No. 47: What is a Balun, and Do I Need One?

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The term BALUN is one of the most vaguely used words in antenna work. It has different levels of specificity, but writers are not always clear on what level they mean. So let's start at the beginning and see if we can straighten out the term. Once we are clear on what we are talking about, we shall be in a better position to decide if we need one. Finally, if we do need one, we can decide on what kind we can use for a given application.

1. **What is balun?** The term balun is a contrived word composed of "balanced" and "unbalanced." In its most generic use, it indicates any device that helps us effect a transition from a balanced transmission line or circuit on one side and an unbalanced transmission line or circuit on the other side. In some of the basic materials that we studied in preparation to get our licenses, we encountered baluns, but without that name attached. Consider a standard link-coupled RF circuit composed of two coils. One side if hot at one end, but the other end is grounded. The other side is hot on both sides. It may or may not have a center ground. This circuit, whether tuned with capacitors for one frequency or left untuned for wide-band use, is a type of balun. However, the actual term grew up in relatively recent antenna work.

When the term balun arose, it was in connection with transmission-line transformers. Transmission-line transformers are specially constructed transformers composed of multiple winding where adjacent turns have a very specific spacing. The spacing forms a transmission line with a characteristic impedance. Therefore, some folks always mean a transmission line transformer when they use the term balun, while others may mean only any device that effects a transition between balanced and unbalanced circuits.

Transmission-line transformers come in many forms. One division is between linear and toroidal baluns, that is making use of transformer coils wound in a straight line or in the form of a circle. The second division is between air-wound transformers and those making use of a core that is normally composed of a ferrite material. So we find air-wound linear transformers, ferrite-core linear transformers, and ferrite-core toroidal transformers. Air-wound toroids are not normally used.

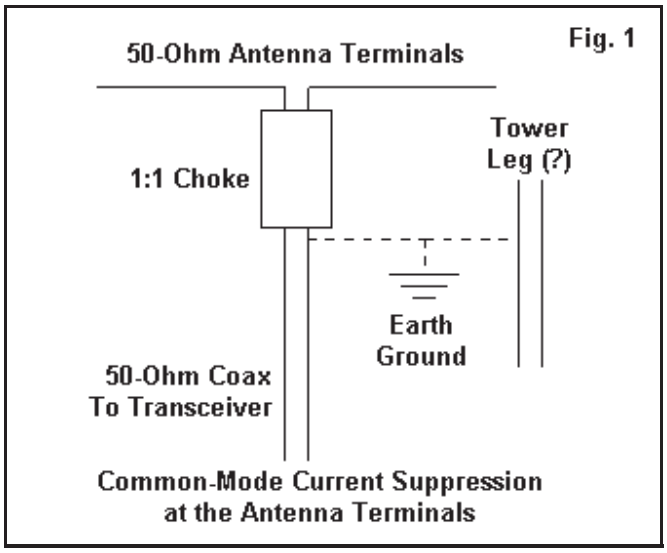
We also find other divisions to think about. For example, there is the matter of the impedance ratio. The most common impedance ratios are 1:1, which uses a trifilar winding, and 4:1, which can use a bifilar winding. 4:1 baluns normally have their high impedance side correspond to the balanced side of the device. Most baluns in the 1:1 to the 4:1 range use a low Zo for the transformer winding. For a 1:1 balun intended for use with 50-Ohm system, the impedance is as low as we can get two round wires to go (about 80 Ohms). A 4:1 balun for transforming 200 Ohms to 50 Ohms might use the geometric mean between the two target values (100 Ohms). Other impedance ratios are

certainly possible. As well, there are ununs, that is, unbalanced to unbalanced transformers that designers use in conjunctions with baluns to effect odd impedance transformations.

There are also design types, such as the Guanella, but the most common distinction is the voltage vs. the current balun. For virtually all amateur antenna system applications, a current balun type is preferred. One of the guiding principles of balun design is that the device should be wide band, covering most of all of the HF region or perhaps a special design for VHF from 6 meters through at least 2 meters.

