



ARNSW Balun Day

Balun construction

Typical Baluns



All built from locally available components.

Balun uses

- Most baluns are used to match the 50Ω output of a transceiver to an antenna.
- A centre fed dipole should have a 1:1 balun to ensure any unbalance in the two halves does not result in radiation from the coaxial line.
- Some antennas require matching to 200Ω and thus a 4:1 balun is required.
- Today the focus will be on 1:1 and 4:1 baluns as these are available in kit form.

Balun design

- Baluns are NOT transformers in the classical sense of two windings coupled by a magnetic core.
- A balun could be made as a transformer but the performance would be disappointing.
- The leakage inductance (this is a measure of the coupling of the two windings) and the inter-winding capacitance would limit the bandwidth of the transformer.
- Winding techniques to reduce these limitations are complex and large magnetic cores are required to support 100s to 1000s of watts of RF power.

Balun performance requirements.

- Wide bandwidth 1.5 to 30MHz or more
 - Low loss. When running at 1kW the loss must be low or else the core will overheat.
 - Simple to build.
 - Available components.
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- All this can be met by using a transmission line transformer.

Transmission line transformers

- For 50Ω 1:1 Baluns the transmission line must be 50Ω .
- This can be coaxial cable or a bifilar parallel transmission line.
- Two types of transmission line transformer have been shown to be efficient at HF.
- The Current balun described by Guanella in professional literature
- The Voltage balun described by Ruthroff.
- Of these two the current balun is simple to construct and has excellent performance.

The 1:1 current balun.

- For 1:1 50 Ω baluns the Guanella current balun can be shown to be superior to all other more complex designs.
- The required function of a 1:1 balun is to pass the desired differential RF current while blocking common mode current caused by an out of balance load.
- All that is required to do this efficiently is enough common reactance on the inner and outer conductors of a coaxial line or the two conductors of a parallel line.

Toroid Baluns

- Winding the line on a low permeability ferrite toroid is an effective method.
- Permeability should be 125 to 250 to give high common mode inductance without losses in the ferrite if there should be an unbalanced load.
- RG316 coax can handle high power at HF and is small enough to fit on a 40mm toroid.

Toroid Baluns What Core Material?



Micro Metals T200-2 Iron Powder Core.

Permeability (μ_i) = 10.

Iron powder is suitable for baluns from about 7MHz to 50MHz but does not have enough permeability to ensure sufficient inductance for below 7MHz.



Micro Metals FT240-61 Nickel zinc ferrite.

Permeability (μ_i) = 125.

Ferrite is suitable for baluns from about 1MHz to 30MHz due to the higher permeability thus ensuring sufficient inductance for below 7MHz.

Permeability above 250 is not recommended as this will degrade high frequency performance.

Toroid Balun Construction



- This is about as simple as possible
- Wind the coax around the toroid and half way cross over back to the start and wind the second half of the total winding.
- This method ensures the start and finish are at opposite ends.

Cannot buy RG316?



- Use 2 parallel 1.25mm enamelled copper wires
- This is approximately a 50 Ω transmission line.
- The same winding method with the crossover can be used to place the start and finish on opposite sides of the toroid.

What about “3 winding” baluns

- Why the third winding?
- This winding is wound as an extra winding physically separate to the transmission line but on the same core.
- Called a compensating winding but does not seem to improve performance.
- At low frequencies couples energy into the core and is of such high reactance at high frequencies to be ineffective.
- Conclusion is it is not required and may degrade performance

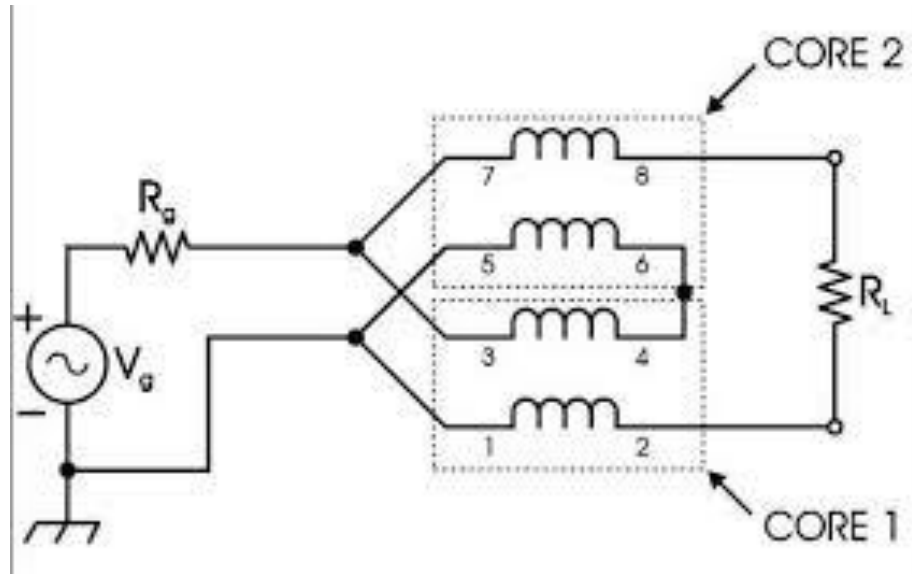
1:1 Balun conclusion

- The current balun is simple and can be shown to be effective.
- Either coax or parallel wire 50Ω transmission line can be used.
- 10 to 15 turns on a permeability 125 core works over 3 to 30MHz
- More turns or higher permeability core will allow operation down to 1.8MHz.

