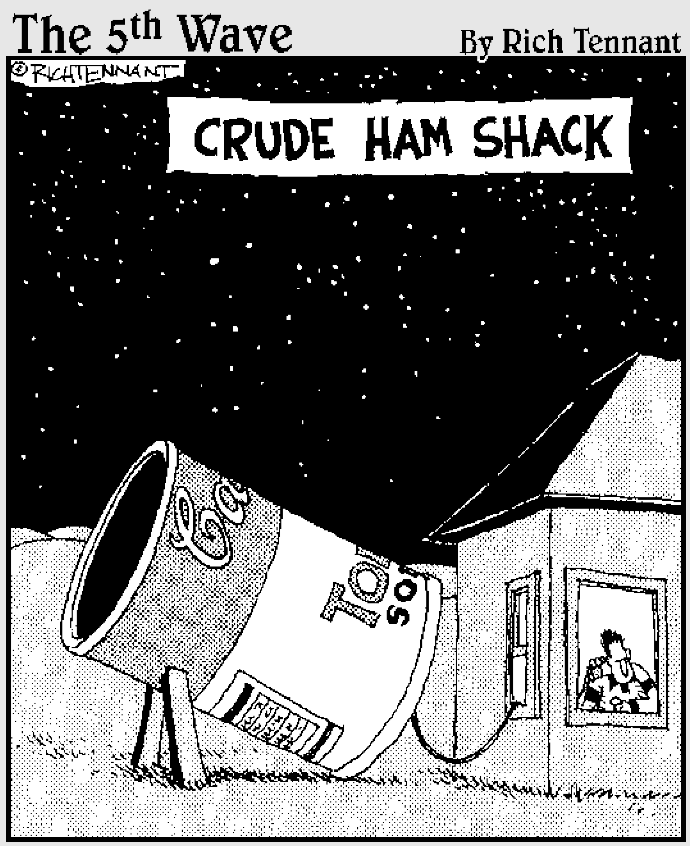
Part IV

Building and Operating a Station That Works



In this part . . .

To take part in all the ham radio fun stuff, you have to assemble your own ham radio station. A station can be pretty simple, but the more you know, the easier setting yours up is. You start by figuring out what you want to accomplish with your ham radio and what your resources are. Then you can choose your radios, antennas, and accessories.

After you get your station together, you discover how to operate the station and keep simple records. You develop the savvy to get on the air with a good signal and a deft hand at the controls. (I wish this book had been around when I was just getting started!)

Chapter 12

Getting on the Air

In This Chapter

- Making decisions about your station
- Choosing radio equipment
- Picking an antenna
- Computers in the shack
- Buying new or used equipment

One of the most common questions an Elmer (mentor) hears (aside from "What's the answer to number 22?") is "What kind of radio should I buy?" An honest Elmer always replies, "That depends!" Which antenna to buy depends on a whole lot of things, too!

Even a casual stroll through the ads in *CQ* or *QST* turns up page after page of colorful photos, with digits winking, lights blinking, and meter needles jumping. Antennas are even more numerous, with elements sticking out every which way, doodads dripping off of them, and all manner of claims made about performance. Then you have to sort through nearly an infinite number of accessories and software packages. The decision can be overwhelming! How do you choose between them?

Setting Goals for Your Station

Don't tell anybody, but you're about to embark on a journey called "system design." You may think making decisions is impossible, but all you have to do is a little thinking up front.

Goals and personal resources

You can find a lot of different activities in ham radio — casual, competitive, technical, public service — which I cover in Part III. While participating in many of them using the same equipment is possible, before you begin acquiring additional equipment is the time to consider these questions:

- What attracted you to ham radio the very first time?
- After reading about the different operating activities and modes available, can you pick two or three that really pique your interest?
- If you know and admire a ham, does he or she do something that you want to do?
- Are you most attracted to the shortwaves or to the VHF and UHF bands?
- What sounds most intriguing — the new digital modes, chatting by voice, or mastering Morse code?
- Will you operate from home, while mobile, or portable? (Or all three?)
- Do you intend to participate mainly for enjoyment or for a specific purpose, such as emergency or travel communications?

All these considerations color your choice of equipment. Knowing your ham radio resources is also important:

- What's your budget for getting on the air?
- How much space do you have available for your shack?
- How much space do you have for antennas?

Now comes the fun part — shopping and choosing!

To get an idea of what products are available, the advertisements in recent copies of *QST, CQ,* and *WorldRadio* magazines show models that are recently introduced. If you have a license, no doubt you receive a copy of a catalog from Ham Radio Outlet (HRO) or Amateur Electronic Supply (AES), two of the large, nationwide equipment distributors. Perhaps MFJ Enterprises sent you a catalog with its extensive line of accessories. If you have a local radio store, make a visit and browse through the catalogs and product brochures. Inquire about upcoming sales or promotions. The goal is to gather a wide variety of information.

Operating from home

A home station is a semi-permanent installation. Along with the radio equipment, you need a little furniture and space to put it in. Operating using voice modes means speaking out loud and probably listening on a speaker. Choosing an appropriate location for your station can minimize impact on other family members. For example, a basement shack should not be right under a bedroom. Garage and attic shacks have wide temperature swings. All in all, a spare bedroom or dry basement area is about the best place. Try to set up the radio shack somewhere that is not disruptive and put a good pair of headphones on your shopping list.

Because most hams operate with external antennas, plan appropriate ways of getting feedlines to them. What's going to hold the antennas up? Larger structures, such as rotatable beams on masts or towers, may need permits or approvals.

TIP

A big part of the amateur service is being available in emergencies. Because you may lose power when it's needed most, consider how you might operate your station with the AC power off. A radio that runs off of 12 volts can run from a car battery for a while. All your computing gear and accessories also need power. If you have a generator, consider how you can power your station, if necessary.

Mobile operation

The small all-band, multi-mode radios available today can put HF, VHF, and UHF bands at your fingertips, so you need to consider those possibilities. Having an efficient HF mobile antenna is harder, so skew your budget for mobile antennas towards the HF antenna.

Driving your station creates its own set of unique considerations. Because vehicles come in so many styles, you need to make a custom installation. Leave some budget for automotive fixtures and wiring. You may find spending a few dollars to have a professional shop make recommendations about power wiring and safety, in particular, prudent.

You can get lots of good ideas by reviewing articles and Web sites featuring mobile operation. I like K2BJ's Web site (`www.k2bj.com`), and a number of links to other good sites is at `www.arrl.org/tis/info/HF-Mobile.html`.

Portable operation

With many levels of portable — from minimalist backpacking to parking the RV — you need to consider being able to carry or pack your entire radio station, including your power source. Start by assigning yourself a total weight budget. Get creative on selecting antennas and accessories to maximize your options for the radio and power.

Some amazingly small radios are available. These radios aren't always the easiest to operate, however. If you're just starting out, you may want to pass up the smaller radio in favor of a rig that's easier to operate and has more features in order to learn more about operating. With more experience, you'll know what features you can do without.

If your station or operating time is limited, concentrate on a single band as you get started. On HF, 14, 17, and 21 MHz are favorites with the low-power and portable operators. These frequencies are open for a large portion of the day and the antennas are small enough to make carrying easy. If you like nighttime operating, 7 and 10 MHz are best. On VHF, 50 and 144 MHz are preferred. Plenty of operators are on those bands which feature interesting propagation.

Operating a hand-held radio

Regardless of what other pursuits you choose in ham radio, you probably want to have a handheld VHF/UHF radio. They're just so darn handy! The hand-held radio can keep you in touch with local family and friends. They're very useful on club and personal outings. Many hand-held radios also feature an extended receive range that may include commercial broadcast stations or police and fire department bands.

If you're buying your first hand-held radio, get a simple, single-band model. You can make a much more informed decision later if you decide to upgrade to a multi-band model with all the bells and whistles. Simple radios are also easy to operate. No new radio you can buy will be missing any significant feature.

If you buy an older used VHF/UHF radio — either hand-held or mobile — be sure that it has sub-audible tone features built-in. These radios often required accessory boards or modifications to include the tones. These days, sub-audible tone is required, and finding the parts to modify an older rig is hard.

Accessories can extend the life and usefulness of a portable radio, such as the following:

- The flexible rubber duck antenna supplied with hand-held radios is well suited for portable use, but isn't as efficient as a full-sized metal antenna. An external antenna greatly extends the range of a hand-held radio while at home.
- Use a high-quality, low-loss feedline for cables of more than a couple of dozen feet. (See the section titled "Feedline and connectors," later in this chapter, for more information on feedlines.)
- A speaker-mike combination allows you to control the radio without having to hold it up to your face.
- A case or jacket protects the radio against the rough-and-tumble nature of portable use.
- Spare batteries are a must! If you have a rechargeable battery, be sure to have a spare and keep it charged. A drop-in charger recharges batteries faster than the supplied wall-transformer model. If the manufacturer offers one, a battery pack that accepts ordinary AA-cells is good to have, especially in emergencies when you may not be able to use a charger.

Regardless of what kind of radio you have, be sure to keep a record of model and serial numbers. Engrave your name and driver's license number on the case in an out-of-the-way location. Mobile and portable radios can be lost or stolen (fate forefend!). Even larger radios sometimes get pressed into service on portable expeditions. Protect your investment against theft and loss! Check your homeowner's and auto insurance for coverage of radio equipment.

