The Bead Balun

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Ferrite beads hsve been used by Hams for quite a few years to “knock” the RF off of computer cables and other lines. Ferrite beads over coax also make an effective 1:1 current balun by preventing the flow of RF currents along the outside of the coax shield. The bead balun amounts to one turn on the core. One advantage of the bead balun installed over coax is that the impedance of the line is not changed.

Like toroid cores, beads come in many sizes and material values. Probably the best material for HF through UHF is equivalent to Amidon material 43. Fortunately, all of the beads I have purchased at Hamfests or ordered from surplus houses have been very similar to material 43.

The impedance of a single solid bead over coax starts relatively low at 1.8 MHz. but climbs rapidly with frequency. Amidon shows 43 material peaking in impedance at about 200 MHz and still having relatively high impedance as high as 1000 MHz. Thus, we can use 43 material beads for RF suppression and baluns throughout the amateur radio spectrum.

Ten of these or the smaller beads stacked in series on coax shows good balance in the HF spectrum from 1.8 to 30 MHz. I have compared bead baluns with other 1:1 baluns in operating situations and find no difference among them.

Split beads which can be opened to “snap” over the coax are also available at Hamfests and on the surplus market. While these are convenient, their effectiveness is less than half that of the solid beads for a given ID and volume of ferrite in the HF bands. Large beads have about 1-1/2 times the ferrite of a solid bead.

Some of you may remember the 2 M/440 antenna project that CCARS sponsored a few years ago. In this case, a single “snap on” bead was an adequate balun for 144 and 445 MHz. Note that in the HF spectrum, the split beads follow a straight line relationship between impedance and frequency. It appears that the split beads become more efficient at frequencies above HF.

While not related to baluns, split beads are most useful for Hams using HF mobile rigs. Beads placed over battery cables and coax to the antenna can prevent RF in the cab from interfering with operation of the transceiver and the auto’s computer. Such problems are a result of an inadequate RF ground to the vehicle chassis.

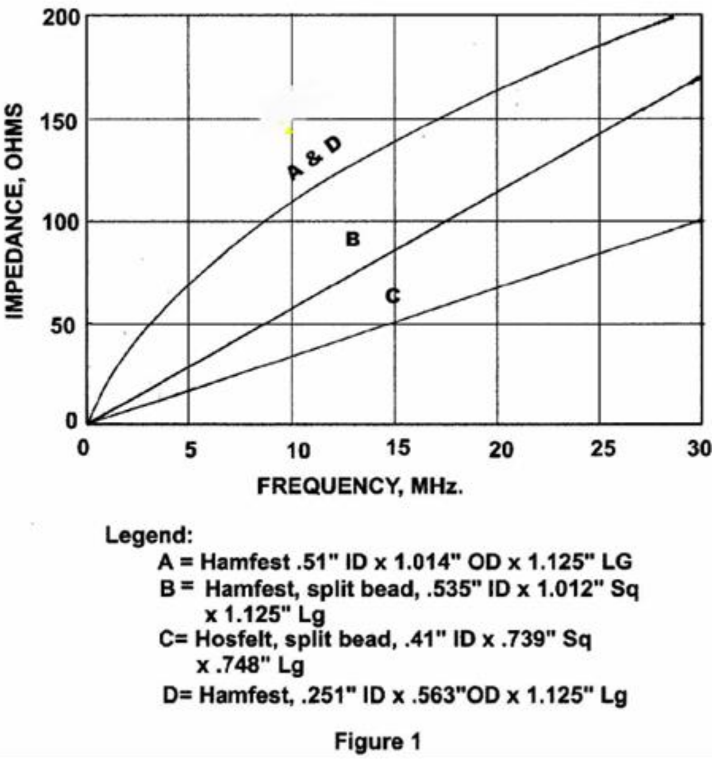

Figure 1

Bead Balun Concepts

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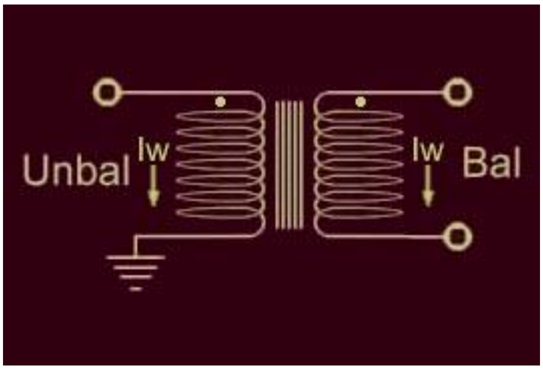
Comparison

A voltage transformer type balun uses magnetic transfer (transfomer action) to produce a balanced signal at the output.