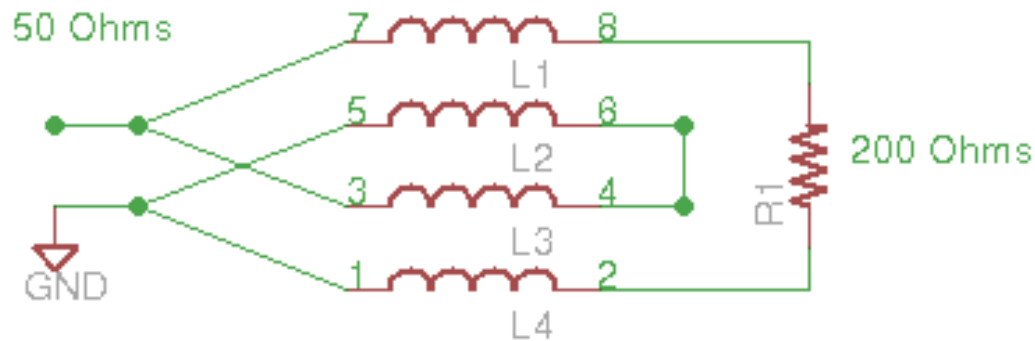
1:4 Balun

- As the transformation is 50Ω to 200Ω the transmission line must be 100Ω .
- Two Guanella transmission line transformers can be connected in parallel on the 50Ω side and in series on the 200Ω side to form the balun.
- 100Ω can be made from 1.25mm wire with 2.0mm heat shrink as the insulator.

1:4 balun schematic.



Two
transformer
cores



Single
transformer
core

Example 1:4 Baluns



- The two transmission line transformers are wound on the same core.



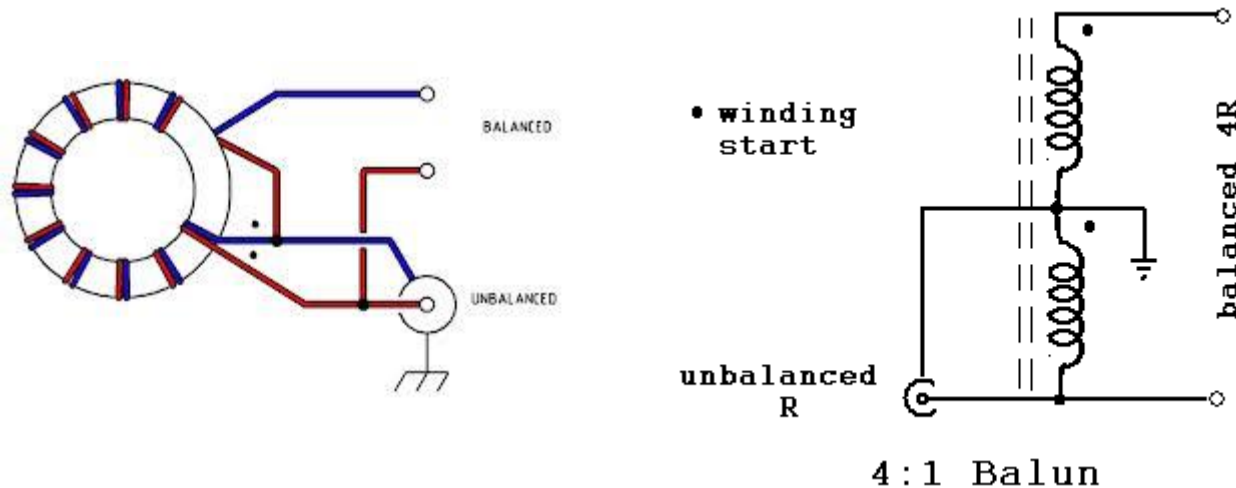
- In this example the two transformers are wound on separate cores to allow for more turns per transformer

Ruthroff 1:4 Balun



This is a simpler 1:4 balun with reduced performance over the Guanella balun but still satisfactory over the 3 to 30MHz range.

Ruthroff 1:4 Balun Schematic



- Uses a 100Ω transmission line transformer to provide a 1:4 impedance step up.
- Only suitable for a well balanced 200 ohm load.

Do These Baluns Work?

- Two measurements demonstrated that the balun is effective.
- 1.
- Place a load on the output 50Ω for a 1:1 and 200Ω for the 4:1.
- Measure the input impedance across 1 to 50MHz.
- The impedance should be 50Ω resistive with very little reactance at 30MHz.
- 2.
- While measuring the impedance short one output at a time to the input ground and the impedance should not change.
- This demonstrates the balun is converting the unbalanced input to a balanced output.

Today's Kits



TetEmtron 4:1 Balun Kit



TetEmtron 1:1 Balun Kit

Completed 4:1 Balun



Completed 1:1 Balun

