Scalar Measurements Using A Broadband Noise Generator

Welcome to the 3rd and 4th Quarter 2013 CSEI Technical Report.

In the past, I've provided detailed scalar measurements (see Downloads Page, Sample_Scalar_Measurements.zip) using a spectrum analyzer with an integrated tracking generator. Tracking generators, especially those integrated with newer spectrum analyzers, provide very accurate methods by which one can measure frequency response, isolation measurements, and even return loss measurements with a RF return loss bridge.

But what if your present analyzer doesn't have a tracking generator, and you can't afford to change to one that does? Modern broadband noise generators offer an alternative to the above, albeit with measurements not quite as accurate. To their advantage, however, they are low cost (a fairly flat response noise generator can be obtained for several hundred dollars), and offers the advantage that it can be used with most modern spectrum analyzers that offer an 'averaging technique' for the primary or secondary traces and preferably offer a SAM RF detector mode.

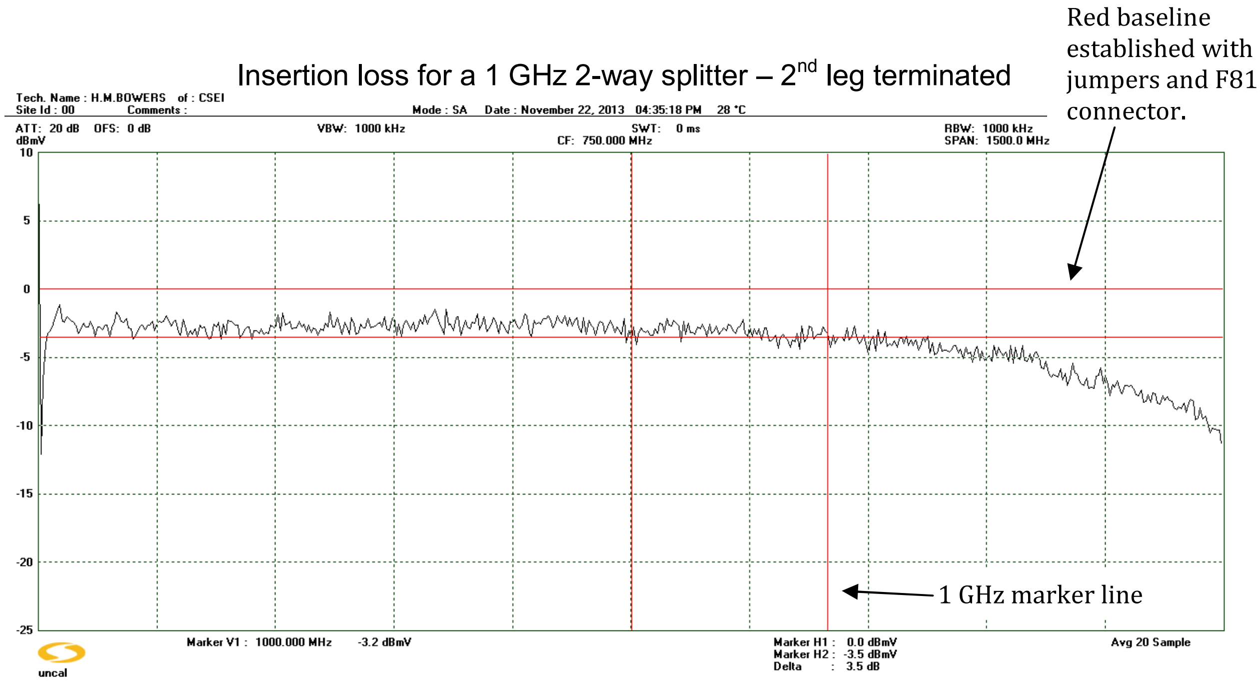
The measurements shown on the following pages use a 5 to 2,150 MHz noise generator from Applied Instruments, that was purchased for I believe in the $100 to $200 range. While certainly not as accurate as a tracking generator, and lacking in automated 'normalization' techniques to account for cable and connector response; it nonetheless offers fairly accurate measurements at a very modest price.

So read on, and be sure to contact me if you have questions regarding the following information and article.

Take care and best regards for the upcoming Holiday season!

