BALUNS – PART TWO –
HOW BALUNS HELP
AND
THE THREE MOST USEFUL VERSIONS

In Part 1 of this series, we explained how imbalances in antenna systems can result in unbalanced ("extra") currents running back down feedlines and into radios....and into soundcard systems.... and then into computers.....basically because one side of the antenna didn't take all that current and the feedline was where some of it ended up.....in effect adding feedline and shack wiring as part of the radiating system.

This isn't desirable if you want digital or transistor systems to work correctly!

I want to emphasize that if all you need to do is CW or Voice SSB communications, and you don't mind the occasional "hot" surface that has a bit of RF potential to it, you can do FINE with a simple dipole fed by coaxial cable, or with a typical manual or automatic tuner! I went for YEARS without any kind of balun at all! The problem comes when you are operating solid state devices like laptop computers, Raspberries, or other devices that will be "upset" or "reset" or "crashed" by significant RF currents flowing in and around your ham radio shack, and you are using antennas that aren't terribly well "balanced" (for whatever reason). In short --- if your computer crashes, then you start to want to add devices that reduce RF current flow in your shack – and you start to want BALUNS.

How do we reduce or prevent unwanted unbalanced currents that are flowing on supposedly "ground" conductors? Basically by making the connection "back to the rig" have a **higher impedance than the (desired) half of the antenna**. If we can add **impedance** to the undesired pathways, then the antenna will start to accept more of the current, and less of it will head back in undesirable pathways.....

But how can you add impedance to, say, the OUTER surface of the coax braid? You must not add impedance to the INNER surface....or you foul up the transmission line. Likewise, with balanced transmission line, how do you change impedance for the *unbalanced* current, but not for the desired (balanced) current from the transmitter to the antenna?

The solution is to add INDUCTANCE in such a way that ONLY THE UNBALANCED CURRENT SEES IT. This is actually easier than it sounds.

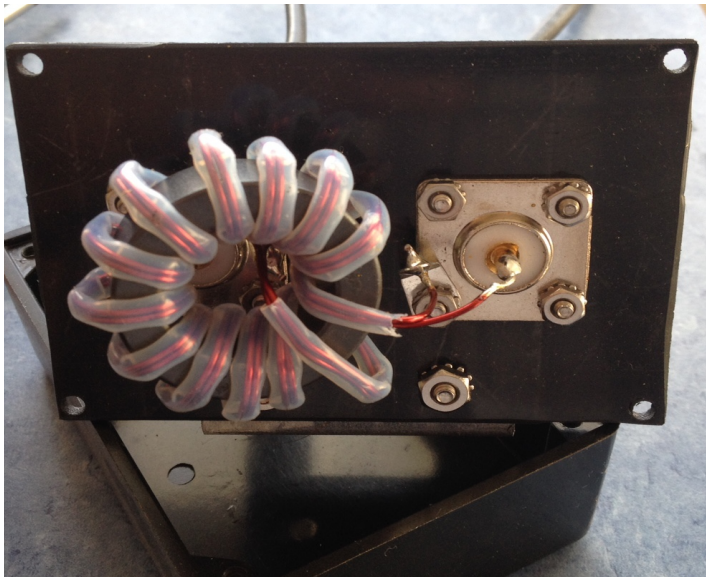
In this Part of the discussion, we're going to look at the Three Most Common Baluns:

BALUN #1: 1:1 Current Balun in the Transmission Line

The most common balun used all over the world is a 1:1 (50 ohms to 50 ohms) current balun inserted in the coax transmission line, either back in the ham radio shack or even right at the center of the dipole, which causes both conductors of the transmission line to spiral several turns around a toroid of magnetic material. The BALANCED currents (which are desirable) will result in zero total magnetic field as the transmission line works its way around the toroid --- so they will experience zero effective inductance. The UNBALANCED currents however, create a magnetic field, with all the induced back-emf's etc that pertain to any inductor, and they experience a reactance that is proportional to frequency and inductance with the standard formulas.

Depending on the type of toroid material (from iron powder T-2 to Ferrite FT-43 or FT-61) you may need a different number of turns to create enough inductance to create a suitable opposition impedance to the unbalanced currents. Remember, for any given inductance, the impedance is proportional to frequency: $Z = 2 * pi * L * f$. Getting more than 500 ohms of inductive impedance at 80 meters is one of the goals (10 times the presumed impedance of the antenna) and avoiding series resonances in the system due to toroid and inter-winding capacitive effects. A standard 1:1 current balun seems to be 10 to 13 turns of either coax or very-closely-bifiliar wires wrapped around a type 43 or type 61 toroid of about 140mm size for 100watts or so, or larger for higher wattage.

