Validating Controlled Impedance Differential PCB Manufacturing Process

by DVT Solutions, LLC www.gigaprobestek.com

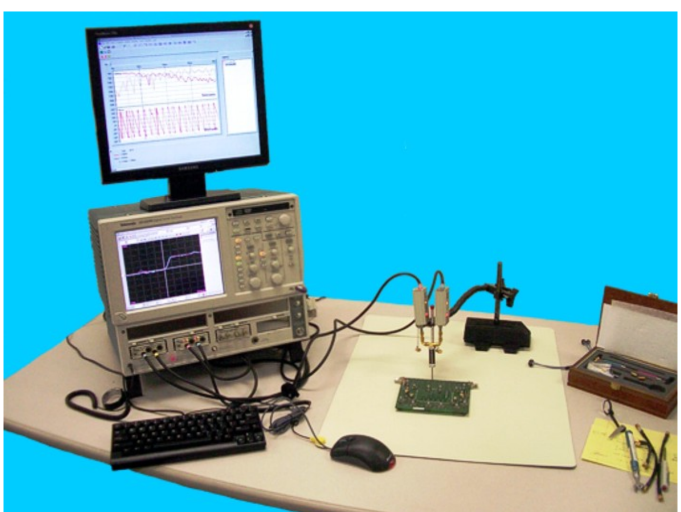
TDR Testing Objective

Research In Motion (RIM) came to DVT Solutions, LLC to validate a few 100 ohm controlled differential impedance pairs 4mm apart on the PCB that goes into their Blackberry mobile phones as a second testing source to verify the data provided from their PCB manufacture correlates and is acceptable. RIM recognizes validating high speed differential traces on their PCB's are balanced 100 ohm interconnects because it confirms the layout tools and the manufacturing processes are performing correctly. When the components are installed on the PCB the circuitry will operate properly and not delay product introduction or lead to the return of 1000's of non functioning phones, saving RIM substantial amount of money.

To validate critical differential controlled 100 ohm impedance traces are made easy using the GigaProbes®, a true odd mode balanced 100 ohm 30Ghz differential TDR probe, a Tektronix DSA8200 with a 80EO4 differential TDR sampling modules. Using faster TDR modules provide added impedance resolution to support testing high speed designs or for Failure Analysis applications. The accessories that come with the GigaProbes® DVT30-1MM-1 include adapters for attaching the probe to a manipulator for hands free probing to free the operator to control the TDR instrument. Two 24Ghz SMA Cables are included to connect the probes to the TDR modules and more.

In this test case, we measure two differential 100 ohm test points and describe it physical layout and determine if the max/min impedance is within +/- 10percent or it is determined this PCB is out of specification the circuit design would not operate correctly. We also show by changing the TDR rise time it has an effect on the impedance measurements. We also list of all equipment used to make these measurements in case you want to reproduce these tests.

TDR Instrument



The DSA 8200/8E04 20GHz TDR sampling system with the uses IConnect® Signal Integrity Software created accurate Impedance measurements for PCB analysis. http://www.tek.com/applications/serial_data/interconnect.html

