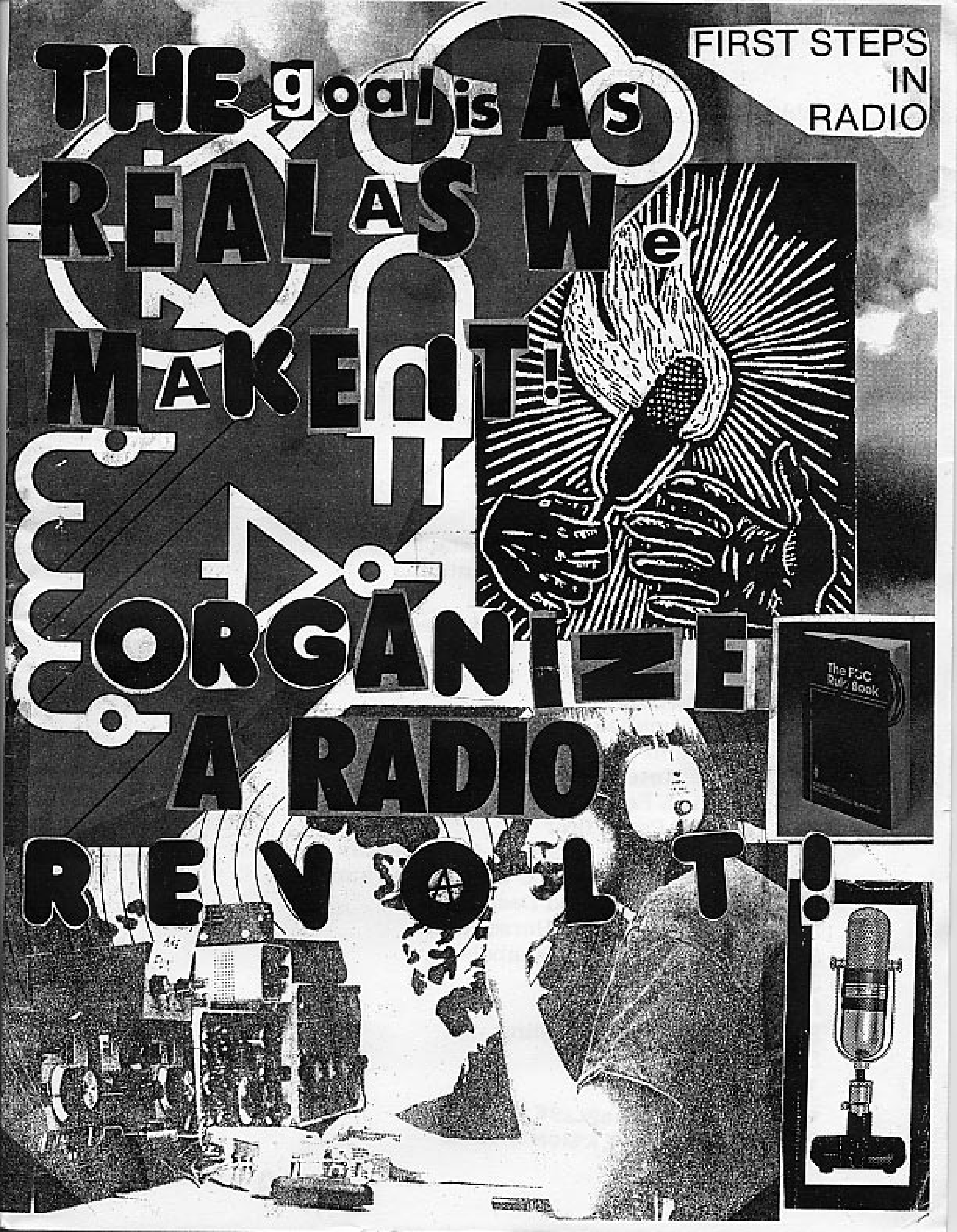

FIRST STEPS IN RADIO
THE goal is AS REAL AS WE MAKE IT!
ORGANIZE A RADIO REVOLT!
The FCC Rule Book

Table of Discontents

Printed on recycled paper

Intro

This is the second version of my free-radio tech zine; it has been fleshed out from its skeletal version. Its purpose is to be a useful centralization of all necessary information and a resource listing for creating an unlicensed radio station on the FM broadcast band in the U.S. My knowledge is mostly in radio physics and my experience is about half a decade of unlicensed, and some licensed, broadcasting in the US and Canada. This zine focuses on the radio technical aspects and touches briefly on studio setup but does not discuss movement history. There are a couple of great books out there about the history of the free radio movement including Seizing the Airwaves edited by Ron Sakolsky and Stephen Dunifer and Free Radio, Electronic Civil Disobedience by Larry Solely.

This zine should be read like a reference book; look up words in the glossary, re-read, and find someone to ask questions of or look at some of the electronics textbooks listed in the Recommended Reading in the back.

Radio is a unique medium. It requires only a minimal amount of money and organization to create a radio station and the money it does take can be offset by ingenuity and research. A radio transmitter can be used for a diverse and almost infinite number of purposes. It also requires very little to benefit from a radio broadcast; a cheap portable receiver with a decent antenna, a one time purchase, can be shared with numerous people and requires no literacy skills to appreciate. Being able to utilize the radio spectrum to share sound of one's own creation with one's community is a fundamental form of human communication.

Radio also has the potential to play a crucial role in revolutionary organizing. It could be a critical part of building a mass movement of resistance by empowering communities with the ability to come together and freely discuss the issues affecting them. Collective organization of a free radio station also has the potential to model the kind of society with which we would like to see Capitalist Imperialism replaced. Media in the hands of the dominant class is a powerful weapon against us. Radio in the hands of the oppressed is a powerful tool of resistance.

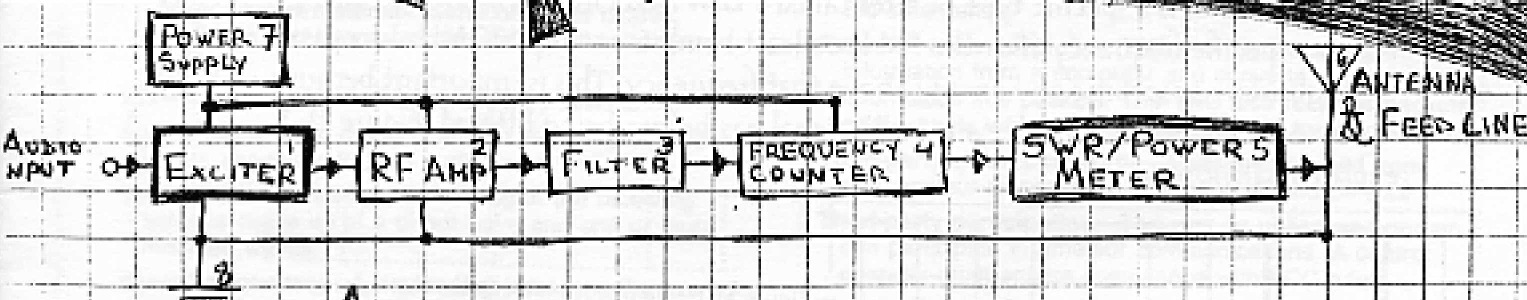
This zine is intended to further revolutionary organizing by providing both a concrete means of organizing resistance, and a way to build the infrastructure of a new society within the shell of the old. The information in this zine could spread like a wireless virus, and eat away at the infrastructure of capitalism. Combined with committed, militant, grassroots political organization working with a coherent program towards clear goals, radio helps us empower ourselves to deliver war to the oppressors and through struggle liberate ourselves.

Let's kick it 'til it breaks,

-Disruption

A Special Thanks goes out to: my Ham radio mentors who had no idea I'd use the knowledge in this way; The Pollinators Affinity Group for their dedication, commitment to struggle, a couple of great actions and telling me to chill when I needed it; MisCellaneous for the studio guide and trying hard to make it all work for longer than necessary time and time again; Spiv, despite our differences, for your dedication to the heartland, your creativity and vitality; The Free Radio Twin Cities Collective for finishing what I started and making my high school dream a reality; The core of the Wireless Virus Collective taking it all seriously and showing me what radical community radio can really be; The Prometheus Radio Project for putting countless time and effort into making Low Power FM a reality while in solidarity with unlicensed radio broadcasters. And all those people who opened up their homes and shared their equipment despite not being completely sure of what we were doing with it, or all the legal implications. Revolution can't happen without you all.

FREE RADIO HARDWARE



ALL THE EQUIPMENT NECESSARY TO RUN A RADIO STATION IS ASSEMBLED IN A SPECIFIC ORDER TO FORM A TRANSMISION LINE. COMPONENTS 2-5 and 8 BECOME MORE OR LESS NECESSARY DEPENDING ON THE SCALE OF THE STATION.

1 **EXCITER:** Generates a carrier signal at a specific frequency and modulates either the frequency (FM) or Amplitude (AM) of that signal with the given audio input.

A Carrier Signal is a standing wave that carries the audio informationto a radio receiver. It is also a form of alternating current. Every wave of any type has cycles, as explained in figure 4-13. The number of Cycles per Second (CPS) is the frequency of the carrier signal. This is usually measured in Hertz (Hz) or Megahertz (MHz) like 93.1 MHz (93.1fm) but, one Hz is exactly the same thing as one CPS. An FM carrier signal changes frequency slightly (by 1-2 KiloHertz, KHz, or so) with the frequency of the sound wave it is carrying. The exciter is the original source of the radio signal. Nothing else generates a signal, only modifies or displays some aspect of the signal that is passing through it.

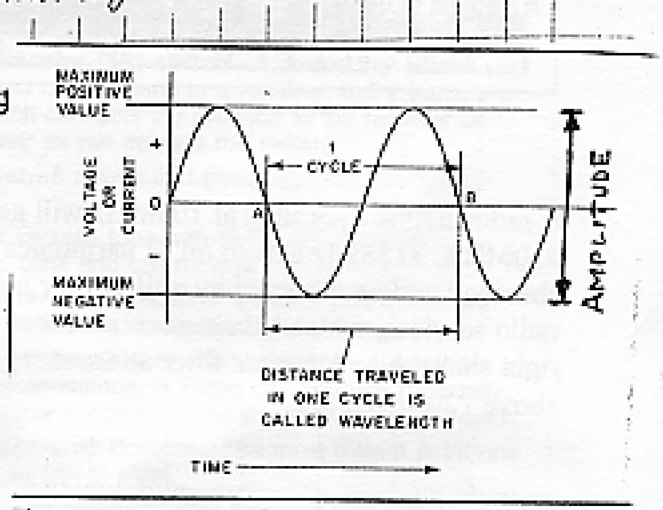


Figure 4-13—The sine wave is one way to show alternating current. Let's follow one cycle starting on line "0" at point A indicated near the center of the graph. The wave goes in a negative direction to its most negative point, then heads back up to zero, becomes more and more positive, reaches the positive peak, then goes back to zero again. This is one full cycle of alternating current

2 **RF AMP:** Boosts the Transmitter Power Output (TPO) of the modulated radio signal, allowing the signal to travel farther and penetrate insulated areas.

The power output of an exciter is pretty low, usually around 1 watt or ½ watt or maybe as low as 1/10 watt. That's enough to do what its supposed to do but not enough to send it more than ½ mile or so. Usually a Radiation Frequency (RF) Amplifier is the next element after the exciter. Together, the exciter and RF Amp constitute a Transmitter though sometimes the exciter itself is also called a transmitter. Quite frequently amplifiers are put in series (one after the other) to increase the (TPO). For example, a 1-Watt exciter will power a 5-Watt amplifier, which will in turn power a 40-Watt amplifier. The TPO, or the amount of power flowing through the transmission line before it gets to the antenna, is one key factor in how far the radio signal will travel but, there are several others which are equally important including type of antenna, antenna height, and the type of terrain in the broadcast area.

3 Filter: The Filter is a specific type of filter called a **Low Pass Filter**. It allows RF energy below a specific frequency (For the FM broadcast band its usually 120MHz) to pass through while absorbing any energy above that frequency. This is important because it cuts out Harmonics, which every radio signal has before being filtered. Figure 11-1 explains harmonics.

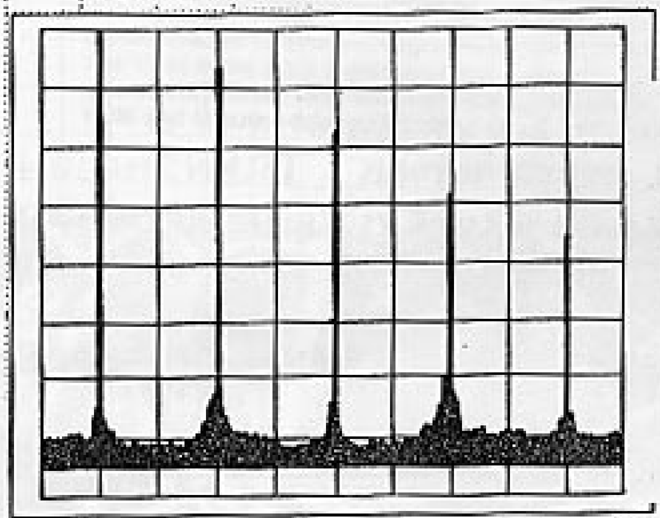
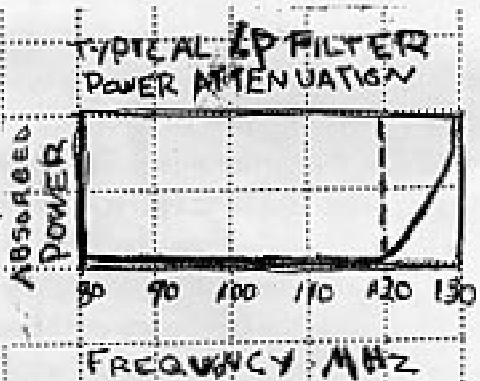


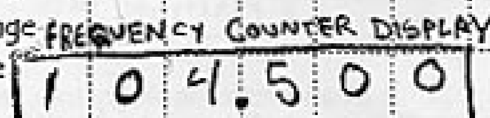
Figure 11-1—Harmonics are signals that appear at integral multiples of the resonant, or fundamental, frequency. This drawing represents a spectrum analyzer display screen, and shows a 2-MHz signal and some of its harmonics. A spectrum analyzer is an instrument that allows you to look at energy radiated over a wide range of frequencies. In this case, the analyzer is adjusted to display any RF energy between 1 MHz and 11 MHz. Each vertical line in the background grid denotes an increment of 1 MHz. The first thick black vertical "pip" represents energy from the fundamental signal of a 2-MHz oscillator. The next pip, two vertical divisions later, is the second harmonic at 4 MHz (twice the fundamental frequency). The pip at the center of the photo is the third harmonic at 6 MHz (three times the fundamental frequency). The second, third, fourth and fifth harmonics are displayed here.

A radio station operating at 105MHz will generate harmonics at 210MHZ, 315MHz and so on. If harmonics aren't attenuated (or absorbed and neutralized) by a filter they may interfere with other radio services, which brings government attention. The graph at right shows how a typical filter attenuates power at frequencies above 120 MHz.



4 FREQUENCY COUNTER: Displays the frequency of the radio signal, assures that you're on the right frequency and helps a lot with trouble shooting.

The reading on the frequency counter will usually change by several kilohertz while sound is coming through the transmitter. So, 104.500 MHz would go as high as 104.502 MHz or as low as 104.498 MHz. If the reading on your frequency counter is changing significantly more than those few kilohertz, if the center frequency changes over time, or there's a reading of all zeros on the counter, then there's a problem with the transmission line and you should turn off the power to all components and do some troubleshooting.



*See page 24 for a D.I.Y. Low-pass Filter Design. Also Many Exciters and Amplifiers have built-in Harmonic Suppression

5. SWR/Power Meter: This one is complicated, but important to understand in order to keep a radio station going. Lets start with the definition of SWR.

Standing Wave Ratio (SWR): A Relative comparison of the amount of signal travelling to the antenna from a transmitter (forward direction) and the amount of signal being reflected back to the transmitter from the antenna. If the forward voltage is twice as great as the reflected voltage the SWR is 2:1 (bad). SWR provides a relative measure of the impedance match between an antenna, feed line and transmitter.

Impedance is a specific kind of electrical resistance, and it relates to how well energy flows through a circuit. A radio station can be thought of as being one big circuit, though it is comprised of lots of individual components arranged in a specific order. In order for the RF energy to flow through each component without any power loss (which becomes damaging heat) every piece from the exciter to the cables to the antenna must have equal impedance, or be "impedance matched." When all pieces of the station are impedance matched the SWR is a perfect 1:1. The standard impedance for every part of the radio transmission line is 50 Ohms.

So, the SWR/Power meter will tell you how much power is reaching the antenna and give the ratio of that power which is being reflected back into the transmission line to complete the circuit. Though you might be able to get away without one for a while if you're using a preassembled and tested transmitter and antenna this is a critical piece of test equipment for long term maintenance of any transmission line, and absolutely necessary when using equipment that is home-built. A low SWR isn't only a desirable measure of an efficient station, its necessary to keep your equipment from being damaged by the heat that comes from having a high SWR. Transmitters and amplifiers are generally rated to handle a specific SWR for a specific amount of time if you're buying kits or prebuilt equipment. The higher your power level is, the lower your SWR must be, for example if your running at 25 watts you can get away with a SWR of 2:1 for a couple of hours, but not at several hundred watts. Usually when you're using the right equipment and you tune it properly you can get a SWR reading of 1:1. Cooling fans and heat-sinks are also an important part of a transmission line, as they help to dissipate the heat that does come from normal operation

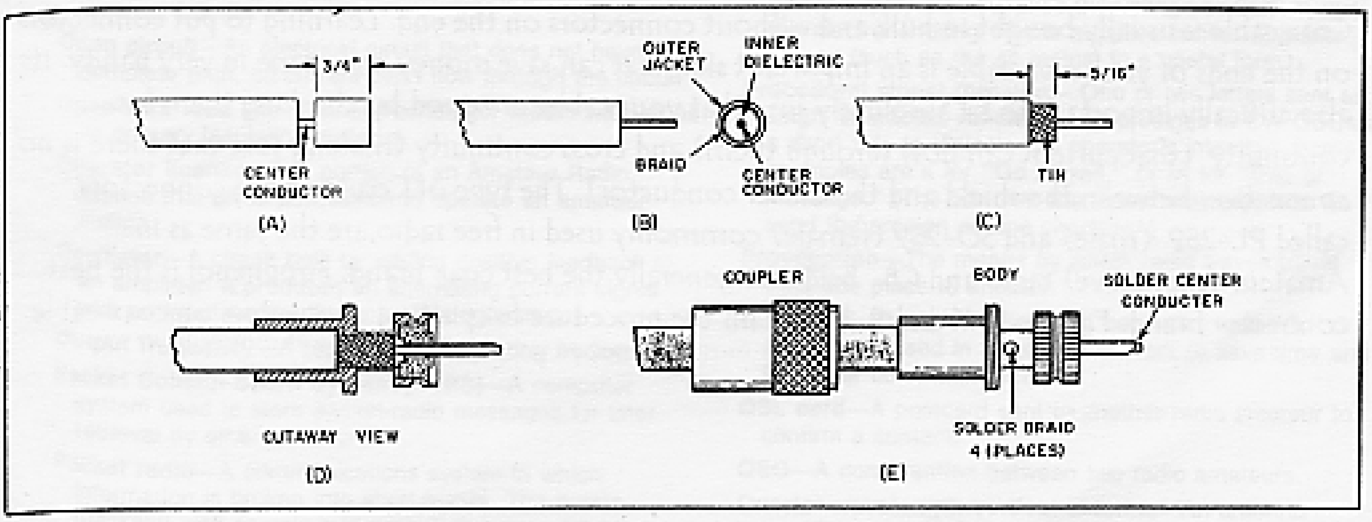


Figure 8-11—The PL-259, or UHF, connector is almost universal for amateur HF work, and is popular for equipment operating in the VHF range. Steps A through E illustrate how to install the connector properly.

6 **Antenna & Feed Line**: Feed line is the cable that carries the radio signal from the last component to the antenna, which radiates the signal off into space. The cable is a specific type called coaxial cable because of the way it's constructed. Like speaker wire, coaxial cable has two conductors, a positive and a negative. Unlike speaker cable "coax" as it's called has a positive conductor in the very center of the cable surrounded by insulation which is then surrounded by braided copper (the negative conductor) outside of which is another layer of insulation. Coax is constructed this way to minimize the amount of signal that is lost as it passes through the cable.

Specific types of coax must be used to connect each piece of equipment in the chain with the piece from output of the last component to the antenna usually being the longest. RG-8 coax is the standard, costs a little under $1/foot, comes in several varieties including RG-8X and RG-8U and is about as thick as your thumb. RG-58 is thinner, cheaper, and generally (but not always) less efficient cable. It is ok for shorter lengths (like between components of the transmission line, ideally no longer than a foot) and lower power levels. It is not good for long sections like the feed line. Each type of coax has a Velocity Factor (VF) rating (radio waves travel at 3×10^8 meters per second in a vacuum, negligibly slower in air and measurably slower in coax cable.) The VF rating tells you how fast the radio signal will travel through the cable. When the RF waves travel quickly more of the signal gets to the antenna before radiating out of the cable, which is considered power loss.

