Why a Balun?

Why a Balun? - by Kurt N. Sterba, originally published in the February 2010 issue of World Radio Online.

While listening to a conversation on 75 meters, Kurt heard more incorrect information on baluns than he thought existed. Such a simple thing should not be made so complicated. It just adds to the hot air already on that band. Here is Krusty Olde Kurt's simplification.

The most popular, simple and effective antenna is the horizontal dipole. It is a balanced antenna, that is, the wires on both sides of the center insulator are of equal length. In the early days of radio it was fed with ladder-line, two wires in parallel spaced by insulators. It, too, is balanced. Feeding a balanced antenna with a balanced feeder works well. Many amateurs still use this method because of the very low loss of ladder-line.

But back around the time of World War II, coaxial cable was introduced. It has certain advantages over ladder-line. It is self-shielded and does not radiate. It can be routed next to metal objects or even buried in the ground with no effect on its operation. But it has a major defect in that it is unbalanced.

The coaxial cable has a center conductor and a surrounding metal shield. The center conductor connects to one side of the dipole and the shield to the other. There are equal currents in the center conductor and in the shield, so we expect equal currents in the two sides of the dipole. This looks simple and straightforward, but there is a problem.

The problem is caused by something called "skin effect." This tells us that, at radio frequencies, the current in a conductor flows just in the "skin" of the conductor and does not penetrate further into the conductor. This means that the current in the shield of the coaxial cable is confined to the inside of the shield. No current reaches the outside of the shield. Therefore, the outside of the shield is just like a third conductor. But this third conductor is connected to one side of the antenna, the same side the inner surface of the shield is connected to.

Now it is possible that not all of the current from the inside of the shield goes into one side of the dipole. Some may go down the outside of the shield. This can cause problems. With less current in the antenna, its radiated signal will be less. The radiation from the outside of the shield brings radiation closer to the house and may cause TVI. When the antenna is used for reception, there will be pickup from the dipole and from the coax shield. Most man-made noise is vertically polarized, so the horizontal dipole discriminates against it. The vertical shield, on the other hand, readily picks up the noise, so your antenna becomes noisier and reception is poorer.

Balun To The Rescue

The current flow down the outside of the shield can be eliminated by use of a balun, a balanced to unbalanced device. There are several ways to make a balun, but all of them place high impedance between the antenna and the outer shield. This prevents any current flow down the shield.

To make a very simple balun, you wind the top portion of the cable into a coil. This does not affect the currents flowing inside the cable but now the outside of the shield is a coil and just like any coil it has inductive reactant that presents an impedance to any flow of RF. At low frequencies it is difficult to get enough inductance to be effective and the coil tends to whip in the wind and is physically unwieldy. But it works.

The "transmission-line" balun is much better. This is a short section of two-conductor transmission line wrapped around a ferrite toroid and connected between the coax and the antenna. The ferrite gives the coil high impedance so no current will flow through it to the coax shield and the antenna sees a balanced line.

Then there is the ferrite bead balun. Enough ferrite beads are placed over the coax to provide a high impedance to RF. This prevents any current flowing down the shield. This is a simple and effective balun and is in widespread use today following its initial introduction to radio amateurs in an article by Walt Maxwell, W2DU, published in 1982.

Matching Transformers

The baluns described above are 1:1 baluns, that is, their input and output impedances are the same. They are useful for connecting 50-ohm coaxial cable to dipoles or other antennas that have impedances close to 50 ohms. But some antennas have higher or lower impedances where an impedance change in the balun can provide a better match.

The transmission line balun adapts itself easily to 4:1, 9:1, 16:1 ratio step-up and step-down transformers. Other ratios are also available. Thus the impedance matching function can be built right into the balun.

At The Transmitter

We have been talking about the use of baluns at the antenna feedpoint. Another common use of baluns is at or near the transmitter. Quite often, ladder-line is used to feed the antenna. But it is difficult to run the ladder-line into the radio shack. So, a short length of coaxial cable is run from the transmitter or antenna tuner out to the ladder-line. At this connection, we have the same problem as before – connecting unbalanced coax to a balanced feedline. Again, a balun is required.

The ladder-line usually has 450-ohm impedance. Since we are connecting a 50-ohm coax to 450-ohm line, it would seem that we need a balun with a 9:1 step-up to get a good match. No, no, no! Remember that the 450-ohm line is connected to a 75-ohm antenna. If the line is a half-wave long we'll see 75 ohms at the bottom, not 450. At other cable lengths we'll see impedance's from less than 75 ohms, up to much higher than 450 ohms. So we are not at all likely to get a match. It is helpful, however, to have a step-up transformer and a 4:1 step-up is a good compromise value to use.

So what I learned….

- Use a 1:1 balun for balanced dipole antenna where both sides of the center insulator are of equal length.
- Use a 4:1 (or higher if needed) balun for antennas that have a higher or lower impedance change between the actual antenna and the feed line.