Allocating resources

When you start assembling a station, you have a range of items to obtain. Not only do you have the radio itself, but antennas, accessories, cables, and power sources. Table 12-1 shows some estimates of relative costs based on the type of station you're setting up. If you pick a radio first, the remaining four columns give you a rough idea of how much you should plan on spending to complete the station. These figures are approximate, but can get you started. I assume all the gear is purchased new.

Table 12-1 Relative Expense Breakdowns

	Radio and Power Supply or Batteries	*Antennas*	*Accessories*	*Cables and Connectors*	*Total Cost Relative to Basic HF Base*
Handheld VHF/UHF	75%	Incl.	25%	Incl.	0.3
Mobile VHF/UHF	75%	20%	Not req'd	5%	0.5
All-Mode VHF/UHF	50%	30%	5%	15%	1.0
Portable HF	75%	10%	10%	5%	0.5
Mobile HF	60%	25%	10%	5%	0.7
Basic HF Base	50%	25%	15%	10%	1.0
Full-Featured HF	75%	15%	10%	5%	2.0

Choosing a Radio

As you can see in Table 12-1, regardless of what kind of station you plan on assembling, a new radio consumes at least half of your budget, which is only appropriate because the radio is the fundamental piece of equipment in ham radio. You interact with the radio more than any other equipment and a poor performer is hard to compensate for.

HF or shortwave radios

HF radios for the home station fall into three basic categories: Basic, Journeyman, and High-Performance. Modern radios all have perfectly useable receive and transmit performance. The differences are found as improved performance in several key areas: ability to receive in the presence of strong-signals, receive signal filtering and filter control capabilities, coverage of one or more VHF/UHF bands, operating amenities such as sub-receivers, number of memories, and built-in antenna tuners to name a few.

- **Basic:** This radio includes a simplified set of controls with basic receiver filter and signal adjustments. Controls may be fixed-value with on and off settings. It also has limited displays and metering, connects to a single antenna, and has little support for external accessories. A basic radio is good for a beginning ham and makes a great second or portable radio later. A computer interface may be available.
- **Journeyman:** This radio includes all the necessary receive and transmit adjustments; most with front panel controls. It has an expanded set of memory, display, and metering functions. You can find models that have additional bands and support for digital data operations. Internal antenna tuners are common as are connections for external equipment, such as transverters and band-switching equipment. A computer interface is available for control by a computer.
- **High-Performance:** Extensive set of receive and transmit controls are available on the front panel or are configurable under a menu system. A state-of-the-art receiver and sub-receiver are included along with complete interfaces for digital data and computer control. Internal antenna tuners are standard and some antenna switching is usually provided. Complete displays and metering, computer-style displays are popular.

Table 12-2 lists some of the more popular candidates in each class. Just the base models are listed. You may find various suffixes tacked on to indicate enhancements. For example, the IC-746PRO is an enhanced version of the IC-746, the Elecraft K2 comes in 5-watt and 100-watt output versions, and the FT-1000 family includes several different variations.

Table 12-2 Home Station HF Transceivers

	Basic	*Journeyman*	*High-Performance*
Alinco	DX-77		
Elecraft		K2	
Icom	IC-718	IC-746 (incl. 50/144 MHz)	IC-756 (incl. 6-meters)

	Basic	Journeyman	High-Performance
Kenwood	TS-570 (S-model incl. 6-meters)	TS-870, TS-2000 (incl. 50/144/440/ 1200 MHz)	
SGC	SG-2020 (20 watts output)		
Ten-Tec	Argonaut (20 watts output)	Jupiter	Orion
Vertex Standard (Yaesu)	FT-600	FT-840, FT-920 (incl. 50 MHz), FT-847 (incl. 50/ 144/440 MHz)	FT-1000

Choosing a filter

In order to keep nearby signals from interfering with the desired signal, a receiver uses filters. These filters must pass the desired signal while *attenuating* (reducing the strength of) unwanted signals just a few hundred Hz away. For many years, the only filter components able to accomplish this feat were quartz crystals, so this type of filter is referred to as a *crystal filter.* A *mechanical filter,* similar to crystals, uses vibrating discs. Receiving filters are applied to the radio signal before it is converted to audio. These filters have a fixed *bandwidth* (the range of frequencies they can pass, measured in Hz) and cannot be adjusted. Find more information on filters on the *Ham Radio For Dummies* Web site.

Fixed-width filters are available with several bandwidths. A radio is always shipped with at least one SSB (single sideband) filter installed (HF radios) or an FM filter (VHF hand-helds and mobiles). The standard filter bandwidth for HF SSB operation is 2.4 kHz. Filters with widths of 1.5 to 2.0 kHz are available for operating under crowded conditions with some loss of fidelity. For Morse code and digital data, the standard filter is 500 Hz wide and is a good option to select. Narrower filters down to 250 Hz are available. The most common filter option to buy is the 500 Hz CW filter, followed by a narrow SSB filter.

TIP

Some Journeyman and High Performance-class receivers allow filters to *cascade* (in other words, the filters are used one following the other) at more than one intermediate stage. If you can afford the extra expense, purchasing the extra filters can often make a significant difference in receiving ability, particularly on a crowded band. To see how cascading works, check out the *Ham Radio For Dummies* Web site.

Digital Signal Processing (DSP, the P can also stand for *processor*) refers to a microprocessor in the radio running special software that operates on, or *processes,* incoming signals, usually on the audio signal before it's amplified for output to the speaker or headphones. More advanced DSP can act on the signals at radio frequencies. DSP can perform filtering functions to remove off-frequency signals, reduce or eliminate several different kinds of noise, or automatically detect and remove an interfering tone. Such abilities make DSP filtering much more flexible than the filtering accomplished by a crystal filter, but DSP performance is just becoming equivalent to that of a good fixed-width crystal filter. In general, the higher the number of bits specified for DSP and the higher the frequency at which the DSP functions are performed, the better the DSP processing performs. (Look in your radio's operating manual or product specification sheet for more information.)

Mobile and portable HF radios

Since the introduction of the Kenwood TS-50, a gold rush of radios has been designed for the portable and mobile operator. Each year sees more bands and better features crammed into these small radios. These radios are quite capable as base stations if space is limited at home or a dual home/portable station is desired. Many include coverage of VHF and UHF bands.

Be aware that because they are so small, these rigs have to make some compromises compared to the high-performance designs. The operator interface is, by necessity, menu-driven. This menu-driven interface makes some adjustments less convenient, although the most-used controls remain on the front panel. The smaller rigs don't include internal antenna tuners at the 100-watt output level as the larger rigs do.

Where can you fit a radio in your vehicle or boat? If you have an RV or a yacht, you may not have a problem, but in a compact car or an 18-foot runabout, the space issue is quite a challenge. Luckily, many radios designed for mobile use, such as the radio in Figure 12-1, have *detachable front panels,* sometimes called *control heads.* A detachable panel allows you to put the body of the radio under the dash or a seat or on a bulkhead. If you share the car or boat, get agreement on where to place the radio before drilling any holes.

Table 12-3 includes examples of several popular mobile/portable rigs and some of their features. Like their larger base station cousins, you have to consider many features and different sets of accessories. Because these radios are small and not all features have a dedicated front panel control, I recommend that you try one before you buy either at a dealers or with a friend who owns one.

Figure 12-1: Most mobile radios have detachable front panels, as this radio does.

Table 12-3 Mobile/Portable All-Mode HF Transceivers

	Model	*VHF/UHF Coverage*	*Power Output*	*General Coverage Receive*	*Detachable Control Head*	*Receives FM Broadcast*
Alinco	DX-70	50 MHz	100 watts	Yes	Yes	No
Icom	IC-706 MKIIG	50/144/ 440 MHz	HF - 100w 50 MHz - 100w 144 MHz - 50w 440 MHz – 20w	Yes	Yes	Yes
	IC-703	50 MHz	10 watts	Yes	No	No

(continued)

Table 12-3 *(continued)*

	Model	***VHF/UHF Coverage***	***Power Output***	***General Coverage Receive***	***Detachable Control Head***	***Receives FM Broadcast***
Kenwood		TS-50	No	100 watts	Yes	No No
	TS-480	50 MHz	HF - 200w 50 MHz - 100w	Yes	Yes	No
Vertex Standard (Yaesu)	FT-100	50/144/440	HF - 100w 50 MHz - 100w 144 MHz - 50w 440 MHz - 20w	Yes	Yes	No
	FT-817	50/144/440	5 watts	Yes	No	Yes
	FT-857	50/144/440	HF - 100w 50 MHz - 100w 144 MHz - 50w 440 MHz - 20w	Yes	No	Yes
	FT-897	50/144/440	HF - 100w 50 MHz - 100w 144 MHz - 50w 440 MHz - 20w	Yes	No	No

Digital data on HF

More and more HF radios are providing a connector or two with a digital data interface to make connecting a personal computer and operating on the digital modes, such as PSK31 or RTTY, easier. A few even have a built-in data modem or a terminal node controller (TNC), which is a type of data modem used for packet radio (see Chapter 11). The key features to look for are accessory sockets on the radio carrying some of the following signals:

- **FSK (Frequency Shift Keying):** A digital signal at this connector pin causes the transmitter to output the two tones for frequency-shift keying, a method of transmitting using two frequencies, usually used for radioteletype (RTTY).

