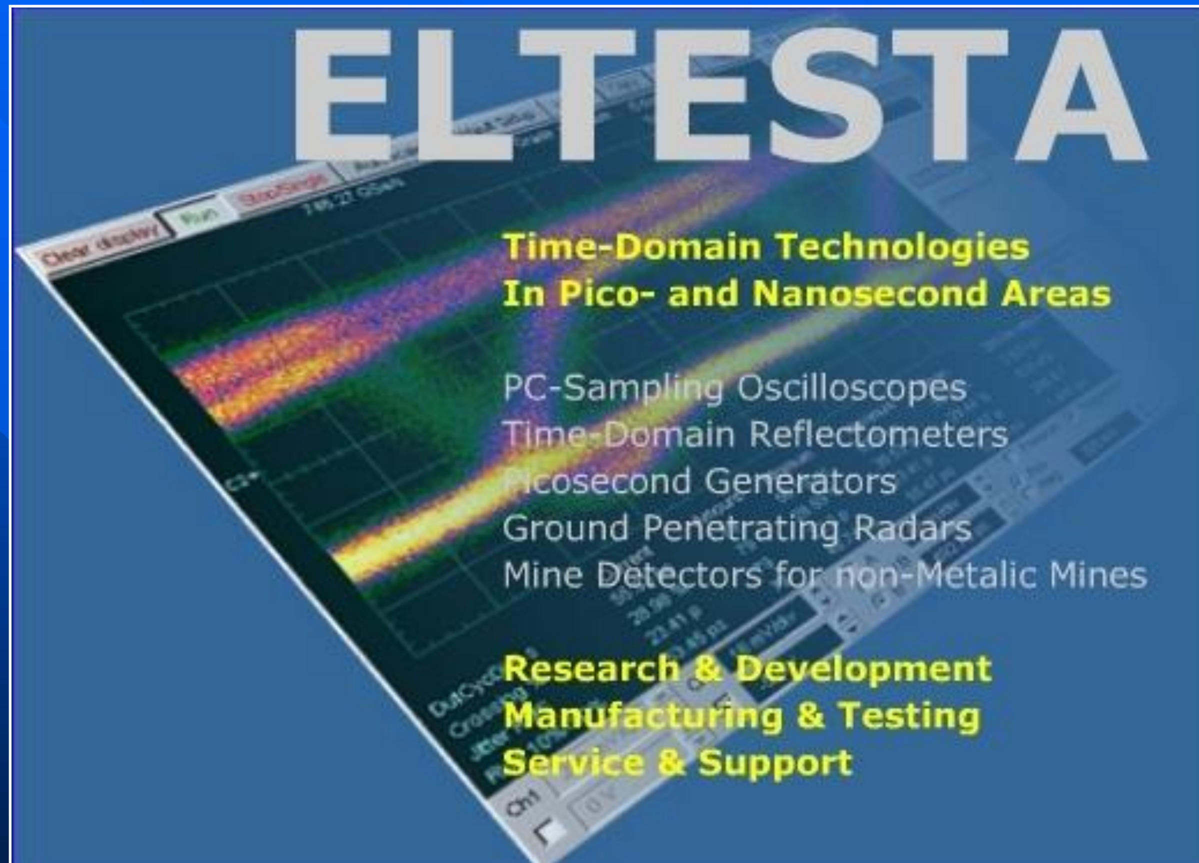
Low-cost High-resolution TDR Measurements with the PicoScope 9211 USB-Sampling Oscillloscope



TDR/TDT Measurements

Time Domain Reflectometry (TDR) is a method of characterizing a transmission line or network by sending a signal into one end and monitoring the electrical reflections.

An example of **Z-profile** of transmission line. Both markers provide distance and Ohm measurements

- A **TDR** step can also be used to make **Time Domain Transmission (TDT)** measure-ments. **TDT** is a technique that allows you to measure the response of a system by sending steps through a device and monitoring the output of the device.
- The measurements are made on signals transmitted through the device, rather that reflections from the device (as in **TDR**).

