Technical Note

Transformation of Samtec Connector Test Data For 85 ohm Differential Impedance Applications

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1.0 Purpose

This paper describes the approach Samtec has taken to transform a measured connector response acquired in a 100 ohm differential measurement system to an 85 ohm measurement system. The purpose is to show how Samtec products will operate in an 85 ohm system.

2.0 Background

The industry has seen a recent emergence of high speed data transmission protocols based on non-traditional system impedances. For example, systems operating in an 85 Ohm differential impedance environment with single-lane bandwidths to 10 GHz and beyond are in development. Also, high definition video transmission standards based on 75 Ohm single-ended systems with 6 GHz bandwidths are already in place.

The move from typical system impedances can lead to measurement and simulation challenges. The majority of high speed, RF, and microwave test instrumentation operates in a 50 Ohm single-ended or 100 Ohm differential environment. Some 75 Ohm single-ended instrumentation is available, but is typically limited to lower bandwidths.

Dedicated systems for characterizing 85 Ohm differential components are currently non-existent. Test methods using standard instruments with custom calibration standards are possible, but not yet straight forward, and will suffer from traceability issues for the foreseeable future. Therefore, characterization of component and channel properties for such emerging systems is not yet a push-button affair.

Fortunately, existing 50 Ohm instrumentation and calibration standards can be employed in conjunction with data post processing routines to adequately characterize components for these emerging systems.

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3.0 Reference Impedance and S-parameters

Generally, it is not difficult to mathematically transform the data from one reference measurement to another. An approach to reference impedance transformation of an S-Parameter matrix is described in [3] which can be applied to ports with differing impedances.

Assume a scattering matrix S with reference impedance of Aii. To compute S' with reference impedance of Bii, the following equation can be used:

$$S' = P^{-1}(S-\gamma)(I-\lambda S)^{-1}P \quad \text{where}$$

$$P_{ii} = \sqrt{\frac{\mathrm{Re}(A_{ii})}{\mathrm{Re}(B_{ii})}\left|\frac{B_{ii}}{A_{ii}}\right|}\frac{2A_{ii}}{A_{ii}+B_{ii}}, \qquad \gamma_{ii} = \frac{B_{ii}-A_{ii}}{B_{ii}+A_{ii}}$$

If we make the assumption that all port impedances are real and the same value the transformation simplifies to a renormalization of the Z-Parameters. The S-Parameter matrix is converted to Z-Parameters then renormalized and converted back to an S-Parameter matrix as shown in [3]. Such transforms can be programmed into a spreadsheet or similar calculator for post processing VNA data. Many RF and SI circuit simulators perform this function automatically.

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4.0 Samtec Connector Data

Samtec maintains a data base of measured connector performance and we will use this existing data as a starting point. We will illustrate the transformation process using data acquired for our RU8 product http://www.samtec.com/technical_specifications/overview.aspx?series=RU8. The data was acquired using a Tektronix DSA 8200 Sampling Oscilloscope and the reference impedance is 100 ohm differential and 50 ohm single ended. We will only use the data from the 100 ohm differential measurements; however the process can also work with the 50 ohm single data. Figure 1 shows a picture of the RU8 connector.

