Feeding Dipole Antennas

Last month, I covered dipole-antenna basics. This time I’ll show what it takes to get RF from your rig to a dipole—and how to make that antenna radiate as much of your signal as possible.

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Communicating via radio fundamentally depends on getting RF to your antenna system—and on making the antenna radiate that energy as efficiently as possible. As simple as this may sound, achieving it can be challenging. Last month, I described how dipole antennas work and how to make them; this time I’ll cover getting RF back and forth between your antenna and your radio. This includes two general subjects: selecting the right feed line, and making the antenna—not the feed line—radiate your signals.

**Feed Lines**

Two general types of transmission lines are usually used to feed dipole antennas. One is *coaxial cable*, which is familiar to most people. Basically, it’s the same stuff that connects your TVs and videocassette recorders to each other, and to the cable TV system.

Coaxial cables commonly used by hams, including RG-8 and RG-58 (both of which are somewhat different from TV coax), and similar types, are useful for feeding resonant dipoles. Such cables offer a reasonably good impedance match to the antenna and to your transmitter, are easy to work with, and are fairly inexpensive. If you use coaxial cable to feed a dipole (or elsewhere in your station), follow the guidelines Dave Newkirk, WJIZ, put forth in his article, “Connectors for (Almost) All Occasions,” in April and May 1991 QST.

One drawback of using dipole antennas with coaxial cable is that most coax has relatively high loss when it’s used to feed nonresonant antennas. (*The ARRL Antenna Book* and *The ARRL Handbook* discuss this in their chapters on transmission lines; see “Further Reading.”) Using an antenna tuner, you can match the impedance present at the shack end of a coaxial feed line to your radio—even if it’s feeding a far-from-resonant antenna—but a good match isn’t an indication of system efficiency. For one thing, high cable loss causes the SWR to be lower at the radio than it is at the antenna’s feed point. Therefore, if you want to use a single dipole antenna on several bands, coax isn’t the best choice.

As I mentioned last month, dipoles are balanced antennas. Therefore, it’s best to feed them with balanced transmission lines. In a balanced transmission line the currents flowing in the conductors are equal in magnitude and 180° out of phase, allowing the line to transfer power without radiating it. If either of these is not the case, the line will radiate, potentially causing RF interference (RFI) and other problems. Fortunately, you can avoid feed-line radiation by following the guidelines I’ll cover in the remainder of this article.

**Open-Wire Feed Lines**

This feed-line type commonly used by hams is known variously as *ladder line*, *twinlead* and *parallel feeders*. I’ll refer to this class as *open-wire line* (even though the conductors may be insulated and are separated by substances other than air). Using open-wire line to feed most dipole antennas eliminates the need for a balun (if the entire feed system is balanced, as discussed later). Open-wire lines have other advantages, especially when used for feeding nonresonant dipole antennas. When used to feed high-SWR loads such as nonresonant antennas, open-wire lines have very low loss compared to coax. Even a badly mismatched open-wire line, such as one feeding a 14-MHz dipole at 21 MHz, has a lot less loss than RG-8 or RG-58 coax performing the same duty. With moderate to long feed lines, that can make a big difference when it comes to making contacts on the air. Open-wire lines are also much better for long feed-line runs than coax, because open-wire lines generally have lower matched loss—loss when operated at low SWR—than varieties of coax usually used by hams.

Characteristic impedances of open-wire feed lines are generally much higher than the 50 Ω of the coaxial cables that hams most often use. Typical ladder line, for instance, has a characteristic impedance of 400 to 450 Ω; TV twinlead, 300 Ω. To use open-wire transmission lines to feed dipoles, you’ll also need to use an antenna tuner, because modern Amateur Radio gear is designed for use with unbalanced = 50 Ω feed lines. If you’re planning to use a dipole antenna on several bands, you’ll need a tuner anyway, because a dipole’s impedance can provide a good match to coax on only one or two HF ham bands.

Widely available from QST advertisers (see the sidebar, “Where to Get the Pieces,” in last month’s article), open-wire transmission lines are usually less expensive than coaxial cable and require no special connectors. If you like, you can easily make your own open-wire line with wire and home-made or store-bought insulators.

One area where open-wire transmission lines are less practical than coax is in routing the feeder from the antenna to the station. In properly used coaxial cable, the RF fields are contained almost entirely within the cable, so coax can be run through walls and near other conductors without special precautions. But in open-wire line, RF fields surround the line at least as far as the wires are spaced apart. Thus, when you’re routing open-wire line, space it at least its width away from any conductive object, and farther if it runs parallel to a conduc-

1Notes appear on p 24.
Further Reading
For more information on baluns and feed lines, see the references listed below. The issues of QST cited here may be available at your local library; if not, contact the Technical Department Secretary at ARRL Headquarters (see page 3 of this issue) for any photocopies you need. (There is a nominal charge for this service).
• G. Hall, ed, The ARRL Antenna Book, 15th ed (Newington: ARRL, 1987). The chapters on transmission lines, matching transmission lines to antennas, and selecting your antenna system contain useful information on selecting and feeding all kinds of antennas.
• J. Beirose, "Transforming the Balun," QST, Jun 1991, pp 30-33. Effective baluns easily made from coaxial cable and ferrite beads are the subject of this article. Transformation ratios of 1:1, 6:1 and 9:1 are covered.

