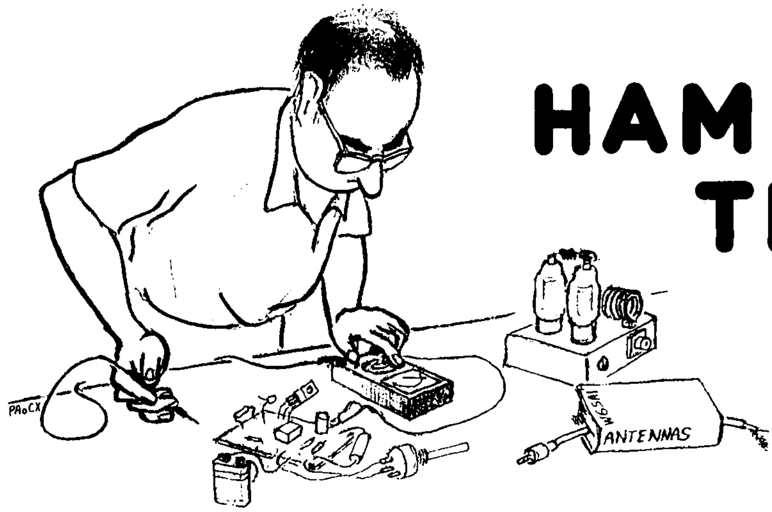


HAM RADIO TECHNIQUES

Bill Orr, W6SAI

A balun for 10 meters

More so than the lower frequency bands, 10 meters is a hostage to the sunspot cycle. When the sunspot count is low, the band is dead. Only spotty, occasional DX shows up as a result of sporadic E or other chancy forms of propagation.

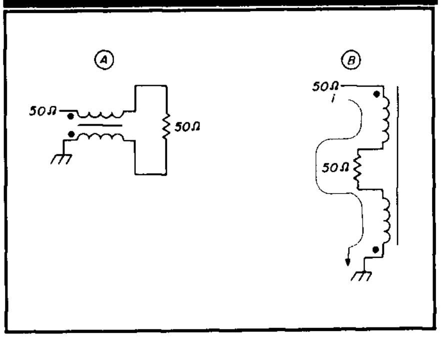
However, when the sunspot cycle is comfortably high the 10-meter band is a DX operator's paradise. Signals boom in from all parts of the world, often with astounding strength. Many recently licensed Amateurs have never had the thrill of 10-meter DX. But after a false start last spring 10 meters is jumping once again, and there's great interest in 10-meter antennas and antenna accessories.

Judging from my mail and conversations with newly licensed hams, the antenna balun is a confusing topic. I hear these questions: What is a balun? What does it do? Do I need one?

How the balun works

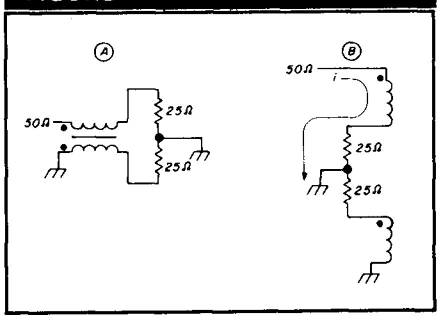
Let's look at the workings of the balun first. The word "balun" stands for "balance-to-unbalance". This implies that a balun provides two equal and opposite-phase voltages with respect to ground when driven from an unbalanced source, like a coax line with one conductor at ground potential. The balun is an ideal device for connecting a balanced antenna (such as a dipole) to a coax line.

FIGURE 1



(A) One-to-one, two-conductor balun matches ungrounded load. (B) Equivalent circuit shows magnetizing current (i) flowing through windings and load.

FIGURE 2



(A) Two-winding balun connected to grounded, balanced load. (B) Equivalent circuit shows magnetizing current (i) no longer flows equally in the windings and the load.