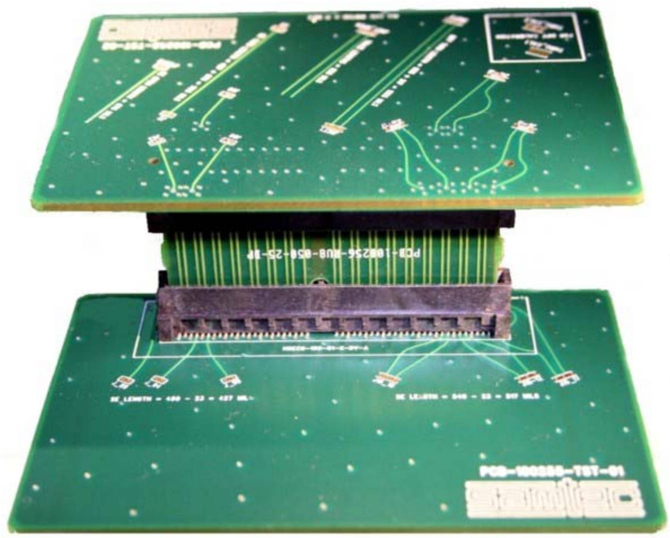

Figure 1. Samtec RU8 Connector

5.0 Data Processing

The data processing involves 2 steps: exporting the insertion loss and return loss data from Tektronix IConnect and post processing the data within Agilent ADS.

5.1 IConnect

IConnect will compute the differential insertion loss using a transmission measurement and a reference waveform. The transmission measurement includes the instrument cabling, microprobe connection to the test board, the test board and connector. The reference plane for the resulting S-parameter is determined by the choice of reference measurement. For the Samtec connector data the reference measurement includes the instrument cabling and the microprobe connection to the test board. The resulting S-parameter (Sdd21) includes the connector, the break out region (BOR) and a short section trace. The probe and test cable effects are de-embedded from the measurement.

A similar method is used to capture Sdd11. The designation "dd" means differential and we only capture the differential response. Note that only Sdd11 is acquired using the existing data, Sdd22 is not available. To create a valid differential touchstone file Sdd22 is required and here we make the assumption that Sdd11=Sdd22. For this reason it is not recommended that the resultant touchstone file be used in simulations. SPICE models are available from the Samtec for simulation purposes and these models are valid for any reference impedance.

Figure 1 below shows an IConnect screen capture of Sdd11 and Sdd21.