Basics equations

For TDR measurements:

Vrefl = Vin (Z-Zo)/(Z+Zo)

Examples:

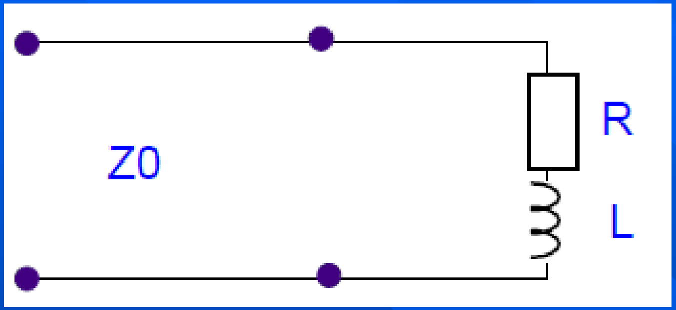
Z=25 Ohm, Vrefl = -1/3
Z= 100 Ohm, Vrefl = 1/3

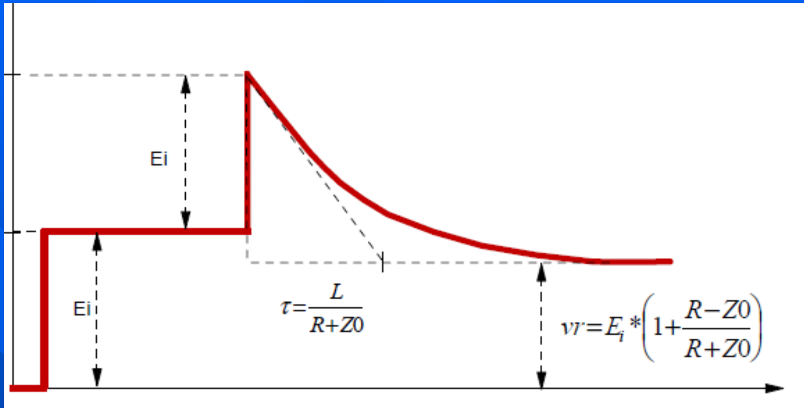
For TDT measurements:

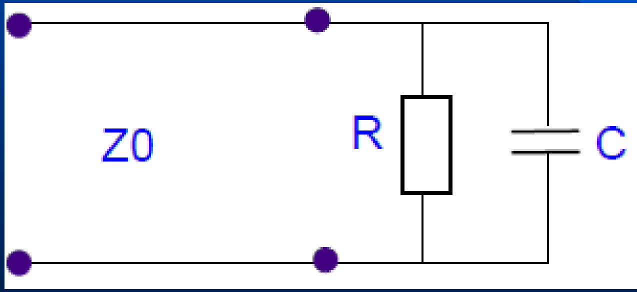
Vthru = Vin * 2Z/(Z+Zo)

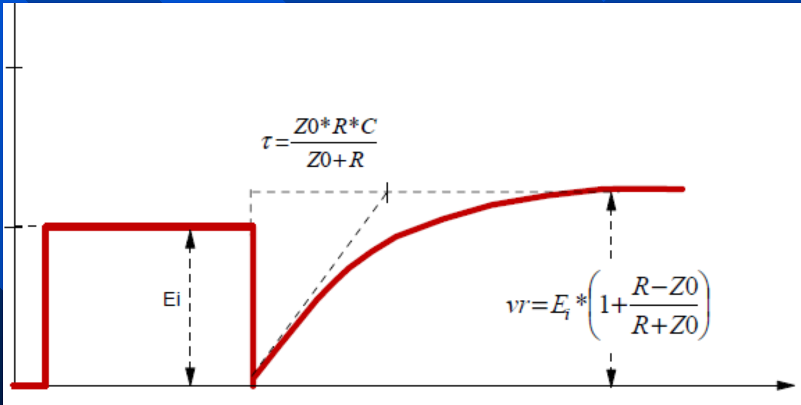
Z - impedance seen in forward direction at the actual location