From another point of view, the balun provides isolation between the coax outer shield and the half of the dipole connected to it. If the balun were not present, some of the current flow in the coax shield would be present on the outside of the shield — not the inside. The current on the outside of the shield can radiate into space, making the coax line part of the antenna.

In the case of a beam, outer shield current can ruin an otherwise good front-to-back ratio, cause loading difficulties, and even lead to TVI and RFI problems. It can also cause erroneous SWR readings regardless of antenna type.

Some beam antennas and dipoles come with baluns, others don't. You can buy or build a balun if you want one. Building a balun isn't difficult, especially for 10 meters.

The 1:1 balun

There are many forms of baluns; the most popular Amateur type is the 1:1 design. This implies that when the balun is used with a 50-ohm coax line, it provides a balanced 50-ohm termination. Amateurs have found that this simple balun works well with balanced antennas having a feedpoint impedance as low as 20 ohms, or as high as 80.

The simplest form of 1:1 balun is a choke coil made of coax line. The line is wound into a multi-turn coil about ten times the diameter of the coax. Most designs specify six to eight turns (**fig. 1A**). The electrical equivalent of this balun is shown in **fig. 1B**. The balun may be either air wound, or wound on a ferrite or powdered-iron core. (More about the core material later.)

If the balun is connected to a balanced and "floating" load (one that is not grounded), the balun will do the job. The magnetizing current (the current that creates the magnetic field in the core) is balanced in the windings and doesn't upset the balanced output voltages. You can see this in **fig. 1B**.

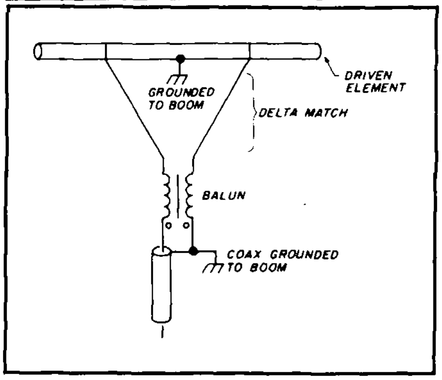
There's no guarantee that the driven element of the antenna is really balanced in an electrical sense. The degree of balance depends upon physical and electrical characteristics (mounting technique, parasitic capacitances, proximity of coax line, etc.) that you can't measure or control. One solution to this problem is to physically ground the center point of the antenna (**fig. 2A**). The load is no longer floating to ground, but the magnetizing current no longer flows equally in the windings and the load! It's shorted to ground by the ground point of the antenna (**fig. 2B**).

Here's an example. Some beam designs employ a balun and delta-match feed system with the driven element grounded to the boom of the array (**fig. 3**). Intuition tells you the design is practical, but the illustration in **fig. 2B** clearly shows that half of the feed system isn't working; the magnetizing current isn't flowing through one balun winding. The two-winding balun isn't doing the job it's supposed to do.

The three-winding balun

In many cases the two-winding balun (coax line wound up into a coil) feeding an ungrounded, floating dipole is adequate. A better solution is the three-winding balun shown in **fig. 4A**.

FIGURE 3



Two-winding balun (coax balun, for example) is shorted out when coax shield and center of driven element are grounded to boom of antenna.

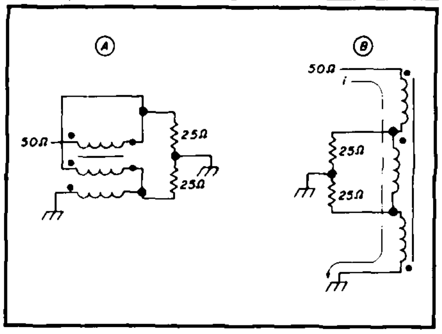
The third winding provides a path for the magnetizing current around the load, regardless of whether the load is floating or not (**fig. 4B**). Note that the polarity of the third winding is reversed. This is the ideal solution to the problem. The majority of 1:1 baluns on the market are made in this configuration. The simple coil-type coax balun can be readily converted into a three-winding balun. I'll tell you how in the next section.

