



## Comparison of Vector Network Analyzer and TDA Systems IConnect® Generated S-Parameters

### Purpose:

This technical note presents single-ended insertion loss (SE IL) and return loss (SE RL) data generated from two different methods: 1) vector network analyzer (VNA), and 2) TDA Systems IConnect®. The purpose of this note is to validate the use of the IConnect® software in generating these parameters as an alternative to the more widely accepted VNA generated data.

### Introduction:

It is well-known that the VNA is the accepted “standard” frequency domain instrument used to determine the IL and RL of various devices. Its calibration techniques lend itself well to the measurement of insert able devices. De-embedding techniques can be used to determine the insertion loss of non-insert able devices. Measuring RL on non-insert able devices remains problematic. With selection of the proper reference measurements, IConnect® can theoretically “gate out”, or de-embed, fixturing contributions. This issue along with the high cost of a VNA, especially for differential measurements, has lead to investigating TDA Systems IConnect® as a viable option for obtaining frequency domain data.

The IConnect® software operates on time domain measurements acquired from an oscilloscope with time domain reflectometry (TDR) and time domain transmission (TDT) capability. Once the necessary measurements are made, the IConnect® calculates the IL and RL from these measurements. Near and far end crosstalk can also be similarly measured in the time domain and calculated in the frequency domain, but is beyond the scope of this document. Only single-ended measurements were performed. The processing of differential data is as simple as the single-ended data in IConnect®, except that four channels are necessary. The same theory applies. At the time of this writing, a differential VNA was not available for comparative data.

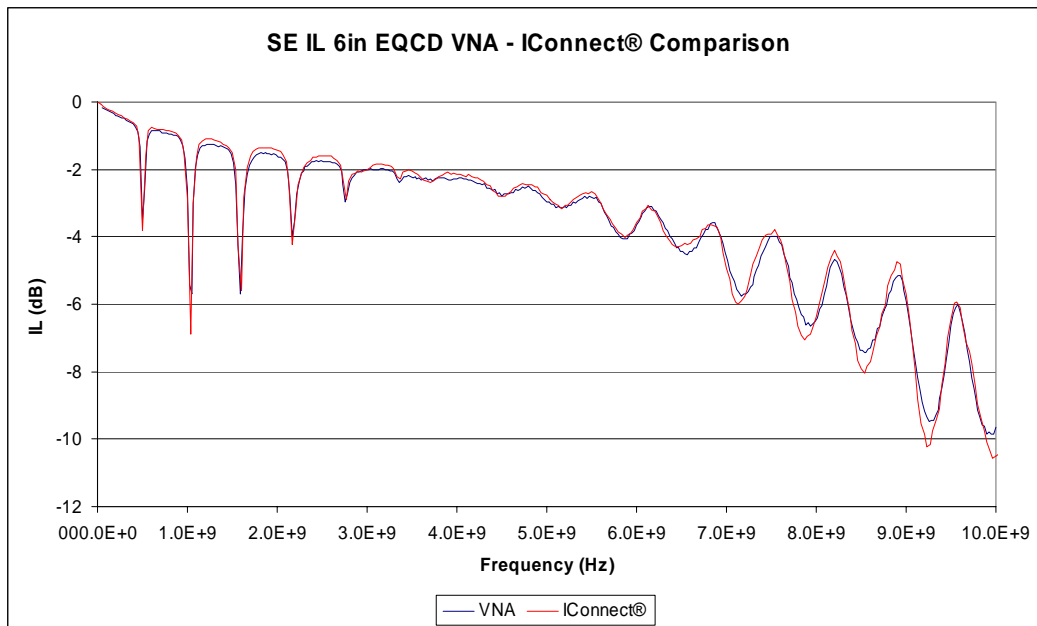
In this comparison, the device under test (DUT) consisted of two Samtec EQCD Series cable assemblies of 6 inches and 1 meter in length. Refer to Figure 1 on page 4. Cable assemblies were chosen because of the combined effects of reflective connectors separated by lossy cable. One measurement of each type was made on the same line of each cable assembly. A more descriptive test procedure is found in the test procedure section on page 4.