We now have at least two devices that will effect the transition: a relatively standard link-coupled pair of RF coils and a transmission-line transformer. There are other devices. Some applications call for convention wide-band transformers, often wound on iron or ferrite toroidal cores. Other applications may call for a simple choke, a device that sets up a high inductive reactance to attenuate the flow of current where we do not want it to go. One way to make a choke that is suitable for a 10-meter antenna application is to make a coil of coax. Another way is to place a series of ferrite beads over a length of 50-Ohm coaxial cable.

2. **Where Should I Use a Balun?** The most common application for a balun is at the terminals of a balanced antenna feedpoint that we are feeding with unbalance coaxial cable. See **Fig. 1**.

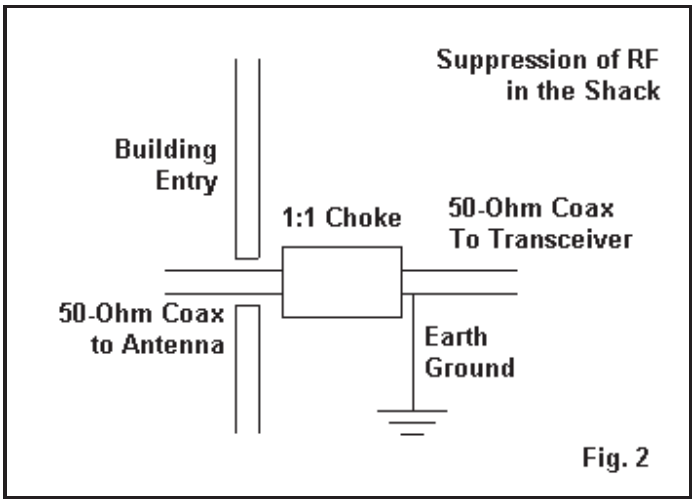


The outer braid of the coax provides an alternative path for antenna currents at the terminals. The current on the braid goes under the name "common-mode current." Common-mode currents do nothing useful for communications. Whether or not they create a problem depends on many variables, but it is always wise to place a choke at the antenna terminals. Since the antenna (including any attached matching network) and the coax are both 50-Ohm devices, we can use any of the 1:1 balun devices available.

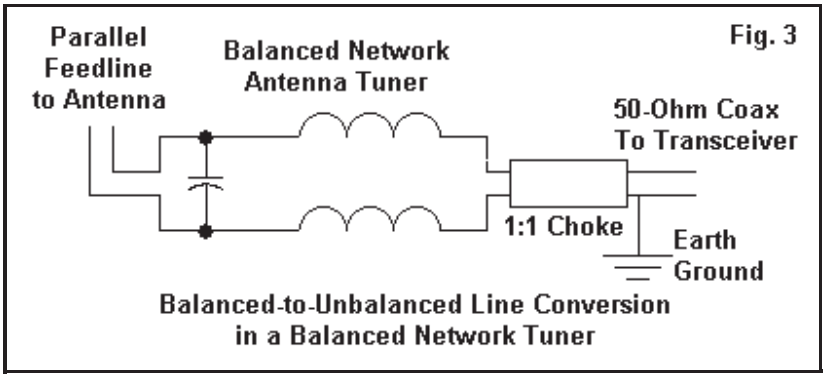
Note the special reference to a tower leg and the earth ground that it implies. If feasible, it is advisable to form a connection between the coax braid of the transmission-line side of the choke and a tower leg. I am assuming that you have your tower--if you use one--well grounded. Such a connection is protection from a number of potential problems, and giving the remnant common-mode currents a path to the earth is one of them. Charge build-up on the antenna now also has a relatively easy path to the earth.

If the coax between the antenna and the shack is long, and if the run turns enough corners, then you may still have common-mode currents in the shack due to signal coupling directly to the coax braid. If you have such a problem, it may show up as a difference between SWR reading on the rig's meter and on an external meter in the line. Or you may get a tingle or a bite from sharp corners of the transceiver case while transmitting. At its worst, it may show up on telephone lines, and it may even lock your VOX or keying circuit on some bands.