A homemade balun for 10 meters

Figure 5 shows a simple and inexpensive air-core three-winding coax balun you can build. The balun is usable over the range of 14 to 30 MHz. You'll need a 25-1/2 inch length of RG-8A/U, a PL-259 plug and 3 feet of plastic covered no. 12 single conductor wire, available from most hardware or home improvement stores.

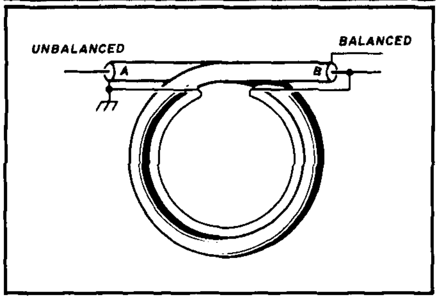
First place the PL-259 on one end of the coax cable. Next, remove 2 inches of the outer jacket of the opposite end of the line. Unbraid the outer braid and twist it into a pigtail. Now remove about an inch of the inner insulation. Place large soldering lugs on the two conductors. You'll attach these to the terminals of the driven element. The exposed joint needs to be carefully covered later with CoaxSeal™ Radio Shack Connector Sealant 278-1645, or equivalent to make sure water doesn't enter the coax cable.

FIGURE 4



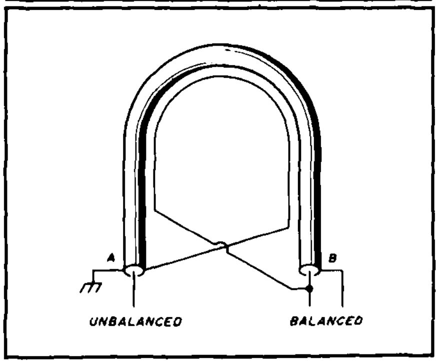
Three-winding balun (A) can feed either grounded or ungrounded load and maintain magnetizing current (B).

FIGURE 5



Coax balun performs properly when third winding is added. Extra winding is cross connected to coax at the ends. (Actual balun has two turns.)

FIGURE 6



Simplified balun drawing showing cross connections.

Winding the balun

Next, wind the coax into a two-turn coil; leave about two inches of coax free on each end. Do this by manipulating the size of the coil. The coax plug and pigtails should lie very close to each other on the same side of the coil. Hold the coil in position with bits of vinyl tape.

Now add the third winding to the coil. Carefully wind the plastic-covered wire in parallel with the coax. This is easy because there are only two turns to the coil. Smooth the wire up against the coax and tape it in place every few inches. When you've finished, the wire will be running closely parallel to the coax and you can tape the coil completely.

Finally, attach the wire to the coax winding. If the coil size is right, there will be about 2 inches (or less) of coax free of the coil at each end. The wire winding is cross-connected at the ends of the coax. (See **fig. 6**.) The end of the wire nearest end A of the coax is connected to end B of the coax. Do this by soldering one end of the wire to the shell (not the ring!) of the PL-259 and the other end of the wire to the free center conductor lead, just before it enters the soldering lug. Trim the ends of the wire as you proceed so that no loose wire is left at either end of the coil. After everything's in place, wrap the complete coil again with vinyl tape and waterproof the wires at one end of the balun with the coax tape.

That's all there is to it! The power rating of the balun is the same as that of the coax line.

You can also make a smaller, lighter balun for low-power applications by substituting RG-58B/U coax for the RG-8A/U. A PL-259 plug and UG-175 reducing adapter are used at one end of the balun; otherwise, all is as described earlier.

Modifying the balun for wideband use

The three-winding coax balun can be modified for lower frequency use. If you use three turns instead of two for both windings, the operating range of the balun is 7 to 30 MHz; with five turns, the range is 3.5 to 18 MHz. A six-turn design didn't work very well as it was difficult to hold the wire coil in close proximity to the coax coil.

