PROJECT BUILD

Build a Classic Multiband Dipole Antenna

We call this antenna a "classic" because amateurs have been using it for more than 100 years. This antenna will allow you to operate on several HF frequency bands, and it radiates signals efficiently, sending much of the RF energy from your radio to far-flung corners of the world.

Antenna Wires and Feed Lines

At the heart of this antenna (see Figure 1) are two wires of equal lengths that meet in the center and attach to a type of feed line known as *windowed ladder line*. The ladder line subsequently connects to a *balun* in or near your station (see "About Baluns" in this issue for more information). The balun then connects to your antenna tuner, and the tuner connects to your radio.

The antenna wires should be as long as possible. The longer the antenna, the more frequency bands will be available to you. Some suggested lengths are listed in Table 1.

The antenna wires may be subject to significant mechanical stress in moderate or high winds, so choose wire that can withstand the punishment. Multistranded 18-gauge copper wire (bare or insulated) is an excellent choice.

Windowed ladder line is available from many different amateur radio retailers (you'll even find it on Amazon). Look for 450-ohm windowed ladder line, and choose a length that will reach from the center of your antenna to wherever the balun will be located. There will probably be some ladder line left over, but that's okay. You can use it for future projects.

Why Use Ladder Line?

Ladder line consists of two wires in parallel that are separated by an insulating material. It is known as a *balanced* line because the energy from the transceiver appears on both wires in an equal and opposite relationship. Neither wire is grounded. In a coaxial cable, one wire (the shield) surrounds a central wire and the shield is grounded. As a result, the electrical relationship between the two wires is *unbalanced*. That's why we call coaxial cable an unbalanced line.

We could spend many pages discussing what all this means for this antenna, but let's make it simple. When you connect your radio to this antenna and operate at many different frequencies, its *impedance* (the total opposition to the flow of energy) will constantly change. Unless you run outside and re-adjust the antenna every time you switch frequencies, the impedance changes will cause excessive *standing wave* levels in the line — a condition you can measure with a standing wave ratio (SWR) meter.

If you use coaxial cable to feed this antenna, an elevated SWR will result in a substantial amount of the energy being wasted as heat in the line. But replace the coaxial cable with a balanced feed line, such as ladder line, and something almost magical happens. Because of the way a balanced line behaves, an elevated

Weighing the Pros and Cons

As you may recall from the previous issue of *On the Air*, there is no such thing as a perfect antenna. Here are some of the pros and cons of this particular antenna.