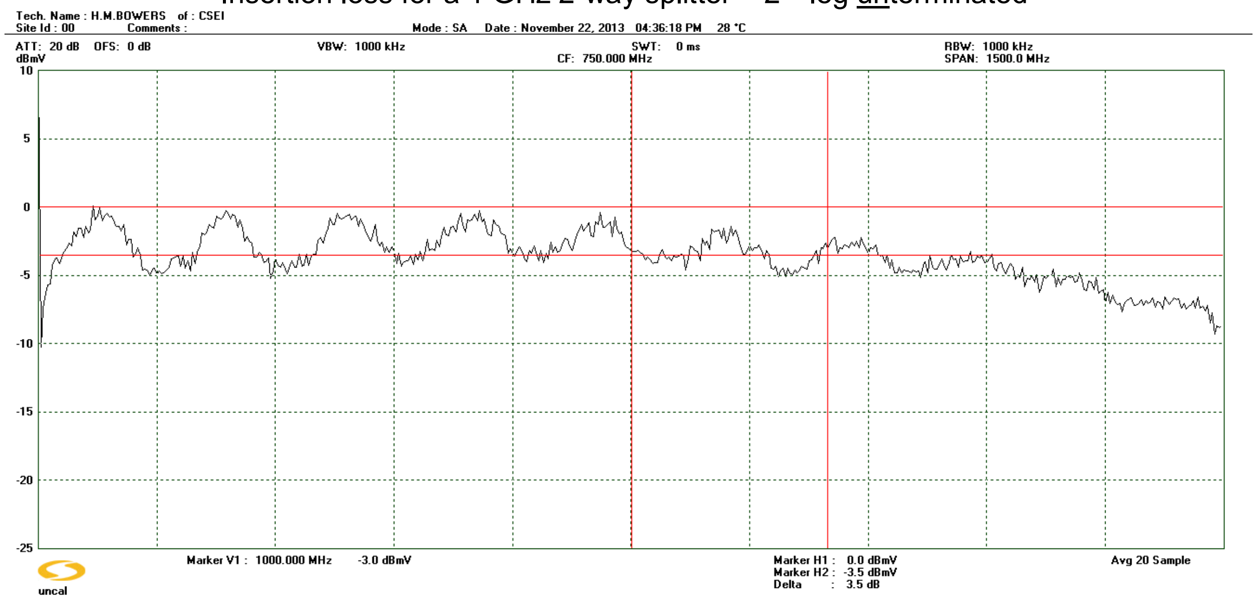
H. Mark Bowers
VP of Engineering
Cablesoft Engineering, Inc.

Insertion loss for a 1 GHz 2-way splitter – 2nd leg terminated



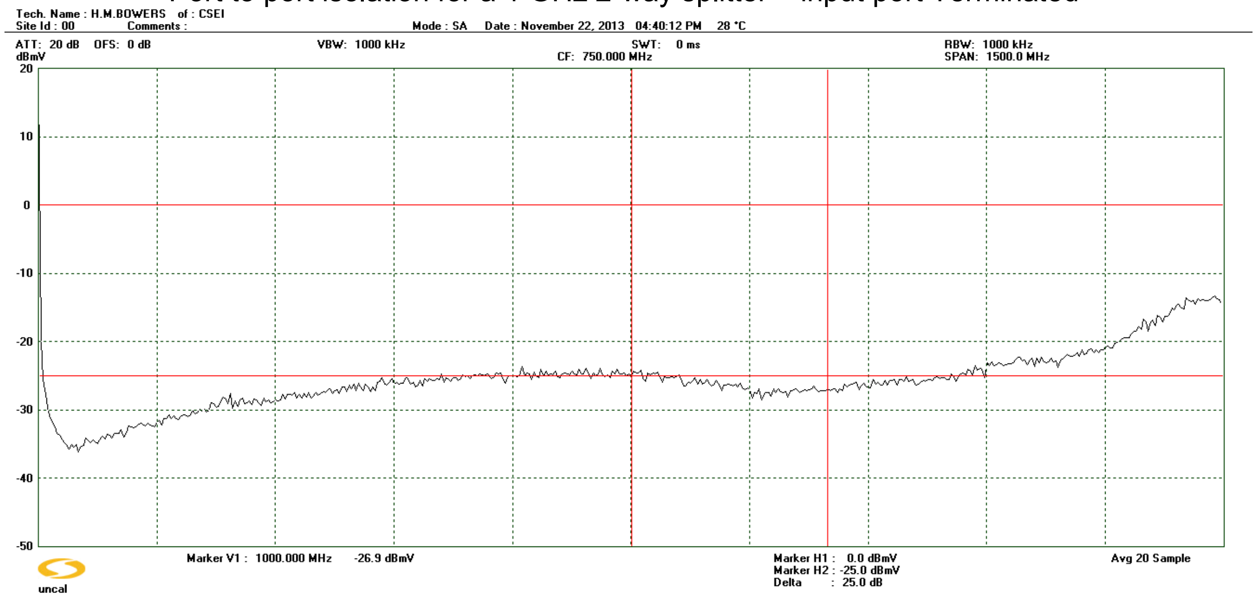
The red line at 0 dBmV marks the baseline (jumper from noise generator to analyzer input using short cables and a F81 connector) response of the noise generator out to 1.5 GHz and beyond. The black line represents the throughput loss from splitter input through one of the two output legs, with the other output properly terminated. Loss at 1 GHz is approx. 3.5 dB! The loss at 1.5 GHz, however, is >10 dB!

