

Using Baluns and RF Components for Impedance Matching



Wideband Transformers and Inductors

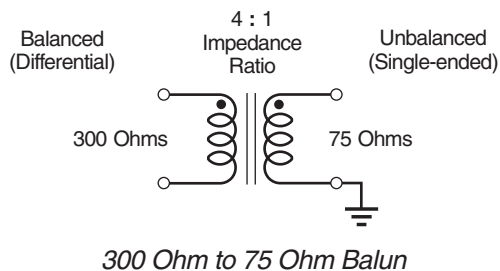
Impedance Matching

Impedance mismatch in a circuit results in energy being reflected back to the source, reducing the amount of power available to the load and possibly causing damage to the power source. Matching the output impedance of the power source to the input impedance of an electrical load maximizes power transfer from source to load. By matching the impedance of the source and load, circuit designers protect the power source from reflected energy and optimize circuit efficiency.

A symmetrical balanced line has two conductors having equal current in opposite (differential) directions. Twisted pair cable and ribbon cable are examples of balanced line cables. An asymmetrical unbalanced (single-ended) line has one conductor connected to ground, such as coaxial cable.

When a balanced source is to be isolated from an unbalanced load, the impedance matching transformer is referred to as a balun. If the impedance of the load matches that of the source, impedance matching is not required, and the balun has a 1 : 1 impedance ratio. When the load impedance is mismatched to the source in a 1 : N impedance ratio, a 1 : N impedance ratio transformer is required.

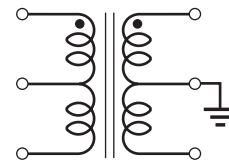
A classic example of an impedance mismatched circuit is a 300 Ohm ribbon cable (balanced) from an antenna attached to 75 Ohm coaxial (unbalanced) receiver input. Without a balun to match the impedance of the load to the source, energy is reflected back from the relatively low-power input signal of the antenna, providing a reduced signal to the receiver.



Baluns provide a 180° phase shift and ideally equal balanced impedances. Wirewound wideband RF transformers

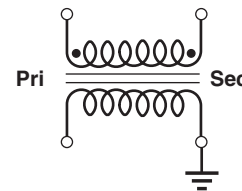
make excellent broadband baluns, providing two 90° phasing lines to create the 180° shift.

Baluns are used with antennas, mixers, and push-pull amplifiers to create the correct phase relationships and to match impedances. Wirewound RF transformers are typically used in push-pull amplifier applications at frequencies ranging from a few kHz to around 2 GHz. Alternative constructions may include center taps for biasing or grounding.



Center Tapped Ruthroff Balun

Ruthroff style baluns provide isolation as well as impedance matching. If isolation is not required, bandwidth can be extended to frequencies as high as 3.5 GHz when connected as a Guanella (transmission line) transformer.



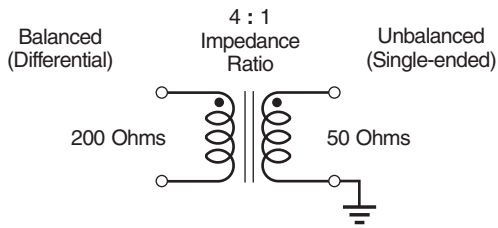
1:1 Guanella Balun

Coilcraft wideband RF Transformers provide a wide range of impedance ratios and frequency bandwidths for use as baluns and for impedance matching. The complete selection of wideband transformers is shown at <http://www.coilcraft.com/wideband.cfm>. These transformers are intended for lower power (~1/4 Watt or less, 250 mA or less) applications.

Simple Balun Connection Example

When attaching a 200 Ohm balanced antenna to a 50 Ohm unbalanced (coaxial) cable, connect the high impedance (200 Ohm) balanced antenna to the high impedance side of the transformer, and the low impedance (50 Ohm) unbalanced end to the low impedance side of the transformer.

This connection steps down the high antenna impedance to match that of the 50 Ohm cable.



200 Ohm to 50 Ohm Balun

High-Frequency Narrow-Band Baluns

For high-frequency narrow band applications that do not require isolation, lumped element designs may be implemented. The availability of tight-tolerance surface-mount chip inductors and capacitors allows for minimal variation in production. Designers can employ circuit simulation to optimize the element values to achieve the required im-

pedance matching network using LC components. Initial design values can be estimated using online calculators such as these:

LC Balun Designer: http://leivire.com/rf_lcbalun.html

LC Matching http://leivire.com/rf_lcmatch.html

Network Designer:

At GHz frequencies, accurate inductor models that include parasitic elements are necessary for getting closer to a reality-based design. Coilcraft's models for air core and chip inductors are measurement based in order to provide accurate simulation of your LC balun or matching network. These models can be found on our website at <http://www.coilcraft.com/models.cfm>

References

Cripps, Steven C., RF Power Amplifiers for Wireless Communications -2nd ed. (Artech House, 2006)