- **Data In/Out:** If a radio has an internal data modem, you can connect these digital data inputs and outputs to a computer. You may need an RS-232 (a type of serial communication) converter.
- **Line In/Out:** Audio inputs and outputs compatible with the signal levels of a computer's sound card, this input is used for digital data when a computer sound card is used as the data modem.
- **PTT:** The same as the push-to-talk feature on a microphone, this input allows a computer or other external equipment to key the transmitter.
- **Discriminator (sometimes labeled DISC):** This input is the unfiltered output of the FM demodulator. External equipment can use this signal both as a tuning indicator and to receive data.

To find out how to configure a radio to support digital data, look on the manufacturer's Web site or ask the dealer for the radio manual. Proper connections for RTTY (radioteletype) operation, packet radio, and other types of digital data should be included, and you can determine if your favorite mode is supported. If the manual doesn't provide an answer, contact the manufacturer to see if someone can tell you how to hook up the radio. Digital data Web sites may also have files on how to interface specific radios to your computer.

Making a decision on amplification

I recommend that you refrain from obtaining an amplifier for HF operations until you have some experience on the air. You need the extra savvy that experience provides to add an amplifier and then deal with the incumbent issues of power, feedlines, RF safety, and interference. The stronger signal you put out when using an amplifier also affects more hams if misadjusted or used inappropriately. Like learning to drive, perfecting the basic techniques is best accomplished before taking hot laps in a stock car.

Most HF radios output 100 watts or more, which is sufficient to do a lot of operating in any part of the hobby. When do you need a *full gallon* of 1500 watts output or even 500 to 800 watts? Many circumstances occur in which the extra punch of an amplified signal gets the job done. DXers use them to make contact over long paths on difficult bands. A traffic handler's amplifier gets switched on when a band is crowded or noisy so that the message gets through clearly. Digital operators use them to reduce the number of errors in received data. In emergencies, an amplifier may get the signal through to a station with a poor or damaged antenna.

HF amplifiers come in two varieties: vacuum tube and solid-state. Tubes are well suited to the high power levels involved. Solid-state amplifiers, on the other hand, tend to be more complex, but require no tuning or warm-up; just turn them on and go. Tube amplifiers are less expensive per watt of output power than solid-state amps, but they are larger and tubes are more fragile.

Don’t attempt to use CB “footlocker”-type amplifiers. Not only are these amps illegal, but they often have serious design deficiencies that result in poor signal quality.

VHF and UHF radios

Many HF radios also include 50, 144, and 440 MHz operations. The Kenwood TS-2000 goes all the way to 1200 MHz! This power makes purchasing a second radio just for VHF/UHF operating less of a necessity for the casual operator. Many ham radio shacks have an all-band HF/VHF/UHF radio backed up with a VHF/UHF FM rig for using the local repeaters and packet radio.

VHF/UHF radios that operate in single-sideband (SSB), carrier wave (CW), and FM modes are known as *all-mode* or *multi-mode* to distinguish them from FM-only radios. If you get serious about operating on those bands and modes, then you may want to purchase a dedicated radio. VHF/UHF-only multi-mode rigs are less common than they used to be because many all-band radios now offer VHF/UHF coverage.

Many of the VHF/UHF all-mode radios have special features, such as full duplex operation and automatic compensation for transponder offsets, that make using the amateur satellites easier. (I introduce amateur satellite operation in Chapter 11.) Satellite operations require special considerations because of cross-band operation and the fact that they are moving, which results in a Doppler shift on the received signal.

An all-mode radio can also form the basis for operating on the amateur microwave bands. Commercial radios are not available for these bands (900 MHz; 2.3, 3.4, 5.6, 10, and 24 GHz; and up), so you can use a transverter instead. The *transverter* converts a received signal on the microwave bands to 28, 144, or 440 MHz bands where the radio treats it just like any other signal. Similarly, the transverter converts a low-power (100 milliwatts or so) output from the radio on back up to the higher band. Bringing the output signal up to 10 watts or more requires an external amplifier.

FM-only radios

FM on the VHF and UHF bands is used by nearly every ham regardless of their favorite operating style or mode. A newly minted Technician licensee can likely use an FM mobile or hand-held radio as his or her first radio. FM is available on the all-mode rigs, but because of the mode's popularity and utility, FM-only rigs are very popular. FM radios come in two basic styles: hand-held and mobile. You can use mobile rigs as base stations at home, too.

Hand-held radios

Hand-held radios come in single-band, dual-band, and multi-band models. With the multi-band radios covering 50–1296 MHz, why choose a lesser model? Expense, for one thing. The single-band models, particularly for 2-meters, cost less than half the price of a multi-band model. You do the lion's share of operating on the 2-meter (VHF 144–148 MHz) and 70-cm (UHF 430–440 MHz) bands, so the extra bands may not get much use.

You can expect the radio to include as standard features encoding and decoding of CTCSS sub-audible tones (tones used to restrict access to repeaters), variable repeater offsets, at least a dozen memory channels, and a DTMF keypad for entering control tones (similar to the tones available on a touch-tone telephone). A rechargeable battery and simple charger come with the radio. (I discuss repeater operation in Chapter 9.)

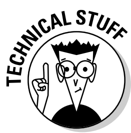
Extended-coverage receiving is a useful feature. I find being able to listen to broadcast FM and the low-VHF land mobile (public safety agencies, paging, and businesses use) bands around 2-meters is very useful. In addition, TV channels 2 through 13 can also receive between 54 and 216 MHz. That's a nice emergency feature, as well as entertaining.

What are your power output needs? The tiny credit-card size radios are convenient, but don't pack much of a punch. Unless you live in an area with excellent repeater coverage, insufficient power leaves you out of touch, perhaps when you really need it. Get a radio with at least 1 watt of output and pick up a spare battery, too.

Base and mobile radios

Mobile radios have a similar set of features as hand-held radios regarding memories, scanning, and controls. The more powerful transmitters used with an external antenna extend your range dramatically. Receivers in mobile radios often have better performance than those in hand-held radios — able to reject the strong signals from land mobile dispatch and paging transmitters on adjacent frequency bands. Information about how receivers perform in such conditions is available in product reviews in magazines such as *CQ* and *QST,* on the ARRL Web site (`www.arrl.org`), and on Web sites such as `www.eham.net` and `www.qrz.com`. Your own club members may have valuable experience to share, because they operate in the same places as you!

You can often use mobile radios for digital data operation on the VHF/UHF bands, particularly packet. When limited to 1200 baud data, as modem technology has advanced, hams have moved to use 9600 baud data. If you plan on using your mobile rig for digital data, make sure it is data-ready and rated for 9600 baud without modification.



Some rigs claim to be APRS or GPS compatible — what does that mean? First, check out the descriptions of the Automatic Position Reporting System (APRS) in Chapter 11. Location information from a GPS receiver is transmitted by packet to a network of APRS computers over VHF radio. A radio compatible with APRS has a serial port for the GPS receiver and an internal packet TNC that can send and receive APRS packets without any other external devices.

VHF/UHF amplifiers

Increasing the transmitted power from an all-mode, hand-held, or even small mobile radio is common. Amplifiers can turn a few watts of input into more than 100 watts of output. Solid-state commercial units are known as *bricks* because they are about the size of large bricks with heat sinking fins on the top. A small amp and external antenna can greatly improve the performance of a hand-held radio so that you don't need a separate mobile rig.

Amplifiers are either FM-only or SSB/FM models. Amplifiers just for FM use cause severe distortion of a single-sideband signal. An amplifier designed for SSB use is called a *linear amplifier* and SSB/FM models have a switch to change between the modes. You can amplify Morse code signals in either mode, with more gain available in the FM mode.

RF safety issues are much more pronounced above 30 MHz because the body absorbs energy more readily at those frequencies. An amplifier outputs enough power to pose a hazard, particularly if you use a beam antenna. Don't use an amplifier at 50 MHz or above if the antenna is close to people. Revisit your RF safety evaluation (see the *Ham Radio For Dummies* Web site) if you plan on adding a VHF/UHF amplifier to your mobile or home station.

Making a selection

Dozens of hand-held and mobile radios are for sale, so use a checklist of features to help you decide on a model. Note the capabilities you want as well as the ones that fall into the nice-to-have category. A checklist and comparison table is available on the *Ham Radio For Dummies* Web site to help you sort through the blizzard of features. The blank spaces are for you to add capabilities.

Choosing an Antenna

I can't say which is more important: the radio or the antenna. Making up for deficiencies in one by improving the other is difficult. A good antenna can make a weak radio sound better than the other way around. You need to give your antenna selection at least as much consideration as the radio.

This section touches on a number of types of useful and popular antennas. If you want to know more about antennas and want to try building a few yourself, you need more information. I can think of no better source for that information than *The ARRL Antenna Book,* now in its 20th edition. Not only a good ham resource, many professional antenna designers have a copy, too. Highly recommended! I include a list of useful antenna design books and Web sites in Appendix B.

HF antennas

At HF, antennas can be fairly large. An effective antenna is usually at least ¼-wavelength in some dimension. On 40-meters, for example, a ¼-wavelength vertical antenna is a metal tube or wire 33 feet high. At the higher HF frequencies, antenna sizes drop to 8–16 feet, but are still larger than even a big TV antenna. Your physical circumstances have a great effect on what antenna you can put up. Rest assured that a large variety of designs are available to get you on the air.