Insertion loss for a 1 GHz 2-way splitter – 2nd leg <u>un</u>terminated



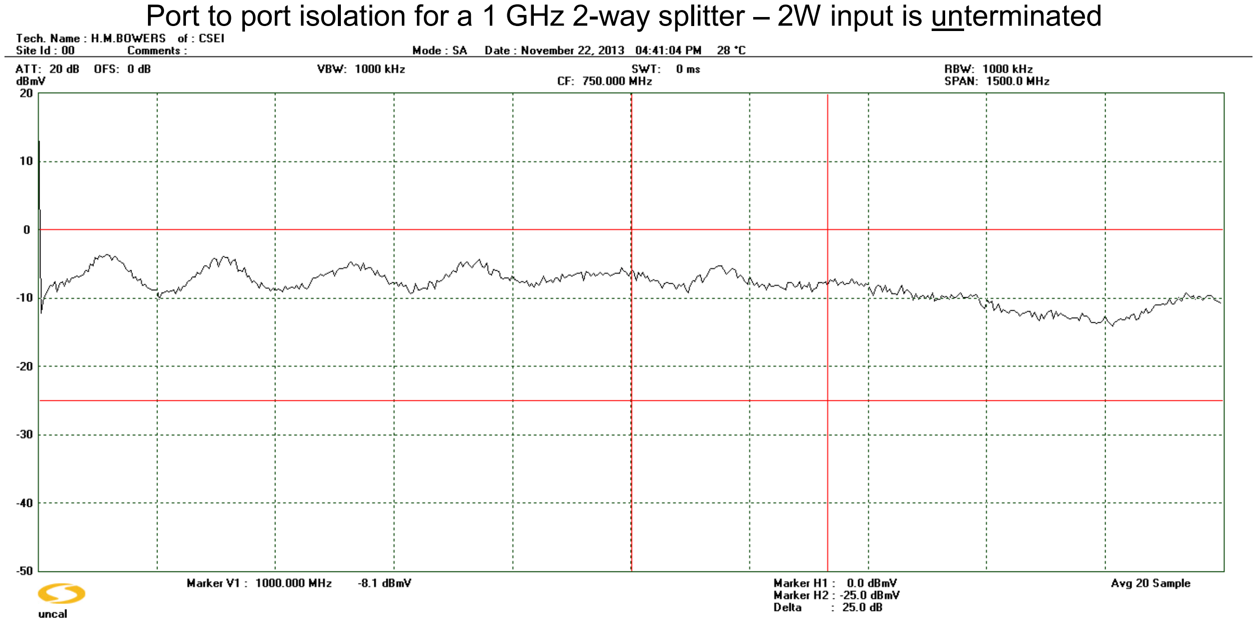
This response trace shows loss through one of the 2-way splitter legs, with the other side unterminated. Note the distinct standing waves in the throughput response. Also note that at some frequencies the ‘thru loss’ is almost 0 dB, while at others it is at 6 dB, due to signal reflections from the unterminated leg and poor isolation between ports.