Examples of the Complex Load Out of TDR Plots

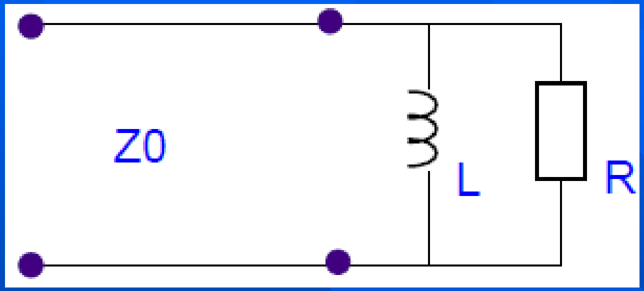


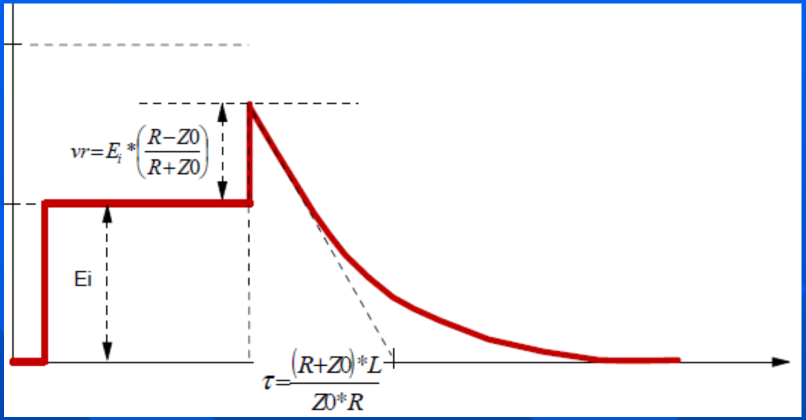


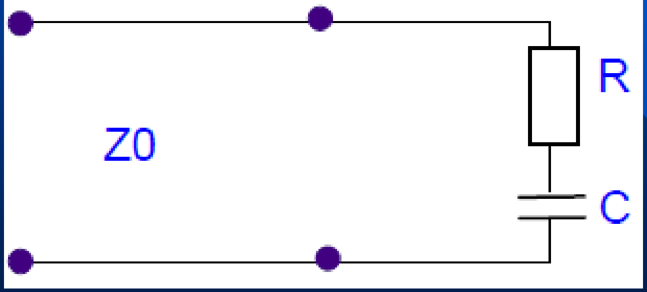


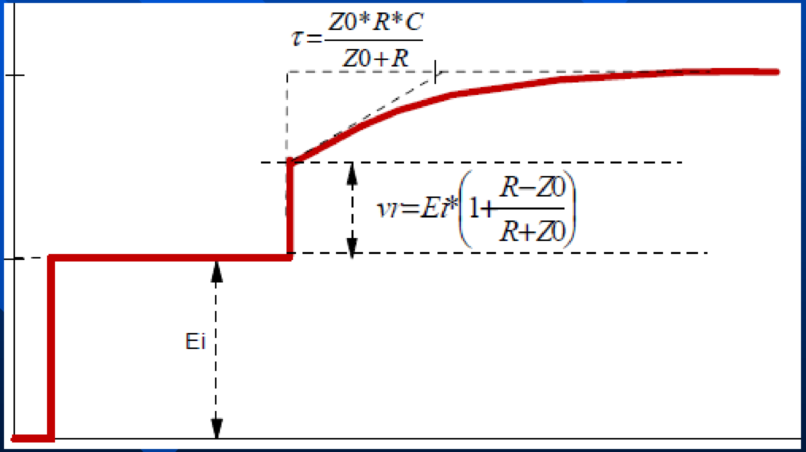


Examples of the Complex Load Out of TDR Plots (cont.)



