73 watts out…pretty good for such a long coax. Now try it again. Pretend it is the year 2011, we have great sunspots and 15 meters is hot. Now just change the frequency to 21.3 MHz and recalculate. Oops, not so good… because 15 meters is a higher frequency we are down to 66.62 watts of output. So try this with the other two coax types, RG-8X and RG-213, from the drop down box and some other bands (like 40 meters phone at 7.2 MHz, 20 meters phone at 14.25MHz, and 10 meters phone at 28.4MHz) to get an idea of what those changes do to power output.

Next month we will review the results of your calculations, and then factor in coax cost and power handling considerations.

Crown City HF #15

Choosing a Coax

Last month we began to figure out which coax to use for the shack we are “virtually” assembling using a coax line loss calculator. We found that using RG-58 with our run of 100 ft. the power out on 3.8 MHz would be 85 watts, but at 21.3 MHz it dropped to 67 watts. Keeping in mind that the greater attenuation will be at the higher frequency let’s also look at the other two coaxes. So if you did your homework last month using the calculator, you would have seen that at 21.3 MHz you would get 73 watts with RG-8X and 81watts with RG-213. So RG-213 is the best of the three in regard to signal loss, but how about power handling.

Here we really do not have much to worry about since we a using a 100 watt transceiver. We would have to consider power handling if we were running a full legal power amplifier because RG-58 and RG-8X can only handle in the range of 200 watts or so. The reason for that is that both RG-58 and 8X are physically smaller and lighter cables. This is sometimes desirable when the weight of the coax has to be born by the antenna as it is in a very common type of antenna called a dipole.

Now the final consideration is price. To figure this out go to www.cablexperts.com website and look at the cost per foot of our three coaxes: RG-58 at 35 cents, RG-8X at 44 cents and RG- 213 at 95 cents. Let’s summarize: RG-8X gives 6 watts more power out of our coax than RG-58 on 15 meters, so that increase cost you $1.50/watt and you get 8 more watts with RG-213 costing you $2.25/watt. So since it we are trying to be thrifty with this “virtual” shack and we are running 100 watts out (don’t need RG-213’s greater power handling) let’s go with a 100 ft. run of RG-8X.

These variables may be different for each of you who are reading this. If you really want to work the higher frequency bands, or plan to use an amplifier, and if the cost and extra weight (you are using it on a beam) of the RG-213 is not a problem, go ahead and use that. The point is you need to understand the basic coaxial cable characteristics that we have just used to make a choice.

Next month we will move up the coax to the point where we connect to the antenna. We will need to make another decision here about the use of a balun.

Crown City HF #16

Feedpoints and Baluns

Now, before we start talking about antennas, we need to think about how we will connect our coax to the antenna, at a place called the “feed point”. One of the things I intentionally held back form the earlier discussion of feed lines during which we rather arbitrarily decided to use coax is something called “balance”. Open parallel lines are “balanced” and therefore work well when connected to a “balanced antenna” (which most are). We choose coax for other reasons that we already covered, but now it presents a problem because it is “unbalanced”. We will skip explaining those terms and stick to seeing what happens if you connect a “balanced”, compared to an “unbalanced” coax, to a dipole antenna which is a “balanced” load? With the “balanced” line all current from each of the parallel wires travels down each arm of the dipole antenna if it is cut the right length for the frequency in use (the antenna is said to be "resonant"). With a coax connected to a dipole all of the current from the center conductor goes down the arm of the dipole that it is connected to, but the current coming along inside our coax's shield, which is connected to the other arm of our resonant dipole, may not do the same. It can either flow down the low impedance path that it sees at the arm it is connected to or it may also want to turn around and flow back down the outside of the coax (towards our shack) depending on the impedance it sees there. If it sees something that resembles a one-quarter wave length (similar to the length of the each of the dipole's arms) much of it may travel that way too. That will change the directivity of your antenna usually in a sometimes unwanted omnidirectional way, and also send unwanted stray rf energy into your shack! That is not as much of a problem if you are using low frequencies (e.g. 80 or 160 meters) and you are not too concerned about the directivity of your antenna, but generally having RF come down the outside of our coax is to be avoided.

Next month we will see how baluns can avoid that problem and also why they come in different physical shapes, matching ratios, voltage and current types and power handling ratings.

Crown City HF #17

Baluns 2

Last month we learned about what a balun might accomplish for you, so let's just say you want to purchase one. How do you go about deciding what the specifications of this balun should be?

To do that we need to define what antenna we are going to be using. Later on we will talk about several possible choices, but for now we will choose one which is simple and inexpensive, basic, economical, and effective. So let's just arbitrarily pick a horizontal center fed one-half wave dipole which (thanks to having some nice imaginary trees around) we can get up 50 feet in the air. Also we have already decided to feed our antenna with one hundred feet of 50 ohm coax (RG-8X) and use a 100 watt transmitter.

The balun will probably be hanging unsupported with the coax hanging down at right angles to the wires arms. So for this application we would place the balun between the two 1/4 wavelength wire dipole antenna's arms. Hence it needs two heavy duty eye bolts to attach the end of the antenna's arms to. The most popular of these units are built inside PVC tubing. The actual balun (often a length of coax surrounded by ferrite core beads) is sealed inside with expansive foam or potting compound and connected to a SO-239 connector at the bottom (to receive the coax) and two wires emerging from the small holes in the PVC tube along the sides near the cap on the top. Each of the two wires connects to one of the wire antenna arms near where they attach to the previously mentioned eye bolts. If you plan to use this for long antennas (80 meters and above) be sure to get a balun with an eye bolt emerging from the middle of the top cap to use for support. I do not have the space go into installation details but each manufacturer includes that information with their products. For permanent use it is critical to seal the unit from moisture (do not seal the small drainage hole at the bottom). Baluns can be made in other configurations, but for our antenna system this type of balun is probably the best choice and is available from several sources (e.g.: Radio Works and MFJ).

What about having lightning protection built into the balun? Some come with that, but it is not essential, as we will be putting something called a surge protector in our coax line and will discuss lightning protection when we finish baluns. There are a few other issues such as power handling, impedance ratios, and current vs. voltage types to cover before we decide which balun to purchase. We will leave those for next month.

Crown City HF #18

Baluns and Line Isolators

Club Bulletin - September 2009 So now we need to look at a few balun specifications such as power handling, impedance ratios, and “current” vs. “voltage” types before we decide which balun to purchase. The physical size of the components inside of a balun determine how much power it can handle. Ones with higher power ratings, therefore, are larger, heavier and more expensive. Too much weight is a problem when you are using a center fed wire antenna like a dipole because it is often difficult to support the center of the antenna. Remember, for the W6KA virtual ham shack we have been building, we have been planning to use a 100 watt transmitter output, so we can use a lighter low-power one rated for ~150v watts. The impedance ratio we want is 1:1 (remember we are using 50 ohm coax and the feed point impedance of our first antenna (we will start with a dipole) will be just a little above that (depending on elevation and such) so this is the ratio most often used. Other impedance ratios (next most common is 4:1) would be for other feed line and antenna configurations. We could use up a lot of space explaining the difference between “current” and “voltage baluns”, but it wouldn’t help you much. Let’s just accept the fact that “current” baluns seem to be favored in amateur radio applications. Baluns come configured as boxes, round tub-shaped things and several other shapes. As described in last month’s CC HF article the most popular are in sealed segments of PVC pipe. The shape does not matter much electronically, but the boxes and tub-like shapes work best when bolted to a mast for a beam antenna and the PVC segments seem best for wire antennas with a hang down coax.

To finish this topic I need to mention that we can also avoid radio frequency energy coming down the outside of our coax by using a “line isolating choke”. Two common and inexpensive options are either making six to eight loops of our coax (~6” diameter, bound together), or putting several snap-on ferrite beads around the coax. These are usually placed just a few inches below the feedpoint attachment. The loops are better for beams and the ferrite beads work well on wire antennas.

I would love to finally get to some real “antenna talk”, but alas, a few more important things need to be covered first. Next month it will be “Grounding”.

Crown City HF #19

RF Grounding

October 2009 “Grounding” amateur radio equipment is done for several reasons. This and the next two of these columns will cover all of these. However, in this article we will discuss “RF grounding” which is done to bleed away undesirable stray radio frequency energy in order to avoid causing radio frequency (RF) sparking and/or burns, damage to or malfunction of our radio equipment, unwanted transmissions leading to RF interference, loss of directivity of antenna systems, reduction of received “noise” and in some types antennas ineffective radiation of signals. We will leave this last matter of grounding specific types of antennas (particularly end-fed verticals and long wires) until we cover them later.

I will start by giving a basic plan for our “W6KA virtual shack” and then explain why this approach was chosen. First of all we need a 24” to 36’’X 2’’ predrilled copper or aluminum bus bar (get from Storm Copper Components) that we will mount just a few inches behind our radio equipment near the back of our shack’s equipment table top. Now we need some short lengths (~6”) of very heavy solid or stranded copper insulated wire, preferably #4 or #6 AWG (get from Home Depot for 89 and 36 cents/ft respectively), should be used to connect the grounding bolt on the chassis of each piece of our equipment straight to the binding posts (bolts, washers and nuts) in the grounding bus bar. Similarly the grounding bus should be connected by a short length (less than 6 feet long; shorter the better) of the same wire, avoiding sharp angled turns, to a copper coated stainless steel grounding rod (Home Depot), at least at least 5 feet in length. To do this we will need to have our shack on the first floor, with the operating position table along an outside wall just beyond which is a area of ground into which the grounding rod can be reasonably easily driven with out the risk of making holes in any buried utilities.

Now all this requires some explanation! For instance I know that you are wondering if this bus bar thing is really essential? No…but it is a very convenient way to connect, disconnect and reconnect equipment to a low impedance RF conductor to carry away unwanted RF. Oh yes, remember that “impedance” is the opposition to flow of RF and that it is very much a function of the surface area and shape of conductors. Because high frequency AC travels on the outside surface of conductors, large flat conductors do not oppose the flow of RF current nearly as much as small round wires…so the bus bar is ideal.

So you may also wonder why we do not use some other kinds of RF conductors: wire (bare, aluminum), braided strap or copper tubing. There is always a running controversy about the relative value of all of these conduits which we don’t have the space to cover here, but what I have suggested will work quite well for the 100 watt station we are putting together.

OK, now, why do we have to find a ground floor area for our shack and keep our grounding wire so short? Again it is because we are dealing with high frequency AC current where conductors also allow RF current flow based of the length of that conductor depending on wavelength. The RF characteristic we must remember is that the “impedance” inverts every 1/4 wavelength. So if we consider the ground wire attachment to the grounding rod to be where we want the RF current to flow off into the earth and we connect a 1/4 wavelength wire to to it from the RF source in our shack, it won't happen. That is because at the other end of the wire the shack equipment would see a very high impedance opposing RF current flow. So, let's say we want to work 10 meters: a 1/4 wavelength would be around 8 feet so we would like to see the connection be made in under, say, 6 feet. If the length of our grounding conductor is OK for ten meters (shortest HF wavelengths) all of the rest of HF spectrum will work well because that means our grounding lead will be even longer before reaching 1/4 wavelength.

Alright, do we really need to ground our station? What is wrong with relying on the ground provided by the third prong on the electrical utility outlets? Suffice to say that ALL the experts recommend against that, and the reasons are largely that it will usually assure that there will be stray RF problems all over your shack and house!

Lastly, what about grounding rods? There are a lot of conflicting opinions about the numbers you should use, how long they should be, how far apart they should be, and what they should be made of. Some hams really get carried away with literally scores of grounding rods in various patterns, multiple buried wires or screens or even buried old metal bathtubs, etc. Maybe one more grounding rod would be nice tied to the first one that heavy wire using specially made clamps or several automotive hose clamps. All this digging and burying things can get expensive and in the in our land of rare lightning strikes, not so necessary.

Speaking of lightning, next month the column will cover the "Safety" aspects of grounding, so our shack won't burn up and we don't electrocute ourselves.

Crown City HF #20

Grounding for Electrical Safety and Surge Protection

We have so far limited our discussion of "grounding" to creating a low-impedance escape route for stray RF in the shack. In this month's article we will first look at avoiding shocks from high voltage equipment in our shack. Then we will look at electrical surges which can come though the electrical power mains or via your other utilities. Both of these hazards can cause equipment damage, painful and even life-threatening shocks.

We will look at equipment generated shocks first. Because what I will be discussing relates not only to personal safety but potential property damage, I need to be concerned about liability litigation. This Bulletin is available to many people beyond just our PRC membership through its publication on the internet. Therefore nothing in this article is meant to constitute advice of any kind. If you require guidance specific to an installation you are doing regarding electrical safety you should consult an appropriately licensed electrician.

Consequently I will need to limit my comments to general principals which should always be followed to avoid shocks. First of all do not use inappropriate (too high amperage or too slow blow) fuses or circuit breakers and do not take them out of your circuits unless you really know what you are doing. Also, do not defeat any power cord grounding 3rd prong by cutting it off or placing it into a 2 prong power socket through a 3 to 2 prong adapter. Also, unless you know that a home or building's power system is actually grounded it is important (and not very hard) to determine if your ground connection is working. (www.acmehowto.com/howto/

homemaintenance/ electrical/ grounding.php). Another absolute rule is do not operate your equipment with the outside cover(s) removed and again don't service your equipment unless you really know what you are doing! With the shack we have been putting together for this Crown City HF series the transmitter we a using (100 watts) does not utilize the life threatening voltages we use with "legal limit" power amplifiers. So you might ask why do we need to be so careful? Well, I believe that the precautions above should always be used, if for no other reason than for all of us to learn the reflex use of safe electrical practices.

So what is this about needing "surge protection" in our virtual shack? Not too long ago the world discovered this term when we began to use computers. Electrical "surges" (and "spikes" which are similar) were around long before that, but much of the equipment connected to our utility power lines was more resistant to these transient increases in voltage (lightning strikes, stopping and starting of heavy electrical equipment, solar flares, faulty wiring, downed power lines, etc.). We know that the microprocessors in computers are particularly sensitive to destruction and now-a-days most amateur radio equipment is loaded with them too! It is just as important to protect your amateur radio gear from "surges" as your computer (always do it!). Basically a surge protector detects sudden over voltage and shunts electrical surge current to ground. Two common types are metal oxide varistors (MOVs) and gas discharge arrestors (gas tubes). We don't have space here for explaining how they work, but I should say something about what we might want to buy, within the bounds of my disclaimer (see above). Again, I will not be making specific recommendations but stick to principles. So WATCH OUT…just because an extension cord with a multi-outlet power strip says it is a "surge protector" that does not make it safe for the shack. One way to get some protection is to get one that carries the Underwriters Laboratories Rating Label as a "Transient Voltage Surge Suppressor". But to do it right you need to Google "Surge Suppressor Ratings" for more details.

These matters may seem like picky little details, but they are essential to protecting our equipment and ourselves from harm. Next month Crown City HF will cover lightning protection, and even though we in Southern California are rarely stricken by this hazard, it is the one of the most dangerous risks we face.

Crown City HF #21

Grounding for Lightning Protection

First of all, be glad that we live in an area with the lowest lightning strike probability (less than one per sq km every 4 years) in the US. Compare that to say East Texas, where my son AJ6O, lives (4-8 per sq km/ year). Some places like Florida it can be up to 16 per sq km/year! Nonetheless we must not be complacent because again both equipment and human safety are at risk.

Since what I will be discussing relates not only to personal safety but potential property damage, I need to remind you that nothing in this article is meant to constitute advice of any kind. If you require guidance specific to an installation you are doing regarding lightning protection you should obtain professional consultation. Also this is a complex field which can only be summarized here due to space constraints, so I will limit my remarks to a few main principles and coverage of the elements of defense which need to be considered, rather than any specific recommendations.

The first thing to understand is that lightening represents a discharge of huge amounts of direct current from a thundercloud to earth. In addition there are superimposed pulses (usually 4 or 5) which make much of the current behave like radio frequency energy, which means it travels predominantly on the surface of conductors. Lightning is most likely to strike something like a 100' radio tower, and you might think that it would be unnecessary to worry about the "virtual" beginner's station we are constructing with let's say a 40 meter dipole strung between some trees at a one half wavelength (66'above ground). Even if there are more elevated conducting pathways, like trees or tall man made structures available, lightning is never predictable and consideration of it must be made for all antennas. Another reality is that there are all kinds of other entry points (electrical service, phone, cable/ satellite TV, etc.) which need to be considered but are beyond the scope of this article. Identifying and protecting them is covered well at the following website:

www.astrosurf.com/luxorion/qsl-lightningprotection. htm.

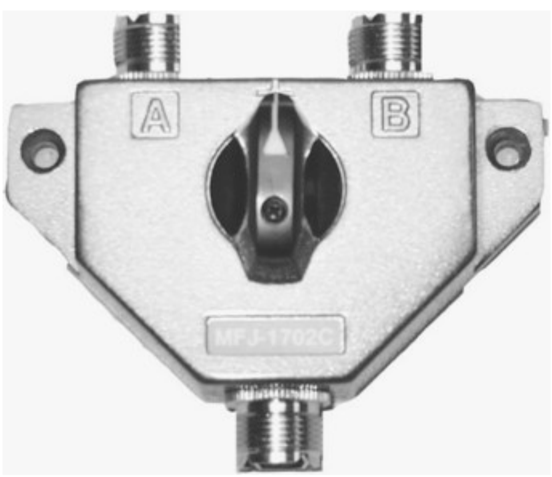
Suffice it to say that a properly built home constructed in recent years should have already had these lightning hazards protected against. If we are unsure we need a professional to inspect the dwelling where our radio room will go.

From here on we will be focused on the feed line from our antenna (we have also arbitrarily selected coax) to our shack. It is the most likely to cause trouble if there is a nearby or direct lightning strike. The first of three critical elements is the wall passthrough (sometimes called a "single point grounding panel or SPGP"). We are going to assume that right behind our virtual radio equipment table is an old fashioned slide up casement type window. Now we will need to find a 5 mm thick, 20 cm/10 inches wide piece of copper or aluminum which is long enough to be fit all the way across the bottom of the window's casement space. We will cut it to fit snugly (to keep bugs out and heat in). Now we need to buy a lightning surge protector for coaxial cable with two SO -239 (female) connectors and a heavy binding bracket or bolt. We are using a 100 watt transmitter so buy one of the 200-400 watt power handling range (MFJ or Cushcraft). It must be securely bonded to the SPGP panel using the bracket or bolt. We will mount it on the outside of the panel to keep any part of the lightning path outside the shack. We will then connect one end to our antenna's coaxial feedline and the other to a short "jumper" coax which we will feed through a large (6'' diameter) hole cut through the SPGP and covered with some insulating material with a coax sized hole in it. This allows for plenty of space to avoid any "spark gap" effect to bring lightning into the shack. Then, for the same reason, be careful to secure the jumper coax so that it does not come close to the metallic part of the SPGP or to the coax going to the antenna. The last element in this defense system is to connect the equipment grounding the bus bar we constructed in October's Crown City HF article to the SPGP. This can use the same 4 or 6 AWG wire we used before. The bond should be mechanical (large bolt and wide copper washers). Now we can (from the outside of the copper panel) connect the SPGP to the ground rod. Just to be safe use the heavier 4

AWG wire for this connection. If our shack does not have a nearby window to use as a pass-though we will need to create an opening or drill holes in the wall for our coax. However we will need to follow the principles outlined above with SPGP in the opening or just outside the shack to keep the lightning current path outside the shack on its way to ground.

All the same controversies I have mentioned earlier still exist about what conductors and ground rod(s) to use. Because of the greatly increased current flows with lightning the issue becomes even more critical. If we were to be erecting our shack where it would be at any increased risk (e.g. on a high hill, on a building or somewhere other than Southern California) we should go with straps or braid conductors and an array of ground rods.

One last thing we need is a coax grounding switch such as a MFJ-1702C for inside the shack.



It is to be placed between the coax connected to our antenna and a short coax jumper which goes to our transceiver's antenna connection. This switch is for a single coax, which is all we need in our shack for now. When our equipment is not in use it must be kept in the grounded position. To keep costs down we will not start out with an antenna tuner or low-pass filter. However, this is where along the feedline chain they will go if we decide (later) that we need them and they would be connected to the bus bar the same way our transceiver is.

There were a number of other products which we may have needed for electrical-lightning protection and grounding that may be hard to find around Los Angeles. However the internet has many useful dealers to choose from. Here are some suggestions:

www.erico.com/products.asp?folderID=199
www.petuniaco.com/index.htm

So much for grounding! Next month we will move to the other end of our coax and start looking at antennas.

Crown City HF #22

Standing Wave Ratio

Back when this column was discussing feed lines, characteristic impedances and feed points, we talked about the importance of "matching". I sneakily avoided discussing standing wave ratios because it was not essential information for buying the coax we decided on. Now, when we are talking about antennas, it matters. Every antenna you make or buy will be judged in part by its standing wave ratio (SWR). Let's see why it matters (or not). Maybe you remember that the if the transmitter's output, the coaxial cable's output and the antenna's feed point impedances are all the same you get the maximum output transfer of power into the electromagnetic field radiating from an antenna. Well, for the last 40 years or so essentially all commercially manufactured amateur radio transceivers (or transmitters) come with a 50 ohm impedance output and if you remember the Crown City HF articles on coax (May and June 2009), we ended up picking a 50 ohm coax for our “virtual shack” because it matched the impedance of almost any transceiver we might buy. That part is easy, but it is not the same with antennas. The feed point (where you connect the coax) impedance of antennas varies above and below 50 ohms. Let’s take, for instance a half wavelength center fed dipole antenna that has been cut to be resonant at the frequency being transmitted. It will generally have 72 ohm impedance. Also, a well grounded quarter wave vertical will have a 35 ohm feed point impedance. Those are actually good matches giving SWRs a little under 1.5 to 1. How did I calculate that SWR? Well, I normally don’t like formulas, but here is an easy one. SWR= Z load (impedance of the antenna in ohms) divided by the Z of the coax or Z coax/ Z load using which one gives an answer > 1. So for the dipole it will be72/50=1.4/1 and for the vertical it is 50/35=1.4 SWRs are always represented with the higher number on top and then “divided by” and “over” are shown as a “/” or “:”.

We could spend several CC HF articles going into the mathematics, formulas and physics of SWR, but I will keep that sort of thing limited to what you “need to know”. However I do need to explain where the term “standing wave ratio” comes from. It applies to measuring the voltage at different places along the feedline (coax). In a perfectly matched antenna system the voltage would be almost the same (VSWR= maybe 1.1 to 1), but if the there were a major impedance mismatch there would be a big differences in the voltage along the feedline which follow a wavelike shape and the Standing Wave Ratio or VSWR would be high. The V in VSWR is commonly dropped and only SWR is used. The word “standing” is used because the wavelike pattern does not move along the feedline and therefore is “standing” still.

So let’s get practical now: Why is SWR important? How should it be measured? What do you do about a “bad” SWR? These are the things you really need to know. So let us start by saying that of all the measurements the average ham does, SWR is probably the one that we do most often. What is more, there are several instruments available to measure it. And it is important where you measure it. Finally, fixing a high SWR can be easy or incredibly difficult.

The first question has two important answers. First, when you have a high SWR it means that a significant part of the power that you would like to have going out through your antenna is being reflected back toward you and is wasted. As we will soon see, that may also cause mischief back at our shack. The power loss in the coax due to SWR is what many hams worry most about, but it is generally not a big problem. For instance at the 1.4/1 SWR in the examples noted in the first paragraph for a 1/2 wave dipole and 1/4 wave vertical, the percentage of that power loss is 2.8%...almost nothing. With SWRs of 1.8/1 and 2.0/1(they sound high don’t they?) you will only loose 8.2% and 11.1%. Not too bad…but somewhere around these levels we do need to start worrying. At a 3/1 SWR 25% will be coming back!

So why worry? Because we must now have an increasing concern about what all that “reflected” radio frequency energy (“rf”) will do back in the shack. If that reflected energy gets back into a transmitter’s last (“final”) stage it can cause serious damage to the power amplifying transistors or vacuum tubes and other components. To reduce the chance of such damage the manufactures of transmitters add circuits that detect excessive reflected power and automatically reduce or shut down the power output of our radios. There are also some other problems like rf sparking and transmitted signal distortion. So with our coax fed antenna we really don't want to work against high SWRs.

Next month we will address the vicissitudes of measuring SWR and address what can be done to reduce excessive reflected rf.

Crown City HF #23

SWR Measuring Instruments

Last month we discussed the importance of avoiding excessive SWRs and to do that we will need an instrument called an SWR meter. The basic ones that are usually purchased by hams are housed in a small box with two coax connectors sticking out, one marked ANT (antenna) and the other marked TX (transmitter). There is a dial and single needle meter with a nonlinear scale marked from 1:1 to infinity indicating the SWR. A knob marked CAL (calibration) is also present. Also there will be a two position switch marked REF (reference) or FWD (forward) and REV (reverse) or SWR. These meters are rated for the maximum power it can handle. In the "virtual shack" that we have been building we will only need it to be just over 100 watts because earlier in these Crown City HF articles it was already decided to use a HF transceiver with this power output and not have an amplifier. On the basic SWR meter there is sometimes a switch for selecting various power ranges. We also have to pay attention to the frequency range of the meter. For our HF use we need it to cover only 1.8-30 mHz. Most of these meters manufactured are for 50 ohm impedances and that is what we want.

You don't need to know the details of what is inside the box to use one. You just connect a short piece of 50 ohm coax with male connectors on each end to the transceiver's output. It will be marked ANT and the other end goes to the TX coax connector on our SWR meter. When making these coax connections be sure to carefully align the hardware and screw down the outer sleeve without forcing it. Many hours of frustration with inexplicably dysfunctional antenna systems can be avoided over a lifetime of hamming by paying attention to this precaution whenever coax connectors are joined. Now the other coax (female) connector on our SWR meter connects to the coaxial cable which feeds our antenna. Next, turn on your transceiver. Put it in "tune", "CW", "FM" or "AM" mode (not "SSB") and turn the "RF output, sometimes called "Power", knob up to about one quarter of maximum. If there is a power range switch on the SWR meter, set it to 100 watts. Have the other switch mentioned above in the REF/FWD position and press the push-to-talk button on your microphone down (or key your code key) and turn the CAL/ADJ knob so the needle is aligned with the calibration point on the meter's dial usually marked CAL. If while in the REF/FOR position the needle cannot be made to reach the CAL point either turn up the transceiver's power slightly of reduce the SWR meter's power selection switch to the next lowest setting. Now turn switch to the REV/SWR position and read the SWR off the dial.

There are many variations on this basic SWR meter. Some meters may have two crossed needles; a feature I like very much. It saves the switch flipping and calibration steps and can tell you both forward and reverse power. They are designed to be left in the antenna's feed line system for continuous reading (the others are not). However, I need to introduce another concept here. Every additional "gadget" that we put in series along the feed line will reduce power output a little. I am talking about power/SWR meters, antenna tuners, splicing together two coaxes with a barrel connector, RFI filters, lightning arrestors, etc. Individually the power loss is not much but they add up! For instance if you tune up your antenna and it has SWR of less than 1.8/1 on the frequencies you use and you know the power into your feed line is good, leave out the in-line Power/SWR meter and any antenna tuner. Only include what you really need.

Also you should know that there is another "Cadillac" (I like that word… it encourages us to buy American) kind of SWR device called a SWR analyzer. It saves lots of work when tuning antennas (we will cover that soon) and gives more information than just the basic SWR meter, like frequency counting, resonant frequency, impedance and SWR vs. frequency curves. However they cost several times as much and the basic SWR meters and are more than we need for this "low cost" shack we are building.

So next month we will see how to use an SWR meter to "tune" our antenna so almost all the RF power we send down the coax leaves our antenna to circle the globe

Crown City HF #24

Using Our SWR Meter to "Tune" Antennas: The Dipole

So what antenna are we going to tune and why we are choosing that particular one? Several times so far in these Crown City HF articles I have mentioned that the dipole antenna is a good choice for the first antenna for the "virtual shack" we are building. Remember that these articles are being written largely for hams who are new to HF activity, so I am trying to stick to what is practical and understandable. It is said that the dipole is the commonest antenna in use by hams today, but the reason I chose this antenna is that it is easy to understand, inexpensive and fun to build!

So what does this antenna look like? In its simplest form it is made up of a 1/2 wavelength of wire separated in the middle by an insulator, called a center connector, that separates the two (now 1/4 wavelength) arms. Since we will be using RG-8X (see CC HF, June '09), a coaxial cable transmission line, we will connect the inner conductor to one arm and the coax's braid to the other. Usually the two insulators are connected to lengths of small diameter but strong antenna cord (rope) which are attached to two objects like tall trees far enough apart to support the antenna well above the ground and out of the trees. I have been talking about the arms being 1/4 wavelength long each, but how do we figure out how long that should be. Now let's say that we want to work CW on the part of 40 meters which is open for use in that mode by Technician Class operators. So we will pick a resonant frequency for this antenna of 7.050 MHz because it is in the middle of that segment. Now the easy way to get the measurements is to go on the internet and paste in

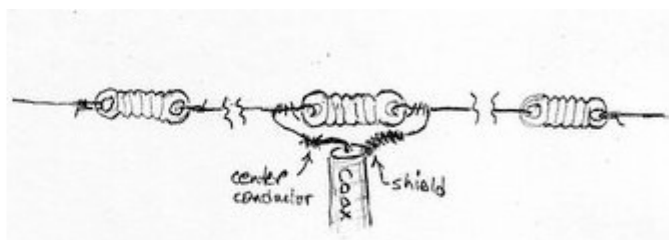
http://www.csgnetwork.com/antennaedcalc.html.

Use the calculator and you will find that each arm should be 33 feet, 2 and 5/16 inches long. Remember that last month we learned that when this kind of dipole antenna has been cut to be resonant at the frequency being transmitted, it will generally have 72 ohm feed point impedance which will match quite nicely with our 50 ohm RG-8X coax and give a low SWR. Once you have made this calculation, we might just cut the wire to the length indicated, haul up the antenna and start transmitting. But things are never quite that simple! The height above ground, interaction with surrounding objects (particularly metallic), inaccurate measurements, and faulty components or connections can all foul things up. So, being careful hams, we want things to be "as good as they can be". That we will do next month with our trusty SWR meter.

Crown City HF #25

Assembling Our Dipole

So last month we calculated that our forty meter "Technician CW" dipole antenna should have each of its two arms cut to be 33 feet, 2 and 5/16 inches long. However, when we cut the wire it should be cut at 12-18 inches longer than the calculated length for some practical reasons we will soon cover. What kind of wire should we use? A good choice would be #12 or 14 stranded copper antenna wire (~16 cents/ft). With the wire antenna arms cut, pull one end of each wire through the hole in the eyelets at the ends of a basic antenna insulator. We will need two more end insulators before we are done and they come in many shapes (e.g "dog bone"). Insulators are usually either PVC or ceramic and cost a dollar or less each. We will be using the first one at the center of our dipole. As the wires emerge from each of the eyelet holes in our center insulator we bend the ends over and twist them in 4 tight turns of wire around the arm wire antenna arms-to-be. One of these ends is then twisted with and soldered to the center conductor wire coming form the middle of the coax. The other goes to the braided shield. Be sure the lengths are cut so these connections are short and remain nearly parallel to the arms and at a right angle to the coax as it drops away.



This assembly around the center insulator is commonly wrapped with good quality electrician's tape to provide weatherproofing at the top of the coax and plastic ties applied to support to the coax's weight. Before applying the tape we must look carefully at our work. Be sure the soldered connections are not cold joints and that there are no "shorts", most commonly between stray tufts of coax shield and the center conductor. We will use a Volt Ohm Meter (VOM) to be sure that all the connections we made are intact and there are no short circuits between the center conductor and the shield.

Now we finally get to the “cutting” of the antenna… but it is a mistake to actually cut the antenna wires again. Why? When the arms are too long it is easy to deal with them, but when they are too short it requires a spliced joint (weak and looks bad!). So we will want each arm to be 33 feet, 2 and 5/16 inches long at which point each end is bent over and through an eyelet on our two remaining (end) insulators and then loosely wrapped back around the antenna wire toward the feed point. The measurement of each arm should be from the center of the center insulator along the arm (wire) to the farthest point away on the curve of the loop that holds the wire to the end insulator. For now the exact length is not as important as being sure that both dipole arms are the same length. That is because if they start out at the same length and we are careful to always shorten or lengthen both of them the same amount during every step of the tuning process, we can avoid ever having to measure the whole antenna’s length again. Theoretically the antenna should be have its lowest SWR at our chosen center frequency of 7.050 MHz and all we have to do is haul it up by means of some support ropes attached to those two tall virtual trees we are lucky enough to have outside our virtual shack. But it is not so easy! Remember, I said earlier that the height above ground and the interaction with surrounding objects would make it necessary to tune the antenna. We will see how to do that next month.

