Agilent Technologies
# S-Parameter and TDR Impedance Measurement Solution Summary

- Built-in S-parameter testing

- Easy and accurate transmission channel/media characterization

Transmission lines for high speed digital communications, such as connectors and printed circuit boards, are required to carefully control the impedance, which may affect the signal integrity of today's fast signals. New standards such as PCI-Express and Serial ATA need accurate characterization of the S-parameters and impedance. With enhanced TDR measurements capabilities, Agilent responds to these test requirements.

TDR measurements are key step toward signal integrity

The simplest configuration for TDR (Time Domain Reflectometry) measurements is a step generator within a wide bandwidth oscilloscope. The reflected signal from the step generator is reflected and represented as voltage or impedance as a function of time. TDT (Time Domain Transmission) typically shows transmission delay. Impedance discontinuities with a device or channel cause distortion of the transmitted signal and TDR/TDT is an important tool to improve signal integrity.

Wideband Oscilloscope

Step Pulse Generator

DUT
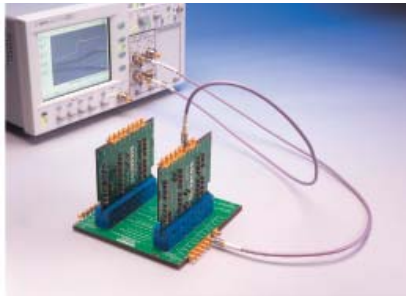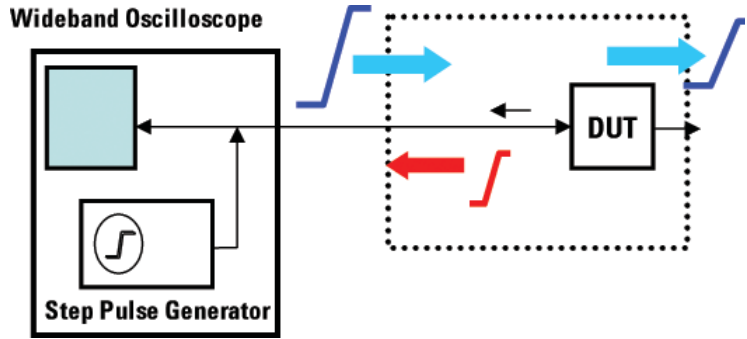
The powerful combination of the Agilent 86100 series Infiniium DCA mainframe and the 54754A Differential TDR module provides a superb solution for TDR/TDT measurements for many years. While responding to a significant demand in recent high speed digital serial interfaces, TDR/TDT measurement features are significantly enhanced for easy and accurate results.*
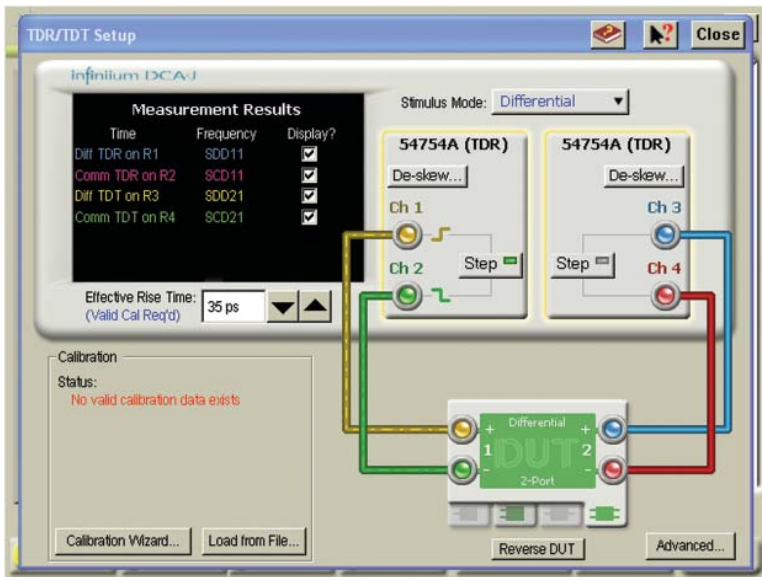