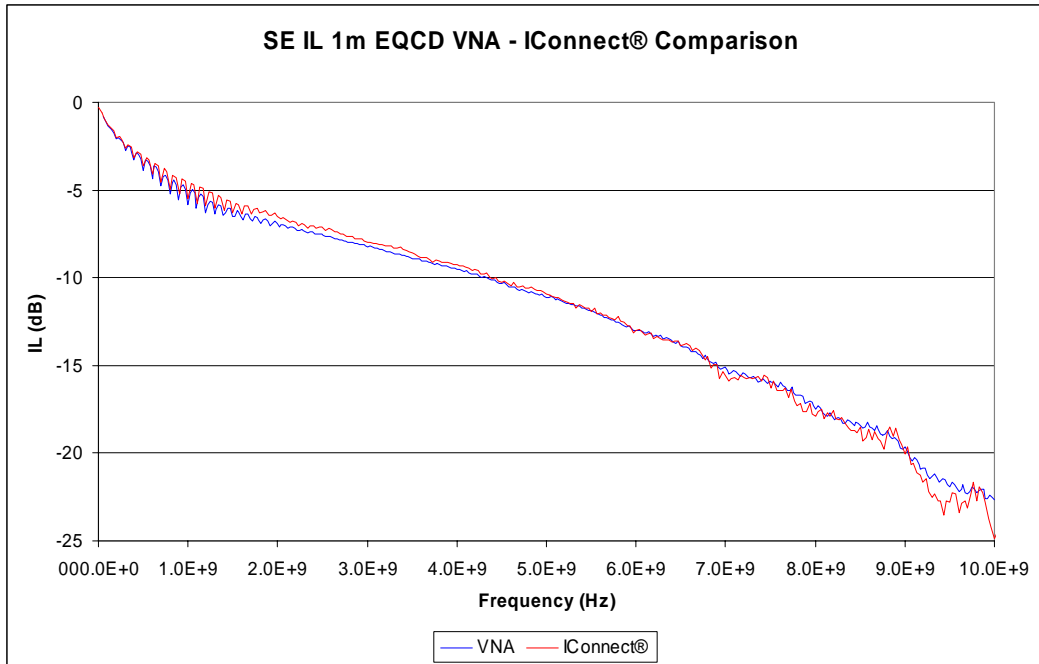
**Results:**

Insertion loss

Plots 1 and 2 show the insertion loss measured by each method on the 6 inch and 1 meter cable assemblies, respectively. The results show the two methods are highly comparable. Pay particular attention to the alignment of the peaks and valleys caused by reflections of the connectors at low frequencies and resonances at high frequencies. For example, observation of the magnitude in Plot 1 at 1.27GHz shows a magnitude difference of 0.16dB. This is within the expected accuracy of the VNA. At the time of this writing, IConnect® accuracies were not known. Differences in the resonance magnitudes can be caused by the VNA IF bandwidth or data point location.