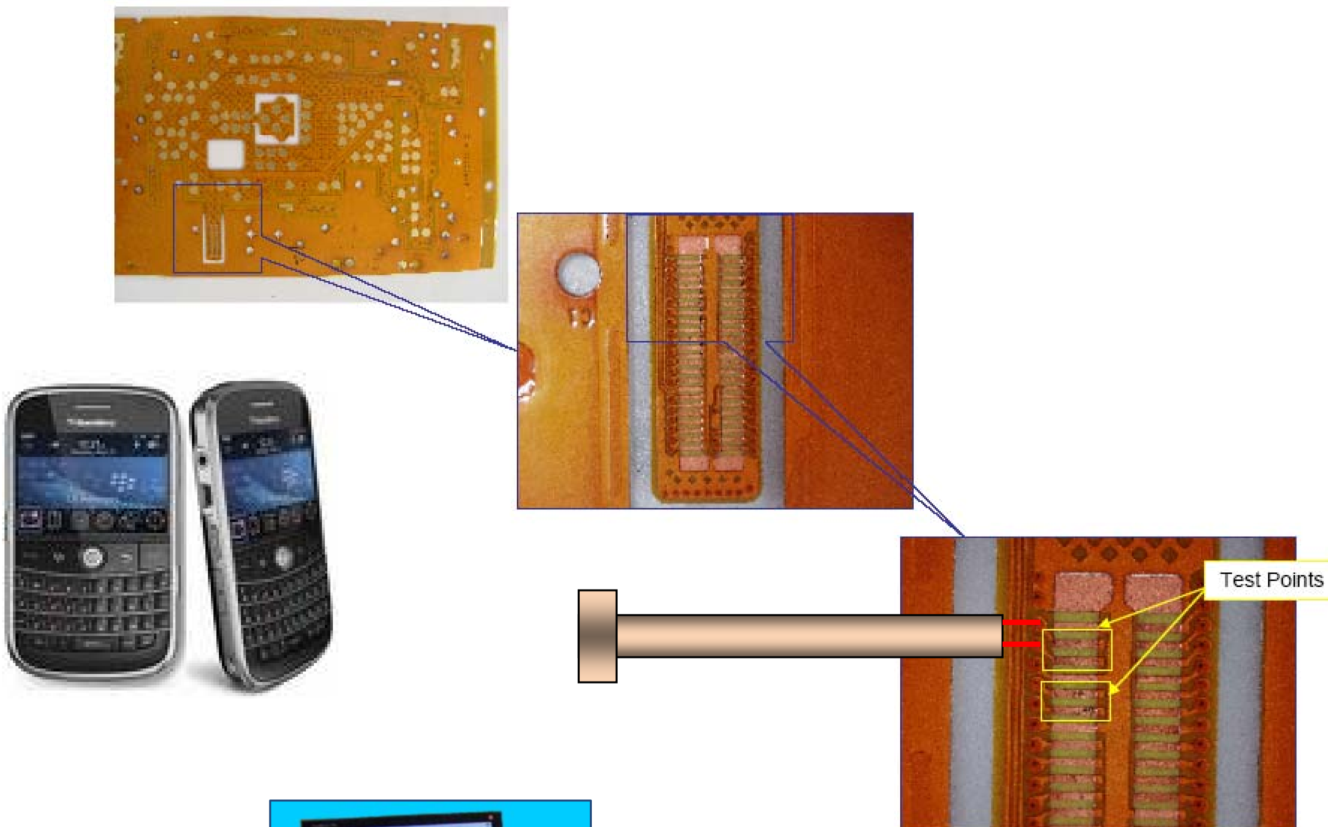
Differential TDR Probes

Connect the DVT30-1MM GigaProbes® to the DSA 8200 Tektronix TDR system for Differential and Single Ended 30 GHz for validating PCB design and manufacturing specifications on critical interconnect test paths. www.gigaprobestek.com

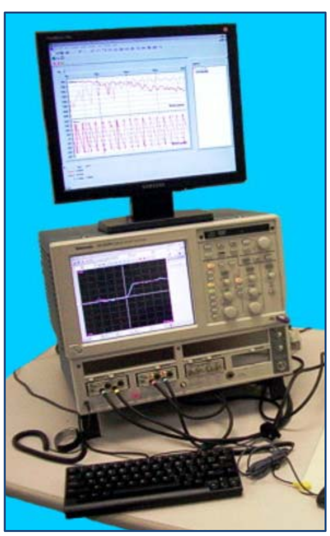
Test Equipment Configuration

The GigaProbes® were installed in probe holder manipulator using the GigaProbeMicroManipulator (GPMMA) accessory for hand free probing. a sampling head extender cable connected the 80E04 TDR sampling head to the Tektronix DSA 8200 mainframe. The cable moved the TDR module closer to the PCB so we could use two 12" 25 GHz ultra-flex cables to connect the GigaProbes® to the TDR sampling head. Once the odd mode differential measurements were acquired, the waveforms are transferred to the Tektronix IConnect® software and converted into impedance waveforms for accurate impedance vs. time or distance graphs.