Wires, verticals, and beams are the three basic HF antennas used by hams all over the world. You can build all these antennas with common tools or purchase them from the many ham radio equipment vendors.

Wire antennas

The simplest wire antenna is a *dipole,* which is a piece of wire cut in the middle and attached to a feedline, as shown in Figure 12-2. The dipole gives much better performance than you may expect from such a simple antenna. To construct a dipole, use 10- to 18-gauge copper wire. It can be stranded or solid, bare or insulated. When completed, its length should be:

Length in feet = 468 / frequency of use in MHz

This formula accounts for a slight shortening effect that makes a ½-wavelength of wire slightly shorter than a ½-wavelength in air. For example, a dipole for 21.1 MHz is 468 / 21.1 = 22.2 feet long. Allow an extra 18 inches on each end for attaching to the end insulators and tuning and another foot (6 inches × 2) for attaching to the center insulator. The total length of wire you need is 22.2' + 18" + 18" + 12" = 26.2'.

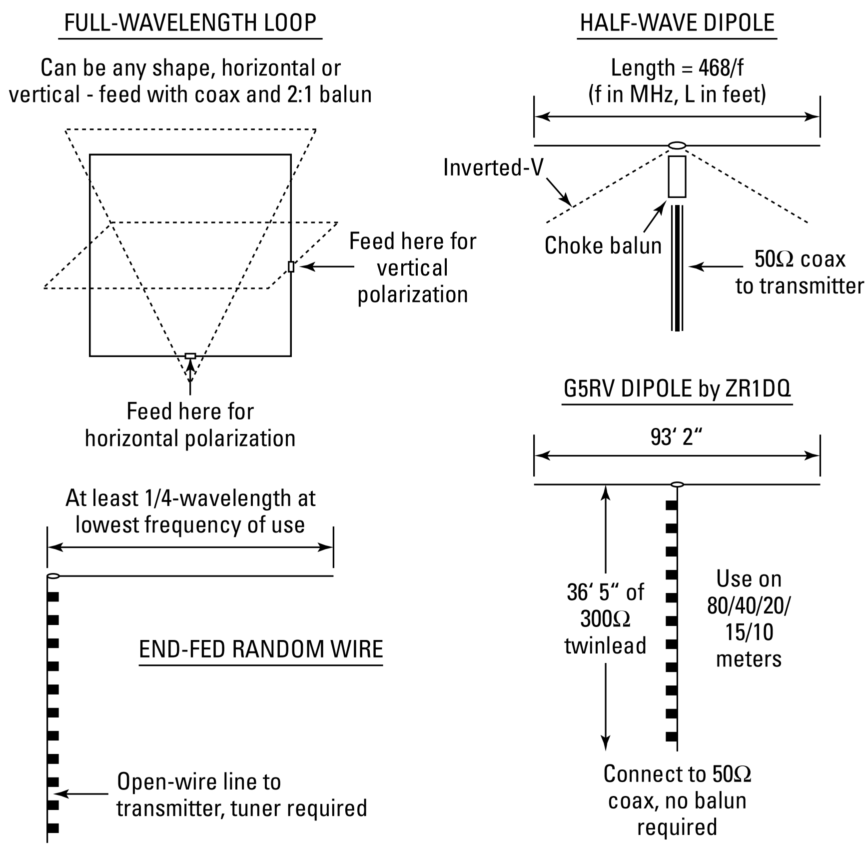


Figure 12-2: Constructing the ½-wave dipole.

To assemble a dipole, follow these steps:

1. **Cut the wire exactly in the middle and attach one piece to each end insulator, just twisting it back on itself for the initial check.**
2. **Attach the other end to the center insulator in the same way.**
3. **Attach the feedline at the center insulator and solder each connection.**
4. **Attach some ropes and hoist it up in the air.**
5. **Check the dipole.**

   Make some short, low power transmissions to measure the SWR (standing wave ratio) as explained in your radio's operating manual. The SWR should be somewhere less than 1.5 to 1 on the frequencies you wish to use.

6. **If the SWR is low enough at too high a frequency or is lowest at the high end of the band, loosen the connections at the end insulators and lengthen the antenna by a few inches on each end.**

   If the frequency of lower SWR is too low, shorten the antenna by the same amount.

7. **When you adjust the antenna length so that the SWR is satisfactory, make a secure wrap of the wire at the end insulators and trim the excess.**

You made a dipole! You can follow the same steps, except vary the lengths, for most simple wire antennas.

You can connect the dipole directly to the transmitter using coaxial cable and use the dipole on the band at which it is ¼-wavelength long or any odd number of ½ wavelengths. For example, the 66-foot long 7 MHz dipole works well on the 21 MHz band, too.

Other common and simple wire antenna designs include:

- **Inverted-V:** A dipole supported at its midpoint with the ends angling down at up to 45 degrees. This antenna only requires one support and gives good results in nearly all directions.
- **Full-wavelength loop:** Attach a feedline at the middle of the loop's bottom and erect the loop so that it is vertical. The feedline then works best broadside to the plane of the loop. These antennas are larger than the dipoles, but radiate a little more signal in their favored directions.
- **Multi-band dipoles:** Wires fed at the center with *open-wire* or *ladder-line* feedline and used with an antenna tuner to cover several bands. These are usually not ½-wavelength long on any band and so are called *doublets* to distinguish them from the ½-wavelength long dipoles.
- **Trap dipole:** Uses some appropriately placed components to isolate portions of the antenna at different frequencies so that the dipole acts like a simple ½-wavelength dipole on two or more bands.
- **The random-length wire:** Attach some open-wire feedline 15 to 35 feet from one end and extend the wire as far and high as you can. A couple of bends won't hurt. You have to convert the feedline to coaxial cable using a balun or antenna tuner. (I describe these on the *Ham Radio For Dummies* Web site.) The random wire's performance is hard to predict, but is an excellent back-up or temporary antenna.

For more information on these and many other antennas you can build, check out some of the antenna references listed in Appendix B. If you don't have the perfect backyard to construct the antenna of your dreams, don't be afraid to experiment. Get an antenna tuner (or use the one in your radio) and put up whatever you can. You can even bend wires or arrange them at strange angles. Antennas want to work!

Vertical antennas

Vertical antennas are nearly as popular as wire antennas. The ¼-wavelength and the ½-wavelength antennas are two common designs. Verticals don't require tall supports, keep a low visual profile, and are easy to move or carry. Verticals radiate fairly equally in all horizontal directions, so they are considered *omnidirectional* antennas.

The ¼-wavelength design is a lot like a ½-wavelength dipole cut in half and turned on end. The missing part of the dipole is supplied by an electrical mirror of sorts called a *ground screen* or *ground-plane.* A ground screen is made up of a dozen or more wires stretched out radially from the base of the antenna and laid on top of the ground. The feedline connects to the vertical tube (it can also be a wire) and to the radials, which are all connected together. The ¼-wavelength verticals are fairly easy to construct and, like dipoles, work on odd multiples of their lowest design frequency.

The ½-wavelength verticals are about twice as long as their ¼-wavelength counterparts, but do not require a ground screen. The lack of a ground screen means that you can mount them on masts or structures away from the ground and are ground-independent. The feedline is connected to the end of the vertical, but requires a special impedance matching circuit to work with low-impedance coaxial feedlines. Several commercial manufacturers offer ground-independent verticals and many hams with limited space or opportunities for traditional antennas make good use of them.

Both ¼-wavelength and ½-wavelength verticals can work on several bands through the use of the similar techniques used in wire antennas. Commercial multi-band verticals are available that you can use on up to nine of the HF bands.

Beam antennas

Any antenna that uses more than one *element* to focus or steer its listening and transmitting capabilities toward one direction is called a *beam,* which is short for *beamforming.* Beams can be as simple as two wires or as complicated as more than a dozen pieces of tubing.

The most popular type of beam antenna is called a *Yagi,* after Japanese scientists, Doctors Yagi and Uda, who invented the antenna back in the 1920s. The Yagi consists of two or more conducting elements (tubing or wires) parallel to each other and approximately 0.1 wavelength apart. The element that the feedline connects to is known as the *driven element.* Other elements called *reflectors* and *directors* are cut to specific lengths and spaced to reflect or direct the energy in a particular direction. Reflectors and directors, because they direct the energy without being directly connected to the feedline, are known as *parasitic elements,* and Yagi antennas are sometimes referred to as parasitic arrays. The most common ham Yagi today is a three-element design (a reflector, a driven element, and a director) that works on three popular ham bands (20, 15, and 10-meters) and so is called a *tri-bander.* Yagis are also made from wires at lower frequencies. Figure 12-3 shows a three-element Yagi beam on a 55-foot mast whose lowest operating frequency is 14 MHz.

Other beams are made from square or triangular loops. They work on the same principle as the Yagi, but with loops of wire instead of straight elements made from rod or tubing. Square-loop beams are called *quads* and the triangles are called *delta loops.*

You may encounter another type of beam that looks like an oversized TV antenna with many angled elements. These beams are *log-periodics,* or *logs,* and the large number of antenna elements enables the antenna to function over all bands in a certain range, just as TV antennas can receive many channels. Hams use logs to cover a range of bands (typically 20, 17, 15, 12, and 10-meters) with a single antenna.

