Creating Differential TDR Waveforms and S11 S- Parameters On a CAT5 Cable

By

DVT Solutions, LLC

www.gigaprobes.com
b.shumaker @comcast.net

View the **CAT5 S-pran.wmv** video first. Next, view the **CAT5 workbook.wmv** video then use this companion workbook with the IConnect waveform viewers located on the resource CD to complete the training session. Although we use a CAT5 cable as a Device Under Test or DUT the principles you learn here can be applied to almost any interconnect system (backplane, IC package or cable).

1. **View CAT5 S-pran.wmv**
2. **View CAT5 workbook.wmv**
3. **Use CAT5 workbook.pdf**

This step by step workbook demonstrates:

- **Creating Differential Voltage waveforms**
- **Creating Differential TDR and Reference waveforms**
  - **Lean to put labels on waveforms**
- **TDR Waveform Filtering to 500ps**
  - **Lean to expand and view waveform detail**
- **Creating Differential impedance waveforms**
  - **Make Impedance, Distance, Inductance and Capacitance measurements**
- **Creating Differential S11 Return loss S-parameters from TDR waveforms**
  - **Measure Return Loss Bandwidth of a CAT5 cable**

TDR Waveforms can be extracted from the supplied CAT5 cable (or a 59" equivalent CAT5 cable) using the following equipment. The IConnect® software and the results can be compared with the waveforms on **Technical Resource CD** for correctness. To complete this exercise, all you need is the IConnect® software, training videos and IConnect waveform sample viewers. The following items are recommended if you want to duplicate the measurements:

- Tektronix 11801 SD24 or TDS/CSA 8200/80EO4 OR Equivalent
- (Optional) 80EO3, 012156900 sampling head extender,
- 30Ghz Differential GigaProbes™ (www.gigaprobes.com)or a Tektronix P80318 Diff. Probe
- National Instruments IEEE interface and IEEE cable
- Differential TDR probes
- CAT5 Cables (supplied) Tektronix
- IConnect™ Signal Integrity Software

You will find a **FOLDER** called **Waveform Viewers** on the **Technical Resource CD**. Each of the following lessons will use these waveform viewers that contain sample TDR waveforms.

CAT5 TDR sample waveform viewers containing TDR waveforms (supplied)