Port to port isolation for a 1 GHz 2-way splitter – input port Terminated



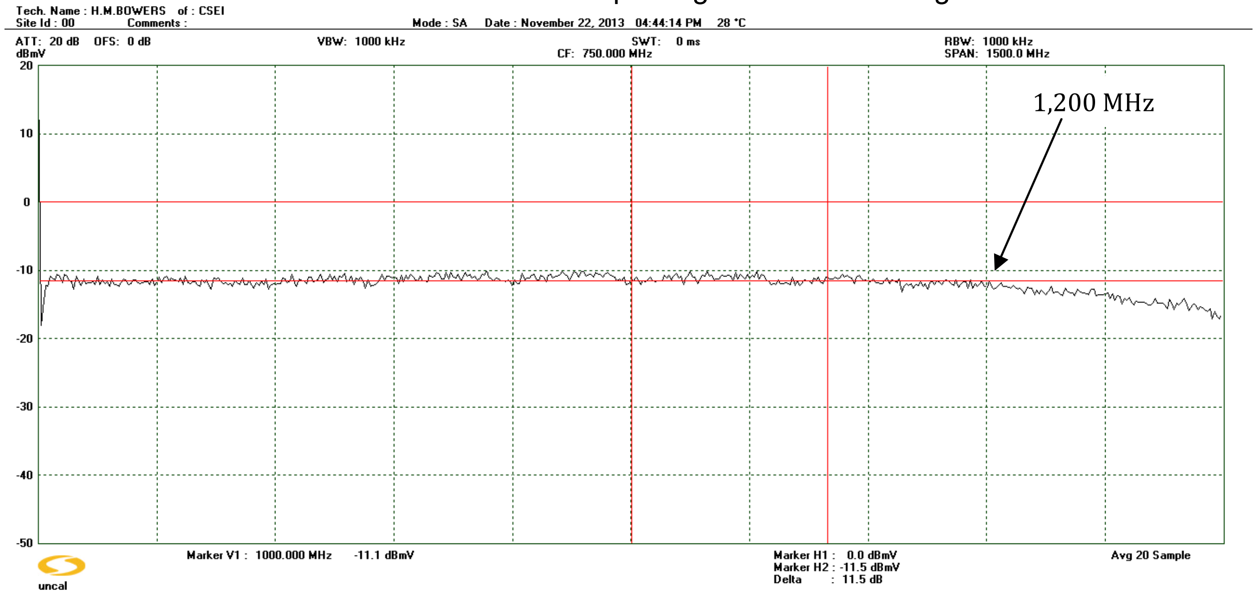
The worst-case (poorest) port-to-port isolation below 1 GHz occurs from approx. 600 to 750 MHz and is 25 dB. The splitter input is properly terminated.

Port to port isolation for a 1 GHz 2-way splitter – 2W input is <u>un</u>terminated



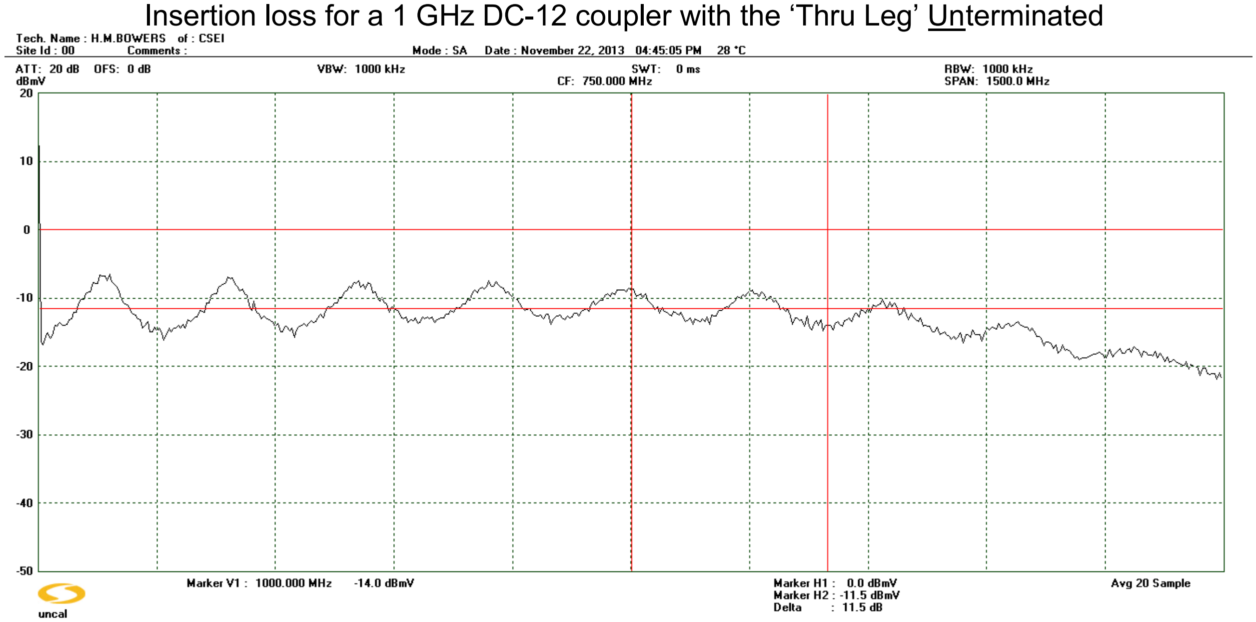
With the splitter input unterminated, one can again see distinct standing waves in the response, with port-to-port isolation varying from a worst case of approx. 4 dB to a best case of approx. 9 dB. This illustrates the need for proper impedance ('Z') matching on the input (actually, all legs) of a splitter used in a downstream or upstream combining network. This is why a well designed upstream downstream combining network will always include distributed, strategically placed low value in-line pads, as they ensure a proper 75 ohm impedance is maintained through the network, with much greater isolation values achieved!

