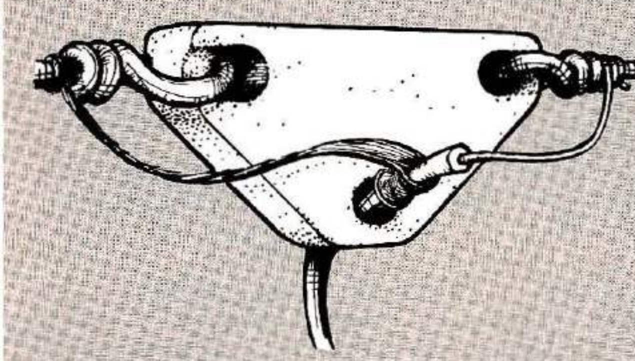


simple dipole antennas

BY JIM FISK, W1HR

One band, two bands, three bands, more . . .

Of the many types of antennas which are described in the amateur magazines, the most popular single-band antenna for 80 and 40 meters is the half-wavelength dipole, fed in the center with low-loss coaxial transmission line. The same type of antenna also provides excellent performance on 20, 15, and 10 meters. The dipole's popularity is not without reason — among its many advantages are low cost, easy installation, and simplicity. Unless you make a poor solder connection, or use old, deteriorated coaxial cable, it's pretty hard to build a dipole that doesn't work right the first time you connect your transmitter to it and call CQ.

The length of the basic half-wavelength dipole antenna shown in **Fig. 1** is given by the simple formula

$$\text{Dipole length (feet)} = \frac{468}{f_{MHz}}$$

$$\text{Dipole length (meters)} = \frac{142.5}{f_{MHz}}$$

where f_{MHz} is the chosen operating frequency in MHz. Calculated half-wave dipole lengths for various frequencies on 80 through 10 meters are given in **Table 1**. Although the method of fastening the insulators, and the antenna's closeness to other objects, will have some effect on the dipole's resonant frequency, it's surprising how close a carefully measured and built antenna will resonate to the design frequency.

Antenna height

For daylight operation on 40 and 80 meters, and for close-in work on the higher amateur bands, antennas that are only 20 to 25 feet (6-8 meters) high work nearly as well as dipoles installed at greater heights. Over longer distances, however, the performance improves almost linearly with heights up to about 50 feet (15 meters), and more slowly for greater heights. If you don't have a couple of 60-foot (18-meter) trees in your backyard to support your dipole, don't worry about it; a low antenna outperforms a high one often enough to make it interesting, especially over distances up to 100 miles (160 km) or so.

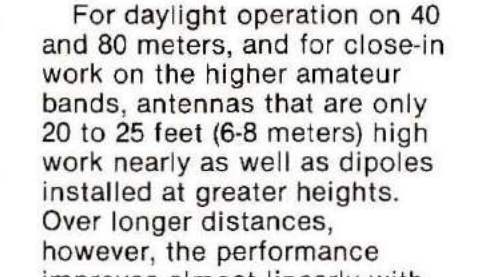


Fig. 1. Construction of the basic-half wavelength dipole antenna. Lengths for various frequencies on the high-frequency amateur bands are listed in **Table 1**.

Dipole radiation resistance

Theoretically, in *free space*, the radiation resistance or antenna feedpoint impedance of a half-wavelength dipole of small diameter wire is close to 72 ohms. When the half-wave dipole is installed over perfectly conducting ground, however, the radiation resistance varies with height, as shown in **Fig. 2**. Unfortunately, you're not going to come anywhere close to a perfect ground unless you have your hamshack on a houseboat anchored in saltwater. Since the ground under your antenna isn't perfect, the radiation resistance won't be exactly that shown in **Fig. 2**, but this graph should give you an idea of the range of values to expect. In practical terms, half-wavelength dipoles which are installed at reasonable heights over average ground provide an excellent match to 50- or 75-ohm coaxial cable, and that's what is important!

Antenna resonance

Every antenna, including the simple half-wavelength dipole, is really a complex electronic circuit consisting of resistance, capacitance, and inductance. At a certain frequency the effects of capacitance and inductance cancel out, and at this point the antenna is said to be resonant.

Below resonance the

antenna looks capacitive, and above resonance it looks inductive. This is important because it means the antenna is resonant at only *one* frequency; since amateurs don't limit their activities to a single, spot frequency, their antennas are seldom used at resonance. This has practically no effect on how well the antenna radiates, but it does affect the feedpoint impedance, the standing-wave ratio (swr), and ultimately, transmitter output power.

Swr itself is usually not a problem, but the output matching networks in most modern amateur transmitters (and transceivers) are designed for a maximum swr of 2:1. If the swr is greater than 2:1, the matching network in the transmitter simply can't compensate for the impedance mismatch, so the transmitter can't be loaded to full power input. In some solid-state transmitters the manufacturers even build in a circuit that shuts down the transmitter if the swr exceeds 2:1.

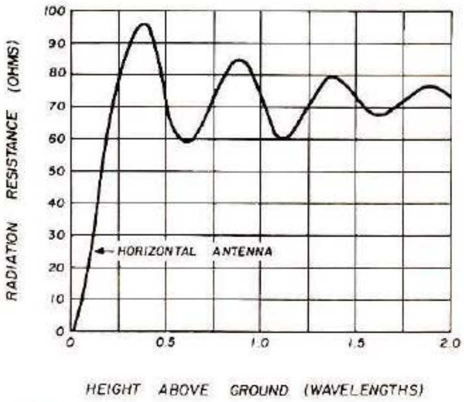


Fig. 2. Radiation resistance or feedpoint impedance of a horizontal half-wavelength dipole varies with height above a perfectly conducting ground. The earth under your antenna is not a perfect conductor, but this graph will give you an idea of the range of values to expect. A half-wave dipole, installed at a reasonable height over average ground, provides an excellent match to 50- or 75-ohm coax.

