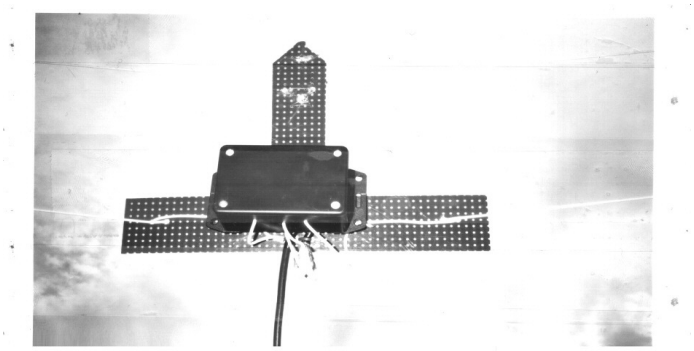
The Case of the Bogus Bifilar Balun Bamboozle



What's really in there, anyway...?

"Baluns, baby... yeah!" - Awesome Powers, international ham of mystery

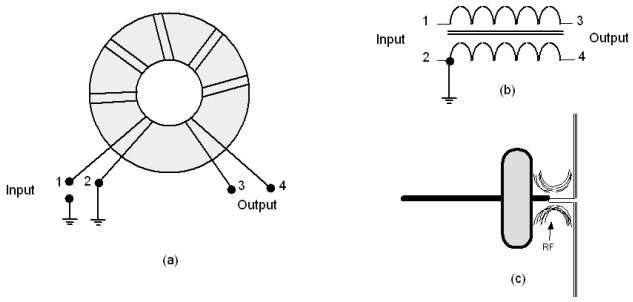
My first article on the Clothesline antenna suggested two different feed strategies, both of which called for a 6:1 balun, in one case placed at the rig, in the other at the feedpoint of the antenna. In both cases it was required to match a nominal 300-ohm to a 50-ohm impedance. That's six-to-one.

By fluke I had had a 6:1 balun lying around which I pressed into service when I built the antenna. But it wasn't long after the article was published that hams from as far away as Sydney started asking, *"Where can I get one?"*

I had seen them advertised commercially from time-to-time, but the question sent me digging for information on making my own. Alas, my edition (96) of the Handbook gave few clues as to how to go about concocting one. Everywhere I looked it seemed like baluns could only be constructed to produce ratios that are squares of whole numbers- 1:1, 4:1, 9:1, and so on.

But a little bit of reading between the (transmission) lines coupled with a fair amount of head-scratching turned up some answers. In the process of solving this mystery, I realised that I have been a victim of the Bogus Bifilar Balun Bamboozle, and I bet I'm not alone. Here's what I mean...

The "Current" Balun...



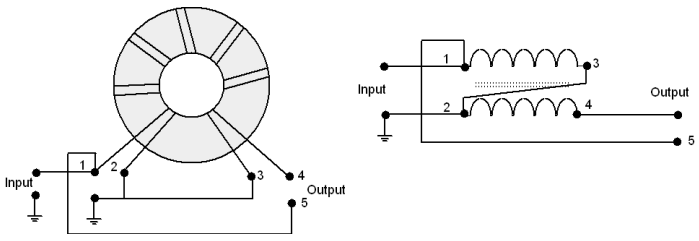
This is your standard 1:1 current balun wound bifilar-style on a toroid core. We're told that the windings form a transmission line, that it changes an unbalanced input into a balanced output, and that the easiest way to make it is to wrap the two windings at the same time, bifilar fashion. Take note for the moment that there are no interconnections between the two windings.

Another way of seeing this device is shown at c- a transmission line running straight through a core of some type of material. This is what we get when we string a bunch of ferrite beads over a piece of coax. Note that the choking action is entirely dependent on the nature of the core; it has little to do with the fact that there's a transmission line running through the middle, or with the nature of that line. A piece of lamp cord, a twisted pair of sweaty socks, a single piece of wire- even a block of wood -would be choked just as effectively.