The new set-up menu, with a

New setup menu is easy-to-understand and easy-to-use

**Test parameters**   **Setup/connection**

TDR Calibration

graphical user interface, provides an intuitive operation, even for users unfamiliar with TDR. Connections between the device-under-test (DUT) and the test ports are graphically displayed, once the stimulus mode
and type of device ports are selected. With the 86100C option 202 installed, not only the time domain results of TDR/TDT are shown, but the frequency results of S-parameters are also displayed (refer to page 4 for detail).

*Note: This document will discuss features available in the 86100C as a mainframe with firmware revision 6.0 and above installed. Some of the features are available in the 86100B mainframe with revision 5.0 installed. These features are not available in the 86100A mainframe.

# TDR Calibration is the quickest way to correct results

To obtain accurate test results, systematic errors introduced from test fixture or cables must be correctly removed. Agilent TDR Calibration establishes a calibration plane with digital filter technologies using Short and Load reference devices, then removes systematic errors to provide accurate results. This can be easily demonstrated by connecting two identical TDR demo boards in series. The first board emulates a test fixture, which degrades the test results of second board in left. After applying the TDR Calibration between the connector of two boards, the effect of first board (fixture) is calibrated-out to show a 50 ohm trace, and the result of the second board is shown as expected on the right side of the trace. The new revision 5.0/6.0 and above adds a feature called time invariant TDR calibration, that maintains the calibrated trace results even after changing time-span (sec/div) or delay position.
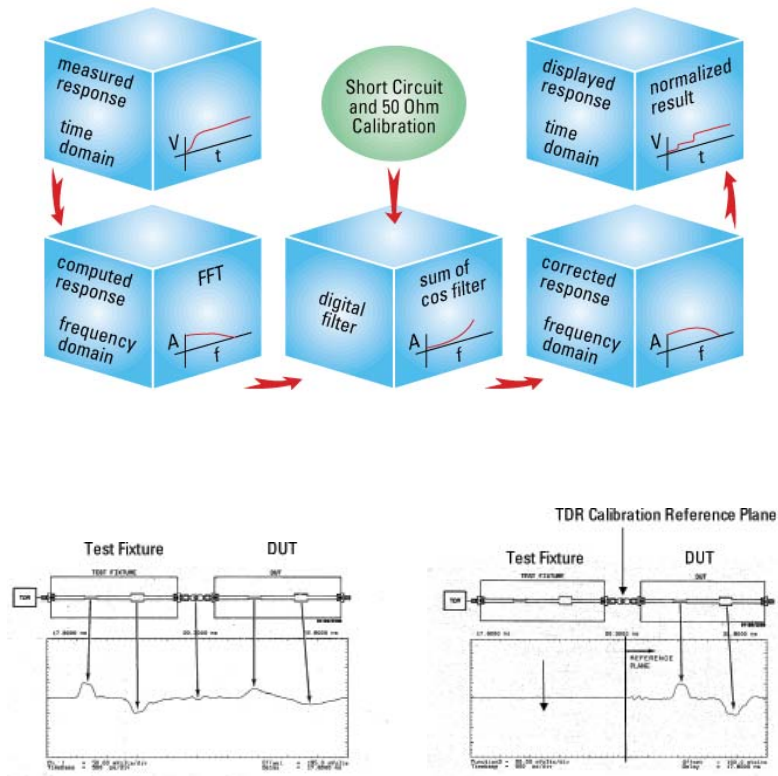
The Agilent Differential TDR solution uses superposition to obtain all of the required S-parameters including return

Complete single-ended and differential testing relies on the electromagnetic theory

loss, attenuation and crosstalk and report the results in single-ended, differential or common mode. Full differential capability is enabled with the use of a second module with dual electrical channels such as the 54754A or 86112A.
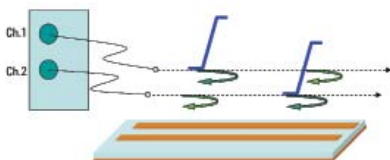
Kit for Complete TDR Calibration

N1024B TDR Calibration kit enables you to perform accurate differential TDR/TDT and S-parameter measurements. Based on extensive SOLT (Short-open-load-thru) calibration technology in VNA (Vector Network Analyzer), the measured results using the 86100 Infiniium scope and TDR module favorably compare to VNA measurements to greater than 15 GHz.