Amateur radio is unique among the radio services in that amateur operators can move at will from one frequency to another. There are exceptions, of course, but professional antenna engineers are accustomed to designing antenna systems for operation on a single frequency. Therefore, there is very little published experimental data on the performance of a half-wavelength dipole over a whole band of frequencies; the information which is available is difficult to translate into practical terms unless you have a degree in advanced

Glossary of Terms

Antenna tuner or antenna matching unit is a device which uses a combination of variable capacitors and inductors to provide a means of matching the low output impedance of your transmitter to the unequal (usually much higher) impedance of the transmission line to the antenna. Also called a Transmatch.

Balun is a device that will provide a transition between an unbalanced (to ground) feedline such as coaxial cable, and a balanced line or antenna such as twin-lead or a dipole. The term is derived from *Bal*anced-to-*un*balanced.

Dipole is literally *two* poles, an antenna that has two poles or "arms" which are separated by an insulator and connected to each other through the transmission line. The dipole is sometimes called a doublet antenna.

Dummy load is a device which accepts rf power and dissipates it as heat. A dummy load should always be used when tuning up a transmitter to eliminate unnecessary transmissions and interference.

Feedline or transmission line is one or more electrical conductors that conduct radio-frequency energy from your radio to the antenna. The most popular feedline used by amateurs is coaxial cable, often called *co-ax*.

Impedance is the apparent resistance of a load in an ac or rf circuit that opposes current into that load. It consists of the ohmic resistance plus the effects of inductance or capacitance in the circuit.

Insulators for antennas are often egg-shaped or cylindrical, are made from ceramic, glass, or plastic, and have small holes at each end: one for attaching the antenna wire, and the other for the supporting line or *halyard*.

Mismatch is short for impedance mismatch, for example, when the impedance of the feedline doesn't match the feedpoint impedance of the antenna. For best efficiency the impedances should be closely matched. The amount of impedance mismatch is defined by the SWR or standing wave ratio (for a perfect match the SWR = 1:1).

SWR is an acronym for standing-wave ratio which is the ratio of a voltage maxima to the voltage minima along a feedline. VSWR or *voltage* standing wave ratio is the more proper term for the same thing. The ideal situation is to have a *flat* feedline — a VSWR of 1:1. The VSWR on the feedline can be changed *only* by changing the impedance at the load (antenna) end of the line.

SWR Bridge is more correctly an SWR Meter because few instruments of this type are true bridge-type units. The SWR Meter samples both the rf energy going toward the antenna (load) and the energy reflected back because of an impedance mismatch. The indicator may be calibrated so either a direct comparison of power levels or their ratio is possible.

Transmatch is a popular type of antenna tuner first described by W1ICP in *QST* and later sold commercially by the James Millen Company. The term is now commonly used to describe all types of antenna tuners and antenna matching units.

Table 1. Length of half-wavelength dipole antennas for various frequencies in the high-frequency amateur bands.

Band	Frequency (MHz)	Use	Half Wavelength (feet, inches)	(meters)
160	1.825	General	256′ 5¼″	78.2
160	1.875	General	249′ 7¼″	76.1
80	3.600	CW	130′ 0″	39.6
80	3.725	Novice	125′ 7½″	38.3
80	3.750	General	124′ 9½″	38.0
75	3.800	Phone	123′ 2″	37.5
40	7.100	CW	65′ 11″	20.1
40	7.150	General	65′ 5½″	19.9
40	7.175	Novice	65′ 3″	19.8
40	7.250	Phone	64′ 6½″	19.7
20	14.050	CW	33′ 3 ¾″	10.15
20	14.150	General	33′ 1″	10.08
20	14.200	Phone	32′ 11½″	10.05
20	14.275	Phone	32′ 9½″	10.00
15	21.100	CW	22′ 2″	6.76
15	21.175	Novice	22′ 1¼″	6.72
15	21.225	General	22′ ½″	6.72
15	21.350	Phone	21′ 11″	6.68
10	28.050	CW	16′ 8¼″	5.09
10	28.150	Novice	16′ 7½″	5.07
10	28.510	Phone	16′ 5″	5.00
10	29.475	Oscar	15′ 10½″	4.84

mathematics — and time to correlate the theory with measured results.*

There's another problem with the published information: it is based on an antenna in free space. When a dipole is installed near ground — even several wavelengths above ground — the antenna behaves differently than it would out in free space. This is further complicated by the fact that the earth under your antenna has different electrical characteristics from every other antenna site, even one at a different spot in your own backyard! Nevertheless, it's possible to come up with some reasonable *guesstimates* of what to expect from real-life, small diameter, half-wavelength dipole antennas.†

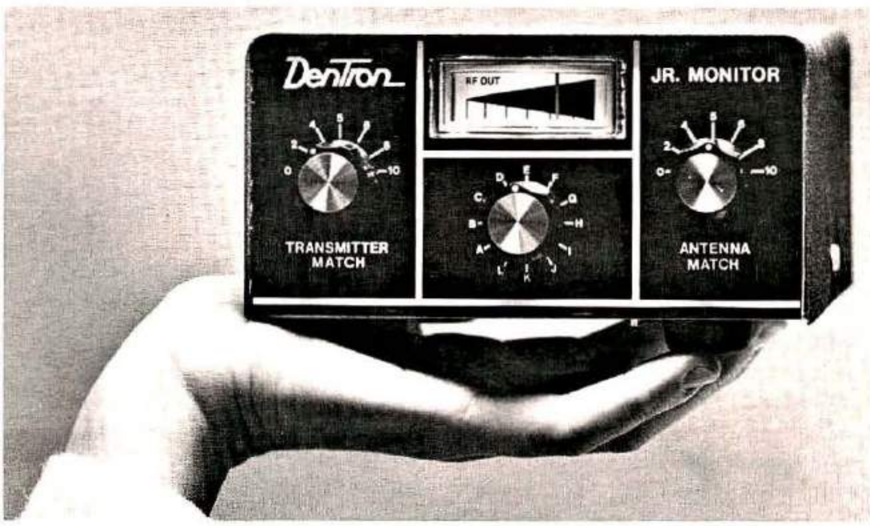
The graph in **Fig. 3** shows the swr, with a 50-ohm transmission line, of a half-wavelength dipole in free space, compared to one installed near ground. The swr you can expect from a half-wave dipole installed in your own backyard will probably fall somewhere between the limits of these two curves. The horizontal axis is marked off in per cent deviation from the center resonant frequency, f_c, so the chart may be used for any of the high-frequency amateur bands. Note that this graph is only for 50-ohm transmission lines. If you use 75-ohm coaxial cable the shape of the curves will change somewhat, but will not be drastically different from those shown.