Insertion loss for a 1 GHz DC-12 coupler leg with the ‘Thru Leg’ Terminated



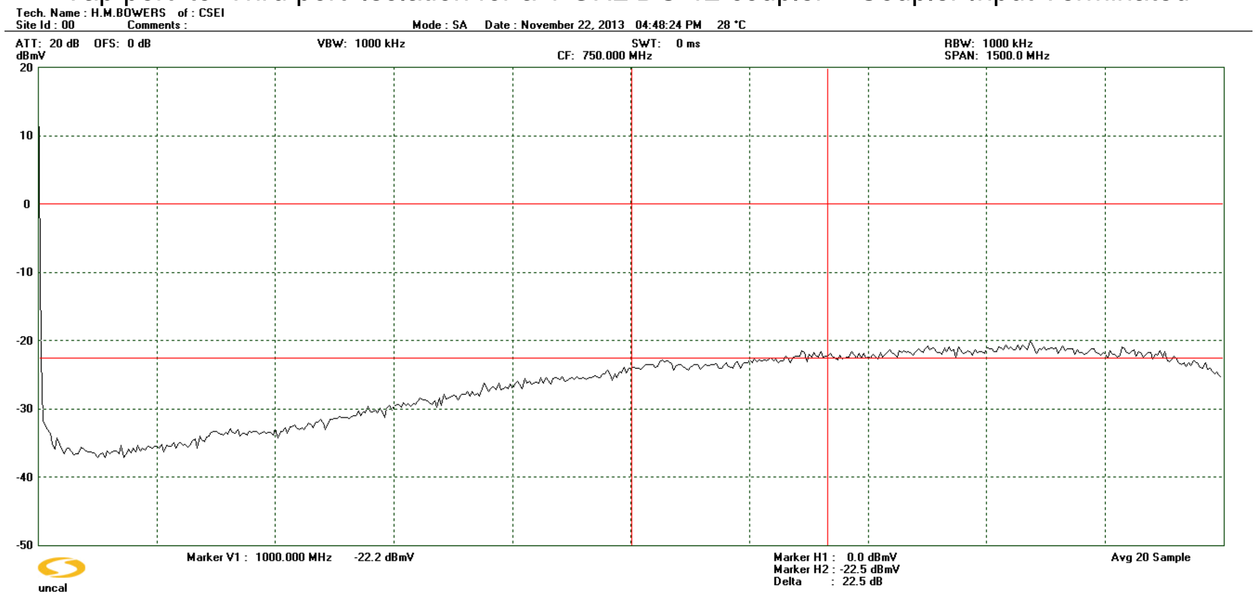
The insertion loss at 1 GHz is 11.5 dB on the tap leg. The tap leg response is flat to 1.2 GHz!