Advantages

- Can operate on several different HF frequency bands
- Is quite easy to build

Disadvantages

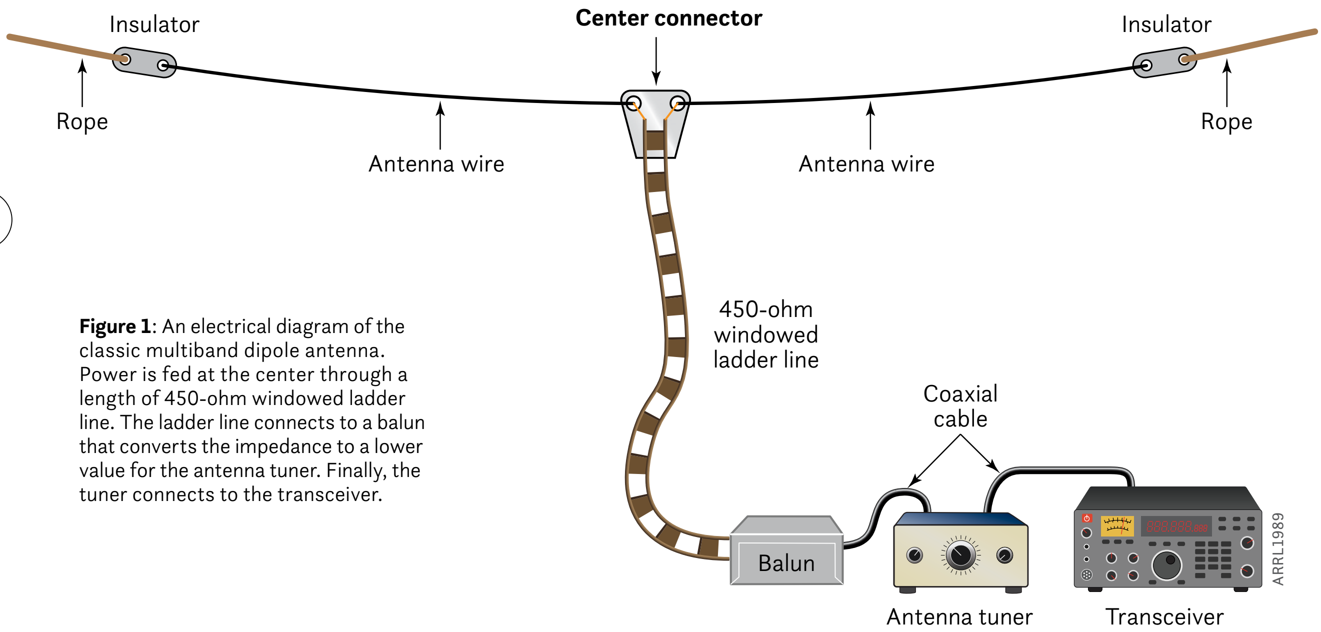
- The antenna requires an impedance transformer known as a *balun*.
- In most cases, you will need to use an antenna tuner.

Despite the disadvantage of potentially requiring additional equipment, the sheer versatility of this antenna makes it worthwhile.

Table 1
Antenna Wire Lengths for the Classic Multiband Dipole

Note: The suggested lengths include an additional amount to allow attachment to the end insulators as described in Step 3.

Desired Bands (METERS)	Total Length (FEET)
80 through 10	135
40 through 10	68
30 through 10	48
20 through 10	34
17 through 10	27
15 through 10	23



1

Figure 1: An electrical diagram of the classic multiband dipole antenna. Power is fed at the center through a length of 450-ohm windowed ladder line. The ladder line connects to a balun that converts the impedance to a lower value for the antenna tuner. Finally, the tuner connects to the transceiver.

SWR is no longer a problem. Even if the SWR skyrockets, little energy is lost.

With a balanced feed line, you can operate at almost any frequency you want without worrying about adjusting the antenna or losing power to the effects of SWR. That's why this antenna design has been a favorite for so long. Not having to be concerned about loss due to SWR is a good thing!

There is a problem, however: Modern transceivers are designed for unbalanced coaxial cables, not balanced feed lines. To connect a balanced feed line to our modern transceivers, we need help from another component in the Figure 1 diagram — the balun.

The Balun

Balun is a combination of the words "balanced" and "unbalanced." The balanced feed line attaches to one side of the balun, and a coaxial cable attaches to the other. The balun acts as a kind of electrical bridge between the balanced and unbalanced conditions.

In this application we're also using the balun to convert whatever impedance exists at the point where the ladder line connects to it, to a much lower impedance that is likely to be within the working range of the next component: the antenna tuner.

In the case of a 4:1 balun, the conversion ratio is 4:1. For instance, let's say the impedance at the ladder line side of the balun is 800 ohms. This means the impedance at the other side of the balun — the side that connects to your antenna tuner — will be 200 ohms (800 / 4 = 200).

If you're balun shopping, look for a model that is rated for the HF frequencies and power levels at which you plan to operate. Resist the urge to save money by purchasing a small, inexpensive balun. Small baluns may not handle the stress that can occur with higher power levels. If you are using a 100 W HF transceiver, consider investing in a balun rated for at least 500 W.

Also, if you'll be installing the balun outdoors, you will need a model that is weatherproof.

The Antenna Tuner

The last item we need to discuss in Figure 1 is the antenna tuner. Some HF transceivers have built-in antenna tuners, but in most cases, these will not be able to handle the impedances they are likely to "see" with this antenna. You may be lucky and discover that your built-in tuner can indeed find an acceptable impedance match (resulting in an SWR of less than 2:1) on several frequency bands, but that would be unusual.