If you study this graph for a minute, you'll see that to maintain an swr of 2:1 or less, you have to limit your operation to within about 2 per cent above or below the center frequency. Except on 80 meters this is not as serious as it looks because the 40-, 20-, 15-, and 10-meter bands all fall between the 2 per cent limits as shown in **Fig. 4** (the entire 10-meter band, 28.0 to 29.7 MHz, is nearly ± 3 per cent of the center frequency, but most amateur operation takes place between 28.0 and 29.0 MHz, which is well within

*Formulas and graphs for the evaluation of dipole antennas operated off resonance are given by R. W. P. King in *Theory of Linear Antennas* (Harvard University Press, Cambridge, Massachusetts, 1956), but this book is not recommended unless you have a solid engineering background. A somewhat simplified discussion of the same material is presented in *Transmission Lines, Antennas, and Waveguides* (Dover Books, New York, 1965), but even here you must be prepared to deal with complex mathematical concepts. ***Editor***

†*Small diameter* in terms of wavelength. On 80 meters this includes wire or tubing up to about ½ inch (12 mm); at 28 MHz a wire size of no. 14 AWG (1.6 mm) or smaller is considered a small diameter for the purposes of this discussion.

The DenTron Jr. Monitor antenna tuner is designed for use with antennas fed with coaxial cable, balanced feedline, or a random length of wire. Power capability is 300 watts (*photo courtesy DenTron*).



the 2 per cent limits).

The 80-meter band presents some problems, however, because each of the band edges is nearly 7 per cent from the center frequency; to maintain a 2:1 swr on 80 meters, you must limit your operation to about 150 kHz of the band. If a half-wavelength dipole resonates at 3.75 MHz, the swr at 3.5 MHz will fall in the range between about 5:1 and 8:1; at 4 MHz the swr will be between 4:1 and 7:1. In both cases the swr is well outside the 2:1 swr limits recommended for amateur transmitters. One solution on 80 meters is to use an antenna tuner or *Transmatch* at the transmitter end of the line as shown in **Fig. 5**. With an antenna tuner in the line, it can be adjusted so the swr seen by the transmitter will be less than 2:1 from one end of 80 meters to the other.

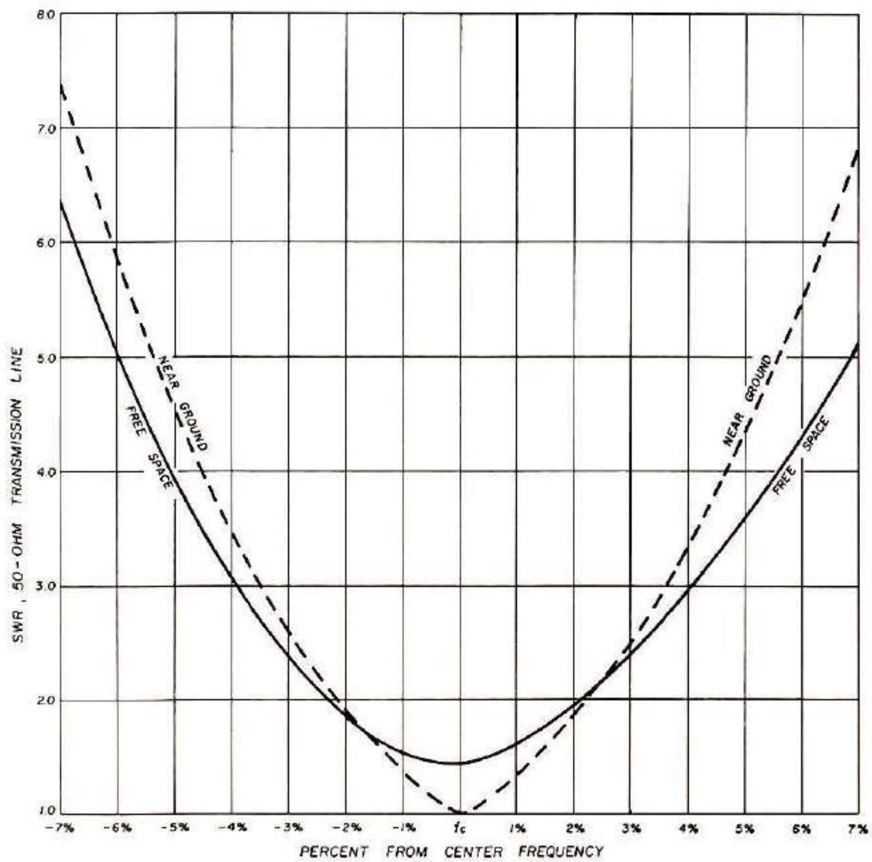


Fig. 3. Swr performance of a horizontal half-wavelength dipole fed with 50-ohm coaxial transmission line in terms of per cent deviation from the design center frequency, F_c. The swr curves of dipoles in free space and near ground are plotted — practical amateur antennas should fall between the limits of these two curves. Operation must be limited to within about 2 per cent of the center frequency for an swr of less than 2:1. Note that the swr increases more rapidly on the low side of resonance than it does on the high side.