N1024A Calibration Kit (3.5mm)		
Device	Qty	Part #
Male Load	2	00902-60003
Male Short	2	0960-0055
Female Load	2	00902-60004
Female Short	2	1250-1834
Cables	4	8120-4948
BNC-M to SMA-F	1	1250-1700
3.5mm F-F	2	5061-5311
Torque Wrench	1	8710-1765

86100C Option 202 extends the TDR capability

The 86100C option 202 Enhanced Impedance and S-parameter Software extends the capability of TDR/TDT measurements.

One touch display for S-parameters

The 86100C Option 202 software offers frequency domain results of S-parameters (S_{11} return loss or S_{21} insertion loss) from time domain TDR/TDT results quickly in a single touch . Up to 6 parameters can be displayed simultaneously and a marker readout quickly pinpoints the values at the desired frequency and allows comparison between traces. Time domain gating function is available, since the frequency data is calculated for the area between the reference plane (at t=0, or marker of triangle) and right most edge.
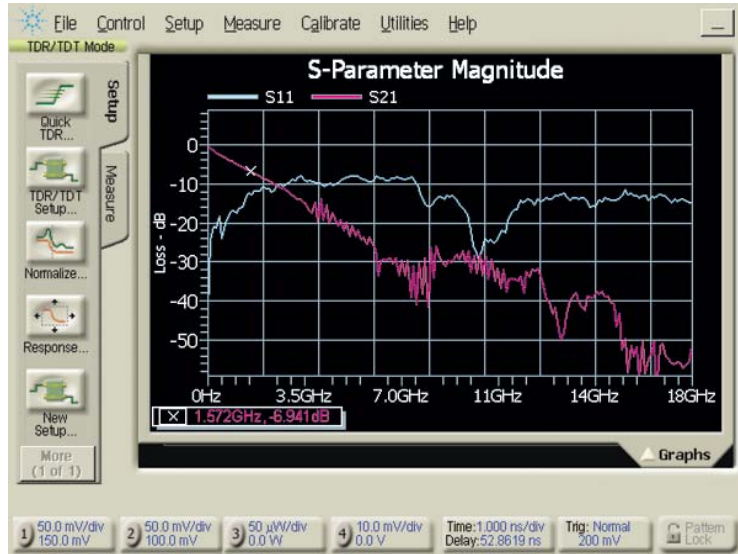
Impedance correction due to multiple reflections

Multiple and subsequent impedance-discontinuities often diminish the reported size, or impedance value, at the position of discontinuities. The 86100C Option202 software adds the TDR Peeling function to calculate the correct impedance value, therefore compensating for these multiple reflection effects.

Extract results to Touchstone files

With the 86100C Option 202 software, S-parameter results can be exported to other applications through the use of a Touchstone file for use in circuit simulation with both .s1p and .s2p formats. The .s2p format provides four S-parameters, two in each direction. If one TDR module and one dual receiver is used, the device is turned around to obtain the reverse parameters. If two TDR modules are used, the measurements can be quickly reconfigured to obtain the reverse parameters without turning the device around.

*Note: 86100C users can obtain the license for the 86100C Option 202 by ordering the 86100CU Option 202 upgrade kit. 86100C Option 202 and 86100CU Option 202 are not available in the 86100A/B.