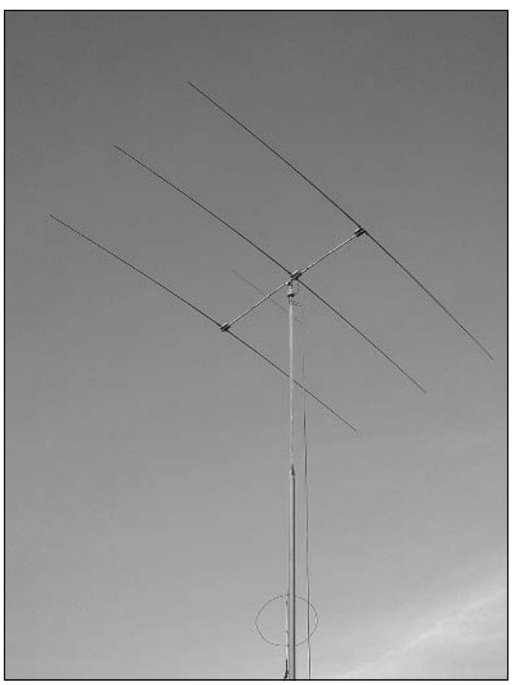


Figure 12-3: My three-element beam antenna.

Whereas wire antennas have a fixed orientation and verticals radiate equally in all horizontal directions, a beam antenna made from aluminum tubing can be rotated. The ability to rotate the antenna allows the ham using a beam antenna to concentrate a signal or reject an interfering signal in a certain direction. You can place small HF beams on inexpensive masts or roof-top tripods, although they overload most structures designed for TV antennas. You also need a *rotator* that mounts on the fixed support and turns the beam. You can control the rotator from inside the shack and have a meter to indicate direction. (See the section, "Supporting Your Antenna," later in this chapter.)

Most hams start out with a wire or vertical antenna. After you operate for a while, the signals you hear on the air give you a good idea of what antennas are effective. After you have some on-the-air experience, you can make a decision as to whether you need a beam antenna.

VHF/UHF antennas

Most antennas used above 50 MHz at fixed stations are either verticals or beams. Verticals are used almost exclusively for FM operation, while beams are used for VHF/UHF DX-ing (contacting a distant station) on SSB and CW.

FM operating is done with *vertically polarized* antennas because of the mode's beginnings in the mobile radio industry. Antennas on vehicles are much simpler to mount vertically. In order to avoid cross-polarization losses (see the sidebar "Antenna polarization"), the base antennas were also verticals. This convention is nearly universal. Even if a beam antenna accesses a distant repeater, its elements are mounted vertically.

SSB and CW operators, on the other hand, use *horizontal polarization.* Many of the VHF and UHF propagation mechanisms respond best to horizontally polarized waves. If you have an all-mode radio and want to use it for both FM and SSB/CW, you need both vertically and horizontally polarized antennas available.

A popular and inexpensive vertical antenna is the simple *quarter-wave whip,* or *ground-plane,* antenna, which works the same as its larger HF cousin. Many hams build a 19-inch long 2-meter ground-plane as a first antenna project. You can extend the vertical to ⅝-wavelength versions, which offer a slightly stronger signal.

TIP

A ⅝-wavelength 2-meter vertical makes a dandy ¼-wavelength 6-meter vertical without any modifications!

Antenna polarization

Antennas radiate and receive *electromagnetic* fields composed of an electric and a magnetic field. Electrons in the conducting surfaces of an antenna move back and forth (creating a current) in the same direction as the oscillations of the electric field. This action causes currents to flow in the antenna, which either radiates a signal if the field is applied from a transmitter via a feedline or receives a signal if the field is caused by a distant transmitter.

The alignment of a radio wave's electric field with respect to the Earth's surface is called its *polarization.* Because the electric field and electron movement are parallel, an antenna's polarization is the same as the direction in which its conducting surfaces are arranged. Vertical antennas are *vertically polarized,* for example. Most Yagi antennas are *horizontally polarized.*

For the most efficient communications, you must orient the receive and transmit antennas so that the electromagnetic fields from each antenna are aligned. If the antennas aren't aligned, then the electric field from the transmitter does not make the receiving antenna's electrons move to make a current flow into the feedline. Such antennas are *cross-polarized* and the resulting loss of signal can be substantial. Polaroid sunglasses take advantage of the fact that most reflected light considered to be glare is horizontally polarized. By using vertically polarized plastic in the lenses, you can eliminate glare by cross-polarization.

Polarization is most important at VHF and UHF where signals usually arrive with their polarization largely intact. On the HF bands, the ionosphere scrambles the polarization so that relative polarization is much less important. Polarization does affect received signal strength, however, and deep signal fades caused by cross-polarization are common at HF.

Because of the reduced antenna size at higher frequencies, the Yagi antennas used by VHF/UHF DXers can have many more elements than at HF. Five to 7 element beams are common on 50 MHz and more than 20 elements are often seen at higher frequencies. These very high-gain antennas also have a narrow beamwidth, which is too narrow for most casual operating. If you choose to use a beam on these bands, 3 to 5 elements is a good choice on 6-meters and 5 to 12 elements at higher frequencies. These antennas are small enough to mount and turn using heavy-duty TV antenna hardware.

Mobile and portable antennas

For VHF, antennas for FM use are almost always vertical. The wavelength at these frequencies is such that a full-sized antenna is the norm. Mobile HF antennas, however, are generally reduced-size versions of verticals used at fixed stations. Horizontally polarized mobile HF antennas are rare due to their size and mechanical considerations. The challenge for mobile HFers is to get the most efficiency out of a short antenna.

You can mount mobile antennas as removable or permanent fixtures. The most easily removed antennas are the *mag-mount* models that use a magnetic base to hold themselves to a metal surface. Mag-mount antennas are available from HF through UHF. The drawback is that the installation isn't as clean as a permanently mounted antenna. Trunk-mount antennas for VHF and UHF are semi-permanent and look better. Drilling a hole in your car for a permanent mount looks best of all. All three options are fairly close in performance. Whichever method you choose, be sure you can remove the antenna from the mount to deter theft and for clearance, such as in a car wash. You can generally route antenna cables under trim, carpet, and seats.

For HF, many mobile stations use the "Hamstick"-type antennas attached to a mag-mount, as seen in Figure 12-4. These antennas are wire coiled on fiberglass tubes about 4 feet long, with a stainless-steel whip attached at the top. The antennas work on a single band and are sufficiently inexpensive that you can carry a whole set in the car. They require that you change the antenna when changing bands. Another design uses *resonators* attached to a permanent base to operate on different bands. You can attach several resonators at once so that several bands are used without changing the antenna. The resonators and fiberglass whip antennas use a standard ⅜-24 threaded mount.

An adjustable design has become popular in recent years with a moving top section that allows the antenna to tune over nearly any HF frequency. These antennas are known as *screwdriver* antennas because they use DC motors similar to those in battery-powered electric screwdrivers. In order of expense, the Hamstick-type antennas are the most inexpensive and the screwdriver antennas the most expensive. Performance varies dramatically depending on mounting and installation, so guaranteeing good results for any of the styles is difficult.

At VHF and UHF, portable antennas are very small, light, and easy to pack. At HF, however, the larger antennas are more difficult to deal with. You can try a lightweight wire antenna if you can find a way to support it above ground. Vertical antennas need a sturdy base and usually a ground system. Telescoping antennas may be an option, and you can use the mobile Hamstick-type whips with a few radial wires.

An antenna that does not present a low SWR (signal wave ratio, a measure of RF energy reflected back to the transmitter by the antenna) requires a tuner for the transmitter to output full power, adding weight and expense. The smaller coaxial feedlines, such as RG-58 types, also have higher losses. Try out the performance of your antenna and feedline before taking off on a major adventure. Avoid unpleasant surprises on the back roads!

Figure 12-4: A "Hamstick"-type mobile antenna on one of my mobile adventures.

Feedline and connectors

Gee, how tough can picking a feedline be? It's just coax, right? Not really, and you may be surprised at how much feedline can affect your signal, both on transmit and receive. When I started out, I used 100 feet of RG-58 with a 66-foot dipole that I tuned on all bands. I didn't know that on the higher bands I was losing almost half of my transmitter output and received signals in the coax! The 50-foot piece I was using on my 2-meter antenna lost an even higher fraction of the signals.

While losing 50 percent or 3dB (decibels) is only about one-half of an S-unit (S-units are a measure of signal strength, roughly equivalent to 6dB each), I lost a few contacts when signals were weak or the band was noisy. To make up that loss with an amplifier costs around $300. Changing antennas to a beam with 3dB of gain costs at least that much, not counting the mast and rotator. That makes the extra $20 to $25 cost of using RG-213 cable look like a pretty good bargain!

Answering the decibel

Time for a refresher on decibels? Decibels, abbreviated dB, are used to measure a ratio of two quantities in terms of factors of 10. A change of a factor of 10 (from 10 to 100 or from 1 to 0.1) is a change of 10dB. Increases are positive and decreases are negative. You can use the following formula to calculate dB for changes in power and voltage:

dB = 10 log (power ratio)
dB = 20 log (voltage ratio)

Decibels add if ratios are multiplied together. For example, two doublings of power (x 2 x 2) is 3 dB + 3 dB = 6 dB. A gain of 20 can also be thought of as x 10 x 2 = 10 dB + 3 dB = 13 dB.