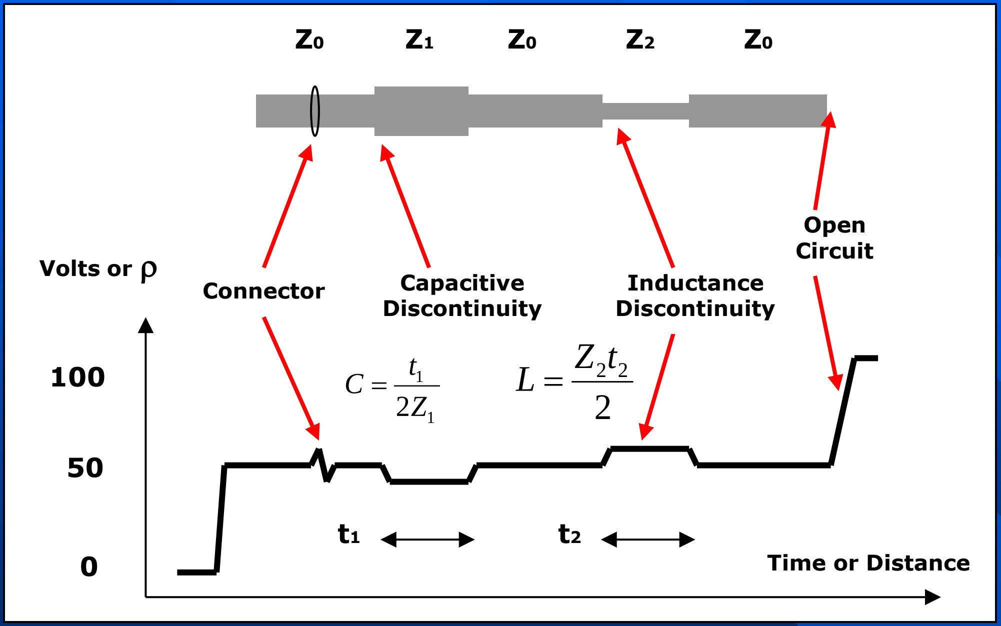






Distributed Discontinuities

TDR Measurement are used to characterize the signal transmission properties

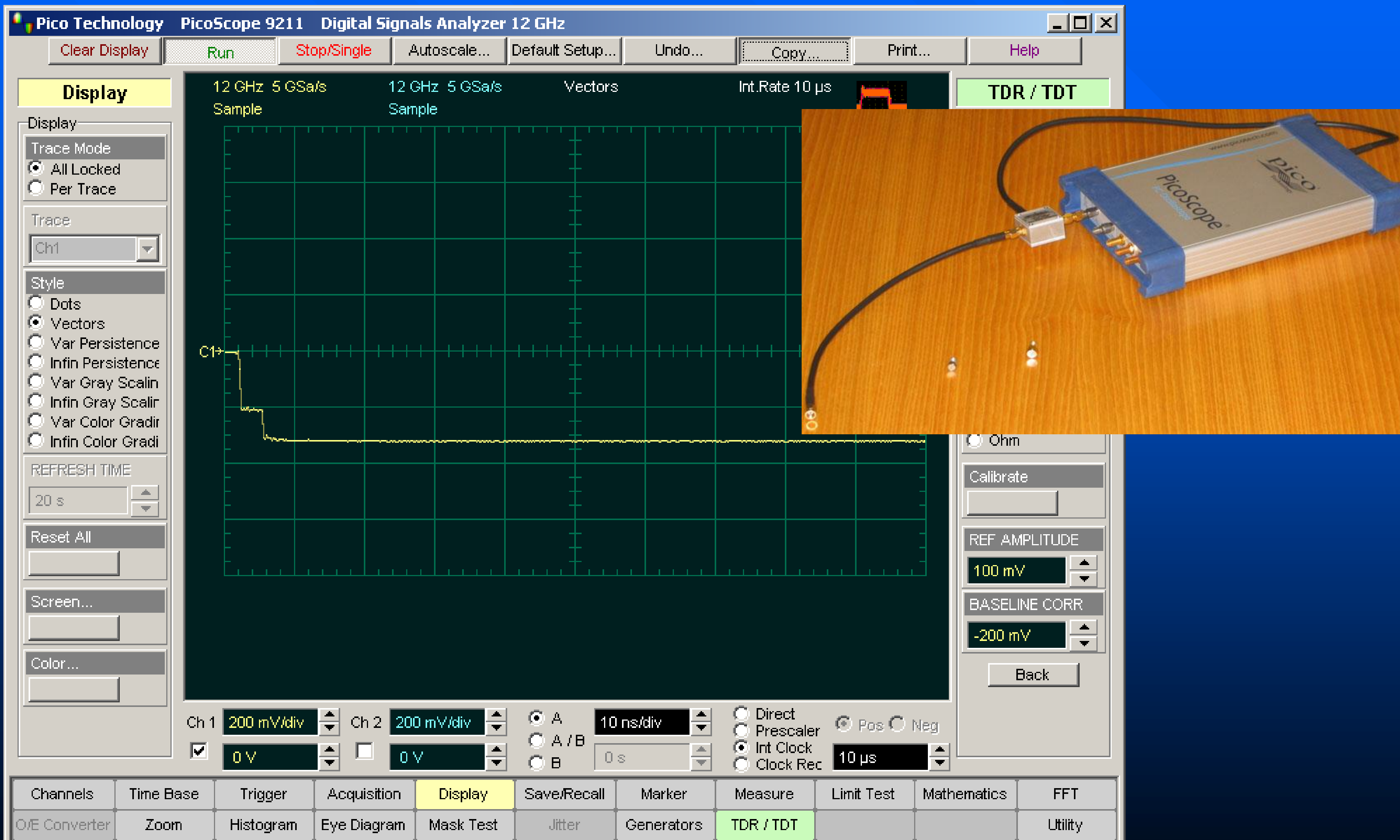


Typical **TDR** Applications:

TDR Measurement are used to characterize the signal transmission properties of:

- Printed Circuit Boards
- Connectors
- IC Packages
- Cables and Interconnects

Equipment connections for TDR measurements



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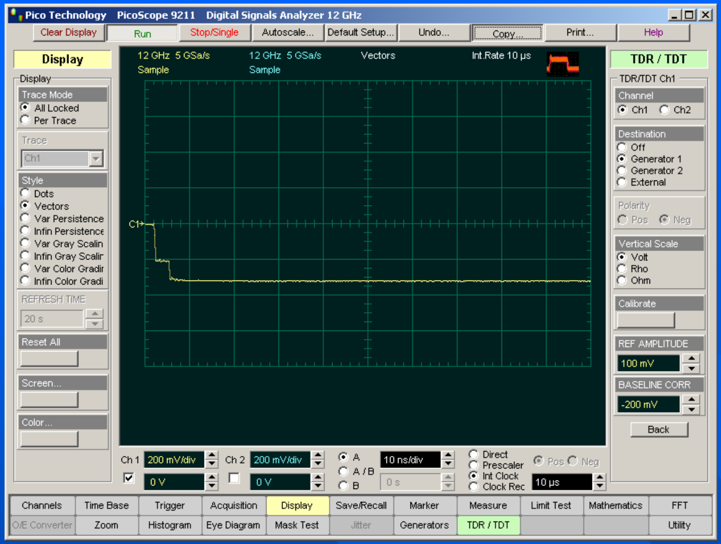
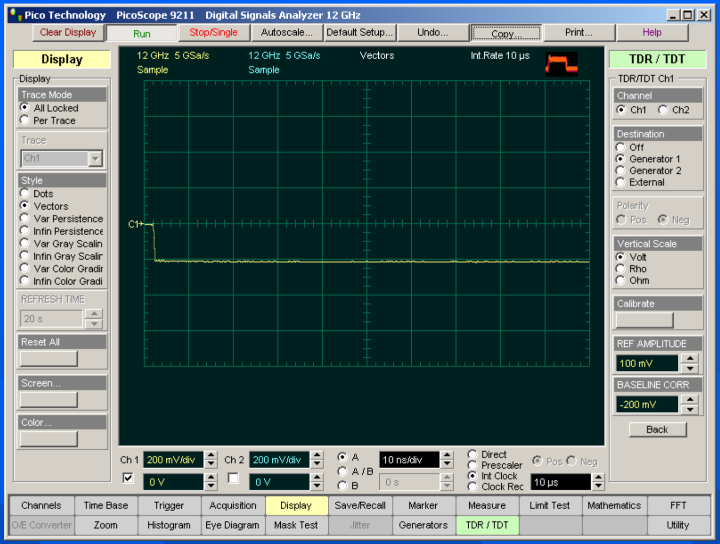
Main TDR Waveform for Different Loads