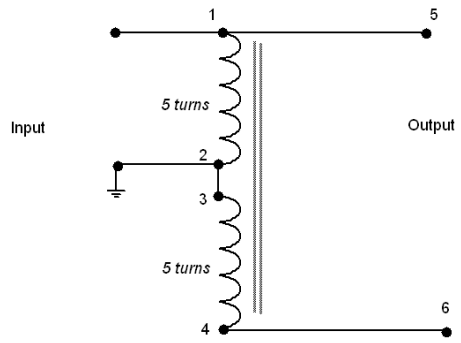
It's the choking action that prevents rf from getting back down the line. It's also the choking action that allows us to establish ground on one side independent of ground (or no ground) on the other side, and go from single-ended to balanced, and vice versa. Because the core represents a high impedance from one side to the other to any non-differential conditions, our grounds (or none) wind up on different planets rf-wise, so they don't interact.

It's the choking action that encourages equal currents to flow in the antenna too. Once the rf current gets out of the transmission line and into the antenna, it's kind of stuck out there- it can't get back around the choke.

The "Voltage" Balun...



Take the original balun and add couple of connections though, and voila- we've got a 4:1 balun. And it's no longer a current balun, we're told, it has been magically transformed into a *voltage* balun (we start getting nervous).
It's usually shown schematically just as you see I think, because it illustrates how to turn our first balun into our second. But this view gives us the impression that there's some sort of mystical, bifilar, transmission-line hocus-pocus going on that makes it work. Redraw the schematic in conventional fashion, and you get this...



The Autotransformer...

This is an autotransformer, and there's nothing mystical about the way an autotransformer works. It's a venerable device that steps up the voltage between input (1, 2) and output (5,6) by the ratio of the turns. In this case there are twice as many turns across the output as there are across the input, so the voltage step-up is 2:1. The impedance difference is equal to the square of the turns ratio, so it's 4:1. Also in this case, the output is centered around ground, so it's balanced. Note that transmission lines are conspicuous by their absence in this schematic.

Note next that point 1, at the input, and point 5, at the output -are the same point. We've lost our choking action because there's no longer a nice, meaty core sitting directly in between the input and the output.

Ok, so no more choke, but this balun does take our single-ended input and create a balanced output, which is precisely what we want a bulun to do, and performs a 4:1 impedance transformation in the process.

Why is it called a voltage balun? It establishes equal but opposite voltages at the output terminals and yes, we can indeed get unequal currents at the output if the load is not balanced, just like you'd get unequal currents if you hooked up a battery to two disimilar loads at the same time. But believe it or not, this applies to our so-called current balun as well!

The difference, though, is that with the current balun, once the different rf currents are out of the line and into the antenna, the horse is out of the barn. They tend to stay out there due to the choking action of the core, and so tend to get shared-out by both legs of the antenna. If you were to take away the choking action, there'd be no difference between these two baluns as far as the ol' current-vs-voltage issue goes. And note again that transmission lines have nothing to do with this.

So I look at the autotransformer schematic, and my thoughts go like this...

Do we still have a transmission line running through a core? I don't think so. I don't see one. Ok, if not- what stops us from viewing this strictly as the beast it is, an autotransformer? The answer would seem to be- nothing.

These considerations then lead me straight back to my original, sixty-four dollar question- so why then are we stuck with only impedance ratios that are squares of whole numbers like 1:1, 4:1, 9:1, etc?

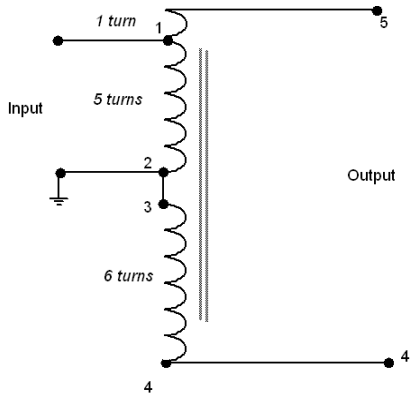
The answer- it's the Bogus Bifilar Balun Bamboozle!

If you wind this balun bifilar-style, you're automatically creating equal numbers of turns in the two coils because you're winding them both at the same time! When you then make interconnections between the coils, you're always hooking up coils with exactly the same number of turns in each.

So the ratios you get are always the ratio of the number of *windings*- not turns -you include in the primary vs the secondary. Since we always pick windings ratios of whole-number-something-to-one, the ratios are always whole numbers, thus the impedance transformations are always squares of whole numbers. It's the bifilar construction technique- and nothing else -that imposes this limitation.

While we're at it, this also explains why you can ignore the number of turns you use, as far as impedance calculations are concerned. It's nothing to do with some magical property of transmission lines. The number of turns just factors out, since they're equal in every winding.