If you memorize these dB-ratio pairs, you can save yourself a lot of calculating, because a precise dB calculation isn't needed very often.

Power x 2 = 3dB	Power x 1/2 = -3dB
Power x 4 = 6dB	Power x 1/4 = -6dB
Power x 5 = 7dB	Power x 1/5 = -7dB
Power x 8 = 9dB	Power x 1/8 = - 9dB
Power x 10 = 10dB	Power x 1/10 = -10dB
Power x 20 = 13dB	Power x 1/20 = -13dB
Power x 50 = 17dB	Power x 1/50 = -17dB
Power x 100 = 20dB	Power x 1/100 = -20dB

A change of one receiver S-unit represents approximately 6dB.

Table 12-4 compares several popular feedlines in terms of their relative cost (based on RG-58C/U) and the loss for a 100-foot section at 30 MHz and 150 MHz. The loss is shown in dB and in S-units on a typical receiver, assuming that one S-unit is equivalent to 6dB.

Table 12-4 Relative Cost and Loss of Popular Feedlines

Type of Line and Characteristic Impedance	*Outside Diameter (in.)*	*Cost per Foot Relative to RG-58C/U*	*Loss of 100' at 30 MHz in dB and S-Units*	*Loss of 100' at 150 MHz in dB and S-Units*
RG-174A/U (50 ohms)	0.100	0.8	6.4 dB/1 S-unit	>12 dB/ >2 S-units
RG-58C/U (50 ohms)	0.195	1.0	2.6 / 0.5	6.7 / 1.1
RG-8X (50 ohms)	0.242	1.5	2.0 / 0.3	4.6 / 0.7
RG-213/U (50 ohms)	0.405	2.1	1.2 / 0.2	3.1 / 0.5
1" ladder line	½" or 1" width	0.6 to 1.3	0.1 / <0.1	0.4 / <0.1

The moral of the story is to use the feedline with the lowest loss you can afford. Open-wire feedline is a special case because you add an impedance transformer or tuner to present a 50-ohm load to the transmitter, incurring extra expense and adding some loss.

TIP

To save a lot of money on feedline, buy it in 500-foot spools from a distributor. If you can't afford to buy the entire spool, share the spool with a friend or two. Splitting the expense is an excellent club buy and can save more than 50 percent over buying cable 50 or 100 feet at a time. Do the same for coaxial connectors.

WARNING!

Beware of used cable unless the seller is completely trustworthy. Old cable is not always bad, but can be lossy if water has gotten in at the end or from cracks or splits in the cable jacket. If the cable is sharply bent for a long period, the center conductor can migrate through the insulation to develop a short or change the cable properties. (Migration is a particular problem with foam-insulation cables.)

Before buying used cable, examine the cable closely. The jacket should be smooth and shiny, with no obvious nicks, dents, scrapes, cracks, or deposits of adhesive or tar (from being on a roof or outside a building). Slit the jacket at each end for about 1 foot and inspect the braid, which should be shiny and show no signs of corrosion or discoloration whatsoever. Slip the braid back. The center insulator should be clean and clear (if solid) or white if foam or Teflon synthetic. If the cable has a connector on the end, checking the cable condition may be difficult. Unless the connector is newly installed, you should replace it, so ask if you can cut the connector off to check the cable. If you can't cut it off, you probably shouldn't take a chance on the cable.

The standard RF connectors used by hams are BNC, UHF, and N-type connectors. BNC connectors are used for low power (up to 100 watts) at frequencies through 440 MHz. UHF connectors are used up to 2-meters and can handle full legal power. N connectors are used up through 1200 MHz, can handle full legal power, and are waterproof when properly installed. (Photos or drawings of connectors are shown in vendor catalogs, such as The RF Connection catalog at `www.therfc.com`.)

Good-quality connectors are available at low prices, so don't scrimp on this important component. A cheap connector works loose, lets water seep in, physically breaks, or corrodes, eating up your valuable signals. By far, the most common connector you'll work with is the PL-259, the plug that goes on the end of coaxial cables. By buying in quantity, you can get silver-plated, Teflon-insulated connectors for just over $1 each, a bargain compared to the price if you buy them individually. Avoid the shiny nickel-plated connectors as they are difficult to solder.

To crimp or not to crimp? You can install a crimp-on connector quickly and get reliable service if you use it indoors in low-humidity, mild temperature environments. Crimping tools, or *crimpers,* are available for less than $50. If you have a lot of connections to make, a crimp-on connector may be a good choice. However, a properly soldered, silver-plated connector outperforms a crimped connector and can be used outside, too.

Supporting Your Antenna

Antennas come in all shapes and sizes — from the size of a finger to behemoths that weigh hundreds of pounds. The one thing that all antennas have in common is that they need to be clear of obstacles and kept away from ground level, which is where most obstacles are.

Before you start mounting your antenna, take a minute to review some elementary safety information for working with antennas and their supports. The short article at `www.arrl.org/tis/info/pdf/0106091.pdf` points out a few of the common pitfalls in raising masts and towers. For working with trees, aside from common sense about climbing, you may want to consult with an arborist.

Antennas and trees

Although Marconi used a kite for his early experiments, a handy tree is probably the oldest antenna support. A tree often holds up wire antennas, which tend to be horizontal or use horizontal support ropes. The larger rotatable antennas and masts are rarely installed on a tree, even on a tall, straight conifer, because of the mechanical complexity, likelihood of damage to the tree, and mechanical interference between the antenna and tree.

Nevertheless, for the right kind of antennas, a tree is sturdy, nice to look at, and free! The goal is to get a pulley or halyard into the tree at the maximum height. If you are a climber (or can find someone to climb for you), you can place the pulley by hand. Otherwise, you have to figure out some way of getting a line through the tree so you can haul up a pulley. You may be able to just throw the antenna support line over a branch. Bear in mind that when a line is pressing against the bark of a tree, the tree can rub and chafe against the line until the line breaks. (This catastrophe always happens at night, in a storm, or right before an important contact.) If the line stays intact, the tree tries to grow around the line, creating a wound, which makes raising or lowering the antenna impossible.

If you intend for the tree to support an antenna permanently, bringing in an arborist or a tree service professional to do the job right, using sturdy, adequately rated materials, is worth the expense. The Radioworks company has a good introduction to antennas in trees at `www.radioworks.com.html`.

Masts and tripods

A wooden or metal mast is an inexpensive way to support an antenna up to 30 feet above ground. If you are handy with tools, making a home-brew mast is a good project and numerous articles about their construction are in the ham magazines. Masts are good candidates to hold up wire HF antennas and VHF/UHF antennas, such as verticals and small beams. If you are just supporting a VHF or UHF vertical, you won't need a heavy support and can probably make a self-supporting mast that doesn't need guy wires. However, if you have high winds or the mast is subjected to a side load (such as for a wire antenna), then it needs to be guyed.

One commercially available option is the telescoping *push-up mast* designed to hold small TV antennas and often installed on rooftops. Push-ups come in sizes up to 40 feet with guying points attached. You can also construct masts by stacking short sections of metal TV antenna mast, but you have to add your own guying points. You can't climb either telescoping or sectional masts, so mounting the antenna and then erecting the whole assembly is up to you. You can also mount a section or two of stacking mast on a chimney in order to support a small vertical. Push-up and TV masts are available along with all the necessary mounting and guying materials from RadioShack, hardware, and home improvement stores.

One step beyond the mast is the roof-mount tripod. The lighter tripods are used for TV antennas and can hold small amateur antennas. Larger tripods can handle mid-sized HF beams. Tripods are good solutions in urban areas and in subdivisions that may not allow a ground-mounted tower. Tripods are available from several tower and antenna manufacturers.

Towers

By far the sturdiest antenna support is the tower. Towers are available as self-supporting (unguyed), multisection crank-up, tilt-over, and guyed structures with heights of 30 feet and up. They are capable of handling the largest antennas at the highest heights, but they are also substantial construction projects, usually requiring a permit to erect. Table 12-5 lists several manufacturers of towers.

The most common ham tower is a *welded lattice tower.* It is built from 10-foot sections of steel tubing and welded braces and you must guy or tie it to a supporting structure, such as a house, at heights of 30 feet or more. A modest concrete base of several cubic feet is required to provide a footing. Lattice towers for amateur use are between 12 and 24 inches on a side and can be used to construct towers well over 100 feet high. Lattice towers are sufficiently strong to hold several large HF beam antennas, if properly guyed.

Tilt-over towers are lattice towers hinged in the middle so that the top sections can pivot towards the ground using a winch. Because of mechanical considerations, tilt-overs are limited to less than 100 feet in height.

Crank-up towers are constructed from telescoping tubing or lattice sections. A hand-operated or motorized winch raises and lowers the tower with a cable and pulley arrangement. A fully nested crank-up is usually 20 to 25 feet high, reducing visual impact to the neighborhood, and you can climb it to work on the antennas. Crank-ups also usually have a tilting base that aids in transporting and erecting the tower. Crank-ups are unguyed and so depend on a massive concrete foundation of several cubic yards to keep their center-of-gravity below ground level to prevent tipping over when fully extended. You can install crank-ups in small areas where guying is not possible; they are available in heights of up to 90 feet.