Quality of TDR step pulse is a key of impedance testing

The quality of the TDR step pulse launched into the DUT influences the TDR measurements. The 54754A is designed carefully to minimize the aberration providing a clean pulse with small overshoot and ringing; this virtually eliminates any confusion among small actual reflections. Digital filtering derived from the TDR Calibration allows the user to simulate different step pulse speeds to verify how the impedance is seen under actual signal pulse speeds. Also a simulation with steps as fast as 10 ps can be displayed with TDR Calibration, resulting in accurate impedance measurements of small and high speed devices.
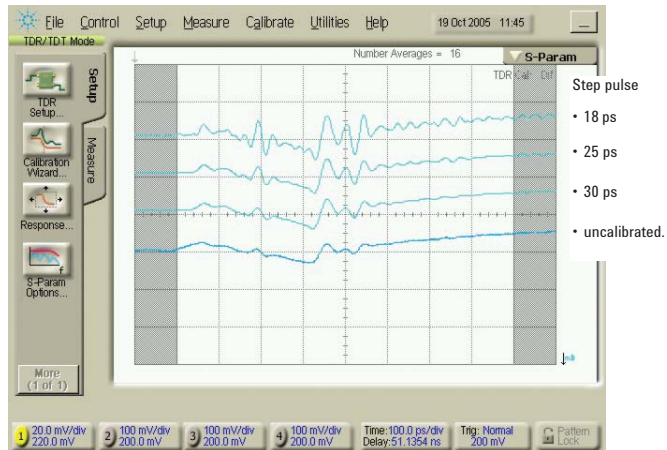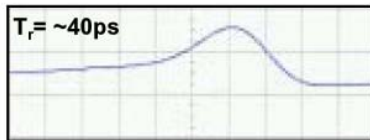

Image file : 13Gbps board, S-E TDR, showing raw, 30ps, 25ps and 18ps traces, white.jpg

54754A TDR step typical specification:
Step rise time : < 35 ps
Step flatness : +5/-3% up to 1 ns
                    < 1 % beyond 1 ns

Improve resolution by making actual step pulse faster

Picosecond Pulse Lab's source enhancement module provides a quick and accurate view of closely spaced discontinuities, by applying a 9 ps step pulse instead of standard approximate 35 ps step pulse. Please note that appropriate receiver bandwidth is needed to be used with the PSPL module (4020 or 4022). The 86118A is the best receiver with 70 GHz bandwidth and contains remote heads to eliminate degradation from cables to the DUT. TDR calibration with recommended 2.4mm calibration devices establishes a clean pulse by removing any aberration effects.

Refer to PSPL information at http:/www. picosecond.com/.

Complete differential characterization via PLTS

S-parameter testing with the 86100C Option 202 provides easy viewing of up to six simultaneous S-parameters. The N1930A Physical Layer Test Solution, based on either TDR or VNA, offers a complete solution for a differential line characterization. PLTS is designed to provide 16 simultaneous S-parameters and extensive calibration, as well as an eye diagram simulation.

	DCA-J with 202	PLTS with TDR
S-parameter coverage	32	32
Simultaneous display of S-Parameters	6	16
# of Calibrations	More	Fewer
Capability	Very good	Better
Dynamic range	~45dB	~45dB
Mainframe supported	86100C	86100A/B/C
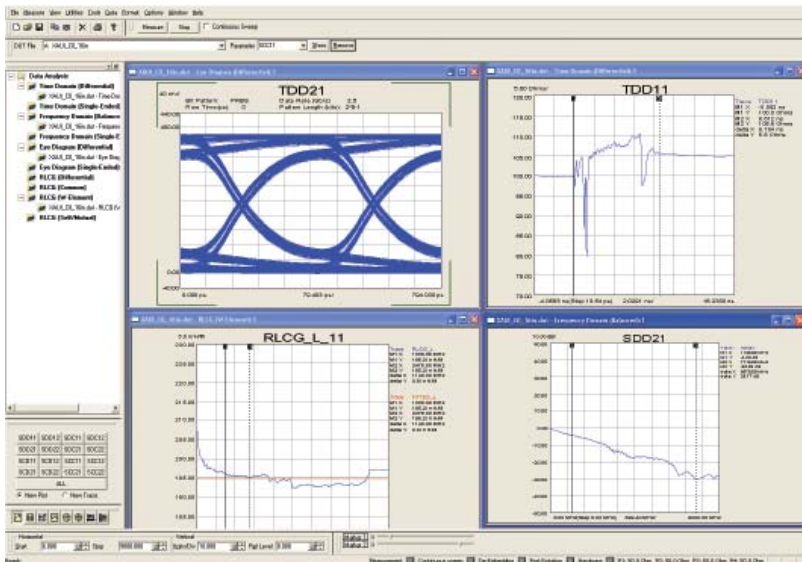
## For more accurate results, use the VNA.