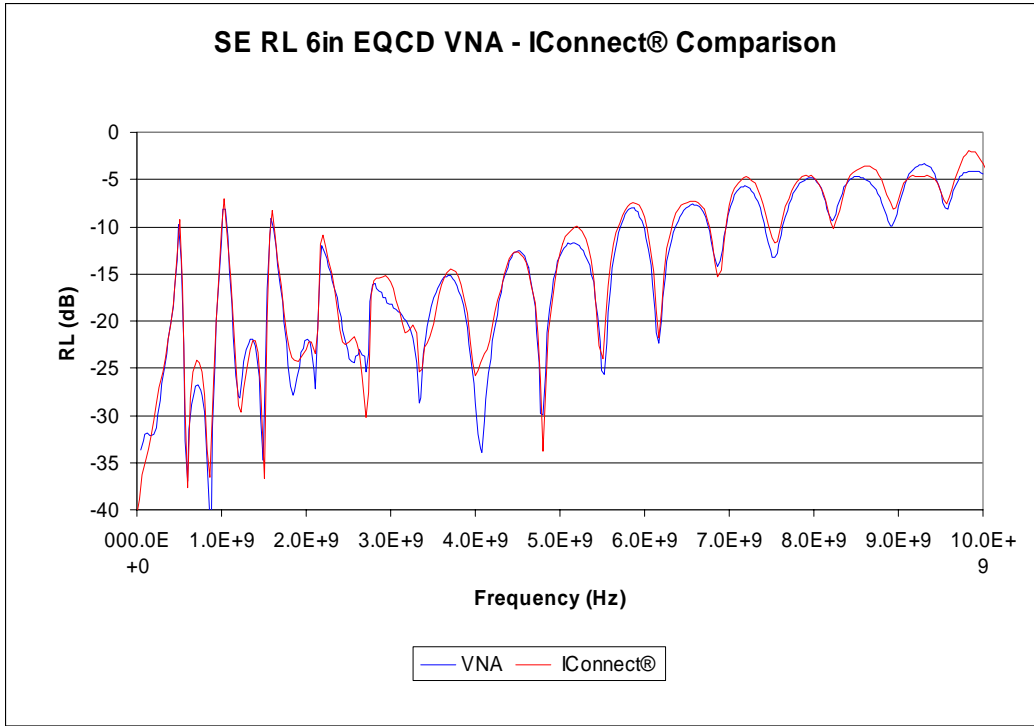
**Plot 1: VNA and IConnect® generated Single Ended IL for 6in EQCD Cable Assembly.**



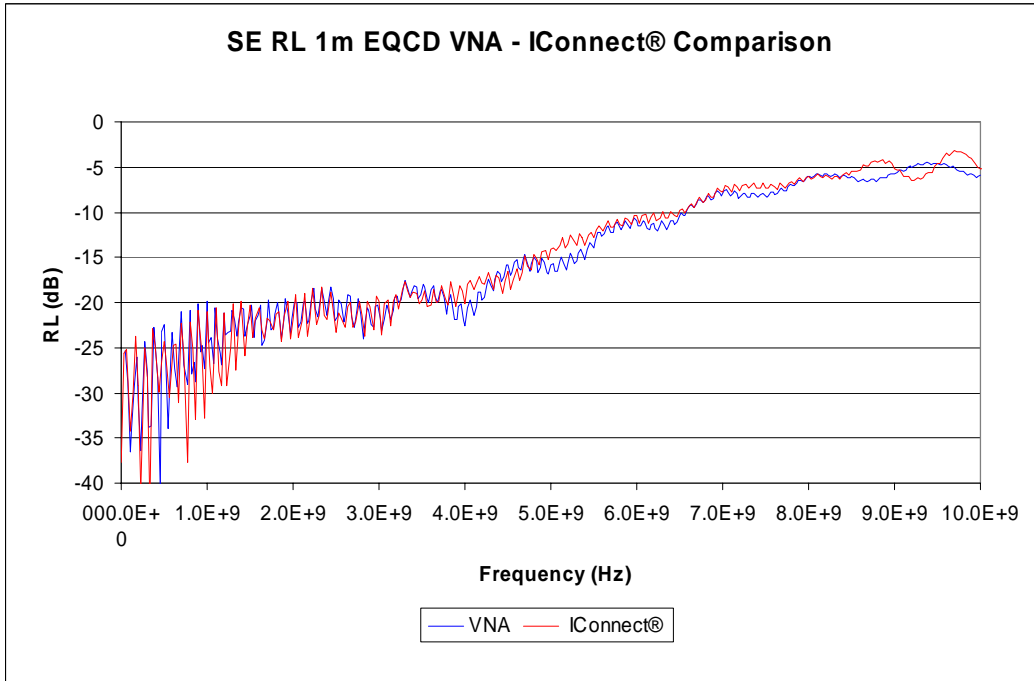
**Plot 2: VNA and IConnect® generated Single Ended IL for 1m EQCD Cable Assembly.**

Return Loss

The return loss also matched well. Slight differences were expected due to the inability of the VNA to achieve a precise calibration or reference measurement at the DUT insertion point. It can be argued that the TDA method is a more accurate method in this case due to the fact that a better reference can be obtained. Although the use of time-domain gating option in a VNA would be a better comparison, this option was not available.