Crown City HF #26

Getting Our Dipole Up: part 1

It is nearly time to put up our “virtual 40 meter dipole”. But in order to decide on the best location for it there are some important considerations we need to address. First we should understand the directional radiation pattern of a dipole because we do get some “amplification” of the power at right angles to the antenna. In technical terms it will have about 2 dbi of gain, meaning that it will concentrate the power equally off the front and back of the antenna so that it acts as if we are radiating 1.6 times our transmitter’s 100 watts of power from the antenna. That effective radiated power (ERP) of 160 watts comes from concentrating the signal to send most of its power off perpendicular to the antenna, but it also it means that off the ends of the antenna there will be reduced radiation. Reception is similarly better in directions broadside to the antenna than off the ends. This means we need to think about how we position the antenna so that it best serves our needs. For instance, let us say that we have a very good ham friend nearly straight north of us in Seattle with whom we plan to spend most of our time on the air chatting (“rag chewing”). We may want to have our antenna positioned with its long axis in an east-west orientation and its best transmitting and receiving characteristics in a north-south direction. On the other hand we may just decide to orient the long axis of our dipole from NNW to SSE because using that placement is most likely to get contacts form the largest concentration of hams which, from Southern California, is just a little north of east across the country. We shouldn’t worry much because this change will hardly be detectable in Seattle. On field day, for instance, we worked the Pacific

North West (and even Alaska) easily with our 40 meter dipole pointed straight east!

Next we need to consider how high up we place our antenna. For instance, if we put it ½ wave length (65+ ft) above ground level we will have a low angle of radiation (good for DX). If we have to place it lower than that the radiation angle goes up and at about ¼ wave length the radiation goes up so steeply that ionospheric refraction is unlikely to result in good skip.

Another consideration is radio frequency interference or RFI. I hate to bring this one up, but if there are any choices about placement of an antenna, it should be considered. There are many causes and cures of RFI, but one thing that is often helpful is just staying as far away from any susceptible electronics as is practical. So, while trying to keep the height and directional considerations that I have just mentioned foremost in our minds, we should make an effort to place the antenna and coax as far as possible from our neighbors' (and our own) TV and phone equipment and lines as possible. Considering RFI as an antenna placement factor now may save us an embarrassing visit by the burly guy next door inquiring why ever since we put up ***that antenna*** his TV picture has wiggly lines and his wife hears your call sign on the phone (she knows it's you…it's on your license plate).

With all these variables to consider while putting up an antenna it begins to seem like an impossible puzzle! But we are not even done yet. There is Mother Nature to contend with. She can whip those wonderful trees of ours around something awful even in Southern California. That can snap our nice dipole in half if we don't support our antenna correctly. Also, we still have tune to our antenna using our SWR meter…and what about power line, lightning and RF safety concerns? We will tackle those in next month's and subsequent Crown City HF articles.

Crown City HF #27

Getting Our Dipole Up: part 2

In last month's Crown City HF we looked at the considerations to be taken into account in the placement of an antenna. Of course often the issue is where can we find the trees, poles, towers and/or other ways to support our antenna? For reasons of simplicity, you may remember, I am taking a few liberties with this virtual shack we are conjuring up. One of them is that right out in the backyard next to our shack we have two beautiful slim but strong 70 foot trees about 80 feet apart. What's more their location is such that a line drawn between them is at right angles to the desired NE-SW radiation focus we desire.

So now the next step is getting some strong antenna ropes up into those two trees (our 40 meter antenna and feed line does not need center support). Because of space limitations it is not possible to go into detail here, but I will recommend a simple, usually successful and durable way to erect our dipole. However, a nice comprehensive article on "Installing Wire Antennas in Trees" can be found at www.radioworks.com. It is a "commercial" article (they try and sell you stuff), but it is the best I have found. We need to get our antenna supporting ropes over a sturdy limb near the tops of each of those tall trees. Remember (from last month's article) that we want to be over the very top limbs to get our antenna at least one half wavelength above ground. That will take something more than your arm, usually a slingshot, casting rod, or bow and arrow (or cross bow), to get a light slippery strong line up there. Heavy monofilament fishing line works well for this. Whatever you use for projectiles, maybe lead fishing sinkers or weighted arrows, remember that there is some risk to the launcher and people, animals and property anywhere near and very long way beyond the target tree. Also, our launcher should wear protective goggles.

Let's just skip a few details and assume that we have gotten (with a little help some ham friends) the fish line over a nice, sturdy, smooth, not very leafy branch 67 feet up. Now you need some strong Dacron/ Polyester braided 3/16 in. antenna rope (350 feet for $50 online at DX Engineering). We will need a lot of it (140+ feet for each end) and it is best if it is not made up of shorter lengths tied together because any knots are weak points and they hang up on the branches and foliage when taking the antenna up or down. The next step involves tying the antenna rope to the fishing line with as secure but non-bulky a knot as can be designed by the Boy Scouts, yachtsmen and surgeons among us. The idea is to keep it from separating and not hanging up while we reel in the fishing line and pull the antenna rope up over and down to the ground on the other side. This usually takes some coaxing, finesse and a few expletives but let's just say we have now also accomplished this step.

Now we will need to deal with another problem, which is the motion that a wind storm creates. Last month I warned about how wind can whip trees around and can snap our nice dipole unless we take some precautions. We have already done some of that because we bought high quality wire and antenna rope. There are complicated pulley systems which rely on the elasticity of longer lengths of antenna rope or even weights to take up the shock of wind gusts, but many hams in Southern California will rely on only the shock absorbing provided by some drooping of the antenna and elasticity inherent in the antenna wire and rope. There is a middle ground, which is to add 30 inch bungee cords between the end insulators of our dipole and our supporting antenna ropes. These bungee cords should be "heavy duty", made of first quality, long lasting rubber (www.bungeeco.com). Care must be taken to make these connections very secure, but since they are to be pulled up from the other end of the rope and, hence, will not pass through the trees and over branches they can be bulky if necessary.

So having connected the end insulators to the bungees and the bungees to the antenna ropes we are ready to haul up our antenna.

Next month we will do that, check SWRs and trim its arms to achieve the optimal resonant lengths.

Crown City HF #28

Getting Our Dipole Up: part 3

In August's article we had connected the ends of the antenna to the supporting ropes and were ready to raise our antenna. So far we have not talked about using pulleys to make this step easier, but if the tree limb is particularly rough or the foliage very dense, making hauling the dipole up and down difficult, you may want to consider using them. Considering our space limitations and because that kind of configuration is usually not necessary, I will not discuss use of pulleys here. Rather I will again refer you to

“Installing Wire Antennas in Trees” at www.radioworks.com.

Before we start erecting the antenna I need to sound a word of precaution and refer you to another website. That is because there are some very real, even mortal, dangers if you are not careful of electrical lines. The best list of precautions I have found is at

www.universal-radio.com/catalog/wideant/safewide.html

Read it carefully!

OK, we better get back to work or we will never get this thing up.

Remember that we want the antenna cut so that it is resonant in the Technician Class CW part of the 40 meter band at 7.050 MHz, so it should have each of its two arms cut to be 33 feet, 2 and 5/16 inches long. Also we left extra length in case the antenna is too short. Again, the measurement of each arm should be from the center of the center insulator along the arm (wire) to the farthest point away on the curve of the loop that holds the wire to the end insulator. Be sure to get this right now, because we are hoping that when we get the antenna up there its SWR will be acceptable and we won’t have to do any trimming or lengthening.

It is nice to have some help (two is best) for the hauling up. One of the assistants can alternately pull on the antenna ropes while the other watches for hang-ups and helps unfurl and lift the coax as the antenna ascends. Both persons should avoid standing where the antenna might fall, in case something snaps.

Ideally we would like to check the SWR as close to the feed point as possible. The reasons for this are not important to this mission and for this configuration, size and height of antenna would be quite impractical. Others would say that you need to have a good low loss 1/2 wavelength (at the desired resonant frequency) of coax to do the initial SWR checks. Also we might haul the antenna up only part way to test the SWR the first time. However, if you have used good materials and the RG-8X low loss coax we decided on earlier, it is usually possible to skip those maneuvers and just haul it up and check the SWR.

One last thing about this step: do not do this on a windy day. The whole operation will be much more difficult for obvious reasons, but not so obvious is that it will make tuning more difficult. Before you tune it you want to have the antenna stable and the tension on the ropes such that there is 1-2 feet of sag to help prevent snapping forces. If the trees are moving around it will be hard to find that configuration.

Now lead the end of our coax (coming down from the antenna) into the shack to connect it to our SWR meter. Back in December 2009’s Crown City HF, we learned about using a lightning surge protector with a single point grounding panel to bring coax into the shack. Bypass that for now (later we will put those in the feed line circuit and check SWR again) and just connect the coax to our SWR meter. Use a short jumper coax to connect the SWR meter to the transceiver. Set your HF transceiver to the target frequency (7.050 MHz), set the mode for CW, and, while listening, tune up and down slightly if necessary to find a clear frequency. Now briefly close your telegraph key while using just enough power to make your measurements to check the SWR.

“Tune in” next month when we actually get around to tuning the antenna. While you wait anxiously for the next edition of the

Bulletin look at last April's Crown City HF to review how your the SWR meter works and memorize this concept (you will use it often): "shortening the antenna moves the resonant frequency higher; lengthening makes it lower".

Crown City HF #29

Tuning Our Dipole, Part 1

Last month we finally got our dipole up between two nice high treetops and so it is time to "tune" it. It would be a good idea to look back to April and September 2010's Crown City HFs and review how to use our SWR meter and understand the meaning of the values since I will not be repeating that material. With the transmit frequency set at 7.050 MHz briefly hold down your CW key (see last month's Crown City HF) and write down the SWR. If it is below 1.5:1 breathe a sigh of relief, particularly if you are a Technician Class operator and only plan to use 40 meters to work CW. You can probably just stop here. You will be working in such a narrow range of frequencies that this antenna will work just fine.

But if the SWR you just measured is above 2.0:1 we learned in April that it is not acceptable. Maybe you just got your General class license and also want to operate on the 40 meter phone band. You will be using a much larger part of the band (more "bandwidth"). Maybe you are a "low SWR fanatic" and would just feel better if it was it lower. For any of these reasons we should do some further tuning which will require lowering the antenna enough to get at the ends. But before we do that we need to do some other measurements to determine what we need to adjust.

So retune our transmit frequency to 7.005 MHz (as close to the bottom of the band as is safe legally) and repeat the SWR measurement. Write down the result and frequency. Then write below it the result you got for 7.050 MHz. Now measure the SWR at every 50 KHz up to 7.295 (not 7.300 to be FCC safe) MHz writing them all down with the frequency measured. In case you have forgotten 50 KHz is .050 MHz. Now here comes the fun.

Say that our initial SWR at 7.050 MHz was 2.2:1…too high. Is that because the antenna is too long or too short? Well to find out we can make a graph with the X axis (horizontal) with equidistant (1/2 inch) marks for every 50 KHz from 7.000 to 7.300 MHz and the Y axis (vertical) along the left starting at SWR 1:1 at the left side of the bottom and then every 1/2 inch mark 1.2:1, 1.4:1, 1.6:1….up to 3.0:1. now, using your SWR readings and frequencies and connect them with what should be a somewhat curved line.

Now let us define the problem that we want to fix as an unacceptably high SWR at the frequency we want to use and we will be working a narrow range of frequencies (e.g. the Tech CW band). First look at where the lowest point of the SWR curve is (its "resonant" frequency). Where is that on the frequency axis (X axis)…at a lower or at a higher frequency than where we want to work. If that resonant frequency is too low the antenna is too long, if too high the antenna is too short (the way to remember that is: you probably already know that long antennas are good for low frequencies, like 3.5 MHz, and higher frequency, 28 MHz, antennas are little short ones). So using our 7.050 MHz unacceptable SWR of 2.1:1 and according to the graph our antenna has a resonant frequency of 7.250, too high, we need to make the antenna longer. How much longer? Well for a 40 meter antenna it turns out (we will skip the math) that about 5-6 inches of lengthening will move the resonant frequency about 100KHz. So, since we need to go about 200 KHz, so we will add 11 inches. How do we do that? Remember back when we made this antenna we folded back extra wire and twisted it around itself. What we can easily do now is release enough wire to make both arms 11'' longer. Twist the wire as before, but do not cut off the extra; you may need it. Now haul the antenna up again and retest the SWR at 7.050, which is generally the hottest part of that band. If it is 1.5:1 or lower, you are good to go and all of the CW portion (7.025-7.125 MHz) will almost certainly be below 1.8:1 and OK. But go ahead check it because if it is not you can "fine tune" it. Just use smaller length adjustments, the same principals and know that if the resonant frequency is too low you want to shorten your antenna and if too high lengthen it.

Next month we will look at the other problem we posed, that is trying to adjust the antenna to cover a broad range of frequencies so we can work both the CW and General Class Phone portions of 40 meters with an acceptably low SWR. That involves "bandwidth" and is a bit trickier because it involves making compromises.

Crown City HF #30

Tuning Our Dipole, Part 2

Last month we had gotten our 40 meter dipole raised and its length adjusted to have its lowest SWR centered over the Technician Class (CW) part of the band, all of which was in a very acceptable SWR 1.5:1-1.8:1 range. But let's suppose one of us who will be using "our virtual shack" just passed her General Class exam and would like to work SSB (phone) on 40 meters… and the rest of us still want to use the CW part of the band. How can we do that?

OK, what we need to do is change the lengths of the arms of our dipole to move the resonant frequency and still be able to use both CW and phone. Remember that resonant frequency corresponds to the lowest SWR along that curve on the graph that we made in last month's Crown City HF. We had trimmed the antenna based on trying to put that resonant frequency to as close as possible to 7.050 MHz. But now we want to move that point on the curve to the right (to higher frequencies) far enough to be about half way between "sweet spots" on the Technician CW (7.025-7.125 MHz) and the General SSB (7.175-7.300 MHz) segments. Well, a good guess would be that those frequencies are around 7.100 and 7.200 MHz, which tells us that 7.150 MHz is the resonant frequency we want to aim for. That should not be a problem?

So how do we get there? We lower the antenna and prepare to shorten each of its arms. [Keep thinking: shorter antennas are for higher frequencies.] But how much shorter? Remember our previous estimate: 5 to 6 inches for every 100 KHz you want to move the resonant frequency. Our antenna therefore needs to have its present resonant frequency of 7.050 to 7.150, that is 100 KHz, meaning we shorten each wire arm 5”- 6”. OK, but now think back. Let’s say the last time we adjusted this dipole we used that 6” per 100 khz (last month we were lengthening) and it turned out to be a bit too long (that is too low a resonant frequency) so you had to shorten the arms one inch each and the resonant frequency (lowest SWR) ended up just where you wanted with the SWR there at 1.2:1. That tells us to use 5 inches per 100 KHz of shortening this time. This last calculation may seem unnecessary. Why not just shorten each arm a couple of inches, haul it back, re-test it , and keep cutting cut off a little more (and then maybe a little more off) until you get the right resonant frequency? Well that works… and probably is even the commonest way these antennas are tuned…but every time you have to adjust length it takes time and puts stresses on your antenna’s components and anchoring points. Don’t think that our antenna is infinitely durable and therefore indestructible…they are not.

Now it is time to check the SWR again and add a second curve to our graph. So lets just say its resonant frequency moved up to 7.160 MHz with a SWR of 1.2:1. A little off our projection, but this is not what we care about. We want to now what is the SWR on the CW and phone bands where we want to work? Well, we check and at the bottom of the CW segment (7.025) and the SWR is 1.6:1 and 1.8:1 at top of the phone segment (7.300). The curve is flat enough that we do not need to do any more adjustments. No more adjustments are needed. But let’s just say they were not, because the SWRs were too high, too close to the “sweet spots” we want to work. We might need to compromise a bit. Let’s listen on the bands for some help. We find that there are just not many hams working the high end of the SSB section. They mostly hang out near the low end where the Extras and some DX wander over into the General Class territory. Also on CW the low end occasionally sees most of the activity and even some DX. So now we move to the low end of the band and looking at your graph (you now have two curves on it) pick where you want the curve to sit. Now all we have to do is play with the antenna’s length to include what we consider the most important (to us) parts of these two sections of 40 meters.

What if we can’t do that? There are ways around that. The easiest fix is an antenna tuner. We will see what one of those can do for us next month.

Crown City HF #31

Antenna Tuners (1)

So when do we need an antenna tuner? Some authorities would say always. Why? Well, remember that back in the March 2010’s installment of the Crown City HF we found out that the greatest power transfer from transmitter to antenna occurs when the antenna presents the same impedance as the coax and the coax does the same for its connection to the transmitter. Because the coax and transceivers most often used by hams are designed to work at an impedance of 50 ohms and our antennas’ feed points are also close to that impedance you might wonder why anyone would eschew the use of antenna tuners. Well they have some good reasons. As I have mentioned before every gadget you put between your transceiver and your antenna (that would includes a low-pass TVI filter and a lightning surge protector) slightly degrades the power transfer. Also, each of them is an expense, so if you don’t need an antenna tuner why waste your time tuning the thing and the money to buy it?

Nonetheless, I would say that we should get one for our “virtual” shack*. Why? Well, there is almost always some degree of mismatch between the antenna and the transmitter. A dipole in free space at its resonant frequency has a feed point impedance of 72 ohms and that can vary up or down depending on the antenna’s surroundings, height above ground, and the electrical characteristics of the ground. So you almost always start with some mismatch.

There will be another problem if we are using a large frequency range, like both CW and SSB, on any given band.

That will be the case since this shack is intended for “Techs” using their 40 meter CW privileges and new “Generals” using SSB. In that case, even if our antenna has a very low SWR at the center of the band, it is likely to be quite high near the two ends of the band. But if we are going to work only a limited portion of one band, say we only have “Techs” using CW, we probably don’t need a tuner.

Also there is the occasional instance when we just can’t get the SWR down to acceptable levels in the parts of the bands we want to work no matter what is done. Finally, maybe when some “Techs” upgrade we will want to use several other of their new band options! One cheap option would be a multi-band antenna like a fan dipole. But they are harder to tune. Sometimes it just will not work on all bands despite multiple attempts at adjusting the antenna (they can be tricky…fix one band and another goes bad).

So before we decide which tuner to buy, what is this antenna tuner? It is a network of capacitors and inductors which are adjusted either manually or electronically to match our transceiver’s output to the SWR (and impedance) it sees at the end of the coax and antenna system to which it is connected.

The biggest decision we need to make before buying one is between manual tuner or an automatic one. Well a major consideration is obviously cost. We need a tuner for HF that will handle our 100 watt transceiver’s output (arbitrary transceiver decision we made a while back), and for now let’s say we want a built-in cross needle SWR meter. I will come back to justify that later. A manual tuner which would fit those requirements safely would cost around $115-120 or you could get a automatic tuner for around $180-200. The obvious difference is that you have to do quite a lot more manual adjusting with the cheaper model. Is that all? Well the manual model has fewer and far less complex circuits to go wrong or be damaged. And there is a deeper level of involvement that some hams enjoy in fussing with the knobs on the manual tuner and seeing your reflected power drop and output soar as the needles swing! However the automatic tuner’s digital readout will tell you that information while you sit back and concentrate more fully on operating your rig! It’s a hard call, but let’s choose the more economic choice and get a manual one.

Next month we will learn something about how antenna tuners work, where the antenna tuner will go in our antenna system and how to adjust those knobs.

Crown City HF #32

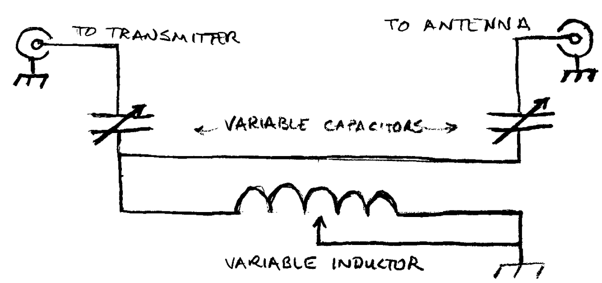
Antenna Tuners (2)

Last month we had decided that we will need a manual antenna tuner and I promised to tell you a little about how they work. I have chosen to go into the electronics a bit deeper than I usually do because I have been helping my grandson (KE5VYT) learn the material covered by his amateur radio exams. Because I can see that some of the concepts that govern AC currents are exemplified nicely in antenna tuners, I thought that my “target audience” might benefit by some greater familiarity with them. So here goes!

In a nutshell the antenna tuner is a matching transformer between the antenna with its connected coax and a transmitter. What do I mean…”a matching transformer”? Well, most commercially available ham radio antenna tuners (MFJ, Dentron, Ameritron, etc) are of the CLC type which means that there are three knobs to tune: two connected to variable capacitors (usually marked “Transmitter” and “Antenna”, and one to a variable inductor (marked “Inductance”). OK, so how does that actually “transform”?

When you took your Technician class you heard about resistance, voltage and current in direct current circuits. Remember…the more the voltage and the less the resistance the more current flowed. Well, with alternating currents (AC is what comes out of a radio transmitter), the force opposing the flow of an AC current is called “impedance” (its symbol is “Z”). Impedance is word we have been using a lot without explanation, but now it is time to change that. It turns out that Z in an AC circuit is determined by resistance (as with DC) plus two new phenomena: capacitive reactance and inductive reactance. We will focus on the fact that both capacitors (which have capacitance that causes the reactance) and inductors (which have inductance that causes a very different form of reactance) are very frequency sensitive.

Capacitors are generally made of plates or sheets of a conductor separated by a non-conductor (air, plastic, etc.) and inductors are coils of made of a conductor. Each has several amazing characteristics. Capacitors offer very little obstruction to the flow with high frequency currents but increasingly block the passage of lower frequency AC and they completely stop DC. Guess what, inductors do almost exactly the opposite! So, by adjusting the amount of capacitance and inductance in a circuit you can “transform” the Z seen by an antenna tuner at the transmitter end of the coax, either up or down, to “match” the always fixed 50 ohm output Z from a transmitter. The actual circuit used is called a CLC because the Cs are symbols for capacitance and the L is for inductance, so there are two variable capacitors and one variable inductor (see diagram below).



The one confusing thing may be the little symbols that look like pitchforks sticking down from the two coax connectors and the variable inductor. Those are ground points which all connect together and represent a continuous path between the antenna coax and the transmitter's chassis ground.

In reality, in order to see what the effect of turning the knobs on our tuner, we need to put a SWR meter between the tuner circuit and the antenna coax termination. But more on that and how to actually adjust the tuner will come next month.

Crown City HF #33

Antenna Tuners (3)

Last month I indicated that our next step would be to buy and find out how to use an antenna tuner. Before we do that we need to decide whether we want an antenna tuner with a built-in cross needle SWR meter or not. Obviously the ones with no SWR meter will cost less than the ones that include a SWR meter. However, so far we have not purchased a cross needle SWR meter for our "virtual" shack, and we need one. A cross needle version is essential as it is very hard to use the single needle kind (takes many more adjustments). I like the convenience as there is one less piece of equipment on the operating desk and in the antenna feed line, so we will need to get the more expensive model.

We will have a 100 watt transceiver, but it has been already decided that we should get a tuner rated for at least 150 watts as antenna tuners are notoriously "over rated" particularly at higher power levels. Arcing in the components can cause damage and limit the power you can use even with a good SWR.

Placement of the tuner in our shack is easy. It should be placed between the antenna and the RF emitter using a short coax "jumper". In our case that would be from the transceiver's output ("HF ant") and the end of the coaxial cable that goes to our dipole antenna. Just in case we decide later on to add other common antenna feed line "accessories", the order from our transceiver out will be: first to the linear amplifier, then to a low pass filter (to decrease interference to household appliances…TVs, phones, radios, etc.) and then a cross needle SWR meter (if not built into the tuner) then to the antenna tuner, through a lightning arrester and on to the coax feed line to our antenna. Ground the tuner, lightning arrester and the chassis of the transceiver. It is also a good idea to have a grounded antenna switch with a connection to a "dummy load" in the antenna system in the shack somewhere, probably between the feed line coax and the tuner.

Now how about actually tuning with your tuner? Well each brand and model is a little bit different and, when you buy one there are almost always good instructions included. Read the instructions for your model. There are a lot of details…follow them.

Most tuners with built in SWR meters have a few more knobs and settings to contend with. Often there is a "Tune" and "Bypass" switch or toggle button. Use the "Bypass" position when starting to tune to give you an indication of the degree of mismatch you will need to deal with. Particularly with a poorly tuned antenna, problems can be aggravated because of feed line lengths which are multiples or oddmultiples of a quarter wavelength at the operating frequency of the antenna. The best on-line antenna tuner manual I have seen in general, and specifically for working out "unmatchable" antenna problems is available at www.mfjenterprises.com/man/ pdf/ MFJ-962D.pdf . On page 8 it gives a very helpful list of coax lengths to avoid by band. Use the "Tune" position for making the adjustments with hints on how to adjust the "inductance" and two capacitance knobs (usually marked "antenna" and "transmitter"). Tuner manuals often give suggestions where to set them for the different bands. The MFJ manual pdf (URL above) has a **Logged Tuning Chart** where you can write down the settings for your most used frequencies.

Remember to use low power CW mode from your transceiver and the lowest power setting for your SWR meter you can (down to 30 watts or so), at least when you are starting out.

Finally, there is sometimes an "Antenna" knob to select the desired antenna connection. Ignore the "balun" and "wire" selections and connections on the back as we are using coax to a dipole.

Well I think that covers the antenna system. We have been working on this general subject for a long time, so we will move on to decide on the transceiver we should acquire for our virtual ham shack. Next month we will start out with some general considerations such as the various functions and specifications that we need and those we can do without while staying within a reasonable price range.

Crown City HF #34

Choosing Our Rig, #1

If you ask Google to define the noun "rig" you will eventually find the one appropriate to our hobby: *"an amateur radio operator's transmitting and receiving set"*. So the next several articles in this series will focus on how we will select the "rig" for our virtual HF shack. While researching this matter I discovered that I rather liked another, less specific", definition of a "rig" This one covers oil drilling, fishing, horse carts, etc. It is: "the gear (including necessary machinery) for a particular enterprise". I like it because it focuses us on the question of what is the particular *enterprise* our shack has in mind for its equipment.

There are many kinds of HF rigs available. We can choose from basic configurations, power levels, features, performance, brands, purchasing sources, and of course price. But to know what we need we have to first discuss and decide on what we want to do in our virtual shack.

Those of you who have followed the series know that some of these decisions have already been made and others can be made now. For cost reasons we already decided we would be using a 100 watt output transceiver. This does not limit us much as the vast majority of the rigs available are in this range. Also, because of the target users group (Technicians using their largely CW privileges and new Generals getting started using the HF bands) we can decide on some things we probably do not want. We should get only those features which are necessary to work worldwide DX when there is good propagation and compete effectively in modestly competitive contests. Also we should avoid particularly expensive or technically difficult features which are not essential to that mission.

To some degree this work is already done for us by the manufactures of amateur radio equipment. They sell ham transceivers the way car companies sell cars. They "package" them by increasing complexity and therefore cost. I will lump them into the following general categories: QRP, mobile/portable, table top basic, and table top "serious". Of course there are some rigs that are in the grey zone between these arbitrary categories. However my ratings will become clearer as we get into specifics. For instance "QRP rigs" are low power (generally <5 watts). Do we want one? Well it is amazing what they can work when the propagation is good, you have the right supporting equipment and you have a skilled operator or a bit of luck. Usually they are popular with hams who have first gained operating skills with more power and then move to lower power as a "challenge". But for now our station we can do without too many challenges.

Mobile/portable radios are usually "basic" in regard to removable heads internal batteries, small size and weight. However they mostly offer the same features (filtering, digital options, etc.) and quality as the "basic" transceivers do. However, with removable (remote)heads (the dial and controls) these radios are a bit more pricy at around $800-900, and with VHF/ UHF add $100-200.

We will skip the "table top basic" rigs and come back to focus on them in next month's article. The table top "serious radios" add features like more digital filtering, built in electronic keying, automatic antenna tuning, much higher frequency stability, VHF/UHF, multiple antenna ports, bigger memories, 200 watt options, voice recorders, spectrum scopes, and even more complex multi-colored panels. These babies range from a little over $1000 to the mid $6000s. Not that they are not worth it to some hams (avid contesters, award chasers, etc.)!

However, following the "economical but very functional" policy for our station (see below) we will be going for a rig from the "table top basic" group in some depth next.

Crown City HF #35

Choosing Our Rig, #2

Last month this column discussed the large range of HF transceivers ("rigs") available to amateur radio operators. I indicated that we will be selecting a rig from my "table top basic" group and that it should be "economical but very functional". What is economical will be perceived differently by each of us. So to set a frame of reference for the rigs, we will consider only those that sell at retail amateur distributors for under $1000 (e.g. Ham Radio Outlet, Amateur Electronic Supply, Universal Radio, Texas Towers. etc…in no particular order). Of course there are ways to beat these prices but in this discussion price comparisons are important and I will use a "rough average" of the above listed dealers at the time of writing this.

Some other matters need to be considered. Older models sell for somewhat less as time goes on and, just like buying a car, closeout specials often provide significant savings. The bad news is, you may miss out on important features in the latest model. Also, sometimes a feature which had to be purchased separately for the previous model as an accessory is now standard and built right into a brand's latest equivalent version at only slightly more cost.

Another issue is "brand loyalty". Some hams become attached to one brand or another, often because they have had a good luck with that brand in the past. Also, some of the knob and switch placement, names of functions (e.g.: RIT vs. clarifier), menu protocols, etc. carry over form one model to another for the same brand. However, it is usually easy to overcome these differences, and it is better to look at the capabilities of each transceiver regardless of brand. Only if there are two radios you like equally well should you consider choosing the brand you know best.

I don't really like comparing specific manufacturers and their various models. I have very little technical knowledge about these rigs. There are good technical reviews available for these radios in the major ham radio periodicals (e.g. QST, CQ). If you are planning to buy yourself a transceiver any available review (try Google) on the model of interest should be read before you making a decision on what to purchase. But unless you understand terms like MDS, dynamic range, third order intercept points, second order dynamic range and image rejection it is likely that only the last few (summary) lines will be helpful. Also remember that what we are doing in these Crown City HF articles is put together a "virtual" station with specific cost limitations and only the capabilities needed for my often cited target group. If you are trying to use this discussion as a guide for your own purchase of equipment it would be best to follow the process of elimination spelled out below while being careful to substitute what your cost limitations are and how you intend to use the transceiver. You can find quite complete descriptions of the specifications on the websites for these radios, talk to other hams and to the salespersons at amateur radio retail stores such as the ones listed in the first paragraph. Also, I am not suggesting that a retail purchase is the best way acquire your rig, but there is an advantage to going to a store where you can see and even try out your prospective purchase and then later receive advice when things go wrong. There are many ways to make this purchase (from E-Bay to other hams) that it would be impossible to cover in the space available.

Back when I started buying ham radios almost all were made in the in the USA… somewhere like Cedar Rapids Iowa or Oceanside California. I would like to be able to say we should "buy American" , but now the only U.S. manufacturers I know of (Elecraft made in Aptos, CA and Ten-Tech in Sevierville, TN), are a bit high end for our "economical" virtual station. Most are manufactured in Japan (Alinco, Kenwood, ICOM, Tokyo, Yaesu,). These radios are well known to US hams and have been excellent performers. All have at least one model in our "basic table top" category…and the Japanese need our money right now. So far, I believe, the Chinese (Wouxun, TYT) have not entered the HF market…but they will! Then it will take a while to find out if their ham radios match up to the others.

So, we will look only at the Japanese manufactured "table top (base) basic rigs". Because we have decided to keep the retail price under $1000, we have eliminated two brands: Kenwood and Tokyo. This price limit also means we don't want to pay for some things like Super-miniaturization, detachable face plates, built in antenna tuners, or 6 meters/VHF/UHF that do not fit our previously stated needs.

Next month we will look at three different models of transceivers that fit our budget and needs.

Crown City HF #36

Choosing Our Rig, #3

If you have not read last month's Crown City HF, please do so because it is essential to understanding what we are looking for in this month's installment. Keep in mind that the rig we are planning to "buy" is for our "virtual" ham shack for a total price of under $1000 including essential accessories.