N5230A option 220 PNA series is a 4 port 20 GHz Network Analyzer as a best companion for the PLTS solution with wider dynamic range and advanced calibration such as TRL (Thru-the-line).

N5230A-220

Comparison between analyzers

VNA is recognized as the most accurate and widest dynamic range solution in the world to characterize transmission lines. The right graph shows a comparison of differential return loss test (SDD11) between the VNA and the TDR with an actual device under test. Blue is a TDR with TDR Calibration, which shows very good matching with VNA (red) up to about 10 GHz. This results show that S-parameters using TDR Calibration are comparable to VNA results.
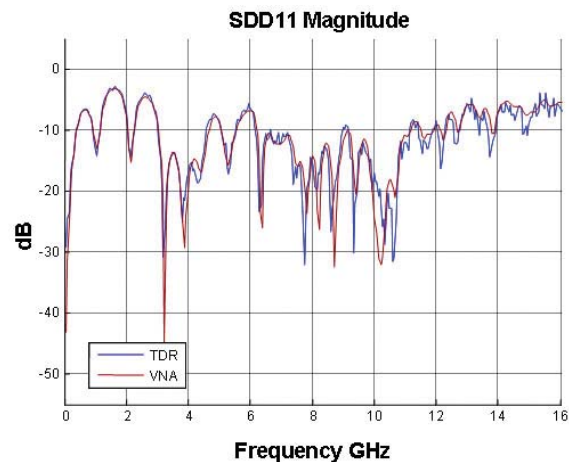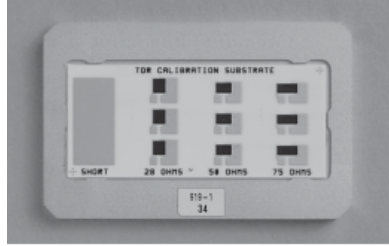
Versatile TDR accessories

N1020A TDR probe kit

N1020A TDR probe kit is a general purpose single-ended TDR probe with a test armature to locate the probe by X-Y-Z positioning. The N1020A-K05 Calibration Substrate is included.

Bandwidth : > 6 GHz
Probe pitch : 1.5 to 5.0 mm

N1020A-K05 Calibration Substrate

Using the precision, thick film resistors that are laser trimmed, this substrate yields the utmost in accuracy to allow TDR Calibration at the end of probe tip.

N1020A-K09,10,11 TDR Cables

SMA connecters are directly connected to three type of high speed digital interface connectors. Short and Load connectors for TDR Calibration are included.

- FireWire (IEEE 1394)
- Gigabit Ethernet (IEEE 802.3Standard) High Speed Serial Data Connector (HSSDC)
- Fibre Channel (ANSI x3.297-1997) DB-9

Differential TDR probe kit

General purpose single-ended and differential probe kits with virtual grounds are designed to complete TDR Calibration with probes using the calibration substrate.

Bandwidth : > 15 GHz Typical
Probe pitch : 0.5 to 3.0 mm

Care for preventing ESD trouble

Input of the 54754A TDR module consists of a precision microwave sampler with maximum input voltage of +/- 2 V DC. Any cable or PC board to be measured is subject to charge the electro static voltage beyond 1000V. This ESD causes damage to the TDR module input circuitry. The user is strongly advised to discharge the printed circuit boards, fixtures and cables prior to connection to the TDR input, by shorting the inner and outer conductors on the tab or edge of connector on the front of the TDRmodule, or by touching a grounded-probe onto the trace of PC board. Plugging in anti-static wrist strap to the mainframe and attaching the strap to your wrist is also highly recommended. Picosecond ATE offers a static protection unit for use in sensitive environments.