To use this antenna on as many frequency bands as possible, you will probably need an antenna tuner with the ability to match a broad range of impedances, typically 6 to 1600 ohms. Most standalone antenna tuners will do the job. The tuner may be manual, which means that you must adjust the tuner yourself, or it may be automatic, which means it does the tuning for you. Automatic tuners are convenient, but they are also more expensive.

You'll often find that manual antenna tuners have 4:1 baluns already built in. If that is the case, you can connect the ladder line directly to the tuner at its balanced antenna terminals and you're done. There is no need to purchase a separate balun.

Built-in baluns are rare in automatic tuners, however. If you want to enjoy the convenience of an auto tuner, you will probably need to purchase a balun to go with it.

If you choose a tuner that requires an external balun, make sure the coaxial cable between the tuner and the balun is *short* — 15 feet or less. High SWRs can exist in this cable and cause excessive loss. Shorter cables mean lower losses. In addition, consider using a low-loss coaxial cable for this connection such as RG-8 or LMR-400.

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Building the Antenna

Materials and Tools

TIP The components used in this project were purchased from Ham Radio Outlet (hamradio.com), but they are available from other retailers as well.

- Bare or insulated wire, at least 18 gauge. See Table 1.
- Two end insulators
- A center insulator that can support ladder line, such as the WA1FFL Ladder-Loc
- 450-ohm ladder line — enough to reach from the center of the antenna to your station while allowing some slack to relieve stress in windy conditions
- A 4:1 balun rated for at least 500 W at HF frequencies
- A manual or automatic antenna tuner
- Wire cutters
- Dacron rope, 1/8-inch diameter — 100 feet
- Soldering iron
- Solder
- A yardstick or measuring tape
- A short length of RG8 or LMR-400 coaxial cable with PL-259 connectors at each end. (Available premade from many amateur dealers.) The coaxial cable connecting the balun to the antenna tuner should be less than 15 feet in length. If your antenna tuner has a built-in balun, you won't need this cable.

Step 1:

Cut the 18-gauge antenna wire to one of the lengths shown in Table 1, and then cut the result into two equal pieces. If the wire is insulated, strip about 6 inches of insulation from just one end of each length (see 2).

Step 2:

Strip away about 3 inches of insulation from the ladder line wires at one end of the line. Depending on the type of center insulator you've chosen, you will probably need to carefully cut away the plastic sections that separate the two ladder line wires.

In this project we're using the WA1FFL Ladder-Loc, as shown in 3. This device provides mechanical support for both the ladder line and the connecting wires. The Ladder-Loc has a cover that is held in place with plastic wing nuts. Remove the cover, and then place the ladder line inside, with the Ladder-Loc support blocks fitting into the center of the line while allowing about 6 inches of wire to extend toward the top. You may need to cut and trim the ladder line again so that it fits properly.

2

If you are using insulated wire for the antenna, start by removing about 6 inches of insulation at only one end of each of the two lengths.

3

Depending on the type of center insulator/connector you choose, you may need to trim away some of the ladder line insulating sections. In this example, we're using a WA1FFL Ladder-Loc, so we needed to cut away enough insulation so that the ladder line will fit properly.

Wrap the antenna wires through the holes at the top of the Ladder-Loc and twist them back on each other (see 4). Route the ladder line wires through the grooves in the top of the Ladder-Loc, and solder them to the antenna wires as shown in 4. Be careful not to use too much heat, or you may damage the Ladder-Loc.

When you're finished, replace the Ladder-Loc cover, and finger-tighten the nuts. Don't use tools.

Step 3:

Attach end insulators to the opposite ends of both antenna wires. There is no need to solder. Instead, pull the wire through the insulator hole and then twist it tightly over itself (see 5). Five turns of wire should be sufficient.