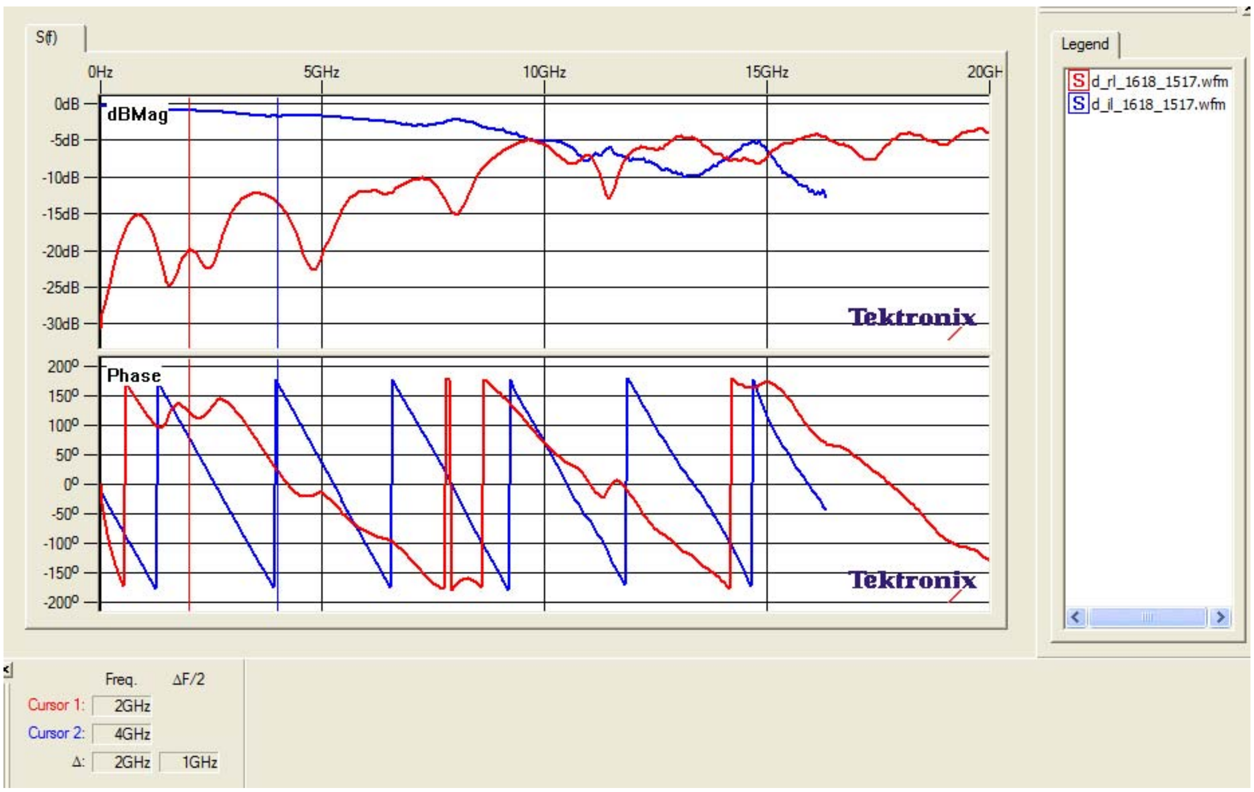

Figure 2. IConnect Screen Capture of Differential Insertion Loss (blue trace) and Differential Return Loss (red trace)

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5.2 ADS

In this specific case, IConnect exports Sdd11 and Sdd21 as a 1 port touchstone file. To create a 2 port touchstone file, the data access component function is used. Here we can create a multiport Touchstone file from individual sub-matrices of the global S-parameter matrix. Care is taken is selecting the start, stop and step parameters of the S-parameter sweep to avoid errors in interpolating between data points. The S-parameter sweep is also a convenient method to truncate sub-matrices that have extended frequency spans. Figure 1 shows that Sdd21 spans 16 GHz whereas Sdd11 spans 20 GHz and this needs to be corrected in the construction of the 2 port Touchstone file.

Also, IConnect exports the 1 port touchstone files with a 50 ohm reference impedance even though Sdd11 and Sdd21 should have a 100 ohm reference impedance. This is important to realize when computing within ADS as the port termination impedance needs to be set to 50 ohms to get the correct response. Figure 2 shows a screen capture of the ADS schematic used to post process the IConnect data. To compute time domain results within ADS there are several options; here we perform a simple inverse Fourier transform using ADS built in functions.