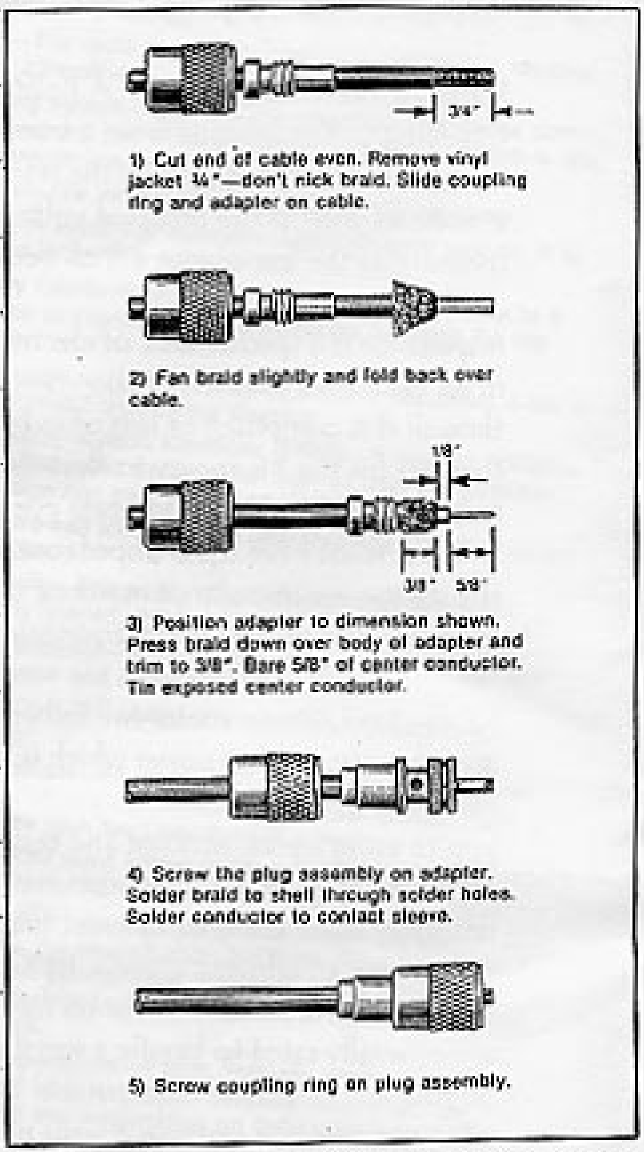


Figure 8-12—If you are using RG-58 or RG-59 with a PL-259 connector, you will need to use an adapter, as shown here. This material courtesy of Amphenol Electronic Components, RF Division, Bunker Ramo Corp.

Coax cable is usually bought in bulk and without connectors on the end. Learning to put connectors on the ends of your own cable is an important skill that can save money and come in very handy. Its also critically important to be absolutely sure that your cables are good by checking them for continuity (that current can flow through them) and cross continuity (making sure that there is no connection between the shield and the center conductor). The type of Coax and the connectors, called PL-259 (male) and SO-239 (female) commonly used in free radio are the same as in Amateur (shortwave) radio and CB. Belden is generally the best coax brand. Amphenol is the best connector brand. Figures 8-11 and 8-12 explain the procedure for putting connectors on coax cable.

An antenna radiates a radio signal like a radiator radiates heat: the farther away from the radiating source the less heat (or signal power) you have. In fact it's possible to burn yourself on a radiating antenna. It's a good idea to never touch the elements of a live antenna.

At FM frequencies the radio waves travel in a straight line until an obstacle is met. This is known as line of sight transmission. If the receiving antenna and transmitting antenna can "see" each other and the path distance is not too great to attenuate the signal, then the broadcast signal can be received. Radio signal strength is based on the inverse square law. Double the distance and the signal strength will be 1/4 of what it was.

Since FM broadcast transmissions are line of sight, the height of the antenna is very important. Increasing the height is more effective than doubling or tripling the power. Due to the curvature of the earth the higher the antenna the greater the distance to the horizon. Increased height will place the antenna above obstructions which otherwise would block the signal. Your antenna should be at least 40-50 feet above the ground. Count yourself lucky if you can site the antenna on a hill or a ten story building.

Imagine a light bulb on top of a tower—the higher the tower is above the ground, the further it will be seen it. The higher up your antenna is, the more receivers will be able to "see" it. The antenna's Height Above Average Terrain (HAAT) directly determines how far it can travel because the higher the antenna is the farther away the horizon.

An antenna is a completely passive part of the transmission line. It requires no power supply but it can play an equally important role in amplifying the signal as the amplifier. DIY antenna construction is a cheap way to build an antenna and amplify the signal strength. There is an almost infinite variety of antenna designs, but the important characteristics are DIRECTIVITY and POLARIZATION.

The Polarization of an antenna can be vertical, horizontal, or circular. Vertical polarization is the most common for FM broadcasting. Theoretically a vertically polarized signal is best received through a vertically polarized receiving antenna. In reality though, buildings, hills and other obstructions in urban areas bend the signal so much that you may find a case where a horizontally polarized antenna (which would be parallel to the ground) works better than a vertically polarized antenna (which would be perpendicular to the ground).

The figure below describes directivity.

In order to get a good SWR reading it is critically important that your antenna is tuned. This means that like a tuning fork for a musical instrument, the length of the elements must be related to the wavelength of the specific frequency it will operate on. Wavelength is usually symbolized by the Greek letter λ Lambda, and can be calculated by the following formula:

$$\frac{11811}{f} = \lambda$$

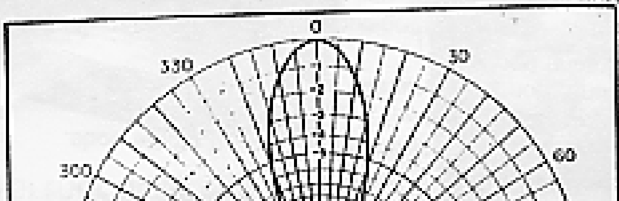
Where f is the frequency in MegaHertz and Lambda is the wavelength in inches.

ANTENNA RADIATION PATTERNS

For many applications, one desirable feature of an antenna is *directivity*—the ability to pick up signals from one direction while suppressing signals from other unwanted directions. Going hand-in-hand with directivity is *gain*. Gain is a measure of how much signal a given antenna will pick up as compared to that from another antenna, usually a dipole. An antenna that has directivity will also have gain, and vice versa. These two antenna properties are useful not only for picking up or receiving radio signals, but also for transmitting them. An antenna that has gain will effectively boost your transmitted energy in the favored direction while suppressing it in other directions.

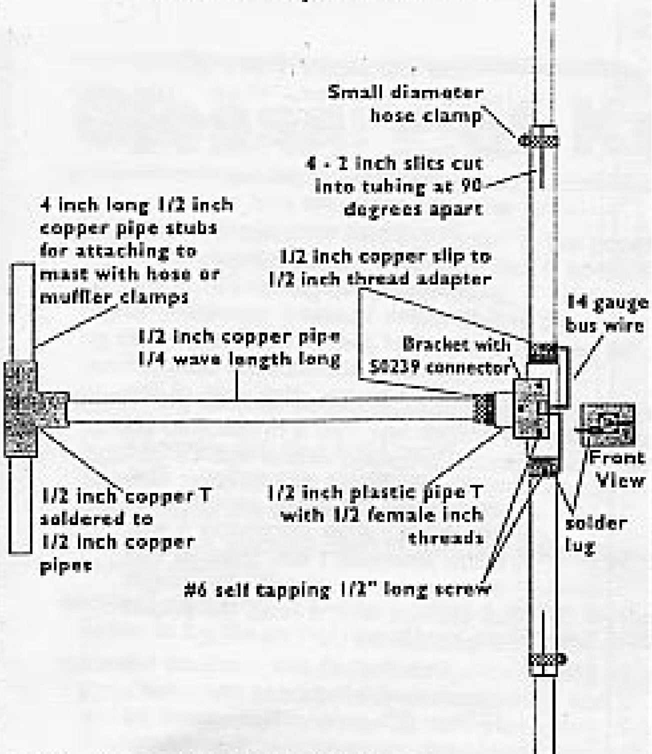
When you mention gain and directivity, most amateurs think of large antenna arrays made with many elements of aluminum tubing. But simple antennas made of wire can also be very effective, as illustrated in the accompanying antenna radiation pattern. This type of pattern indicates both the gain and the directivity of a specific antenna. The pattern shows the relative power received at a fixed distance from the antenna, as a function of the direction, when the antenna is used for transmitting. If the antenna is used for receiving, the pattern shows how the antenna responds to signals from various directions. (In the direction where the antenna has gain, the incoming signals will be enhanced, and the incoming signals will be suppressed in other directions.)

Directivity in a pattern is indicated by one or more long, thin lobes, called major lobes. An antenna with less directivity than this one would have lobes which were fatter; one with no directivity at all would have a pattern that was a perfect circle. The smaller lobes in a pattern are called minor lobes. Radiation patterns are one of the most useful tools in measuring antenna performance.



The calculated or theoretical radiation pattern of an extended double Zepp antenna. In its favored directions, this antenna exhibits a gain of approximately 2 decibels over a half-wave dipole. Such an antenna may be made with a horizontal wire hanging between two supports. (The wire is 1.28 wavelengths long at the operating frequency and should be fed at the center with open-wire line.) The axis of the wire is along the 90/270-degree line of the chart.

Tunable Dipole Antenna



1. Solder all copper pieces before attaching to the 1/2 inch plastic T.
2. The aluminum tubing is attached to the copper fitting with two self-tapping #6 screws, 1/2 inch long — one on each side.
3. The antenna element to which the ground side of the S0239 is attached always points downward.
4. Tune the antenna by adjusting the length of the adjustable elements. Length in inches is equal to 2952 divided by frequency in MHz.

But What if I Have Trouble?

INVERSE SQUARE LAW

$$\frac{1}{x^2}$$

$$\frac{1}{2^2} = \frac{1}{4} \Rightarrow \frac{1}{4^2} = \frac{1}{16}$$

$2 \times 2 = 4$

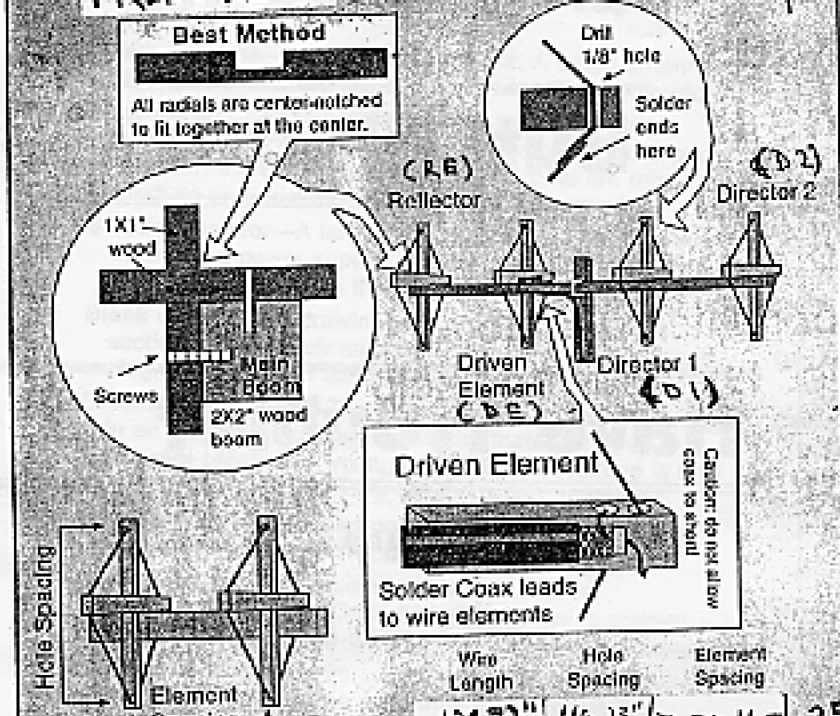
$4 = 1/4\,(16)$

An antenna is rough tuned by adjusting the length of the radiating element(s). Many antenna designs are based on or derived from what is called a dipole, two radiating elements whose length is roughly equivalent to 1/4 of the wavelength of the desired frequency of transmission. Wavelength in inches is determined by dividing 11811 by the frequency in megahertz. The result is either divided by 4 or multiplied by .25 to yield the 1/4 wavelength. A correction factor of .9 to .95, depending on the diameter of the element, is multiplied times the 1/4 wavelength resulting in the approximate length of each element.

Fine tuning the antenna requires the use of an SWR power meter.

Following are plans for several different antennae.

FREE RADIO 4 Element Quad 97.9 fm



	Wire Length	Hole Spacing	Element Spacing
Reflector	129.32"	45.23"	
			> 30.4 = .25λ
Driven Element	121.62"	42.51"	
			> 18.49 = .15λ
Director 1	116.84"	40.91	
			> 19.33 = .16λ
Director 2	111.11"	38.85	

10 db gain
in only 6 feet!

Hints: After beam is assembled, find the balance point and drill holes for U bracket.

Horizontal or Vertical polarization is changed by feeding the driven element from side or bottom.
Use side feed for Vertical polarization!

The center conductor of the coax will travel around the driven element wire and short to the coax shield! All Quads do this.

Parts List

- 1 - 2" X 2" 72" wood
- 8 - 1" X 1" 54" wood
- 1 - 2" U clamp with nuts and washers
- 8 - 1.5" wood screws
- 95 feet of 14 gauge wire
- Coax cable

Cut four pieces of wire about 6 inches longer than the measurements shown. Feed each wire through the four holes in the cross elements. Twist together the ends and solder the joint.

The driven element will require special care. An additional hole will be needed for the coax. The shield of the coax is solder connected to one end of the element wire and the center conductor is soldered connected to the other end of the element.

When I first built this antenna I knew something was wrong. This would short the center conductor to the shield. After discussing it with fellow amateurs I was assured that the design was correct!! The length of element wire creates the proper impedance for the frequency.

Now that all the elements are constructed, it is time to attach them to the 6' boom. They must be spaced properly. The proper spacing creates the gain for the antenna. Use two screws to attach each elements to the boom.

Pick up the antenna and find the balance point. This is the position you should use to mount it to the vertical mast.

If you want vertical polarization, the coax should feed from the side of the quad; for horizontal polarization feed it from the bottom or top.

Spacing Between Elements

RE ←.25λ→ DE ←.15λ→ D1 ←.16→ D2

Length of Elements

RE = 1.06 DE ≈ 1.07λ

D_1 = .96 DE ≈ .96λ

D_2 = .91 DE ≈ .92λ

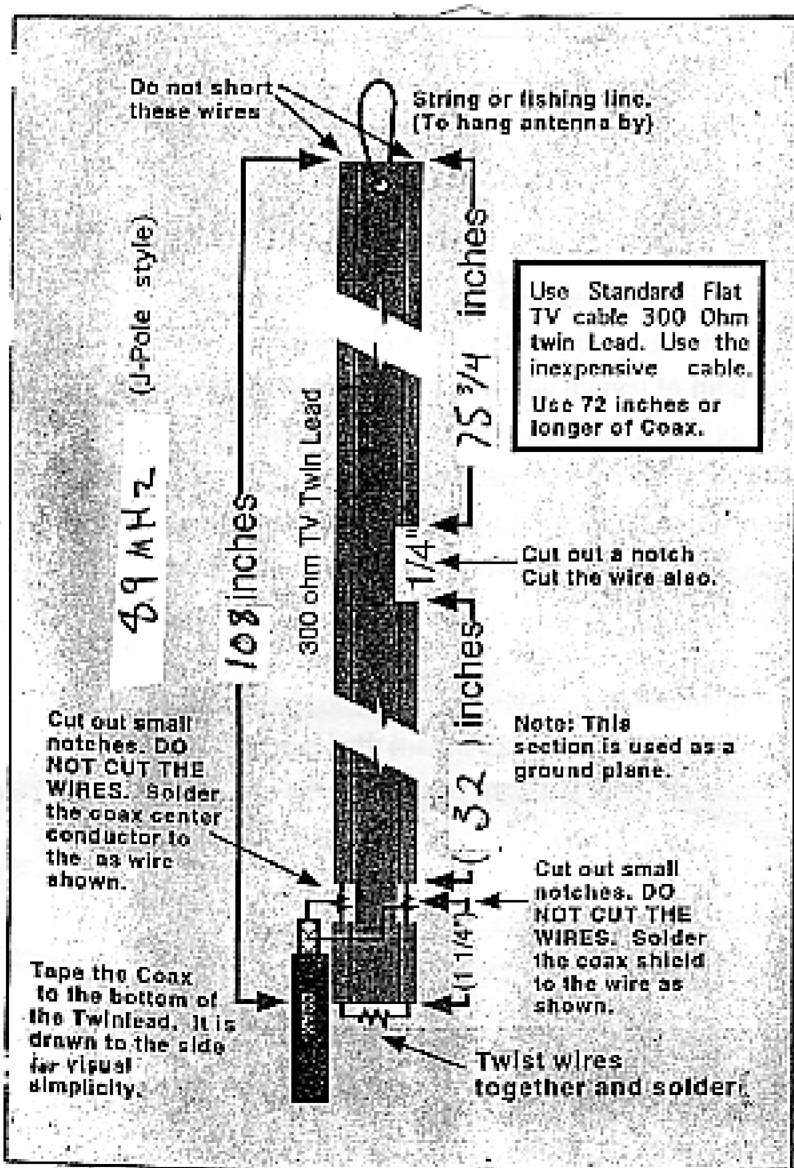
DE = 1 DE ≈ .99λ

Frequency Scaling

THE LENGTH OF THE ELEMENTS OF AN ANTENNA CHANGES WITH THE FREQUENCY IT'S INTENDED FOR. HIGHER FREQUENCY = SHORTER ELEMENTS. TO FIND THE LENGTH OF ANY ELEMENT FOR A NEW FREQUENCY, USE THIS FORMULA:

$$L_2 = \left(\frac{f_1}{f_2}\right) \times L_1$$

WHERE L_1 IS THE CURRENT LENGTH OF THE ELEMENT, f_1 IS THE CURRENT FREQUENCY f_2 IS THE NEW FREQ. AND L_2 IS THE NEW LENGTH



Use a pair of wire cutters or scissors and remove the insulation as shown. You only need to cut wire in one place. BE CAREFUL and only remove the insulation from the points where the coax connects to the twin lead.

After you have the insulation removed, twist the two sides of the twin leads together as shown (at the bottom of the antenna). Place some solder at the connection to insure full contact.

Connect the coax to the twin lead as shown. It should be connected 1 & 1/4" from the bottom. Use solder at these points also.

You may tape the coax to the twin lead to prevent stress on the solder points. Tape will also help prevent the wires from rusting.

Cut the twin lead to exactly 104" from top to bottom. Make sure you have cut the ground side notch 15 & 1/4" from the ground connection point.

Place a loop of plastic or other no conducting rope at the top of the antenna to hang from the ceiling.

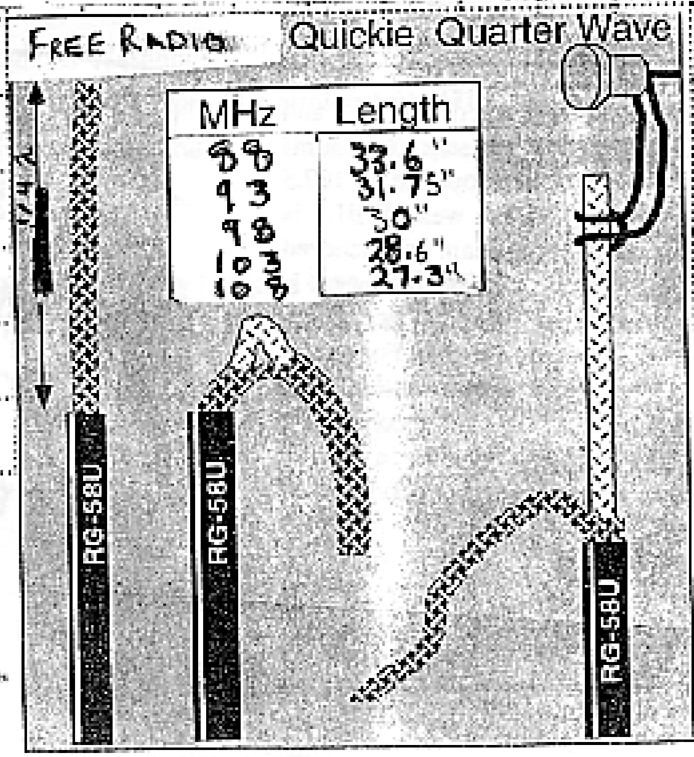
This antenna will have a gain of at least 3 db.