So first we will look at the "table top basic" rig made by Yeasu that is under our target price (the FT-450D). To me it is a classic looking radio with lots of very nice features, but its price is close to our limit at $899. You will see why that is a problem later when we buy other essential accessories (like a power supply) and pay the sales tax. This transceiver is more expensive because it comes with a few nice things that we previously decided we don't really need: 6 meter coverage, several nice state-of-the art receiving filters, a recorder, digital voice announcement and a built in automatic antenna tuner. The FT-450 model (same radio but without the built in tuner, it is now discontinued) was reviewed quite favorably in the December 2007 QST*.

So what about the Alinco DX-SR8T model? It sells for around $630 and it does have the features we really need. That price is $350 less than the Yeasu FT-450D. The price just dropped $80 in the few weeks since I started researching this article. To me the radio as a whole doesn't have a very good look, when compared with the other transceivers we are considering. You may be saying to yourself "who cares what a rig looks like". Well, just remember, we are going to be spending a long time staring at this thing while we work the world. The Alinco SR8T just happens to have been reviewed in this month's QST* as being "functional" but with some "quirks and shortcomings".

Our last entry, the ICOM IC-718, at $640 is priced between the Alinco and the Yaesu. This is the radio I think we should get. It has a better look to it than the Alinco to my eye. It is easier to read the button and control designations and has a bit better display. In addition it includes a DSP automatic notch filter and AF speech compression. Both will be helpful when contesting, which is one of the things we plan to use this rig for. Also having had several ICOM radios, I can attest to the fact that they were very reliable and durable. This transceiver was characterized in its December 2007 QST* review as "easy to operate and gets the job done at a reasonable price".

Why not go for the more loaded Yaesu? We had budgeted $1000 for the rig and we would be under that. Well for one thing there are some more things (besides sales tax) that will probably push the "rig's" purchase price over our limit. For instance, these radios all require a 14 VDC power supply for use as a base (not mobile) transceiver. Also we need a code key (remember we have technician class operators with mostly CW privileges on HF). We may want other things like a desk microphone since we said we want to use this rig for contesting. Also adding a CW and a SSB filter would help during heavy traffic such as during contests. As much as I trust Yaesu products and would love to get the FT-450D, in order to stay within our budget for the entire rig, I think we should go with the IC-718. OK, so why not save more money and get the Alinco. The reason is that it lacks some features (see above) that I think we need to fulfill the mission we defined for our “virtual” shack (see earlier articles).

Picking your known amateur radio equipment is a highly individual matter. I am sure many of our seasoned readers would choose differently if they were buying a rig for themselves. But remember that this rig is for hams who are new to HF and we are trying hard to keep the cost down. If you are using this article to make a purchase for yourself it can be used as a guide to think about what you are looking for in a radio. But it is not a recommendation for you to buy the IC-718 because your needs and financial considerations are almost certainly different.

So where do we go next month? We will begin looking at rig accessories.

*If you are a member of the ARRL, these reviews can be found easily by going to www.arrl.org/productreviews”.

Crown City HF #37

Transceiver Accessories (1): A Power Supply

So last month we picked a transceiver that was priced at $640 and we have arbitrarily decided that our budget for a “tabletop basic rig” (radio, sales/use tax, power supply and accessories) would be up to $1000. Let’s see how we do.

A word about sales tax first. If we purchase the equipment in Los Angeles County, right now the tax would be $63.38. One way to get around the sales tax would to buy it from a dealer with no sales locations in our state. The shipping cost would be much less than California sales tax, so you would save money. Legally if you buy it out of State but plan to use it here you need to pay the state the same amount in “use tax”, and California is recently increasing its efforts to collect the tax on out-of-state mail and internet purchases. Therefore, so I don’t end up behind bars for recommending this method of tax avoidance, we will plan to buy the radio from a local amateur radio equipment dealer. There are some other advantages to doing that I have already mentioned in Crown City HF #35 (May 2011). So the sales tax now brings our total cost to $703.

Now we need a power supply to make the IC-718 work. Therefore we need to know its recommended direct current input voltage and maximum current delivery specifications, which are 13.8 volts and 20 amperes. There are many power supplies available in this range. So what else do we need to consider?

The biggest decision is do we want a linear (low frequency transformer) versus a switch-mode power supply? A detailed explanation of the difference in components and circuitry is not necessary to make our choice, but some understanding is necessary. A linear power supply contains a low frequency transformer to step AC at 60Hz from 110 volts to the 13.6 volts we want. Such transformers and smoothing capacitors are larger and heaver than those used in switching circuits which run at high frequencies (~10 KHz to 1 MHz). So typically a linear power supply for our IC-718 would weigh 27 lbs. and measure 5x11x11 inches while a switching power supply would weigh 4.2 lbs. and measure 2.8x7x9.4. So why would we even consider a linear over a switching power supply, since they are heavier and bulkier? Is it price? Well if you compare the two, usually they are fairly close, maybe a little more ($10-20) for the linear supply. So that's not why. A few years ago there was concern about RF interference from the high frequency components in switching power supplies which operate right in the ham bands, but with better filtering and shielding, that does not seem to be a problem any more. Some hams like linear over switching because they are thought to be able to tolerate more physical and electrical abuse, although I found no real proof of that. Noise from fans may also be more of a problem for switching power supplies, some more than others.

So let us look at one additional consideration: whether or not to buy a power supply with built-in metering. Most of the popular amateur radio models come with or without metering. Usually there are two meters, one for current and one for voltage. There is no real reason to have them…they rarely tell you anything you need to know. Nonetheless, I like them. They look good and sometimes they are helpful. If you keep track of how much current your transmitter uses when it is working at the desired power level on each band segment you use, when something seems wrong and your other metering is not showing power output, or is confusing, check your power supply current. If is where you expect it to be you can relax: if it is low something is wrong (check drive power setting, SWR, etc.).

Of course those "unnecessary meters" increase the price of the power supply, but only a surprisingly small $20.

It is important that we get a "regulated" power supply because it contains a circuit, often a diode bridge rectifier, large capacitor and a voltage regulator IC, which assures a constant output voltage. If we buy our power supply new from a ham radio store, almost any model we buy will be regulated, but at a swap meet or on E-Bay, we need to check on this.

As best I can tell the two brands used most by hams for this application are Astron and MFJ. The MFJs are a little cheaper. We are talking about supplies rated for 13.8 DC volts and at least 20 amperes continuous and 25 amps surge. We will be getting a metered version. I have several Astron and MFJ power supplies and I cannot tell any important difference between them but the Astrons are a little quieter (fan noise) and seem to me to be sturdier. Astron is a Southern California company, so at last we get to buy American! The Astron SS-25M, at about $140, is our choice.

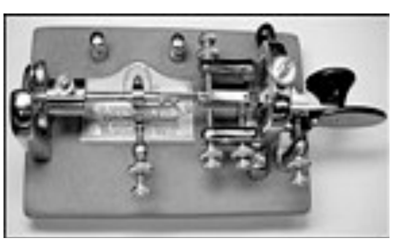
So we now have $160 left in our budget and we have one more essential accessory to buy, a code key. We will look at that next month.

Crown City HF #38

Transceiver Accessories (2): Morse code key(s)

There is one last "essential" accessory that we need to purchase to make our rig functional for the beginners to HF. That is a Morse code "key". The problem is that there are several different kinds of keys. They range in price $11.00 to $559 and are brass, chrome or gold plated. The high end keys feature oil impregnated bronze pivot points, matched ceramic contact inserts, micrometer adjustments, optical sensors (instead of contact points) and aircraft quality ball bearings. Finally they come in several basic designs.

The picture on the left shows a so called "straight key" which is the basic design used for 150 years, first telegraphy and later with radio communications. This is the key most hams start out with because inexpensive models work well and their operation is simple. All you need to know is push down on the knob (to close the keys electrical contacts) and then let up quickly to send a dit or after a slight pause to send a dah. The actual element durations and spacing used in sending Morse code are beyond the scope of this article, but suffice it to say that it is controlled by the sender's brain and therefore varies between individuals, differences between operators being termed "fist". But at higher speeds these differences can make copy difficult and errorless sending is hard and tiresome above speeds of 20 words per minute. The one shown above has a shorting switch (not essential) with the usual contact spacing and spring tension adjustment. The model (Ameco K4) is brass with an adjustable ball bearing pivot points and sells for an amazing $20. Unless it can be conveniently screwed down to our shack's operating surface it needs a heavy base to stabilize it and keep it from scooting around. That sells for an additional $16.00.



Another option is the "bug" (see picture on the left) which has a key motion parallel to the table top and is designed to produce dits and dahs by moving a single paddle from side to side. The mechanism was ingenious for a time before of electronic keyers. A firm called Vibroplex still manufactures these keys. They begin at a price of around $150.

During the 1970s solid state electronics developments produced a reliable and much more easily adjustable way of sending more error free high speed code, the "electronic keyer". These IC based circuits, along with what was at first a single lever and ultimately two levers (one for dahs and one for dits) evolved. One series perfect of dits, the other does repeating dahs each exactly three times the length of the dits for as long as they're pressed. One of the advantages of electronic keying with dual side-by-side paddles (shown above) was the ability to use the "iambic" sending technique. Again this is not the place to try to teach code techniques, but briefly it allows the repetition of odd dits and dahs just sent by squeezing the paddles together. This means fewer finger motions and (presumably) smoother, less tiring and faster sending. Very good paddles for use with an electronic keying circuit sell for as little as $110 from Bencher. The rig we purchased for our HF beginners' "virtual shack" comes with a built-in electronic keying circuit, so we already have that.

So with this background I need to draw some conclusions about what key(s) we should buy. First of all we need a straight key. That is how most (but not all) beginners start. There are fancy straight keys that cost several hundred dollars, but the one mentioned in the first paragraph with its base will be $36. Last month, after buying our rig and power supply we had $160 left to spent from $1000 budget. If we get the suggested straight key we will have $124 left, just enough to also buy the Bencher dual paddle iambic capable key! Also, most of those who start sending CW with a straight key will eventually switch to electronic paddle keying. Some others may wish to go straight to the paddles to avoid having to learn two ways of sending Morse code.

I should probably wrap things up now in regard to buying our "rig", but next month I will take one more Crown City HF to discuss a few "optional extras". I do this in order to familiarize potential buyers of this type of HF equipment about other useful accessories that are commonly available.

Crown City HF #39

Transceiver Accessories (3)
The "optional extras"

Last month I finished selecting the transceiver, power supply and code keys for our virtual shack's "under $1000 rig". In this article I will discuss some other accessories that, if you are personally buying an HF transceiver, would improve operating capabilities and/or convenience. The first is a desk microphone.

So why would anyone want a desk microphone, since the transceiver already comes with a hand microphone. I personally do not have one in my own shack, but I would guess most hams do. After a while they buy one because it is convenient not to have to tie up one hand holding a microphone. This is particularly true during a contest, as a net control, managing traffic, running a pile-up or just a long rag chew..

The recommended ICOM desk microphone for the IC-718 is their SM-30. It is available retail for $140. It is nice to get the one designed for the radio you already own because there are often variations in "mic" socket compatibility on different brands and models of ham rigs. Although one can usually work a fix for a mismatch, it is a bother.

The "Cadillac" of the amateur microphone business is the Heil Sound company in Fairview Heights, IL (another chance to buy American). Their basic microphone (the HM-12 model), with its attached handle, is only $70. But don't let that fool you, because to get all you need to match the ICOM microphone, you need to buy a base ($77) and the connecting cable ($26).

That adds up to $33 more than the ICOM and there are many hams who like the better audio quality enough to pay that. Of course Heil makes more products which, if we were really going to be doing contesting in a big way, we would eventually want (combined earphone and mike sets, boom mounts and foot operated push-to-talk switches.

Next I would like to consider add-on filters. So, you are probably wondering what can these do for our rig. They are crystal filters which we would place in the IC-718's receiver's intermediate frequency stage to make it easier to avoid interference from stations operating on frequencies near where you are working. If they are so good, why weren't they included when we bought our transceiver? Well, they are fairly pricey (~$200 each), you generally need two of them (one for CW and one for SSB) and most hams don't need them. Only under crowded band conditions, such as during popular contests, do you need them. The filters are calibrated by their band pass width. The available ICOM CW filters are 250 Hz and 500 Hz, , while SSB filters are set at 1.8 and 3.3 kHz. If we were planning to buy filters for the "virtual" shack we would probably go for the wider ones (500 Hz, FL-52A and 3.3 kHz, FL-257). Filters like these require installation, but they are plug-in and in other similar rigs I have found them to be easily put in.

There are lots of other accessories one might get (e.g. from a carry handle at only $20 to ICOM's top line power amplifier at $5000), but I have to stop somewhere!

Next month I will move to a new area of HF. Now that we have a station put together we will cover how to make the experience of operating the HF bands most enjoyable. Lets talk about getting on the air ("operating'') and some of he other things we need to know in order to enjoy HF. We will start with arranging the operating position and equipment of our station.

Crown City HF #40

Setting Up Our HF Station (1): Location, Location….

Now that we have bought the equipment for our "virtual"* HF beginner ham shack, how do we put it together and how do we operate it. Remember that these articles are directed to our hams that are about to or have just started using the HF bands and for these Crown City HF articles we are always striving to keep it simple and low cost. So let's start with location.

Location is important! Ideally we would like to have our shack and antennas located on a large piece of property on an easy to reach medium sized hilltop with a few tall, skinny trees. We want friendly antenna-tolerant neighbors who live at least several hundred feet away from any place we might erect an antenna. Additionally, we would like to have no overhead utility wiring and no nearby radio noise generators. We would like an unshared room on the ground floor.

Right you are…it is too good to be true! Unless you are very rich, live where land is cheap and have a sympathetic family and neighbors, there will always be several of the above wish list items which will not be ideal. But what follows are some suggestions for making the best of your less-than-perfect location.

If your shack will be where there is limited space for antennas, there are many solutions. They probably will not prepare you to win the CQ WW DX Contest but will provide good continental coverage and, when propagation is very good, worldwide DX contacts. There is not space here to give the details, but here are two web sites that give a number of good solutions:

www.alphadeltacom.com,
www.spiromfg.com <link deleted> ,
http://www.audiosystemsgroup.com/LimitedSpaceAntennas.pdf

and http://www.arrl.org/shop/Small-Antennas-for-Small-Spaces-2nd-Edition

Now if your problem is neighbors, your own family or some covenant restricting your antenna erecting plans, try these:

Hidden Limited Space Antennas (book by Robert J Trasiter) available at www.amazon.com and DX Zone (www.dxzone.com/catalog/Antennas/Stealth/) for several links.

If your problem is “noise” a short summary taken from my October 2008 Crown City HF may be helpful: “Modern civilization creates lots of electromagnetic interference. Some of the most common offenders are: overhead high tension power lines, automotive ignition systems, fluorescent and neon lighting, dimmer switches, welding machines, computers, electrical motors, TV sets, satellite receivers, cordless phones, etc. Some of these sources can be identified and suppressed or avoided. When you have the option, locate your station and its antennas as far as possible away from high power lines, neon lights and large electric motors…” Finding and correcting each of these types of problem is beyond the limitations of this article. However, the best place to find information is in the “RF Noise Reduction Resources” section of

www.dxzone.com.

There are several good websites and books given there.

The last on the wish list above was a nice unshared room on the ground floor. As a minimum one really needs about four feet of desk space with enough depth to have room to operate in front of your equipment (about 3 feet). Of course you can share a room, but it should be one that is not noisy and where your talking will not disturb others. The actual position should not be close to antennas because of RF exposure considerations (see http://www.qsl.net/w0jec/) for information on FCC requirements and a calculator. Being on the first floor makes grounding simpler. Have a look back at the October, November and December 2009 Crown City HFs for “grounding”, where you will find: “OK, why do we have to find a ground floor area for our shack and keep our grounding wire short? Again it is because we are dealing with high frequency AC current where conductors also allow RF current flow based on the length of that conductor, depending on wavelength. The RF characteristic we must remember is that the “impedance” inverts every ? wavelength. So if we consider the ground wire attachment to the grounding rod to be where we want the RF current to flow off into the earth and we connect a ? wavelength wire to it from the RF source in our shack, it won’t happen. That is because at the other end of the wire the shack equipment would see a very high impedance opposing RF current flow.”

This has not been a totally comprehensive coverage of shack location issues, but it covers some of the commonest ones. The next articles will cover other aspects of setting up your shack and operating HF.

Crown City HF #41

Setting Up Our HF Station (2): Furniture and Power

This month’s article will begin to cover how we will arrange our virtual shack. First we need to decide where the antenna feed line (coax) will enter the room. If there is a convenient double hung window (an older one that slides up and down) that makes things easy. If the room arrangement allows, we should try and get our operating position and desk as close to that as possible. because that will be the most direct way to bring the coax in and grounding equipment connection out. In four installments of Crown City HF (from Oct.’09 through Jan.’10) grounding the 120 volt AC power connection, antenna system and station equipment was discussed in detail.

Doing that correctly is very important to protect your equipment, your house and yourself. If you do not have a double hung window you will have to bring the feedline inside via a weather-proofed hole drilled in the outside wall. Sometimes on a ground floor there is a basement vent or other access to space under the floor and the lines can use that as an entry point and then by drilling up through holes in the flooring. However you gain feed line entry, use the single point grounding panel and equipment grounding buss bar concepts described in the above mentioned articles.

Now let’s arrange the furniture and equipment. We will want an operating desk which is at least two, and better three, feet deep and three to four feet wide. Obviously, even more space would be best as the insatiable desire of all hams to acquire more radio equipment will eventually take up more and more space. The table should be sturdy enough to hold the weight of you equipment. Ideally there should be some drawers for manuals, ham correspondence, etc. Overhanging shelves are nice too for some more light radio equipment, a few books, clocks, and pictures. Lighting hung under the shelving is convenient.

Two comfortable office type chairs would be ideal. This bench-like desk configuration is not that easy to find, so it may be that you will have to improvise. For instance, a low cost solution is to buy a smooth unfinished door at Home Depot, paint it to match the shack’s décor and use it as the table top. That is done by setting it on top of a pair of two drawer filing cabinets (one at either end) chosen to place the door at the right height. Above that add some wall mounted shelves and you have what you need.

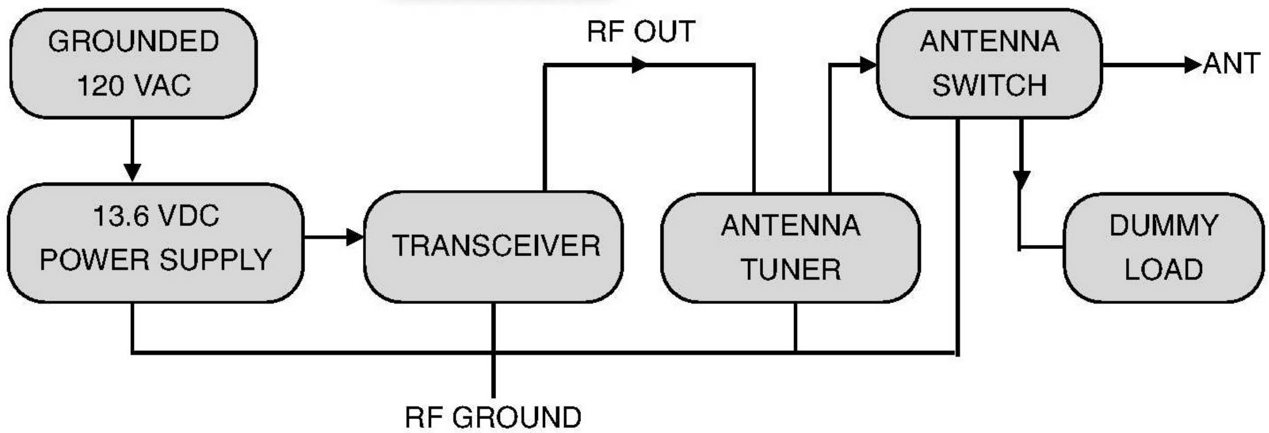
By the way, when you select the lights for your shack take into consideration that several kinds of lights and/or their controls emit radio frequency emissions that may cause unwanted noise in you receiver. If possible, have your transceiver hooked up to your antenna and put the lighting system(s) you plan to use in the shack close to it. Now listen to each of the bands with the radio set to AM reception. Turn the lights on and off and note any hums, buzzes, whistles or an increase in the background noise level on the S-meter with the lights on. If the noise is noticeable, look for some other lights.

Next lets look at getting power to your equipment. With the equipment we have said we would purchase for this “virtual” station, most ordinary household wall sockets will be adequate for our 100 watt transceiver. Even a few other appliances like modest lighting and a clock will not blow your 10 amp 110 volt AC circuit breaker. If you are planning a 1.5 KW amplifier, you’d better get a separate circuit, preferably 220 vAC. We should also consider rewiring the power outlets to our “virtual” shack with grounded third prong sockets if you don’ t already have then. Checking with a ground tester is also a good idea. We should have another look at the Crown City HFs that I mentioned in the first paragraph to review grounding principles again.

Next month we will cover the arrangement and interconnections between our pieces of equipment.

Crown City HF #42

Setting Up Our HF Station (3): Equipment Arrangement



So this month we will assemble the electronic equipment in our virtual shack. Above you can see a diagram of a suggested placement of various pieces which will make up our radio station. The lines represent the various interconnections which must be made and the arrows indicate the direction that power flows during transmission.

Let's follow that power from left to right beginning at the "Grounded 120 VAC" electrical plug. That means we must use a three prong wall connection which has been tested to verify the grounding. The next connection is between the power supply and the transceiver carrying 13.6 volts DC. Some hams do not like to shorten the red and black factory supplied wires that come with the transceiver "just in case" the rig might move to where the extra length would be needed, such as in a mobile installation. That is not a good idea because if there is any stray RF in the shack (from either your rig or an external interference source) the longer these power leads are, the more it will be picked up and delivered back into your transceiver's receiver. These unshielded power cables are particularly vulnerable. Nonetheless the concern for excess length also holds for other wires or coax connections. The rule is: plan the arrangement of your equipment to keep them short and make them just long enough to do their job comfortably. The other connection to the transceiver is the radio frequency (RF) ground. You can see from the diagram that all of the electronic equipment is connected together and to a good earth ground (see Crown City HF, RF Grounding, PRC Bulletin, Oct '09).

The next connection is between the transceiver and the antenna tuner. If we get a power amplifier it will go here before the tuner. The diagram shows "RF Out" and, of course, that is only during transmitting. Lest it confuse you, all these coax connections are two way streets carrying much weaker RF signals in the opposite direction during periods of reception. These short coax connections are called "jumpers" and are usually RG-58 or RG-8X coax that are 2 to 3 feet long. They are terminated on both ends with PL-259 (male) connectors. The lengths of jumper coaxes are so short that there is little difference between the two in regard to power loss.

Now let us focus on the antenna tuner. The assumption in this diagram is that there is a cross-needle SWR meter built into the antenna tuner. If that is not the case, we will need to put one in between the tuner and the antenna switch. Earlier in this series of articles we decided on a manual antenna tuner. That was done largely on the basis of cost, but automatic antenna tuners are increasingly being built into transceivers for little added cost. So if we had purchased such a rig the 2nd and 3rd boxes along the bottom of my diagram would be together in one box.

Also, if we have a very well matched single band antenna with a low SWR across the part of the band we want to work…and that is all we want to do…we might want to leave the tuner out entirely. That situation doesn't apply very often, so we chose to use one in our "Virtual Shack".

Lastly, let's look at the dummy load. So what is that? Well, there are times when you would like to be able to test something about your transmitter that requires transmitting into a "perfect" 50 ohm load without being hooked up to an antenna. It doesn't come up often, but when it does it is "impolite" to do that on the air and if done other than for brief periods can even be illegal. By having a dummy load, you have a non-interfering legal alternative with a guaranteed 50 ohm entirely resistive impedance match mimicking the perfect antenna system over a wide range, typically 0-150 MHz. There are two basic types, both contain non-inductive (not wire wound) 50 ohm resistors. They differ in how they dissipate the heat created during testing. The easiest to use is the air cooled (fins) type. They are smaller and a little cheaper (~$40) but not as efficient at dealing with heat so the test transmit power and duration are more limited. The other type has the heat dissipated by immersion into oil in what usually looks like a paint can. If one has a convenient place under the operating desk and keep it sitting in a pan so when (not if) it leaks or spills, the oil filled one is worth the extra twenty bucks it will cost.

Next month we will start actually operating our station!

Crown City HF #43

Operating an HF Station (1): Before You Transmit

This article will cover the preparations necessary before you begin transmitting. Right off the bat I need to say that these articles cannot provide *all* the details needed for really outstanding operating. These Crown City HF discussions which will get you started and, hopefully, make your ham radio operating easy and correct. However, I would suggest that you purchase a helpful paperback book, "The ARRL Operating Manual for Radio Amateurs" which has a good collection of articles on many of the subjects we will be covering here. If you get it, do a bit of browsing so you know what is there. Then as we move along, use it as a reference to look in more detail into things that are unclear or which really interest you.

Also, try and find an experienced ham that will let you sit in during one, or preferably several, radio operating sessions. We hams know that what gets new hams turned on is successful HF operating. Hence, you can find lots of us willing to help get new HF operators started.

Practically every article written on this subject starts out with the following advice: "Listen,

Listen, Listen”. The reasons are simple. It is easy to do, there is no risk of embarrassing yourself, and you see how it is really done. It is very good advice, but it is not enough. At some point you really need to take key or microphone in hand and begin operating! It really helps to watch and be guided by an experienced ham as you do that.

Another resource is the ARRL website (www.arrl.org) . That is a goldmine of information on many aspects of amateur radio operating and, particularly if you decide not to get the Operating Guide as much of the same material is available on the ARRL’s website. I will reference some of the specific ARRL web pages.

I know that all of you have been exposed to the FCC Rules and Regulations that dictate the operating practices of American hams when you were studying for the FCC exams. However it is easy to forget some of the details. From the ARRL’s home page you go to the Regulatory and Advocacy section to find them. You can also find the Part 97 on the FCC’s website which is nicely set up by topic:

http://www.access.gpo.gov/nara/ cfr/ waisidx_10/47cfr97_10.html <link deleted>

Of particular interest should be the frequencies and modes available to your class of license (sections 97.301 and 97.305). Look at the bands for which you have privileges and the equipment to operate (e.g. the right antenna). Go to your computer and in your word processing program type up those that you will **actually use**. Use a font that, when printed, you can easily read from across your operating desk. Make that into a small sign that you can quickly refer to and post it at your operating position somewhere up behind your rig. You will use it often at first until you eventually have it memorized.

There is a nice color chart showing all bands with the privileges and modes on the ARRL website. You may want to post that too, but it contains too much information to use quickly and easily. In fact, there will be several more things to post in easy sight, so you might consider getting a cork board and some thumb tacks!

Next month we will look at what other information you may want to have on that cork board and a few other items that are helpful to have nearby.

Crown City HF #44

Operating an HF Station (2): More … Before You Transmit

Last month we were in the process of putting together a few helpful things around the shack before you start transmitting. I had recommended a cork board on the wall behind you transceiver which can be seen easily from your operating position. So far I indicated the value of a list of the frequencies and modes you can use. Now while you are putting up those signs it will be very helpful to have a list of “ham speak”. I mean terms and abbreviations like the frequently used Q signs. Ones like QSL, QTH, QRZ, QSO, QSY, QSB, QRM, QRL, and QRT. Also if you don’t know it well you should show the NATO phonetic alphabet for Amateur Radio and signal reporting system we use. Have enough of the RST definitions there to avoid giving impossible reports like sending a 5 (perfectly readable) by 1 (faint signals, barely perceptible). Another thing that will be helpful to have posted is a Fahrenheit to Celsius conversion chart. Because the propagation is so good right now and pretty soon you are likely to be talking to some DX. The weather is a common subject so you need to understand that essentially the whole DX world uses the Celsius scale, so surprise them and give them your local area temperature in a way they can understand. The best F to C chart I have found is at www.weatherwizkids.com/ temperature-conversion-chart.htm.

Next, I would start out with an old fashioned hand written logbook. They are pretty cheap at your ham store or the ARRL. The modern way is to use a computer which simplifies QSLing and award chasing. But why add another level of complexity to operating at the beginning. To log correctly you need to use Universal Coordinated Time (Zulu time and GMT are more or less the same thing) so it is nice to have a 24 hour clock in the shack set on UTC (strangely the letters in this acronym are out of order…something to do with a compromise with the French I believe) in the shack. It is a good idea to have a radio controlled "atomic" clock. They are available with 24 hr time options and their prices have become quite reasonable. Having a precisely set timepiece helps to know when to expect the other ham to show up in a "sked" (scheduled contact) or exactly when to start a net. You should use also use military time, hence the need for a 24 hr clock. When logging in UTC one tricky thing is to get the date right. After midnight in London (Greenwich), which is 4 PM PST or 5 PM PDT, you use tomorrow's date. The FCC does not require you to use a log book (they once did), but they do require "station records". An example is that Part 97 says that the "FCC will presume that the station licensee is also the control operator, unless documentation to the contrary is in the station records." The log is the obvious place to keep this and other similar information. I find that logging pays off particularly when you get into award chasing and even if you do not plan to do that now, you may change your mind. There is a very good article on logging at www.arrl.org/keeping-a-log which covers such things as computerized logging in case you want to start out that way.

I guess the following things are obvious, but I think I will just mention them for completeness. You will need some lined paper tablets, pencils with good erasers (or pens if you never make mistakes), a good light that doesn't cause radio frequency interference and a nice comfortable "office type chair". Finally every ham worth her (or his) salt must have a big sign with your call sign on it so you can have your picture taken in front of your equipment. Now you are ready to actually operate in the HF bands. In subsequent Crown City HFs we will discuss how to get on the air, find someone to talk to, what you might say…and more.

Crown City HF #45

Operating an HF Station (3): Time to transmit #1

Well it is time for you, as a first time (or near-first time) HF operator, to make a contact. A couple of Crown City HF pieces back I recommended that you sit in with an experienced ham when he/she is operating at his/her home station. If you do that, ask for a chance to take the microphone and get the butterflies out of your stomach.

Another thing that is helpful is to set up a "sked" (a time and frequency to meet on the air) with the same or another ham friend. Pick a band for which you and your friend have privileges and that is not very crowded. It is best if he/she lives not too close to prevent overloading each others receivers (5+ miles), but not too far (10-20 unobstructed miles) so you know that either ground wave or line-of-sight propagation will allow for an easy and reliable QSO. Use single sideband (SSB, it is likely to be your most commonly used HF mode) and remember to set your rig to the correct sideband. Some transceivers automatically chose the correct sideband, but not all, so check. HF stations transmitting on 160 meters through 80 meters use lower sideband (LSB on your transceiver display), upper sideband (USB) on 60 meters, LSB on 40 meters and then USB on all bands with lower wavelengths (higher frequencies). Also, to avoid frustration during this first sked, it might be helpful to establish telephone contact the first time (before starting) to more easily navigate through some common problems like: the having the frequency you have picked be already in use, one of you has forgotten about the sked or is having technical problems. Have your ham friend make the first radio call to you so you get the opportunity to tune your receiver, which is one of the things that commonly gives new SSB operators trouble. Many new HF operators have only used VHF/ UHF FM or their home or car AM radios and find tuning SSB difficult. It would take too much space here to explain why we use SSB with its greater tuning difficulties, but there is a good article written for new hams on this subject at www.hamuniverse.com/ ssbinformation.html. Tuning will become very important to you if you use SSB. It really becomes critical when engaged in contests or you are trying to reach a station in the middle of a "pile-up" (many stations calling the same station, usually a rare DX station).

Being only a little off frequency can make the transmitting station's signal distorted and if you respond on that frequency, your audio may also be unintelligible. If you are using USB and are tuned below the other station's frequency, you will hear only the highest audio frequencies, the so called "Donald Duck" speech. If you are below you will hear the lowest frequencies associated with the other station's audio, more difficult to describe but clearly distorted (like talking with your mouth very full). As you reach the operating frequency of the station you are trying to tune to, the voice will begin to sound more and more like normal human speech. That pattern of hearing the "Donald Duck' sound below the true frequency is reversed when using LSB.