One avenue to a cure that is highly effective (but, like all things in amateur stations, not universally perfect) is to install a second choke at the shack entry, as shown in **Fig. 2**. This 1:1 choke is not doing anything but attenuating currents on the outside of the coax line (where all transmission-line currents are on the inside, between the center conductor and the inside face of the braid). Note once more the reference to an earth ground. You may wish to place the second choke on the outside wall, close to the ground, so that you can have the shortest possible distance for the lead to the ground rod.



The third major application for 1:1 baluns or choke may not involve any activity by the user. There is a new generation of balanced network tuners on the market, a partial replacement for link-coupled tuners of years gone by. The better of these tuners include on the input side a 1:1 balun. The tuner is for balanced parallel transmission lines at the output. The tuner changes the output terminal impedance to 50 Ohms, but the line is still balanced, so a 1:1 balun on the input side effects the change from balanced to unbalanced or single-ended lines to the transceiver. See **Fig. 3**.



All of these applications call for a 1:1 balun, that is, a balun that does not effect any kind of

impedance transformation. We only need to effect the balanced-to-unbalanced transformation while choking out any extraneous currents that may want to exist on the outside of the coax braid.

3. **What Kind of Balun Should I Use?** Theoretically, you may use any type of 1:1 balun or choke available. In principle, any of the major types will do the jobs just described. Here are some options.

a. *Coiled coax*: The coiled coax choke can be useful at the antenna terminals. For 10 meters, you may coil about 4-6 feet of RG-8/213 or RG-58 (for lower power) into 6 to 8 turns. Do not scramble wind the turns. Instead, wind them in a coil form and tape the turns together. You may use a short piece of 4 to 6 inch PVC as a form, although some folks have used empty plastic soda bottles as a form. (Protect any form from UV, since the sun will make the form go brittle in under a year without protection.) Coax coils are quite effective on single bands, but less effective for multi-band use.

b. *Commercial 1:1 current baluns*: These devices come on many forms, usually potted inside permanently cemented PVC. Some have coax connectors at both ends, while others have wire leads on one side. A few are designed for wire-antenna center insulator/balun use, and may even have a top hanger eyebolt for inverted-Vee installations. Some current baluns are air wound, while others use either ferrite rods or ferrite toroids.

Most of these units are bulky. Their best application is usually at the shack entry point, where weight and size do not make a major difference. Some have a built-in ground strap for easy connection to an earth-ground system. Balanced network antenna tuner makers use bare baluns inside the tuner case. (If you are thinking about buying one of the new balanced tuners, be certain to find out whether the tuner includes the balun, because it is essential to proper operation.

c. *Ferrite bead chokes*: Walt Maxwell, W2DU, first devised these chokes in the 1980s, and they are highly effective. For HF use, the builder places about 50 Type 77 or type 73 ferrite beads over a length of coax. Type FB77-1024 beads fit over RG8/213 and similar larger diameter coax. Type FB73-2401 beads fit over RG58 for lower power applications. Walt's original design used the smaller beads of a length of RG-142, which appears similar to RG-58 but uses a Teflon dielectric and silver-coated wire to handle higher amateur powers. Of course, you must protect the assembly from the weather with a coating of some durable sort.

I tend to prefer the ferrite bead chokes at the antenna terminals, especially with beams. They weigh less than most current baluns and coax coils, and they are less bulky. You can usually tape them to the antenna boom. I have used them for about a quarter century with good success in both shack entry and antenna terminal applications.

So far, we have dealt with only 1:1 baluns and chokes. For coax systems, these are the ones that we need to effect balanced-to-unbalanced transitions (or vice versa) and to attenuate common mode currents that may exist on the outside of our coax braid.

Due to the history of antenna tuners in the last 3 decades, the most talked-about balun is the 4:1 variety. In fact, when many hams think "balun," they almost automatically think "4:1 balun." We find them in almost all single-ended (unbalanced) network tuners as a way to simulate a balanced tuner output. So it looks like our work with baluns is only half done. The odds are 4:1 that next time we shall look in more detail at applications--both good and bad--for the ubiquitous 4:1 balun.