Insertion loss for a 1 GHz DC-12 coupler with the ‘Thru Leg’ Unterminated



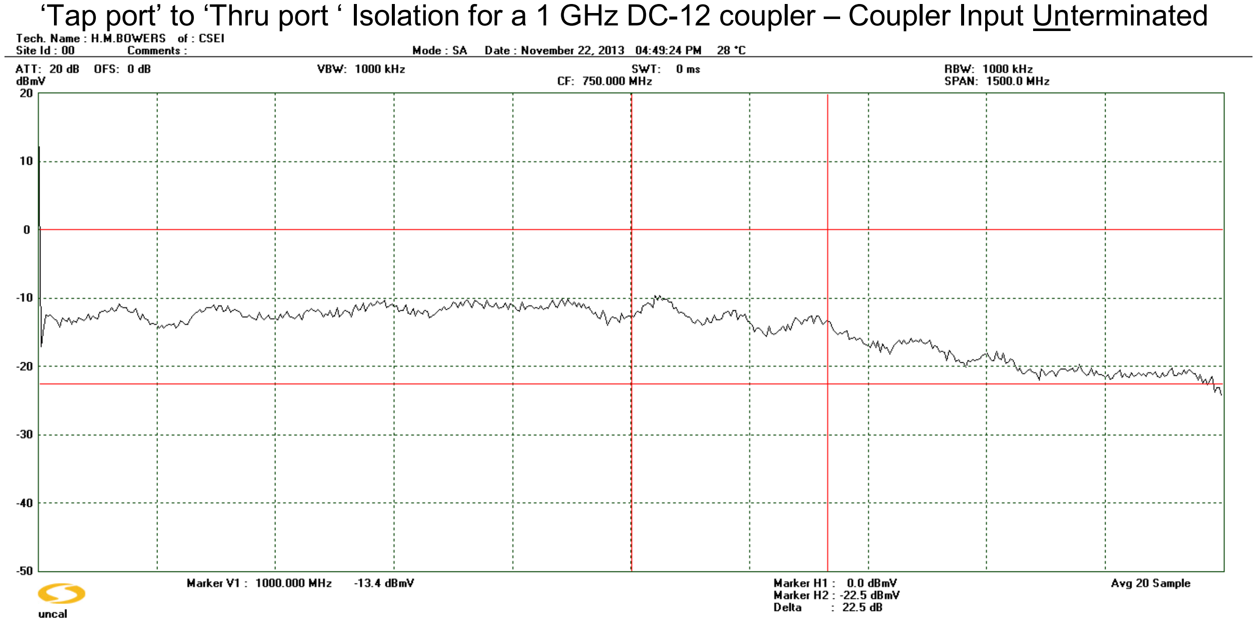
Again, large response variations and a distinct standing wave pattern are seen in the tap leg feed when the thru-leg has a poor impedance match.

‘Tap port’ to ‘Thru port’ Isolation for a 1 GHz DC-12 coupler – Coupler Input Terminated



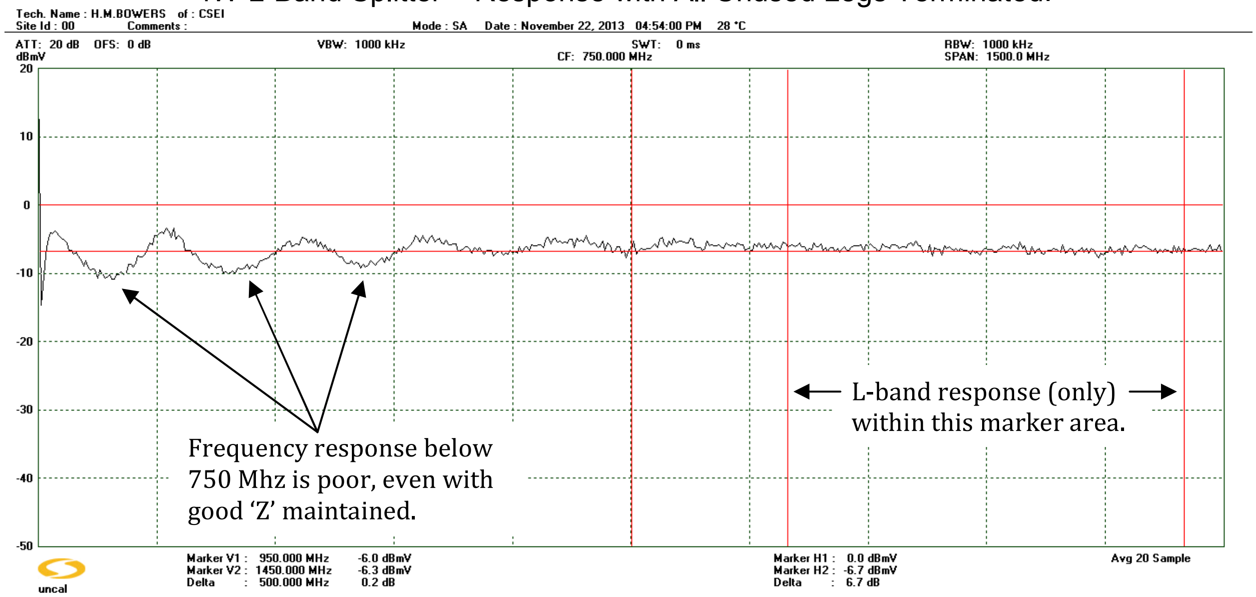
Tap to output port isolation varies from approx. 23 dB (at 1 GHz) to 36 dB (at 75 MHz) depending on the frequency measured. This is similar to, but considered an improvement over, the isolation measured on the 2-way splitter.