The 1:1 impedance transformation is achieved by making the impedance of each winding the same. If changing the number of turns on one (or more) winding changes the voltage, it is a voltage balun.



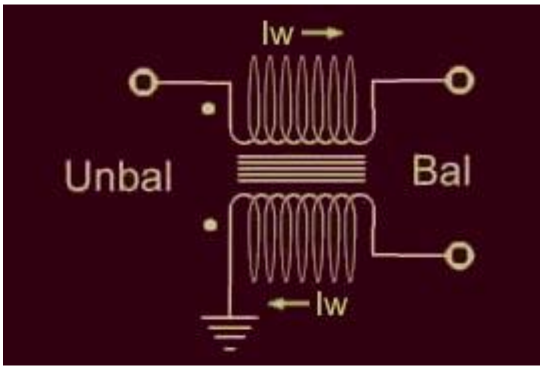
Simple 1:1 voltage balun

A 1:1 current balun controls currents. There is **NO** transformer action. Equal and opposite (balanced) currents cancel each other out and present a low impedance.

Common mode currents produce a mutually inductive magnetic field that presents a high impedance to these, unwanted, signals.

If the number of turns on one winding is made different to the other, the action will remain the same. There will now be a small impedance associated with balanced currents, but still a much higher impedance for to common mode currents.

If changing the number of turns on one (or more) winding changes the the current, it is a current balun.



Simple 1:1 current balun

Balun Bandwidth

The type of balun used depends on what you want to achieve and what bands you are working. If you are going for maximum coverage of bandwidth, you will not have an antenna as good on one particular frequency but a wide bandwidth balun is best.

If you are looking for maximum signal using a Narrow Mode such as CW or SSB, it is pointless using a wideband antenna (ergo balun). Choose a narrow bandwidth balun.

Type of Balun

The best balun to use is the one that does the job with the least loss, of course.

On 6m and above, most generally use a dedicated antenna. A ½ wave loop made of RG-214 has an insertion loss of roughly 0.03db and so is the lowest loss balun I could find. This is a **voltage balun**.

A common mode choke (ugly balun) - **current balun** - wound with RG-58 using the recommended lengths has a loss of roughly 1.2db. In addition, some sort of impedance matching may be needed so a voltage balun is the only real alternative.

On HF, a wide bandwidth is desirable. Voltage baluns are either too big or too inefficient. If you use a tuner, that does all the impedance matching necessary so a simple current balun after an unbalanced tuner has the lowest insertion loss. In this situation a current balun is best.

If a wound balun with impedance matching is needed, the auto-transformer types are generally more efficient.

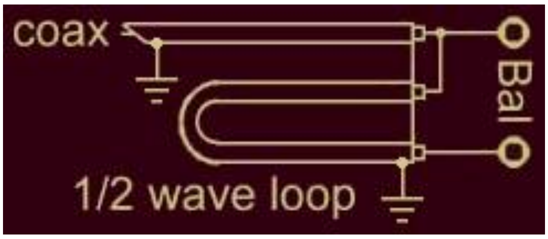
Winding coils with coax

There are situations where winding coils with coax is useful, but there are some strange misconceptions. The centre conductor is surrounded by a good conductor that contains any magnetic or electrical fields it (centre) produces. The inner conductor therefore produces no magnetic effect whatever in the coil or any former it is wound on unless it is by currents it induces in the outer.

Coils of coax around a former do not constitute a transformer. They form a choke on the outer conductor only.

Voltage baluns using coax

The ½-wave length coax balun is highly recommended where it can be used - usually impractical on HF. This is a very low loss balun.



This balun works on the same principle as transformer baluns - in fact - it is a transformer balun.

One side of the signal is transmitted as is and the other side is produced by delaying the signal by half a wave length. This inverts the signal to produce the opposing one.

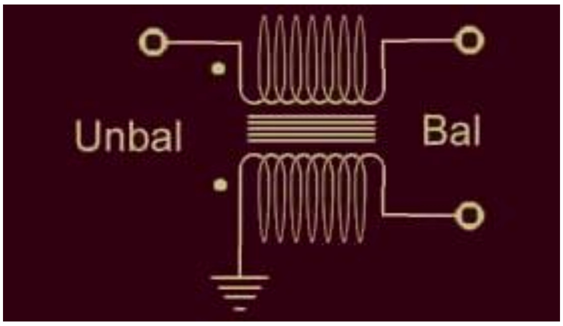
These baluns work well enough but have the disadvantage of being restricted to a very narrow band of frequencies. They are the best if narrow bandwidth is what you want.