Self-supporting towers are triangular in cross section, are constructed of truss-like sections like lattice towers, and rely on a large concrete base for center-of-gravity control. They are simpler and less-expensive than crank-ups. Available at up to 100 feet, they have similar carrying capacity to lattice towers. Mounting antennas along the length of a self-supporting tower is more difficult than for a lattice tower with vertical supporting legs.

Table 12-5 Tower Manufacturers

Antenna	*Web Site*	*Lattice*	*Crank-Up*	*Self-Supporting*
U.S. Towers	Sold through Ham Radio Outlet		X	
Rohn Industries*	`www.rohnnet.com/Index.htm`	X		X
Trylon	`www.trylon.com`			X
Heights Tower	`www.heightstowers.com`	X	X	X
Universal Aluminum Towers	Sold through distributors			X

** Rohn was purchased by Radian, a Canadian company that plans on continuing to manufacture tower components to the Rohn specifications. As of publication, it's not clear if the Rohn name will be used. Rohn towers have been a staple of ham radio antennas for decades and the Rohn brand will still be around for a long time.*

Be extremely careful when buying a used tower or mast. Unless it has been in storage, exposure to the elements can cause corrosion, weakening welds and supporting members. If disassembled improperly, the tower can be damaged in subtle ways difficult to detect in separate tower sections. A tower or mast that has fallen is often warped, cracked, or otherwise unsafe. Have an expert accompany you to evaluate the material before you buy.

You can construct self-supporting towers from unorthodox materials such as telephone poles, light standards, well casing, and so on. If it can hold up an antenna, rest assured that a ham has used it to do so at some time. The challenge is to transport and erect the mast, then climb it safely and create a sturdy antenna mounting structure at the top.

Regardless of what you decide to use to hold up your antennas, hams have a wealth of experience to share in forums such as the TowerTalk e-mail list. You can sign up for TowerTalk at `www.contesting.com`. The topics discussed range from mounting verticals on a rooftop, to which rope is best, to giant HF beams, and how to locate True North. The list's membership includes experts who can handle some of the most difficult questions.

Is it a rotor or rotator?

A *rotor* is a part of a helicopter and has nothing whatever to do with ham radio. A *rotator,* on the other hand, is a motorized gadget that sits on a tower or mast and points antennas in different directions. Rotators are rated in terms of wind load, which is measured in square feet of antenna surface. If you decide on a rotatable antenna, you need to figure out its wind load in order to determine the size rotator it requires. Wind load ratings for antennas are available from the antenna manufacturer. The most popular rotators are made by Hy-Gain (`www.hy-gain.com`) and Yaesu (`www.yaesu.com`).

You need to be sure that you can mount the rotator on your tower or mast; some structures may need an adapter. Antennas mount on a pipe mast that then sits in a mast clamp on top of the rotator. If you mount the rotator on a mast, as on the left in Figure 12-5, you must mount the antenna at the top of the rotator to minimize side loading. In a tower, the rotator is attached to a *rotator plate* (a shelf inside the tower for the rotator to sit on) and the mast extends through a *sleeve* or *thrust bearing* (a tube or collar that hold the mast centered above the rotator), as at the center and right of Figure 12-5. Because using a bearing in this way prevents any side loading of the rotator, you can mount antennas well above the tower top if the mast is sufficiently strong.

An indicator assembly called a *control box,* which you install in the shack, controls the rotator. The connection to the rotator is made with a multi-conductor cable. Install the feedlines to the antennas in such a way so that they can accommodate the rotation of the antennas and mast.

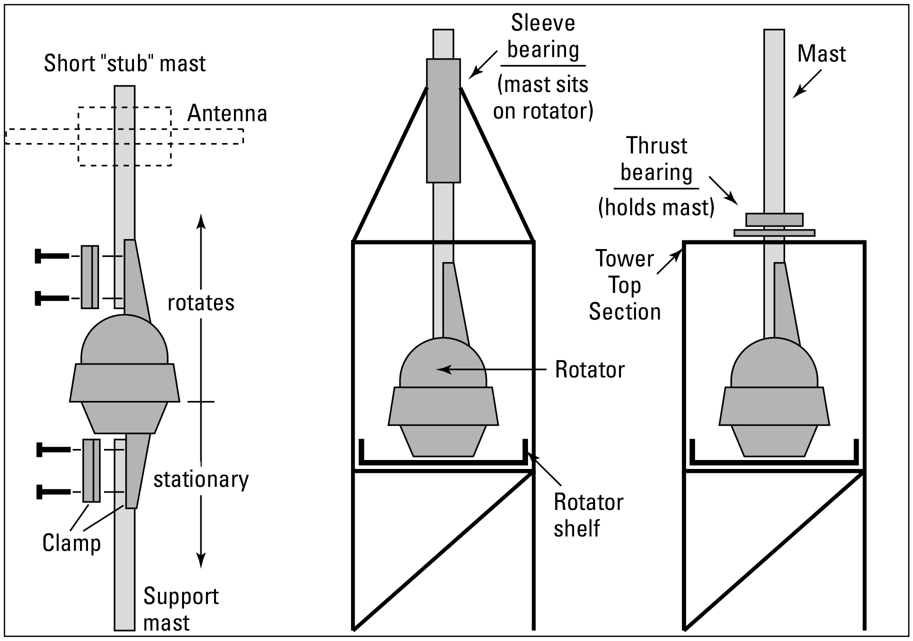


Figure 12-5: Mounting a rotator on a mast and on a tower.

WARNING!

Used rotators can be risky purchases. They are always installed in exposed locations and wear out in ways not visible externally. Even if the rotator turns properly on the bench, it may jam, stall, or slip when under a heavy load. Either buy a new rotator or get a used one from a trusted source for your first installation.

Radio accessories

You can buy or build hundreds of different gadgets to enhance whatever style or specialty you choose. Here's some information on the most common accessories that you need to get the most out of your station.

Mikes, keys, and keyers

Most radios come with a hand microphone, although if you buy a used radio, the hand mike may be long gone or somewhat worn. The manufacturer-supplied hand mikes are pretty good and are all you need to get started. After you operate for a while, you may decide to upgrade.

If you're a ragchewer, some microphones are designed for audio fidelity with a wide frequency response. Net operators and contesters like the hands-free convenience of a headset with an attached *boom mike* held in front of your mouth. Hand-held radios are more convenient to use with a combined *speaker-microphone* combination accessory that plugs into your radio and clips to a shirt pocket or collar. Your radio manufacturer may also offer a premium microphone as an option or accessory for your radio. Heil Sound (`www.heilsound.com`) manufacturers a wide range of top-quality microphones and headsets.

TIP

The frequency response of a microphone can make a big difference on the air. If you operate under crowded conditions, the audio from a microphone whose response emphasizes the mid-range and higher frequencies is more likely to cut through the noise. Some microphones have selectable frequency responses so that you can have a natural-sounding voice during a casual contact, then switch to the brighter response for some DX-ing. If you're not sure which is best, ask the folks you contact or do an over-the-air check with a friend who knows your voice.

Morse code enthusiasts have thousands of keys to choose from, spanning over a century of history (see Chapter 10 for more info). Beginners often start with a straight key and then graduate to an electronic keyer and a paddle. If you think you'll use CW a lot, I recommend going the keyer/paddle route right away. Many rigs now include a keyer as a standard option. You can plug the paddle into the radio and you're on your way! CW operators tend to find paddle choice very personal, so definitely try one out before you buy. A hamfest often has one or more key-bug-paddle collectors and you can try many different styles. The ham behind the table is likely to be full of good information, as well.

If you decide on an external keyer, you can choose from kits and finished models. Programmable memories are very handy for storing commonly sent information, such as your call sign or a CQ message. Sometimes I put my keyer in beacon mode to send a stored CQ message repeatedly to see if anyone is listening on a *dead* band. (If everybody listens and nobody transmits, the band sounds dead, but may be open to somewhere exciting.) A number of computer programs send code from the keyboard. Browse to `www.ac6v.com/morseprograms.htm` for an extensive listing of software.

TIP

What is a *voice keyer?* That sounds like an oxymoron! A voice keyer is a device that can store short voice messages and play them back into your radio as if you were speaking. Some are standalone units and some use a sound card. Voice keyers are handy for contesting, DX-ing, calling CQ, and so forth. Models also store both CW and voice messages, such as the MJF Contest Keyer (`www.mfjenterprises.com`) and the Super Combo Keyer (`www.arraysolutions.com`).

Antenna tuners

While your new radio may be equipped with an antenna tuner, a number of situations can occur in which you need an external unit. Internal tuners have a somewhat limited range that fits many antennas. Antennas being used far from their design or optimized frequency often present an impedance that the rig's tuner can't handle. If balanced feedlines are used, you may need a tuner that can handle the change from coaxial cable to open-wire feedlines.

Tuners are available in sizes from tiny, QRP-sized units to humongous, full-power boxes larger than many radios. Table 12-6 lists a few of the manufacturers offering an assortment of tuners. If you decide to purchase a tuner, choose one that's rated comfortably in excess of the maximum power you expect to use. I highly recommend getting one with the option to use balanced feedlines. The ability to switch between different feedlines and an SWR meter (which measures reflected RF power) are nice-to-have features.