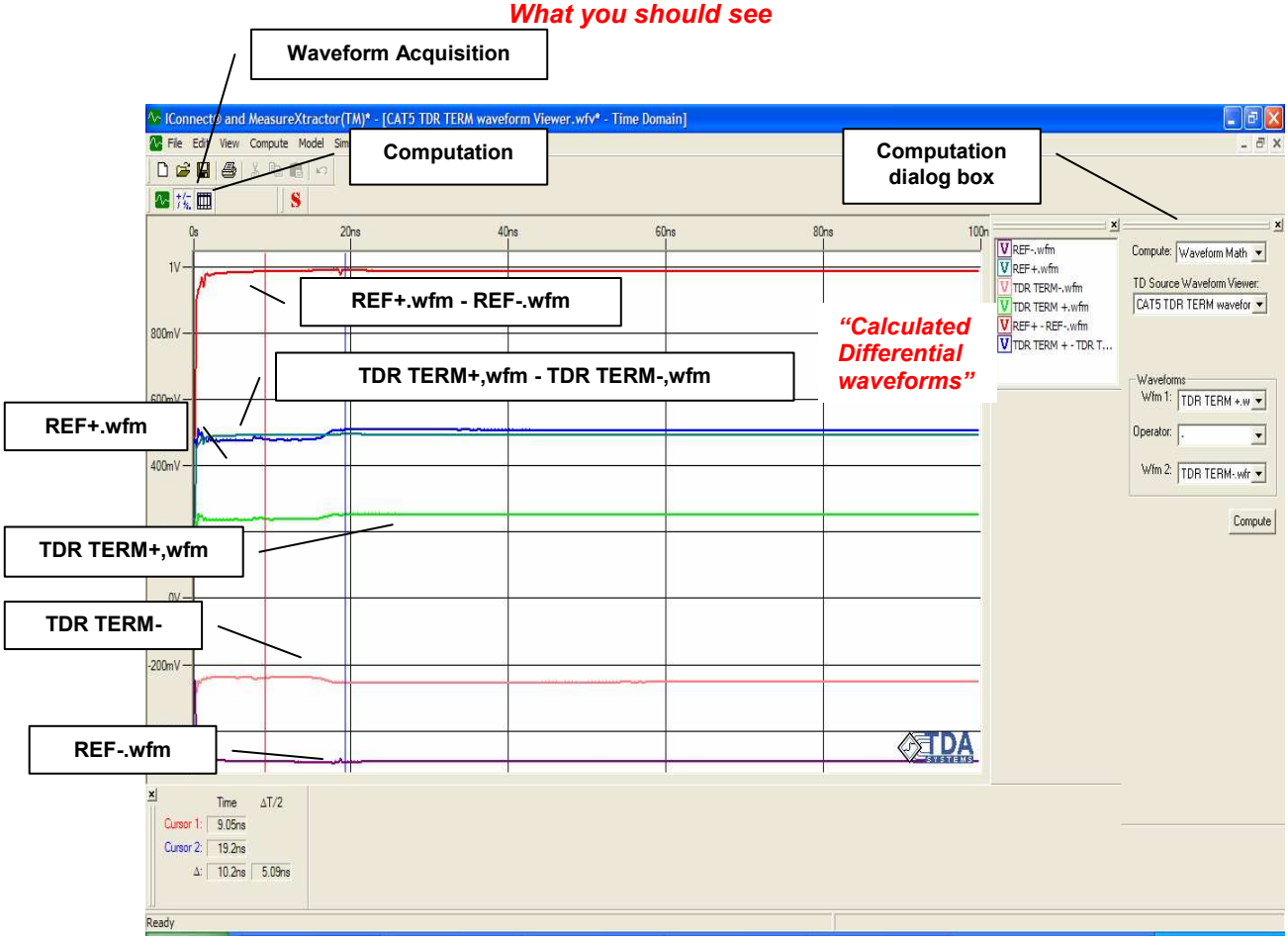
1. CAT5 Unterminated Waveform.wfv
2. CAT5 Differential Waveform Viewer.wfv
3. CAT5 TDR TERM waveform Viewer.wfv
4. CAT 5 S11 Waveform Viewer.wfv

Creating Differential VOLTAGE TDR Waveforms

Start IConnect®

1. **Load Waveform Viewer:** File/OPEN/CAT5 TDR TERM waveform Viewer.wfv
2. **View Waveforms :** View/ waveform Legend
3. **View Computation Window:** View/Computation or select Computation Icon

What you should see



COMPUTING: Differential TDR and Reference waveforms

1. Put the follow In the **COMPUTATION** Dialog box

Compute: Waveform Math
TD Source Waveform Viewer: CAT5 TDR TERM waveform Viewer.wfv
Waveforms:
Wfm 1: TDR TERM +.wfm
Operator: -
Wfm 1: TDR TERM -.wfm