Since tuning from that high audio frequency side seems to be easier, when you are hunting "CQ-ing" stations it is better to tune from low frequencies to higher ones on USB and the opposite for LSB. Many hams use a technique by which, when approaching an SSB signal, they rock the tuning knob back and listen for the received audio to become more and less natural. Then move a little toward the natural sounding side and start rocking again, and slightly narrowing the frequency covered by rocking. Eventually the best sounding audio is identified. Most modern transceivers have two tuning speeds, fast (for moving quickly around the bands) and slow (for careful tuning when you are zeroing in on a station). Learn to use that slow/fast function, which is usually a toggle button on your front panel. Another common mistake is trying to tune a station after the operator has stopped talking. You have to learn to recognize that exact instant when the transmission (speech) stops. This can be particularly difficult in situations like pile-ups and contests. Immediately stop trying to tune until you hear the station you are after start speaking again and then start rocking again.

Next month we will contact that local ham friend, learn how to make some important transmitter adjustments with his/her help and then go looking for a QSO with a ham you do not know!

Crown City HF #46

Operating an HF Station (4): Time to transmit?

Last month you had arranged to make a radio contact with a local ham friend for your first HF QSO. You asked him to call you on a specific frequency at a certain time (a “sked”). It is best to do this first with a post-pubescent male as that is far and away the commonest voice tonal quality you will be working. Also, I suggested that you establish telephone contact with him before the contact started. Last month in this column we discussed tuning a SSB station, and you should have been practicing that.

Now the phone is ringing and your ham friend is on the line and tells you to listen while he calls you. Ask him to make it a long call to let you get your tuning just right. That is when his voice sounds normal , not like Donald Duck or mush mouthy. When he finishes you reply with the his call sign, then “from”, and then yours. Follow with “you’re a 59”. It should be 59 since you are so close together.* You might, just as well, say 5 and 9, 5 by 9, or some will say just Q5 (I am trying to find out the origin of the “Q” when used his way…no luck yet… but it seems to mean “readability” or R in the a RS(T) signal report). Remember…you were going to post an easily readable RST sign on the poster board near your operating position www.acsu.buffalo.edu/~maxwell/RSTInfo.html . Always give truthful signal reports.** It does no good to inflate a signal report. You may think that it will make the other operator feel good, but it just causes confusion when other different reports are inexplicably obtained. If the ham friend is very loud and the audio is distorted you should turn on the “attenuator” which most transceivers have. That is usually an on-off push button and knob on its front panel.

Since we are planning to use this opportunity to do some testing of our transmitted audio let’s start with talking into the microphone correctly.

There are differences between various brands and models of microphones, so first look up what your transceiver’s manual recommends. Don’t be surprised if you do not find much about how to hold (we will assume it is the hand-held that came with the radio) and speak into your microphone. It can, if present, give you an idea what to expect, but is not all that important because you are going to do your own testing. Have the power output on your radio set so your ham friend is hearing you clearly. In SSB mode turn your mic gain up slowly from about 25% of maximum while speaking at a conversational volume with your mouth 2-4 inches from the microphone’s face, whichever seems most natural. Watch the ALC meter, particularly the peaks, and notice when they start to cross out of the ALC zone. As you continue to turn up the mic gain they will appear to hit a kind if “invisible wall” as the ALC circuit cuts in to limit them. When you just start to notice that effect…stop. Record (what o’clock it is) or mark (with a small dot of white out) that position of the mic gain knob. Your ham friend should be listening to be sure that the transmitted audio is not distorting or too weak.

Now we need to play a bit with position of the microphone face. Here you will need to rely on you ham listener to pick up what might be small differences in the audio quality and you move from one inch to six inches away from the mic while you count from 1 to 6 using the same volume of speech. Try it several times, each time having her write down the best sounding number. That will tell you what the best distance at which to hold your mic is. Then turn your mic slightly (try zero, 30 and 45 degrees) and then try saying some tongue twisters*** with “Ts”, “Ps” and “Bs”. These letters cause the release of small busts of air which some microphones do not tolerate when delivered straight on. Try this a few times. Say (over the air) the angle you are using each time so your ham friend can write down which is best.

Now, using your best (as determined above) mic gain, speaking distance and microphone angle, let’s try to determine your optimum “compression” level (sometimes called “voice processing”). This circuitry works in SSB to focus the transmitter’s power in the part of the audio spectrum that is most easily understood and should only be used when band conditions are difficult. But since your ham friend is there and running tests let’s see where your rig’s best compression setting is. Start talking normally and at a constant level. With the compression starting on low, slowly turn it up. Use numbers and count to 10. Have your friend tell you when your voice just started to ***not*** sound quite like ***you*** anymore, but well before he was no longer able to understand you. Note that number or position on your COMP knob for future use (in contests and pileups) and then turn off the compression for everyday operation.

Thank your friend for the help and offer to run the same tests for him if he would like. At the end of a series of transmissions sign off giving your call sign (if this took longer than ten minutes you should have already done that one or more times). Now you are ready, in our next Crown City HF, to talk to a ham you do not know over the air.

* If because of the close proximity, the signal is so loud it is distorting, ask him to reduce transmitter power.

** This does not apply to radio contests where every contact, even if you can barely make out the call sign, is a 59. OK, you are not telling the truth but everybody knows it.

*** Try “Peter Piper picked…”, Rubber baby buggy….” and “A tutor who tooted…. For the complete tongue twisters and others: http://thinks.com/words/tonguetwisters.htm#T

Crown City HF #47

Operating an HF Station (5): Talk to lots of Hams… at Field Day

At the end of last month’s Crown City HF I said that this month I would get you on the air, talking to a ham you didn’t know. Well, with Field Day coming up soon (June 23rd and 24th), I thought I would bring back a modified version of my June 2009 “Amplifier” article to encourage you to participate in our Club’s Field Day activities. So here are most of things you need to know to do some operating:

When making a contact with another station, certain information must be exchanged and usually in this order: the number of transmitters the club is using, the Field Day operating Class, and the ARRL section. So an example might be “3 alpha San Diego” but you would write down 3A SD. There will be a sign at each station giving the “exchange” that we (W6KA) will use and also a list of all the ARRL section abbreviations. We are in the Los Angeles section and that abbreviation is “LAX” (not “LA”…that is for Louisiana). Canadian stations also participate and they have RAC section identifiers. Other stations outside the USA use “DX” instead of a section identifier. Note that we do not exchange readability, signal strength or tone info in this contest. Both stations must receive and record all of the exchange for the contact to qualify for points. The band, mode, date and time will be automatically be recorded by the logging computer.

There are two ways to work any contest… and we usually switch back and forth between them. One way is by **calling CQ.** Just find an open place on the band and say “CQ CQ CQ Field Day, W6KA, Whiskey Six Kilo Alpha”. Now when you (hopefully) hear another station replying with their call sign, quickly have the logging computer operator enter it into the computer to check if it is a duplicate. If you have not previously worked the station just say the call sign of replying station, then follow with “eg: 4 alpha LAX, over”. They should reply by saying that they did (“QSL” or “Roger”) or did not copy all of your info. Then they will give their exchange information, and ask if you copied (sometimes said as “QSL?”). If you copied 100% you say “roger” or “QSL”. may say “thanks, good luck in the contest”. If you missed some part of the exchange just ask them to repeat that info (e.g. “please repeat your section”). Now…since you were the one calling CQ on that frequency…it is yours to keep using. So quickly say “QRZ (means anyone calling me?) W6KA?” or you can just call a quick CQ again.

The other way to work Field Day is to **answer CQs.** These exchanges are a little different. In this case, when in the process of tuning up and down the band you hear a station calling “CQ Field Day”or say “QRZ”, you should first quickly check the dupe list to be sure you have not already worked that station and if it is a new call sign then just come back with your call sign and listen. If that station answers with your call sign and gives its exchange, you should reply by saying “we copy” (or say “QSL”), and give the W6KA exchange info. Listen until they acknowledge a solid copy reception and then move off that frequency looking for other stations calling CQs (or QRZ). By convention the frequency is theirs to keep using.

Before you do your first stint at the microphone, it is a good idea to just listen while someone else operates through a dozen or so contacts. Then, maybe, work for a while doing the logging and checking dupes as the logging computer operator before taking the mike. It may all seem a little complicated, but it isn’t. It is quite logical and once you have done it a while it will flow naturally.

None of the above is set in stone…all sorts of variations can be used as long as the call sign and information get exchanged and is recorded! Again, listen to what other operators are doing. You will hear many operators add “we are…” and “good luck in the contest” to their exchanges, but good contest practice avoids extraneous comments.

I hope this gets you to come to Field Day and talk to a lot of hams you don’t know… you’ll like it!

Crown City HF #48

Operating an HF Station (6): Time to Talk to a Ham You Have Never Met

For the last few issues of the Bulletin this column has been trying to get our “virtual” HF amateur radio station on the air. In last month’s Crown City HF we learned about operating during Field Day. So in the next few days you will have your chance. Elsewhere in this Bulletin you can find the date, time and location. It is a great opportunity to get on the air. Although the Field Day operating would give experience with an HF transceiver and the “feel” of communicating over long distances by radio, it is a contest and you don’t get to do much “talking”. So that is what we are going to do now.

OK, you should use the transceiver settings that you figured out during the local QSO with your friend that we discussed two months ago in this column. When you were talking with him we had turned up the “RF Power or Transmit Power” only until he could just hear you easily, but now turn it up to about 50% if it is digital preset in your transceiver’s menu or half way around if it is a knob. If we don’t get any results at this level we will probably turn it up more, but for now it helps to protect your radio and avoids interfering with other hams to not do that.

Now we will need to find a part of the band you have chosen to use (legal for your class license) and look for a place where there is some modest activity with QSOs loud enough to hear and understand what is being said. Three kilohertz is roughly the bandwidth of a well (voice) modulated SSB signal so you need to find a space that wide where there is no activity and set your rig’s transmit frequency to the middle of it. Now listen for 20 seconds or so. If you hear no modulated signal then you can transmit in short (>5 seconds) bursts of carrier wave to see if your transmitter is working. Do that by having your transmit mode set to FM or CW (the latter will require a code key). Another courtesy is to speak “is this frequency in use?...and give your call sign. We will skip over checking your SWR and, tuning your antenna tuner because we covered that back in the Crown City HFs from January to March 2011. But I will assume that you have now tuned that for a low SWR. Now, while transmitting a carrier wave quickly note that either the meter on your transceiver or the forward power on your double needle SWR meter reads something like 50 watts if your rig is rated at 100 watts max (most transceivers will put out a maximum CW carrier at 100 watts, but check your manual under “Specifications”). Then the SWR meter should show something below 1.8 to 1 or lower. Why not turn the power up to full output for this step? You can do that, but if you encounter a very high SWR and you continue for very long (more than a few seconds) it can damage your transmitter’s components. Today transmitters with transistor finals have circuits that sense high SWRs and shut down or turn off the power output. But these don’t always work and repeated high power tuning into high SWRs can damage your finals. Also, most SWR meters are more accurate at lower power. But now you know it is safe so, while transmitting a carrier turn up the RF power while watching the power output. Stop when you approach 100 watts. Re-check the SWR…it may go up a bit…but keep it below 2.0:1. Now switch to SSB using the correct sideband (USB vs. LSB) for the band you are using and stay within the frequencies allocated for your FCC granted privileges.

So now there is a choice to be made. Are you going to use this empty place on the band and call “CQ” or tune up and down the band looking for someone else calling “CQ”. When you CQ you are asking any station that can copy you and wants to talk to answer you (a “general call”). Or you can be the one looking for a CQ to establish contact. Another less common way, but perfectly OK, is to wait until the end of a QSO and call one of the stations involved using their call sign then “from” and then your call sign slowly and clearly.

Next month we will explore more ways to make a contact.

Crown City HF #49

Operating an HF Station (7): Time to Talk to a Ham You Have Never Met (3)

In the last Crown City HF we had gotten to the point of having to find an empty place on the band and call “CQ” or tune up and down the band looking for someone else calling “CQ”. Remember that a CQ is a request for any station that can copy you and wants to talk, to answer you. Use what you learned about finding a clear place on the band to transmit (3 KHz wide and ask if frequency is in use) and begin calling. A common way to do that is just saying “CQ, CQ, CQ…this is Kilo India Six Alpha Bravo Charlie standing by”. It is best to use the phonetic alphabet for your call sign because it is easier to decipher. SPEAK CLEARLY! Think about making it easy for the guy trying to copy your call sign. Talk slightly slower and in the same way (loudness and distance from the mike) that worked best in the test with your local ham. The most common mistakes new hams make are to cut off the beginning and end of transmissions by incorrect use of the push-to-talk button, mumbling, and running words together (usually by talking too fast). Now the three CQs followed by your call and “standing by” is the simplest form. **There are all kinds of ways to do this.** Although as a general rule using a short CQ call is the best way to go, if there are relatively few stations on the band (meaning it will probably take longer for someone receptive to a CQ to stumble onto you) it is reasonable to repeat “CQ, CQ, CQ…this is Kilo India Six Alpha Bravo Charlie” once more. Or you might just add one or two more “CQ, CQ, CQ”s. Also you can throw in a “KI6ABC” (call sign, not phonetically) or two before the “standing by”. That ending can be other things like “over”, “go ahead”, or “calling and listening”. The “this is” will often be said as “from”. Some other additions are used such as “CQ forty meter phone” or a “…calling CQ” after your call sign. Both are entirely unnecessary. These variations are done to break up some of the monotony of calling CQ the same way over and over when there have been no responses. There are special ways of calling CQ in contests (use of QRZ for CQ) and targeting (“CQ DX Europe”…etc.). Now, after ending your CQ call, quickly let up on the push to talk button and listen carefully. The response to your call will most often be your call sign followed by the other station’s call sign. Sometimes, in congested conditions, the reply will be just their call sign. Now come back and begin the QSO. I will discuss what to say to them in a later article.

What about tuning up and down the band looking for other stations calling CQ?

OK, but before we get started, I would like to review how to "tune the band" which was partially covered back in Crown City HF in the March 2012 issue of our Bulletin. We talked about tuning a SSB signal. High frequencies associated with a signal are easier to hear when the station is approached from below (tuning up the band) on USB and down the band on LSB than the low frequencies when the station's operating point is approached from above (tuning down the band). Therefore, if operating USB it is easier to start at the lowest frequency of interest and tune UP the band looking for stations on increasingly higher frequencies.

This reverses when we operate LSB.

Some radio users tend to always keep the signal sounding slightly high in pitch, believing they can understand the voice better that way. This is fine for receiving, but if you use a transceiver, the other station would hear your voice correspondingly low pitched. Then they may retune so you sound normal high. If you notice that someone has replied to you and slightly changed frequency so their audio is giving you low pitched speech but can easily understand do not retune. But if you are having readability trouble use your "clarifier" (sometimes called receiver incremental tuning or RIT). That is a "smallish" knob on your radio's front panel and often requires pushing a nearby button to turn it on. Rotating it can make the received audio clearer. It moves the center of your received signal's frequency slightly up or down, but leaves your transmitted signal unchanged. This avoids having to play "frequency tag" with the other station. Remember to turn it off when that contact ends!

Next month you will respond to a CQ and we will look at a few general ways the contact can go: the short "award chasing" QSO, the contest, the rag chew, and the net.

Crown City HF #50

Operating an HF Station (8): How to respond to a "CQ"

This month we will look at how to respond to a CQ call if we are hoping to just chat for a while. "In ham radio, extended conversation, as opposed to just exchanging basic information ...is called rag chewing" according to Wikipedia. It does not define what extended means and probably should have added that there is no formal structure as in nets, roundtables and contests. Some form of rag chewing is probably the most common form of HF QSO, so we will start here.

No one ever calls a "CQ rag chew" but there are some clues that you can use to tell who is likely to be interested in an "extended conversation". First of all listen to see if they are making a general call or if it is a directional call. Most of you have heard the term "DX" used and, since it is presumably shorthand for "distance", you might think that it has something to do with how far the stations are apart. That would mean that a ham in San Diego talking to someone in Presque Isle, Maine, (3,300 miles) would be DX. Not so, since "DX" also implies a QSO from one country to another. So if that California ham is talking to a ham in Tijuana that is properly called "DX". So if you hear a US ham calling CQ DX or CQ to some specific place (like "CQ Europe") it is best not to answer that call. Next, if you hear "CQ contest", and you are not really in the contest, so you don't know the expected exchange, don't go there (we will cover contests later). If you hear someone calling CQ and there are many hams calling back (that's a "pileup") it is probably some rare DX station and even if you get acknowledged that station does not want to chat.

There are some other clues you can use. What frequency the CQ is made on is a general indication of intent since the usual pattern is for stations interested in DX to hang out in the lower frequencies of any given HF band. That is usually where stations wanting a brief "award eligible contact" go, not rag chewers. They can be anywhere, but the mid portion of the bands is usually where they go. The high ends are generally for nets. We will discuss award chasing and nets later.

OK, so you hear someone making a general CQ call and you are interested in rag chewing. Go ahead and answer with the call sign of the station calling CQ, followed by "from" and then your call sign using the phonetic alphabet. If band conditions are poor repeat it speaking slowly and clearly. If he hears you, the response will be either your call and "go ahead" or something like your call "from" his call, then "thanks for coming back, you are 5 and 9 (or whatever your signal report is), my location (may say QTH but when working phone plain English is encouraged) and my name is__(spelled out phonetically)__. Then the contact is usually turned back to you with an "over", "go ahead" or maybe a "how copy". It is common to conclude with your call sign, a "from", and his call sign just to verify that the call signs are correct, particularly if readability is not too good. After this, under most circumstances, you need identify with your own call sign only every ten minutes and at the end of the QSO.

Your response should be along the lines of "solid copy" (if true) or "QSL" or "roger". Then it is a nice touch to use the contacted ham's name and follow with your information and the turn it back. From here on anything can happen but usually topics like the weather, radio equipment, when you got your general class license, the band conditions, something you have just done are about to do, family, cars, sports, etc. One way to get started is to comment on something the other ham said that you have some connection or interest in like where they live ("I spent 1995 there..."), their antenna ("I've been interested in getting one of those."), or maybe ask about the recent conditions on this band ("have you heard any good DX...?"). It is best to stay away from, politics, religion or anything likely to be controversial.

Sometimes ending a rag chew can be a little uncomfortable. But when time dictates (work, meals, bedtime, etc.), or it just seems that you are running short of things to talk about, just politely say that you have enjoyed the QSO and need to wrap things up. Offer a "best 73". Common (but trite and unnecessary) things to say at this point are "hope to see you down the log" and "I'll be clear on your final". Sign off with his and your call sign (his is not essential).

Occasionally one station or more stations will decide that your conversation is so intriguing that they would like to join in. They do that by saying their call sign between transmissions. Your response should be (usually) to invite them in to join the discussion (it usually enhances the discourse). Then the conversation is guided by using call signs or names to indicate who goes next.

Next month we will explore several other kinds of contacts.

Crown City HF #51

Operating an HF Station (9): Working a CQ WW DX Contest

One great way to learn to operate a HF station is to participate in a contest. Our Club will be competing in an international (DX) contest over the last week in October which is sponsored by the CQ Magazine people. Their CQ WW contests are considered to be among the very best. With the very good solar radiation we have been having there should be lots of interesting activity. Please read this month's "The Presidential Amplifier" for details on how to sign up for an operating slot and take advantage of this wonderful opportunity.

For those of you who are unacquainted with this contest here are some tips on how to work this contest: The CQ WW will be similar to Field Day except we will use a fixed (commercially powered) station with one transmitter, but we will have many operators putting us in a "multi-single" station category. We compete with the other stations in that category. It is a contest using SSB (no CW). The point of the contest is to "exchange" information with other amateur radio stations. These contacts count towards our score (see lower down). The data which we have to be sure that the station we are contacting gets correctly from us is our call sign, their signal report and our CQ DX zone number. We also have to get their information for the contact to count.

There are two ways of getting this information. The first is tuning up and down the band and when a contest station is found calling "CQ Contest" or "QRZ Contest" followed by their callsign, and after checking with our logging computer to see that it is not a duplicate, we answer back with our callsign (W6KA). If we hear our callsign repeated back we are in business. If the other station is confident that they have our callsign that station will usually give its information (the "exchange": a signal report (in contests they are always "59") and their CQ DX Zone number. Our response (our similar data) is "59…zero three"). This is called "search and pounce" and is the easiest way to start our when learning. Sometimes many stations are calling the same station you are trying to get (called a "pile-up"). There are tricks to get your call answered, but we don't have space to go into all of them. However, one simple thing is to write down the frequency of that station and resume searching. Then, after a few minutes, come back and try recalling.

The other way to work is called "running". That involves finding an unoccupied frequency (see the June 2012 Crown City HF) and calling CQ. There are lots of ways to do it but the simplest is to just say "CQ, CQ Contest, Whisky Six Kilo Alpha". And then if a station gives their call sign we repeat it back. If you are not sure what they said, you say "QRZ" and give what you did get. Once you are sure you have it right, and the computer tells you it is not a duplicate, the exchange proceeds as noted above.

Those are the basics! Scoring is complicated, but it is important to have some knowledge of it so you understand why it is important to work hard to get some stations and to ignore others at times when more "valuable" stations are workable. So here is how it works. You get one "multiplier" for each different CQ DX zone and DXCC country contacted on each band. Contacts between stations on different continents are worth three points; between stations within the North American continental boundaries count two points. Contacts between stations in the same country are permitted for zone or country multiplier credit but have zero point value. The final score is the result of the total points multiplied by the sum of your zone and country multipliers. Do not worry, the logging computer does all the math. Then we send off a data file to the "CQ magazine people" who check to see that we have gotten correct information. They then declare the winners!

So that is the short course: CQ WW DX 101. Work the contest and have a great time!

Crown City HF #52

Operating an HF Station (10): Nets

Last month I took the opportunity to interrupt our discussion of "QSOs" to encourage readers to sign up for the CQ WW DX Contest and discuss contesting. So now we will get back on track and move on to another kind of contact.

It may be a stretch to call participation in a net a "QSO" but lots of hams participate in nets and, for instance, our club has a net. It is on VHF (see Calendar section of this Bulletin). They can be a very enjoyable part of ham radio.

So what is a net? It is a meeting of hams on a scheduled time and frequency usually on a repeating basis (eg. daily, weekly, etc.). These nets generally have a "focus" such as an organization, like our radio club, emergency communications, message passing, DX, QRP, award chasing, geographic areas, maritime mobile, youth, and many more. Some are very formal and businesslike while others are largely for what might seem to be just an organized ragchew. A good example is the National Traffic(NTS), organized and operated by members of the American Radio Relay League (ARRL). Its major EmComm function is to handle health and welfare messages in concert with their ARRL's Amateur Radio Emergency Services. Several of our members are active in this important net.

Nets have different formats. One of the formats used is called a "directed (formal)" net and is run by a net control station. The net control operator opens the net and, using a script, calls for regular participants to check in and asks for traffic (emergency first) and announcements. After the regular participants check in, most nets ask for visitors and this is your chance to be recognized if you are new. After that point there is considerable variation in what happens. The best approach is to just listen to the net a few times until you know how it works. If a net you enjoy is run by an organization, they will usually make that known and information on how to join is given.

There are also "informal nets" which follow much less rigid protocols. It may or may not have a net control operator to direct activities. If not, it usually works as a round-robin. I mentioned earlier that a "round robin" was a form of QSO. Actually all it means that several hams conduct a QSO by passing the conversation to the next person on frequency by naming or giving the callsign of the next speaker. Informal nets sometimes precede or follow formal nets.

There are a number of places to find lists of HF nets but the HF Radio Nets Page at www.ac6v.com/nets.htm is easiest to use, I believe. The listings are by topic on the first page in a useful "Quick Find" directory.

Another good one is, of course, from the ARRL at: http:// www.arrl.org/arrl-net-directory. Have a listen and when you find one or two you like…jump in. Try it, you will like it!

Next month we will move back to some more technical talk.

Crown City HF #53

Back to Antennas

The inspiration for these Crown City HF articles came during a Pasadena Radio Club December 2007 holiday dinner. The venue had been arranged by then outgoing president Ray Overman. Just as we all showed up for a Japanese dinner at Shogun's in Hastings Ranch, with thoughts of sushi and sake dancing in our heads, a large amount of smoke began billowing out of the roof. As the Pasadena Fire Department arrived and chased us away, we moved down the hill to Robin's BBQ. I was sitting across from Peter Fogg, our 2008 president-to-be, when he somehow talked me into writing this monthly column for the Bulletin. He thought it should be about how to get started in HF amateur radio and directed to our members who were about to upgrade to General Class, or had recently done so. Last November Peter passed away, but this column remains as a small piece of his PRC legacy. Hence, I will continue to follow his suggestion to keep things targeted to the group he recommended.

We will be going back to antennas for a couple of reasons. First of all, it is said that a good antenna is the most import piece of equipment a ham's shack can have. I believe that is true. Also, it is possible for most hams to understand enough technical information about antennas to choose the right antenna for their needs, location and bank account. Taking that one step further, it is fun to make your own antennas and exciting to find out that "home brewed" antennas can really work well. As I have said before, I will do my best to stay away from any complex math, charts and theory…

except where something essential to understanding an important concept or antenna characteristic, in which case I will try and summarize. Also, there are a very large number of excellent books, manuals and Internet articles available on this subject and I intend to reference some of those when a more detailed explanation might be interesting and useful.

If you have been following these Crown City HF articles you will have already covered some basic material regarding antenna systems. Starting with CCHF #12 (March 2009) and ending with CCHF #33, this column covered feedlines, baluns, SWR, antenna tuners and we built and put up a 40 meter dipole antenna. I will make reference to these often and they can be found in our marvelous new website at http://w6ka.net/bulletin.php.

I hope to cover a variety of high frequency antennas such as verticals, quads, loops, long wires. Next month we will go back to our basic single band dipole and see what we can do to it to make it cover more bands, give it more bandwidth, make it more or less directional, etc. It would be a good idea to have a look at Crown City HF #25, “Assembling our Dipole”, June 2010 to refresh your memory.

Crown City HF #54

Dipole Variations (1): The inverted V

Why did we choose to build a dipole as the antenna for the “virtual station” that we created earlier in this series of articles (Crown City HF, June 2010)? Well… as I pointed out at the time… the dipole is easy to make (we did that) and it is probably the most popular ham antenna. But also I made it possible by putting our make believe shack in a property big enough to hold a one half wave length (~67 foot) long 40 meter antenna and with appropriately placed trees. But what could we have done if our available area was smaller with no trees around the edges. There are several possibilities, but one commonly chosen is the “inverted V antenna”.

So what is it? Basically it is a dipole, very similar to the one we made, but instead of having the two arms come out horizontally, those of the inverted V slope downward. Let’s consider the usual, and probably best, configuration which is a 45 degree angle down from horizontal (more than that is not recommended). If you do the geometry you can see that the two ends of the antenna move 18 feet closer together. Also important is the fact that it requires only one high supporting point in its middle. So if we have a single tall tree near the center of our property, or maybe an antenna tower for a tri-band beam, and you want something on 40 and/or 80 meters, this antenna will work almost as well as a flat dipole, particularly at these frequencies where it is most often used.

There are a few other differences. For instance, to cover the same frequencies with similar SWRs, a shortening of the antenna's arms from 3-5% is required. A very helpful online calculator is available at www.csgnetwork.com/antennaeivcalc.html for determining inverted V element lengths. For the purposes of this calculator the degrees of the inverted Vs are from horizontal. A standard dipole is parallel to the ground and is horizontal; a 15 degree inverted V is almost parallel to the ground while a 75 degree inverted Vee is almost perpendicular to the ground. So let's look at an example. If you had a standard dipole tuned to 7.15 MHz it should be 65' 5 15/32" long (both arms) and decided to turn it into a 45 degree* inverted V resonant to the same frequency it would be 62' 2 3/16" long. Be sure to leave the ends of the antenna wires extra long (see the CC HF article cited above) to do some adjusting for a minimum SWR. Another difference with the inverted V is that it can be further optimized by raising and lowering the ends of the arms to achieve an additional improvement in SWR.

Another slight difference is the horizontal radiation pattern. At optimal heights (at least 1/4, but better 1/2, wavelength) above ground, a standard (flat) dipole radiates a variable "figure of 8" pattern which gives a 2 dBi (about 1.4 times the power) gain at right angles to the antenna whereas the 45 degree inverted V will radiate equally in all directions (omnidirectional). This may be desirable in some cases. Also, because of a major influence on antenna height and ground characteristics this may be a difference that makes no difference.

In choosing between a standard dipole and an inverted V there is one other consideration, that is the power you want to use. Because the center of the inverted V antenna is supported, one can use heavier coax, baluns and wire which may be needed for "full legal power". Of course a center support can be added to a standard dipole… but it can be costly and inconvenient.

There are a few other points to remember if you plan to construct an inverted V. Keep ends of the supporting ropes over 8 feet up so they are above where people can be injured by running into (trauma) or even touching (burns) them. Remember to do the same careful grounding discussed earlier in these articles when we put up the dipole. Because the inverted V is most often used for the lower frequency bands, some special problems exist. Try and get the antenna up as high as is practical. Because of their longer wavelengths, useful DX radiation angles deteriorate below 1/2 wavelength and quickly reach the "cloud warming" stage below 1/4 wavelength. Since most of the radiation occurs near the middle, the highest point in an inverted V, this configuration has some advantages when fighting for elevation.

Next month, we will look at some other useful dipole variations.

*Watch out when figuring out these antenna dimensions because some charts and calculators use "apex angle" which is the angle between the two arms that are hanging down. Therefore the 45 degree antenna in the example would have a 90 degree "apex angle".

Crown City HF #55

Dipole Variations (2): Fan Dipoles

So far in this column we have only discussed single band antennas. Our "virtual shack" started out with one 40 meter dipole, but inevitably the lure of operating on other bands will force us to consider what to do about a more complex antenna system. First we have to decide which of two ways to go: erect one or more additional antennas or modify/replace our existing dipole. Although the former solution has some advantages it is, for most hams, not the best. Multiple single band antennas are generally easier to tune and a bit more efficient, but they are more expensive and tend to clutter up your property with hardware that only you appreciate. So let's see if we can make our simple dipole into a multiband dipole. Let's consider the **fan dipole** as our first option.

The fan dipole looks a like a regular dipole with extra arms. Instead of a single pair of wire arms coming away from the center feed point (usually a center insulator and SO-239 fed by 50 ohm coax) there will be one or more additional pairs of wire arms cut to different frequencies. Usually the arms are arranged with each wire directly below the next longest pair (but not always). The top pair's length is cut as if it were a standard dipole, but below the arms must be slightly shortened as they will each be in a slightly inverted V configuration. The distance between the arms will determine the angle at which they will be from the top flat dipole. One way is to start with some suggested lengths and then adjust similarly to how we tuned our flat top dipole. See Crown City HF#25, "Assembling our Dipole", June 2010, and also in last month's article on inverted V antennas.

You can find some suggested starting arm lengths for each side (from the feed point to the folded back end) at www.eham.net/articles/12399.

Remember to leave extra wire length of 12-18 inches turned back and twisted around its wire arm to be used for lengthening if needed during tuning. These antennas are a bit trickier to tune because of interaction between the many arms. Let's consider a two band fan and let's say that it has two pairs of arms cut to be resonant at 10 and 20 meters. That means that a 10 meter signal coming up the coax from your transceiver gets to the feed point and will flow out the 10 meter arm unimpeded by reactance (opposition to the flow of alternating current caused by inductance and capacitance due to too long or too short dipole arms). Because a 20 meter arm is exactly the wrong length (an even multiple) it will have a high reactance and little radio frequency current will flow in that arm. Their resonant frequencies are also affected by other things, such as the height above ground, nearby metallic objects etc. Also the process becomes a little more difficult with a common configuration which has four pairs of arms and covers 10, 15, 20, 40 and 80 meters. Wait minute…how can a four arm fan dipole cover five bands? I just mentioned that even multiples present a high reactance, but in the case of 15 and 40 meters the latter's length is roughly three times the resonant length of the former's, thus offering little opposition to rf flow at that frequency.

A detailed description, titled "My Fan Dipole Project" by John Petroccelli, WA2HIP,

http://wa2hip.com/jrpetro/My_Fan_Dipole_Projects.shtml

takes you through building and tuning a fan dipole. If you are going to build or plan to tune a fan dipole that you have purchased… have a look at it.

Next month we will look at some other ways to alter the standard dipole to make it function on multiple bands.