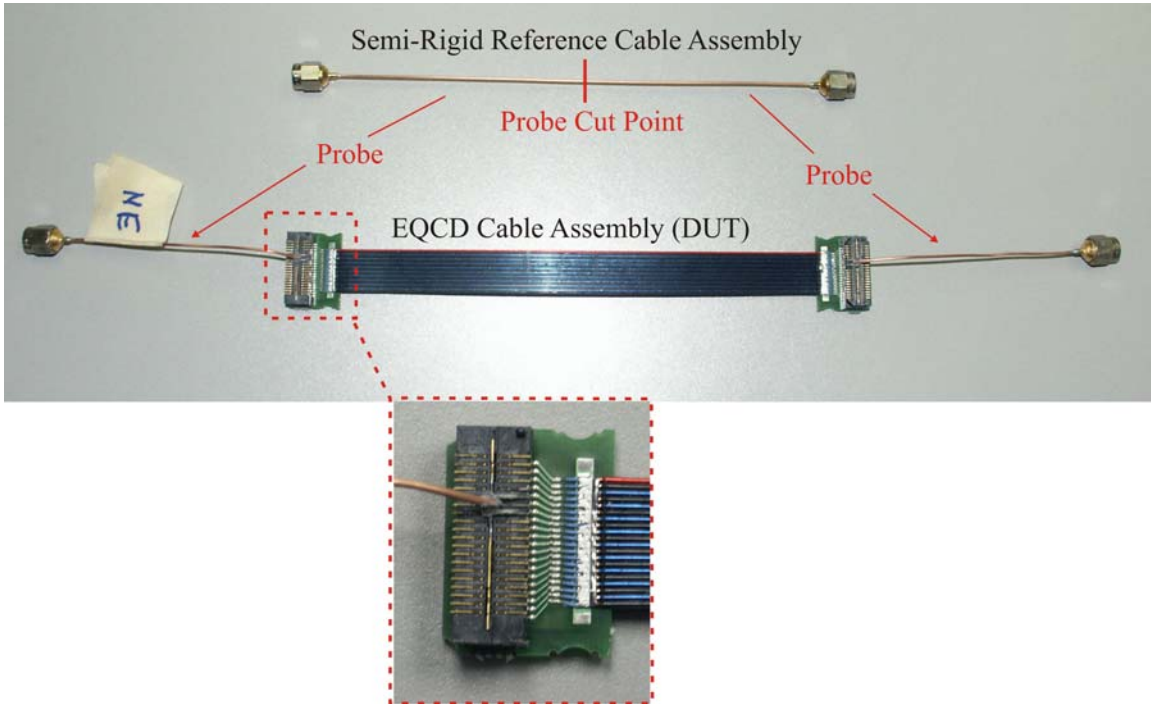


Plot 3: VNA and IConnect® generated Single Ended RL for 6in EQCD Cable Assembly.



Plot 4: VNA and IConnect® generated Single Ended RL for 1m EQCD Cable Assembly.