This antenna can be built for any frequency you may need. Just make sure the length of the radiator is correct. If you need to look up the exact length for each band, see the Simpleton's Guide to Quarterwave Antennas. You may attach the radiator to a wood board to help support it.

You must use RG-58 or similar size coax. The larger RG-8 style is much too hard to work with when you attempt to pull out the center insulation.

You may be tempted to unbraid the shield instead of opening a hole and pulling out the center insulation. Try unbraiding the wire and you'll get so frustrated with the braid tangling in themselves, you'll cut off the work and start over.

Good luck and remember to have fun when you work on the hobby we call F S U!



10-7. FM Broadcast Antennas

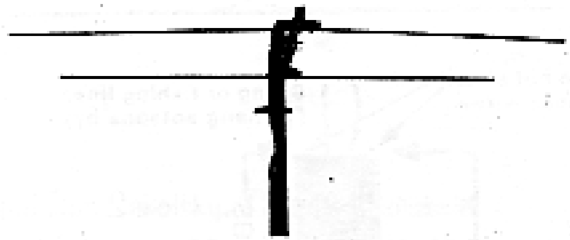
Multidriven element and basic Yagi antennas provide sharp unidirectional patterns and high gain for long-distance reception on the FM broadcast band. Extra dollars must be invested in a rotator and a sturdy mast or tower. On occasion a rotator may not be needed if your objective is to beam on some far away metro area, or just in some one favored DX direction.

The antenna of Fig. 10-20 consists of a reflector, two directors, and three driven elements. The use of two or more driven elements minimizes the wideband matching problem. The antenna impedance is about 300 ohms instead of the low value of a regular Yagi which requires a matching network that can restrict bandwidth. You can use 300-ohm twin lead with the antenna or feed a coaxial line by using a 4-to-1 matching transformer.

Often a simpler and less costly solution is attractive. There are two common problems. One possibility is that you live in a small city or town a modest distance from a metro area and you would like a good gain and a broad pickup pattern toward the target. A second possibility is that you live in a metro area and you would like some cut back in the received signal levels from the metro locals as you aim your antenna toward more distant stations.

In such situations you may wish to use the small two-element minibeam of Fig. 10-21. It has some gain, good back rejection, and will operate well without a matching device. A dipole and parasitic director combination were chosen because the front-to-back ratio is somewhat better than for a dipole and reflector pair. The director spacing is about 0.1 λ and, although the antenna impedance drops low, the back rejection is good and mismatch to a 50-ohm line is not too serious. It is a compact antenna and requires little space. Figure 10-22 gives the dimensions.

One example of its performance is a clean changeover between WBYO (Boyertown PA) and WBLS (New York City) with 180° rotation (easy arm-power rotation of a PVC mast). Both operate on 107.5 MHz. WBYO is about 20 miles due west; WBLS is about 70 miles ENE. When the beam is anchored ENE, the New York and New England reception is fine and there is minimum interference from Philadelphia stations on adjacent channels. For example, I can receive a clean WQXR signal on 96.3 MHz despite WWDB on 96.5 MHz. My FM receiver is a GE Superadio II. It is a superb AM portable but not especially great on FM. Thus, it makes a good receiver for putting FM antennas through tests.



(A) FM minibeam.

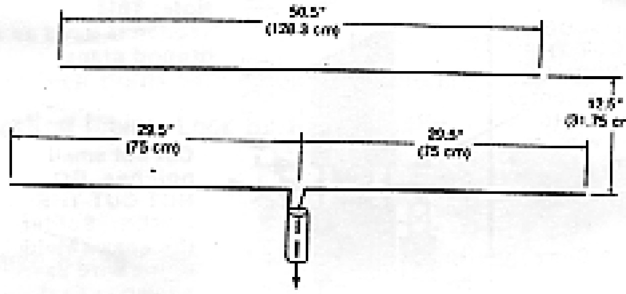


Fig. 10-22. FM broadcast minibeam dimensions.

This makes for a *GREAT* receiving antenna, just build it and point it in the right direction!

YAGI ANTENNA DESIGN AND CONSTRUCTION

– DESIGN PHASE

Determine your frequency of operation in Megahertz. If you are using a range of frequencies, choose one in the middle for your antenna design frequency.

) Calculate the wavelength (λ) in feet for your design frequency. Use this equation:

$$\frac{491.8}{\text{frequency MHz}} = \frac{\lambda}{2} \text{ (feet)}$$

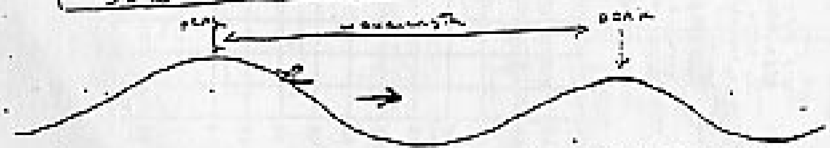
Remember: This equation gives you a HALF wavelength, so be sure to multiply your quotient by 2 for the full λ.

* Wavelength is mathematically related to frequency by the speed of light, which is estimated at 3×10^8 m/s (meters per second). RF (radio frequency) travels at the speed of light in a vacuum. Radio waves will incur some reduction in speed from the medium in which they travel, but in air the reduction is negligible.

Imagine surfing in the radio ocean. You can count the seconds between the peaks of each swell. This is the period, or frequency, of your waveform. If you know how fast the waves are moving (3×10^8 m/s), you can use the simple equation from your high school physics class to calculate the distance, or wavelength, between each peak.

RATE × time = distance

$$\text{Rate (speed) } 3 \times 10^8 \text{ m/s} \times \frac{\text{time (period)}}{\text{freq. (MHz)}} = \frac{\text{distance}}{\text{wavelength}}$$



Fortunately, the equation $\frac{491.8}{f} = \frac{\lambda}{2}$ has the speed of light conversion already built in! AND the meters to feet.

3) Next, determine what boom length you want to work with. The boom is the long, thick piece which supports your elements. The boom is not part of the electrical RF situation: the elements do all the work. Length of elements is determined by many precise factors, but boom length is determined by practicality and convenience. Booms can be metal (aluminum works best because its lightweight yet firm). PVC, wood, or any other material that works. Usually they are made of hollow pipe.

When you have your boom length in feet, then determine its length in wavelengths (using the λ in feet for your frequency). Ex. A five foot boom for a 100 ft. λ would render a boom length of $1/20$ λ.

Use this guide to make a directional BROADCAST ANTENNA for your PIRATE RADIO STATION, OR SMALL, MOBILE BEAMS FOR A UHF OR CELL-PHONE LINK-UP FOR YOUR STATION'S ROVING STREET CORRESPONDENTS. HAPPY BEAMING!

4) Use Figure 21 (from the copied portions of the ARRL Antenna Book) to determine your optimum number of elements is relevant to your boom length (or array length) in λ.

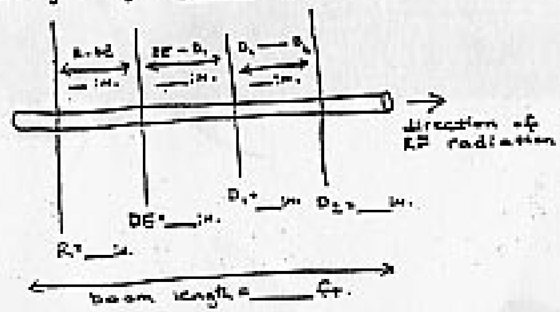
5) Use Table 2 to determine your optimum element spacings. Spacing is dependent on the number of elements used. The table gives spacings in λ, which we must convert to inches.
Ex. λ=100 ft. spacing= .05 λ. .05 of 100 = 5 ft. 5 ft × 12 in/ft = 60 in.
You need each spacing: Reflector to Driven Element, DE to Director 1, D_1 to D_2 etc.

6) Determine your element diameter in λ. You must already have the material you will use to make elements (element stock). We are using 1/4" aluminum rod. The diameter of the element in λ is dependent on the value of λ, which is dependent on your frequency.
Ex. λ=100 ft. element diameter .25 in. $100 \text{ ft} \times \frac{1200 \text{ in}}{.25 \text{ in}} = 300$ $\text{diam.} = \frac{\lambda}{300}$

7) Use Figure 13 to derive the optimum lengths of your Reflector, Driven Element, and Director if you are only using one (3 element beam). The R is longer than the DE, Directors are shorter.

8) Use Figure 22 to determine the lengths of each director if you are using two or more (4+ element beam).

9) Draw and label a diagram for your array which specifies:
Design freq. = ______ MHz.



D.I.Y. YAGI ANTENNA!

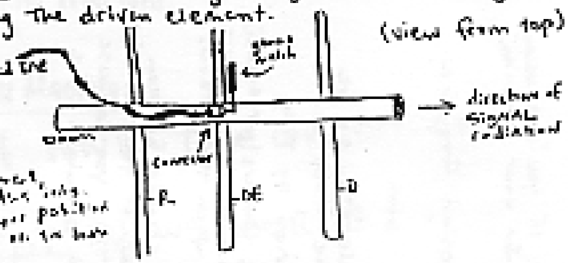
13

– CONSTRUCTION PHASE

1. Cut boom to desired length.
2. Cut elements to appropriate lengths. (Leave a tiny margin of error, 1-3/16", for R and DE). Cutting the R and DE a little long and the directors on the short side will give you an array with good bandwidth or a wide range of frequencies at which the SWR is usable. You can fine tune the array by filing a bit on the element lengths. Tuning (adjusting length) is less critical if you build your array for wider bandwidth. Label each element R, DE, D_1, D_2 etc.
3. Measure and mark the center of each element.
4. Measure where each element will go on boom and mark the spot of each one. (Remember spacings!) Label each spot for corresponding element.
5. Drill a straight hole through both sides of your hollow boom where each element goes. File until holes are just big enough for element.
   ☆ Alignment is crucial! Insert your first element before drilling the next one. Use the element to sight down the boom and check that you are drilling so that elements will be perfectly parallel.
6. Drill holes for screws through one side of boom, coming at each element at a right angle. Choose a drill bit the size of the shaft of screws, not including the threads.
7. Insert elements in appropriate order and screw firmly into place. Be sure elements are screwed in at the center.

– FEED POINT

The feed point is the point at which the RF current enters the antenna from the feed line (coaxial cable). A connector must be affixed to the boom at the center of the driven element. The feed line connects to one side of the connector on the side of the Reflector element. The other side of the connector has a central pin, which is soldered to a piece of copper wire. The wire is part of the gamma match made in the next step. At this step you just need to make sure the pin of the connector is placed so that the copper wire bent at a right angle, will be alongside (parallel) but not touching the driven element.



If you use [illegible] to make a [illegible] matching [illegible] [illegible]

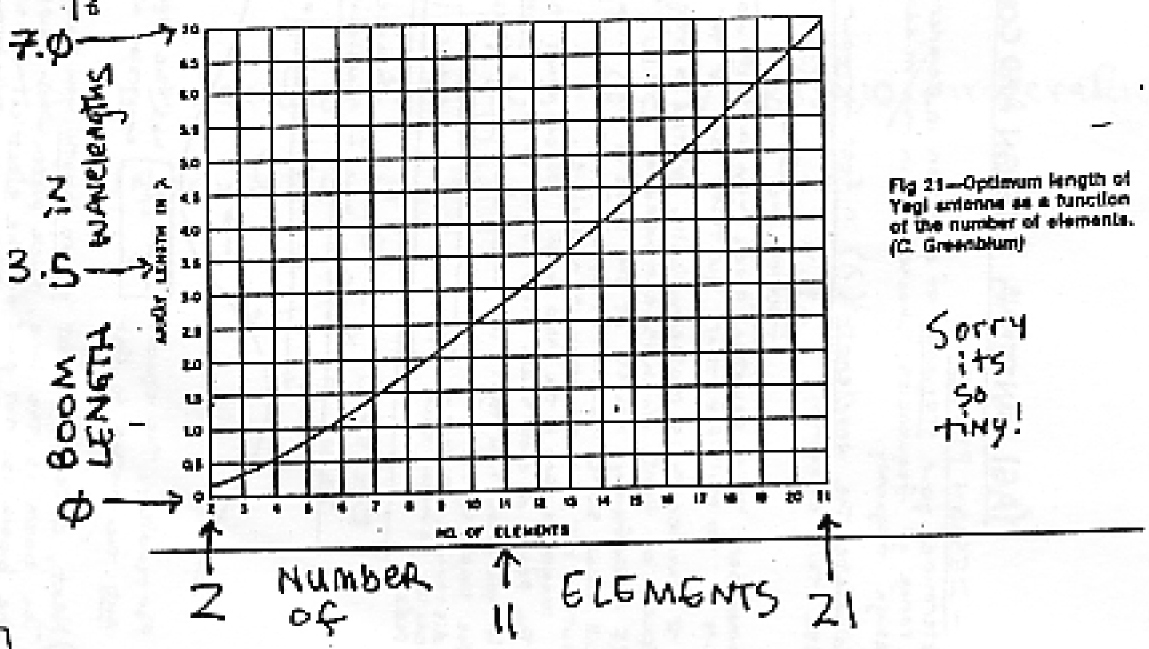
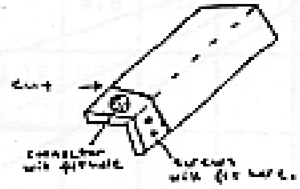


Fig 21—Optimum length of Yagi antenna as a function of the number of elements. (C. Greenblum)

Sorry its so tiny!

(8) To hold the connector onto the boom you must use a mounting device. Cut a strip from a stiff piece of aluminum angle with one side large enough to drill/file a hole the right size to accommodate your connector, and the other long enough to put two screws through to your boom.

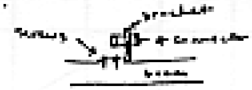


We are using aircraft aluminum alloy angle cut in a strip sized to accommodate a BNC-type connector

(9) File down a flat spot on your boom where the mounting bracket will be screwed down. Prepare screw holes on bracket and boom.

(10) Drill out a hole on bracket for connector. You will probably have to enlarge it with a circular file.

(11) Attach the connector to the bracket and screw it down to the boom.



– GAMMA MATCH

(12) Cut and straighten a piece of plastic shielded copper wire (regular 12 guage house wire). Start at around a half the length of one side of your DE. Strip the plastic off about ½" one one end.

(13) Cut a straight piece of ¼" interior diameter copper tubing. Lengths will vary for each frequency and you may have to experiment a bit. For a 3m antenna it may be six inches, while for GMRS (UHF) it may be only ½" long.

(14) Cut a piece of plastic tubing that your 12 guage wire fits inside, and which in turn fits into the copper tubing.

(15) Solder a ring terminal onto stripped end of wire, and another onto pin of connector. Terminals are connected with a nut and bolt to couple the wire to the connector in a detachable way

(16) Fit wire, tubing, + copper tube piece together in a sliding gamma arm and couple into connector.

(17) Make an aluminum strip holder to attach gamma arm (at copper tube) driven element. Slide to adjust capacitance. (see photos.)

(18) USE AN SWR meter to tune your ARRAY to A 50 ohm match. The array is tuned when you have acheived the lowest possible Standing Wave Ratio (SWR). Try for a 1:1 ratio. Do not transmit into a 3:1 ratio or higher!

Free Radio Cascadia ... taking back communication from the corporate media...

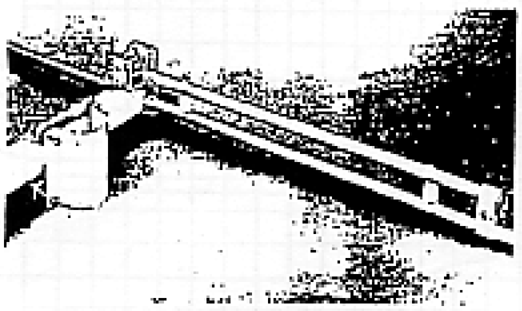
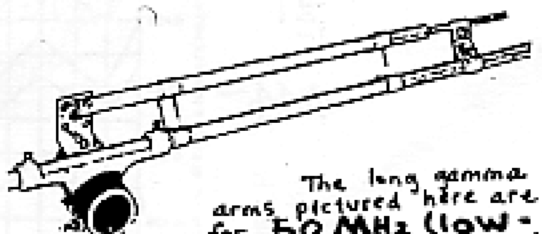


Fig 34—Typical gamma match construction. The variable capacitor, 50 pF, should be mounted in an inverted plastic cup or other device to protect it from the weather. The gamma arm is about 12 inches long for 50 MHz. The same construction technique may be used for 144 MHz, with an arm length of about 5 in.

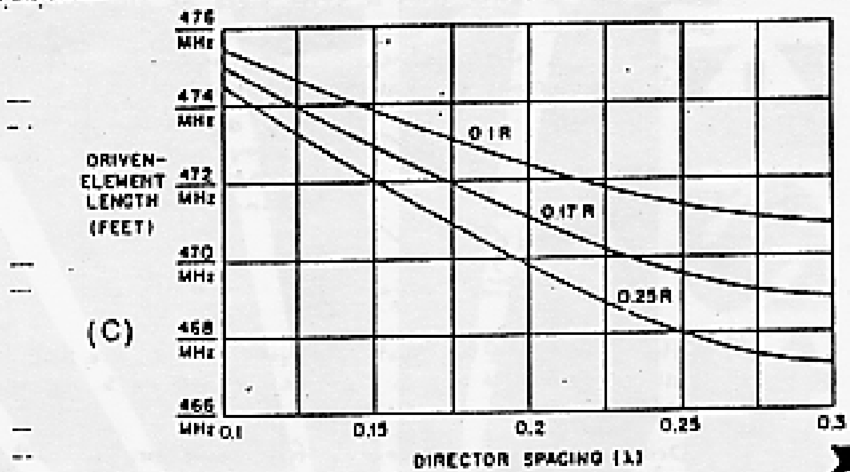


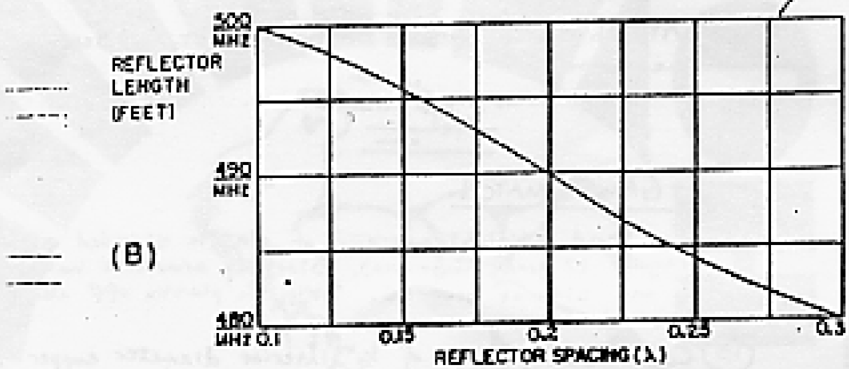
The long gamma arms pictured here are for 50 MHz (low-band VHF) UHF matches are much smaller.

Fig 35—Gamma matching section using tubular capacitor. The sheet-aluminum clip at the right is moved along the driven element for matching. The small rod can be slid in and out of the 15-in. tube for adjustment of series capacitance. The rod should be about 14 in. long for 50 MHz.

16

Fig 18—Element lengths for three-element Yagis. These lengths will hold closely for tubing elements supported at or near the center.





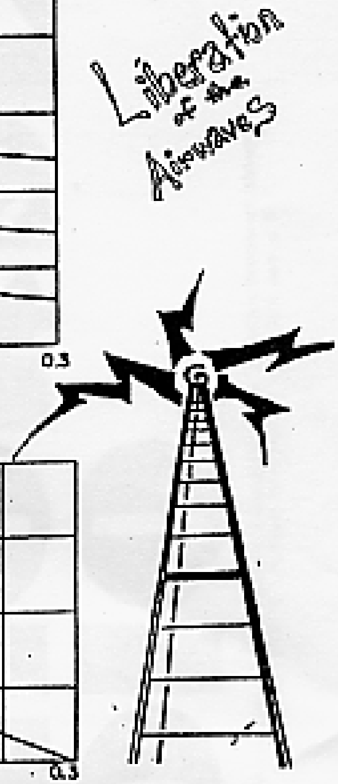


Table 2
Optimum Element Spacings for Multielement Yagi Arrays

No. Elements	R-DE	$DE-D_1$	D_1-D_2	D_2-D_3	D_3-D_4	D_4-D_5	D_5-D_6
2	0.15-0.2 λ						
2		0.07-0.11 λ					
3	0.16-0.23	0.16-0.19					
4	0.18-0.22	0.13-0.17	0.14-0.18 λ				
5	0.18-0.22	0.14-0.17	0.15-0.20	0.17-0.23 λ			
6	0.16-0.20	0.14-0.17	0.16-0.25	0.22-0.30	0.25-0.32 λ		
8	0.16-0.20	0.14-0.16	0.18-0.25	0.25-0.35	0.27-0.32	0.27-0.33 λ	0.30-0.40 λ
8 to N	0.16-0.20	0.14-0.18	0.18-0.25	0.25-0.35	0.27-0.32	0.27-0.33	0.35-0.42

DE—Driven Element; R—Reflector; D—Director; N—any number; director spacings beyond D_6 should be 0.35-0.42 λ.