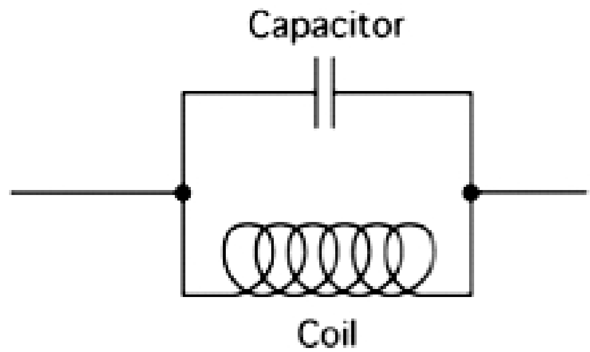
Crown City HF #56

Dipole Variations (3): Trapped Dipoles

Last month we began looking at how a basic dipole antenna could be modified to work on several ham bands by discussing the fan dipole antenna. Another option is the trapped dipole.

To explain this variety of multiband dipole and understand some terms that we have been using, and will be using even more, we should spend a little time now on the electronic principles that apply to "traps", also called "antenna loading coils". In your study for the Technician Class license you were introduced to capacitance and inductance and the General Class questions cover reactance, impedance and resonance. Let's see how these properties of capacitors and inductors work in a trap. By using the correctly designed components spaced at the correct intervals along the arms of a basic dipole antenna it will display resonance, and therefore maximum electromagnetic radiation (radio waves or signal), on a number of different bands.

Reactance is the opposition to the flow of alternating current (AC) offered by inductance and capacitance. Inductance is a property of the effect of (usually) magnetic fields created in wire coils that oppose AC flow. A critical characteristic is that the higher the frequency, the more opposition. This opposition is called inductive reactance. Capacitors store electrostatic energy (usually) between separated metallic plates. Capacitors have the opposite effect on AC, so they allow higher frequency AC to pass with less opposition than lower frequencies. This opposition is called capacitive reactance. So in order to make a trap we need to make a tuned circuit* (see figure below).



A "tuned circuit" in the parallel configuration.

(a "coil" is a common kind of inductor)

It is nothing more than a capacitor and an inductor connected in series or parallel. When arranged in series, they present low impedance to alternating current of the same frequency as the resonance frequency of that circuit and high impedance to the flow of other frequencies. The circuit's resonance frequency is determined by the values of inductance and capacitance. However, for antenna traps we need the parallel configuration. Also, impedance is the electrical term used to measure the opposition to alternating current circuit caused by its capacitive reactance, inductive reactance, and resistance.

We know that the HF transmitters we use work by emitting alternating current (AC) at radio frequencies (RF) at 1.8-30 MHz. If such a tuned circuit is placed at the appropriate place along the antenna elements of a dipole at one quarter wavelength (equal distances) from the feedpoint they each block ("trap") the flow of RF therefore acting to insulate the remainder of the dipole from the antenna system. This requires choosing the capacitance and inductance so the trap is resonant** in the middle of the band where you want to operate.

You can buy the individual traps (available at www.unadilla.com/pricelist/traps). If you are an electronically sophisticated builder, look at www.qsl.net/ ve6yp/CoaxTrap.html with its automatic Coax Trap Design calculator. Trap building and the tuning of the traps, along with the antenna itself, requires some expertise…more than any antenna we have discussed so far. Of course the easiest way is to buy the trap dipole antenna you want already assembled with the traps already tuned. The largest selection I could find is available at

http://www.amateurradiosupplies.com. They also make combination trapped dipoles and fan dipoles.

Trapped dipoles do work well on multiple bands. There is some small power loss in all traps, they are tricky to build and tune and also a little pricey. They are heavier than simple wire dipoles and present bit more wind loading. They are particularly useful because they are physically shorter on the antenna's lowest frequency (we will cover antennas for limited space later).

* these circuits have many uses : filters, oscillators, etc.

** resonance is nicely explained at http:// hyperphysics.phyastr. gsu.edu/hbase/ electric/serres.html

Crown City HF #57

Dipole Variations (4): Center-fed Zepp-type Dipoles

For the last two months we have studied two antenna variations, fan and trapped dipoles, which allow for multiband operation. These dipoles rely on their feed point impedance to be near the 50 ohms which is the coax and transceiver connection impedance generally used by hams. However, this kind of resonance occurs at only one antenna dimension, wavelength, per band which is why separate antennas are needed on each different HF band*.

Back in the days of powered steerable lighter than air dirigibles the (early 20th century) German Zeppelins were equipped with end-fed antennas so a single wire could trail out behind during flight, hence its "Zepp" name. Additionally, these antennas needed to cover several different frequencies in order to communicate with stations in countries using several different bands. What they came up with was an open wire ladder-type feed line hanging down and a single wire trailing behind the airship. This antenna was tunable to many frequencies due to that feed line's tolerance to high SWRs**. Subsequently, despite the failures of dirigibles, the Zepp antenna has survived. The end-fed (and off-center-fed) Zepps will be revisited in a later Crown City HF article, but since we are working on center-fed dipole variations for now we will stick to the center-fed form of Zepp.

The center-fed Zepp antenna is another solution for station locations with space limitations that preclude the use of more than one antenna. Today the usual configuration is to use a basic horizontal dipole configuration that is at least 1/2 wavelength long at the lowest frequency you plan to use. That length is about 135 feet for an 80 to 10 meter antenna. There are many variations using different lengths and different feed points. For instance the "McCoy Dipole" is supposed to be "as long as possible". Because this is a non-resonant antenna and many other factors affect tuning (height, terrain, nearby objects, etc.) so it is best to expect to have to do some length adjusting and use a really good antenna matching system (tuner).

At the feed point, connect each one of the two wire ends of the dipole to one of the two wires of the parallel feed line. The transmission line's length is not critical because this antenna system is used with a robust matching system (antenna tuner), and a balun which corrects for the unbalanced coax output of today's transceivers and the balanced antenna/feed line (see the Crown City HF articles on "antenna tuners" in CC HFs of January, February and March, 2011 and "baluns" in July and August 2009). However the length of the feed line may need some adjustment to allow even the most heavy duty antenna tuner to fully match and avoid arcing due to high impedance mismatches. A commonly recommended solution this problem is try removing or adding 1/8 wavelength of transmission line for the problematic band. Some popular antenna designs, for instance the "G5RV", connect a 50 ohm coax below a segment of parallel transmission line to eliminate the need or improve the ease of matching. We will cover those options a subsequent CC HF article.

To avoid interaction between the antenna and the open transmission line, that portion near the feed point should be routed away at right angles to antennas arms. This kind of antenna can be used in an inverted V. However, because as the arms are lowered they begin to interact with the feed line, the angle between horizontal and antenna arms should be no more than 25 degrees. The "sloper" and "vertical dipole" configurations are also used but similar feed line proximity considerations exist with the ground and possibly a tower.

* there is one exception: 15 and 40 meters. (see Crown City #55, Jan. 2013)

** these feed lines will be covered next month

Crown City HF #58

Dipole Variations (5): Why parallel conductor feed lines?

In last month's Crown City HF I indicated that to use a center-fed dipole as a multiband antenna it was necessary to have a parallel conductor feed line because of their "tolerance to high SWRs" with a footnote promising to explain this. To begin with, most hams today use coaxial cable to connect their antennas to their shack's equipment. It is easy to handle, can be coiled, does not interact with nearby metallic structures and presents a 50 ohm impedance which matches to the output of virtually all transceivers we use now. "Parallel-conductor feed lines" serve the same function but they have several different characteristics; some make them more difficult to work with while others sometimes make them very useful.

Before we go on I need to explain the terminology because it is a little confusing. First, "feed line", "feeder" and "line" are generic expressions used pretty much interchangeably with “transmission line”. These include any conducting system that carries radio frequency signals between antennas and remote transmitting and receiving equipment. One kind of feeder is coaxial cable (coax)* which is widely used and pretty well understood by hams.

The other, less commonly used transmission lines are the subject of this, and the next, Crown City HF. And They are generically called “parallel conductor feedlines”.

They are also known as “open-wire balanced lines” or “open wire feedlines” (“open wire” relates to their difference from coax where a single conducting wire is enclosed in a conducting shield). The original form of these consisted of two parallel wires, bare or insulated, usually #12-#14 wire, separated by spacing rods. These are made of insulating materials (wood, plastic, etc.) designed to hold the wires 1–6” inches apart and spaced every 4 to 12 inches along the length of the feedline, thus creating the appearance that led them to be called “ladder lines”**. Consequently air is the insulator (dielectric) between the wire (conductors) over nearly the entire length. The characteristic impedance is 450 and 600 ohms. These lines are often homebrewed but they can be purchased at the price of ~60 cents a foot. An excellent article on the subject can be found at www.athensarc.org/ ladder.asp . It even includes how to decide how long to make it (and lengths to avoid), a way to get this somewhat unwieldy feeder into your shack and how to construct a lightning suppressor using two spark plugs! This type of feedline is useful if, for instance, cost is not a consideration (or if you make it yourself) and if you have a long run between the shack and antenna and you hate to lose power before it gets to your antenna.

Another kind of parallel conductor is the “window line”. This is a commercially manufactured product which comes as with the two parallel #14-16 wires about 3/4” apart molded into the edges of a plastic ribbon (usually polyethylene or PVC) with rectangular windows cut out every inch or two. The usual impedance is 450 ohms. Those windows are there to reduce power loss across the dielectric, lighten the line and slightly reduce wind drag. This sells for about 21 cents a foot compared to 90 cents/ ft for RG-213 a commonly used low loss coax. This feedline is often seen in popular antennas such as the G5RV and the center-fed- Zepp because of the unique properties of high SWR tolerance and the much greater ease of handling.

The third kind of parallel conductor feedlines in common use are called “twin leads”. Before the days of cable and satellite television there were two small bolts on the back of TV sets about an inch apart to which you connected a 3/8th inch wide plastic ribbon with two plastic encased #22 stranded wires along its edges. The impedance is 300 ohms. Twinlead is still around and if you are using 100 watts or less it can be used for a feedline. I have a soft spot for this stuff because my first phone QSO was made using a feeder and folded dipole made entirely out of TV twin lead (on 10 meters, AM, 5 watts, Los Angeles to Shreveport, LA). There is a heaver duty foam dielectric version which can handle up to 200 watts and with less power loss. This feedline is often used by QRP enthusiasts and also to build “roll up J-pole” vhf and uhf antennas like the ones some of us made at PRC’s last Field Day.

Now that we have covered the varieties of parallel conductor feedlines I can answer the question of why we should use one for our center-fed Zepp antenna… next month.

*previously discussed in Crown City HFs March-July 2009.

** some of the literature on this subject uses the term ladder line for any parallel feedline except twin lead.

Crown City HF #59

Dipole Variations (5): Center-fed Zepp-type Dipoles (3) Why parallel conductor feed lines?

Last month we started to answer a question about why we would want to use parallel conductor feedline with a center-fed Zepp dipole multiband antenna. We began to explore the physical and electrical characteristics of the various kinds of such feedlines. Next we will look at the differences between the two most commonly used ones: “ladder line” and “window line”. Remember, the ladder line is the one where the wires are separated by spacers while the window line is covered in plastic and separated by a ribbon of that material with windows cut in it. We have already mentioned the prices (last month), so if you buy them, ladder line is about three times as expensive as window line. Also window line has some advantage in handling, e.g. it coils more easily and is less likely to kink. There is somewhat more loss across the plastic ribbon than there is with the air dielectric of ladder line. Another difference is that in rainy, snowy or icy weather there tend to be increased loss and impedance changes when there is a plastic ribbon separating the conductors. Last month I pointed out circumstances where each type of parallel conductor feedline tends to be used. Now let’s compare them as a group with coaxial cable.

Some advantages of coax are that it can be coiled, is not affected by proximity to metallic objects, picks up less unwanted ambient RF (radio signals), greater tolerance to bad weather and wind, wide availability with a 50 ohm impedance (which matches modern ham transceivers) and can easily be compatible with rotating beam antennas. Low cost (particularly if you make your own ladder line) and minimal matched line loss are the major advantages of parallel feeders.

At last I will get around to answering the question posed in the title of this article: the ability of parallel conductor feeders to tolerate badly mismatched antenna feedpoint impedances without losing a large amount of power compared to even a high quality coaxial cable is the reason that we need to use parallel feedline with the center-fed-Zepp. That antenna is designed to work over a wide range of HF bands so it will inherently be mismatched, even badly mismatched, much of the time. So how does the parallel open wire configuration do that? The spacing between the conductors is a very small percentage of the operating wave length and the direction of RF flow, being opposite, will be 180 degrees out of phase, so the radiated fields will (because they are so close) almost exactly cancel each other out even in the face of a high SWR thereby eliminating its effect. That is also why parallel feeders are rarely used above HF frequencies and never above VHF: the distance between conductors becomes too far as a percentage of wave length for the canceling effect to work.

Next month's CC HF article, in our examination of multiband antennas, we will look at the popular G5RV antenna.

Crown City HF #60

G5RV Antennas

*"The **G5RV** is the most popular multiband antenna in the world. It is low cost and provides good performance on most HF bands."*(www.amateurradiosupplies.com, G5RV page).

That is a pretty impressive statement and true, although it leaves out some important details. In the space available here I will cover some of its important characteristics.

First of all I need to give credit for designing this antenna (1946), **Louis Varney**, G5RV. It is still called the "Varney antenna", but the problem is that he described several versions. So let's begin with defining what the most common form of the G5RV is today, before we tackle the other variations. It is a ~102 foot long center-fed dipole (three half waves on 20 meters), fed by a parallel conductor feedline (see last month's Crown City HF) which acts both as a matching section and as part of the radiating antenna of varying length (26-34 feet), depending on the type used, but electrically one half wavelength on 20 meters, then some balun, coax loop RF choke or ferrite beads and then a length of coax connected to a "robust" antenna tuner.

Its ingenious design was intended to make it possible to use one relatively simple and cheap antenna on all of the ham bands from 10-80 meters. The advance over the center-fed Zepp was the coax's lower SWR on many ham bands and the advantages of having coax to run over much of the feedline run and into the hamshack. When Varney first designed the G5RV, antenna tuners were in their infancy and the "WARC bands" (30 meters, 17 meters and 12 meters) were not ham bands until 1979. Varney and others have responded with several modifications which ended up as described in the paragraph above because there were some entire bands and parts of others which presented very high SWRs either making them not tunable and attempts to do so sometimes led to burned up baluns, antenna tuners or transmitter finals. Tricks such as using long lengths of lossy coax (like RG-58) and different dimensions, which we will see below, initially helped make this antenna easier to use. More recently changes in balun and antenna tuner design along with transmitter final protection circuits have resulted making the antenna an even more useful option when choosing a single multiband antenna. The quote in the first sentence of this article indicates that the G5RV has "good performance on most HF bands", which is true with the modifications mentioned above, including balun or line isolation and the antenna tuner. Otherwise it does work well on 40, 20, and a part of 10 meters (depending on location, especially height, and ground characteristics) as originally designed. Bands that don't work too well are 80, 21, 12, and other parts of 10 meters.

The G5RV has turned out to be a very good DX antenna on its basic working band of 20 meters (remember that an antenna cut to three half-waves is a resonant dipole) because of its radiation pattern. In an excellent article available at www.hamuniverse.com/g5rv.html which covers in detail how, on each HF ham band, the different parts of the antenna participate in radiating and matching. Also, it gives the facts as to how the G5RV performs on each band. If you plan to make your own G5RV it gives information on exact lengths of the dipole, matching parallel conductor stub and coax depending on the specifications of each. There are several admonitions pointed out by the author and others, which are quite detailed. Some of them are: care must be taken to drape the 34 foot long matching stub away at right angles to the arms of the dipole, careful sealing of the matching stub and coax (or balun/RF choke) junction, good support of the center insulator and above mentioned junction as wind twisting is a problem with this antenna, and, as always with parallel conductor feedline, keep it away from metallic structures.

This antenna seems to be something that most hams can make themselves, but some authors caution that the tuning is tricky. They can be purchased readymade for around $100 with a 1:1 balun. Tuning may still be necessary because of local factors mentioned above. You do need to have good antenna tuner, which should be designed to handle high SWRs and significantly more power than you are planning to run.

Next month we will look at some of the variations on this antenna.

Crown City HF #61

G5RV-like Antennas

Last month this column covered the G5RV antenna. Here we will look at several “G5RV-like” [my term] and how they can improve on their “parent” antenna’s performance. Remember that the nice thing about the G5RV was it is a fairly simple (no traps and only one radiating arm on each side of the feedpoint) multiband antenna which works on bands from 3.5-28 MHz. That means on 80 meters it is about 30 feet shorter than a regular dipole, allowing it to be used when space is limited. Also its radiation pattern is low and provides good DX communications. However as pointed out in the on-line article (www.hamuniverse.com/g5rv.html), which I mentioned last month, one learns that several bands present problems with high SWR if the antenna is not used with a robust antenna tuner. So let’s look at several variations.

Although the standard G5RV is shorter than an 80 meter dipole, it is still too long for the available space for some hams. The **G5RV Jr** is an answer. We will eventually cover other ways to manage space restrictions in a later CCHF article, but this is one of the ways, and it seems reasonable to discuss it now.

The **ZS6BKW** antenna is similar to the G5GV but has a shorter (93’ vs. 102’) dipole and the 450Ω ladder line is longer (39.8’ vs. 31’), so if you have a smaller property to work with and some slightly taller trees, ZS6BKW will be a better fit. Also ZS6BKWs work better on 40 and 10 meters and less well on 80 meters than the G5RV. “Working better” means they offer a lower SWR.

Another variation is the **W0BTU** has OK matches on all bands from 80 to 10 meters, except for 30 and 60 meters, with a 97' dipole, a 39.5' 450 Ω window line and it uses 75 Ω coax.

The information available on this group of antennas contains considerable "author bias" because much of the writing comes from the designer and/or retailer of the antenna. I believe that, like most of the antennas we have discussed so far in CC HF, these "G5RV offspring" are relatively easy to build antennas, but they are a bit more complicated than the dipoles. So, in order for you to get an idea of the pricing and variety of the readymade ones that are available, and decide to buy or build, I have listed below several web sites that offer this type of antenna:

www.amateurradiosupplies.com/g5rv-antennas-s/56.htm

www.mfjenterprises.com/Product.php?productid=MFJ-1778

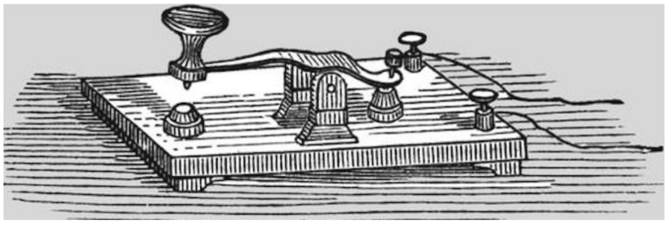
www.antennasmore.com/g5rv.htm

www.radioworks.com/cg5rv.html

If you decide to build or buy one of this type of antenna first have a look at

http://vk1od.net/antenna/G5RV/optimising.htm <link deleted>

Next month Crown City HF moves on to a new class of antennas, the loops. They are probably underappreciated by the amateur radio community. Is a loop right for you?



Crown City HF #62

Loop Antennas (1)

The loop antenna has been used since the early days of radio, but it was not until around 1938 that Clarence Moore, ex-W9LZX introduced it for shortwave (HF) radio broadcasting. Loops are relatively easy and inexpensive to build and work well. They function rather differently than the dipoles we have been discussing. It is an interesting type of antenna and may have characteristics suitable for your particular needs as an amateur radio operator or curiosity as an experimenter.

There are several varieties of loops. The antenna is made of a continuous length of wire or tubing in a shape such as a single square, rectangle, pyramid or circle. They are usually classified into large and small categories. We shall start by discussing large loops, those between ½ to one wavelength (λ) as these are the sizes similar to the dipole like antennas we have discussed so far (actually often larger). Although some of the material on large loops is applicable to small loops, they are also quite different. Therefore small loops will be specifically covered later when we look at antennas for hams with limited space.

Loops work both as verticals and horizontals. Maybe the most widely used configuration is in the "cubical quad" which is a type of Yagi beam. We will wait until Crown City HF gets to beams before we discus that antenna in depth. However at the cubical quad's heart is a loop driven element, usually a single square turned on its side (called a "diamond"). Loops can be fed with coax or parallel conductor feedlines. These antennas can be used on multiple HF bands with appropriate baluns and antenna tuners. They often fit into odd shaped lots and even into attics better than other shaped antennas.

The length in feet of a full-wave loop is 1005 divided by frequency in MHz. So, if you want to work the General Class portion of 40 meter phone we divide 1005 by 7.2 so the length of the entire loop should be about 139.6 feet. If it needs to be a square, divide by 4 to get the length of each side (34.9') or, say, an equilateral triangle divide by 3 (46.5'). Less than full sized loops can be used but loops shorter than .75 λ on the lowest frequency you plan to use are to be avoided. See the dimension calculator which covers many sizes and shapes at http://mysite.verizon.net/ka1fsb/loopcalc.html#. This calculator saves a lot of time if you plan to build a loop.

The wire loop's position in relation to the ground and the location of its feedpoint determines the antenna's polarity. If all of its arms are parallel to the ground, it radiates horizontally no matter where it is fed. When the wire's entire loop is perpendicular to the ground it is called a vertical loop, but its radiation may be horizontally or vertically polarized, depending on the location of the feedpoint. Feeding at a bottom (or top corner) of a diamond shaped loop or at the midpoint along the bottom (or top) of a square loop produces horizontal polarization. Vertical polarization occurs when the feedpoint is at a either side corner of a diamond shaped loop or at the midpoint along either side of a square loop. Horizontal polarization is usually chosen to decrease received noise on the HF ham bands.

Another interesting characteristic of this antenna is its high "Q". In practical terms one can think of the "Q" of an antenna as how rapidly the SWR rises as the frequency is raised or lowered from its exact resonant point as one transmits through the antenna. The more rapidly the change occurs the higher the "Q" and the more narrow a frequency range can be used without retuning your antenna tuner. With today's antenna tuners, particularly the automatic ones, this is not a big problem. As we will see later, loops are usually used with an antenna tuner for other reasons, too.

The various shapes of the loops have differing characteristics. For instance, a circular loop has a feedpoint impedance of 135 Ω, while a square loop fed at the midpoint of its bottom arm is 120 Ω and a triangular (often called a delta) loop is 105 Ω.

Crown City HF #63

Loop Antennas (2)

Loop antennas work somewhat differently than the others we have been looking at. A loop generates field lines that are magnetic, not electric as with the other antennas. This occurs because the closed conductor loop acts like a huge air core inductor which allows escape of its magnetic field, which ultimately results in a radiated electromagnetic signal. This does have one important consequence: loops demonstrate much less reliance on a good RF ground due to a poor electric field with earth. This means it is not necessary to install extensive radials such are often needed for verticals. Of course some grounding for lightning surges and shock prevention is always needed, no matter what antenna system you use.

Vertical loops are directional. The best way to describe their directivity is to draw a loop antenna shape on a piece of paper (e.g.

circle, triangle, square, etc.). The major radiated lobe is right through the center of the loop coming out at you at right angles to the paper and equally so, straight out the back of the paper. Due to the radiation pattern, the larger the area inside the loop, the greater the gain of the loop. The circle wins here by 1.13-2 dB (over a dipole). Reported gain figures for antennas are often conflicting and they do vary between the shapes, antenna height and soil composition. Here the difference makes little difference as the gain is not impressive. There are several reports of meaningful gain (3-4 dBs…a doubling of power) off the sides of loops at harmonic frequencies (eg. on 15 meters with a 40 meter antenna). They may be exaggerating, but most authors commenting on these antennas, particularly while discussing the vertical delta loop configuration, swear that this is a “top performing DX antenna” and provides “big time DX”. The usual explanation for this performance is its low angle of radiation, said to be 10-15º.

Square horizontal loops are omni-directional (360º) and can be fed at any point. Rectangular loops have some small bidirectional gain at right angles to the longer arms.

Above I mentioned that the feedpoint impedance of loops varies from 105 Ωs to 120 Ωs for square and triangular antennas, the most often used configurations for large loops. Most of the usually used 50 Ω ham feedlines do not match this very well, but with a good antenna tuner and coax, the high SWR can be managed. RG-59 is available at 70 Ωs, but probably makes little difference. A balun is generally recommended to connect the balanced loop antenna to the unbalanced coax and prevent feedline radiation. Some authors recommend using parallel conductor feedlines all the way from antenna to antenna tuners because, as was explained back when we covered the badly mismatched Zepp antennas, they substantially reduce feedline losses in the face of high SWRs. These parts of the loop antenna’s system must be rated for power well over your operating output power. Also, avoid using a loop on a frequency lower than its design frequency. Two articles which cover the matching problems in more detail than is possible here are:

http://www.qsl.net/kd4sai/loopant.html

and

http://www.rcarc.org/presentations/AB2EW%20Loop%20Antenna.pdf

Next month we will cover small loop transmitting antennas as we start to look at antennas that can be used when there are space or other limitations.

Crown City HF #64

Limited Space Antennas: Small Loops

A small loop (aka magnetic loop) antenna is one of the solutions to the problem of limited space. This is particularly true if there are other restrictions such as exist in apartments and condos where the only options are locating an antenna indoors or on a porch. As with large loops (see the last two CC HFs) they do not depend on grounding for their efficiency. Also, if mounted vertically, they function well even when located close to the ground. These small loops have a circumference of one tenth of a wavelength or less whereas the large loops are usually between one half to one wavelength. These loops are effective from 160 meters to 6 meters. Several authors report results of these small loops to perform better than dipoles particularly at and above 40 meters.

So if that is true, why aren't they more popular with hams? In several recent amateur radio magazines I could not find even one advertised, although several are available (from MFJ for instance). Also they are a little complicated to build yourself. There are good internet articles

(http://www.aa5tb.com/loop.html and http://www.rcarc.org/presentations/AB2EW%20Loop%20Antenna.pdf

on the subject which encourage building your own…but it seems tricky even using the dimension calculators provided. The July 2013 QST, pages 91-93, has another article which looks easy to follow.

Also as mentioned in the previous articles on large loops, these small loops also have high Qs. That means they have narrow bandwidths and the need for careful and frequent tuning.

Another issue is that because of the powerful fields generated near these antennas, they require limiting power if the antenna is not kept well away, at least one tenth wavelength, from metallic objects like towers. This effect also dictates limiting power to QRP levels when the antenna will be near people. If the antenna is to be mounted for horizontal polarization, it does need to be elevated to at least one half wavelength.

Despite these limitations, these antennas are useful if your space and other considerations dictate a small footprint antenna. Next month we will begin to look at vertical antennas, another antenna solution when space is limited.

Crown City HF #65

Vertical Antennas (1) Basic

"Horizontally polarized antennas such as inverted vees, horizontal dipoles and longwires can give good DX performance if they are located high above the earth, but some hams can't get the needed height and hams with small lots don't have the real estate for a fullsize horizontal antenna. Fortunately, antennas can also be configured vertically and in the process can show a significant improvement in the low-angle radiation needed for DX as compared to a low horizontally configured antenna."

http:// www.arrl.org/hf-vertical

One might wonder why I am starting a discussion now on vertical antennas when I am supposed to be covering limited space antennas. The quotation above explains why and makes the claim that they may have a DX advantage over horizontally polarized antennas because of their low-angle of radiation. Let's explore that assertion.

What is the angle of radiation and how does a "low angle of radiation" benefit working DX? What evidence is there that there is an advantage for vertical over horizontally polarized antennas?

Let's look at what should be correctly called the "vertical angle radiation".

Back when we discussed propagation (see the Feb. and Mar. 2008 issues of Crown City HF by going to PRC Bulletin archives at www.W6KA.net) we learned that most DX occurs by way of skip caused by reflection of radio waves off the ionosphere's F layers back to the earth and sometimes by their bouncing off the earth back to the F layers again and so on around the curved surface of the earth. If you think about the geometry, the closer the majority of the power of your transmission is to the curved surface of the earth when it leaves an antenna, the farther away it will encounter the ionosphere (compared to a signal which is focused higher up). Hence the reflected wave will similarly be back to earth farther away with each skip. A low angle of radiation is important because with each skip there is a loss of power by one half or more…so the fewer the better. For DX vertical angles of radiation of 3-10 degrees are optimal. For instance a vertical angle of 5 degrees will yield 1000-1500 miles to the first return to earth while if it were 40 degrees that would be about 300-500 miles.

How do vertical antennas' radiation angles compare, let's say, to a dipole at 35 feet on a common DX band like 20 meters. In the table* below you can see how the dipole's major vertical lobe pattern compares to that of the three most commonly used vertical antenna configurations.

ANTENNA TYPE	VERTICAL LOBE
Dipole (as above)	15-45 deg.
One quarter wave vertical	10-55 deg.
Three eighths wave vertical	8-40 deg.
One half wave vertical	5-35 deg.

Note that as you move down the list to the last two verticals you have the most focused and lower angles of radiation. This is the major evidence that supports the claim made in the quotation above.

Next month we will continue the explore HF vertical antennas.

*modified from The Vertical Antenna Handbook, Paul Lee (N6PL), 1996

Crown City HF #66

Vertical Antennas (2): Vertical Dipoles

So far the dipole antennas we have discussed in CC HF were horizontally orientated, but it is possible turn a dipole on its side when space is limited and/or you prefer the omnidirectional radiation pattern that verticals provide. A common vertical dipole configuration is where the feed line enters the center of the antenna, ideally at right angles to its arms. This geometry is often difficult to achieve and this angle can be reduced to 45 degrees with little effect, but the coax should be kept well away from the arms, or distortion of the radiation pattern occurs. It is important that the tip of the lower dipole arm be kept well above the ground (at least 10 feet, preferably higher) to avoid contact with people and electromagnetic interaction with the earth. This design is not used much in HF work but in some circumstances it can be a good solution when options are limited.

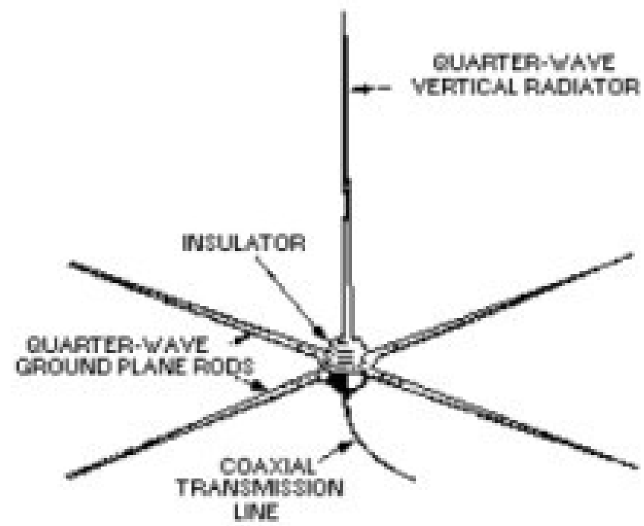
There is another configuration of the vertical dipole which is often more practical and "stealthy". Also, this is an easy antenna to homebrew. In this design the coax is brought up through a hollow bottom element to attach to the top of the bottom element and the bottom of the upper element. The two lengths of metal tubing (usually aluminum or copper) need to big enough to allow passage of the coax (without any coax connector) you intend to use They each need to be one-quarter wavelength (1/4 λ) at the center of frequencies you intend to operate. You can use www.kwarc.org/ant-calc.html to calculate the element lengths. This antenna is for one band only and is best for 10-20 meters, as it becomes unwieldy, because of size, at lower frequencies. Before purchasing the tubing check to see that you can get a size of PVC pipe that will fit snugly over the metal tubing available. You will need a 6” for 10 meters, and up to a foot for 20 meters. The coax you are using is brought up through the bottom element, then and on up through the bottom of the PVC pipe and out through a hole in the side at the middle of the PVC segment. Then that bottom element is slipped over the bottom half of the PVC and the top element is likewise slid over the top of the PVC and both are positioned 1/4” from the emerging coax. The two metal tubes are held in place with bolts passed through holes drilled all the way through both sides of both the PVC and metal tubing near the ends of each element. After the braid is peeled down and away from the coax it is attached to the lower metal tubing using the above mentioned bolts with a nut and lock washer. The center conductor is likewise attached to the upper metal element. The bottom end of the lower element should be the same. A common way to mount this antenna is to use another length of PVC tubing mounted in a tripod attached to the lower element. Another way is to use a handy tree (if you are lucky enough to have one). Throw or shoot a non-conductive line over a high limb and securely hang the top of the antenna from that. To avoid RF radiation from the coax getting into your shack and improve the ease of tuning, some kind of feed line isolation is a good idea. Tuning will require cutting length off the elements or moving the elements on the PCV center piece farther apart.