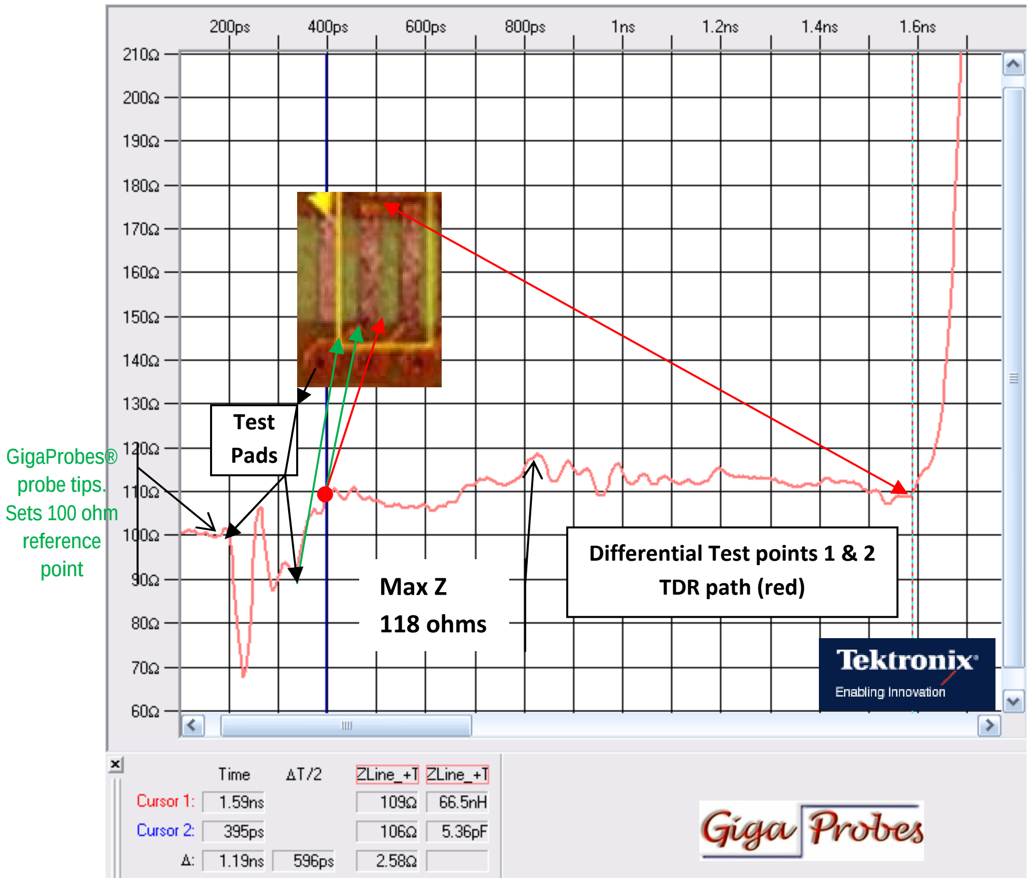
Below is the RIM Blackberry PCB identifying the locations of the two differential 100 ohm impedance test points for differential impedance verification. The pad pitch are 400u (15.7mils) with an impedance specification of 100 ohm +/- 10%.

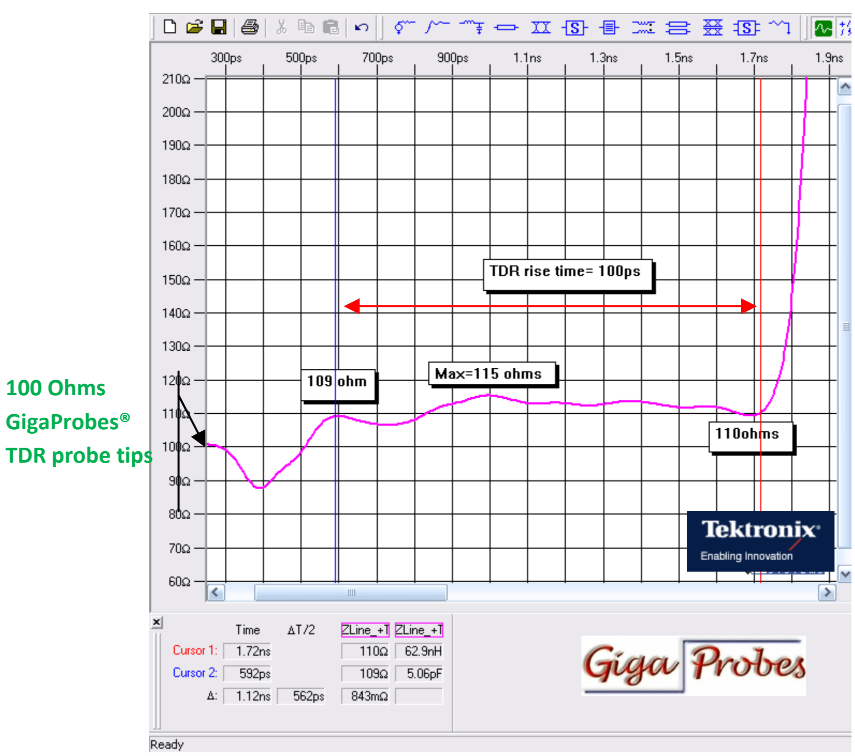


(Right) Tektronix DSA 8200 with 80E04 20GHz TDR modules. IConnect® SI software is resident on the DSA8200 operating system and displaying the test results on a separate flat panel. The test results can be stored on the scope or network.