86100C DCA-J has a powerful solution - Jitter Analysis

The 86100C is a powerful wide bandwidth oscilloscope which enables accurate RJ/DJ separation, TJ (Total Jitter) analysis, and detailed jitter decomposition. The 86100C Option 200 software allows simple operation through a one-key solution, then displays the jitter test results in histogram charts and tabular format. Frequency extraction of periodic jitter (PJ) further enhances troubleshooting. The core technology is in the option 001 Extended Trigger, which uses PatternLock to display a single value waveform allowing precise analysis of each edge.
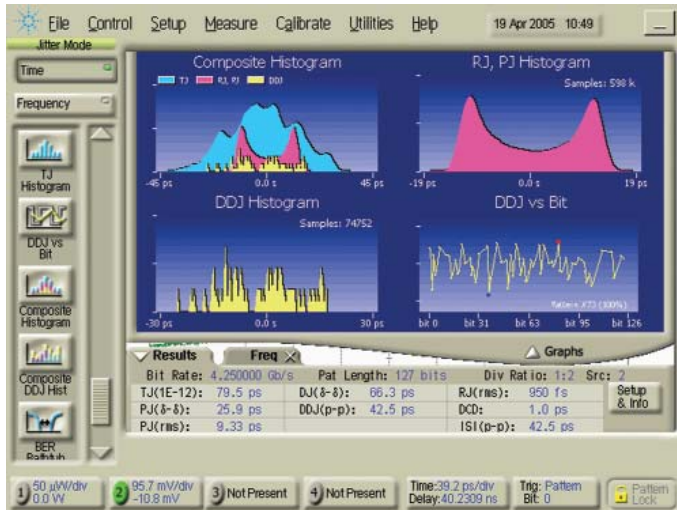
Equalizer Simulation

High speed digital signals are often affected by intersymbol interference (ISI) which is due to bandwidth limitations of transmission line such as PC boards. One very effective solution is to equalize the receiver circuit. The 86100C Option 201 provides a Linear Feedforward Equalizer simulation to estimate the eye shape after your equalizer circuit. This is facilitated by quickly choosing the tap spacing and values, either automatically or manually.
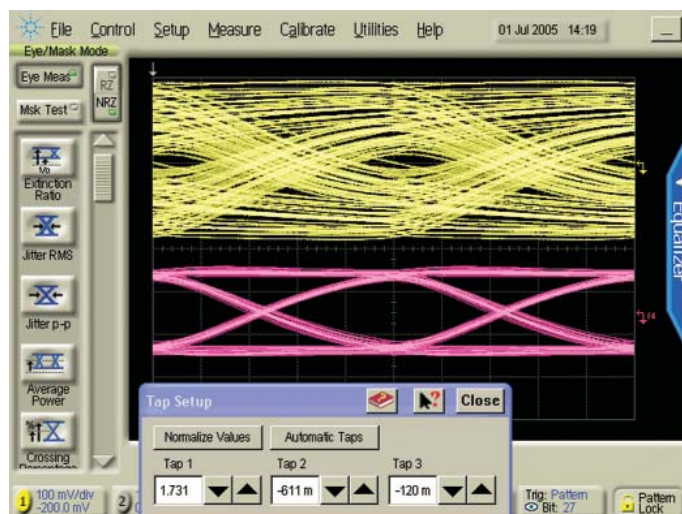
Recommended Configuration for system on front page

- 86100C Infiniium DCA-J mainframe
- 86100C option 202 Enhanced Impedance and S-parameter Software
- 54754A Differential TDR module
- 86112A Dual 20GHz Electrical Module (for differential TDT measurement)
- N1024B TDR Calibration kit.

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