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Improved directivity Reflection Bridge

Learn how to make your T1-6T Reflection Bridge work at higher frequencies up to VHF

In reflection mode we use the Reflection bridge to sense the power reflected from the DUT because of the mismatch condition. The bridge directivity and insertion loss determine the quality of a bridge. Poor directivity beside limiting the dynamic range of the bridge also introduces more error when the bridge is used close to its directivity limit because of the source signal getting through the arms and interfering with the true reflected DUT signal. This effect is reduced to minimum by the VNA during Open/Short/Load calibration which cancel the interfering signal, and quality of the bridge becomes not that critical. But if you want to use your T1-6T bridge at frequencies beyond the VNA range (with a signal generator, logarithmic amplifier and scope) to measure Return Loss, quality of the bridge will determine the dynamic range of the RL being measured. With a 30dB directivity bridge maximum of 30dB of Return Loss could be measured. That is why it is a good idea to have a high directivity bridge. This page describes a change in the T1-6T bridge to improve its directivity when used as a standalone tool, in applications other than N2PK VNA.

The reflection bridge used in N2PK project uses Minicircuits T1-6T 1:1 transformer to deliver the reflected power to the Detector. The transformer's primary is connected to the diagonal of the 50 Ohm bridge, and the secondary passes the signal to the Detector. It appears though that replacing the transformer with a 1:1 balun produces better result.

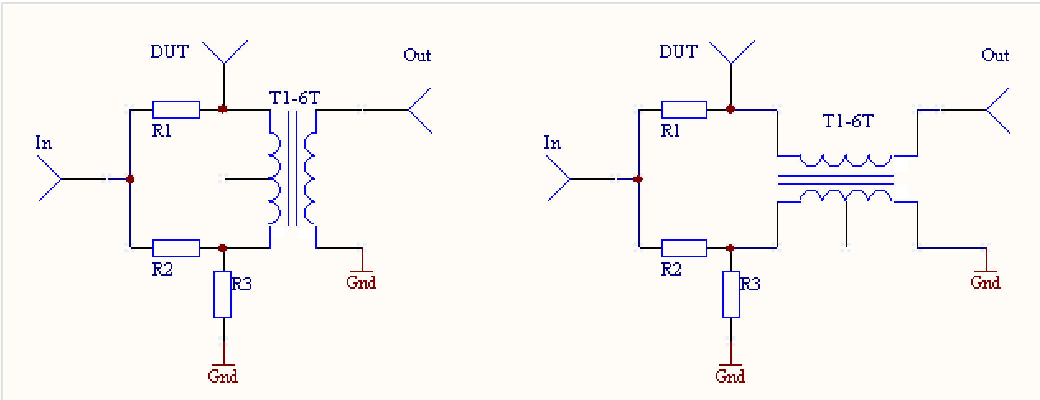


Fig 1. Classic (left) and modified (right) bridge configuration

Same T1-6T transformer can be used, it just needs to be rotated to change the windings connection to the bridge arms. Below are the experimentally taken charts that compare the same bridge with T1-6T in classic and balun configuration. The test setup included HP8656B signal generator, Minicircuits power splitter, ADI dual channel logarithmic detector, HP digitizing oscilloscope, Minicircuits 50 Ohm load, and T1-6T bridge under test.