‘Tap port’ to ‘Thru port ‘ Isolation for a 1 GHz DC-12 coupler – Coupler Input <u>Un</u>terminated



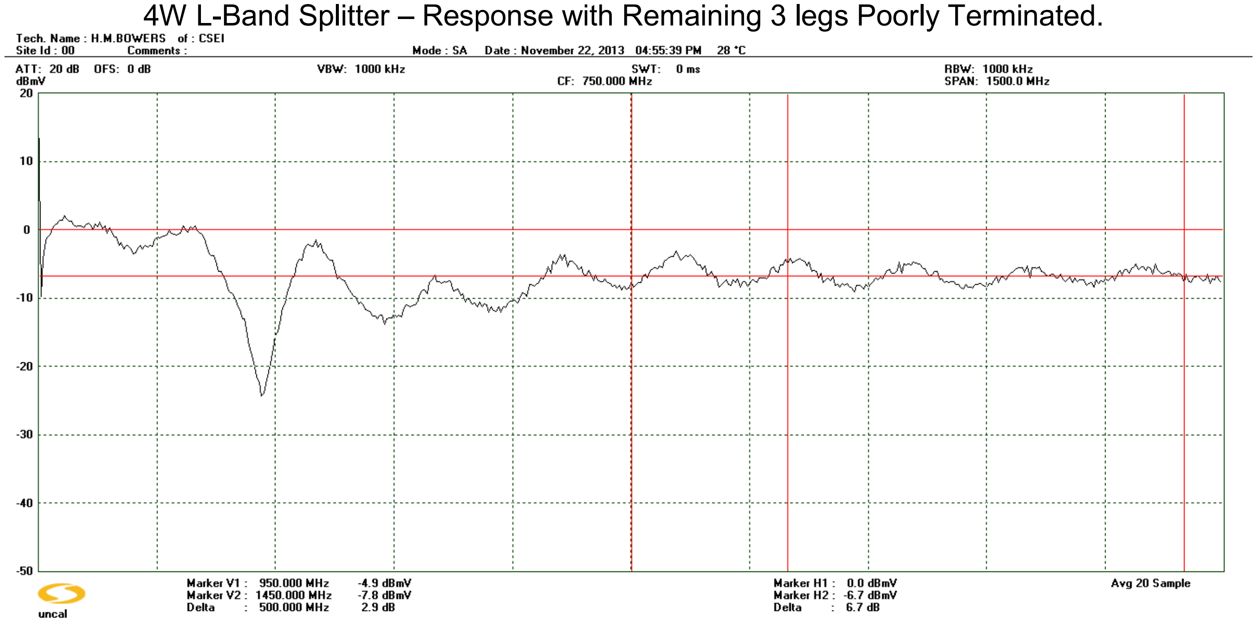
Isolation between the tap port and thru port with the input un-terminated is poor, but considered an improvement over the 2-way splitter under similar poor impedance match conditions. This illustrates why directional couplers offer improved isolation performance as compared to splitters when used in ‘combining networks’.

4W L-Band Splitter – Response with All Unused Legs Terminated.



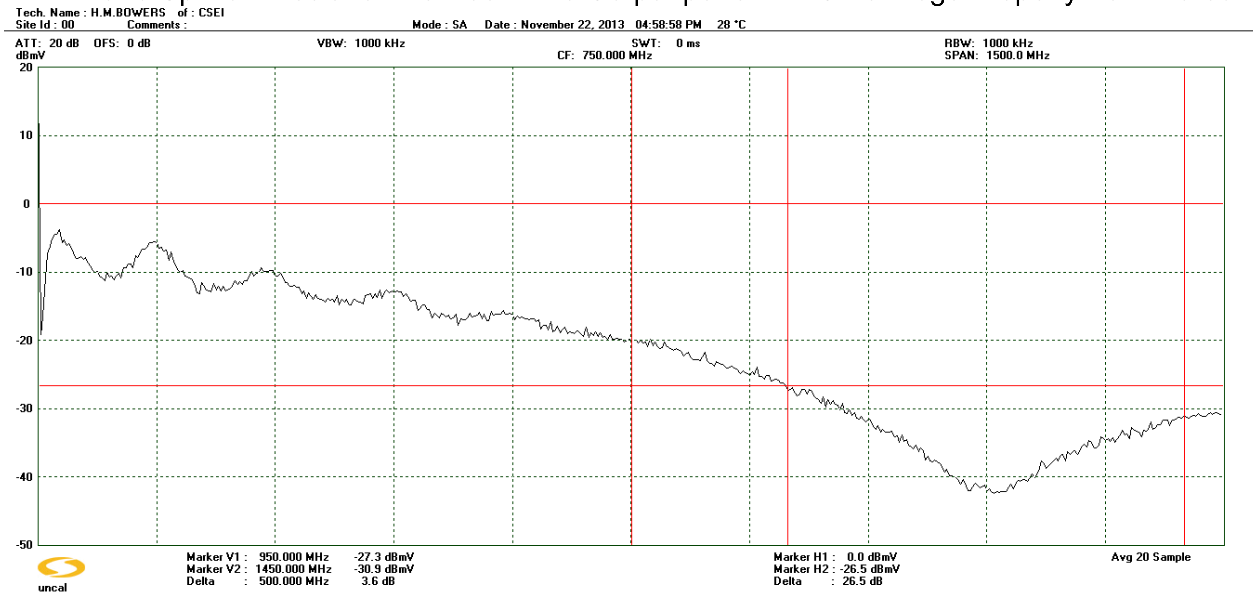
Actual 950 to 1450 MHz response is between two red vertical markers, with insertion loss at 6.7 dB.