The length of the half wave loop is calculated from both the wavelength and the velocity factor of the cable. RG213 typically has a velocity factor of 66%. For 144.4 MHz, the wave length is 299.8/144.4 (2.076 metres) divided by 2 (1.038m) multiplied by velocity factor giving 685 mm. To be sure, consult the technical specifications of the coax you are using.

It is important to use the best coax you can for the balun, even if you use lousy coax for the feedline. Since the electrical fields in both halves of the dipole will affect the other, the average insertion loss will be less than 0.05db.

Core-type current balun

Highly recommended. This is a very low loss balun and ideal for use with a tuner.



This balun works by controlling currents. The two windings must be in the same sense (dots at the same end).

The magnetic fields of opposing balanced working currents will cancel each other out and so present very little impedance (other than the resistance of the wires) to these currents.

On the other hand, common mode currents will produce a mutually inductive magnetic field and face a high impedance.

I tried but was unable to measure any insertion loss associated with either the bolt or the toroid former (powdered iron) for working currents. There was some but the meter needle was so close to the same value in and out, I really could not say what the loss is. As soon as I have the time, I will measure the impedance to common mode currents with various formers.

Common mode choke or *ugly balun*

Not recommended. There are better ways of achieving the same effect.

This type of balun is one of the easiest to make but more difficult to explain. It would be easiest to build up a picture. Consider the following situations.

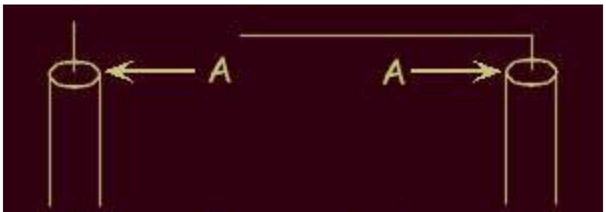


Fig a - outer conductor open

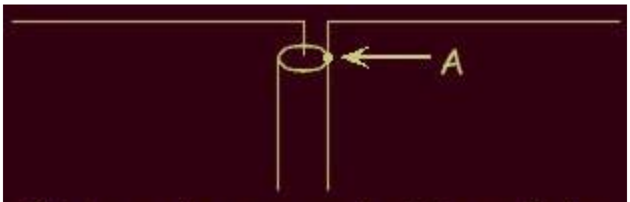


Fig b - outer connected to radiator

Figure (a) shows the situation where the outer conductor is not connected to anything. It doesn't matter what happens with the inner conductor, there can be no current at point A because it isn't connected. Current must have at least some place to flow. Where a single radiator is present like this, the electric field on the inner tries to work against the coax outer and produces common mode currents that simply heat the coax.

Figure (b) shows the situation where the outer conductor is now connected to a radiator. In this situation, there are still common mode currents. The coax shield is a pseudo ground and isn't trying to push any current anywhere.

With unbalanced line it is only the inner that is driven. The coax shield only conducts working currents because they are pushed by the inner. The electrical field created along the radiator connected to coax centre is partly working against the coax.

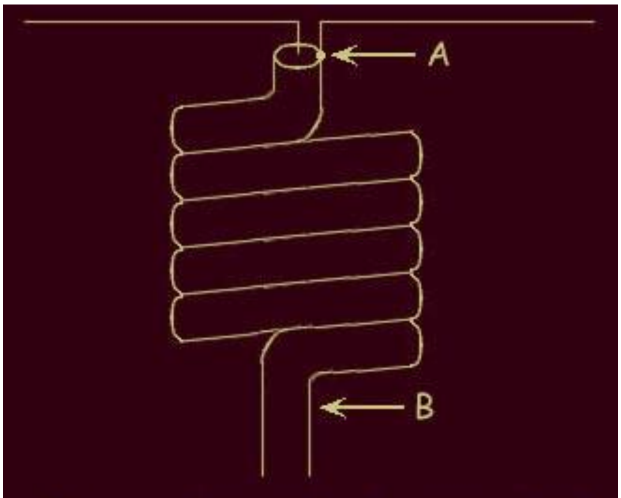


Fig c - outer conductor connected to same place via choke

Figure (c) shows the situation where the coaxial cable is wound into a choke. A choke is nothing more than a **BIG** inductance. An inductance resists a change in current both magnitude and direction. As frequency increases, the impedance increases.

At Radio Frequency, the impedance is so big, neither induced current can pass through it except for the working currents on the inside of the shield. Point A can have currents induced by the electrical field in the radiators but this current can't pass through the choke and to ground.

I have called called it a ½ common mode choke instead of an ugly balun because it affects the outer conductor only. Because both the magnetic and electrical fields generated by the inner conductor are contained within the coax, they are unaffected and thus the currents in the inner conductor are unaffected.

Another way to do it

More ferrite is usually required than two pieces, but you get the idea.