Dipole length vs frequency

If you use the formula to calculate the length of a dipole for your chosen operating frequency, and carefully cut your antenna to the correct length, it should resonate very close to the desired frequency. However, nearby objects (including ground) may slightly move the resonant frequency away from the desired point.

If you want to resonate your dipole on a precise frequency, cut it slightly longer than the calculated length and put it up. Then install an *accurate* swr bridge in the transmission line and measure the swr at different frequencies near the desired center frequency. If you plot the swr values on graph paper, you should end up with a graph similar to that shown in **Fig. 3**; the point of minimum swr is the resonant frequency.

Since the dipole was cut slightly longer than the calculated length, the point of minimum swr should be *below* the desired operating frequency. To move the minimum swr point up to the desired spot, you simply have to shorten the antenna by a small amount. On the 80-meter band, the resonant frequency of a half-wave horizontal dipole changes appromixately 2.5 kHz per inch (1 kHz per cm) — slightly less near 3.5 MHz, and slightly more near 4.0 MHz. On the other high-frequency amateur bands the variation with length is greater, as detailed below:

40 meters	9 kHz/inch	4 kHz/cm
20 meters	36 kHz/inch	14 kHz/cm
15 meters	80 kHz/inch	31 kHz/cm
10 meters	142 kHz/inch	56 kHz/cm

Suppose you want your dipole to resonate at 3.725 MHz, the center of the 80-meter Novice band. The calculated length for a half wavelength dipole at 3.725 MHz is 125 feet, 7½ inches (38.29 meters). If you cut the antenna about 12 inches (30 cm) longer than the calculated length and put it up, the point of minimum swr will be lower in the band, say at 3705 kHz, 20 kHz below the desired frequency. Since the resonant frequency changes by about 2.5 kHz per inch (1 kHz per cm), if you shorten the antenna by about 8 inches (20 cm), the antenna should resonate very close to 3.725 MHz. (Be sure to shorten the antenna equally at both ends — in this case, 4 inches or 10 cm from each end of the dipole).

Simple multiband antennas

There's no doubt that the most efficient (and simplest) multiband antenna is a half-wavelength dipole, cut to

Typical antenna tuner construction. This is the popular Transmatch circuit described by W1ICP in *QST*. Many manufacturers build similar units around the same basic design, and many amateurs have built their own (*photo courtesy the James Millen Company*).

resonate at the lowest operating frequency, center fed with open-wire transmission line through an antenna tuner. The only real problem with this arrangement is that the open-wire feedline should be installed well away from any metal objects, with no sharp bends. The transmission line may be either transmitting type twinlead, TV ladder line, or a pair of no. 12 or 14 AWG (1.6 to 2.1 mm) wires spaced 2 to 4 inches (5 to 10 cm) apart.

Many amateurs shy away from antennas fed with open-wire feeders because they don't like antenna tuners, but if you want efficient, all-band operation with a single antenna, this is the only way to go. Every other multiband antenna is a compromise.

Multi-dipole antennas

Another simple multiband antenna is the multiple-dipole shown in **Fig. 6**. On the lower frequency band the longer pair of wires acts as a conventional half-wavelength dipole, and the shorter wires have negligible effect on operation. On the higher band the short dipole radiates and the long one goes along for the ride.

If the two dipoles are on harmonically related frequencies — say 3.525 MHz and 7.050 MHz — this arrangement works quite well, but if the resonant frequencies are not harmonically related, the swr on the higher band may be greater than expected. For example, assume the low frequency dipole is resonant at 3.725 MHz, and the high-frequency dipole is tuned to 7.125 MHz. At 3.725 MHz the antenna will perform as advertised, but at 7.125 the swr will be higher than expected.

If you run a curve of swr vs frequency, you'll find that minimum swr will occur near 7.450 MHz, the second harmonic of the frequency to which the longer dipole is cut. This happens because at 7.450 MHz, the 3.725 MHz dipole appears as a simple high resistance of several thousand ohms across the transmission line. Below 7.450 MHz, however, it looks like an inductor and the resulting inductive reactance drives up the swr.

The solution to the problem is both simple and effective: just increase the length of the higher frequency dipole (lowering the resonant frequency) so it looks slightly capacitive. This will cancel

The Collins 637T multiband dipole is used primarily in military applications, and consists of two spring-loaded reels of wire. To use the antenna you simply unreel the wire to the proper length (indicated by the calibrated dial on the end plate). This dipole can be used on any frequency between 3.3 and 30 MHz, but you have to re-adjust the length for each band (*photo courtesy Collins Radio Company*).

out the inductance presented by the lower frequency antenna.

Assuming the minimum swr occurs at 7.450 MHz and you want minimum swr at 7.125 MHz — a difference of 325 kHz — then the higher frequency dipole should be lengthened approximately 3 feet (90 cm) for minimum swr on 7.125 MHz. This is based on the fact that the resonant frequency of a 40-meter dipole changes approximately 9 kHz per inch (4 kHz per cm).

When installing multiple-dipole antennas be sure to space the ends of the two dipoles several feet (1 meter) apart. If the antennas are spaced closer than this, slight changes in spacing between the two dipoles when the wind blows will cause large variations in the swr.

This same type of multiple-dipole arrangement can be used on more than two amateur bands, but the secret to success is to cut each dipole somewhat longer than the calculated length. Then, starting at the lowest operating frequency, trim each one for minimum swr. This may require raising and lowering the antenna several times, but the final results will be worth it.