In most cases, a simple balun can eliminate this problem.
A balun is simply a device that interfaces an unbalanced system (coaxial feed line) to a balanced system (the dipole), providing the antenna and the feed line with the terminations they need, and keeps the feed line from becoming part of the antenna. Walt Maxwell, W2DU, put it succinctly in 1985 when he said that a balun's "primary function is to provide proper current paths between balanced and unbalanced configurations." In so doing, a balun forces RF in the feed line to flow into the antenna, instead of down the outside of the coaxial cable's outer conductor. (See "Further Reading," especially the articles by Roy Lewallen, Walt Maxwell and Jack Beirose, for the reasons for this.)

Three Simple Baluns You Can Build
Because the 50-Ω impedance of common coaxial cables (such as RG-8, RG-213, RG-58 and miniature RG-8) closely matches the impedance of a resonant dipole, the balun you use doesn't have to perform any impedance transformation. That makes the balun-building task much easier. Three effective and very simple baluns in wide use today are described as choke baluns because the high impedance they place on the outside of the coax keeps RF from flowing back down the outside of the cable. Each is made primarily from coaxial cable.

Bead Baluns
You can make an effective and simple balun using special ferrite balun cores stacked over the outside of a coaxial cable. (See Fig 1.) The cores don't affect the RF currents flowing on the cable's center conductor and the inside of its braid, but they stop RF current flow on the outside of the braid. Because the beads are one-piece units just large enough to slide over the outside of RG-8/RG-213 cable, put them on before you connect the cable to the antenna. Keeping this balun as close to the antenna's feed point as possible lets the balun do its job best, but it may be effective elsewhere on the line.

Once you've placed the cores over the feed line, securely tape the cores together and to the coax, so that the cores can't slide down the cable. These cores are somewhat fragile (they chip and break easily if dropped), so be careful when handling them.

A Coaxial-Choke Balun for the Shack
In his February 1990 QST article, Rich Measures, AG6K, described the rationale for using a choke balun made from coaxial cable, and explained how to build such a balun. You can make this kind of choke balun by winding 15 or so feet of coaxial cable in a single layer on a piece of ABS plumbing pipe between 3 and 5 inches in diameter and about a foot long. (See Fig

Fig 1—A bead balun made from several ferrite beads stacked on a piece of RG-8 coaxial cable. These cores chip easily, so they should be taped together and to the cable to prevent damage. (Tape is omitted here for clarity.)

Fig 2—A coaxial-choke balun, wound from RG-58 on a piece of ABS plumbing pipe, effectively stops the flow of RF on the outside of the coax shield, but doesn't impede current flow inside the cable.
A Formless Coaxial-Coil Choke Balun

Roy Lewallen, W7EL, described this variation on the coaxial-choke-balun theme in The 1991 ARRL Handbook for Radio Amateurs on page 16-9. This effective balun simply consists of a coil of cable, turns taped conveniently together, as shown in Fig 3. A table on page 16-9 of the Handbook gives the appropriate number of cable turns you should use in making such a balun. This is a function of frequency and cable type.

A coaxial-choke balun in the shack in conjunction with a bead balun or formless coaxial-cable balun at the antenna covers both bases. In fact, coaxial-choke baluns and bead baluns work comparably; use whichever best suits your situation. Also, keep in mind that all three kinds can effectively stop RF current flow on the outside of coaxial-cable braid when placed at locations other than the antenna’s feed point.11 If putting a balun at the feed point is inconvenient, try placing one elsewhere on the line. Feel free to move it to its most effective and convenient location. Choke baluns are suitable for much more than dipoles. Use them with any low-impedance, coax-fed antennas, such as Yagis, quads, verticals and so on.

Hitching a Feed Line to Your Dipole

No matter what kind of feed line you choose for your dipole, you’ll have to securely mount it to the antenna’s feed point. Fig 4 shows how to attach both kinds of feed lines to a dipole center insulator. The open-wire-fed dipole insulator needs nothing more than a shot of clear spray lacquer to protect it from the elements. The coax junction, however, unprotected in Fig 4 for clarity, must be completely sealed for long-term reliability. Tips on these subjects are offered in the sidebar called “Dipole Construction and Adjustment” in last month’s article.

Summary

No matter what you feed your dipole with, it’s important to remember that the dipole itself is only part of your antenna system. The system consists of every cable, connector and wire that comes after the radio’s RF-output jack. If you take shortcuts anywhere in the system, your ability to communicate with other stations may suffer. As you’ll hear many hams say, a station is only as effective as its antenna system.

Acknowledgment

Thanks to ARRL Technical Advisor Roy Lewallen, W7EL, for contributing to this article.

Notes

2 “Antenna Here is a Dipole” introduces dipole resonance.
3 This is because, at HF, feed-line loss is mostly in the conductors (not the insulation). Because open-wire feed lines have higher impedances than coax, lower currents flow in open-wire lines at a given power level, and resistive loss is proportional to conductor current. Lower current therefore translates to lower HF loss in open-wire lines than in coax.
4 This is true for simple single-wire dipoles, but doesn’t apply to multiband, resonant dipoles such as the parallel-multiband and trap varieties described in the last month’s “Antenna Here is a Dipole” (see note 1).
5 See note 1.
7 In the cases of dipoles that are badly mismatched to the feed line (such as very short antennas), especially lossy antennas, and other unusual circumstances, making a dipole radiate most of the applied RF can be difficult. Garden-variety dipoles, however, tend to be very efficient—usually well over 95%.
9 These cores are available from Amidon Associates, 2216 E Gladwick St, Dominguez CA 90220, tel 213-763-5770, fax 213-763-2250 as part numbers FB-77-1024 (for RG-8-size cables) and FB-72-2401 (for RG-58-size cables). See The ARRL Handbook for Radio Amateurs, pp 16-9 and 16-10, for more information on ferrite-bead selection for this application.