2. **Select:** COMPUTE button

NEXT, Load the REF waveforms

Wfm 1: REF+.wfm
Operator: -
Wfm 1: REF-.wfm

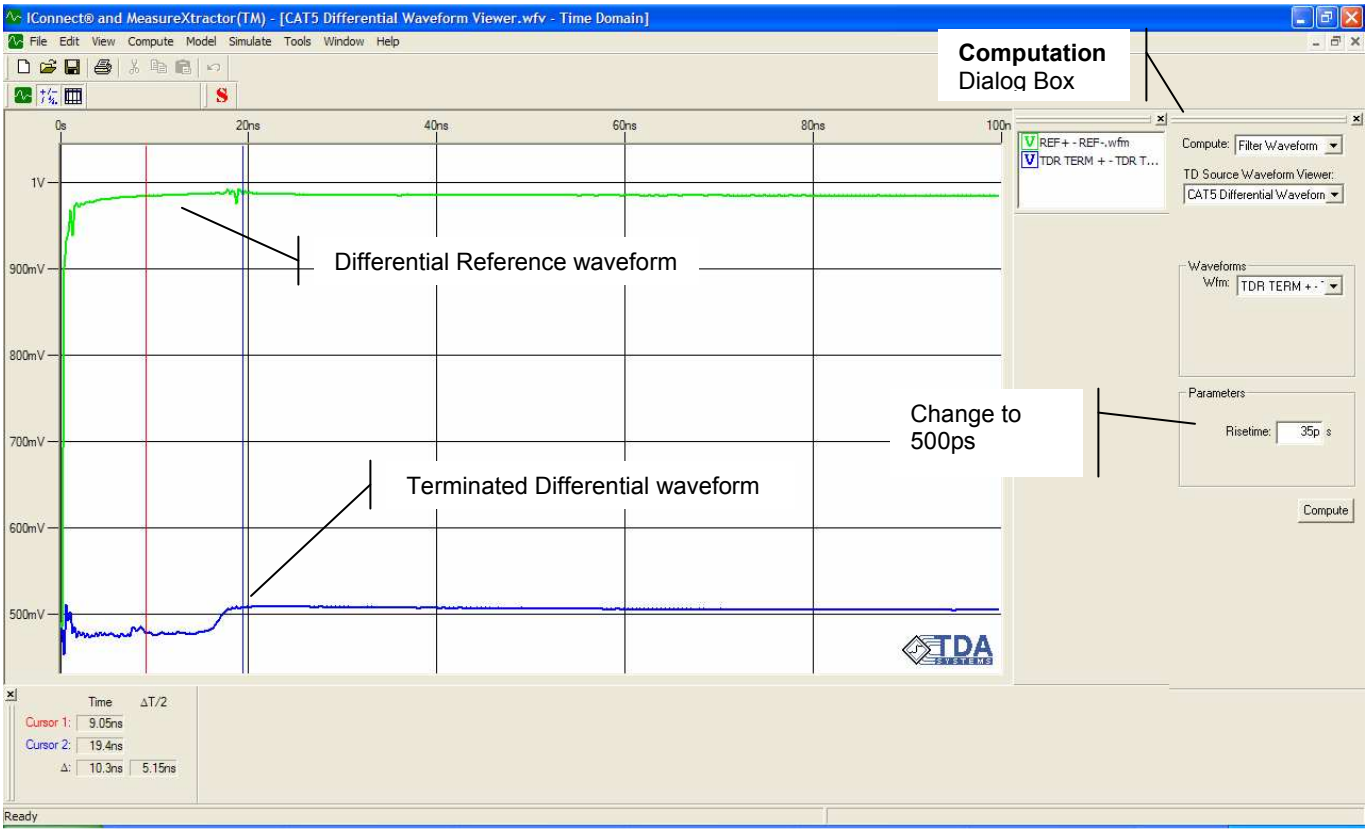
3. **Select:** COMPUTE button

NEW Differential Waveforms put in WAVEFORM VIEWER:
* TDR TERM+.wfm - TDR TERM-.wfm
* REF+.wfm - REF-.wfm

TDR Waveform Filtering to 500ps

1. **Load Waveform Viewer:** File/OPEN/ CAT5 Differential Waveform Viewer.wfv
2. **View Waveforms:** View/ waveform Legend
3. **View Computation Window**: View/Computation or select Computation icon

What you should see



Filtering the Differential TDR waveform:

Put the following in the IConnect®
COMPUTATION Dialog box:
Compute: Filter Waveform
TD Source Waveform Viewer:
CAT5 Differential Waveform Viewer.wfv

Waveforms:
Wfm: TDR TERM+.wfm - TDR TERM-.wfm

Parameters:
Risetime: 500ps
Select: COMPUTE button

Filtering the Differential Reference waveform:

Put the following In the **COMPUTATION** Dialog box
Compute: Filter Waveform
TD Source Waveform Viewer: CAT5 Differential Waveform Viewer.wfv
Waveforms: Wfm: REF+.wfm - REF-.wfm

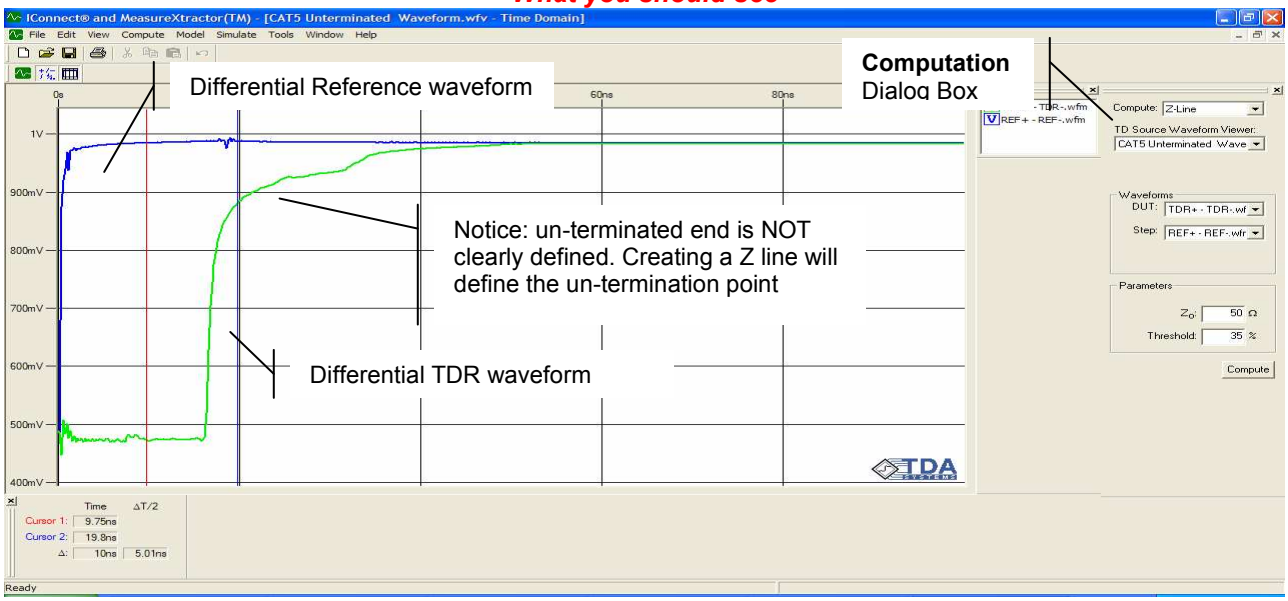
Parameters:
Risetime: 500ps
Select: COMPUTE button

NEW Waveforms put in WAVEFORM VIIEWER:
REF+.wfm - REF-.wfm (500ps) & TDR TERM+.wfm - TDR TERM-.wfm(500ps)

Creating Differential IMPEDANCE Waveforms

1. **Load Waveform Viewer:** CAT5 Unterminated Waveform.wfv
2. **View Waveforms :** View/ Waveform Legend
3. **View Computation Window**: View/Computation or select computation icon