**Test Procedures:**



**Figure 1: Reference and fixtured 6 in EQCD cable assemblies.**

VNA

- 1) The VNA was set up with the following parameters:

$f_{\text{start}} = 50\text{MHz}$	Number of Points = 401
$f_{\text{stop}} = 10\text{GHz}$	IF Bandwidth = 3KHz

- 2) A full 2-port 3.5mm calibration was performed on the VNA at the end of two 3.5mm test cables using an HP 85052B calibration kit.
- 3) The insertion loss of a 0.032" semi-rigid cable assembly terminated with SMA's was then measured and stored. Refer to the top of Figure 1 above (note: at this point, a thru reference measurement was taken and stored on the same semi-rigid cable assembly in the time domain).
- 4) The semi-rigid cable assembly was cut in half. On each end of the cut cable assembly probes were made by removing 1mm of the outer conductor and dielectric. This resulted in two probes with 1mm probe tips. (Note: At this point, an open reference measurement in the time domain was made on one probe and stored).
- 5) Small copper plates were machined which grounded the center blade and two connector pins adjacent to a signal pin on the connectors that will mate to each end of the cable assembly. The probes were then soldered to complete the fixturing. Refer to Figure 1 above.



- 6) The fixtured connectors were mated with the cable assembly and the SMA probes were attached to the reference plane at the end of the 3.5mm test cables.
- 7) Return loss ( $S_{11}$ ) was measured across the sweep band and stored. Note that the far end was terminated at  $50\Omega$  into port 2 of the VNA.
- 8) Insertion loss ( $S_{21}$ ) of the SMA probes, fixturing, and DUT was measured and stored.
- 9) The insertion loss of the DUT was taken by scalar subtraction of the magnitude obtained in Procedure 3 from the magnitude obtained in Procedure 8.

TDA IConnect®

- 1) The Tektronix CSA 8000 was set up with the following parameters:

Record Length = 4000

$t_{base} = 3\text{ns/division}$

These settings allowed for 301 points from 0Hz to 10GHz with a frequency step of 3.33MHz.

- 2) The 0.032” semi-rigid cable assembly terminated with SMA’s was attached to channel 1 and 4 of the TDR.
- 3) With the pulser of channel 1 on a thru reference was measured through the semi-rigid cable assembly was measured and stored as a thru reference via the IConnect® software. (Note: at this point, a thru reference was also made on the VNA in the frequency domain).
- 4) The semi-rigid cable assembly was cut in half. On each end of the cut cable assembly probes were made by removing 1mm of the outer conductor and dielectric. This resulted in two probes with 1mm probe tips.
- 5) One of the probes was attached to channel 1 of the oscilloscope.
- 6) With the pulser of channel 1 on the open reflection was measured at the probe tip and stored via the IConnect® software.
- 7) Small copper plates were machined which grounded the center blade and two connector pins adjacent to a signal pin on the connectors that will mate to each end of the cable assembly. The probes were then soldered to complete the fixturing. Refer to Figure 1 on the previous page.
- 8) The fixtured connectors were mated with the cable assembly and the SMA probes were attached to channels 1 and 4 of the oscilloscope.
- 9) The pulser of channel 1 was turned on.
- 10) A terminated reflection of the of the SMA probes, fixturing, and DUT was measured and stored via the IConnect® software. The termination was provided from channel 4.
- 11) A transmission measurement was made thru the SMA probes, fixturing, and DUT on channel 4 and stored via the IConnect® software.
- 12) Return loss was calculated in IConnect® with the open reflection measurement (Procedure 6) used as the Step and the terminated reflection measurement (Procedure 10) as the DUT.
- 13) Insertion loss was calculated in IConnect® with the thru reference measurement (Procedure 3) as the Step and the thru transmission measurement (Procedure 11) as the DUT.



**Equipment:**

- 1-Hewlett-Packard 8720ES Vector Network Analyzer
- 1-Tektronix CSA 8000 Communications Signal Analyzer
- 2-Tektronix 80E04 Sampling Modules
- 1-Agilent 85052B 3.5mm Calibration Kit
- 1-TDA Systems IConnect® Software, Revision 3.0.2 MX.

**References:**

- TDA Systems IConnect® TDR Software User Manual, Version 3.0 .
- Agilent 8720ES Users Guide, Version July 2000.