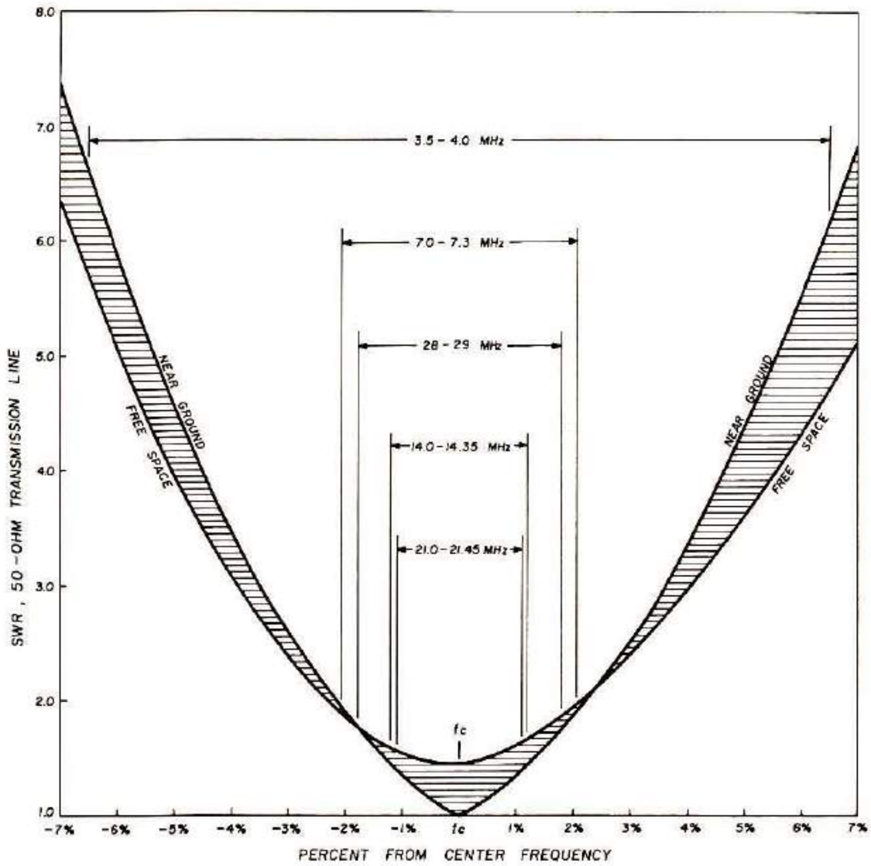


Fig. 4. Percentage bandwidth of the high-frequency amateur bands and how they compare with the swr curves of **Fig. 3**. Dipoles cut at the center of 40, 20, 15, and 10 meters are within the 2% bandwidth required for a 2:1 swr; on 80 meters the 2:1 swr bandwidth is about 150 kHz. One solution for operation to the 80-meter band edges with a single dipole is to use an antenna tuner, as discussed in the text.

Trap dipoles

One popular multiband antenna that has found widespread use on the high-frequency amateur bands is the *trap* dipole shown in **Fig. 7A**. The traps are tuned circuits which are used to electrically connect or disconnect the outer sections of the dipole as you change bands. At the lowest operating frequency the traps look like small inductors in series with the antenna wire so the dipole appears essentially as a continuous piece of wire (**Fig. 7B**). On the higher frequency bands where the tuned circuits are resonant, the traps exhibit a very high resistance and look like insulators (**Fig. 7C**); this effectively divorces the ends of the antenna from the center section.

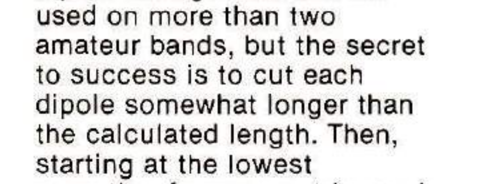


Fig. 5. Using an antenna tuner to provide a good match to your transmitter when using a half-wavelength dipole on 80 meters. If line loss is low, the swr on the line between the tuner and the antenna is of little importance. The lowpass filter behaves as it should only when it's terminated in a matched load, so it should be placed between the transmitter and the antenna tuner.

Purists often point out that the efficiency of the trap dipole is lower than individual dipoles for each of the bands because traps are not perfect insulators. Theoretically this is true, but in practice an accurately tuned multiband dipole with high-*Q* traps compares favorably with separate full-size dipoles so far as bandwidth and operating efficiency are concerned.

Shown in **Fig. 8A** is a trap dipole for the 15- and 20-meter amateur bands. Since these two bands aren't harmonically related, it isn't practical to use the parallel dipoles of **Fig. 6**. The trap dipole, however, provides excellent performance. As shown in **Fig. 8A**, the center section of the antenna is resonant at about 21.15 MHz; this length is very close to that given in **Table 1**. The overall antenna is resonant at about 14.15 MHz. If you compare this length with that given in **Table 1** for the same frequency, you'll see that the trap dipole is about 3½ feet (1 meter) shorter. This shortening is due to the small loading inductance contributed by the traps. Note that each of the traps is about 4 inches (10 cm) long; this dimension must be included in the overall length. A similar arrangement for 10 and 15 meters is shown in **Fig. 8B**.

If you want to operate on three amateur bands, an additional set of traps can be installed in the dipole as shown in **Fig. 9**; this trap dipole is designed for the 10-, 15-, and 20-meter bands. In this antenna the center, 10-meter, section is the normal length while the 15- and 20-meter lengths are shortened slightly by the loading of the traps. The use of two traps decreases the bandwidth over which you can operate with an swr less than 2:1, but this three-band dipole can be used from 28.0 to 28.6 MHz, and over the entire 15- and 20-meter bands with swr less than 2:1. (Remember that height above ground affects swr, so in some cases you may have to prune the antenna length slightly to obtain best performance.)