4W L-Band Splitter – Response with Remaining 3 legs Poorly Terminated.



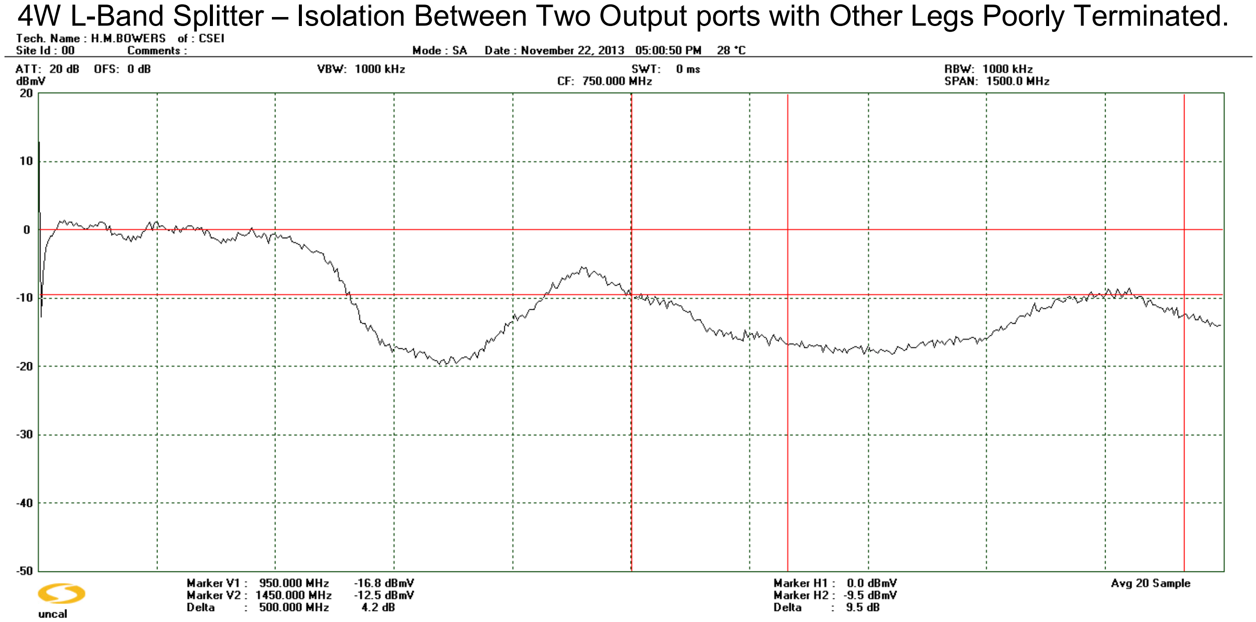
The L-band splitter is not as badly affected by poor termination on the remaining legs *in the 950 to 1450 MHz range*; however peak/valley response variation is still 3 to 5 dB.

4W L-Band Splitter – Isolation Between Two Output ports with Other Legs Properly Terminated.



Between 950 to 1450 MHz, port to port isolation varies from 27 dB (950 MHz) to approx. 42 dB (approx. 1,200 MHz) depending on the frequency of measurement.

4W L-Band Splitter – Isolation Between Two Output ports with Other Legs Poorly Terminated.



Port-to-port isolation varies from approx. 10 dB to 17 dB in the band of interest; however it can be seen that isolation at other frequencies is very poor, with the isolation at essentially zero dB from 0 to 300 MHz!

Finally, be sure to download and review the ‘Scalar Measurements ZIP file’ (first download choice) for comparison between the accuracy of these measurements as compared to the more accurate method that employs an internal tracking generator!