

Application Notes

Marki Microwave Baluns, Transformers, and Pulse Inverters

By Marki Microwave, Posted Wed Mar 13 2013 14:00:00 GMT-0500 (Central Daylight Time)

Baluns, transformers, and pulse inverters are related products in that each will take a single ended input and provide an inverted signal, in the sense that the negative voltages become positive and the positive voltages become negative. A pulse inverter performs this function in the most straightforward way, simply reversing the voltage of an input signal. A 'transformer' in the microwave sense generally means a device that will transform one voltage into another at a given current, and in doing so will transform the impedance. The word 'balun' is a portmanteau of 'balanced' and 'unbalanced'; a single ended input to a balun will create an image version of itself with half of the power (on the positive output) and an inverted version with half the power (on the negative output). In this sense it is similar to an out of phase or 180° power divider, except that a balun is inherently a 3 port device, while a 180° hybrid is a 4 port device.

There are two main types of baluns: those that transform the input impedance and those that do not. If the balun divides the input voltage into two parts, while keeping the input current, then the output impedance on each line will be half of the impedance of the input line impedance. This is a 1:1 transformer, as no impedance transformation takes place (although generally the input lines are 50 ohms and the output lines are 25 ohms, because two 25 ohm lines makes 50 ohms differential). If the balun cuts the current in half to match the voltage drop then it is an impedance transforming balun, called a 1:2 transformer (because the 100 ohm differential output impedance is twice that of the 50 ohm input).

Here are some relevant performance criteria for Marki Microwave balun/transformers and pulse inverters:

Bandwidth



While not a figure of merit in its own right, each performance metric of a balun is limited to a certain band. On the low end it tends to be limited because the device is only a fraction of a wavelength long. On the high end it is limited because the symmetry required to maintain balance is difficult to maintain at shorter wavelengths, just as with an in-phase or quadrature power divider.

Rise/Fall Times

Related to the bandwidth, the rise and fall time determine how well the balun can handle data. The risetime needs to be less than around 1/3 of the bit period to ensure good data transmission with minimal amplitude eye closure. For example, the BAL-0010 has a rise/falltime of 20 ps, allowing it to transmit with a period up to 60 ps or around 17 Gb/s.

Amplitude and Phase Balance

In an ideal balun the two outputs will be identical inverses of each other at every frequency. In reality the two outputs will have slightly different amplitudes and slightly different time delays, resulting in the phase of the output of the two signals being slightly off from each other. A typical balun application will require an amplitude balance of better than .5 dB and phase balance of 5° or better. Most applications are more sensitive to phase imbalance than they are to amplitude imbalance.

Common Mode Rejection

A balun can be used to reject common mode noise (noise that is present on both the positive and negative polarity signals); this is one of the major benefits of differential signaling. How well a balun can cancel out the common mode noise from two differential inputs is called the common mode rejection of the balun. How much is necessary depends on the application.

Isolation

Unlike a magic tee or 180° hybrid power divider a balun does NOT have any intrinsic isolation. The isolation indicates how much power from a signal going into one arm will show up in the other arm, assuming all ports are terminated with matched loads. Hybrids resistively terminate in-phase signals, leading to isolation. Baluns reactively terminate signals, and so the isolation is simply equal to the insertion loss of the device.

Insertion Loss, Return Loss, and VSWR

As with all passive RF and microwave components, the insertion loss refers to how much power is lost in transmission. In 2:1 baluns this is 6 dB (3 dB for the

power splitting and another 3 dB for the matching), but in 1:1 baluns the nominal insertion loss is only 3 dB.

The return loss and VSWR for baluns tends to be better at the common port than at the differential ports.

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