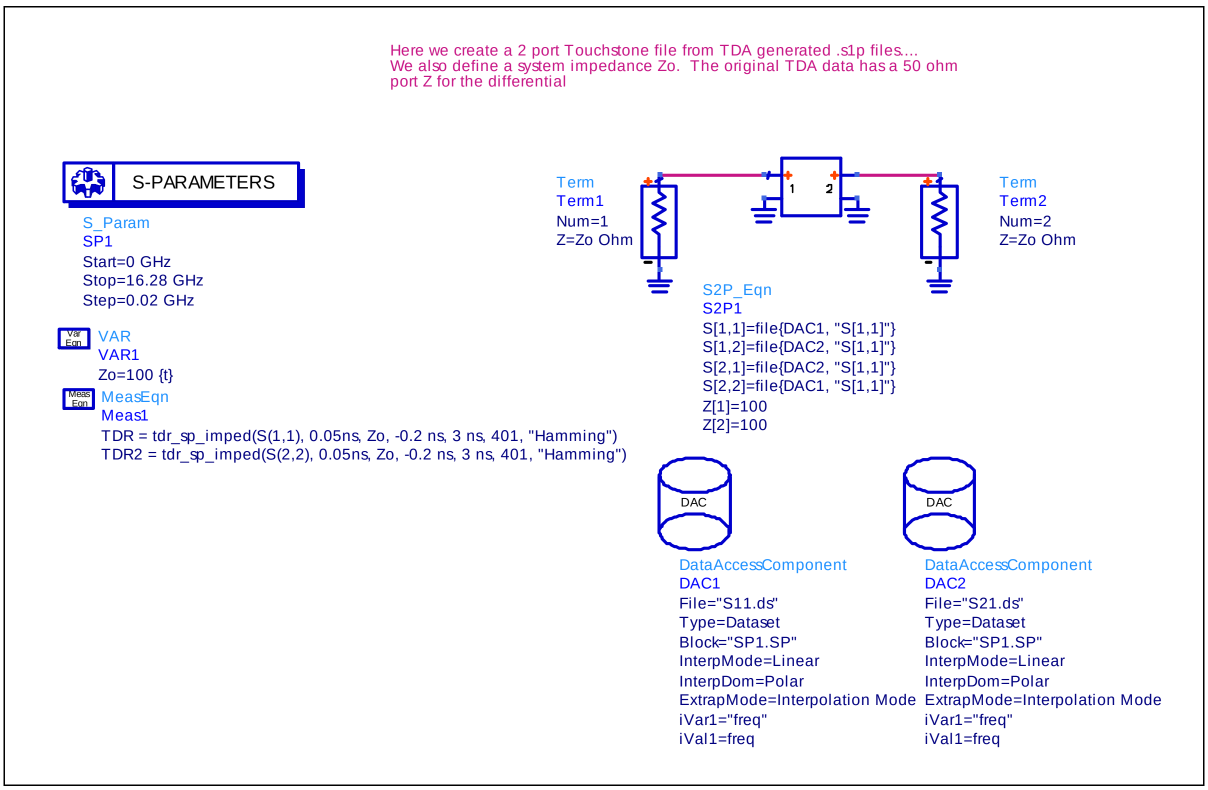

Figure 3. Screen Capture of ADS Schematic used to Post Process IConnect 1 Port Touchstone Files

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6.0 Typical Results

To illustrate the effect of connector performance in different reference impedance systems, we will plot differential return loss, differential insertion loss and the time domain impedance profile.

6.1 Differential Return Loss

Figure 3 shows the differential return loss for the RU8 connector with a 100 ohm reference impedance and with an 85 ohm reference impedance. Notice that this connector has a better match in an 85 ohm system up to approximately 1.5 GHz.

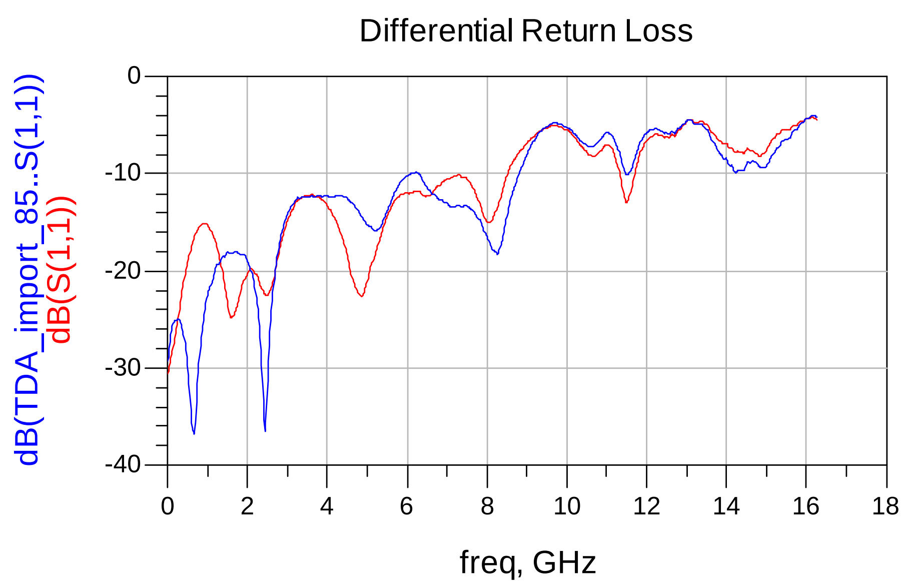

Figure 4. Differential Return Loss of Samtec RU8-150-25-DP-S-DV
Red – 100 ohm Reference Impedance, Blue – 85 ohm reference Impedance

6.2 Differential Insertion Loss

Figure 5 shows the differential insertion loss of the RU8 connector with 100 ohm reference impedance and with 85 ohm reference impedance. Notice that the difference in transmission performance is fairly minor.