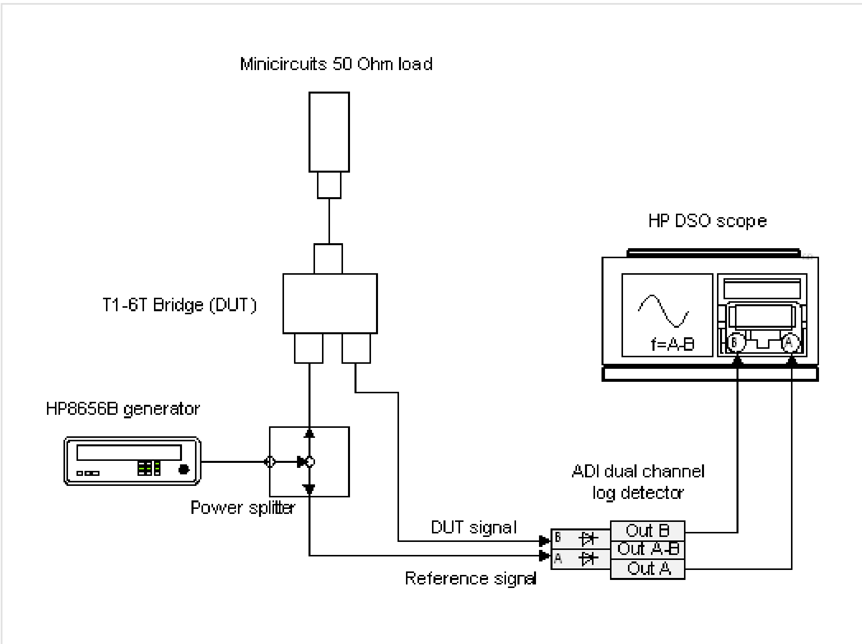


Fig 2. T1-6T bridge test setup. All measurements were done relative to the reference signal on channel A of the dual logarithmic detector.

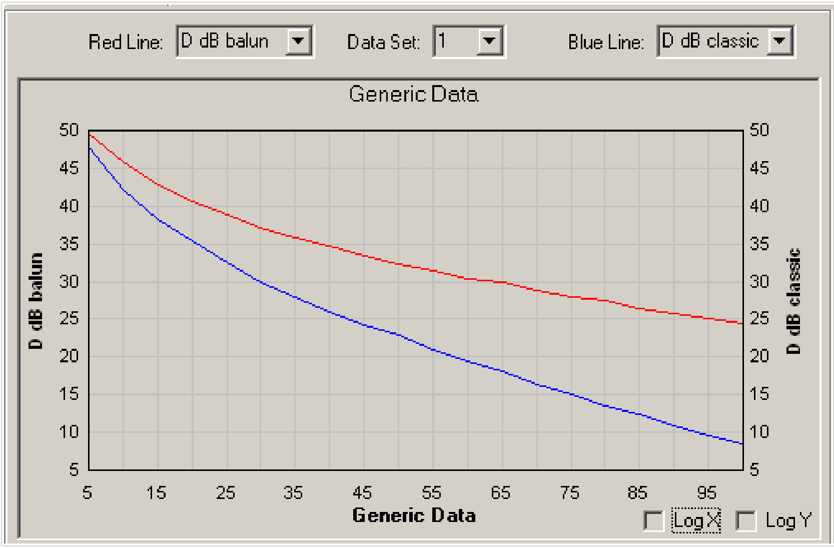


Fig 3. Bridge directivity in dB with T1-6T in classic (blue) and balun (red) configuration from 5 to 100MHz.

Improvement begins from 3dB in 10MHz area, reaching 10dB at 50...55MHz. It is even more noticeable when scanned through a wider range of frequencies (see the 200MHz chart below). The updated bridge could be used with limitation to 200MHz, still having good directivity on 2m band. At these frequencies the insertion loss of the modified bridge does not raise that much as that of the classic bridge.

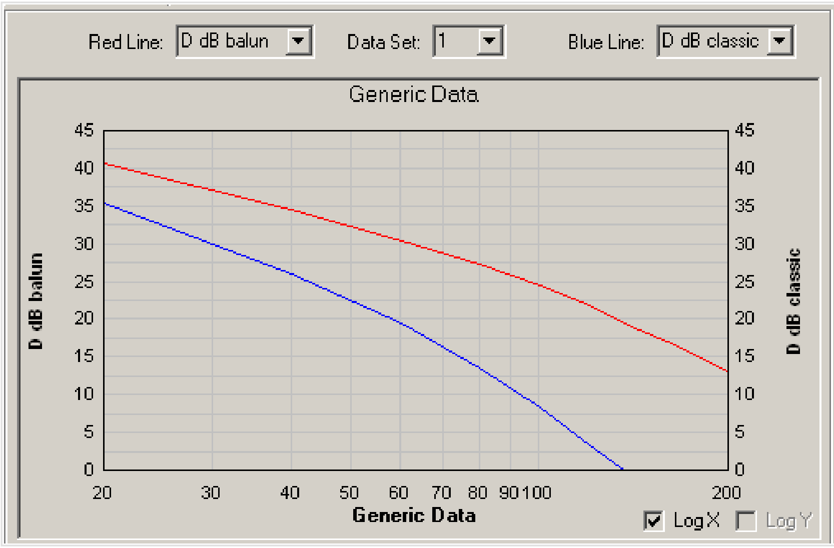


Fig 4. Bridge directivity over a wider frequency range 20 to 200MHz.