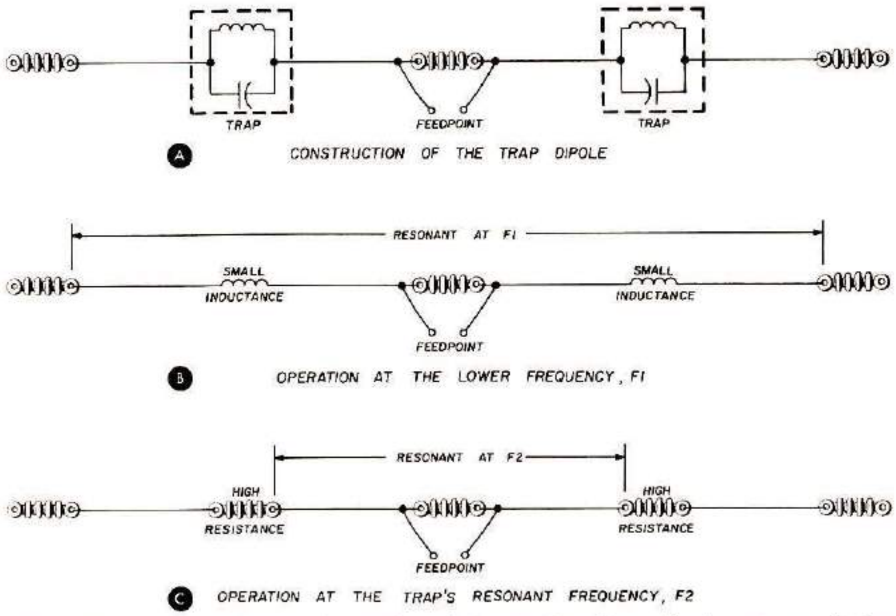
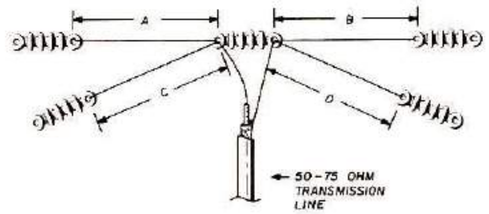


Fig. 7. Basic construction and operation of the two-band trap dipole antenna. At the lower frequency, *F1*, the traps appear as small inductors in series with the antenna, **B**. At the higher frequency, *F2*, the traps exhibit very high resistance and the traps look essentially like insulators, **C**.



$$A + B \text{ (LOWER FREQUENCY)} = \frac{468}{f_{MHz}} \text{ (FEET)} = \frac{143}{f_{MHz}} \text{ (METERS)}$$

$$C + D \text{ (HIGHER FREQUENCY)} = \frac{468}{f_{MHz}} + \text{CORRECTION FACTOR (FEET)}$$

$$= \frac{143}{f_{MHz}} + \text{CORRECTION FACTOR (METERS)}$$

Fig. 6. Multiple dipole antennas can be used for operation on two amateur bands, but if the center frequencies are not harmonically related, the higher frequency antenna must be lengthened slightly for low swr as discussed in the text. Multiple dipoles are usually built with no. 12 or 14 AWG (1.6-2.1mm) hard-drawn copper or copper-clad steel wire.

Trap construction

In most cases the traps are built around antenna strain insulators as shown in **Fig. 10**. The inductor is a short section of air-wound coil stock such as that manufactured by B&W.* The capacitor is a high-voltage ceramic capacitor such as the Centralab 850S series; these capacitors will handle up to 2000 watts PEP in this application. For power levels below 500 watts the Centralab 850A series of capacitors, rated at 3000 volts, is satisfactory. One of the best ways to connect the trap to the antenna wire is to use small electrical service connectors like the Burndy KS90 *Servits* which are available from electrical supply stores.

After the traps have been built, they have to be adjusted to the correct frequency. This is most easily done with a grid-dip oscillator (use your receiver to make sure the dipper is

*B&W coil stock, Centralab ceramic capacitors, and antenna insulators are available from G. R. Whitehouse, 15 Newbury Drive, Amherst, New Hampshire 03031.

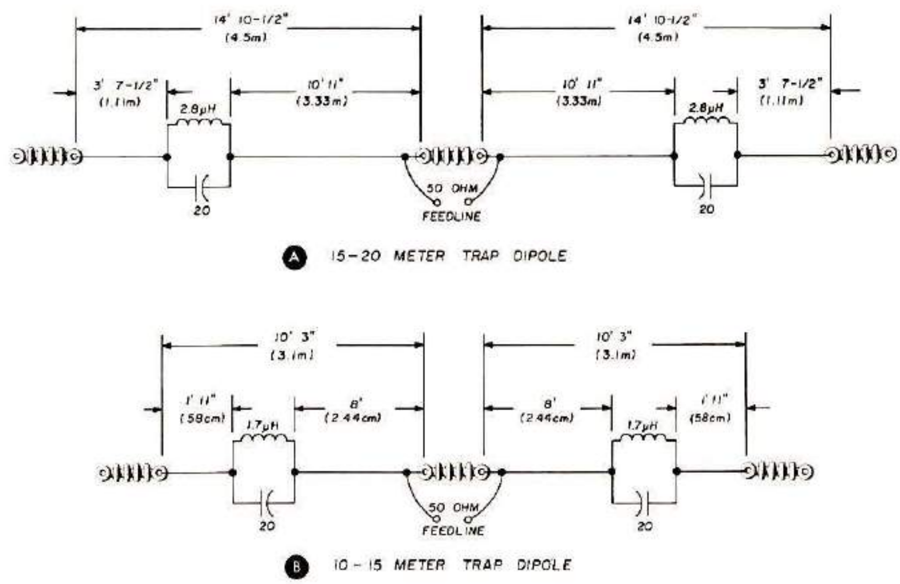


Fig. 8. Two-band trap dipoles for 15 and 20 meters, **A**; and 10 and 15 meters, **B**. The capacitors should be high-voltage ceramic units such as the Centralab 853A series. The inductors are made from sections of B&W coil stock. For the 15-20 dipole use 8 turns of B&W 3025 coil stock; for the 10-15 dipole use 6 turns of B&W 3025 coil stock.

tuned to the right frequency).