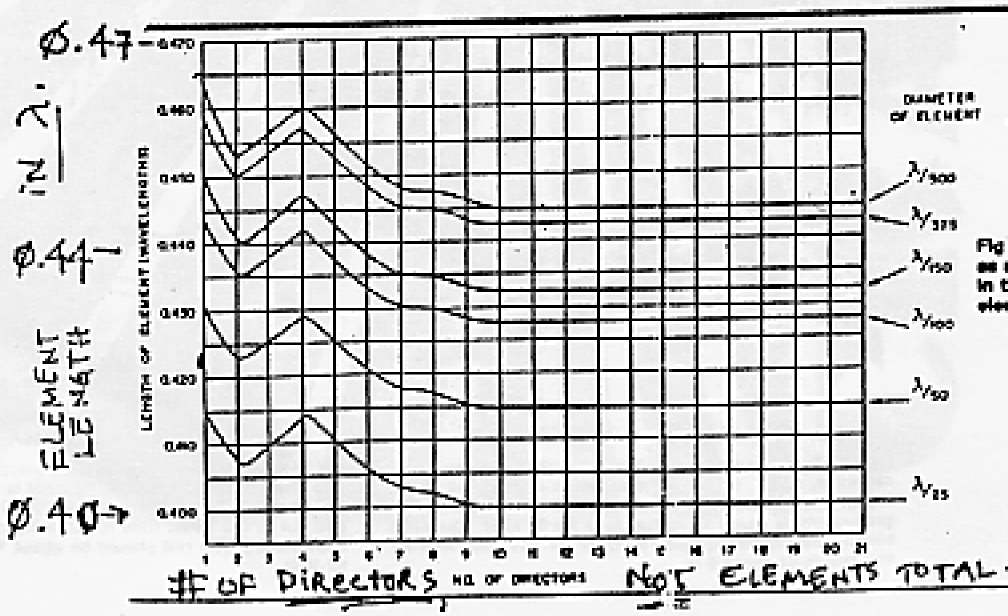
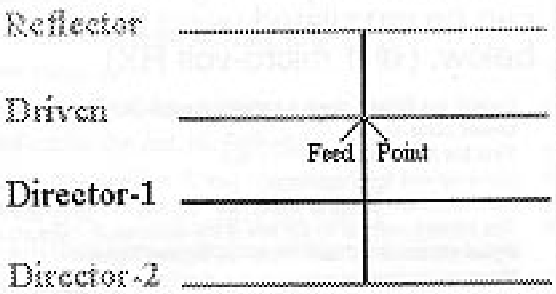


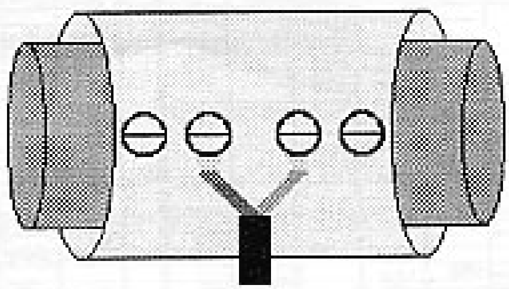
Fig 22—Length of director as a function of its position in the array for various element thicknesses.

Free Radio Direct Connect Beams

Here are some lengths and spacings for various direct connect beams. The layouts are straight forward and are illustrated below. Your SWR should be less than 1.3:1 with these designs.



The driven element is cut into two halves and insulated from the boom with nonmetalic material. Then the two wires of the coax are connected, one to each section of the driven element. You may drill small holes and use sheet metal screws to accomplish this.



The reflector, director 1, and director 2 can be attached directly to the boom by a variety of methods.

4 element beam center frequency 97.9FM

2 Meter 4 element beam 1/2" diameter tubing	Element Length	Element spacing from Reflector
Reflector	57"	*****
Driven	53 7/8"	36 5/16"
Director 1	51 5/8 "	73 3/8"
Director 2	51 ½"	107"

	Freespace	Over ground 30 feet
Gain	8.43 dbd	10.34 dbd @ 5 degrees 13.71 dbd @ 10 degrees
F / B	13.32 db	13.60 db at 5 degrees

THIS DESIGN MODIFIED FROM THE ANTENNA ELMER
http://members.home.net/AC3L

BOB SIMPLETON'S GUIDE TO TRANSMITTER RANGE

brought to you by **Amateur Radio Trader**

How far away can my signal be heard? That is perhaps the most often asked question in amateur radio. Unfortunately like most questions in this exciting hobby, the answer requires a little work.

We will focus on line of sight propagation on the VHF & UHF bands. These are the most common bands used by both mobile and base operations.

To properly estimate a signals range, you must have a few important figures:

- Frequency / Band
- Transmitter power (in watts)
- Antenna height (from sea level)
- Antenna gain (net after coax loss)

Using this estimator table you should be able to calculate the range of your signal. This table can be used not only for mobile or base operation, repeater owners can also estimate the range of their mountain top repeaters!

Follow the six steps listed above and you should have a fair estimate of your signal range.

These instructions assume a receive signal in the 1 microvolt range. One microvolt is considered a strong signal strength. Most modern radios have a .15 microvolt sensitivity.

If you wish to estimate the maximum distance your signal can be heard, you can move up the distance table six lines every time you divide the receive signal by one half. For a .5 micro volt signal, move up six lines. For a .25 microvolt signal, move up 12 lines.

While these figures are just an estimate, you'll find that they are usually reliable.

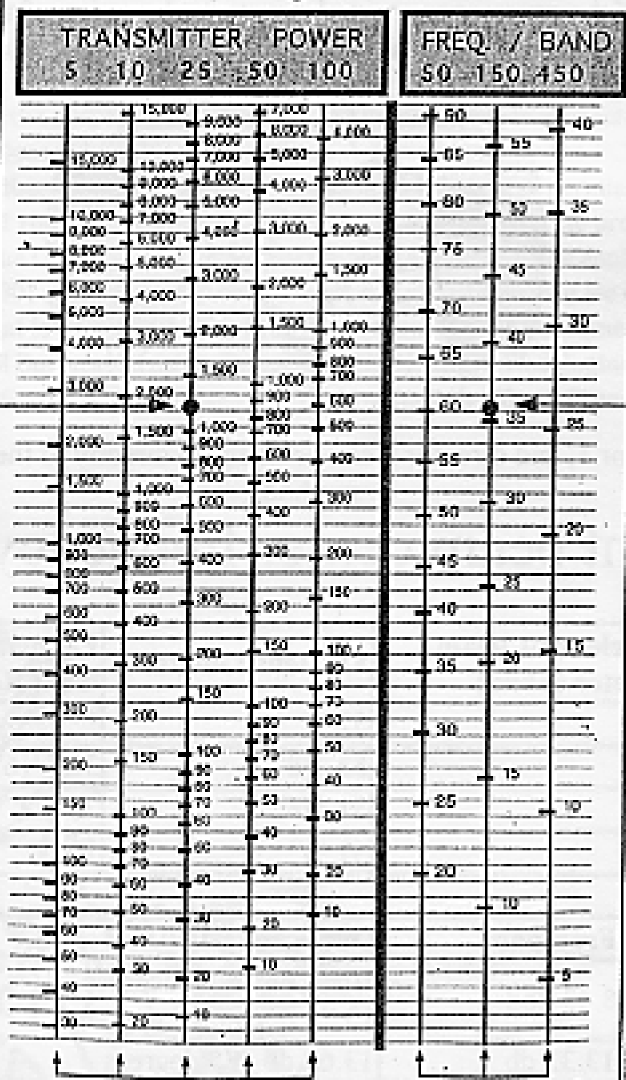
73 and remember to have fun.

Look for "Simpletons Ham Dictionary" in 1996.

The distance your signal will travel can be calculated using the table below. (@ 1 micro-volt RX)

1. Locate the height of your antenna on the proper transmitter power column.
2. Find the line closest to that point.
3. Move up one line for every dB gain of your antenna system.
4. Move across the line to the proper vertical frequency band.
5. The closest number to the line is the distance in miles your signal will travel with a 1 micro-volt receive signal.
6. Move up six lines to calculate the .5 micro volt range.

Transmitter Range Estimator



Radio signal strength is based on the Inverse square law; Double the distance and the signal strength will be 1/4 of what it was. This chart is a rough way of calculating signal strength at specific distances. Obviously it was intended for ham radio and not FM broadcast radio, but the average of the 50MHz and 150MHz results should give a reasonably accurate reading, though I think that this chart is a little on the generous side

* In theory the range of a transmitted radio signal is infinite regardless of power used, basically it goes on and on forever until it encounters an obstruction. More power helps to penetrate any obstructions. Given this, when engineering and planning a station it is always better to consider the issues that limit the range.

Range is limited by:

a) How far the transmitting antenna can effectively see. If you stand where the antenna is mounted and look out with a pair of binoculars, wherever you can see it is possible to transmit to. This can sometimes be up to 20, 30 even 40 miles if you are looking out from a mountain top.

b) Other sources of interference or other stations operating on the same frequency. For example the antenna may be able to see 20 miles, but if another station is on the same frequency 20 miles away, it will block/interfere with the signal.

c) Transmission power. If the antenna can see 20 miles, but say 1 Watt ERP of power used, it's very likely that about 1 mile of range will result. This is quite simply because there is not enough power to propagate the signal 20 miles. If 50 Watt ERP is used, it's very likely that 20 miles of range will be achieved. This is because 50 Watt ERP is ample power to propagate a strong signal 20 miles. If 1 Million Watts of power is used, it is very likely that signal will only propagate just over 20 miles. This because the range is limited as described in point a) above.

Assuming the antenna has a clear view, the frequency is clear and an average quality portable receiver is used, typical transmission power ver range figures are as follows:

Watts ERP	Range Miles
1	1.5
2	2.1
4	3.0
8	4.2
16	6.0
32	8.6
64	12.0
128	17.0
256	24.0
512	34.0

HOW TO LIVE LONG ENOUGH TO ! REVOLT!

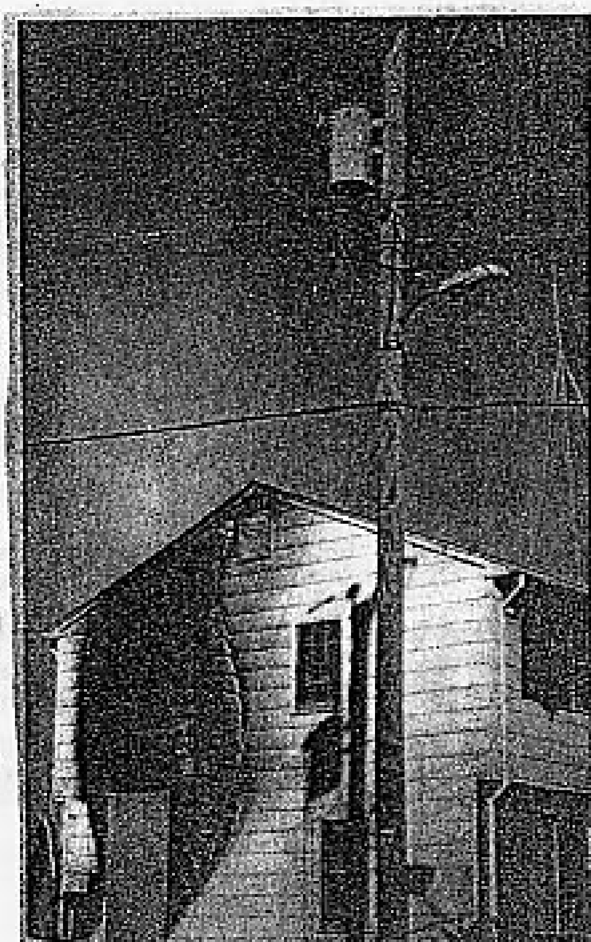
Antenna safety is one of the most important ideas to keep in mind when you're setting up your station. Antennas for the ham bands are often large, requiring care and attention to detail when they are installed. Here are a couple of points to keep in mind when putting up your antenna.

1) Be sure your antenna materials and supports are strong—strong enough to withstand heavy winds without breaking.

2) Keep away from power lines!

If your antenna falls, it could damage your house, garage or property. If it falls into a power line, your house might end up like the unlucky CBer's shown in the photo. A windstorm knocked over his ground-plane antenna, sending it into a 34,500-V power line. The resulting fire damaged his house extensively.

Safety pays! Accidents *are* avoidable, if you use good sense.



* THIS IS BORROWED FROM THE VERONICA KITS WEBSITE

7. POWER SUPPLIES

Most of the transmitters and amplifiers used in micro broadcasting require an input voltage of 12 to 14 volts DC. Higher power amplifiers (above 40 watts) require 24-28 volts DC. In a fixed location the voltage is provided by a power supply which transforms the house voltage of 110 volts AC to the proper DC voltage.

Power supplies are not only measured in terms of their voltage but current as well. A higher power amplifier is going to require a greater amount of input power as compared to a lower power amplifier. Output current is measured and specified as amps. A power supply is selected on the basis of its continuos current output which should be higher than the actual requirements of the amplifier. Power supplies operated at their fully rated output will have a tendency to overheat under continuos operation. An amplifier which requires 8 amps will need a power supply with a 10 to 12 amp continuos capacity. In most cases the following ratings are suggested for transmitters requiring 13.8 volts.

1-5 Watt Transmitter 2-3 Amps
10-15 Watt Transmitter 5-6 Amps
20-24 BGY33 Based Unit 10 Amps
40 Watt Transmitter 12 Amps

Any power supply you use must have a regulated voltage output along with protection circuitry. Some reasonably priced brands include Pyramid, Triplite and Astron. Do not use any of the wall transformer type of power supplies. Such units are not adequate for this application. Higher power transmitters require power supplies with an output voltage of 28 volts. Astron is the best manufacturer of this type of power supply. A 75 watt transmitter will require a power supply with a current rating of 6-8 amps and 28 volts.

For mobile applications voltage can be fed from the cigarette lighter socket of a car with the correct plug and heavy gauge wiring. This may not work well in some newer vehicles with are reported to have some sort of current limit protection on the lighter socket. Check with an auto mechanic about this if you are in doubt. Electrical systems on newer vehicles are rather sensitive and can be damaged if not properly understood. Another problem with mobile operation is battery drain. A 20-40 watt transmitter running for 4-5 hours can deplete the battery to the point where the vehicle may not start. It is better to have separate battery running parallel to the charging system with an isolator. Isolators are available from Recreational Vehicle accessory suppliers. Use a high capacity deep discharge type of battery. Lead acid batteries are not very benign. Acid can leak and spill on people, clothing and equipment. It is best to keep the battery in a plastic battery box. Vapors from the battery are explosive in confined areas. Keep this in mind for mobile vehicle operations. You might consider using a gell cell type of battery which is sealed and can not leak. These are a bit pricey but have far fewer problems. A good quality gel charger must be used to ensure battery longevity. Smaller gel cell batteries work really well for setting up a low power (6 watts or less) transmitter on a street corner as a public demonstration of micropower radio. In Berkeley a 6-watt micropower station is set up at the local flea market as a community demonstration on weekends. It is called Flea Radio Berkeley. Transmitters can be set up at demonstrations and rallies so motorists can tune their radios to the frequency which is displayed on large banners near the streets and listen in on what is happening. This has worked very well. Use your imagination to show how micropower broadcasting can be brought into the community.

4. Earth Ground

The very final element of a radio transmission line is the Earth Ground. The Earth Ground serves the purpose of grounding or eliminating unwanted energy by providing that energy with an faster path to where it naturally wants to go: the earth. Grounding your antenna and transmission line is often necessary to reduce your SWR and helps protect a building from lightning. All of the metal cases and shielding in the coaxial cable is part of the ground system. The cases of the transmitter, amplifiers, the negative lead on the feed line (the coax between the SWR/Power meter and the Antenna) and the antenna itself should ideally all be connected by 12 gauge stranded copper wire to an 8-foot solid copper rod driven at least halfway into the ground. If you cant get a rod into the ground then the next best thing is the cold water pipes in a building. The metal body of a car/truck/van is usually a sufficient ground as well. Audio equipment should be grounded separately from transmitting equipment and they should ideally be running on separate electrical circuits.

Blanket Interference

Blanket RF Interference occurs near every transmitting antenna. It is an area in which all other radio signals or electromagnetic fields are blocked out by your radio signal. If you look at the inverse square law $\left(\frac{1}{x^2}\right)$ its clear that the strength of the radio signal is very high when very close to the antenna. The interference caused near the radiating source may disrupt other radio stations, telephones, TV's, cell phones etc. or you may hear the radio station playing through stereo systems or guitar amplifiers even when they're turned off. For most free radio stations this is probably a very small area, probably just the building the station is operating in or neighboring buildings. For corporate radio stations the area of blanket interference is much higher. The size of the blanket area increases with the power of the radio station. The FCC ignores most interference complaints that don't come from wealthy corporate entities. Things you can do to curb this interference include installing high-pass filters on TV's, phone lines, etc., shortening all speaker or phone cables, and wrapping them in aluminum foil then attaching a grounding wire from the foil to the screw in the middle of the electrical outlet faceplate or other suitable ground. It's good to consider your neighbors when turning on a radiating antenna.

A Brief Discussion of Scale...

A radio station doesn't need to be anchored to a studio, a building, or power lines in order to be effective. Once you connect an exciter to its power supply and an antenna, and turn it on, you have a radio signal. That last bit about power supplies (an excerpt from Stephen Dunifer's tech primer, no need to re-write what's already been written...) was a nice lead in to a discussion of the scale and portability of your radio setup. So, consider three different examples of radio stations on different scales: first there's the standard, a studio or maybe even two, and a transmitter room in the basement or attic of a house with an antenna on a mast on the roof. It has hard-wired electricity from the power grid, a large mixing board, and a lot of non-portable equipment. Second, there's a station set up inside of a car, van, or truck. It runs on a second battery inside the car, has minimal studio equipment--maybe just a small DJ mixer, one mic, one tape deck--and a magnetic-mount antenna on top. Third there's an exciter, a small amp and a battery in a backpack with antenna hidden in an umbrella and a microphone and a portable tape deck for an audio source.

Each scale of station has its pro's and cons. The first example can put out the most power, since the power supply doesn't have to be carried. It can also produce the best sound quality and build a strong listener base because its signal can be received reliably. It is also the easiest for the FCC to locate and steal equipment from. One microradio station once made the FCC dig up its transmitting equipment, which had been buried in the back yard before they could take it.

The second example is definitely harder to locate and shut down. However it requires some vehicle modifications, can't put out quite as much power (though it could still put out plenty, depending on how many batteries you want to add) and a car can be pulled over easier then a house can be searched, even though municipal and state police have no jurisdiction without an FCC agent.

The third example is great for demonstrations like the march on the FCC headquarters several years ago. It has considerably less potential power output, is more likely to be damaged in transport, and lower sound quality. Also if only one person is wearing a backpack with a cable going to an umbrella its going to be obvious who has the transmitter. Having a lot of dummy setups solved this problem.

Another possibility is a remote studio or transmitter and the use of a Studio-Transmitter Link (STL). A studio could be set up in a house and use a 2-way radio channel for a link to a transmitter in another building, or in a vehicle. Someone standing on the street could be remotely operating a transmitter with a cell phone, CB, or 2-way radio.

The possibilities really are endless. Each type of station has its purpose and the more creativity the better. Think about how you would use a radio transmitter, come up with your own ideas and do it!

FINDING A FREQUENCY

Before you can proceed any further you must determine if there are any available frequencies in your area. Due to frequency congestion in the large urban metroplexes such as Chicago, Boston, LA, NYC, etc. this may be a bit difficult. You will need several items to do a frequency search: a listing of the all the FM radio stations within a 50-70 mile radius of your area; and a digitally tuned radio. There are several databases on the world wide web which can be searched for FM radio stations in any given area. Here is one: www.airwaves.com/fccdb.html

Channel separation is the biggest problem. FM broadcast frequencies are assigned a frequency channel 200 kilohertz wide. Good broadcasting practice requires that at least one channel of separation must exist on either side of the frequency you intend to use. In other words, if you have picked out 90.5 as a possible frequency then 90.3 and 90.7 should be clear of any receivable signals. This is why a digital receiver is an important item for the frequency search.