Next month we will look at the more common vertical antennas. The electrical length of vertical antennas is a critical factor in the way they perform. We will see how this affects the performance of vertical antennas.

Crown City HF #67

Vertical Antennas (3): Quarter Wavelength Ground Planes

Electrical length of an antenna is the number of wavelengths of the signal propagating on the driven element at the design frequency. The electrical length of vertical antennas is a critical factor in the way vertical antennas perform. The most commonly used lengths for verticals are one quarter, three-eighths and one-half wavelength (λ) long. We will eventually look at each of these configurations. The simplest to understand is the one quarter wave (1/4 λ) “ground plane” antenna (below) so we will start there.



A 1/4 λ vertical can be can be viewed as a 1/2 λ horizontal dipole turned on its side with the bottom one-half replaced by “radial” elements (or even a large conducting surface like an automobile roof) that mimic the electrical function of one arm of a dipole. The other arm is the top half, a single element called the vertical radiator. At the center insulator the central conductor of the coax is connected to the vertical radiator and the outer shield to all of the radials. The diagram above shows its simplest form; it is the one hams use most often in VHF and UHF applications, but works well on ten meters because its simplicity and physical size is very practical. Also, the one shown above has only 4 radials, which works on the higher bands because it is not hard to get well away from the ground in terns of wavelengths. 1/4 λ verticals on lower HF frequencies are also used, often as multiband verticals that work by using traps to create vertical radiators that function as 1/4 λ verticals on several bands. Ground plane antennas have essentially no gain (+ 0.3 decibels, “dB”s) when compared to the standard isotropic radiator. We will look at dBs and gain of the different wavelength verticals later. Radials of different lengths, or a large conductive surface (metal, salt water), are needed to eliminate ground losses when these antennas are mounted close to the ground. The length of the elements for vertical antennas can be obtained by using the on-line calculator at http://www.csgnetwork.com/ antennaevcalc.html . The radiation patterns of the various verticals that we will be discussing are shown and compared at http:// www.mapleleafcom.com/ PDFs_Downloads/ Radiation_Patterns_Verticals.pdf. They would take up too much room to show here. You might consider printing it from your computer as we will be discussing these patterns later. These patterns can be distorted by nearby metal structures, height of the antenna above ground, the conductivity of the soil and the radial system used. Also the number of radials is important and varies depending on a number of factors.

Radials are an important subject relative to vertical antenna performance so we will discuss them in more detail next month.

Crown City HF #68

Vertical Antennas (4): Ground Losses

In last month’s CC HF I gave you the quote: “A 1/4 λ vertical can be can be viewed as a 1/2 λ horizontal dipole turned on its side with the bottom one-half replaced by radial elements...that mimic the electrical function of one arm of a dipole.”

The efficiency of those radial elements is greatly affected by the characteristics of what we will call “ground” (it could be soil, salt water or your metal car body) beneath them. So before we discuss radials further let’s look at what makes the “ground” so important in making our vertical antenna efficient. Why is it so important when it comes to how many radials we use, their depth of burial, how long they should be and how high an elevated vertical antenna system needs to be?

The ground plane antenna shown in last month’s article functions well because that type is almost always used well above the 1/4λ where ground effects become negligible. For instance that would be only 1/2 meter for a 2 meter antenna, whereas a 40 meter antenna would need to be 10 meters (~35 feet) up to reach the same effect. The problem is “ground losses”. These losses are due to the attenuation of the antennas’ effective radiation of radio frequency energy because of the strong field which these antennas radiate downward around the base of the vertical element. This power is dissipated as heat in the earth and lost to the radiated electromagnetic wave as it returns to the antenna. The problem is that most soil is “lossy”, that is it conducts this RF current poorly… that is it has low “conductivity”.

This varies depending on the composition of the surface. Salt water has the best conductivity and is stated to be 5000. These numbers are best used for comparison (the higher the number, the better). The maps shown below were generated by the FCC and show a conductivity of 8 for most of Los Angeles County, so you can compare that to other areas in the USA, which range from 2-30.

As we will see later in these articles, the cure for this poor conductivity is to have many radials or elevate the antenna. Presumably the higher the conductivity the better and maybe fewer radials will be necessary unless you can get your antenna on a several story house / building or move your rig to an ocean going boat! However the actual conductivity is almost always trumped by practical considerations such as the terrain/

structures and space you have, the amount of wire you can afford and are willing to take the effort to install.

Next month we will look at those practical aspects of radials. As I have mentioned, vertical antennas can be excellent DX antennas largely because of their lower angle or radiation. So far we have been talking largely about the 1/4 λ ground plane type verticals. There are other wave length verticals which we will also cover.

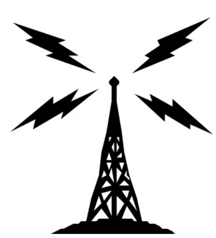
Crown City HF #69

Vertical Antennas (5): Radials(1)

So now we are going to go over radials. Back in January when we looked at 1/4 wavelength (λ) verticals we briefly discussed them and pointed out their role in preventing ground losses, which we looked at closely last month. Now we need to get down to the practical matters of how long and how many radials does one need. Let us go back to that 1/4 λ vertical (aka monopole) ground plane antenna because of its simplicity. Remember the figure showing the “ground plane” antenna with a single radiating vertical element and four equally spaced elements horizontal, labeled “quarter wave ground plane rods”. The vertical element was 1/4 λ long and the horizontal ones were 1/4 λ long plus 2-3% . It was also mentioned that this configuration worked efficiently as long as the antenna was elevated more than a quarter of a wavelength above ground. Because the size of the antennas and the height needed to prevent interaction with the ground go up dramatically as you go down in frequency, most HF vertical antennas are mounted on the ground. So, because most of us live in urban areas, like Pasadena, the soil’s conductivity is so poor that we can’t just drive in a ground rod and expect a good result.

Why do we need to increase the conductivity? Last month’s CC HF simplified the problem by saying “power is dissipated as heat in the earth and lost to the radiated electromagnetic wave as it returns to the antenna”. Some authors simplify the answer by the quip that ”Worms may enjoy the heated soil, but the power lost is subtracted from your radiated signal”. That loss of power determines the “efficiency” of the antenna, that is, the earth acts as a non-radiating resistance in your antenna system and thereby decreases the RF current flow through the radiating vertical element. The physics of this gets a bit complicated having to do with E and H fields, radiation resistance, the dielectric effect, etc. However, the important thing is that if you want to make lots of DX QSOs with a ground level vertical antenna you have to let the worms shiver and have a good system for improving the conductivity of the ground under its base.

A somewhat expensive and labor intensive way to do this is to install a metal “ground screen” (e.g. chicken wire) on or just under the ground’s surface. This needs to extend at least a ½ λ in all directions from the antenna’s base. Sometimes it is elevated off the ground (a few yards) in which case it is called a “counterpoise system”. Most urban hams prefer to put down “radials”. These usually consist of insulated or non-insulated wire, often #12, of various length and numbers. Symmetrical spacing is best. That sounds simple, but the hard part comes when you try and figure out what to do for *your* antenna on the backyard space *you* have. Recommendations vary from 13 to 120 radials and lengths from 0.1 to 0.5 λ! What should you do if you have a multiband vertical? Can “top loading” help? Can’t I just use a “no radials” vertical? We will start working on these issues next month.



Crown City HF #70

Vertical Antennas (6): Efficiency

At the end of last Month's CC HF I mentioned several questions that we need to answer in order make or buy a vertical for our own use. To do that, we need to look at some antenna properties which distinguish various vertical antenna configurations.

I try to avoid as much technical terminology as possible and stick to what is needed to make equipment choices that the average ham is likely to need to make in setting up a good but affordable (I borrowed that word from somewhere) HF station. In this and future CC HFs we will be covering some terms and concepts which commonly come up in articles, antenna discussions and advertisements. What's more, they are helpful in explaining how we can achieve the goals of reliable HF local and DX communication as we explore other antenna systems. Specifically, we want to know that the radio frequency current we are delivering to the antenna we have will be releasing its electromagnetic waves with as much power as possible and in the right direction. What we will cover here is particularly important where vertical antennas are considered.

The first thing we want an antenna to do is release the greatest possible percentage of the power your transmitter and feedline is delivering to it by radiating that energy from the actual antenna as useful electromagnetic waves. The amount radiated over amount delivered the is called the efficiency. Unfortunately it is never possible for this to reach 100% because there are always some losses. The feedline loss is usually small, particularly when using open parallel line or high quality coax, lower frequencies and short runs (see the CCHFs in May and June 2009*). The other major loss is when part of the electrical and magnetic fields, those generated by the radio frequency current electrons zipping up and down the vertical element, must traverse materials with low conductivity (see February's CC HF*). These are most often the soil under a ground mounted or low vertical antenna or maybe a close-by tree, or "lossy" traps and these losses will be in the form of heat. These are wasted as far as your antenna's ability to communicate is concerned. In the form of an equation "efficiency" is the ratio of the radiation resistance of an antenna to the total resistance of the antenna system. The "radiation resistance" the useful part and is the assumed resistance that when put into the power formula ($P=I^2R$) would give the power radiated from an antenna as electromagnetic waves.

The importance of this is that the factors lowering the efficiency of an antenna, particularly poor soil conductivity, can be modified by supplying a more conductive (less resistive) return path. Understanding these concepts will help prepare one for understanding how it is that statements often made in regard to verticals such as "no radials necessary" and "Without radials, a vertical antenna can still radiate, but not very well" are misleading. I hope to show how these statements can both be true if you understand the properties of the many kinds of vertical antennas and how they are mounted.

Next we will deal with several terms which describe some more concepts that are important in judging the performance of various antenna configurations.

**you can find these PRC Bulletins on our website at www.W6KA.net, courtesy of the editor, John Minger, AC6VV and our webmaster Graham Bothwell, AF6QR*

Crown City HF #71

Vertical Antennas (7): Basics (3) Gain and Decibel

We have been looking at vertical antennas and the basic antenna design concepts that are important for evaluating the performance of various configurations in order to better decide which, if any, vertical antenna would be best for our own use. Last month in the Bulletin* we covered antenna efficiency. We learned that under certain circumstances because of the importance of ground losses in reducing the effectiveness of some vertical antennas they fail to deliver signals (DX) around the world. So what else will help us understand these interesting antennas?

Probably next thing we should explore is **antenna gain,** which refers to the ability of an antenna to concentrate transmitted radio waves in the direction of the intended receiving station. The gain of an antenna is defined as the ratio of the power gain to that of a reference radiator and the reference antenna needs to be specified. Although usually this is a theoretical (imaginary) lossless "isotropic radiator" which is a single point in space radiating equally in all directions. Another standard reference antenna is the 100% efficient ½ wavelength (λ) dipole. This antenna's efficiency cannot quite be reached in the real world but can be pretty closely approximated under ideal conditions (low loss materials, high and in the clear). This relative increased (or decreased) radiation is measured in many directions and plotted as a radiation pattern. However the **gain** of an antenna is usually given as that which occurs in the direction of maximum radiation. Antenna test ranges using signal strength measurements are plotted along at least two slices called *principal planes* (more in next month's CCHF). The ratio of the reference radiator to the antenna being studied is generally given in decibels which are abbreviated as **dB**. When used in this context (measuring antennas) the abbreviations are **dBi** when the antenna is compared with an isotropic source. More commonly, in amateur radio discourse **dBd** is used where the comparison is made to the dipole described above. Since the dipole has a 2.14 dB gain over an isotropic antenna, and hams are often acquainted with dipoles, we tend to use dBd terminology, particularly in antenna advertisements. Decibels are important for hams to understand so we will digress a bit to explore decibels.

OK, so why do we use decibels instead of just saying something like the antenna "triples the effective power" or "increases the antenna power 300%"? Most of us are accustomed to linear units but dBs follow the generally unfamiliar logarithmic scale. So why not keep things simple and stick to what we know? There are a couple of reasons. Firstly, it is because our hearing just happens to function on a logarithmic scale. It turns out that in humans subjective sensation (in this case hearing the audio generated by radio transmissions) follows the logarithm of the intensity of the stimulus (Fetchner's Law)**. By using a base ten logarithmic scale, each dB represents a noticeable increase (or decrease) in signal strength. Also the use of logarithms makes it much easier to graphically represent a large range of values. If you must know the equation for calculating an antenna power gain in dBs it is: 10 times the log of the ratio of the output power to the input power. If you need to review some of your high school math, check out *"Common Logarithms: Base 10"* on the Internet at www.mathsisfun.com/algebra/ logarithms.html.

However, if you want to do it the easy way, to convert power gain ratios to dB, go to

www.rapidtables.com/electric/ decibel.htm .

Also when you multiply power ratios you add or subtract (power losses are negative numbers) which is supposed to make the math easier. Here are some examples which will help you understand decibels:

• The doubling (2X) of power is a dB ratio of 3. If we double that again (four times the power) we add 3+3 and get 6dB. If we double it again (now eight times the power) we need to add again (6 plus another 3) so we get 9 dB.

• When the numbers get bigger you can see the effects of the base 10 logarithm more clearly. For instance if the power ratio increases by ten times you have a 10 dB gain. A one hundred time increase in power is (10+10) 20dB.

Before we leave decibels, here are some final facts:

• Lest we forget that receiving a strong signal is just as important as sending a powerful one, the gain of an antenna is the same, in both directions. Also, one of your receiver's S-units represents roughly a 6db change (a 4X change).

• While we are discussing decibels, you should also know that the dB voltage ratio change is a 20 log calculation (not log 10, like power).

• A historical note: The "bel" part of decibel was named for Alexander Graham Bell.

So we have gotten through antenna gain and decibels. Next month we will cover radiation patterns.

* you can see these PRC Bulletins on our website at www.W6KA.net , courtesy of the editor, John Minger, AC6VV and our webmaster Graham Bothwell, AF6QR (http:// w6ka.net/ bulletin.php).

** http://en.wikipedia.org/wiki/Weber %E2% 80%93Fechner_law

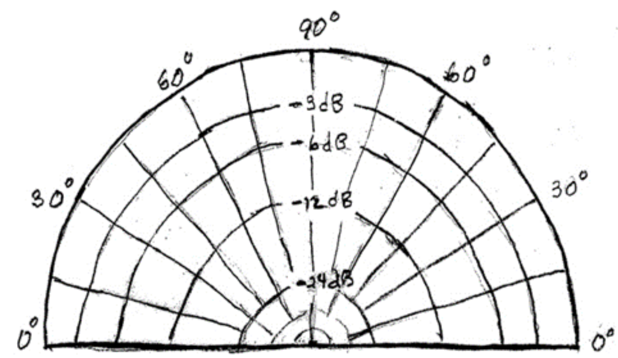
***we will get back to these different wave-length verticals and also beam antennas later.

Crown City HF #72

Vertical Antennas (8): Radiation Patterns (1)

In last month's CC HF article we explored antenna gain and then got off into decibels. We saw that antenna gain referred to the ability of an antenna to concentrate radio waves in a specific direction compared (as a power ratio) to a reference radiator. Often, in amateur radio, that is a dipole antenna. The gain of any given antenna is defined as the ratio of the power gain to that of a reference radiator in the some direction

An antenna's radiation pattern is shown by a graphic portrayal of its gain in different directions from its radiator in order to describe how the antenna sends (and receives) radio waves. An antenna radiates energy in all directions therefore to completely represent an antenna's radiation



pattern fully we would need a three dimensional depiction. However, for the sake of simplicity, two slices are usually used, called principal plane patterns. They are referred to as the azimuth plane pattern and the elevation plane pattern. The term azimuth refers to the horizontal and is theoretically circular from the perspective of looking straight down from right over the top of a vertical radiator. The elevation plane is as seen from the side of a vertical antenna. When used with vertical antennas these are often half circles and show the radiation angles from zero (parallel to ground) to 90 degrees (straight up). Sometimes for vertical antenna patterns only 90 degrees are shown because the radiation from an omnidirectional antenna is simply a mirror image of the other half. The figure to the left shows a common way of representing the grid. You can see concentric half circle lines labeled with minus dBs. These can be spaced by several different conventions called polar coordinate scales (e.g. linear, logarithmic and ARRL log). Each yields a somewhat different pattern, particularly in regard to the magnitude of minor radiation lobes. The ARRL log method is what hams see most and is a compromise between the other two. The radiation pattern, which may contain one or more lobes is made by “connecting the dots” based on signal strength measurements taken on an antenna test range. The outer half circle is usually chosen to pass through the point of maximum radiation. The numeric markings on the other (further in) concentric lines represent less power (negative dBs). There is no such lobular pattern shown on the grid depicted above…that will come later. Then we will see that a “smoothed” line which traces the power, in negative dBs compared to the maximum plotted, on many different radiation angles gives the graphic we call a directional plane pattern. Because we are discussing vertical antennas we will be looking only at elevation planes. Since azimuth plane radiation patterns will always be nearly circular so this plane does not help us to choose between the various antenna configurations. On the other hand they pass through the point of measured maximum radiation. However patterns in the elevation plane are quite helpful when trying to compare vertical antennas.

While discussing radiation planes it would be helpful to review polarization because some antenna gurus grumble about it causing “problems” with HF verticals. The worry is that radio communication can degraded when there is a polarization mismatch. That is because what we call radio waves contain two kinds of energy fields: electrical and magnetic. The direction of polarization is determined by the orientation of its transmitting antenna. By convention the field parallel to the electric field is called the E-plane. For a vertical antenna it is at right angles to the Earth's surface and that field is referred to as being vertically polarized. The magnetic field (M-plane) of a radio wave is at right angles to that of the electric field and for a vertical antenna is referred to as having horizontal polarization. It is well known that when vhf and uhf line-of-sight transmissions do not have these fields aligned between transmitter and receiving antennas there is a loss of signal strength due to the mismatched polarization effect. For radio waves in the HF bands, particularly when working over long distances, electromagnetic waves are subject to the effects of reflection, refraction and diffraction. These are the result of such things such as the ionosphere and rough terrain at points of skip off the earth and they distort the waves’ polarization. Thus in HF

DX communications matching antenna polarity is not of much importance.

Next month we will look at a few more antenna principles important to understanding vertical antennas.

Crown City HF #73

Vertical Antennas (9): Radiation Patterns (2)

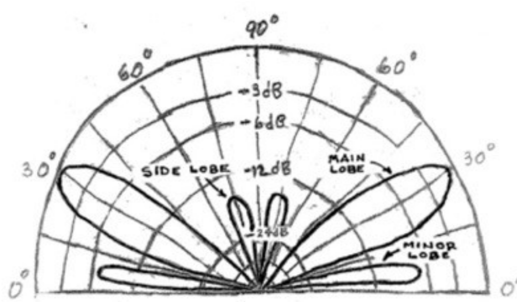
In last month's CCHF we began to look at antenna radiation patterns. However there are a few more antenna principles to go over before we apply them to vertical antennas. Let's look at those now.

Have a look back at the January 2014's CC HF at the drawing of a 1/4λ ground plane. The radiating element is the single vertical element. When transmitting, a **reactive near field** closely surrounds that element. Here the magnetic field is dominant. With ground mounted verticals, particularly those with their base within 1/4λ of earth, this field is responsible for the ground losses we discussed in the January, February and March 2014 CC HFs. This is the field that is responsible for reducing a vertical antenna's efficiency when it is close to lossy ground and dictates the use radials, a counterpoise, or a ground screen to reduce power losses due to the ground.

The **radiating near field** is a transitional zone between the near and far fields where the reactive fields fade while the radiating fields begin to dominate.

The far field region determines the antenna's radiation pattern which is what we will now discuss. We will focus on that because we are usually hoping that our antennas will communicate over long distances. **Radiation patterns** show the power emitted by an antenna as a graphic of angular directional power variation measured in an antenna's far field. The grid used to plot this was shown in the figure below. These patterns are described by several terms which are useful characteristics which help hams decide which vertical antenna they might want to buy or build.

In the figure below you can see the most often "named" radiation lobes which have been added to the blank elevation grid discussed in last month's CCHF. The largest lobes reaching the outer semicircle are the **main lobes** (or major lobes). The smaller lobes sticking up at 75 degrees are side lobes which are defined as any lobe in a direction other than that of intended radiation needed for the desired communication.



Presumably that direction (nearly straight up) is unlikely to be useful unless you are talking to the International Space Station. It is also a minor lobe, as are the two lobes at about 10 degrees. Any lobe other than a main lobe is considered a minor lobe.

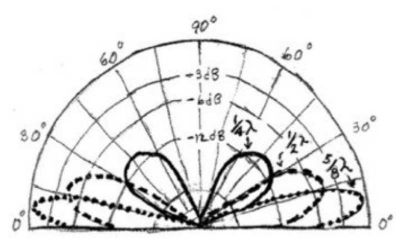
Another frequently used lobe designation with horizontal antennas (dipole, yagi, etc.) is a **back lobe** which is opposite to the main lobe. Since we are presently covering vertical antennas there is no opposite lobe. There are a few other popular antenna specifications also not appropriate to vertical antennas. **Beamwidth** is one. It is usually given as the "half-power" or 3dB "beamwidth, that is the number of degrees which contain half the radiated power. However, they don't apply now since we are discussing non-directional single element vertical antennas which radiate nearly equally in every direction in the azimuth plane. **Front-to-back ratio** is also not applicable to these antennas for the same reasons. These three parameters are particularly important with multi-element horizontal beams (to be discussed later in this CC HF series).

Crown City HF #74

Vertical Antennas (10): Different Wavelengths (1)

We have been looking almost entirely at the . 1/4λ (λ=wavelength) variety since we started studying verticals (see the "CC HFs" from Jan to March 2014). Now we are going to look at single band vertical antennas which are different fractions of a wavelength long.

But, for comparison, first let's go back to that vertical (monopole) "ground plane" antenna because of its simplicity. Remember the figure showing that antenna with a single radiating vertical element and four equally spaced elements horizontal labeled "quarter wave ground plane rods" (CC HF Dec. 2013*). The vertical element was 1/4λ long and the horizontal ones were 1/4λ long plus 2 -3% . It was also mentioned that this configuration worked efficiently as long as the antenna was elevated more than a quarter of a wavelength above ground. Because the size of the antennas and the height needed to prevent power robbing interaction with the ground go up dramatically as you go down in frequency, most HF vertical antennas are mounted on or near the ground. So, because most of us live in urban areas, like Pasadena, the soil's conductivity is so poor that we can't just drive in a ground rod and expect a good result. Rather a system of radials is needed.



Now we are going to look at two other popular lengths: 1/2λ and 5/8 λ. There are other lengths but, after 1/4λ, these are probably the most popular. They have the advantage of focusing their power output to give additional gain and are claimed to have less need for extensive radial systems. There is considerable debate about how important radials are, with many authorities noting that, although good results can be achieved without radials, their efficiency suffers significantly.

However there are some drawbacks to these longer antennas. Their size makes them more unwieldy (particularly on bands greater than 40 meters) and they often require guying. They also need some method of matching as feedpoint impedances are higher. Tuning is said to be more difficult and they are prone to detuning due to coupling if too close to the ground.

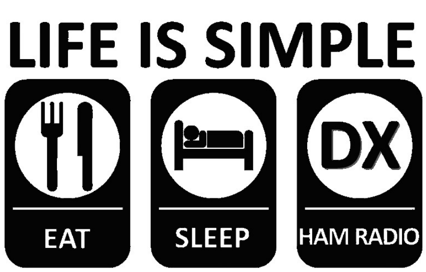
What makes them able to provide more gain? In last month's CC HF we looked at radiation patterns. The grid below shows the difference in major lobe radiation between 1/4, 1/2, and 5/8 λ configurations. You can see that not only is the radiation take-off angle smaller (lower) but the peak power lobe is narrowed (focused) and therefore greater as you go from 1/4 to 1/2 to 5/8 λ.

This means that those extra lengths give the better performance when working DX.

So how do these work? The 1/2 λ vertical is essentially a horizontal dipole turned 90 º and fed from (usually) below. At the ends of end fed dipoles the feedpoint impedance and voltage is high. This creates two problems: there must be a matching network which is rugged enough to handle the power level you plan to use. There begins to be a problem at levels as low as 100 watts. This characteristic makes them so they are, arguably, relatively immune from the power sapping effects of poorly conductive ground nearby. This point is debated with some authorities claiming that a 5/8 λ vertical may be truly called a “no radials needed” antenna. Others agree that it may work well without them but it performs better with radials. However, with or without radials, it will need to be kept outside with its high voltage areas well away from people, animals, anything flammable (including trees) or conductive due to shock, arcing and the associated fire risks.

This is worth it if you have limited or no space for a radial system and you can provide a place for the antenna where the safety precautions mentioned above can be met. You will have an antenna with a nice low radiation angle and a 0.45 dB gain over a dipole. That should get some good DX!

Next month we will look at the 5/8 λ vertical, a good DX antenna that does require radials.



Crown City HF #75

Vertical Antennas (11): Different Wavelengths (2)

Last month we started to look at vertical HF antennas longer than the basic 1/4 λ (wavelength) monopole. You saw from the radiation patterns that as the length of antenna increases the major radiation lobe lowers which improves DX capabilities. Also there are differences in feedpoint impedance and the requirement for radials. We will not cover all potential wavelength possibilities, some longer than the 5/8th and some shorter than 1/4th λ, but we will have looked at the most widely used verticals. Let’s look at one more such antenna, the 5/8th λ vertical.

So what does adding another 1/8th of a wave length do in regard to improving the antenna’s performance? Probably most importantly it lowers the angle of radiation to 16 degrees…ideal for DX. Also, the gain increases to almost 2dB over a dipole and about 3 dB (double the effective radiated power) over a 1/4 wave vertical.

Since every time we look at a longer vertical configuration we seem to get additional performance, you might wonder what would happen if we were to continue to have even longer ones.

There are those who believe that a 0.64 λ radiating element, which is slightly longer than the 5/8th λ (0.62λ), gives slightly more gain before additional lengthening causes the radiation pattern to break up and lose gain.

The 5/8th λ is one of those antennas that get called a *no radial antenna*. See below for more on that. So why doesn’t everyone use 5/8th λ verticals? Well… it is because they are bigger, more expensive, require good matching networks and not everyone wants to work DX.

One additional comment about the use of radials: although claims are made that some verticals do not require radials most of the non-commercial literature supports what was said in CCHF last month, that "… although good results can be achieved without radials, their efficiency suffers...". However there are a few things we can do to minimize those efficiency losses if restrictions limit your ability to provide any or very much in the way of a radial system. Next month we will look in more depth at this important aspect of vertical HF antennas.

Crown City HF #76

Vertical Antennas (11): Radials (3)

Last month I mentioned that there are some things that can be done if restrictions limit the ability to provide any, or very much, in the way of a radial system. First we can elevate the antenna. Back in the April 2014 Crown City HF the importance of ground losses was discussed. Well, if you raise a vertical antenna the effect of ground losses diminishes. Fortunately the attenuation of power output for verticals drops off most rapidly close to the soil so that most of the effect is gone by 1/4λ (λ=wavelength) and almost inconsequential above 1/2λ of elevation. We know that wavelength shortens as frequency goes up, that is why only a few (3-4) radials are needed for most vertical VHF and UHF antennas. On the other hand this little fact of physics also works against us the lower we get into the HF frequencies.

One alternative to radials is a "counterpoise". A counterpoise consists of one or more wires in a network insulated from the ground connected to one side of the feedline. Multiple wires are often used to give multiband performance and are of different length (see below for lengths). They are placed parallel to the soil surface in order to make a good capacitive connection acting as an indirectly connected ground. The better this connection (the more counterpoise wires and the closer to the earth) the greater antenna efficiency due to reduced ground current power losses. How radials differ from a counterpoise is somewhat blurred in discussions of this subject, but radials touch or are buried in the ground. A counterpoise does not. So why not use a counterpoise all the time. Well, a counterpoise is a compromise and should be used only where pavement, or roof mounting, or an apartment above the first floor make the use of ground level or buried radials impossible. That is because a counterpoise is not as efficient as good radials. Suggested length are: 160 meters 123 - 136 feet, 80 meters 65 - 70 feet, 40 meters 34.5 feet, 30 meters 24.3 feet, 20 meters 17.3 feet, 17 meters 13.5 feet, 15 meters 11.6 feet, 12 meters 9.8 feet and 10 meters 8.6 feet.

Another tool that can be used to fight ground losses when radials are not an option is the "capacitance hat". This can take many forms. Search www.google.com for "capacitance hat antenna", then click on "images". They may consist several spoke-like radiating rods, loops, cages or other. For vertical antennas they are most often placed at the top of the radiating element but can go lower down. The usual reason for using them is that they allow the use of a shorter main radiating element while maintaining resonance. Capacitance hats also help to increase the bandwidth of the vertical radiator. They usually need a loading coil at the antennas base. They are often used with HF mobile antennas in order to shorten impractically long antennas as low overhangs, wind loading and antenna bending problems do limit their utility. I bring them up because the “cap hat” does redistribute current in a vertical monopole antenna away from its base which helps reduce ground losses and improves efficiency.

I should briefly mention one other tool which is particularly useful to hams with a station location which precludes or limits the use of radials and/or is elevated so that a counterpoise is required. That is the use of an artificial RF ground (e.g. MFJ-931) whenever your situation requires a ground wire is approaching or longer than .λ on the highest frequencies you wish to use avoiding a high reactance. Not only does that improve antenna performance but also this piece of equipment can keep stray RF out of your station and its equipment. A good review of an artificial ground is at www.deltaalfa. com/ mfj-931.

Beginning next month we will look at some practical aspects of radials: how many? How long? Laid on the ground or buried? If buried, how deep? What kind of wire? Etc. .

Crown City HF #77

Vertical Antennas (12): Radials (4)

Now we will look at some of the practical questions about radials. For the last few months we have spent time on the questions such as “do I need radials” and if I can’t have them “what are some ways to mitigate the need for radials”. So now let’s imagine that you have lots of flat open unobstructed space near your first floor shack. Yes… such a place probably exists somewhere. Since each antenna site has its own variations most of us will need to use this scenario as a target. By knowing the ideal you will have a baseline from which can make plans that work for you.

Also, we will again use the **1/4λ (λ= wavelength) monopole mounted and fed with its base at ground level** as the basic antenna. Not only is it the simplest to homebrew (make yourself) and most inexpensive, but it benefits most form having a very good radial system. When it does it performs well. Another important point is that a ground rod closely attached to the base of a monopole does not contribute much to reduction of ground losses and unless you are living in a very high soil conductivity area (a salt marsh) its only real function is as a DC ground.

EFFICIENCY:

Speaking of performance one thing to get clear is that, particularly with vertical antennas (except vertical dipoles), the measurement of SWRs may be misleading… that is a low SWR does not guarantee an efficient antenna. Because of the problem of ground losses (which we discussed in Crown City HF, February 2014) there can be major power loss occurring even though there appears to be a good SWR. One tipoff that you are experiencing a misleading reading is when the SWR is *too good* and exists over an excessively large segment of the band. Vertical antennas are generally considered "noisy", so also be suspicious of the very "quiet" vertical. This may be a function of its inefficiency. If you don't have access to antenna modeling software, or a laboratory grade antenna test range, the quality (quantity, readability and distance) of on the air contacts is the only true test.

NUMBER OF RADIALS:

The number of radials needed is not so easy to determine! Almost every blog, book and magazine article I can find on the subject comes up with a different number. Most assume "average ground conductivity" so they should be somewhat similar…but here is a sampling of these diverse recommendations:

…only four ground radials is going to have a big negative impact

… …use 4, 8 or 16 radials

… …to get 80% efficiency you need 55 radials about 0.228λ long

...more radials equals higher efficiency … more short radials are generally better than a few long ones

… If only a few radials are going to be used, they need to be very long …more short radials are generally better than a few long ones

…15 radials cut at 1/4λ in #12 to #18 AWG are a prerequisite

…ground radials is probably 8, closer to 16, well you would do better with 32

…increasing the number of radials from 10 to 20 for example the improvement in signal strength is only 1/10th of an S-point.

…50-60 radials appears to be the amount required to get into the "flat" part of the efficiency curve for fair soil - diminishing returns

So how do we deal with this rather confusing information? Putting several studies together there is some general agreement that efficiency of ground level 1/4λ monopole verticals goes steeply up between 0 and ~10 radials. After that it improves more slowly between 10 and 20 and only a little between 20-30. After that there is some slight increase in signal, but it probably makes little real-ham radio-world difference. There is not room in our Bulletin for the tables and graphs to show this but

http://www.w0btu.com/Optimum_number_of_ground_radials_vs_radial_length.html

includes a very helpful table from the *ARRL ANTENNA BOOK 20th Edition, Chapter 3 (The Effects of the Earth), p. 3-10*.