What you should see

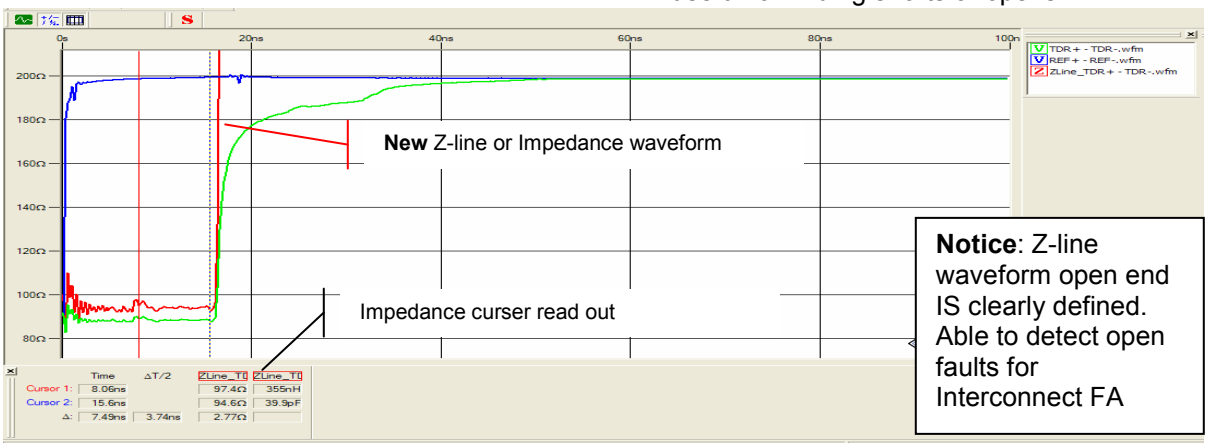


Put the following In the IConnect®
COMPUTATION Dialog box

Compute: Z Line
TD Source Waveform Viewer:
CAT5 Unterminated Waveform.wfv
Waveforms:
DUT: TDR +.wfm+ - TDR-.wfm
Step: REF+-REF-.wfm
Parameters
Z_0: 100 ohms
Threshold: 35%

Select: COMPUTE button

NOTE:
Click on waveform and the vertical scale will be in Ohms vs. Time. This can be changed to Ohms vs Distance in the options menu if you know the Er values of the material. Right click on the waveform and select curser readout to read direct impedance, distance, and inductance, capacitance and delta values. The Z line or impedance waveform illustrate exactly where the waveform is un-terminated, useful for finding shorts or opens.