Place the assembled trap in a clear space away from any metal objects and loosely couple it to the dipper. For best results the traps should be tuned slightly *below* the operating frequency — this gives maximum bandwidth. The traps will also work if they are tuned to the center of the operating band, but the 2:1 swr bandwidth won't be as great. Adjusting the traps so they dip about 50 to 100 kHz below the band edge seems to give the best results. For coarse frequency tuning adjustments slightly prune off turns from the coil about one-quarter turn at a time; for fine adjustments simply expand or compress the outer turns.

5-band trap antenna

If you build a trap dipole for 40 and 80 meters and analyze its operation on the higher amateur bands, you'll find that the traps appear as small capacitors in series with the antenna wire at the higher frequencies. These capacitors have the effect of increasing the resonant frequency as compared to a simple dipole of the same overall length. By carefully choosing the inductance-capacitance ratio in the traps, it's possible to design a trap dipole that will provide a good match to 75-ohm transmission line on 80 through 10 meters.

Just such an antenna is shown in **Fig. 11**. This five-band antenna was designed by engineers at Cape Kennedy and is known as the "5-Band Cape Antenna." Each of the traps consists of a 50 pF ceramic capacitor (Centralab 850S-50Z) in parallel with a 10 μH inductor built from 15 to 17 turns of B&W 3905-1 coil stock. The traps are tuned to 7.1 MHz.

If you don't have enough room in your backyard to put up the 106-foot (32.3 meter) "5-Band Cape Antenna," shown in **Fig. 12** is a four-band trap dipole that covers 40 through 10 meters; the overall length of this antenna is only about 55 feet (16.8 meters). Each of the traps consists of a 25 pF capacitor in parallel with a 5.1 μH inductor built from commercial coil stock. For best results the traps should be tuned to 14.1 MHz with a grid dipper.

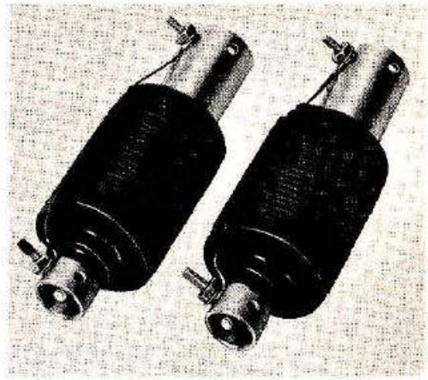
Waterproofing the traps

There are several methods for protecting the traps from the ravages of rain and snow. One of the neatest is to use short sections of 4-inch (10 cm) PVC drain pipe available at plumbing supply houses.* The trap is placed inside a section of plastic pipe and end caps are cemented on with PVC solvent (do this outdoors or in a well-ventilated area). Holes are drilled in the end caps for the antenna wire to pass through; after the antenna wire is installed, seal the hole with RTV or bathtub caulking to keep the moisture out.

Another method of waterproofing the traps is to use a short section of large-diameter Lucite tubing with large corks that are meant for Thermos bottles.

If you're really budget minded, you might consider using the round, flexible, plastic "squeeze" bottles that contain various household products. Cut the bottom off the bottle, insert the trap and antenna wire, and cement the bottom back on with bathtub caulking or RTV.

*PVC drain pipe is also available from Sears. The catalog number for the 4-inch (10 cm) pipe is 42G23131N; the matching end caps are catalog number 42G23119.



Commercial multi-band antenna coils manufactured by the Microwave Filter Company, 6743 Kinne Street, East Syracuse, New York 13057. Several models are available including the KW-40 trap for 40 meters, and the KW-10, KW-15, and KW-20 for 10, 15, and 20 meters. The KW-40 can be used by itself to build a five-band dipole, but operation is a compromise on 20 through 10. For lower swr performance on the higher bands, the other traps should be used as well. Total length of a five-band dipole using all eight traps is about 100 feet (30 meters). The traps are completely waterproof and will handle up to 1000 watts.

Baluns

Simple, center-fed dipoles first became popular with the development of efficient, flexible, low-impedance twin-lead transmission lines which matched the dipole's nominal 72-ohm center impedance. Even after amateur transmitters with unbalanced pi-network output circuits became standard, many amateurs continued to use twin-lead to feed their

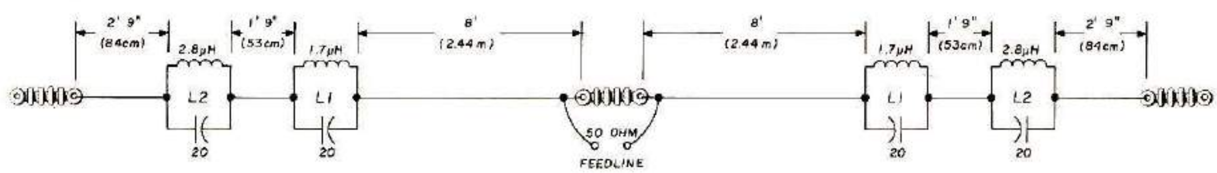


Fig. 9. Three band trap dipole for 10, 15, and 20 meters. The capacitors are high-voltage transmitting ceramics such as the Centralab 853A series. The inductor in the 10-meter trap (L1) is 6 turns of B&W 3025 coil stock; inductor L2 in the 15-meter trap is 8 turns of B&W 3025 coil stock. For best performance and greatest bandwidth the 10-meter trap should be tuned to 27.8 MHz; the 15-meter trap is resonated at 21.85 MHz.