Once you have a complete listing of all the FM radio stations look for possible frequencies with the appropriate channel spacing. Depending on topography, distance and the output power of the other stations certain "used" frequencies may in fact be open. Compile a list of the possible frequencies. Then, using a digital FM receiver with an external antenna, scan and check these frequencies. Do this from a number of locations and at varied times within the area you propose to cover. In most cases weak, intermittent, or static filled signals can be ignored and counted as either usable or providing the necessary channel separation. Hopefully you will find at least one or two usable frequencies.
If you live in a more rural area or some distance from a large urban area, finding a usable frequency should not be very difficult. 87.9 can be used as a frequency under two conditions. One, if there is not an existing station on 88.1, and two if there is not a TV Channel 6 being used in your area. After compiling your list of possible frequencies have your friends check them out on their receivers or radios as well. It is helpful to do since a variety of different receivers will more accurately reflect the listening conditions in your area. After all of this you should have a workable list of frequencies to use.

Note: I don't think that the database listed above is working right now so unfortunately the only other one I know of is the FCC's own database at http://www.fcc.gov/mmb/asd/welcome.html
The drawback of this database is that you have to enter a specific type of Latitude and Longitude coordinates, and then it doesn't give you the frequency, but the channel (1 through 200) that each station is using. You can get the rough coordinates for your city by searching for a nearby radio station and entering its coordinates into the search. That will at least get you the list of stations. If trying to use this database gets too complicated, just check around the band in your area as described above for the quietest spot on the dial. Even a weak signal on or one channel away from your frequency will limit your range, but remember, these airwaves are as much (if not more) yours than they are theirs! Don't let their technocracy keep you off the air! Some may say its rude to just turn on a transmitter on a quiet spot, but its got to be done if we're going to have a voice, do the best you can, and be prepared to shut down and move if you get an FCC knock.

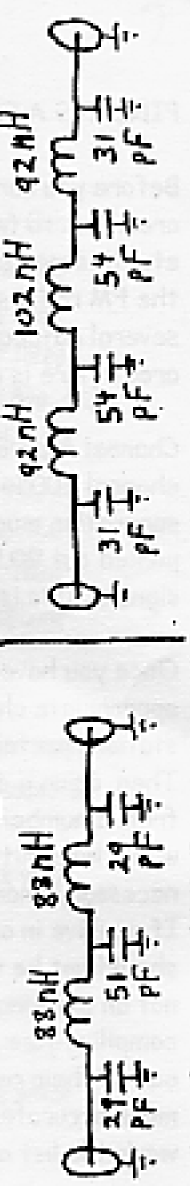
Also - check out www.radio-locator.com and www.theradiosource.com/products_LPFM_Plan.htm

D.I.Y. LOW PASS FILTER
(THANKS RADIO FREE CASCADIA!)

For the capacitors get silver micas rated at 500 V, they are avaliable from RF parts (http://www.rfparts.com/) or from really well stocked electronics stores in big cities. Get as close to these theoretical values as you can but its not that critical within a couple pf. Remember that capacitors add in parallel (the opposite of resistors) so you could, for example, place two 15's next to each other to get 30 or put a 1 next to these to get 31. If 100 or 200 Volt rated components are all you can get its probably ok if you are running less than 20 Watts.

The inductors can be wound out of wire. I like to get silver plated copper wire from the local hippy jewelry supply store because silver is a really good conductor and it makes the filter really pretty, but copper wire works as well for the non perfectionist. Actually measuring inductance at these small values is rather voodoo, the variables theoretically are the diameter of your wire, the diameter of the coil, the number of turns per inch of the coil stock and the actual number of turns in your coil. If you wind coils on a 1/4 inch x 20 bolt with 22 gage wire, you will have about 500 nH per inch. For the 88 nH make about 4.5 turns, for the 92 nH make about 5, for the 102 nH make 5 or a little more but expect to have to squish it. Be sure to leave ample wire to connect your coils to the capacitors, you can always cut extra off afterwards. If you wind your coils all the same direction they will interact as if they were one big coil. This degrades filter performance. Wind adjacent coils in opposite directions to minimize this effect. Additionally placing each coil in its own shield box will further defeat this "mutual coupling" but is probably overkill except for the artist. Solder the components as close together as possible, even straight wire does have inductance. Connect your filter to a 50 ohm environment with a connector or coaxial cable by simply soldering the in and out points to center conductors and the grounds to the small piece of copper clad board stock on which you build the filter. I like to keep a couple of test cables around with connectors installed on one end which I temporarily attach to a new filter to check it out.

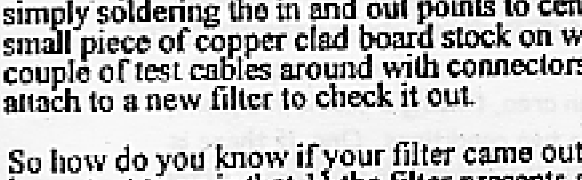
If you are running more than 10 watts consider this filter:



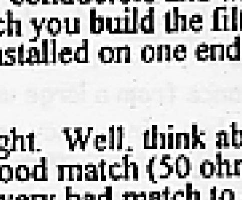
So how do you know if your filter came out right. Well, think about it, what's important to us is that 1) the filter presents a good match (50 ohm impedance) to our desired 88-108 signal and that 2) it presents a very bad match to our harmonic frequencies reflecting them away from the antenna. The first criteria is measurable with the instruments at hand. Connect the transmitter to the SWR meter to the filter to the dummy load (in that order). Now, if you have previously tuned the output of your transmitter to 50 ohms (by patching the transmitter to the SWR meter to the dummy load and tuning your transmitter for maximum FORWARD power with the variable capacitors in its output) then you know that everything in your coaxial system: transmitter output, feedline, dummy load, everything except your filter is 50 ohms

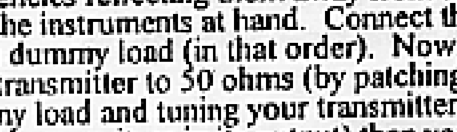
Since the SWR meter is placed before the filter it will indicate any mismatch encountered there (note that the impedance seen at the output of your filter effects the impedance seen at the input so it is important that your filter is terminated into the 50 ohm dummy load for this test). Fire up the transmitter, calibrate the meter and measure the SWR into your filter. You can now tune the filter by squishing and spreading the coils. Your filter is tuned when it is at (or very close to) a 1:1 SWR.

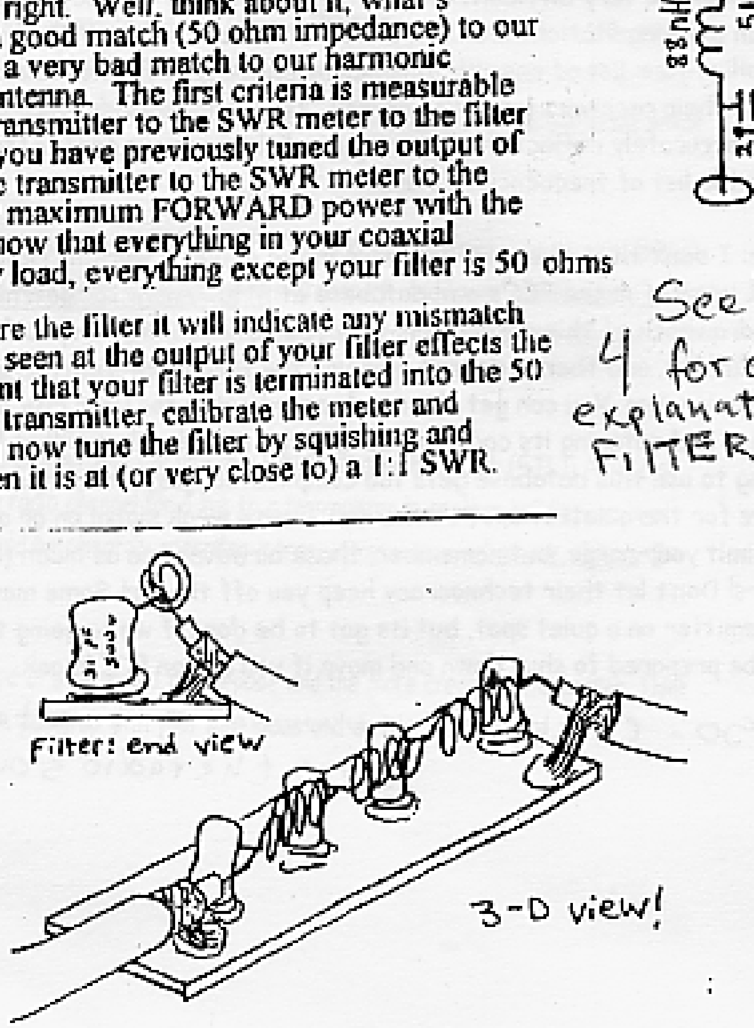
See Page 4 for an explanation of FILTERS



Filter: side view


Filter: end view


Filter: top view


3-D view!

An Overview of Studio Components for a Radio Station –by DJ Miscellaneous

This is not a definitive technical manual, it is a semi-organized layout of the 'street knowledge' I've gathered doing audio for a community station. Some of it is oversimplified for simplicity's sake. Some terms are used assuming that if you don't know what they mean, you can look them up. I took some basic electronics courses at MATC, but none of it dealt with sound production or broadcasting.

1. Control Board or Mixer- A dj mixer is good to start with. You should be able to hook up 2 line sources (cd or tape), 2 phonographs and a microphone. DJ mixers usually have a cueing channel for cueing the next source in the headphones. A dj mixer with a few more "line ins" could run you about $150 new and set you off to a good start. Numark and Vestax are both decent brand names. Gemini is not too durable, along the lines of Optimus (the radio shack brand), but to get started anything can do. Not many stations start out with a studio mixing board, unless you have one donated and have a good tech person to hook it up. But for most stations that are just getting started, with only a working knowledge of home stereo systems, a dj mixer will be a simpler choice. When you run out of inputs on your dj mixer, then is a good time to invest in a studio type board. You will have a better idea about what you need and want in a mixer. Also, your dj mixer is still usable for it's phono inputs, the mixer can be run into your new main board.

2. Record Players -2- Technics 1200s are $500 each new, but if you have the cash, they are DURABLE and will save you a lot of time salvaging turntables. Home stereo record players wear out fast and many have automatic features that and get in the way. Having a person able to maintain record players is a must. DJ Misc needle cartridge of choice is the ortofon concorde model. Stanton's 500 range needles are good too.

3. CD Players -2- Portable players work well and are compact. The best ones have a time counter, a line-out jack (other than the headphone), and a pause and repeat function. CD Changers are nice too, for autopilot.

4. Tape Decks (as many as you can get)- Decks usually die before you have enough, but 3 is good. Two of them to mix between and one to record shows. The third deck can be a boombox radio tape deck that is actually receiving the on air signal. This is a good way to check the signal and the boombox can also double as a studio monitor.

5. Microphones -2- I recommend spending at least $60 on your first mic and getting an omni directional or cartoid mic. Windscreens really help smooth out the p's and ss's. Note if your mixer takes XLR or ¼" phone plug connectors for the mic.

6. VCR – Great for recording or playing 6hrs of shows.

7. Phone Patch – For calling your favorite Corporate Rock radio stations and harassing their djs on your station. (disclaimer: we in no way advocate the harassment of people on air with out their knowledge, but it sure sounds like fun)

8. Studio Monitor- The monitor can be anything from a boombox to a pro monitor speaker system. A good middle of the road setup is to use an old stereo receiver and some decent speakers. Setup

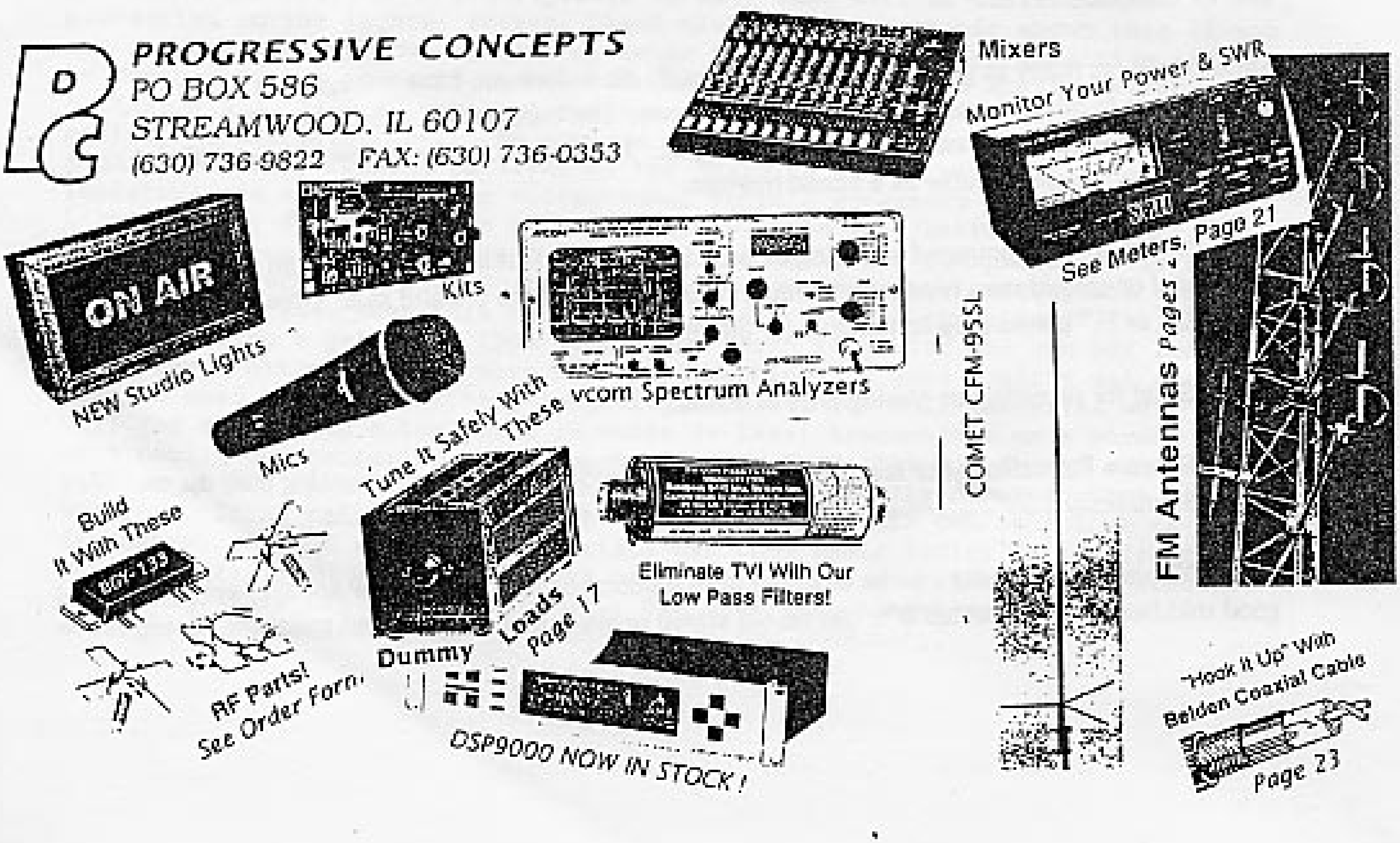
your monitor to be receiving the air signal, so you can keep tabs on it. Also, if the receiver has a decibel meter, it can be handy when adjusting the audio gain on the transmitter.

9. Headphones- a few pairs. Things to look for in phones- metal parts and joints, replaceable ear foam, thick, solid cords. Koss headphones have a lifetime warranty, and they are good for it.

10. Graphic Equalizer- put it after your mixer to fine tune the on air eqing. Especially useful for eqing out the 60 Hz hum sometimes caused by cheap microphones.

11. Compressor/Limiter (gate)- These highly recommended devices usually come in one audio component. Compression evens things out, makes loud stuff softer and soft stuff louder. Ever notice that commercial radio is all the same volume level? I like a little compression to make up for inexperienced djs, but too much lacks dynamics. A limiter limits the over all loudness. When a dj is "in the red" on the VU (decibel) meter, they are over modulating the signal, and it will sound distorted and cause spurious harmonic frequencies. Setting a limiter/gate will not allow the overmodulations to even get to the TX and this also prevents transistors from running hot in your audio and radio frequency circuits. The compressor limiter is the last audio component before the transmitter.

Grounding your studio equipment is a great way to escape the Hummmmm-drummms. If your setup is not grounded it will carry the 60 cycle hum. You will notice that turntables have grounding wires, they connect to a screw or lug on your dj mixer or stereo receiver . A wire should be attached to a screw on each audio component's case have them chain to a wire that is connected to a ground. A ground can be a water pipe (cold-right where it comes into the building, is the best), a radiator, an electrical conduit or a copper rod or pipe driven into the ground (4-8 feet deep). Ideally, the ground is different than the grounding rods being used for the antenna and transmitter.



WHEN THE FCC KNOCKS ON YOUR DOOR

Note: The following discussion assumes that you are not a licensed broadcaster.

Q: If FCC agents knock on my door and say they want to talk with me, do I have to answer their questions?

A: No. You have a right to say that you want a lawyer present when and if you speak with them, and that if they will give you their names, you will be back in touch with them. Unless you have been licensed to broadcast, the FCC has no right to "inspect" your home.

Q: If they say they have a right to enter my house without a warrant to see if I have broadcasting equipment, do I have to let them in?

A: No. Under Section 303(n) of Title 47 U.S.C., the FCC has a right to inspect any transmitting devices that must be licensed under the Act. Nonetheless, they must have permission to enter your home, or some other basis for entering beyond their mere supervisorial powers. With proper notice, they do have a right to inspect your communications devices. If they have given you notice of a pending investigation, contact a lawyer immediately.

Q: If they have evidence that I am "illegally" broadcasting from my home, can they enter anyway, even without a warrant or without my permission?

A: They will have to go to court to obtain a warrant to enter your home. But, if they have probable cause to believe you are currently engaging in illegal activities of any sort, they, with the assistance of the local police, can enter your home without a warrant to prevent those activities from continuing. Basically, they need either a warrant, or probable cause to believe a crime is going on at the time they are entering your home.

Q: If I do not cooperate with their investigation, and they threaten to arrest me, or have me arrested, should I cooperate with them?

A: If they have a legal basis for arresting you, it is very likely that they will prosecute you regardless of what you say. Therefore, what you say will only assist them in making a stronger case against you. Do not speak to them without a lawyer there.

Q: If they have an arrest or a search warrant, should I let them in my house?

A: Yes. Give them your name and address, and tell them that you want to have your lawyer contacted immediately before you answer any more questions. If you are arrested, you have a right to make several telephone calls within 3 hours of booking.

Q: Other than an FCC fine for engaging in illegal transmissions, what other risks do I take in engaging in micro-radio broadcasts.

A: Section 501 of the Act provides that violations of the Act can result in the imposition of a $10,000 fine or by imprisonment for a term not exceeding one year, or both. A second conviction results in a potentially longer sentence. If you are prosecuted under this section of the Act, and you are indigent (unable to hire an attorney), the court will have to appoint one for you.

Q: Are there any other penalties that can be imposed upon me for "illegal broadcasts?"

A: Under Section 510 of the Act, the FCC can attempt to have your communicating equipment seized and forfeited for violation of the requirements set forth in the Act. Once again, if they attempt to do this, you will be given notice of action against you, and have an opportunity to appear in court to fight the FCC's proposed action. Realize, though, that they will try to keep your equipment and any other property they can justify retaining until the proceedings are completed. You have a right to seek return of your property from the court at any time.

Q: If the FCC agents ask me if I knew I was engaged in illegal activities, should I deny any knowledge of FCC laws or any illegal activities?

A: No. You will have plenty of time to answer their accusations after you have spoken with an attorney. It is a separate crime to lie to law enforcement officials about material facts. Remain silent.

This antenna is made from 1/2" copper tubing and it is soldered together with plumbing Tees, elbows, and nipples.

J-Pole Antenna tuned for 89 Mhz in the FM broadcast band
G. Forrest Cook WB0RIO

Based on the 146 Mhz design by Ed Humphries, N5RCK

It is possible to get a 1:1 SWR reading with this antenna. Move the coax clamps up and down in parallel for the minimum SWR then trim the length of the long element for resonance. To find the resonance point of the antenna, sweep the FM-10A VFO while observing the SWR. It will be minimum at the resonant point. Shortening the antenna will raise the resonant frequency. Use minimal power so as not to interfere with anybody and never exceed the legal ERP limit. All antenna tests should be done in a clear area, preferably where the antenna will permanently reside.

Q: If I am considering broadcasting over micro-radio, is there anything I can do ahead of time to minimize the likelihood of prosecution?