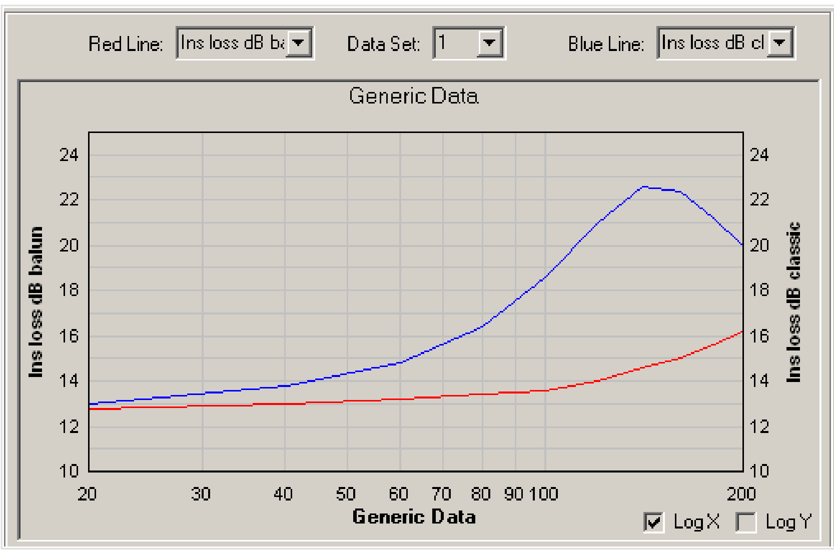


Fig 5. Bridge insertion loss over a wider frequency range for classic (blue) and balun (red) bridge.

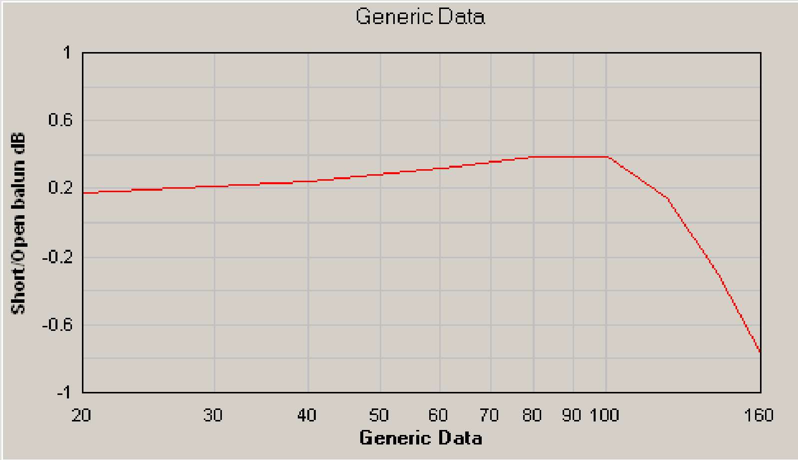


Fig 6. A modified bridge maintains good balance between Open and Short references up to 160MHz

It is probably only worth modifying the bridge if it is going to be used at frequencies above 20MHz, where its directivity is 6dB better than that of the classic bridge. Below 20MHz the classic bridge has good directivity and should be used as it is. Again, this is in context of using the bridge as a separate device in the setup configurations other than the VNA one.

A practical setup configurations that could utilize the modified T1-6T bridge would include a signal generator, a log detector and a voltmeter or scope to measure the log detector DC output. Then one could use the balun'ed T1-6T bridge to scan his 2m antennas or filters for the Return Loss.