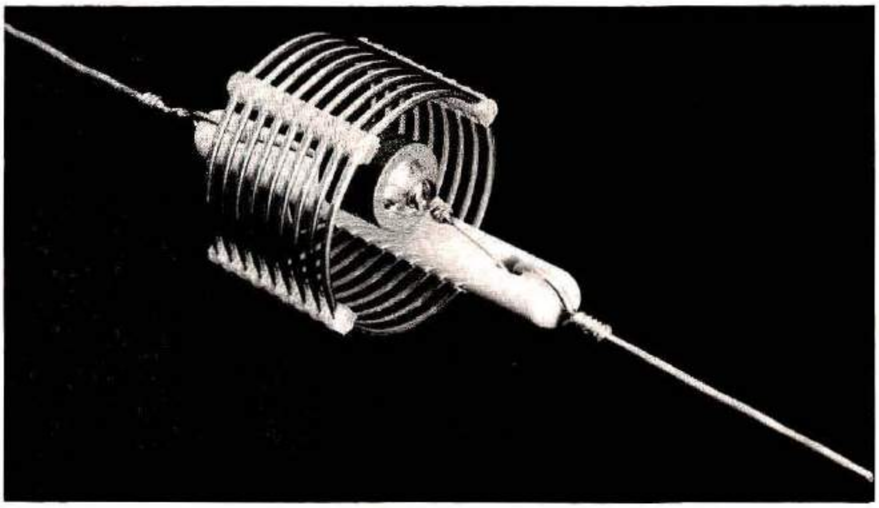


Fig. 10. Method of building the traps for multiband dipole antennas. The coil stock is air wound with no. 12 AWG (2.1mm) on a 2-inch (50mm) diameter form, 6 turns per inch (B&W 3025 or equivalent). The capacitor is a 7500-volt ceramic transmitting type (Centralab 850S series or similar). This design will handle the amateur power limits of 2000 watts PEP. For power levels up to 500 watts, the coil may be built from smaller diameter coil stock, and the capacitor may be the smaller 5000-volt Centralab 853A series.

dipoles by grounding one conductor of the twin-lead and connecting the other lead to the center pin of the transmitter's coaxial output connector.

This arrangement seemed to work just fine, but the word gradually got around that you couldn't feed a balanced transmission line with the unbalanced pi network.* Most amateurs dutifully switched from twin-lead to coaxial cable — and the antennas worked fine, just as they apparently did with the twin-lead. Then the purists came up with the edict that you couldn't feed a balanced antenna like the dipole with unbalanced coaxial feedline unless you put a balancing device such as a balun between the feedline and the antenna. Many amateurs quickly installed the required baluns, but noticed very little difference in antenna operation.

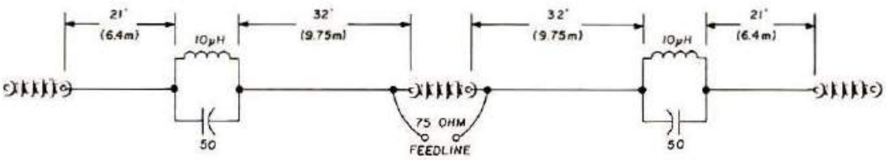


Fig. 11. Five-Band Cape Antenna for 80 through 10 meters which was designed by engineers at Cape Kennedy. The inductor is 15 to 17 turns of B&W 3905-1 coil stock (2½" 6.4cm diameter, no. 12 AWG 2.1mm wire, wound 6 turns per inch). The capacitor is a ceramic Centralab 850S-50Z. The traps should be tuned to 7.1 MHz by carefully pruning one end of the coil a little at a time.

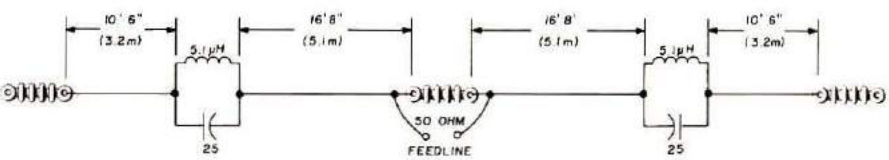


Fig. 12. Four-band trap antenna for 40, 20, 15, and 10 meters. The overall length is only 55 feet (16.8 meters), 10 feet (3 meters) shorter than a normal single-band dipole for 40 meters. The inductors are 9 turns of B&W 3905-1 coil stock (2½" 6.4cm diameter, no. 12 AWG 2.1mm wire, wound 6 turns per inch). The capacitor is a high-voltage transmitting type. The traps should be carefully tuned to 14.1 MHz.

Admittedly, there is some skewing of the dipole's radiation pattern when it's fed directly with coaxial cable, but for the average installation, where the antenna is less than 50 feet (15 meters) above the ground, the pattern is so distorted by nearby objects that the skewing goes unnoticed. With a balun installed, however, you'll notice poorer reception of local vertically polarized signals. This is important because most man-made noise is vertically polarized, so a dipole with a balun *may* be somewhat quieter than a dipole without one.

If you are using a high-gain beam which is designed for balanced feedline, the use of a balun is much more important because pattern skewing can be very noticeable without the balun. Amateurs who use simple balanced antennas such as dipoles, however, are about equally split on their use of baluns. If you want to install one on your dipole, it certainly won't do any harm, and it will probably reduce the amount of man-made noise your receiver hears.

Harmonic radiation

Some amateurs avoid multiband antennas because they're afraid of excessive harmonic radiation. Fortunately this is not a problem with modern transmitters and transceivers because they have sufficient harmonic suppression built into the design. If you carefully tune your transmitter into a dummy load before you go on the air, and operate with a swr of 2:1 or less, you should have no problems with unwanted harmonics. **HRH**

*Unbalanced to ground; the output of the pi network is "hot" with respect to ground. A balanced line such as twin-lead must have equal magnitude, opposite polarity rf currents flowing on each of the two conductors to prevent rf radiation. When twin-lead is connected to a pi network, the currents in the conductors are not balanced, so the line acts like a radiator; this may lead to problems with television and hi-fi interference.