Doug Demaw

Baluns —

Do We Need Them?

Anyone who has worked with antennas has heard the term "balun" or "balun transformer." But, few users of this interesting device have a full understanding of how and when to use a balun. Under a given set of conditions, this item can be a remedy for a problem, or it can worsen an existing malady.

The term "balun" means, literally, "balanced to unbalanced." For example, a balanced antenna such as a dipole or loop, may be fed with an unbalanced feed line (coaxial cable) by means of a balun transformer.

The addition of a balun at the antenna feed point helps prevent the feed line from radiating or picking up signals. This preserves the normal pattern of the antenna (prevents pattern distortion because of feeder effects).

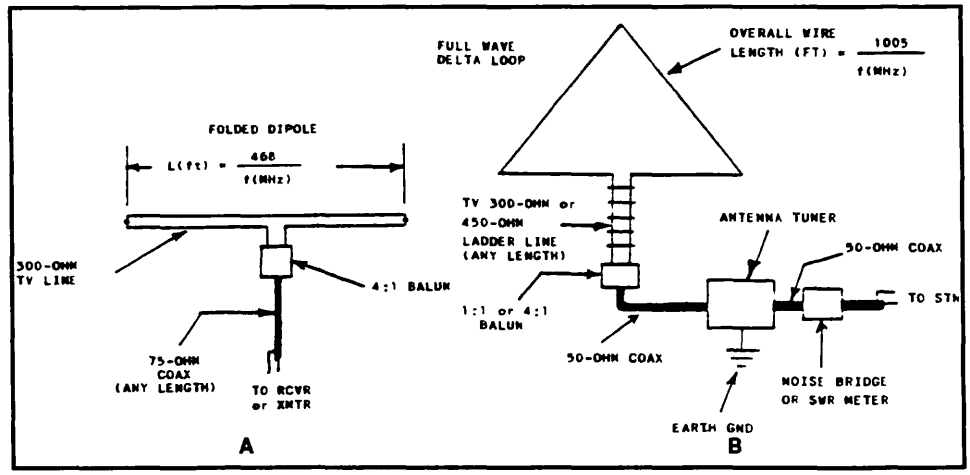

Figure 1 -- Examples of how a balun is used to (A) convert a 300-ohm folded dipole for use with 75-ohm coaxial feed line. This is a single-band antenna as shown. Diagram B shows a multiband Delta Loop that is fed with TV ribbon or 450-ohm ladder line and tuned for an SWR of 1 by means of an antenna tuner. A noise bridge or SWR meter is used to indicate when the SWR is 1:1. The balun may be located just outside the radio-room window to avoid a need to route the feeders through the wall of a house.

The Nature of Baluns

The correct pronunciation for this device is "bal-un." It is commonly mispronounced as, for example, "bal-oon" or "baylon."

What is a balun, electrically speaking? It is a broadband (untuned) transformer. A broadband transformer, when used in a proper electrical environment, can operate from, say, 1.8 to 40 or 50 MHz with minimal signal loss. It is important to understand, however, that any transformer will introduce some loss. A well designed and applied balun should introduce no more than 1 dB of loss.

Baluns are used also for transforming one impedance to another. The most common balun transformation ratios are 1:1 and 4:1. An example of where we might use a 4:1 balun is to match the balanced 300-ohm impedance of a folded dipole to a 75-ohm coaxial feed line. In a like manner, we can match a 200-ohm balanced antenna to a 50-ohm coax line by means of a 4:1 balun.

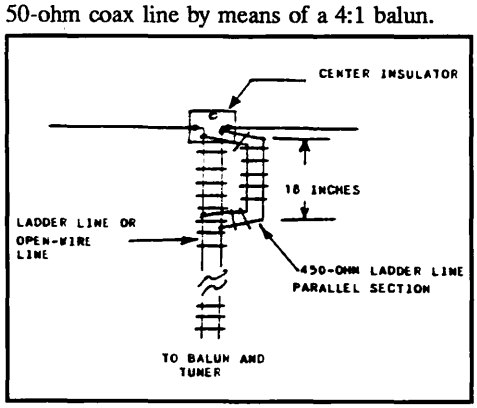

Figure 2 -- Open-wire or ladder-line feeders tend to break at the antenna center insulator. The line can be strengthened by placing a short length of 450-ohm ladder line in parallel with the main feed line, as shown. The new line section is taped to the primary feeder at four points. See text for data on a new type of ladder line that is more rugged than conventional ladder lines.

A 1:1 balun, on the other hand, can be used to feed a balanced 50-ohm antenna with an unbalanced 50-ohm feeder.

Some Balun Pitfalls

Most baluns are wound on magnetic cores such as powdered iron or ferrite. This provides a lot of necessary inductance (for the low-frequency range of the balun) with a minimum number of turns of wire. It also helps to reduce losses while minimizing the unwanted effects of inductive and capacitive reactance. Such reactances can impair the balun performance at the high end of the transformer operating range.