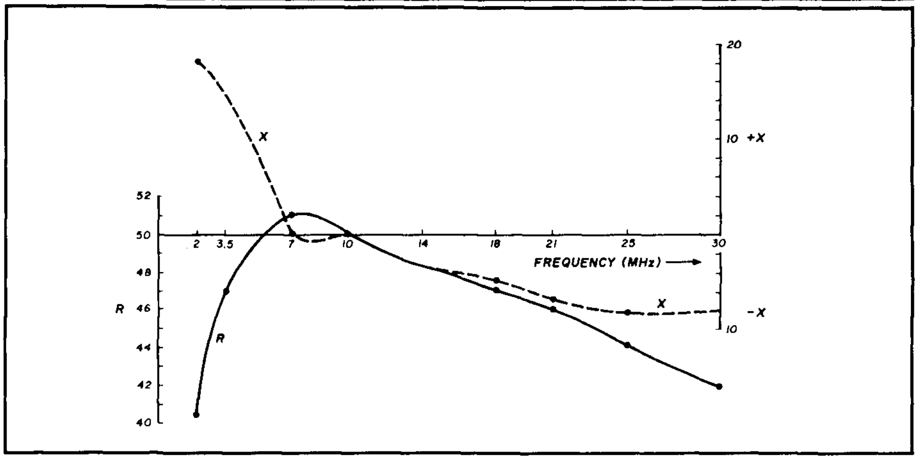
The ferrite-core balun

The air-core balun I've described is somewhat limited in low-frequency response. Even the five-turn design wasn't too good at the low-frequency end of the 80-meter band. You can extend the low-frequency limit by adding turns to the balun, but it's difficult to make an air-core balun that's electrically unbalanced function properly on the 80-meter band.

The solution is to use a higher permeability core. Both ferrite and powdered-iron cores that will do the job are available. The core can be a rod or a toroid. At the higher frequency end of the spectrum the core is almost "invisible," but the core is most important as the frequency of operation is lowered. At 80 meters, the entire balun field is contained within the core. Some manufactured baluns must be derated on 80 meters to prevent the core from running too hot. Many of them won't function at all on 160 meters. But the need for a balun on the lower bands is questionable; few highly directional antennas are used at these frequencies. In the case of a simple antenna like a dipole, current flow on the outside of the coax is no big deal. If the coax line is made an odd multiple of a quarter wavelength (1/4, 3/4, etc.), and an effective ground is used on the transmitter, current flow on the outside of the coax will be at a minimum.

The perfect balun really exists only in the laboratory; practical low-cost baluns work, but exert some influence on antenna resonance. Wideband, Amateur-style ferrite-core HF baluns usually have a design frequency of about 10 MHz and are useful over the 3.5-30 MHz range. Air-core coax-wound baluns have about the same design frequency, but are useful only down to about 4 MHz. In either case, above or below the design frequency, the balun appears as a reactive load and introduces its own SWR anomaly into the picture. **Figure 7** shows the SWR response of a typical wideband balun working into a 50-ohm load. The balun is good, but not perfect. The reactive effect of the balun, when you're operating with an antenna, is to move the resonant frequency of the antenna either higher or lower. A beam cut to 14,150 kHz, for example, may seem to be resonant at 14,220 kHz and "look like" 48.5 ohms when checked through a 50-ohm balun.

FIGURE 7



Ferrite-core trifilar balun shows good response between 6 and 25 MHz. Performance is poor at 80 meters (3.5-4.0 MHz) and 10 meters (28-30 MHz). Balun is terminated in 50-ohm noninductive load.

Dial cards for the TL-922A amplifier

I was working Bob, KL7DJI, in Fairbanks, Alaska the other day; he gave me a great idea for tuning charts for a linear amplifier. I made up a set, and they have proved invaluable for quick band changes (**fig. 8**).

The idea is simplicity itself. Cut a dial card from heavy paper. (I used index cards to make mine.) Slot the card to

(continued on page 109)