In this photo the toroid has been wrapped with teflon tape (the kind plumbers use for pipe fittings) to protect the teflon insulated wire and the wires kept close together with some insulating tape --- some designs run them inside a plastic tube; others use 2-conductor speaker wire.



This photo of a popular commercial balun shows the wires inside a tube.

At VHF frequencies, you can create significant amounts of inductance by merely coiling coax into 3 or 4 turns with a radius of say 4". Four turns makes 3.1 microHenries of inductance; and due to the 146 MHz frquency, that is actually 2,800 ohms of inductive reactance!!! (https://www.eeweb.com/tools/coil-inductance http://www.66pacific.com/calculators/inductive-reactance-calculator.aspx) That goes a long way to discouraging unbalanced RF currents from continuing along the outer surface of the coax braid.

The same loops at 80 meters? Only 68 ohms.....that won't be that much of a discouragement to the flow of 80 meter unbalanced currents. Type 61 ferrite material with a permeability of 125 can be used to make a balun by wrapping coax or close-together parallel wires around it about 13 times. That makes about 25 microhenries and now we have 557 reactive ohms which is much better to discourage unwanted currents --- and on 40 meters, it will be over 1K; on 20 meters it will rise to over 2,000 ohms reactance. http://toroids.info/FT140-61.php Shift to type 43 material and you can get even more inductive reactance. (http://www.fair-rite.com/wpapers_anotes/use-of-ferrites-in-broadband-transformers/)

http://www.vkham.com/Info/ferro/balun_winding.html FT-140-61 material

Kit: https://www.amazon.com/KiloWatt-Antenna-Balun-FT-240-61-core/dp/B00O9MG7PC

BALUN #2: 1:1 Current Balun At The Antenna

Balun #2 is actually the same thing as Balun #1 --- just you position it right at the antenna so that the input comes from the transmission line and the output goes to either side of a dipole. The hardest part

is the physical mounting of the balun and the strain relieving of the tension in the antenna so that it doesn't pull on the wires coming from the balun. You can do this multiple ways, from installing eyelet screws, to just drilling holes in the plastic to loop the antenna through, and having pigtail wires from the balun that can then be soldered to the dipole wires.

In my opinion, the most important thing in waterproofing is to have a way for water to get OUT. There is almost no way to prevent ALL water from getting IN, so I think (personal opinion) that the most important them is go have some place for water to get OUT.

Commercial center insulator baluns:

MFJ-918 $25: https://www.mfjenterprises.com/Product.php?productid=MFJ-918

Homemade center insulator baluns are frequently constructed inside PVC electrical boxes and conduit boxes:

BALUN #3: 4:1 Voltage Balun

Because baluns often involve inductors, toroids, and windings, it is quite natural to vary the winding ratios and use them to create impedance transformation as well. A simple autotransformer (auto- because the primary winding is also part of the secondary wiring) with twice as many turns going to the antenna as to the input transmission line will step the voltage up by a factor of 2, reduce the current by a factor of 2 ---- so the impedance (V/I) steps up by four times.

A voltage balun just forces the VOLTAGES at the other end to be the same, which isn't considered as useful as forcing the currents to be the same, but it requires only ONE TOROID.

A very common use of a 4:1 voltage balun is in the construction of a coaxial-transmission-line-driven WINDOM antenna, which can be used without much more tuning required, on several bands. Here are some examples:

Educational Paper: http://www.packetradio.com/windom.htm

Windom Antenna with center voltage 4:1 balun: https://packetradio.com/catalog/index.php?main_page=product_info&cPath=49&products_id=2784&zenid=15d2adeef9d16712cdcf9c9686105cd9
$70 and you add the wire.

Here is the center balun of that antenna:

You can easily make one of these yourself: http://www.rason.org/Projects/balun/balun.htm

4:1 CURRENT BALUN

Adding a second toroid can force the currents at the input end to be the same. MFJ sells an interesting balun that includes a switch so that it can be 1:1 or 4:1:

MFJ-911H: https://www.mfjenterprises.com/Product.php?productid=MFJ-911H

Making a 4:1 Current Balun Yourself:

The best home-made baluns seem to involve TWO cores:

http://www.kn9b.us/guanella-balun

http://vk6ysf.com/balun_guanella_current_1-4.htm