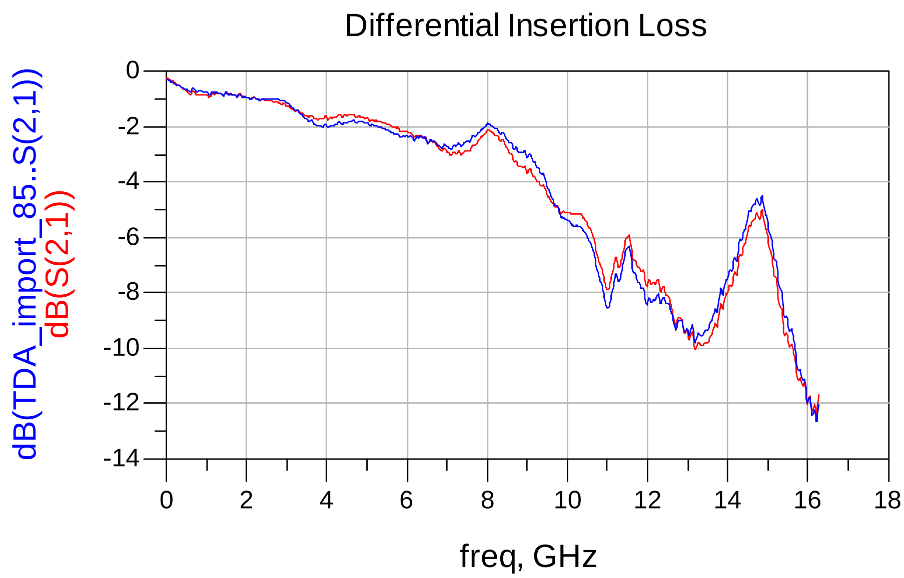

Figure 5. Differential Insertion Loss of Samtec RU8-150-25-DP-S-DV
Red – 100 ohm Reference Impedance, Blue – 85 ohm reference Impedance

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6.3 Differential Impedance Profile

Figure 6 shows the differential impedance profile of the RU8 connector with 100 ohm reference impedance and with 85 ohm reference impedance. The short length of 100 ohm test traces are visible after the 85 ohm transformation (blue trace) at about 0.15 nSec. It is important to note that the connector impedance response (between 0.15 nSec and 0.7 nSec) is not affected by the choice of the reference impedance. This is the reason that a SPICE model of the connector can be used in systems with a non-standard reference impedance such as 85 ohm differential.