So how do we escape the evil clutches of the Bogus Bifilar Balun Bamboozle? Have a look...



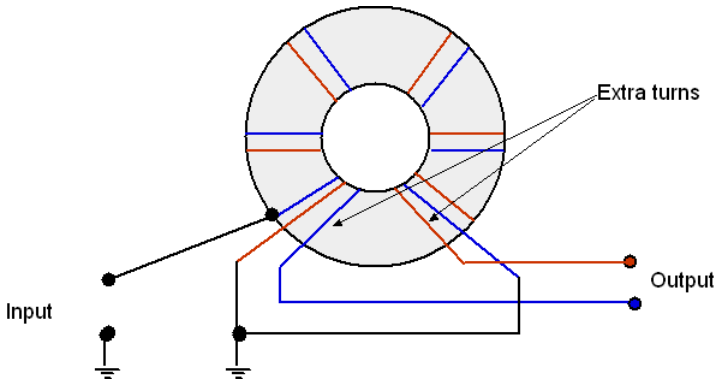
This is the same autotransformer as in the previous diagram, we've just changed the turns ratio by adding a turn on each end. The primary still has 5 turns, but now the secondary has 12 (5+1+6).

The turns ratio is now 12/5, which equals 2.4. Square that, and you find our impedance transformation is 5.76 -very close to our sought-after 6:1! And all we've done is side-step the

Bifilar Bamboozle and wind our balun with the *turns* ratio we really want! And we're still going from single-ended to balanced, and our load is still centered around ground!

(Clothesline afficionados take note- the nominal feedpoint impedance of the Clothesline is 288 ohms. This divided by 50 ohms is 5.76, exactly the number we've got right here!)

Wound onto a core, it'll look something like this...



Still looks pretty much like your basic, transmission-line-style, bifilar-wound balun doesn't it?

Although it appears to be the grandfather of all those other baluns, the basic 1:1 choke-type balun we started with is actually a special case that has little to do with any of the others. Most of the rest of those other bifilar and trifilar wound baluns you see- the ones with the whole-number-squared-ratios -look to me like they're electrically identical to what we see here. The only thing I can see that's different is the turns ratio, which doesn't have to be limited to those whole-number squares- it can be anything you wish.

If you now look back at the schematic for this balun, you may get the impression that it could be wound monofilar (in english, with a single piece of wire) and I think you'd be right. In fact I've done this repeatedly, and the baluns work fine.

To the purists who cry that these windings *must* be wound transmission-line style, I say this- wind them that way if you want. My guess is that the extra turn or two to get the proper impedance ratio you need has *got* to be worth whatever minor loss you might encounter because a turn or two aren't perfectly paired. In fact they still can be, it's just a question of how you lay it out.

And if you do insist, I have a question for you- what characteristic impedance will you choose for your line? For anything other than a 1:1 balun, aren't you guaranteed a mismatch at one end or the other, or else both?

All choked up...

But now comes the real crunch. That original 1:1 choke balun- and only that one -has a special quality. It's choke-y nature will encourage equal currents to flow across our feedpoint when our load is not perfectly balanced.

In many cases there's no working difference. When there is though, the choke balun is thought to improve antenna radiation and isolate the feedline from the antenna, which minimises interactions and feedline radiation. It can also choke off common-mode noise picked up by the antenna on receive, quieting down your heaphones.

So, can we work up that current-choke-type balun to provide for impedance ratios other than 1:1? Maybe even for non-whole-numbers-squared-ratios, like 5.76:1?

One very good soultion is to simply drop the 1:1 choke on the output of our 5.76:1 voltage type, and we're there. It's simple, and it works great. The insertion loss of the 1:1 is negligible, and we get a nice, choked output with the impedance ratio that we want; it'll do the job just fine.

Is there a more elegant way? Can we make a single balun that gives us the current-choking behavior we want, *and* allows us our choice of impedance ratios? Well, yes to both but- I'm not going to tell you how. *C'mon,* you're a ham! You'd love to figure this out on your own, wouldn't you?

Look in the Handbook or other literature, find mention of a 4:1 current transformer, and apply the same thinking I've used here. All you have to do is use your head, and don't get fooled by the Bogus Bifilar Balun Bamboozle- your 5.76:1 current balun awaits.

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