Step 4:

Attach lengths of Dacron rope to each end insulator. Use the rope to suspend the antenna as high as possible, which means you'll need to estimate how long the ropes should be, and cut their lengths accordingly. (We suggest 100 feet of rope for this project, but you may discover that you need more.) While any rope can be used, Dacron resists breakdown caused by the ultraviolet rays of the sun.

You can suspend the ends of the antenna from tree branches, poles, or whatever supports you have available. The antenna doesn't have to be flat across the top. You can hang one end of the antenna from a branch and slope the rest toward the ground and secure the end near the top of a fence, as shown in 6. Even a low bush will do, as long as the wire is a 4 or 5 feet above ground.

You can also bend the antenna wires to squeeze them into tight spaces; they don't have to be perfectly straight. It is also possible to attach the rope to the top of the Ladder-Loc, raise the Ladder-Loc as high as possible, and then slope both legs downward to within a few feet of the ground. This configuration is known as an *inverted V*.

With the antenna aloft, route the windowed ladder line downward and perpendicular to the antenna wires. Attach it to the balun (or antenna tuner). Don't allow the line to knot or kink. Keep the ladder line at least a few inches away from large sections of metal (such as aluminum siding), and don't allow it to lie on the ground. Either condition will change the electrical behavior of the line and potentially cause problems.

If you end up with more ladder line than you need, don't coil the excess. Instead, cut the surplus line, leaving only what is necessary to reach the balun. Plan to leave some slack in the ladder line so that it can be flexible on windy days.

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4

Use solder to attach the ladder line wires to each of the antenna wires.

5

Attach end insulators to the opposite ends of both antenna wires. There is no need to solder. Instead, pull the wire through the insulator hole and then twist it tightly over itself.

6

You can hang one end of the antenna from a branch, slope the rest of it at an angle, and secure it near the top of a fence, as shown here. Use whatever configuration you can, according to the space you have available.

Step 5:

Connect the ladder line to the balun (see 7). If your tuner has a built-in balun, connect the ladder line to the appropriate posts at the tuner.

Step 6:

Connect a coaxial cable from the balun to the antenna tuner (see 8). This cable needs to be as short as possible — no more than 15 feet. If you are using an antenna tuner with a built-in balun, just connect the antenna tuner to the radio with a short length of coax.

Step 7:

If you are using a manual antenna tuner, place your radio in the transmit mode with low power (10 W or less) and choose a mode such as CW, RTTY, AM, or FM so that the radio generates a continuous signal. Following the tuner's user manual, adjust the controls to achieve the lowest SWR on each frequency band you hope to use. Your antenna tuner may have a built-in SWR meter for this task, or you can use the SWR meter in your transceiver (if it has one). Write down the final tuner knob positions for each frequency band. This will allow you to quickly reconfigure the controls when you switch from one band to another.

If you are using an automatic tuner, follow its operating instructions and, once again, use low transmit power for your initial tests. When the tuner is searching for the lowest SWR, you're likely to hear clicking noises, but this is normal. Many auto tuners light a green LED (see 9) to indicate when they've found acceptable SWRs. These tuners will also store the low-SWR settings in memories, which allow them to reconfigure themselves rapidly when you change bands.

It is possible that you may not be able to achieve an acceptable SWR (below 2:1) on each frequency band. This is due to impedance variations caused by the length of the windowed ladder line, the height of the antenna above ground, and more. You may want to try adjusting the length of the windowed ladder line as this may allow you to find acceptable SWRs on more bands. For example, if you are using a 66-foot-long antenna, try ladder line lengths between 42 and 52, 73 and 83, 112 and 123, or 145 and 155 feet.

Regardless of the amount of ladder line you use, you should still find that this single antenna system puts you on the air on several bands and does so very well!

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Attach the windowed ladder line to the balun. In this example, the balun posts have wing nuts. These often make attachment easier because you can simply tighten the wing nuts with your fingers.

8

Connect a short length of coaxial cable between the balun and the antenna tuner. (See the left-hand side of the balun.) The shorter the length, the better.

9

Many automatic antenna tuners light a green LED to show it has achieved the lowest possible SWR.