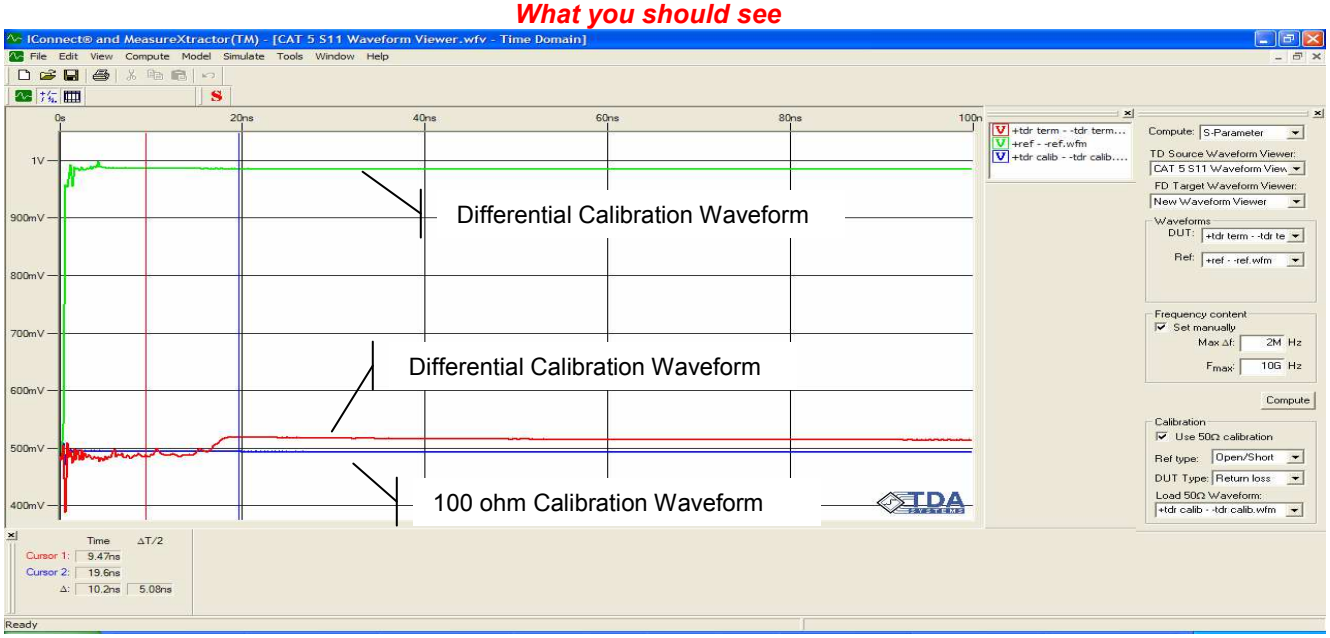


Notice: Z-line waveform open end IS clearly defined. Able to detect open faults for Interconnect FA

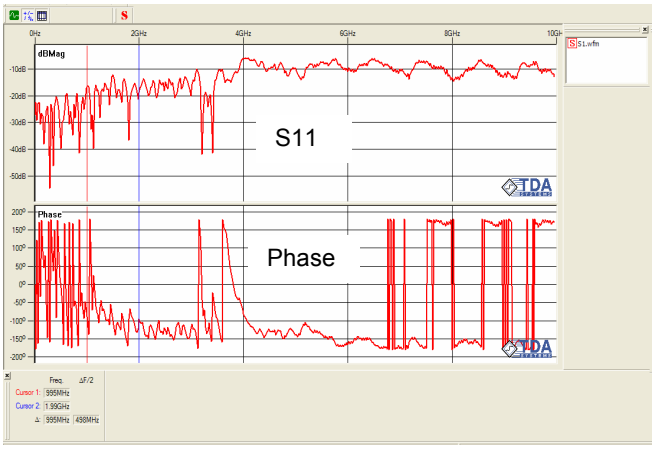
Creating S11 Return Loss S parameters

Load Waveform Viewer: File/OPEN/ CAT 5 S11 Waveform Viewer.wfv
2. View Waveforms: View/ waveform Legend
3. View Computation Window: View/Computation or select Computation icon

What you should see



Compute: S-Parameters
TD Source Waveform Viewer:
CAT5 Unterminated Waveform.wfv
Waveforms:
DUT: TDR TERM+.wfm - TDR TERM-.wfm
Step: REF+-REF-.wfm
Frequency Content:
Set Manually
Max delt f: 2M
Fmax: 10G
**** Calibration*:**
Use 50ohm calibration
Ref Type: Open/Short
DUT Type: Return Loss
Load 50ohm Waveforms:
+tdr calib - -tdr calib.wfm
Select: COMPUTE button



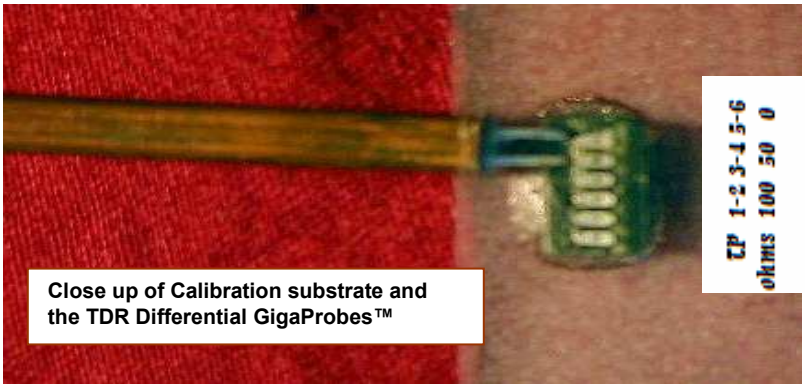
*** Creating a 100 ohm Differential *Calibrated* TDR Waveform:**
Without changing the TDR time base used to acquire the Reference and TDR waveform probe across the GigaProbe™ GP10CS calibration substrate and acquire the + and - TDR Calib wavefrom. Use waveform math to create +tdr calib - -tdr calib.wfm.