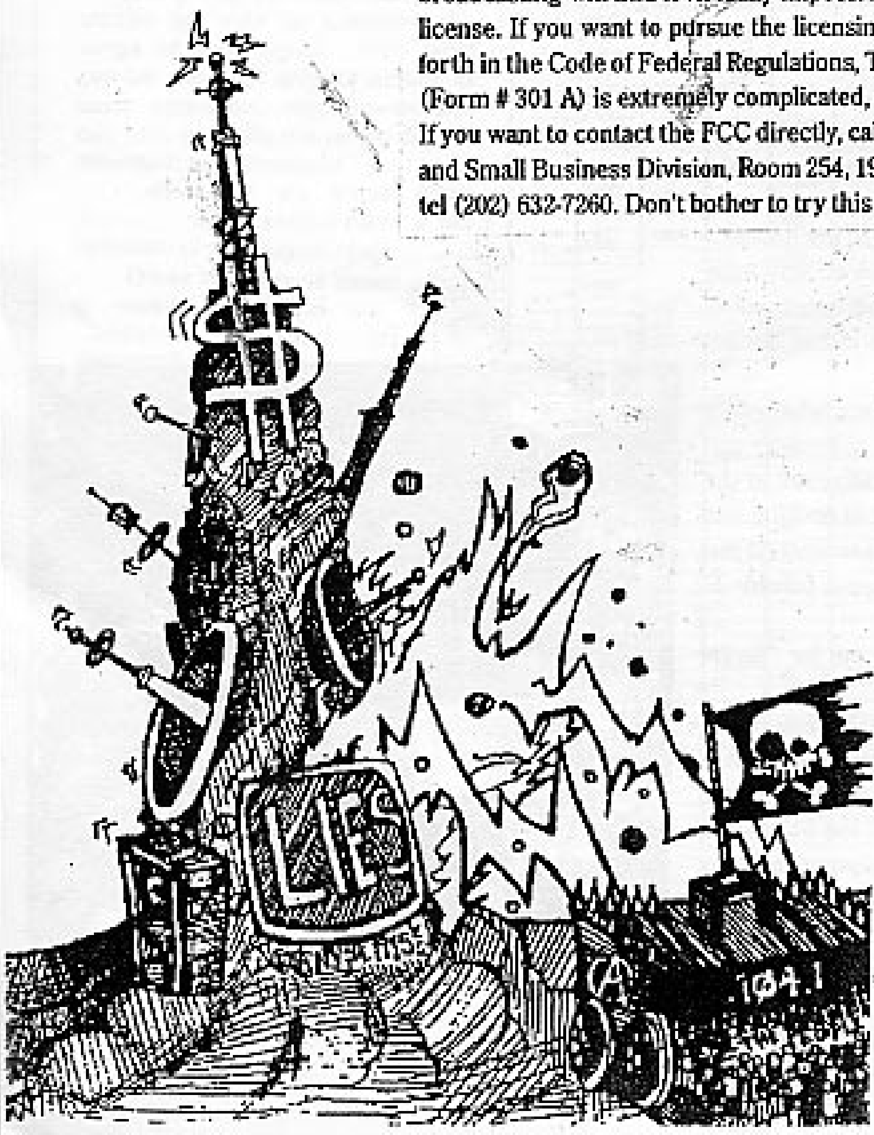
A: Yes. Speak with an attorney before you are approached by law enforcement to discuss the different aspects of FCC law. Arrange ahead of time for someone to represent you when and if the situation arises, so that you will already have prepared a strategy of defense.

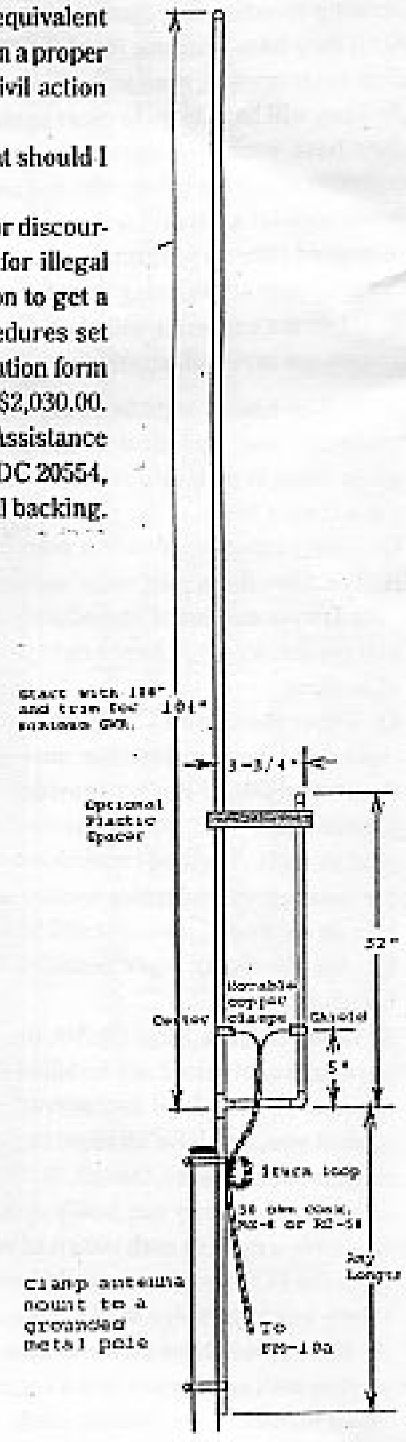
Q: What can I do if the FCC agents try to harass me by going to my landlord, or some other source to apply pressure on me?

A: So long as there is no proof that you have violated the law, you cannot be prosecuted or evicted. If there is evidence of misconduct, you might have to defend yourself in court. Depending upon what the FCC said or did, you might be able to raise a defense involving selective prosecution or other equivalent argument. If the conduct of the agents is clearly harassment, rather than a proper investigation, you can file a complaint with the FCC or possibly a civil action against them.

Q: If I want to legally pursue FCC licensing for a new FM station, what should I do?

A: It isn't the purpose of this question and answer guide to advocate or discourage non-licensed broadcast operations. A person cited by the FCC for illegal broadcasting will find it virtually impossible to later obtain permission to get a license. If you want to pursue the licensing procedure, see the procedures set forth in the Code of Federal Regulations, Title 47, Part 73. The application form (Form # 301 A) is extremely complicated, and requires a filing fee of $2,030.00. If you want to contact the FCC directly, call them at their Consumer Assistance and Small Business Division, Room 254, 1919 N St. NW, Washington, DC 20554, tel (202) 632-7260. Don't bother to try this without significant financial backing.





Federal Communications Commission
Compliance and Information Bureau
1550 Northwest Highway
Park Ridge, Illinois 60068

May 29, 1997

CERTIFIED MAIL NO. P583 182 965
<u>RETURN RECEIPT REQUESTED</u>

FILE: 97-0527

Mr. J.

Milwaukee, WI 532

Dear Mr. :

We have information that you are operating on FM Broadcast Radio frequencies. You do not posses a licence to operate on the FM Broadcast Radio frequencies. You are apparently operating in violation of Section 301 of the Communications Act of 1934, as amended, (47 U.S.C. 301).

Under the Communications Act and the Commission's Rules and Regulations, radio transmitting apparatus, other than certain low powered devices operated in accordance with Part 15 of the Commission's Rules and Regulations, may be operated only upon issuance by this Commission of a station license covering such apparatus. Unlicensed operation may subject the operator to serious penalties provided for in the Communications Act.

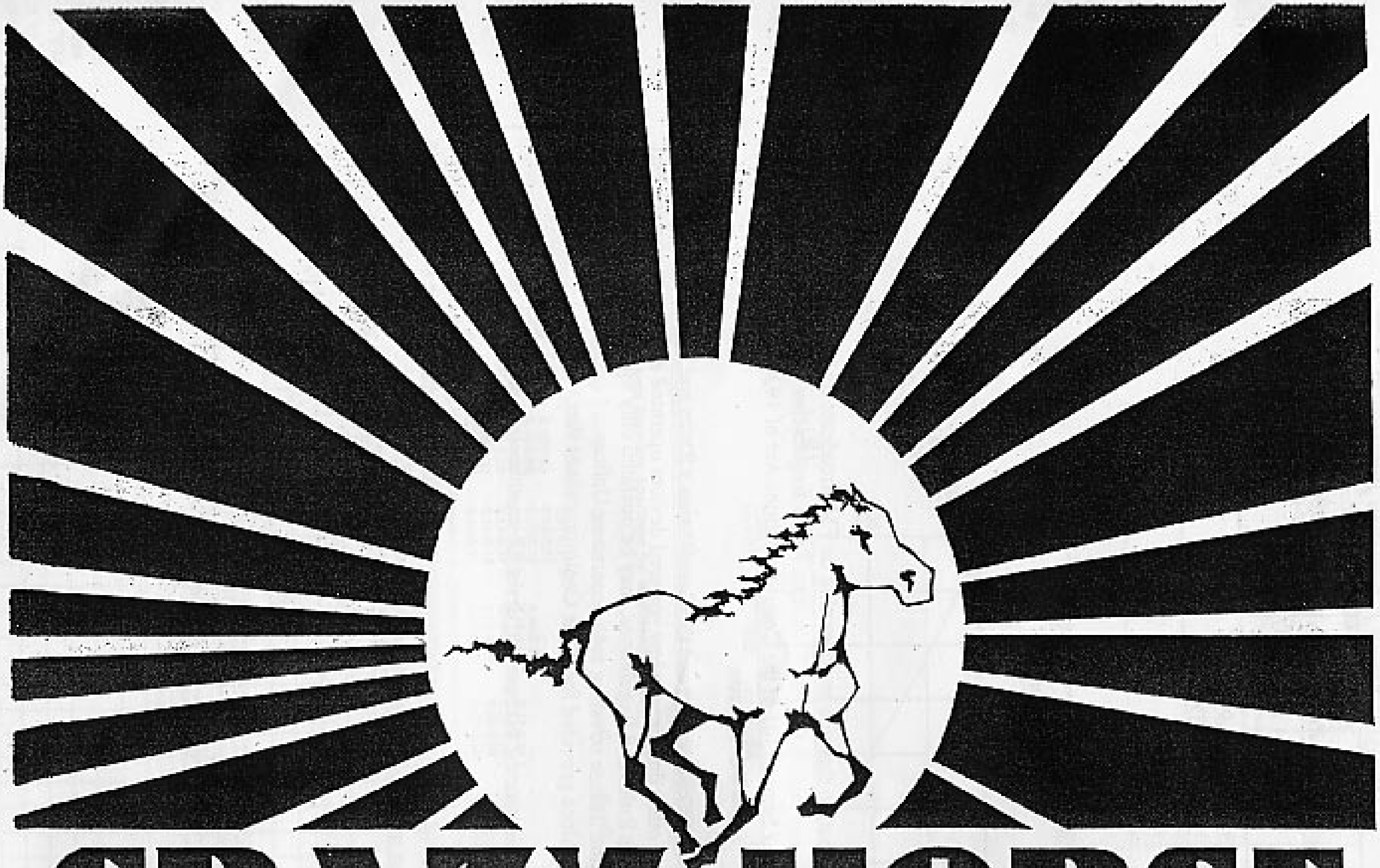
You are hereby instructed to cease and desist all unauthorized broadcast operation immediately.

Any comments which you would like placed in this file may be sent to the above address. When replying, please make reference to File Number 97-0527.

Sincerely,

G. Michael Moffitt
District Director

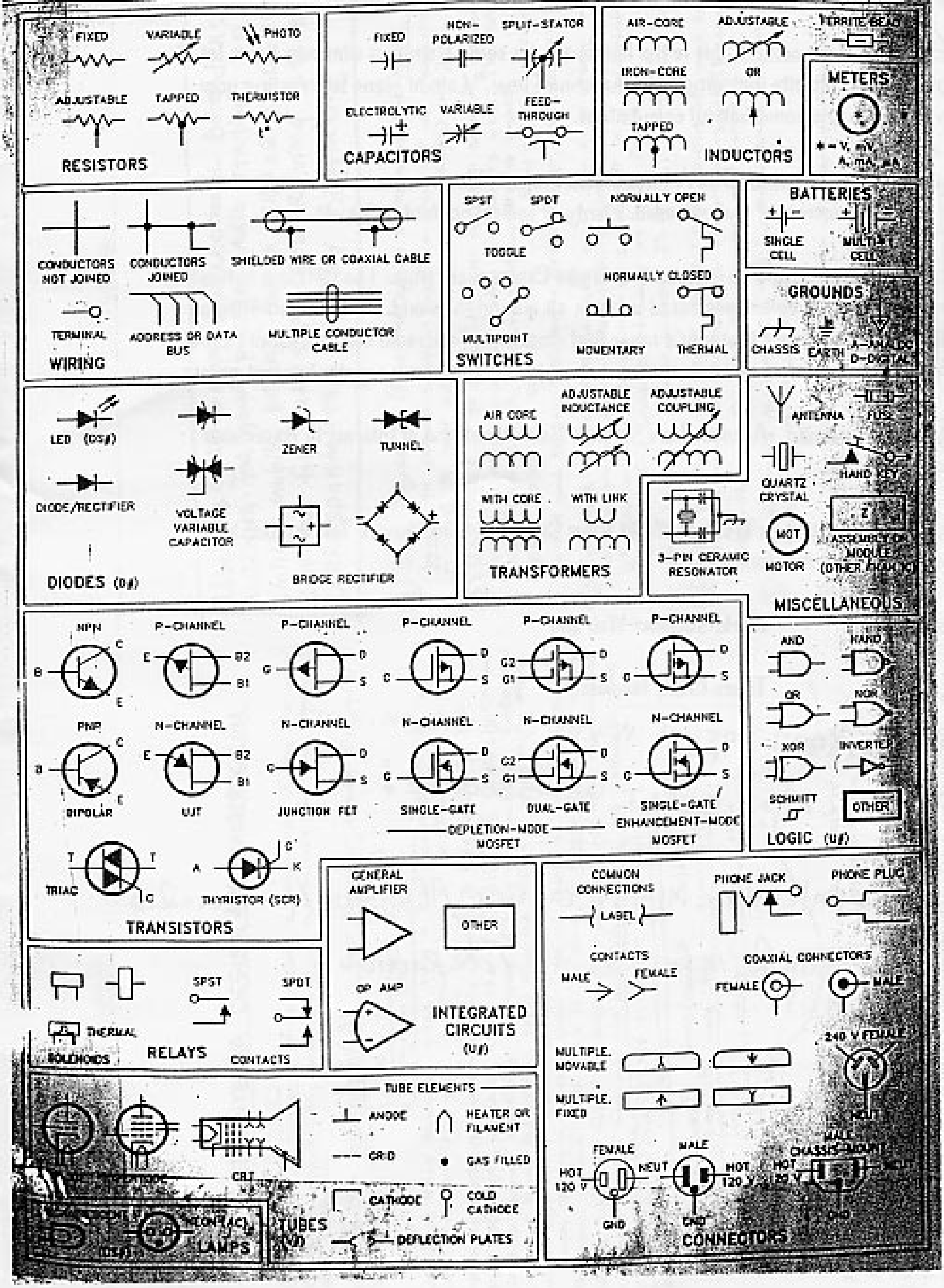
cc: Sent First Class Mail



CRAZY HORSE RADIO

Crazy Horse Radio was conceived inside Wounded Knee II 1973 as a way to run around Uncle Sam's stupidity, born in the attic of Nottingham Co-Op of Madison Wisconsin 1974, and broadcast round-the-clock for 2000 hours when the Menominee repossessed the Alexian Brothers Abbey at the biginning of 1975. Micmac AIM sister Anna Mae was a D J.

Schematic Symbols



Online Resources

Http://Members.home.net/ac31 this is the homepage for some Ham guy who sure has a lot of helpful info on his site including "The Antenna Elmer," Lots of plans for creating your own antennae and some helpful calculations.

http://www.radio4all.org/radio The A-Infos Radio Project. This site has a lot of radio shows that people have created and uploaded. Plenty of radical content, news etc.

http://www.indymedia.org The Independent Media Center main page. The IMC is a network of autonomous media collectives based in cities all around the world. Plenty of uncensored audio content and news that you'd never find elsewhere. Free radio stations ideally should be broadcasting a lot of this information to people who don't have regular internet access.

http://www.tao.ca/ainfos A-Infos News Service. News about and of interest to Anarchists around the world.

http://www.workers.org/ww Workers World News Service, I think they're Trotskyites, but some of the news is interesting...

http://wsws.org World Socialist Web site

http://rwor.org Those Crazy Maoists

OH yeah, don't forget www.theonion.com, AMERICA'S FINEST NEWSSOURCE!

Suppliers

http://www.ldbrewer.com LD Brewer is probably the main supplier of free-radio equipment on this continent. He sells kits and pre-assembled hardware from a variety of manufacturers for inflated prices and uses the money to fund his FACTS: First Amendment Church of Truth and Scientology. He ran a huge station with a giant antenna tower in his back yard until the feds carried out an armed raid of his house and stole all his gear and a picture of Jesus. The benefit of buying through Doug Brewer is that you can usually get stuff faster from him than from the UK, but only if he likes you. Try visiting the manufacturers websites first.

http://www.vernoica.co.uk Veronica Kits—One of my favorites, they sell easy to construct kits that are both inexpensive and highly stable. It takes a while to get equipment shipped form the UK, but if you have the time, its worth the wait. I've never had problems with customs yet.

http://nrgkits.fm NRG Kits used to be part of Veronica or something like that. Similar stuff, I've never ordered from them, but they're out there.

http://palstarinc.com Palstar Inc. is a Ham radio supplier but they're SWR/Power meters are excellent and cheap. Make sure you get one that covers the FM frequency range (88-108MHz). I like the WM150, its ideal for free radio, and sold cheaper here than through Brewer.

Http://www.broadcastwarehouse.com Broadcast Warehouse, also in the UK, sells an excellent 1 Watt exciter that competes with the Veronica exciters at a similar price ($135 for a kit). Also, they're great about repairing their old equipment, so if it breaks you can ship it back to them and they'll fix it cheap.

http://www.progressive-concepts.com Progressive Concepts, good broadcast equipment cheap. Especially the Comet CFM-9 5/8 Wave groundplane antenna for $110.

Recommended Reading

Seizing the Airwaves, Edited by Stephen Dunifer and Ron Sakolsky. This book covers a lot of the radical history of illegal radio broadcasting, and has a small technical section in the back from which I borrowed some material for this zine.

Free Radio, Electronic Civil Disobedience, by Larry Soley. This is an excellent history of the free radio movement and it covers things that *Seizing* leaves out. The author is a communications professor at Marquette University in Milwaukee, WI and always supports his local pirates.

Zeke Teflon's Guide to Pirate Radio, by Zeke Teflon. An excellent tech guide with lots of schematics for transmitters, amplifiers, antennae etc. It's a little old, but still very cool.

Pirate Radio Operations, by Andrew Yoder. Another tech guide with some discussions About mobile broadcasting and other interesting topics. Look for the dramatic image on the cover...

Now You're Talking, compiled by the Amateur Radio Relay League. I blatantly plagiarized a lot from this book. It's a guide for amateur (HAM) radio operators to get their first license. Ham radio is two-way communication over radio so it's not technically broadcasting, but all of the info is the same. This book has coherent and in-depth explanations of radio physics, electronics, safety, and just about everything else technical. If you want to learn it, or just want a solid reference, this is the book. There are also several other technical guides for more advanced licenses so if you really wanted you could learn a hell of a lot about radio from these books. They're usually sold at radio shack or you can order them from ARRL.org. Don't tell ham operators what you're doing though, they're usually real assholes about this stuff.

3 Meter Revolt, a zine by Free Radio Cascadia. I took their Yagi and low-pass filter designs and included it here. It's a pretty good tech zine and has a few cool stories about free radio in it.

33 1/3 (A Full Revolution) put out by Free Radio Bob and later The Wireless Virus. I used the J-pole antenna design and the letter from the FCC from it. It's a pretty cool little zine, but I have no idea where you'll find it. Count yourself lucky if you got a copy.

Glossary of Key Words

AC power-line filter—A filter connected in the power line to an amateur transmitter or transceiver. It keeps RF energy from entering the power line and radiating from power lines near a house. A line filter in the power line to other electronic devices will keep unwanted RF energy from entering them as well.

Alternating current (ac)—Electrical current that flows first in one direction in a wire and then in the other. The applied voltage is also changing polarity. This direction reversal continues at a rate that depends on the frequency of the ac.

Alternator—A machine used to generate alternating-current electricity.

Amateur operator—A person holding a written authorization to be the control operator of an amateur station.

Amateur service—A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest. (*Pecuniary* means payment of any type, whether money or other goods.)

Amateur station—A station licensed in the amateur service, including necessary equipment, used for amateur communication.

Ampere (A)—The basic unit of electrical current, equal to 6.24×10^{18} electrons moving past a point in one second.[1] We abbreviate amperes as *amps*.

Amplifier—A device usually employing electron tubes or transistors to increase the voltage, current or power of a signal. The amplifying device may use a small signal to control voltage and/or current from an external supply. A larger replica of the small input signal appears at the device output.

Amplitude modulation (AM)—A method of combining an information signal and an RF (radio-frequency) carrier. In double-sideband voice AM transmission, we use the voice information to vary (modulate) the amplitude of an RF carrier. Shortwave broadcast stations use this type of AM, as do stations in the Standard Broadcast Band (540-1600 kHz). Few amateurs use double-sideband voice AM, but a variation, known as *single sideband*, is very popular.