Also the "gold standard" article on the subject (John O. Stanley, K4ERO/HC1, "Optimum, Ground Systems for Vertical Antennas",

QST, Dec 1976, pp 13-15) and can be found in the ARRL QST archive on the internet at http://www.arrl.org/arrlperiodicals- archive-search**. The article includes an important new concept, "the total length of radial wire installed". CC HF will get into what wire to use and what it costs in a later CCHF. Also laying down radials is "stoop labor", so we should strike a balance that avoids using more and longer radials that makes no practical difference to antenna performance.

Next month we will continue to look at radials.

*** You need to be an ARRL member to get access. If you happen have one, there is a* *reproduction of Stanley's article's table on page 6, chapter 5 of the ARRL's "Simple and Fun Antennas for Hams", 2002-08.*

Crown City HF #78

Vertical Antennas (13): Radials (5)

Last month we used the bottom fed 1/4λ (λ=wavelength) monopole with ground level or buried radials as the basic antenna in our discussion of radial length. We will stick with this same model for the reasons mentioned before as we look at radial length.

As with numbers of radials, the length is not easy to determine either! As we did before, let's look as some comments from ham journal articles, antenna books and the internet:

• *The rule of thumb is a little longer than 1/4λ*

• *Is the length of the radials critical? Well, actually not.*

• *If you put out some truly long radials like 1/2 wave or better you will start to realize some of the gain this antenna promises…*

• *If your property line prohibits running a full 1/4 wave radial out in each direction, don't worry if you can only achieve part of this length.*

• *… they [radials] can be shorter than 1/4λ*

• *Can the radials be longer than 1/4 wave [length]? Yes, they can. In fact, longer radials tend to give improved performance.*

• *Feel free to run your radials out to the limits of your property line.*

• *A 50 foot radial works better than a 33 foot radial, and a 100 foot radial works even better…*

• *Ground radials seldom need to be longer than two tenths of a wavelength regardless of the height of the antenna*

• *…you can run the radial out to your property line, and then bend it to complete the length of the run..*

• *Shorter radials do work. A maximum of .28 wave length seems to certainly be an upper limit for ground radial length.*

• *…[radial length] importance drops off quickly beyond 1/8th wavelength from the base of any vertical antenna, where the RF field density per unit area goes down sharply.*

• *Due to detuning of the ground, insulated wires laid on the ground tend to be electrically 1/4λ (wavelength) when the physical length is close to .28 wavelength.*

• *…ground laid radials designed to supplement ground return currents in the earth need not be resonant.*

So now that we have that straight we know exactly what to do…right. Well there are some lessons we can learn from these comments. Since the beginning of this series (CC HF January, February and March 2014) on vertical monopoles the we have heard about antenna efficiency reduction when they are close enough to interact with the earth. These ground losses can sap much of their radiated power unless managed (CC HF Feb. 2014) largely by elevation and/or good radials. Since we are discussing ground based 1/4λ monopole vertical antennas, a good radial system is what we need. That would be simple if everyone who would like to use this kind of antenna had large, flat symmetrical back yard and lots of money and time. In order to stay with practical constraints we must consider the cost of materials for the radials, and the time, effort and back pain (plus associated chiropractic fees) necessary to put in an extensive field of radials. Another consideration is that the precious "gain" we have been fighting for is the power directed toward the receiving station at an optimum radiation angle. What we are usually working to get is a readable signal a long way away (i.e. DX). It is generally thought that to double that distance requires a quadrupling of the useful signal power. So how does that all fit together?

Because of space limitations I have to refer you once more to the "gold standard" article that I referenced last month. It is the one by John O. Stanley, K4ERO/HC1, "Optimum, Ground Systems for Vertical Antennas", in QST, Dec 1976, pp 13-15. It can be also be found in the ARRL QST archive on the internet at http://www.arrl.org/arrlperiodicals-archive-search**. His Table 1 includes, as a Configuration Designation, "the total length of radial wire installed". As an example of staying within practical constraints let's look at couple examples using his data.

So his first example is a 16 radial with 0.10λ long radials. Looking at 40 meters the radial lengths would be 4 meters times 16 radials which is 64 meters (210 feet) of wire. Twenty meters would be half of that and eighty meters would be a whopping 420 feet of radials. Often a radial length of 0.25λ length is recommend, in which case the 16 radials would be ten meters long and that jumps the total radial length for a 20 meter monopole to an amazing 160 meters (525 feet). When you double that for 80 meters you can see how the low frequency bands complicate things.

There are a few more aspects of radials which CC HF will cover next month.

** You need to be an ARRL member to get access. If you happen have one, there is a reproduction of Stanley's article's table on page 6, chapter 5 of the ARRL's "Simple and Fun Antennas for Hams", 2002-08.

Crown City HF #79

Vertical Antennas (14): Radials (6) Relation to Ground

Let us continue exploring *"radials" for 1/4λ* ground level monopole base fed vertical antennas.* We have been using this "ground level" term to mean that the feedpoint is at the base of the radiating vertical element and is the take-off point of the radials at the ground's surface. These usually spread out like wheel spokes from the base of the 1/4λ vertical element. They are assumed to be parallel to the earth. Now we will look at some practical matters such as how should they be laid out.

First let us look at what exactly *ground level* means for radials…that is whether they should be placed on top of the top of the soil, just under it or even several feet above it.

Obviously it is *easier* to lay your radial wires on the surface. This is most important if they are being used for the lower frequency bands with longer radials. The goals are to keep the wires away from garden tools, unappreciative eyes and avoid tripping accidents. If you can prevent these problems you can probably save some time and energy this way. Just lay the wires down where you want them; then they will need to be fastened down. That is usually done with down with "sod staples" *(Google the term)*. If you are going to put your wire down on a grass lawn, mow so it is very short before laying out the wires and then avoid, after deploying them, mowing again as long as you can stand it. If you are planting new grass and want to keep cutting the grass over your radials, grasses such as Bermuda or St Augustine are suggested. Allegedly in a few weeks the wires will start to disappear into the grass and soil.

Many hams have a situation which makes surface radials problematic so their radials need to be buried. How does one do that?

The trenches can be dug with narrow trowel, a “V” shaped hoe or one of several other common garden tools. However if you plan to lay a lot of wire, your soil is hard and/or you have a back problem…consider viewing a nice video essay on YouTube about the the subject at

http://www.powerlinenoise.com/n0rq/how-to-bury-radials/ .

It recommends using a tool called the *Black & Decker LE750 Edgehog landscape edger/trencher* which can be set to make a narrow 1-1.5 inch deep trench. That depth is commonly recommended. Avoid placing deeper wires as the soil above radials very slightly saps power. More importantly the deeper you dig the more dirt you have to move in and out of the trenches. If you go to the above YouTube link there are several other nearby helpful videos.

Another way to accomplish the job of reducing ground loss under a low vertical (not exactly ground level) is to use an elevated radial system, otherwise called a **counterpoise**.

This kind of counterpoise consists of a network of wires, cables or a metal screen parallel to the ground under an antenna which is suspended anywhere from a few inches to several yards above the ground**. This type of counterpoise functions as one plate of a large capacitor with the conductive layers of the earth acting as the other. Capacitance increases (a good thing) with greater plate area and smaller plate spacing. However it is generally suggested that a counterpoise should be 8 or more feet above ground level to avoid injury to passersby. They can be mounted higher up, particularly for the lower frequency HF bands and will still function well because the capacitance varies as a function of wavelength.

Next month we will deal with a few last details such as what wire and pattern to use,

* λ = wavelength

***** A counterpoise can also take the form of a single wire, a few wires draped on a roof, a car or a few short elements mounted around and perpendicular to a vertical antenna.***

Crown City HF #80

Vertical Antennas (15): Radials (7) Wire and Pattern

Crown City HF in your Bulletin was used to publish an article on Operating Our [WPX] Contest Equipment. So now it is time to get back to vertical antennas and finish up our discussion on radials. So, as promised back in January, we will take a look at radial system construction details for a ground level vertical antenna.

So what do we use for the actual radials? The following is my summary of recommendations from several antenna books and internet sites which seem to generally agree:

- Radial wire should probably be # 14-16 AWG* bare hard drawn copper solid or copper-clad steel. The cost of 14-16 AWG copper-clad steel is about 10 cents/foot (see http://thewireman.com/antennap.html). Solid copper is about twice that. Insulated wire is also OK. It is a bit more expensive and may be very slightly less efficient as a radio frequency return path than uncoated wire.

• What about the pattern of the radials? Ideally they should be laid out as compass points with all wires equally distant from its neighbor on each side, straight, lined up exactly with another radial opposite it and all equally long. However that is often not possible because of terrain and unmovable obstacles. Despite these problems, most installations can be made to roughly approximate the ideal by a bit of bending and trimming of radials where necessary. Somewhat distorted radial patterns often work quite well. Fortunately, by far the most important part of the radial pattern is the part closest to the antenna's base…which is usually the easiest part to lay out following the classic arrangement. Also that fact dictates that if, for whatever reason, you have to choose between fewer longer radials versus more short ones, choose the latter.

• What about grounding the system? Despite all those radials, grounding of the coax braid close the radial take off points is still necessary and coax surge protection are still needed. Those subjects have been covered in Crown City HFs back in the Feb. 2010, Oct. and Nov. 2009 Bulletins.

• One final point is that there are many ways of securing radials at the base of a vertical antenna. They range all the way from just binding the radials and coax to the grounding rod to using a manufactured radial mounting plate. They take many forms (see google images "vertical antenna radial mounts")

Also it is highly recommended that at the base of these antennas a 1:1 balun or line isolating choke is used in the feedline (see CC HF Sept. 09).

Next month we will start to look at multiband verticals.

* AWG=American Wire Gauge

Crown City HF #81

Vertical Antennas (16): Multiband (1)

It is time now to move on to another kind of vertical: the *multiband*. In looking over recent copies of QST, CQ and several ham radio retail store web sites I was struck by how many manufacturers produce them (e.g. Butternut, Chameleon, Cushcraft, Comet, Diamond, DX Engineering, Hustler, GAP, hy-gain, Jet Stream, Maldol, MFJ, MP Antennas, S9 and Stepp IR). Most of these companies make several models. My reason for mentioning this is that (1) they must be pretty popular or they would not keep making them, and (2) there is no way I can discuss each one individually. So…I will start with some generalizations.

Choosing a multiband vertical HF antenna is complicated because there are so many basic design and hybrids. So before going into specific types I would like to suggest a few steps one should take before building or buying one:

• Use these CC HF articles on vertical antennas as a primer to get familiar with what is available so you can better understand the manufacturer's and dealer's descriptions of their products. You need to do a lot of reading between the lines of antenna ads. Remember that they are telling you the good stuff and leaving out the not so good while trying to sell you their product. Knowledge is power.*

- Decide what bands you want to use. The more bands you want, the more complex (harder to build/tune, expensive) the antenna will be.

- Read the available reviews in ham journals like QST and CQ. You will notice that there are not many antenna reviews, whereas they love to review transceivers and other ham goodies. I wonder why.

- Have a look at customer comments in places like *EHam* and *QRZ Forums*. They can be confusing since often contributors have contradicting views. Keep in mind that we are more likely to contribute to such sites when dissatisfied, but evidence of recurring problems and patterns of satisfaction do show up.

- When reading the manufacturer's claims about the need for radials or guys, gain and ease of re-tuning when changing bands, be a little skeptical.

- Ask around at our radio club for hams with various multiband verticals. Particularly seek their experience with building, tuning and durability.

- If you have boiled your choices down to a few antenna models, go online and look at their user manuals (they all have them). They give you some idea of building and tuning complexity.

- Figure out what you can afford. It is a generally accepted ham radio lore that the money spent on a really good antenna system is the most cost efficient way of improving your station. But multiband verticals range from a little over $100 to ten times that much…be realistic.

- Almost all of these antennas have additional costs: radial wires and fastening plates, tilt bases (useful in high wind areas and for tuning), guy kits, matching units, kits for additional bands, etc. They can add up, so include the ones you need in the price for each antenna before comparing costs.

- Assess the space requirement for each different antenna. Some have fairly long sideways protuberances (arms, capacitive hats, non-radial radials, etc.). Will it fit where you plan to put it?

Next month CC HF will begin looking at the different basic designs used to construct multiband verticals.

*Commonly attributed to **Sir Francis Bacon,** the expression "*ipsa scientia potestas est*" ('knowledge itself is power') occurs in Bacon's *Meditationes Sacrae* (1597).

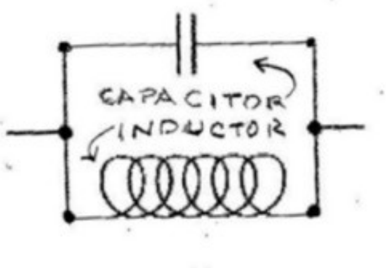
Crown City HF #82

Vertical Antennas (17): Multiband (2) L-C Trapped

So far we have been talking mostly about verticals with the architecture of 1/4 wave length (λ) monopole, so we will start with multiband antennas that are variations on that basic design. First let's look at the "L-C Trapped Vertical".

This is one of the most popular multiband vertical antennas. There are several manufacturers and they come in configurations which allow the use of many different bands. They are relatively low cost, easy to assemble and to tune.

These antennas use parallel tuned circuits called **LC circuits**, also known as resonant circuits, tuned circuits, tank circuits, resonators, or traps. Below is a circuit diagram of a parallel tuned circuit.



We could get sidetracked easily here discussing resonance, vectors, phase, reactance, impedance, etc. However, what you need to know is that, in this configuration and with the right components, this kind of circuit will largely block the passage of frequencies above its design frequency but not impede lower ones. Thus if you want 10 meters to be the highest frequency band on the lowest segment of your antenna then make a trap with the L and C values such that they choke off RF current above that band and place that trap 1/4λ* up from the base of the vertical radiator. That turns a much longer antenna into a 1/4 λ 10 meter monopole. It also adds inductance which provides physical shortening for the lower frequency bands' segments along the antenna above it. If you want also use this antenna for, let's say, 15, 20 and 40 meters you just add more of these "traps", starting with the next higher point being a trap that blocks frequencies above 15 meters, and so on for 20 and 40 meters. They are placed to create a shortened quarter wave antenna below each band's trap. To simplify things… think of it as one vertical monopole using tuned circuits, which turns itself magically into several different quarter wave antennas depending on the frequency you send it.

Once tuned, this antenna usually does not need an antenna tuner unless a lot of extra bandwidth is needed and usually only on 80 meters. It does need radials about 1/4λ long at the lowest frequency you plan to use. Hence tower mounting is difficult but roof and ground mounting are good options.

Sounds pretty good so far. Well nothing is perfect, particularly when it comes to vertical antennas. One problem is that any L-C trap has some resistance to current no matter the frequency. It arises in the wire used for the coils and is hard to get to below 0.5 dB per trap ("low loss"). It can be several times higher. When you have a five band antenna the antenna may have almost 3dB loss which reduces your radiated power almost in half.

Also, because the traps act like loading coils for each band above the first (closest to the antenna base), the antenna segments between traps must be shortened to maintain quarter wave resonance. The problem is that the greatest radiation occurs from the bottom of the antenna. And when it is shortened, for the reason just mentioned, the radiated energy requires a path clear of trees, houses, hills and the like. It is not too bad if you have a big open flat space well away from your home or the antenna can be mounted on your roof. Unfortunately many hams don't have these options.

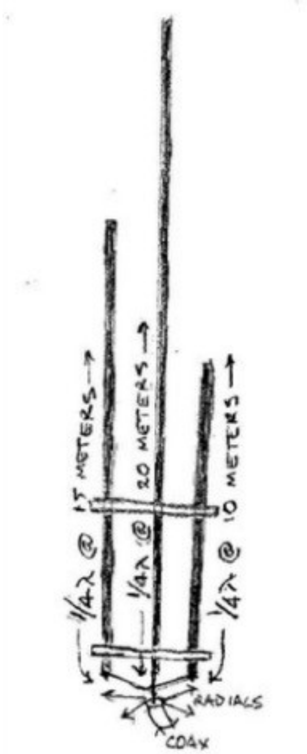
Despite some drawbacks L-C trapped vertical antennas are an attractive choice for the reasons mentioned in paragraph two above. Next month we will look at parallel element multiband vertical antennas.

* λ=wavelength

Crown City HF #83

Vertical Antennas (18): Multiband (3) Parallel Element

The parallel element multiband vertical is appealing for two reasons. It is easy to understand and not very hard to homebrew*. It is essentially several 1/4λ vertical antennas with parallel elements, bundled together ~7" apart (to avoid interaction), with their bases at ground level connected together and to the center conductor of the feedline coax and the other connected to a radial system (see figure below). There can be just one or several vertical radiators shown, depending on the bands to be used, However adding more elements , particularly for lower frequencies (longer), starts to make this antenna unwieldy, requiring guying.



It works on the same principal as described for the way a fan dipole works (see the January 2013 Crown City HF), that is the RF current flows differentially to the arm that is a . wavelength (resonant) for the frequency delivered to its bottom…hence "automatic" band switching. With good radials the bottom half of this antenna becomes a electrical mirror of the active upper half (see CC HF January 2014). The antenna is easy to tune with only one adjustment per band! These have the same radiation patterns and "gain" described for other 1/4λ*** verticals as described in that article.

These antennas are not commonly commercially available, but the good news is that one can be easily and inexpensively built. With a little hybridization (using a loading coil/whip on the 40 meter radiator for electrical shortening) and a few circularly placed aluminum tubes with stabilizing acrylic discs or strips a durable several band vertical can be constructed. The WA5BAR design is shown in ARRL's "Simple and Fun Antennas for Hams", 3rd edition chapter 5. Pages 8-11. That antenna can be simplified by limiting the number of bands covered and mounting only three elements for one's favorite bands. These can easily be mounted side by side along acrylic strips as shown in the figure above. An RF choke is needed on the coax near the antenna's base. This antenna does require a good radial system but that would not need to be extensive if it can be roof mounted (see CC HFs Oct. 2014 -Jan. 2015).

Next month we will look at stub systems for multi-band vertical antennas.

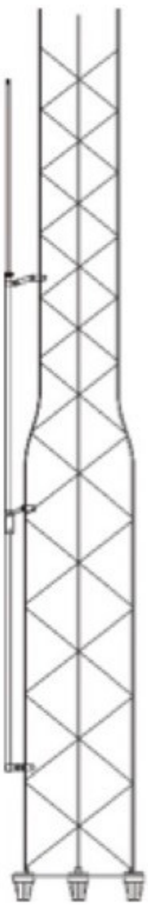
* make at home rather than buy commercially

*** λ=wavelength

Crown City HF #84

Vertical Antennas (19): Multiband (4) Stub Systems

There are several vertical antenna configurations which use “stubs”. You may have heard of stubs that are used in feed lines for matching purposes by providing capacitive or inductive reactance. They are usually a lengths of feedline connected to the conductors like “Ts” at one end and left open or short-circuited at the other.



On vertical antennas they take on a somewhat different form. The figure on the left shows how stubs are used on tower based antennas (see figure on the left). They work by isolating portions of the antenna to create resonant 1/4 λ* and 3/4 λ radiators on several bands. Last month CC HF featured parallel element vertical antennas which are somewhat similar in that they work on the same principle: the RF current flows differentially to the arm that is a 1/4 or 3/4λ from its bottom for the desired frequency. With this antenna, that would be the base of tower for each stub.

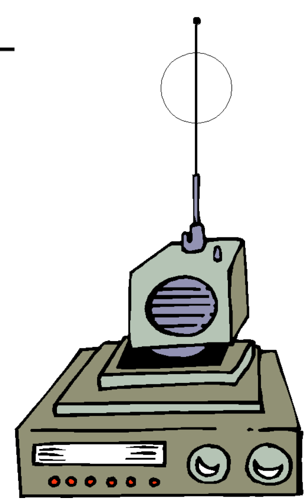
Vertical antennas based on a tower as a radiator are quite effective but they are relatively expensive and they need a foundation similar to other towers. Also, one of the reasons verticals are chosen by amateur radio operators is that they have spouses and/or neighbors who (sadly) don’t appreciate the geometric beauty of a stately antenna tower.

There are other slimmer vertical antennas that also use 1/4λ stubs at least for some of their additional band coverage without having to add somewhat lossy and expensive traps. These hybrids will be discussed later and the often add other matching components such as capacitive hats and end loading. These will be discussed in later CC HF articles.

I need to explain something now that we are getting into more complex vertical antennas. I mentioned earlier that there are many of these antennas for sale and also that there are few scientific reviews out there. Also you may have noticed that I have avoided naming manufacturers and model numbers. I do that because I am not trying to review and/or recommend specific verticals. That should be done by others who are qualified to do that. Rather, I have been trying to discuss the components that are used in multiband verticals. Earlier in this series we looked at many configurations, such as the 1/4 λ radiator mentioned above, and covered their performance characteristics. By looking back the recent CC HFs I hope you can recognize the components of a multiband you might consider buying and figure out how it actually works.

Next month we will move on to multiband vertical dipoles.

* λ = wavelength



Crown City HF #85

Vertical Antennas (19): Multiband (5) Stub Systems

In the December 2013 Crown City HF (#66) we looked at monoband vertical center fed dipoles. We saw that they had some useful characteristics: they require much less room than a horizontal dipole, are one of the "stealthiest" antennas and relatively easy to home brew. They also are one of the few vertical antennas which really are largely immune from ground losses as long as the lower dipole element is kept at least ten feet above ground.

However there are problems presented by this configuration that limit its popularity as a design component of multiband antennas. One is managing the pattern distortions caused the by its feedline, unless kept more than 45° away from the bottom arm. That problem can be solved by leading a coaxial cable up through hollow bottom dipole element to feed the middle of the antenna (see the CC HF article cited above). Another problem is that because these are 1/2 λ long, they are twice as long as the much more popular 1/4 λ designs that we have been reviewing in this section on vertical antennas. This is particularly true when the bands to be covered include longer wavelengths like forty meters and up. These would be 63 feet long…very unwieldily, windblown, and need good guying.

The length problem can be dealt with by traps, capacitive hats, right angling the lower element, stubs and matching networks. For instance a popular antenna using the vertical center fed dipole design is only 12 feet long!

Next month we will further explore multiband verticals which, despite unconventional feed points, function well because of matching networks.

Crown City HF #86

Vertical Antennas (20), Multiband (6) Base Fed Monopoles

When this column started looking at vertical antennas we explored single band vertical monopoles (CC HF December 2013-July 2014), in some depth: radiation patterns, ground losses, feedpoints, resonance, electrical length, etc. Those discussions were mostly focused on single band monopoles, but now we will look at how that configurations can serve many HF bands. There are, however, some real advantages to such antennas. If your spouse or neighbors who do not appreciate the beauty of a more complicated vertical they can easily be disguised as flagpoles or lighting standards. When made of metal they can even be used as the radiator. If not conductive they can support a vertical wire which is unlikely to be recognized as an antenna. If you have limited space this antenna probably will not work because these antennas require a good radial system (CC HF March 2014).

Such an antenna requires some compromises in order to be used on the different HF bands. Basically there are several ways to do that. One of the ways is to pick an antenna length which, although not exactly resonant on any of the bands to be used, the impedance mismatch is tolerable on several bands. Remember, we have often discussed the importance of having the transmitter, feedline impedance and antenna impedances nearly the same to avoid power robbing standing waves and high SWRs (see January-March 2011 CC HFs). Not only is power lost but when these conditions exist most transceivers and amplifiers either reduce power or turn themselves off when confronted with such conditions. It is easy to deal with the transmitter to coax match, 50 ohms to 50 ohms…but the mismatch will vary for each band and will give SWRs unacceptable to your equipment.

The ARRL antenna claims that “Anything can be made to radiate, if fed properly”. Often this can be done with a robust antenna tuner (CC HF March 2011) and/or reducing the transmitter’s power output.

Many of this type of vertical have their matching network at the base of the antenna. This reduces feedline mismatch losses importantly. A balun at the base of the antenna also increases the antenna system efficiency.

In early days there was a matching coil with tapping points that could bypass various portion along the coil for different bands. This was originally done by hand. More recently, particularly in mobile applications, the equivalent action is accomplished by a motorized remote adjustment of the inductor’s value. There are many matching circuit designs and remote tuning adjustment mechanisms now available. Any further exploration of them is beyond the intent and space available for these articles.

Published comparisons of the multiband monopole verticals with the multiband antennas we have been discussing in recent CC HFs are lacking. Statements made in ads contain manufacturer bias. The choice of a base fed monopole vertical often will be made based on esthetics.

Crown City HF #87

Bye-Bye Verticals; Hello Beams

Well…it is time to move on. I am burned out on vertical antennas! We could go on almost forever, dissecting the many hybrid multiband verticals on the market, but honestly, there is very little reliable (non-commercial) information available to report on. I have tried to go over the basic designs and components that make them up, so you have some idea what you are buying or making. So let’s move on to beam antennas.

What does “beam antenna” mean? Up until World War II began the standard amateur antennas were dipoles and mostly simple 1/4λ* verticals. We have discussed in previous CC HFs how a dipole slightly focuses the radiated power at right angles to its arms. Also we saw that by changing the feed point’s electrical location on vertical antennas we can lower your transmitted power’s angle of radiation and make it more likely to work DX stations. But today the way amateurs are able to focus their power more effectively is by using a “beam”, and the most commonly used such antenna is the “Yagi” antenna. Before we look further into this beam configuration, I would like to tell a little of the compelling tale of the origin of this antenna.

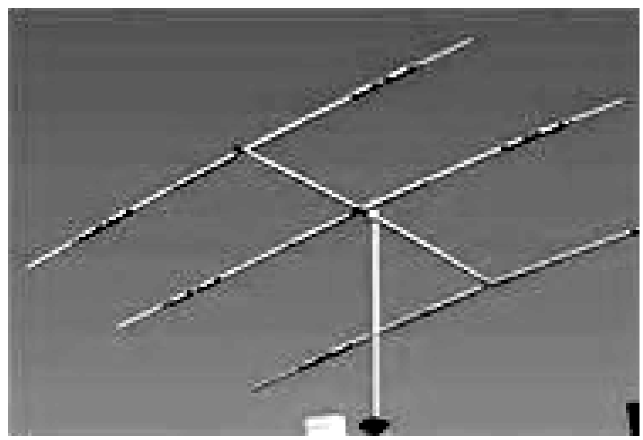
I have generally avoided dwelling on history in these Crown City HF articles, but because I have spent quite a few years in the world of academic university research, the story of this antenna appealed to me. Also, the term generally used by hams for this antenna seems a bit unfair to me: it is generally referred to by hams by the name of someone possibly not its true inventor.

The Yagi Antenna was “invented” in the laboratory of Dr. Hidetsugu Yagi, the electrical engineering Professor (like a Department chairman in USA) of Tohoku Imperial University, Japan, and his Assistant Professor, Dr. Shintaro Uda. Their results were first published in 1926. The actual work on their directional antenna was probably done by Uda using a method of measuring radio frequency signal strength newly discovered by Yagi. The value of this discovery was not appreciated in their own country. Because it was originally published only in Japanese, it was not until Allied engineers, who had heard lectures by Dr. Yagi in English before the war, began to use Yagi antennas in radar applications, that its great value was generally recognized. So we should probably call this the “Yagi-Uda” antenna. Some articles do use that term, but most hams just call it a Yagi. It still happens in academics today…the boss gets the glory.

So what is a Yagi antenna? Almost all hams at the level that these articles try to reach, Technicians or early Generals, already know and have seen them. It is that thing on the top of our Club’s tower on Field Day. It is probably the most common amateur radio HF station antenna. As shown, it consists of boom on which three elements (cross arms, see photo) are mounted. The one closest to the vertical mounting pole is one half wave length in a monoband Yagi, and is called the “driven” element. It is connected to the system’s feedline. One of the elements is slightly shorter than the driven element, and the other is slightly longer. The shorter one is called the “director” and the longer one is the “reflector”. There are often additional elements, usually directors. Any element other than the driven element is called a “parasitic” element. As pictured, each element carries loading coils to give it triband capability. The antenna does not increase the total power output of the transmitted signal, rather it guides and concentrates it in the direction of the intended receiver by steering radio frequency energy away from (sides and back) where it does little good. Fortunately it also improves the intended incoming signal and attenuates potentially interfering signals from unwanted directions. Huell Howser would say “That’s amazing!”

The way Yagis work is interesting, and their many configurations are complicated. We will explore these in future CC HFs

*λ=wavelength



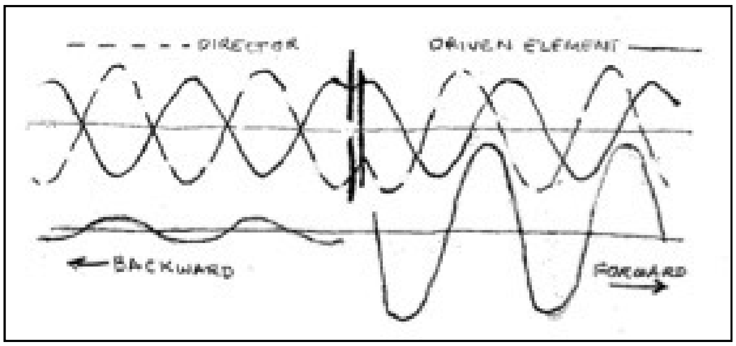
Crown City HF #88

How Do Yagis Work?

While researching how Yagis work I came across an engrossing article on “How Antennas work” http:// www.arrl.org/files/file/Technology/tis/Why%20an %20Antenna%20Radiates.pdf. It is somewhat technical, something I have tried to keep at the “necessary to know” level in these CC HFs. However, with all the reading I have done for the CC HFs that I have written about antennas, I have always had the feeling that the magic of transmitting “radio waves” using antennas still escaped me. This article, written by Kenneth MacLeish, W7TX, appeared in November 1992 QST. I reference it for those of you who are curious about this bit of the physics of electromagnetism so critical to radio transmission. The paper is actually understandable if you stick with it. It explains the role of concepts such as phases, phase lag, out-of-phase, vectors (E and B), Lorentz’ force law, coulomb field, magnetic field, radiation field and the induction field. If nothing else the article gives one an understanding of the complexity of the phenomenon that allows us to communicate all the way across the Solar System! Also it will show you why I am not able to give you a comprehensive commentary here on “How Yagis Work”; rather we will stick to concepts that are helpful for a ham to know in order to make decisions about buying or building one.

Last month we learned that the Yagi-Uda “beam” (Yagi for short) antenna allows us to redirect power more in a desired direction. Also the general description of the elements and locations were covered. So this month let us explore why the driven element is ½ λ* long, the reflector slightly longer and directors are progressively shorter? Well, it is because of the physical characteristics of the elements. By making the parasitic element not quite resonant but somewhat shorter or longer than λ/2 (plus or minus about 5%) the phase of the element's current with respect to its excitation from the driven element is modified. If the correct lengths and spacing are used the radiated fields all emerging in a forward direction from the antenna with their phase shifted so that they are additive, while those traveling backward nearly cancel each other. The result is an antenna with most of its radiation and reception going forward but little from the sides and back.

See the figure which demonstrates the phase interaction of a two element (director and driven) Yagi. The bottom horizontal line and superimposed waveforms show that effect on forward and backward power magnitude. Reflectors work in a similar fashion.



There are multiple variations in design. Probably the most common in use for ham radio HF uses one radiating element, one director and one reflector. The usual variation on that is the addition of additional directors.

Although in the early development of the antennas trial and error was used, today computer design can control multiple factors to tailor forward gain, front to back ratio, beam width, etc. (see CC HF Gain and Decibels May 2014 and Radiation Patterns, June 2014) Because changing any one of several of a Yagi’s specifications will alter more than one aspect of the radiation pattern, computer modeling has been a big advance.

Next month CC HF will begin to look at different Yagi designs. .