Using a calibration waveform makes more accurate S-parameters by normalizing cable and probe discontinuities. This procedure is similar to the VNA calibration procedure.

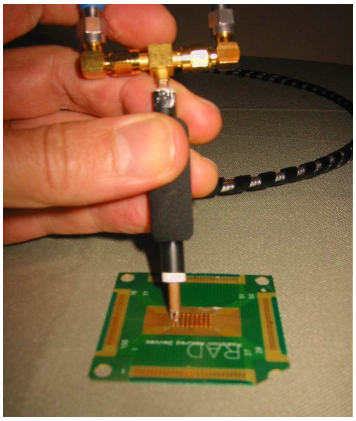
100, 50 & 0 ohm TDR/VNA 10GHz Calibration Substrate

NEW GP10CS Calibration Substrate for Complete DVT Solutions 20Ghz TDR Gigaprobes™ or for any TDR or VNA probe with a 1 mm S-S or S-G pitch. This is the world's first calibration substrate that uses Diamond Particle Interconnects. The calibration substrate pad resists bandwidth degradation due to grease or contaminates due to handling and requires 5 grams of contact force to make contact from DC to 10GHz.

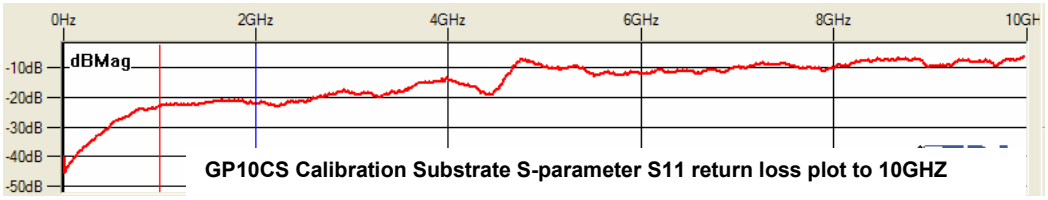
This probe calibration substrate is used with TDR and VNA test instruments to calibrate 100 ohm differential or 50 ohm single ended probes for s-parameters measurements using Tektronix IConnect software. Each calibration substrate contains robust precise elements for calibrating out the unavoidable errors and losses.



Close up of Calibration substrate and the TDR Differential GigaProbes™



TDR GigaProbes™ probing a Diamond Particle interface interposer. Replaces traditional sockets



GP10CS Calibration Substrate S-parameter S11 return loss plot to 10GHZ

A Close-up view of a Diamond Partial Interconnect showing several sharp points that at as many probe tips in parallel reducing interconnect inductance. www.pitek.us.com

Ordering Information

For Pricing, Application Notes, Seminars, Signal Integrity Consulting and SI Probe Stations visit: http://www.gigaprobes.com

Ph (650) 593-7083 or (415) 738-8607 fax (650) 593-1236 E-mail B.shumaker@comcast.net or mayrand@earthlink.net

Characteristics

Bandwidth – 10 GHz.
Pitch – 1 mm
Impedance – 100 Ω differential, 50 Ω common mode, 0Ω Single Ended
Test Pads- Diamond Particle Interface
Usage – > 1.5 million insertions
Contact Force – 5 gram 10 GHz BW

Diamond "Particle Interconnect" (PI) overview

Particle Interconnect replaces soldering, wire bonding, and on-bump bonding with environmentally safe, room temperature diffusion bonding at very low contact force, with no thermal stress at bonding temperature.

- Ultimate technology for electrical/mechanical/thermal interconnection.
- Best price and performance interconnect technology.
- Bandwidth > 100 GHz bandwidth or 10ps rise time degradation
- MTBF lifetime of > 1.5 million insertions.
- 25 point diamond contact penetrates oxide adhesive, oil and dirt
- Extreme temperature range from -270° C to > 450° C, and extreme acceleration.