AMTOR (Amateur Teleprinting Over Radio)—A form of **radioteletype** that provides error-detecting capabilities. See **Automatic Repeat Request, Forward Error Correction and Selective-call identifier.**

Antenna—A device that picks up or sends out radio waves.

Antenna switch—A switch used to connect one transmitter, receiver or transceiver to several different antennas.

ASCII (American National Standard Code for Information Interchange)—A seven-bit digital code used in computer and radioteleprinter applications.

[1]Numbers written as a multiple of some power are expressed in *exponential notation*. This notation is explained in detail on page 3-2.

Atom—A basic building block of all matter. Inside an atom there is a positively charged, dense, central core surrounded by a "cloud" of negatively charged electrons. There are the same number of negative charges as there are positive charges, so the atom is electrically neutral.

Attenuate—To reduce in amplitude.

Audio frequency (AF)—The range of frequencies that the human ear can detect. Audio frequencies are usually listed as 20 Hz to 20,000 Hz.

Audio-frequency shift keying (AFSK)—A method of transmitting radioteletype information. Two switched audio tones are fed into the microphone input. AFSK RTTY is most often used on VHF.

Automatic Repeat reQuest (ARQ)—An AMTOR communication mode. In ARQ, also called Mode A, the two stations constantly confirm each other's transmissions. If information is lost, it is repeated until the receiving station confirms correct reception.

Autopatch—A device that allows repeater users to make telephone calls through a repeater.

A1A emission—The FCC emission designator used to describe Morse code telegraphy (CW) by on/off keying of a radio-frequency signal.

Backscatter—A small amount of signal that is reflected from the Earth's surface after travelling through the ionosphere. The reflected signal may go back into the ionosphere along several paths and be refracted to Earth again. Backscatter can help provide communications into a station's **skip zone.**

Balun—Contraction for *balanced to unbalanced*. A device to couple a balanced load to an unbalanced source, or vice versa.

Band-pass filter—A circuit that allows signals to go through it only if they are within a certain range of frequencies. It attenuates signals above and below this range.

Band spread—A receiver quality used to describe how far apart stations on different nearby frequencies will seem to be. We usually express band spread as the number of kilohertz that the frequency changes per tuning-knob rotation. Band spread and **frequency resolution** are related. The amount of band spread determines how easily signals can be tuned.

Bandwidth—The range of frequencies that will pass through a given filter. For a signal, bandwidth is the width of the frequency band outside of which the mean power of the total emission is attenuated at least 26 dB below the mean power of the total emission, including allowances for transmitter drift or Doppler shift.

Battery—A device that stores electrical energy. It provides excess electrons to produce a current and the voltage or EMF to push those electrons through a circuit.

Baud—The unit used to describe the transmission speed of a digital signal. For a single-channel signal, one baud is equal to one digital bit per second.

Baudot—A five-bit digital code used in teleprinter applications.

Beacon station—An amateur station transmitting communications for the purposes of observation of propagation and reception of other related experimental activities.

Beam antenna—A directional antenna. A beam antenna must be rotated to provide coverage in different directions.

Beat-frequency oscillator (BFO)—An oscillator that provides a signal to the product detector. In the product detector, the BFO signal and the IF signal are mixed to produce an audio signal.

Bleeder resistor—A large resistor connected across the output of a power supply. The bleeder discharges the filter capacitors when the supply is turned off.

Block diagram—A drawing using boxes to represent sections of a complicated device or process. The block diagram shows the connections between sections.

Breakdown voltage—The voltage that will cause a current in an insulator. Different insulating materials have different breakdown voltages. Breakdown voltage is also related to the thickness of the insulating material.

Broadcasting—Transmissions intended to be received by the general public, either direct or relayed.

Calling frequencies—Frequencies set aside for establishing contact. Once two stations are in contact, they should move their QSO to an unoccupied frequency.

Capacitor—An electronic component composed of two or more conductive plates separated by an insulating material.

Carbon-composition resistor—An electronic component designed to limit current in a circuit; made from ground carbon mixed with clay.

Carbon-film resistor—A resistor made by depositing a gaseous carbon deposit on a round ceramic form.

Ceramic capacitor—An electronic component composed of two or more conductive plates separated by a ceramic insulating material.

Centi—The metric prefix for 10^{-2}, or divide by 100.

Characteristic impedance—The opposition to electric current that an antenna feed line presents. Impedance includes factors other than resistance, and applies to alternating currents. Ideally, the characteristic impedence of a feed line is the same as the transmitter output impedance and the antenna input impedance.

Chassis ground—The common connection for all parts of a circuit that connect to the negative side of the power supply.

Chirp—A slight shift in transmitter frequency each time you key the transmitter.

Coaxial cable—coax (pronounced ko'-aks). A type of feed line with one conductor inside the other.

Color code—A system in which numerical values are assigned to various colors. Colored stripes are painted on the body of resistors and sometimes other components to show their value.

Communications terminal—A computer-controlled device that demodulates RTTY and CW for display by a computer or ASCII terminal. The communications terminal also accepts information from a computer or terminal and modulates a transmitted signal.

Computer-Based Message System (CBMS)—A system in which a computer is used to store messages for later retrieval. Also called a RTTY mailbox.

Conductor—A material that has a loose grip on its electrons, so that an electrical current can pass through it.

Connected—The condition in which two packet-radio stations are sending information to each other. Each is acknowledging when the data has been received correctly.

Contests—On-the-air operating events. Different contests have different objectives: contacting as many other amateurs as possible in a given amount of time, contacting amateurs in as many different countries as possible or contacting an amateur in each county in one particular state, to name only a few.

Continuous wave (CW)—Morse code telegraphy.

Control operator—An amateur operator designated by the licensee of a station to be responsible for the transmissions of an amateur station.

Control point—The place where the control function takes place.

Coordinated Universal Time (UTC)—A system of time referenced to time at the prime meridian, which passes through Greenwich, England.

Core—The material used in the center of an inductor coil.

CQ—The general call when requesting a conversation with anyone.

Critical angle—If radio waves leave an antenna at an angle greater than the critical angle for that frequency, they pass through the ionosphere instead of returning to earth.

Critical frequency—The highest frequency at which a vertically incident radio wave returns from the ionosphere. Above the critical frequency, radio waves pass through the ionosphere into space.

Cubical quad antenna—An antenna built with its elements in the shape of four-sided loops.

Current—A flow of electrons in an electrical circuit.

Cutoff frequency—In a high-pass, low-pass or band-pass filter, the cutoff frequency is the frequency at which the filter output is reduced to ½ of the power available at the filter input.

D layer—The lowest layer of the ionosphere. The D layer contributes very little to short-wave radio propagation. It acts mainly to absorb energy from radio waves as they pass through it. This absorption has a significant effect on signals below about 7.5 MHz during daylight.

Detector—The stage in a receiver in which the modulation (voice or other information) is recovered from the RF signal.

Delta loop antenna—A variation of the cubical quad with triangular elements.

Deviation ratio—The ratio between the maximum change in RF-carrier frequency and the highest modulating frequency used in an FM transmitter.

Dielectric—The insulating material used between the plates in a capacitor.

Dielectric constant—A number used to indicate the relative "merit" of an insulating material. Air is given a value of 1, and all other materials are related to air.

Digipeater—A packet-radio station used to retransmit signals that are specifically addressed to be retransmitted by that station.

Dipole antenna—See **Half-wave dipole**. A dipole need not be ½ wavelength long.

Direct-conversion receiver—A receiver that converts an RF signal directly to an audio signal with one mixing stage.

Direct current (dc)—Electrical current that flows in one direction only.

Directivity—The ability of an antenna to focus transmitter power into certain directions. Also its ability to enhance received signals from specific directions.

Director—An element in front of the **driven element** in a Yagi and some other directional antennas.

Direct waves—Radio waves that travel directly from a transmitting antenna to a receiving antenna. Also called "line-of-sight" communications.

Double-pole, double-throw (DPDT) switch—A switch that has six contacts. The DPDT switch has two center contacts. The two center contacts can each be connected to one of two other contacts.

Driven element—The part of an antenna that connects directly to the feed line.

Duct—A radio waveguide formed when a temperature inversion traps radio waves within a restricted layer of the atmosphere.

Dummy load (dummy antenna)—A device used when you want to test or tune a transceiver without sending a signal out over the air. Instead of sending the signal to an antenna, you send it to the dummy load, which dissipates (gets rid of) the output power.

DX—Distance; foreign countries.

DX Century Club (DXCC)—A prestigious award given to amateurs who can prove contact with amateurs in at least 100 DXCC countries.

E layer—The second lowest ionospheric layer, the E layer exists only during the day. Under certain conditions it may refract radio waves back to Earth.

Earth ground—A circuit connection to a cold-water pipe or to a ground rod driven into the earth.

Earth station—An amateur station located on, or within 50 km of, the Earth's surface intended for communications with space stations or with other Earth stations by means of one or more objects in space.

Electric field—An invisible force of nature. An electric field exists in a region of space if an electrically charged object placed in the region is subjected to an electrical force.

Electrolytic capacitor—A polarized capacitor formed by using thin foil electrodes and chemical-soaked paper.

Electromotive force (EMF)—The force or pressure that pushes a current through a circuit.

Electron—A tiny, negatively charged particle, normally found in an area surrounding the nucleus of an atom. Moving electrons make up an electrical current.

Electronic keyer—A device that generates Morse code dots and dashes electronically.

Emission—The transmitted signal from an amateur station.

Emission privilege—Permission to use a particular emission type (such as Morse code or voice).

Energy—The ability to do work; the ability to exert a force to move some object.

False or deceptive signals—Transmissions that are intended to mislead or confuse those who may receive the transmissions. For example, distress calls transmitted when there is no actual emergency are false or deceptive signals.

F layer—A combination of the two highest ionospheric layers, the F1 and F2 layers. The F layer refracts radio waves and returns them to Earth. The height of the F layer varies greatly depending on the time of day, season of the year and amount of sunspot activity.

Feed line—The wires or cable used to connect your transceiver to an antenna. See **Transmission line**.

Field Day—An annual event in which amateurs set up stations in outdoor locations. Emergency power is also encouraged.

Field-effect transistor volt-ohm-milliammeter (FET VOM)—A type of multimeter. The meter circuit uses an FET amplifier to provide more accurate readings than can be obtained with a VOM. The FET VOM is the solid-state equivalent of a VTVM.

Fills—Repeats of parts of a previous transmission—usually requested because of interference.

Filter—A circuit that will allow some signals to pass through it but will greatly reduce the strength of others.

Fixed resistor—A resistor with a fixed nonadjustable value of resistance.

Forward Error Correction (FEC)—A mode of AMTOR communication. In FEC mode, also called Mode B, each character is sent twice. The receiving station checks the mark/space ratio of the received characters. If an error is detected, the receiving station prints a space to show that an incorrect character was received.

Frequency—The number of complete cycles of an alternating current that occur per second.

Frequency bands—A group of frequencies where communications of a particular service, such as the amateur service, are authorized.

Frequency Coordinator—A volunteer who keeps records of repeater input, output and control frequencies.

Frequency deviation—The amount the carrier frequency in an FM transmitter changes as it is modulated.

Frequency modulation—The process of varying the frequency of an RF carrier in response to the instantaneous changes in the modulating signal.

Frequency privilege—Permission to use a particular group of frequencies.

Frequency-shift keying (FSK)—A method of transmitting radioteletype information by switching an RF carrier between two separate frequencies. FSK RTTY is most often used on HF.

Fundamental frequency—The desired operating frequency of an oscillator.

Fuse—A thin strip of metal mounted in a holder. When too much current passes through the fuse, the metal strip melts and opens the circuit.

F1B emission—The FCC emission designator used to describe frequency-shift keyed (FSK) digital communications.

F2B emission—The FCC emission designator used to describe audio-frequency shift keyed (AFSK) digital communications.

F3E emission—The FCC emission designator used to describe FM voice communications.

Gain—A measure of the directivity of an antenna.

Gamma match—A method of matching coaxial feed line to the driven element of a multielement array.

General-coverage receiver—A receiver used to listen to a wide range of frequencies. Most general-coverage receivers tune from frequencies below the standard-broadcast band to at least 30 MHz. These frequencies include the shortwave-broadcast bands and the amateur bands from 160 to 10 meters.

Giga—The metric prefix for 10^9, or times 1,000,000,000.

Grace period—The time FCC allows following the expiration of an amateur license to renew that license without having to retake an examination. Those who hold an expired license may not operate an amateur station until the license is reinstated.

Grid—The control element (or elements) in a vacuum tube.

Ground connection—A connection made to the earth for electrical safety.

Ground waves—Radio waves that travel along Earth's surface.

Guided propagation—Radio propagation by means of ducts in the atmosphere.

Half-wave dipole—A basic antenna used by radio amateurs. It consists of a length of wire or tubing, opened and fed at the center. The entire antenna is ½ wavelength long at the desired operating frequency.

Ham-bands-only receiver—A receiver designed to cover only the bands used by amateurs. Usually refers to the bands from 80 to 10 meters, sometimes including 160 meters.

Hand key—A simple switch used to send Morse code.

Harmonics—Signals from a transmitter or oscillator occurring on whole-number multiples of the desired operating frequency.

Hertz (Hz)—An alternating-current frequency of one cycle per second. The basic unit of frequency.

High-pass filter—A filter designed to pass high-frequency signals, while blocking lower-frequency signals.

Horizontally polarized wave—An electromagnetic wave with its electric lines of force parallel to the ground.

Impedance-matching network—A device that matches the impedance of an antenna system to the impedance of a transmitter or receiver. Also called an antenna-matching network or Transmatch.

Input frequency—A repeater's receiving frequency.

Insulator—A material that maintains a tight grip on its electrons, so that an electrical current cannot pass through it.

Intermediate frequency (IF)—The output frequency of a mixing stage in a superheterodyne receiver. The subsequent stages in the receiver are tuned for maximum efficiency at the IF.

Inverted-V dipole—A half-wave dipole antenna with its center elevated and the ends drooping toward the ground. Often called an inverted V.

Ion—An electrically charged particle. An electron is an ion. Another example of an ion is the nucleus of an atom that is surrounded by too few or too many electrons. An atom like this has a net positive or negative charge.

Ionosphere—A region of charged particles about 30 to 260 miles above the Earth. The ionosphere bends radio waves as they travel through it, returning them to Earth.

J3E emission—The FCC emission designator used to describe single-sideband, suppressed-carrier voice communications.

Key clicks—A click or thump at the beginning or end of a CW signal.

Kilo—The metric prefix for 10^3, or times 1000.

Ladder line—Parallel-conductor feeder with insulating spacer rods every few inches.

Line of sight—The term used to describe VHF and UHF propagation in a straight line directly from one station to another.

Lower sideband (LSB)—The common single-sideband operating mode on the 40, 80 and 160-meter amateur bands.

Low-pass filter—A filter designed to pass low-frequency signals, while blocking higher-frequency signals.

Major lobe—The shape or pattern of field strength that points in the direction of maximum radiated power from an antenna.

Malicious interference—Intentional, deliberate obstruction of radio transmissions.

Matching network—A device that matches one impedance level to another. For example, it may match the impedance of an antenna system to the impedance of a transmitter or receiver. Amateurs also call such devices a Transmatch, impedance-matching network or match box.

Maximum usable frequency (MUF)—The greatest frequency at which radio signals will return to a particular location from the ionosphere. The MUF may vary for radio signals sent to different destinations.

MAYDAY—From the French "m'aider" (help me), MAYDAY is used when calling for emergency assistance in voice modes.

Mega—The metric prefix for 10^6, or times 1,000,000.

Metal-film resistor—A resistor formed by depositing a thin layer of resistive-metal alloy on a cylindrical ceramic form.

Metric prefixes—A series of terms used in the metric system of measurement. We use metric prefixes to describe a quantity as compared to a basic unit. The metric prefixes indicate multiples of 10.

Metric system—A system of measurement developed by scientists and used in most countries of the world. This system uses a set of prefixes that are multiples of 10 to indicate quantities larger or smaller than the basic unit.

Mica capacitor—A capacitor formed by alternating layers of metal foil with thin sheets of insulating mica.

Micro—The metric prefix for 10^{-6}, or divide by 1,000,000.

Microphone—A device that converts sound waves into electrical energy.

Milli—The metric prefix for 10^{-3}, or divide by 1000.

Mixer—A circuit used to combine two or more audio- or radio-frequency signals to produce a different output frequency.

Modem—Short for modulator/demodulator. A modem modulates a radio signal to transmit data and demodulates a received signal to recover transmitted data.

Modulate—To vary the amplitude, frequency, or phase of a radio-frequency signal.

Modulation index—The ratio between the maximum carrier frequency deviation and the frequency of the modulating signal at a given instant in an FM transmitter.

Monitor mode—One type of packet-radio receiving mode. In monitor mode, everything transmitted on a packet frequency is displayed by the monitoring TNC. This occurs whether the transmissions are addressed to the monitoring station or not.

Multiband antenna—An antenna that will operate well on more than one frequency band.

Multimeter—An electronic test instrument used to measure current, voltage and resistance in a circuit. Describes all meters capable of making these measurements, such as the **VOM**, **VTVM** and **FET VOM**.

Multimode transceiver—Transceiver capable of SSB, CW and FM operation.

Mutual coupling—When coils display mutual coupling, a current flowing in one coil will induce a voltage in the other. The magnetic flux of one coil passes through the windings of the other.

Negative Charge—One of two types of electrical charge. The electrical charge of a single electron.

Nets—Groups of amateurs who meet on the air to pass traffic or communicate about a specific subject. One station (called the *net control station*) usually directs the net.

Network—A term used to describe several packet stations linked together to transmit data over long distances.

Neutral—Having no electrical charge, or having an equal number of positive and negative charges.

Neutralization—A method of preventing oscillation in an amplifier stage.

Nucleus—The dense central portion of an atom. The nucleus contains positively charged particles.

Offset—The 300- to 1000-Hz difference in transmitting and receiving frequencies in a transceiver. For a repeater, offset refers to the difference between its transmitting and receiving frequencies.

Ohm—The basic unit of electrical resistance, used to describe the amount of opposition to current.

Ohm's Law—A basic law of electronics. Ohm's Law gives a relationship between voltage, resistance and current ($E = IR$).

Omnidirectional—Antenna characteristic meaning it radiates equal power in all compass directions.

One-way communications—Transmissions that are not intended to be answered. The FCC strictly limits the types of one-way communications allowed on the amateur bands.

Open circuit—An electrical circuit that does not have a complete path, so current can't flow through the circuit.

Open-wire feed line—Parallel-conductor feeder with air as its primary insulation material.

Operator license—The portion of an Amateur Radio license that gives permission to operate an amateur station.

Oscillator—A circuit built by adding positive feedback to an amplifier. It produces an alternating current signal with no input except the dc operating voltages.

Output frequency—A repeater's transmitting frequency.

Packet Bulletin-Board System (PBBS)—A computer system used to store packet-radio messages for later retrieval by other amateurs.

Packet radio—A communications system in which information is broken into short bursts. The bursts (packets) also contain addressing and error-detection information.

Paper capacitor—A capacitor formed by sandwiching paper between thin foil plates, and rolling the entire unit into a cylinder.

Parallel circuit—An electrical circuit where the electrons follow more than one path.

Parallel-conductor feed line—Feed line with two conductors held a constant distance apart.

Parasitic element—Part of a directive antenna that derives energy from mutual coupling with the driven element. Parasitic elements are not connected directly to the feed line.

Parasitics—Oscillations in a transmitter amplifier that are not related to the operating frequency.

Peak envelope power (PEP)—The average power supplied to the antenna transmission line during one RF cycle at the crest of the modulation envelope. Transmitter power is measured in terms of PEP.

Phase modulation—Varying the phase of an RF carrier in response to the instantaneous changes in the modulating signal.

Pico—The metric prefix for 10^{-12}, or divide by 1,000,000,000,000.

Plastic-film capacitor—A capacitor formed by sandwiching thin sheets of Mylar™ or polystyrene between thin foil plates, and rolling the entire unit into a cylinder.

Polarization—Describes the electrical-field characteristic of a radio wave. An antenna that is parallel to the surface of the earth, such as a dipole, produces horizontally polarized waves. One that is perpendicular to the earth's surface, such as a quarter-wave vertical, produces vertically polarized waves.

Positive charge—One of two types of electrical charge. A positive charge is the opposite of a negative charge. Electrons have a negative charge. The nucleus of an atom has a positive charge.

Potentiometer—Another name for a variable resistor. The value of a potentiometer can be changed without removing it from a circuit.

Power—The rate of energy consumption. We calculate power in an electrical circuit by multiplying the voltage applied to the circuit times the current through the circuit.

Power supply—That part of an electrical circuit that provides excess electrons to flow into a circuit. The power supply also supplies the voltage or EMF to push the electrons along. Power supplies convert a power source (such as the ac mains) to a useful form.