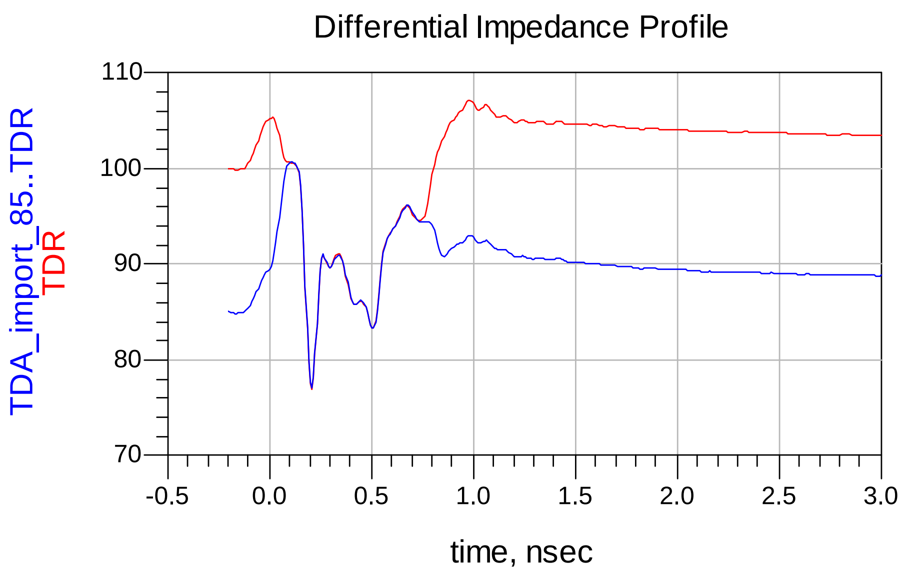

Figure 6. Differential Impedance Profile of Samtec RU8-150-25-DP-S-DV Red – 100 ohm Reference Impedance, Blue – 85 ohm reference Impedance

7.0 Conclusion

We have shown a methodology to post process existing time domain data for use in non-standard reference impedances, such as 85 ohm differential. The methodology is general and can be easily adapted to other impedances.

We also examined one specific example, an RU8 connector. For this product we showed that it is a better match to an 85 ohm system than it is for a 100 ohm system as illustrated by the improved return loss performance with an 85 ohm reference.

While we see an improvement in return loss for this specific connector, the transmission characteristics are relatively unchanged. The differential insertion loss of the connector is nearly the same with either a 100 or 85 reference impedance.

8.0 References

[1] Julian Ferry – Samtec, Jim Nadolny - Samtec, Craig Rapp – Samtec , OJ Danzy – Agilent, Mike Resso – Agilent , “Characterizing Non-Standard Impedance Channels with 50 Ohm Instruments”, presented at DesignCon, Santa Clara, CA, 2009
[2] Jan De Geest – FCI, Dana Bergey – FCI, John Lynch – Intel, Dennis Miller – Intel, Stefaan Sercu – FCI, “Improving System Performance by Reducing System Impedance to 85 Ohms”, presented at DesignCon, Santa Clara, CA, 2007
[3] The Anritsu Company, “Arbitrary Impedance” Application Note
[4] Pozar, David M “Microwave Engineering”, Addison-Wesley, 1990
[5] A. Lymer, “Improving Measurement Accuracy by Controlling Mismatch Uncertainty,” techonline.com, July 2002. [Online]. Available: http://www.techonline.com/article/printArticle.jhtml?articleID=192200507. [Accessed: Nov. 8, 2008].
[6] Agilent Technologies, Appl. Note 56, “Microwave Mismatch Uncertainty.”
[7] Agilent Technologies, Appl. Note 1287-12, “Time Domain Analysis Using a Network Analyzer. “
[8] Maxim Integrated Products, Appl. Note 2866, “Converting S-Parameters from 50W to 75W Impedance.”
[9] V. Duperron, D. Dunham, and M. Resso, “Practical Design and Implementation of Stripline TRL Calibration Fixtures for 10-Gigabit Interconnect Analysis,” presented at DesignCon, Santa Clara, CA, 2006.
[10] R. Schaefer, “Challenges and Solutions for Removing Fixture Effects in Multiport Measurements,” presented at DesignCon, Santa Clara, California, 2008.
[11] Maxim Integrated Products, Appl. Note 3250, “Characterizing the S-Parameters of 75W Circuits using 50W Lab Equipment.”
[12] Agilent Technologies, Appl. Note, “Impedance Measurement Handbook.”

9.0 Resources

Agilent E5062A 75 Ohm VNA

Agilent E8364B 10 MHz - 50 GHz PNA Series Analyzer with an N4421B 10 MHz – 50 GHz S-Parameter Test Set

Agilent Physical Layer Test System software (PLTS) Version 4.50

Agilent ADS 2008 Update 2 Advanced Design System

Tektronix IConnect and MeasureXtractor ™ 4.0.0

Tektronix DSA 8200 Sampling Oscilloscope

Samtec Final Inch® PCB reference design