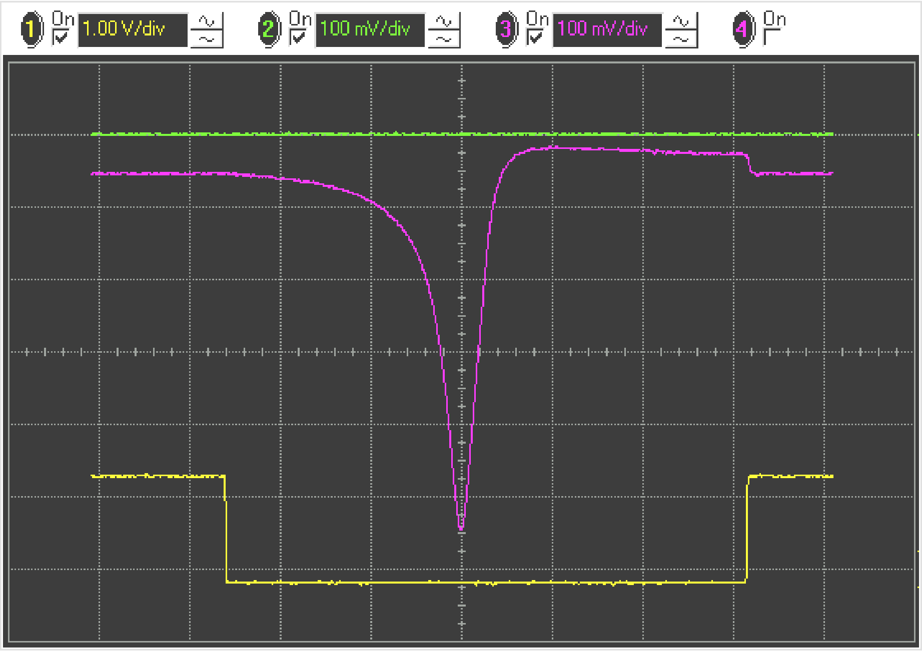
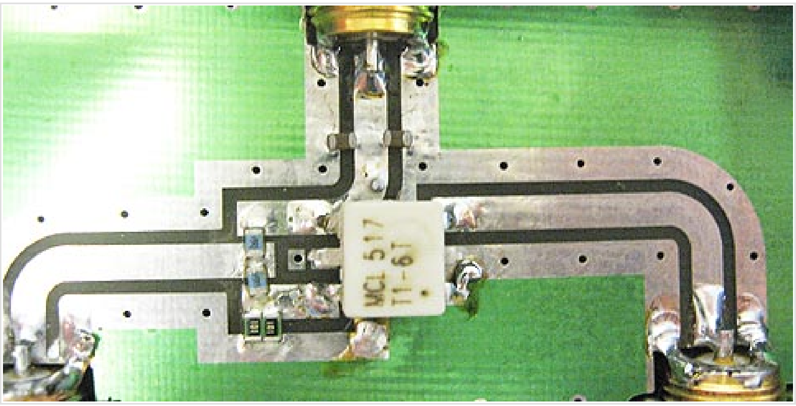


Fig 7. Example of utilizing a standalone modified T1-6T bridge to measure the Return Loss of a DUT. The yellow line is the sweep generator gate pulse from f_lower to f_upper, the green line is the Open reference level, and the pink line is the DUT. The DUT channel is scaled 0.1V/div and measures -0.55V at the dip. The log detector used in the setup has slope of 50mV/dB. This makes the Return Loss at the dip 0.55/0.05=11dB

To modify the bridge, remove the T1-6T transformer and two 8pf capacitors. Straighten the middle leads of the transformer with the nose pliers so that they float not touching any of the PCB pads. Then solder the transformer back but rotated as shown in the picture (watch the dot mark). This will change the windings arrangements and make the T1-6T to work as a balun.



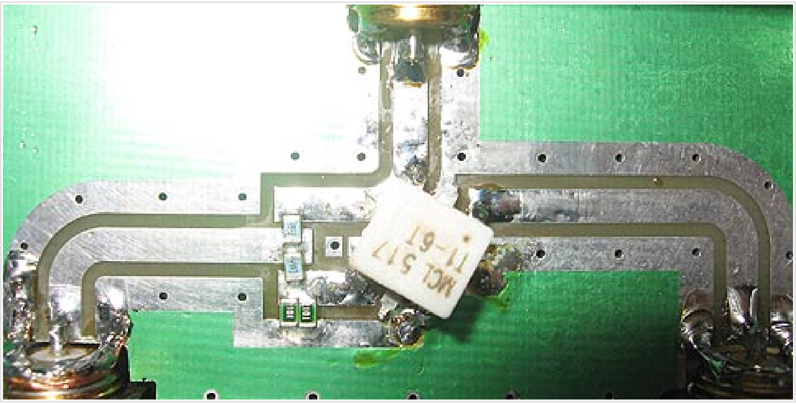


Fig 8. Classic (top) and modified (bottom) T1-6T bridge. Note the capacitors removed.

The v4.1 VNA board kits are supplied with two reflection bridge boards. The builder than could dedicate one bridge to the VNA activity and modify the second one to have it handy as a generic purpose bridge for the RL measurements beyond the working range of the VNA.

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