(Left) GigaProbes® probing Blackberry PCB 100 ohm differential 400u test pads





Measurements for Differential Test Points 1 & 2

TDR rise time measured *<u>at the probe tip</u>*= 35ps

TDR SETUP: 20 GHz TDR sampling input, 200ps/Div, 5000 point record length with each measurement containing 128 averages.

TDR Probe: 30 GHz GigaProbes® (www.gigaprobestek.com) 100 ohm true odd mode differential probe. Probe pitch was set to measure .4mm or 400 micron pitch

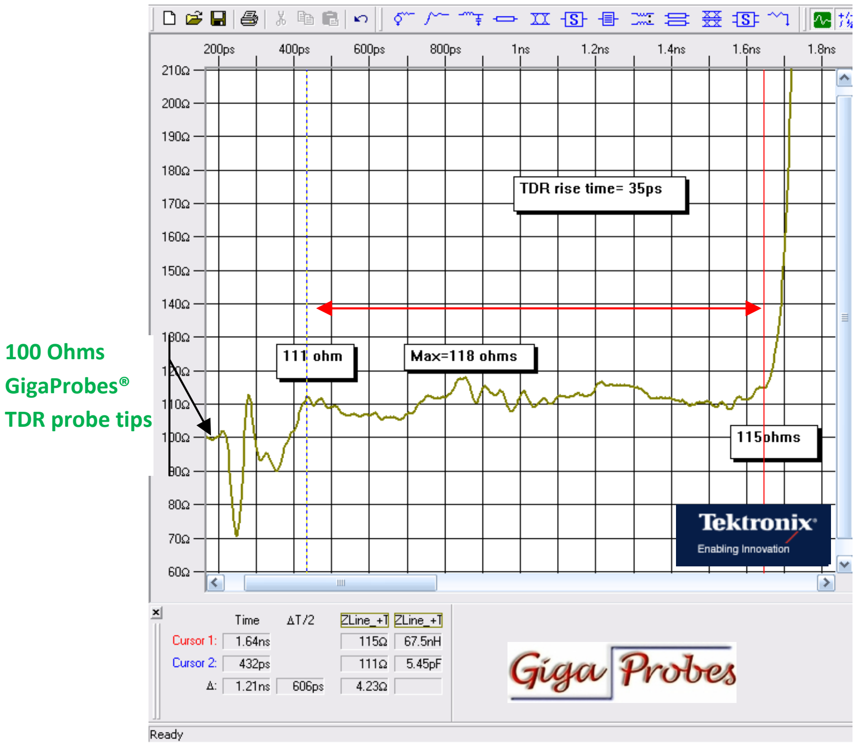
SI Software: IConnect®

Observation: Test pads show a C/L resonance with a min Z= 67 Ω, max Z= 106 Ω impedance discontinuity. The Test pads are connected via a thin trace (green arrows show length) to the Test Points that rises from 89 Ω to 109Ω. The differential test points TDR path is defined by the red arrows. The differential test points 1 & 2 measure Min=109Ω, Max=118Ω and are defined by the two cursers. *The Max impedance was out of manufacturing specifications by 8 ohms.*