Attention must be paid to the core type and size when a balun is used with a transmitter. Too small a core can saturate in the presence of RF power. Saturation causes core heating or damage. The permeability of the core (ferrite) will change when saturation occurs, and it may not return to its original value after the core cools down.

Baluns and other types of broadband transformers are intended for low impedance levels -- typically from about 10 ohms to perhaps 600 ohms. A balun that joins a 50-ohm line to a high impedance load, such as a 1,000-ohm antenna, is apt to arc between the winding and the core, and it may saturate.

Furthermore, the transformer may no longer be capable of ensuring the proper phase relationship when it is used in so hostile an environment. Huge cores and extensive high-voltage insulation are sometimes used to allow safe operation of a balun in a high-impedance-load situation, but I don't recommend you do this.

A balun can disrupt the antenna standing-wave ratio (SWR) in some systems. This is caused by (1) poor balun design (unwanted reactances) and (2) by virtue of the lead length from the balun to the antenna feed point. These leads become part of the antenna and this can change the antenna resonance (lower it). This is a problem especially at the upper end of the HF spectrum.

There are two excellent books which cover the theory and design of broadband, magnetic-core transformers and baluns.[1] I recommend these books for those of you who wish to build your own baluns.

Examples of Balun Use

Figure 1 shows examples of how you might employ a balun for a multiband HF antenna. Open-wire or "ladder line" feeders are specified to minimize transmission-line losses. The baluns convert the balanced antenna feed point to an unbalanced condition which permits the use of coaxial cable. An antenna tuner or transmatch is used at the station end of the line to provide a 50-ohm match to the receiver and transmitter. This provides a 1:1 SWR for the equipment. Maximum power transfer always occurs when two unlike impedances are matched.

Some manufactured HF Yagi beam antennas call for a coil of coaxial cable at the antenna feed point (8 or 10 turns of RG-8 with a 6- or 8-inch coil ID). This device should not be confused with a balun. It is actually a choke that presents a 50-ohm input and output impedance. This choke prevents RF energy from appearing on the shield

braid of the overall coaxial feed line. In effect, it isolates the feeder from the antenna in a manner that is similar to that of a balun.

Problems with Ladder Line

Antennas that are fed with open-wire or molded ladder line are prone to failure over time because of the feed line moving to and fro in the wind at the antenna feed point. Most ladder lines contain no. 18 Copperweld wire. This conductor becomes brittle from stress and breaks at the feed point.

Figure 2 shows a cure I developed for this problem. It involves placing a 2-foot section of ladder line in parallel with the main feeder at the antenna feed point. This strengthens the feeder at the critical point and greatly minimizes wind stress. W4THU, who operates The Radio Works, is now offering an excellent 450-ohm ladder line that contains 19-strand, NO. 16 copper-clad conductor. This line is able to withstand considerable flexing and stress without breaking. The larger conductor size helps minimize feed-line losses.[2] W4THU also sells a line of excellent baluns that have large cores and will handle up to 2 kW of RF power.

I am using one of The Radio Works B4-2KX remote 4:1 baluns just outside my radio room. It is connected between 100 feet of 450-ohm ladder line and a 10-foot run of RG-8 coax cable that is attached to my antenna tuner. The balun runs cool at maximum amateur power. The antenna is a full-wave 160-meter loop that I use from 1.8 to 29 MHz.

Do You Need a Balun?

Baluns are not beneficial with HF-band dipoles that are less than 1/2 wavelength above ground. Low-height dipoles and other antennas generally exhibit a high radiation-angle pattern that is essentially omnidirectional. Any pattern distortion caused by the feedline will never be noticed. Conversely, a dipole that is 1/2 wavelength or greater above ground exhibits the classic figure-8 pattern, and a balun can help to preserve this pattern.

Baluns are helpful in assuring an impedance match for certain antennas. They are beneficial also for interfacing a balanced antenna to an unbalanced feed line. Many commercially-made antenna tuners, matchers or transmatches contain a 4:1 balun. This permits us to use an antenna with balanced feeders for multiband purposes.

In any event, the balun needs to be protected from dirt and moisture to prevent it from arcing when RF power is supplied to it. Coax Seal, a commercial putty-like product, is excellent for protecting the balun from moisture and air pollution at the points where the coax connector is mounted and where the terminals or wires for the balanced antenna are situated.

Coax Seal is useful also as a covering for the electrical connections where the feeder or balun attaches to the antenna. This prevents oxidation and subsequent resistive antenna joints.

Home-made baluns are described in *The ARRL Handbook* and *The ARRL Antenna Book*. Suitable core material may be purchased from Amidon Associates, Inc., P.O. Box 956, Torrance, Calif. 90508.

A final word: Baluns do not cure TVI.

mt

References

1 D. DeMaw, *Ferromagnetic Core Design & Application Handbook*, Prentice-Hall, Inc., Englewood Cliffs, N.J. 07632.

J. Sevick, *Transmission Line Transforers*, 2nd edition, The ARRL, Inc., Newington, Conn. 06111.

2 The Radio Works, Box 6159, Portsmouth, Va. 23703. Large catalog available.