Procedural signal (prosign)—One or two letters sent as a single character. Amateurs use prosigns in CW QSOs as a short way to indicate the operator's intention. Some examples are K for "Go Ahead," or $\overline{AR}$ for "End of Message." (The bar over the letters indicates that we send the prosign as one character.)

Propagation—The means by which radio waves travel from one place to another.

Q signals—Three-letter symbols beginning with "Q." Q signals are used in amateur CW work to save time and for better communication.

QSL card—A postcard sent to another radio amateur to confirm a contact.

QSO—A conversation between two radio amateurs.

Quarter-wavelength vertical antenna—An antenna constructed of a quarter-wavelength long radiating element placed perpendicular to the earth.

Radiate—To convert electric energy into electromagnetic (radio) waves. An antenna radiates radio waves.

Radio frequency (RF)—The range of frequencies that can be radiated through space in the form of electromagnetic radiation. We usually consider RF to be those frequencies higher than the audio frequencies, or above 20 kilohertz.

Radio-frequency interference (RFI)—Disturbance to electronic equipment caused by radio-frequency signals.

Radio-path horizon—The point where radio waves are returned by tropospheric bending. The radio-path horizon is 15 percent farther away than the geometric horizon.

Radioteletype (RTTY)—Radio signals sent from one teleprinter machine to another machine. Anything that one operator types on his teleprinter will be printed on the other machine.

Ragchew—A lengthy conversation (or QSO) between two radio amateurs.

Random-length wire antenna—An antenna having a length that is not necessarily related to a wavelength for which it is used.

Reactance—The property of an inductor or capacitor (measured in ohms) that impedes current in an ac circuit without converting power to heat.

Reactance modulator—A device capable of modulating an ac signal by varying the reactance of a circuit in response to the modulating signal. (The modulating signal may be voice, data, video, or some other kind depending on what type of information is being transmitted.)

Receiver—A device that converts radio signals into audio signals.

Receiver incremental tuning (RIT)—A transceiver control that allows for a slight change in the receiver frequency without changing the transmitter frequency. Some manufacturers call this a clarifier (CLAR) control.

Receiver overload—Interference to a receiver caused by a strong RF signal that forces its way into the equipment. A signal that overloads the receiver RF amplifier (front end) causes *front-end overload*.

Reflected wave—A radio wave whose direction is changed when it bounces off some object in its path.

Reflector—An element behind the driven element in a Yagi and some other directional antennas.

Refract—To bend. Electromagnetic waves are refracted when they pass through a boundary between two different types of material, such as into or out of an ionospheric layer.

Repeater station—An amateur station that automatically retransmits the signals of other stations.

Resistance—The ability to oppose an electric current.

Resistor—Any material that opposes a current in an electrical circuit. An electronic component especially designed to oppose current.

Resolution—The space between markings on a receiver dial. The greater the frequency resolution, the easier it is to separate signals that are close together. Frequency resolution and **band spread** are related.

Resonant frequency—The desired operating frequency of a tuned circuit. In an antenna, the resonant frequency is one where the feed-point impedance contains only resistance.

RF burn—A flesh burn caused by exposure to a strong field of RF energy.

Rig—The radio amateur's term for a transmitter, receiver or transceiver.

Rotary switch—A switch that connects one center contact to several individual contacts. An antenna switch is one common use for a rotary switch.

Rotor—The movable plates in a variable capacitor.

RST—A system of numbers used for signal reports: R is readability, S is strength and T is tone.

Safety interlock—A switch that turns off ac power to a piece of equipment when someone removes the top cover.

Schematic symbol—A drawing used to represent a circuit component on a wiring diagram.

Secondary station identifier (SSID)—A number added to a packet-radio station's call sign so that one amateur call sign can be used for several packet stations.

Selective-call identifier—A four-character AMTOR station identifier.

Selectivity—The ability of a receiver to separate two closely spaced signals.

Semiconductor—Material that has some properties of a conductor and some properties of an insulator.

Sensitivity—The ability of a receiver to detect weak signals.

Series circuit—An electrical circuit where the electrons must all flow through every part of the circuit. There is only one path for the current to follow.

Shack—The room where an Amateur Radio operator keeps his or her station equipment.

Short circuit—An electrical circuit where the current does not take the desired path, but finds a shortcut instead. Often the current goes directly from the negative power-supply terminal to the positive one, bypassing the rest of the circuit.

Simplex operation—A term normally used in relation to VHF and UHF operation. Simplex means you are receiving and transmitting on the same frequency.

Sine wave—A smooth curve, usually drawn to represent the variation in voltage or current over time for an ac signal.

Single-pole, double-throw (SPDT) switch—A switch that connects one center contact to one of two other contacts.

Single-pole, single-throw (SPST) switch—A switch that only connects one center contact to another contact.

Single sideband (SSB)—A common mode of voice operation on the amateur bands. SSB is a form of amplitude modulation.

Skip—Radio waves that are bent back to Earth by the ionosphere. Skip is also called **sky-wave** propagation.

Skip zone—An area past the maximum range of ground waves and before the range of waves returned from the ionosphere. An area where radio communications between stations is not possible on a certain frequency.

Sky waves—Radio waves that travel through the ionosphere and back to Earth. Sky-wave propagation is sometimes called **skip**.

Sloper—A ½-wave dipole or ¼-wave end-fed antenna that has one end elevated and one end nearer the ground.

Solar-flux index—A measure of solar activity. The solar-flux index is a measure of the 2800-MHz radio noise from the sun.

Solid-state devices—Circuit components that use semiconductor materials. Semiconductor diodes, transistors and integrated circuits are all solid-state devices.

SOS—A Morse code call for emergency assistance.

Space station—An amateur station located more than 50 km above the Earth's surface.

Space wave—A radio wave arriving at the receiving antenna made up of a direct wave and one or more reflected waves.

Speech processor—A device that increases the average power of a sideband signal, making the voice easier to understand under weak signal conditions.

Splatter—The term used to describe a very wide-bandwidth signal. Splatter is usually caused by an improperly adjusted sideband transmitter.

Spurious emissions—Signals from a transmitter on frequencies other than the operating frequency.

Stability—A measure of how well a receiver or transmitter will remain on frequency without drifting.

Standing-wave ratio (SWR)—Sometimes called VSWR. A measure of the impedance match between the feed line and the antenna. Also, with a Transmatch in use, a measure of the match between the feed line from the transmitter and the antenna *system*. The system includes the Transmatch and the line to the antenna. VSWR is the ratio of maximum voltage to minimum voltage along the feed line. Also the ratio of antenna impedance to feed-line impedance when the antenna is a purely resistive load.

Station license—The portion of an Amateur Radio license that authorizes an amateur station at a specific location. The station license also lists the call of that station.

Stator—The stationary plates in a variable capacitor.

Subatomic particles—The building blocks of atoms. Electrons, protons and neutrons are the most common subatomic particles.

Sunspots—Dark spots on the surface of the sun. When there are few sunspots, long-distance radio propagation is poor on the higher-frequency bands.

Superheterodyne receiver—A receiver that converts RF signals to an intermediate frequency before detection.

Superimposed hum—A low-pitched buzz or hum on a radio signal.

Switch—A device used to connect or disconnect electrical contacts.

SWR meter—A measuring instrument that can indicate when an antenna system is working well.

Teleprinter—A machine that can convert keystrokes (typing) into electrical impulses. The teleprinter can also convert the proper electrical impulses back into text. Computers have largely replaced teleprinters for amateur radioteletype work.

Television interference (TVI)—Interruption of television reception caused by another signal.

Temperature inversion—A condition in the atmosphere in which a region of cool air is trapped beneath warmer air.

Temporary state of communications emergency—When a disaster disrupts normal communications in a particular area, the FCC can declare this type of emergency. Certain rules may apply for the duration of the emergency.

Terminal node controller (TNC)—A TNC accepts information from a computer and converts the information into packets. The TNC also receives packets and extracts information to be displayed by a computer.

Third-party communications—Messages passed from one amateur to another on behalf of a third person.

Third-party participation—The way an unlicensed person can participate in amateur communications. A control operator must ensure compliance with FCC rules.

Ticket—Commonly used name for an Amateur Radio license.

Toroidal inductor—A coil wound on a donut-shaped ferrite or powdered-iron form.

Traffic—Messages passed from one amateur to another in a relay system; the amateur version of a telegram.

Transceiver—A radio transmitter and receiver combined in one unit.

Transformer—A devic that changes ac voltage levels.

Transmatch—See **Matching network**.

Transmission line—The wires or cable used to connect a transmitter or receiver to an antenna.

Transmit-receive (TR) switch—A device that allows you to connect one antenna to a receiver and a transmitter. The switch connects the antenna to the receiver or transmitter as you operate the switch.

Transmitter—A device that produces radio-frequency signals.

Triode—A vacuum tube with three active elements: cathode, plate and control grid.

Troposphere—The atmospheric region just above the Earth's surface and below the ionosphere.

Tropospheric bending or **enhancement**—A weather-related phenomenon. A Tropo can produce unusually long-distance propagation on the VHF and UHF bands.

True or **Geometric Horizon**—The most distant point one can see by line of sight.

Twin lead—Parallel-conductor feed line with wires encased in insulation.

Unidentified communications or signals—Signals or radio communications in which the transmitting station's call sign is not transmitted.

Upper sideband (USB)—The common single-sideband operating mode on the 20, 17, 15, 12 and 10-meter HF amateur bands, and all the VHF and UHF bands.

Vacuum-tube voltmeter (VTVM)—A type of multimeter that includes a vacuum-tube amplifier to provide more accurate readings than can be obtained with a VOM.

Variable capacitor—A capacitor that can have its value changed within a certain range.

Variable-frequency oscillator (VFO)—A circuit used to control the frequency of an amateur transmitter.

Variable resistor—A resistor whose value can be adjusted over a certain range.

Vertical antenna—A common amateur antenna, usually made of metal tubing. The radiating element is vertical. There are usually four or more radial elements parallel to or on the ground.

Vertically polarized wave—A radio wave that has its electric lines of force perpendicular to the surface of the earth.

Virtual height—The height in the ionosphere from which radio waves appear to be reflected when they are returned to Earth.

Volt (V)—The basic unit of electrical pressure or EMF.

Voltage—The EMF or pressure that causes electrons to move through an electrical circuit.

Voltage source—Any source of excess electrons. A voltage source produces a current and the force to push the electrons through an electrical circuit.

Volt-ohm-milliammeter (VOM)—A type of **multimeter**, a device used to measure voltage, current and resistance. The VOM is the least expensive (and least accurate) type of multimeter. (See also **field-effect transistor VOM** and **vacuum-tube voltmeter**.)

VOX (voice-operated switch)—Circuitry that activates a transmitter when the operator speaks into a microphone.

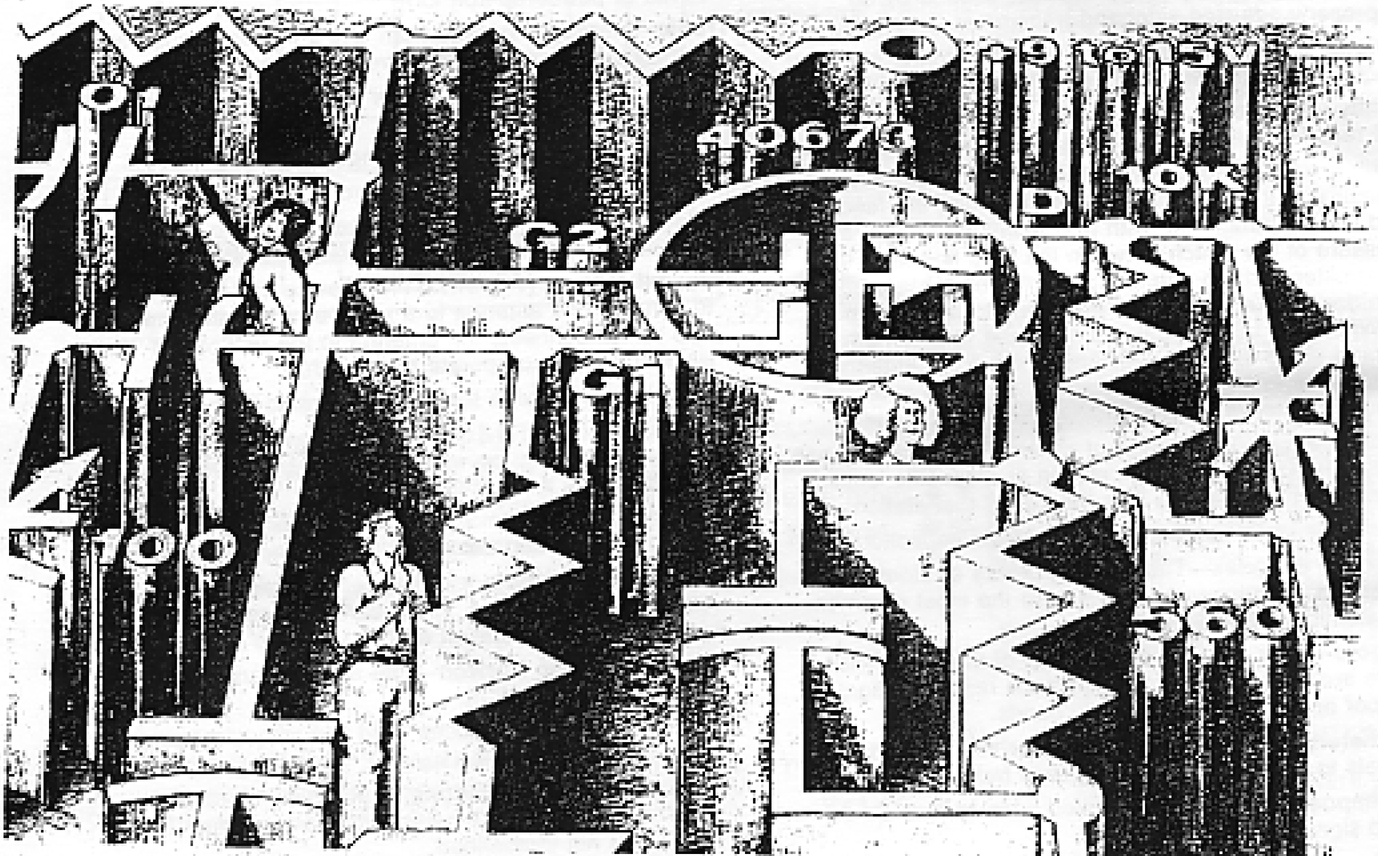
Watt (W)—The unit of power in the metric system. The watt describes how fast a circuit uses electrical energy.

Wavelength—Often abbreviated λ. The distance a radio wave travels in one RF cycle. The wavelength relates to frequency. Higher frequencies have shorter wavelengths.

Wire-wound resistor—A resistor made by winding a length of wire on an insulating form.

Yagi antenna—The most popular type of amateur directional (beam) antenna. It has one driven element and one or more additional elements.

Zero beat—When two operators in a QSO are transmitting on the same frequency.



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BOB SIMPLETON'S GUIDE TO QUARTER WAVE ANTENNAS

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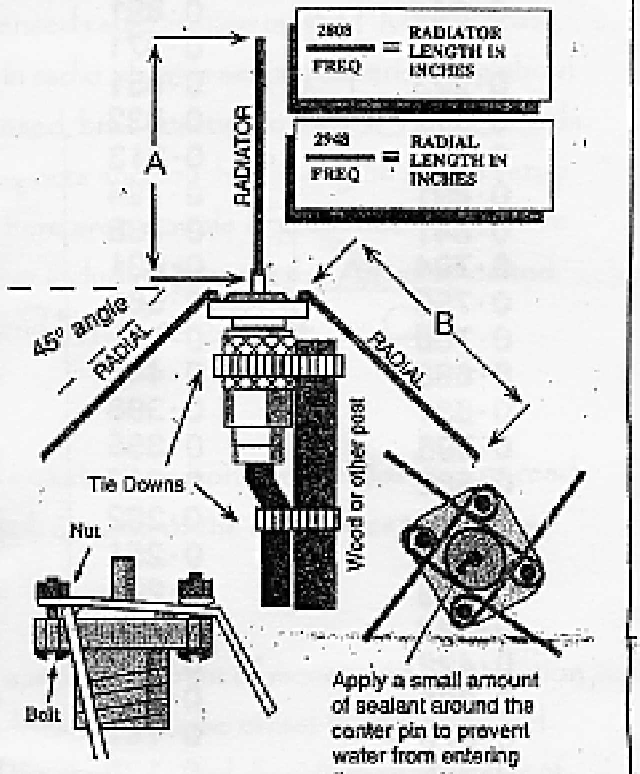
One of the simplest antennas you can build is a quarterwave ground plane antenna. It is small in size and is inexpensive.

The only part you will need to buy is a SO-239 panel mount connector. You can use an old wire hanger for the radiator and radials.

You will need to use your soldering iron or gun to attach the radiator to the center post of the SO-239. File any paint or coating from the radiator wire before soldering. Cut the radiator to the proper length before soldering it. If you can find a short copper tube to help secure the radiator to the SO-239, your antenna will stand up to high winds.

The radials may be soldered or attached with screws. Screws are the easier method if you take the time to overlap them as shown in the diagram. Cutting the radials may be done after the construction is complete.

The radials should be bent to an angle of 45 degrees for 52 ohm base impedance. If the radials are perpendicular to the radiator, the base impedance is approx. 36 ohms. Radials parallel to the radiator have an impedance of approx 75 ohms.



THE DECIBEL TABLE

The Decibel (dB) is a convenient way of expressing amplifier power gain, transmitter harmonic output, power loss in feeder cables etc. However, figures quoted in dB are not understood by all and it is useful to have a table to convert dB into figures that everyone understands.

For example, the NRG 100 watt power amplifier has a gain of 20dB. If you look at the table below you will see this is a gain of x100. One Hundred times!

Another example, a poor quality 100 watt power amplifier has a gain of just 5 dB. The table below shows this to be a laughable x3.16 (Three times and a bit)

Please print out this document, you will find it a very handy reference when looking at manufacturers figures

Voltage ratio (equal impedance)	Power ratio	− dB +	Voltage ratio (equal impedance)	Power ratio
1·000	1·000	0	1·000	1·000
0·989	0·977	0·1	1·012	1·023
0·977	0·955	0·2	1·023	1·047
0·966	0·933	0·3	1·035	1·072
0·955	0·912	0·4	1·047	1·096
0·944	0·891	0·5	1·059	1·122
0·933	0·871	0·6	1·072	1·148
0·923	0·851	0·7	1·084	1·175
0·912	0·832	0·8	1·096	1·202
0·902	0·813	0·9	1·109	1·230
0·891	0·794	1·0	1·122	1·259
0·841	0·708	1·5	1·189	1·413
0·794	0·631	2·0	1·259	1·585
0·750	0·562	2·5	1·334	1·778
0·708	0·501	3·0	1·413	1·995
0·668	0·447	3·5	1·496	2·239
0·631	0·398	4·0	1·585	2·512
0·596	0·355	4·5	1·679	2·818
0·562	0·316	5·0	1·778	3·162
0·531	0·282	5·5	1·884	3·548
0·501	0·251	6·0	1·995	3·981
0·473	0·224	6·5	2·113	4·467
0·447	0·200	7·0	2·239	5·012
0·422	0·178	7·5	2·371	5·623
0·398	0·159	8·0	2·512	6·310
0·376	0·141	8·5	2·661	7·079
0·355	0·126	9·0	2·818	7·943
0·335	0·112	9·5	2·985	8·913
0·316	0·100	10	3·162	10·00
0·282	0·0794	11	3·55	12·6
0·251	0·0631	12	3·98	15·9
0·224	0·0501	13	4·47	20·0
0·200	0·0398	14	5·01	25·1
0·178	0·0316	15	5·62	31·6
0·159	0·0251	16	6·31	39·8
0·141	0·0200	17	7·08	50·1
0·126	0·0159	18	7·94	63·1
0·112	0·0126	19	8·91	79·4
0·100	0·0100	20	10·00	100·0
$3·16 \times 10^{-2}$	10^{-3}	30	$3·16 \times 10$	10^{3}
10^{-2}	10^{-4}	40	10^{2}	10^{4}
$3·16 \times 10^{-3}$	10^{-5}	50	$3·16 \times 10^{2}$	10^{5}
10^{-3}	10^{-6}	60	10^{3}	10^{6}
$3·16 \times 10^{-4}$	10^{-7}	70	$3·16 \times 10^{3}$	10^{7}
10^{-4}	10^{-8}	80	10^{4}	10^{8}
$3·16 \times 10^{-5}$	10^{-9}	90	$3·16 \times 10^{4}$	10^{9}
10^{-5}	10^{-10}	100	10^{5}	10^{10}
$3·16 \times 10^{-6}$	10^{-11}	110	$3·16 \times 10^{5}$	10^{11}
10^{-6}	10^{-12}	120	10^{6}	10^{12}