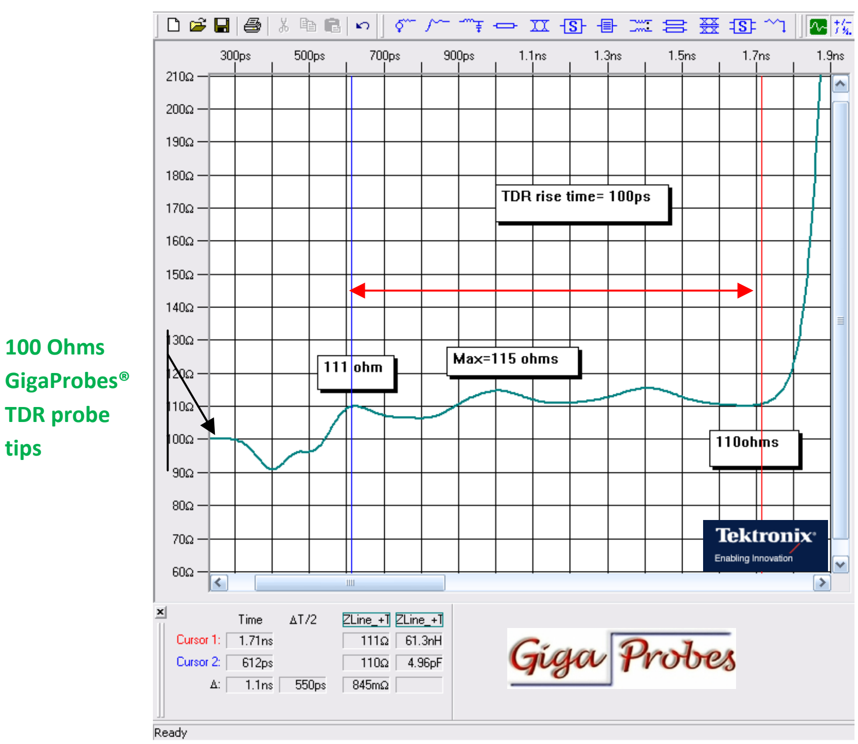
Test points 1 & 2 TDR Rise Time filtered to a 100ps. Observation: less impedance resonance and max impedance is less by 2 ohms but still out of spec. Test points are defined by the blue and red cursers. **TIP**: *Set the TDR rise time to the same rise time (or a little faster) as the device transceivers to view the same impedance load as the device will function under.*

Measurements for Differential Test Points 3 & 4

Measurement setup is same for test points 1 & 2



Observation: Test pads show a C/L resonance with a min= 70.5Ω, max Z= 112 Ω impedance discontinuity on the test pad. The pads are connected via a thin trace (shown as green arrows in previous diagram) to the Test Points that rises from 91 Ω to 110Ω. The TDR differential test point's path for test points 3 & 4 Measure: Min=106Ω, Max=118Ω and are defined by the two cursers. The Max impedance was found to be out of manufacturing specification by 8 ohms.



Test points 3 & 4 TDR rise time filtered to a 100ps. Observation: fewer impedance resonances. The Max Impedance is less by 3 ohms. The Differential test point length is defined by the blue and red cursers. **TIP:** *This filtered waveform can be converted to a SPICE model using IConnect® with fewer T segments reducing run times.*

Test Summary

Using a Tektronix the DSA8200/80EO3 TDR, IConnect® SI software and a GigaProbes® in the 100 ohm differential mode we were able to measure both differential test points. These TDR waveforms were imported to the Tektronix IConnect® to create an impedance plot for each set of differential test points that gave us improved impedance detail that we were able to physically observe the physical path to describe the test pad, thin connector trace and the actual differential test points. Since the Device Driver rise time was not known, two plots were produced showing a 35ps and a 100ps TDR plot. This information determines if faster device drivers can be used with the existing design or if the interconnect will need an improved layout or if better PCB material must be used to support faster signals.

Observation and Recommendations

1) Resist was left on the PCB test points so it made it difficult to make contact since this is a hard non conductive material. Fortunately the *conductive diamonds* on the GigaProbes® could cut though the resist but it would be easier and take less time if the resist was removed before taking the measurements.
2) It is recommended that the GigaProbes® be installed in a probe manipulator so once the probes are make contact, activities associated with operating the scope and IConnect® software can be done without holding the probe in place. If the probe moves while making the measurements they have to be re-taken extending test time and risk acquiring an in accurate waveform.
3) It is recommended that the Sampling TDR module be put on an extender. This allows for shorter cables that reduce TDR rise time degradation, provides less drag on the manipulator and the operator is not crowded up against the TDR making these measurements more difficult to perform and fatigues the test operator.
4) In the future, it is recommended that the TDR *rise time* is adjusted in IConnect® after the raw measurements are acquired to the *rise time* of the device driver. This will help create an impedance plot that is similar to the application data speed and avoid showing impedance discontinuities that will not affect the application or create concern by showing excessive impedance discontinuities or higher peak impedances.
5) Max and Min impedance values were extracted because these values are more meaningful to engineering than the average value because large impedance changes cause excessive signal jitter and reduces return-loss bandwidth. In both measurements, the max impedance values were out of specifications and the PCB manufacture had to tune the differential transmission lines to meet specifications before the boards we accepted by RIM.