** λ=wavelength*

Crown City HF #89

Yagi-Uda Antennas (2) - The two-element Yagi

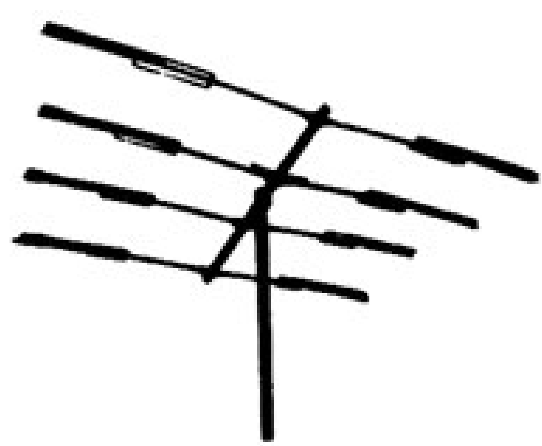
As we saw in last month's CC HF, a Yagi antenna consists at least 2 elements, one of which is a dipole which is connected at its center point to the feedline from your transceiver. That one is called the driven element. In a single band design it is of a length which resonates on the band for which it is to be used (we will discuss multiband Yagis in later CC HFs). In the vast majority of these antennas used by hams there is just one driven element a ½ λ* in length. The feed point is at the center and its impedance varies from 10 ohms to around 60 ohms, depending upon the number of elements and their spacing. This often requires some form of matching network which will also be covered later. The importance of matching is discussed in March 2010 CC HF.

The second element in a 2 element Yagi, can be slightly longer and is called a reflector. It might also be shorter in which case it is called a director. A reflector concentrates RF energy back toward the driven element (the front of the antenna) and the director does the opposite. Elements are most often attached to a boom at their center points but can be suspended by insulated guys to poles or trees. The latter arrangement prevents rotation which is an important advantage on bands with frequencies higher than 14 MHz where smaller physical size make changing directionality easier so that using a rotor is universal. Sometimes used on 40 meters, its size, cost and wind loading start to make such antennas less attractive to most hams.

The 2 element rotating Yagi is a quite good antenna although it is not often used much. At an element spacing of about 0.2λ* the input impedance is close to 50 ohms so matching is unnecessary or simple. It is light weight with little wind loading. Often a rather inexpensive a TV antenna rotor and/or tower will often work well. Its front-to-back not as "good" as you get with more elements. But that loss of directivity lets you hear more stations answering your CQ off the back of the beam. The 2 element Yagi gives ~3.5x the focused forward power over a dipole while a 3 element gives an increase of ~5.5X increase. We will get into gain and dBs for Yagis later, but for now that means, very roughly, that a 2 element beam quadruples the focused power…not too bad. But, adding another element nearly doubles it again (again roughly). So having 3 elements seems to be worth it. I can't find a single manufactured two element Yagi beam in my QSTs, CQs or on line, but there are many 3 element Yagis offered for sale.

Next month we will look at three or more element monoband Yagis.

** λ=wavelength*



Crown City HF #90

Yagi-Uda Antennas (3): The Three, and More, Element Yagi (1)

Last month we looked at the two element beam Yagi, and I noted that it was a pretty good antenna yet most hams using horizontal Yagis used those with 3 or more. So let's see what adding that extra elements does for us. To see what happens we need to review a few concepts that we have covered in earlier Crown City HF (CC HF) installments and introduce some new ones that are helpful to understand when home brewing or buying a Yagi antenna. Although I will try to "keep it simple"*, we need to understand the parameters which are altered when elements are added to the two element beam. Along with power gain the other design goals we need to look at are radiation patterns, bandwidth, radiation resistance,matching and practical structural construction considerations*. The latter are the length of the boom and number, spacing, length and diameter of the elements.

The main reason to have more elements is to increase focus on the antenna's radiated power in the direction of the intended receiver. It is an oversimplification to equate increasing antenna gain with increasing the number of elements…although it is usually true. However a linked determinant is the boom length. Longer booms are given more elements because it is then relatively easier to reach other desired performance goals.

Looking at horizontal azimuthal radiation patterns probably is the best way to starting to show the effects of adding an additional element. These drawings represent theoretical antennas designed using compromises often made in order to design an "antenna" which is optimal for amateur radio use. We will look more closely at these parameters next month.

2-Element Yagi Beam

3-Element Yagi Beam

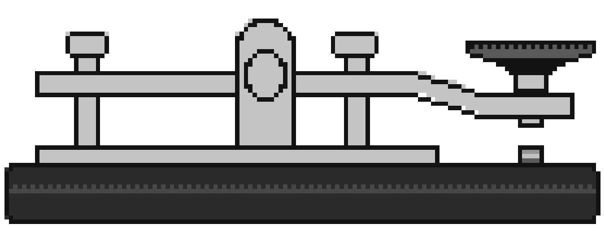
These azimuth views are representations (as if you were above looking straight down) of the amounts of major lobe radiation emanating from the center of the driven element (where the lines cross) outward with the front of the beam to the right. Let's review some of the components of these patterns.

First these drawings only show the major lobes; there are small side lobes that rob some of the forward directed power, but they are not significantly different between the two designs and quite weak. What is important is that the lobes to the right of the center crossing point differ in size with the 3-element beam being larger and the 2- element being considerably smaller. This gives "directionality'. In the vertical antennas, we have just finished looking at radiation that is spread equally in all horizontal directions (no directionality). With all Yagi beams there is concentration which limits the side and back radiation. Above you see that although the 2-element beam radiates disproportionately forward there is a smaller backward lobe . This demonstrates a beneficial "front-to-back ratio". Although the general rule is that the reflector should be 5% longer than the driven element, that varies a little based on the elements' spacing and diameter The spacing of the reflector to the driven element is between 0.1 and O.25 λ with maximum gain at about 1.5 λ but. The improved front-to-back ratio of the 3-element beam also offers better reception. Interfering signals from the rear are and sides are attenuated.

So what is the difference in forward gain? The patterns above are not designed to show that difference. Although the exact design can vary these figures some, in general the antenna gain is 4-5 decibels (100 watts effectively becomes 250-325 watts over a dipole) for a two element Yagi. Add a director element and the decibel gain is 7-7.5 for a three element configuration (100 watts becomes effectively 500-560 watts). Pretty good!

As mentioned above “things” happen when more directors are added. We will begin to explore those next month.

**These articles began back in 2009 when Peter Fogg, KA6RFF (SK) then president of our Club, suggested that I write a monthly article for the Bulletin “aimed at Technician Class hams and new Generals who are getting started using the HF bands”. He advised me to “keep it simple”. Antenna design is not simple. The ARRL’s “Antenna Book” has almost 1000 pages, of which almost 50 are on “Yagi Arrays”. Today the complexities are dealt with when the many variables are fed into computers programed to take these into consideration when designing antennas based on user requirements. In this column we will only be able to explore those variables superficially.*



Crown City HF #91

Yagi-Uda Antennas (4): The Three, and More, Element Yagi (3)

Last month we ended up looking at the effects on gain of adding elements to Yagi beam antennas. I mentioned that other things happen when more directors are added. So what are those “things”? They include bandwidth (good SWR across a band), impedance matching, effects on the radiation pattern (angle of radiation/ front to back ratio) and physical size.

What is “bandwidth” and what are the effects of adding, and of the placement, of parasitic elements (elements other than the driven element*)? It is defined as the frequency range between the frequencies at which the gain drops by one-half. When a Yagi antenna has more elements added the bandwidth narrows. That means that you are limited to using a smaller piece of a band or employing some matching technique which mitigates the power lost. There are several ways to do that matching and they will be discussed in a later Crown City HF.

Of interest, it is not only the tuning (lengthening or shorting) of the driven element that alters the feedpoint impedance. It is also the diameters and placement (spacing) of the reflectors. Directors are usually spaced between 0.05λ and 0.2 λ. Spacing below 0.2 λ decreases bandwidth and lowers feedpoint impedance below the optimal 50Ω level. Reflecting elements that are equally spaced and all the same length give greater gain but the bandwidth narrows. Bunching of the reflector, radiator and first director is used to lower SWR and increase front-to-back ratios. Widening the spacing increases bandwidth, but lowers gain at expense of bigger side radiation.

While we are on parasitic elements the obvious question is how many?

First we need to look at the physical problems introduced by element and boom length. Let's look at the dimensions of a popular commercially available 3 element (reflector, driven and director) 20 meter monoband horizontally polarized Yagi antenna. This antenna has almost certainly benefitted by computer modeling compromises. Its large well known manufacturer (to remain nameless), therefore, makes an antenna that is designed for amateur radio operators. We are interested here in its physical characteristics which are boom length 16'6"; longest element 37'; turning radius 20'. That is already a pretty large antenna.

The dimensions of the 4-element model of the same antenna are boom length 26 feet, longest element 36"6", turning radius 22"6". The 4-element beam on 20 meters, depending on expected weather, is sort of a quantum leap which requires a heavier duty rotor, tower and sometimes, adding guying. Of course, as the design band goes to shorter wave lengths, the size decreases, hence a similar 10 meter Yagi would be half the size of a 20 meter of similar design. A 3 element 40 meter design would have an almost twice the size of the 20 meter Yagi. That is prohibitively large for most hams. We will explore the importance of these physical dimensions again soon when we look at multiband antennas.

There is another issue which needs to be looked at while on this subject: feedpoint impedance matching for Yagi beams. We will do that next month.

** The first parasitic element added is usually a director because adding more reflectors adds very little more gain.*

Crown City HF #92

Yagi-Uda Antennas (5)
The Three, and More, Element Yagi
(4) Matching

For maximum transfer of power from the feedline to an antenna we need the feedline's impedance to closely match the antenna's feedpoint impedance. This is not a new concept for CC HF readers; it has come up often. Getting that to occur is referred to as "matching" and because Yagi antennas present with feedpoint impedances that vary from 10 to 60 ohms (Ω). In fact they are usually on the low side (8-30 Ω) of the ideal of 50 Ω, the same as most coax used by hams. Several suitable devices are available to do the matching and the most common are listed below.

The *quarter wave linear transformer* is one simple way. Assuming a feedpoint impedance of 25 Ω, two parallel i.e. connected together at both ends) of 75 Ω coax 1/4λ* long, and mounted between the feedline and feedpoint, will give a close match.

Another way is the *series-section transformer*. It involves inserting (in series) coax "matching section" of any characteristic impedance well away from that of feedline coax. The length depends on the frequency of use, the coax's impedance and velocity factor.**

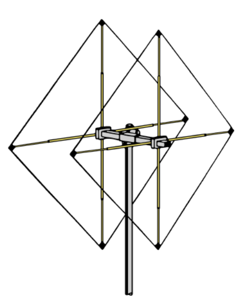
Another option is use of a *delta match*. An advantage of this and the next, method of Yagi matching, is that the 1/4λ driven element is a continuous conductor and can be mounted directly to the metallic boom. If fed by a balanced feedline its two parallel conductors spread out in a V shape and the ends connected to the driven element at points equidistant form its center. The distance between those points is determined by appropriate formulas**. If an unbalanced feedline like coax is used a balun (see two paragraphs below) is needed between the delta match and coax.

This solution, called the *gamma match*, involves connecting the coax's braid to the center braid conductor to the 1/4λ driven element continuous conductor's center point. The center conductor of the coax is connected through a variable capacitor to one of its arms at a calculated distance from the center**.

The use of *baluns* was mentioned above and the subject has been discussed earlier in this CC HF series. They are used for going from unbalanced feedlines to a balanced antenna as noted above. Here they are employed for matching the often low Yagi feedpoint impedances to 50Ω coax. They come in different impedance matching ratios (1:1, 2:1, 4:1), operating frequency ranges, power ratings, and line isolation properties. A *current* type balun that will fit the impedance to be matched, the power of your transmitter and the architecture of your Yagi, is what you are looking for.

**λ=wavelength*

***The calculation for dimensions can be found in the ARRL Antenna Book in the chapter on "Coupling the Line to the Antenna".*



Crown City HF #92A

Yagi-Uda Antennas (6) - Multiband (1)

In the last few CC HFs, while we have been looking at Yagi-Uda antennas, the discussion has been limited to monoband antennas.

Now we will move to multiband Yagis and because the three element trapped Yagi is far and away the most popular HF amateur radio beam, we will spend most of our time focusing on that variety. But a few words need to be said about stacked three element monoband beams on three different bands as another way to go. Stacked means on one tower with all antennas mounted on the same mast.

You could put up the three antennas on separate towers and avoid some electromagnetic interaction and wind loading considerations. However, it is not done very often. You do see it in pictures in ham magazine antenna issues showing DX award chasers and contesting clubs antenna farms. But they are few and far between. Why? Well, you need a large open area on your property, a lot more coax and there is the cost of two extra towers and rotors.

So why would anyone want to put up, say, three single band antennas rather than one "tribander"*. Remember earlier, when CC HF covered monoband Yagis, that there are multiple factors that go into today's computerized design characteristics. Hence compromises need to be made even when designing when only for one band. Well a multiband beam is even more complicated. Spacing (element interaction) and traps two (slightly lossy, on each side of each of three elements) cause a small decrease in gain and poorer front-to-back ratio.

These articles are meant to be for new Generals, or Technician class, hams who are about to upgrade and want to know what to in the way of building an HF station. We have covered less expensive and more "stealthy" antenna such as dipoles and verticals which can be a good way to start. But if you really want to experience HF over several of the higher frequency bands (where the DX largely lives) and can manage the extra cost, aesthetics and have a place to put it, a triband beam is the way to go. Be aware that because they are directional a beam antenna requires a rotor and unless you have an easy roof mount, some kind if tower. Also, remember that because of antenna size considerations you will need another antenna or so for 7 MHz and below.

**another name for a three band Yagi, usually for 10, 15 and 20 meters*

Crown City HF #93

Yagi-Uda Antennas (7): Multiband (2)

We mentioned last month that stacked monoband Yagi's were a way to get a little more "power", bandwidth and better front-to-back ratio over several of the higher HF frequencies than single multbanders. For most hams there is a better alternative: the triband trapped Yagi.

OK…let's see what basic designs are available.

The most common use trapped elements to cover 10, 15 and 20 meters using 3 elements. Four traps are needed on each element (2 on each side of the boom). Sometimes two traps are included in a single assembly making it appear that there are fewer traps. Bandwidths are approximately 500 kHz on 10, 300 kHz on 15 and 200 on 20 meters, a bit less than monobanders. The traps work in the same way as was described in earlier CC HFs articles covering trapped dipoles and verticals and suffer similar small power losses. They also have a small risk of failure, particularly due to extreme weather. Design and manufacturing are critically important. Despite these shortcomings in practice, there is not much difference. It is hard to compare the available gain figures between manufacturers; so often they are not given in magazine ads and catalogs. In general these antennas have somewhere around 8 dB gain over a dipole (around 6x power amplification) and cost about $600. If you Google "hf yagi antenna reviews" you might get some help…but just as likely get confused. Building one from plans is possible but making traps is probably best left to the experts.

Crown City HF #94

Yagi-Uda Antennas (8) - Monoband (3) Stacked

In a previous CC HF I mentioned that stacking monoband Yagi's was another way to get a little more "power", bandwidth and better front-to-back ratio when compared to using several single multiband antennas for the higher HF bands (e.g. 10, 15 and 20 meters). Also we have learned that multiband trapped Yagis are a little lossy and suffer a bit from design compromises.

So how about just putting up three freestanding monoband beams on individual towers instead. Well, the problem is that because having to have two more separate monoband beams to give the band coverage of a tribander is expensive and requires more real estate. The increased expense over a monobander would also be the two additional rotators and towers. Each of the two extra rotators will cost about $300-$400 and each 40 ft tower from $700-$1500 plus mounting hardware and a base. Three monoband antennas will cost around $200 more than one triband yagi (~$700 vs.~$500).

So why not just "stack" monoband Yagi's, one for each band you want, on one mast and tower? Well, nothing is perfect. Stacking does only require one tower, one rotor, less real estate and gives no trap loss. The bad news is that when we put antennas too close together they "interact".

If that is the problem, why can't we just move the monoband Yagis farther apart? Well, there are both electromagnetic and mechanical considerations which must be balanced. Let us look at the electromagnetic issues first. It would take up too much space here to discuss the details of the interaction, but there is a good article on "Stacking Yagi Antennas" at http:// www.ifwtech.co.uk/g3sek/stacking/stacking2.htm with nice drawings which cover both the stacking of similar monoband antennas and different single band antennas. The concept of "capture" is explained and its importance in determining the spacing of stacked antennas.

A common configuration for stacking dissimilar monoband antennas is the "Christmas Tree". That means having the smallest (10 meter) beam at the top and the largest (40 meter) at the bottom. Ten-foot separation is one common recommendation. In order to avoid degrading an antenna's gain and pattern each beam's capture aperture should not overlap. However, because the smaller the antenna, the smaller the capture area. Hence others recommend only 7 feet separation between the 10 and 15 meter Yagis an 9 feet between the 15 and 20 meter antennas. G3SEK, the author of the internet article referenced above, says the right way to know what these distances should be is to"…run a computer model of the array…".

G3SEK also admonishes that stacking "…is very poor mechanically". It is easy to see that compared to using a triband beam, the wind load of three Yagis above a tower, with the spacing required, creates a lot of leverage on the single mast. Wind loading can cause failure of the mast, commonly bending it over just above the rotor in strong winds.

So, although you get some gain and radiation pattern improvement, it takes a lot of money, work (erecting it) and a favorable location (not windy) to beat a triband Yagi by stacking monoband Yagis.

Crown City HF #95

Cubical Quad Beams

The major competition for Uda- Yagis ("yagis") in the beam antenna arena is the cubical quad. You can't find an article about them which does not start out with the story of Clarence Moore, W9LZX, an Ecuadorian missionary. I don't want to break the chain!

In 1939 Moore developed (and named) the "quad" beam antenna because heavy coronal discharge was burning up the tips of the elements of his shortwave broadcast station's Yagi antenna due to the thin high Andean air. The description of this phenomenon from William Orr's, W6SAI, "All About Cubical Quad Antennas", (2nd Edition, 1970) is riveting. Their station, was located in Quito, Ecuador at 10,000 feet of elevation. It was operating on 25 meter AM shortwave and was beaming 10,000 watts back to the US.

Here is Orr's depiction: "Giant coronal discharges sprang full-blown from the tips of the driven element and directors, standing out in mid air and burning with a wicked hiss and crackle. The heavy industrial aluminum tubing used for elements of the doomed beam glowed with the heat of the arc and turned incandescent at the tips. Large molten chunks of aluminum dropped to the ground as the inexorable fire slowly consumed the antenna."

Most of us will not have to worry about that particular problem. So why might one consider using a quad beam instead of a Yagi? Well, only a few hams do. That is, US hams…as hams in other countries seem to like quad beams better than we do.

The cubical quad beam's development was dependent on the work done on loop antennas starting in the 1920s. Various shaped loops can be used (particularly delta or triangular) and they share similar performance. In this and later articles on quad beams we will stick to the configuration which uses four equal one-quarter wavelength (square) per side as it is the most popular. Also, we have previously covered loop antennas and here, and future articles on quad beams, we will be talking about arrays with at least two loops in the arrays.

There has been a long standing debate about whether quads slightly outperform Yagi arrays of equal boom length. The boom length is the more important gain determinant and we will be comparing beams with the same boom length.

Not too long ago a significant quad superiority was a widely accepted view. Even now a major manufacturer claims 1-2 dB more gain, better front-to-back ratio, greater side rejection, less QRN, lower radiation angle and greater efficiency at lower elevations. In some physical aspects there is no debate as quads do have less weight with today's materials and a shorter turning radius. However the truth and importance of the other clams is not so clear.

Crown City HF #96

Cubical Quad Beams - Quad vs Yagi

Last month's CC HF ended by relating the claimed advantages of the two element quad array over the three element Yagi beam: more gain, better front-to-back ratio, greater side rejection, less QRN, lower radiation angle, greater efficiency at lower elevations, less weight with today's materials and a shorter turning radius. If all this were true and really mattered why do we see hams using so many Yagis and so few quad arrays?

All you have to do is Google **Yagi vs Quad** and you get at least 15 references to this controversy*. As mentioned before, we will stick to contrasting the two element quad array with the three element Yagi beam (the usual comparison). Also, every major antenna book has a section on this too, so if you are thinking of making one yourself there is plenty to wade through. Here I will try to summarize the important points.

Right now we are only discussing monoband antennas of similar length booms, not multibanders. We will do that in later CC HFs.

So let's explore the claims of 1-2 dB improvement in gain. Apparently this idea (or myth?) has been around a long time…since the early 50s…almost as long as the quad beam itself. In the 1974 William Orr "Cubical Quad" book that I mentioned last month, he rates a two element Yagi at 5.5 dB, a two element quad at 7.3 dB, a three element Yagi at 7.7 dB and a three element quad was at 9.3 dB. He doesn't mention boom length and we know from earlier CC HFs that we now know that the length of the boom is the biggest factor determining gain for beams (number elements just happens to be greater on longer booms).

In recent times the figure most often given based on newer antenna modeling is no more than 1.5 dB gain. Some more current articles on this subject say that the difference is only one dB or less and that other factors are more important…such as height above ground and element spacing. In any case there is not much difference. Does this gain advantage actually matter when we want to work DX or break into a pile up? Probably not.

* The most comprehensive of these is 17 pages long: www.w8ji.com/quad_cubical_quad.htm

Crown City HF #97

Cubical Quad Beams - Quad vs Yagi (2)

In last month's CC HF we began looking at the reputed advantages of cubical quad over Yagi beams by looking at gain. We concluded that the quad gain was at best only slightly greater. Now what about other characteristics?

After slightly more forward gain, an improved front to back ratio (F/B)* and front to rear ratio (F/R)** are the next most often claimed advantage of quads over Yagis. These parameters vary as the signal moves across a desired band. And also they are a function of the antennas design (boom length, element number and spacing etc.). In general, however to get the extra forward power advantage from a quad there is a greater dB drop as one tunes to the band extremes than that which occurs with a Yagi.

Lighter weight and smaller turning radius make the quad somewhat easier to mount. This means that the rotor and tower need not be quite as robust and therefore less expensive.

The wires on a quad are susceptible to breakage which leads to the necessity to lower the antenna and favors using a tilt over or crank up. Quads also stick down below the boom and may require a higher mounting on the mast pole.

Originally cost favored quads, particularly multiband, when they were built of bamboo spreaders (arms). That is because there are no traps which are the expensive and heavy parts of a multiband Yagi. The problem was that weather often deteriorated the bamboo occasionally requiring replacement. Today spreaders are made of lighter weather resistant fiberglass which alleviate that problem. After recently exploring the internet, several amateur store catalogs and periodical magazines for the pricing of 10, 15 and 20 meter two element quads versus similar Yagi three element beams, it seems the cost differential today of the actual antenna is minimal. But, as mentioned above, the cost of the tower and rotor may be significantly less.

So it seems that there are other claims such as that the quad works better at low heights. Again, they are debated, but if there is a difference it is small. There are also several advantages to Yagis such as the greater ease of adding extra elements and boom length.

The philosopher Alfred Korzybski (July 3, 1879 - March 1, 1950) coined the phrase "A difference which makes no difference is no difference." I suggest that this observation may apply here.

**the ratio of forward power to power output directed 180° to the rear*

***the ratio of forward power to the average power from 90 to 270 degrees to the rear*

Crown City HF #98

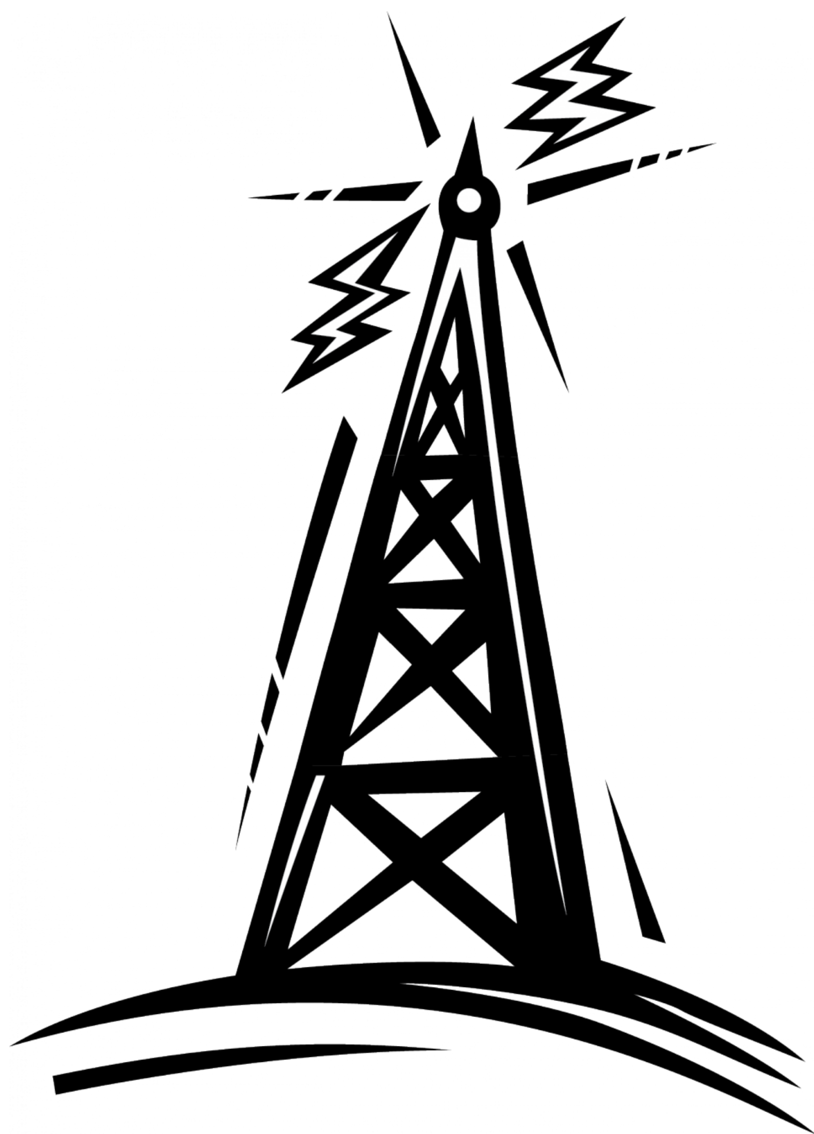
Cubical Quad Beams - Multiband Quads

Up to this point in most of our discussion of quad beams the focus was on monoband beams. However most hams have multiband beams, most often covering 10, 15 and 20 meters and, increasingly, they include the WARC bands: 30, 17 and 12 meters. One of the reasons sometimes given for starting out with a quad over a Yagi is that it is somewhat easier and cheaper to begin with a 20 meter monoband quad two element beam, and later add bands as you need them. To add higher frequency band loops all it takes is some more wire (#14 bare stranded copper is usually recommended), locate a plan showing wire length and placement, where and how to attach the wire to the spreaders, how to fashion matching stub(s) and how to feed the new driven element loops. It does not sound all that easy, but it avoids buying the expensive traps needed for a Yagi upgrade.

There is a very informative website (www.cubex.com) with several detailed essays on choosing, building and buying quads of all kinds. If you are a builder but don’t fancy tracking down the plans, finding and buying (or making) the parts, Cubex has kits available. Their two element 10, 15 and 20 meter kit sells for $550. Structural integrity of a quad beam can be a problem, probably more often than with Yagis, and is very important in climates where strong winds and/or icing occur. So it is usually worth starting with well-made parts and materials.

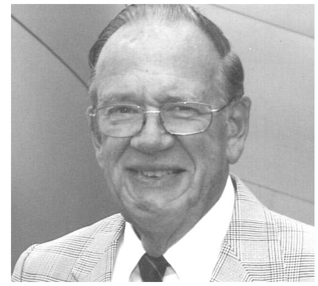
Feeding a multiband quad is a bit tricky. The driven elements can be fed from a single feedpoint by one 50Ω coax, but there are some additional interelement effects which reduce gain. These can be reduced significantly by feeding each band's driven element separately. To avoid having to run multiple coaxes all the way from the antenna's feedpoints to the RF output/input point in your shack, a common arrangement involves mounting a remotely controlled coax switch on the antenna itself.

Several years ago (2009) the late Peter Fogg KA6RJF (then president of our PRC) asked me to write a Bulletin column for our club's Technicians, to encourage upgrading and for new Generals, to help them build HF equipped shacks. I believe that I have pretty much fulfilled that request. Our Board has recognized that many of our new members are drawn to amateur radio by its great value in emergency communication. This is largely the domain of VHF and UHF with increasingly digital, computer and satellite technologies. So this will be the last of the CC HFs. I would hope that the space this column usually takes in our Bulletin can be quickly filled by articles written by one or more club members with more savvy than I have about those areas.



Crown City HF

About the author



Tom Berne (W6TAG) was a ham radio operator from the time he was a teenager, sharing that passion with his children, grandchildren, and friends. His interest in ham radio and public health and safety led him to coordinate disaster preparedness activities in Silver Lake and Royal Oaks.

He was tireless in the support of the Pasadena Radio Club, as club President, as an absolutely dependable officer and board member, as the spark plug who initiated our twice yearly contests and provided most of the equipment for them, and as a mentor and teacher who wrote his Crown City HF column to introduce new and upgrading hams to share the joys of HF ham radio he had known since 1952. His column ran in the *Pasadena Radio Club Bulletin* for the better part of ten years.

Dr. Thomas Van Cleave Berne M.D. was born on April 8, 1936, in Los Angeles, California, to Clarence J. Berne, M.D., and Esther Van Cleave Berne, Ph.D. He met his wife Cynthia in high school, proposed on the bank of the Seine in Paris, and they were happily married for 60 years.

He loved to spend time with his children, Susan, Katie, and John, and his grandchildren.

Like his father, Tom dedicated his life to surgery: teaching, patient care, and research. After completing undergraduate studies at Pomona College and USC, he graduated from USC Medical School in 1960 and then completed his surgical residency at the now Los Angeles County/USC Medical Center (LAC/USCMC).

He served as a Fellow in renal transplantation at Guys Hospital in London from 1966 to 1967. Upon his return, Tom established a renal transplant program and performed the first kidney transplant operation at LAC/USCMC. He joined the faculty of USC in 1967, rising to the rank of tenured Professor, and was instrumental in establishing the LAC/USCMC Level 1 Trauma Center.

He served on the staff of not only LAC/USCMC but also Good Samaritan Hospital and the USC Norris Cancer and University Hospitals. He served as president of several surgical societies, including the Pacific Coast Surgical and Western Surgical Associations, and was widely published. Through his mentorship, Tom inspired doctors now working throughout the world. With Cynthia, Tom loved traveling and visiting friends all around the world. He also enjoyed scuba diving, skiing, and USC football.

Tom passed away peacefully on Friday, October 27, 2017 at the age of 81. He was in good health until the end.

About the Editor

Bob Ross (WA6JLP) started in ham radio around1956 as a Novice and Technician (K0QPJ). While belonging to the college ham club and enjoying their Collins equipment, he built and used a 6m mobile transmitter and converter and well as several Heath Kits.

While relatively inactive during the family years, Bob and his wife, Susan (K0QPJ) are now participating with the Sierra Madre Emergency Communication Team (SMECT). Bob continues to tinker with the radio equipment including two 2m mobile units and a ham shack.

Other activities include So Calif Hudson Car Club President and Editor as well as the Editor of the national Hudson Historical Society magazine.

During his working years Bob was a project engineer and manager at Electro-Optical Systems in Pasadena. While there, he was fortunate to be the Project Engineer responsible for the design, fabrication and testing of the JPL solar panels for the Ranger Moon project as well as the Venus, Mercury and Mars encounters.

Notes

Early History of the Pasadena Radio Club

Circa1953 - Club formed at Farnsworth Park, Altadena with 7 members

1953 - Obtained W6KA club call from Tom Nykirk, W6KA, (SK) as two-letter call sign is ideal for Field Day and public relations.

1953 - Joined RACES

1959 - Club meetings at Altadena Sheriff Station

1959 - First annual club dinner of record

1960 - Belonged to Council of Radio Clubs.

1960 - Affiliated with ARRL with 15 members

1961 - Field Day at San Rafael Towers.

RACES Involvement was plentiful!

1962 - First Transmitter Hunt

1972 - Articles of Incorporation

1972-4 - Meetings at Republic Federal Savings, Altadena.

1974 - Meetings at Altadena Library

1976 - Meetings at Glendale Federal Savings, Pasadena.

1977 - Joined with Flint Peak repeater

1970s-80s - Many Special Communication Events: Caravans, bicycle/walk-a-thons

1980 - Fifty-two members

1984 - Meetings at Pasadena Red Cross Headquarters

1987 - Present bulletin developed

1985 - First club FCC license examination and Club patch.

1986 - Started Novice and Technician classes with examinations

1986 - Meetings at Pasadena Westminster Church

1989 - Club's first special-event QSL card

1989 - Installed and operated first ham station W6KA/mobile on American Red Cross Rose Parade Float.

1990 - Meetings at Kaiser Permanente