They're called "antenna tuners" but they don't really "tune" an antenna at all! A more accurate name for these gadgets is an *impedance matcher.* The impedance matcher acts like an electrical gearbox to transform whatever impedance exists at the end of the feedline to the 50 ohms radios like to see. Your antenna doesn't even know it's there. This subject is discussed in detail in both *The ARRL Antenna Book* and *The ARRL Handbook.* In addition, the online article, "Do You Need an Antenna Tuner?" from *QST,* is online at `www.arrl.org/tis/info/tuner.html`.

Table 12-6 Antenna Tuner Manufacturers

Manufacturer	*Web Site*	*Balanced Feedline*	*High-Power (>300 watts)*	*Automatic Tuning*
MFJ	`www.mfjenterprises.com`	Yes	Yes	Yes
Ameritron	`www.ameritron.com`	Yes	Yes	No
Vectronics	`www.vectronics.com`	Yes	Yes	No
LDG Electronics	`www.ldgelectonics.com`	External balun adapter	Yes	Yes
SGC	`www.sgcworld.com`	Yes	Yes	Yes
Alpha-Delta	`www.alphadeltacom.com`	Yes	No	Yes

Why is a rotator's wind load rated in square feet?

A rotator's job is to turn antennas and hold them in place against the pressure of the wind. The wind's pressure tries to turn the antenna against the rotator's braking mechanism. The rotator has to maintain control of the antenna when the brake is off and the antenna is turning against the wind. Both holding and turning the antenna require the rotator to exert torque on the mast that holds the antennas. As long as the rotator can exert more torque than the wind on the antenna, all is well. Torque caused by the wind on the antenna is difficult to specify exactly, but if a maximum wind speed is assumed, then torque is directly related to antenna area, which is easy to specify. Thus, rotators are rated in square feet of wind load. If multiple antennas are mounted on a single rotator, you must add their individual wind loads together. Rotators for amateur service are available with ratings starting at 3 square feet.

Along with the tuner, you need a *dummy load.* The dummy load is a large resistor that can dissipate the full power of your transmitter. The MFJ 260C can dissipate 300 watts, which is adequate for HF transceivers. High-power loads, such as the venerable Heathkit Cantenna or MFJ 250, immerse the resistor in a cooling oil. The dummy load helps minimize your transmitter causing interference during tune-up. HF dummy loads may not be suitable for use at VHF or UHF, so check the frequency coverage specification before you buy.

Computers in the Shack

As with just about every other activity, a computer can be involved. Ham radio is no different and has embraced computers more intimately than in most hobbies. Originally just used as a replacement for the paper logbook, the computer has evolved nearly to the point of becoming a second op: controlling radios, sending and receiving CW, and linking your shack to thousands of others through the Internet.

PC or Mac or . . . ?

Most ham shack computers are Windows-based machinery. The vast majority of software available for ham applications runs on the Win9*x*/2000/XP operating systems, with a healthy number of MS-DOS applications that run in MS-DOS windows on Win9*x*/2000.

Linux has an increasing number of adherents, particularly among the digital mode enthusiasts. Here are a few Web sites that focus on Linux software:

- **Hamsoft:** radio.linux.org.au
- **Terry Dawson VK2KTJ's listing:** www.radio.org/linux
- **AC6V.com:** www.ac6v.com/software.htm#LIN
- **Tucson Amateur Packet Radio:** www.tapr.org

The Macintosh computing community is making additional inroads to ham radio software and programs are available for all of the common ham radio uses available. The Ham-Mac mailing list is full of information for Mac fans (mailman.qth.net/mailman/listinfo/ham-mac). You can find Macintosh ham radio software at dogparksoftware.com and www.blackcatsystems.com. A useful Web site that is devoted to bringing together Macintosh computers and ham radio is www.machamradio.com.

Regardless of what platform and operating system you prefer, software tools and programs are available to help you enjoy any type of operating you like. While some software is supplied by commercial businesses, the amateur community has developed an amazing amount of shareware and freeware. Hams freely contribute their expertise in any number of ways, and developing software is a very popular activity.

Digital modes

Operation on most of the digital modes is rapidly converging on the sound card as the standard device to send and receive data. With a simple audio and transmit control interface, your computer and radio form a very powerful data terminal. Proprietary protocols, such as PACTOR II and Clover, require special hardware and software available from the protocol developer. I list specific software packages for the popular digital modes in Chapter 11. MFJ Enterprises (www.mfjenterprises.com) and West Mountain Radio (www.westmountainradio.com) both manufacture popular data interfaces.

If you choose to use an external multi-mode controller for the digital modes, such as the Timewave PK232 or DSP599 (www.timewave.com), Kantronics KAM (www.kantronics.com), or MFJ 1278B, you only need a terminal program, such as Hyperterm, which is built into Windows, or Symantec's Procomm-Plus (www.symantec.com). Numerous other terminal programs are optimized for ham radio digital data (which I list in Chapter 11).

Radio control

Radios are now provided with an RS-232 control interface through which you can monitor and control nearly every radio function. That flexibility has led to a number of radio control programs that put the front panel on a computer. Some radio manufacturers have a radio control package that you can purchase or download with the radio. A number of third-party programs integrate with logging software. If control interfaces are interesting to you, join a user's group for your radio on Usenet or via one of the ham radio portals (see Chapter 3).

Hardware considerations

Outside of computation-intensive applications, such as antenna modeling or high-performance data modems, you don't need to own the latest and greatest speed-demon computer. If you're thinking about upgrading a home computer, a computer that's a couple of years old does just fine in the ham shack. Furthermore, the flood of cheap, surplus computers available for a song means that you can dedicate a computer to its own specific task, such as running a packet node or monitoring an APRS Web site, so as not to tie up your main computer. Even a clunky old 486 DOS does just fine monitoring 1200-baud packet data, for example.

If you decide to purchase a new computer for the shack, be aware that the standard interface in ham radio for data and control is the RS-232 serial port. These ports are being phased out on new computers in favor of USB 2.0. (Serial ports are now referred to as *legacy* ports.) Integrating a USB-only PC into the ham shack means that you either have to purchase a serial port expansion card or use USB-to-RS-232 converters. The serial port expansion cards likely have fewer compatibility and driver issues, but the USB converters are easier to install.

Computer RF interference can also be an issue in the ham shack. The two main sources of interference are the monitor and data cables. If you have a noisy monitor — one that emits a lot of RF energy — the interference can be very tough to get rid of because shielding in monitors is almost non-existent. Ferrite cores are available from RadioShack (part numbers 273-104 and 273-105) that you can place on cables to choke off the interfering signals. Place the cores as close as possible to the connector on the device generating the interference. One core may be required at each end of the cable. Ground the metal case of any computing equipment, as well.

Buying New or Used Equipment

New equipment is always safest for a neophyte and it has that great new radio smell, too! If the equipment doesn't work, you have a service warranty or the customer service representatives can help you out. Sales personnel can help you with information about how to set up a radio or any accessories and may even have technical bulletins or application guides for popular activities. To find out where to buy new gear, get a copy of *QST, CQ,* or *WorldRadio.* The major dealers all run ads every month and some are virtual catalogs. For the smaller and local stores, check out the ARRL Technical Information Service's Web page at `www.arrl.org/tis/tisfind.html`.

While buying new equipment is safe, used gear is often an excellent bargain. Hams always love a bargain. You can find nearly any imaginable piece of gear with a little searching on a number of online swap sites, including eBay. (Look for these sites through the portals and reflectors listed in Chapter 3.) I like to buy and sell through the ham radio Web sites — my favorite is the Classified pages on the eHam.net portal (`www.eham.net/classifieds`). The ARRL and QRZ.com both have for-sale ads and quite a few other sites are springing up all the time. Enter **ham trade** or **ham swap** into an Internet search engine. As with shopping at hamfests, get help from an experienced friend before buying.

What about buying through mail order? Internet and toll-free telephone numbers make shopping for rock-bottom prices easy, but shopping by mail order has some drawbacks. The first is that you have to pay for shipping, which could add tens of dollars to your purchase. You may also have to pay for shipping to return equipment for service. Second, the local radio store is a valuable resource for you. RadioShack probably doesn't carry replacement parts for your WhizBang2000 nor does it probably have a new battery pack for that 10-Band PocketMaster. When you are stuck in the middle of an antenna or construction project, you don't want to have to stop and wait for UPS to deliver materials. My advice: Buy some things through the mail and some locally, balancing the need to save money against the need to support a local store.

Upgrading Your Station

Soon enough, usually about five minutes after your first QSO, you start thinking about upgrading your station to hear better or be stronger. Keep in mind the following tips when the urge to upgrade overcomes you. Remember the old adage, "You can't work 'em if you can't hear 'em!"

- The least expensive way to improve your transmit and receive capabilities is with better antennas. Dollar for dollar, you get the most improvement from an antenna upgrade. Raise them before making them larger.
- Only consider more power after you improve your antennas. Improve your hearing before extending the range at which people can hear you! An amplifier doesn't help you hear better at all.
- Buying additional receiving filters for your radio is a whole lot cheaper than a new radio.
- The easiest piece of equipment to upgrade in the station is the multimode processor between your ears. Before deciding that you need a new radio, be sure you know how to operate your old one to the best of your abilities. Improving your knowledge is often the cheapest and most effective improvement you can make.

By taking the improvement process one step at a time and by making sure that you improve your own capabilities and understanding, you can achieve your operating goals quicker and get much more enjoyment out of every ham radio dollar.