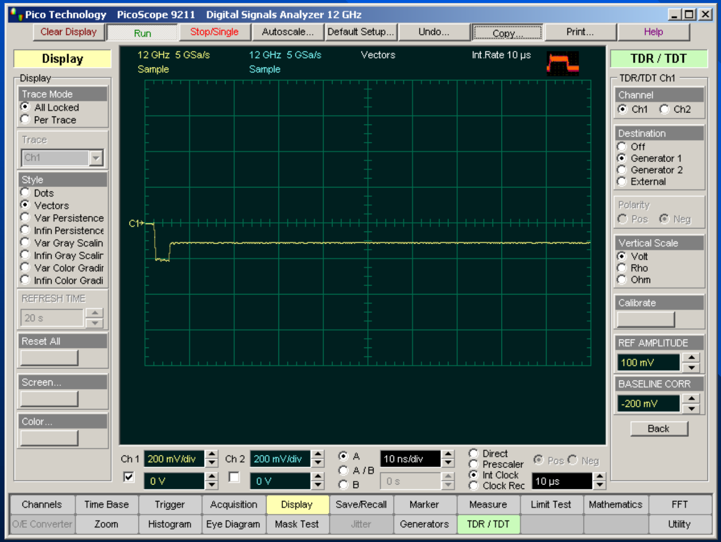
Open



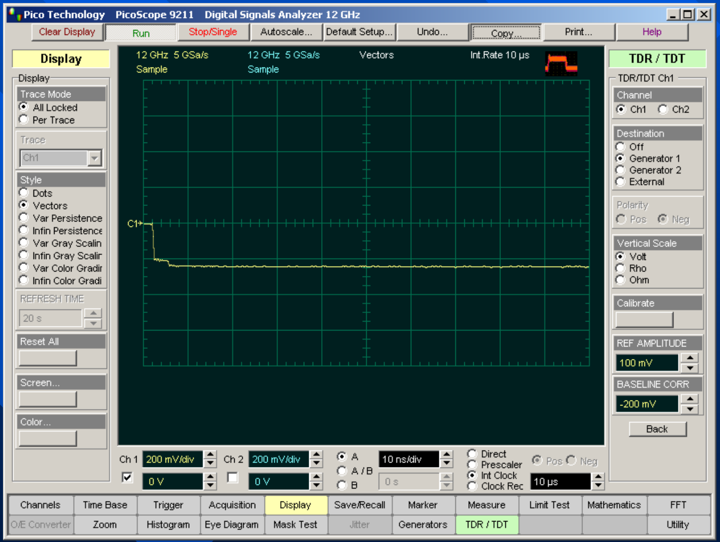
50 Ohm



Short



85 Ohm



Vertical Scaling in TDR/TDT

The three choices for TDR are: Volt, Rho, Ohm

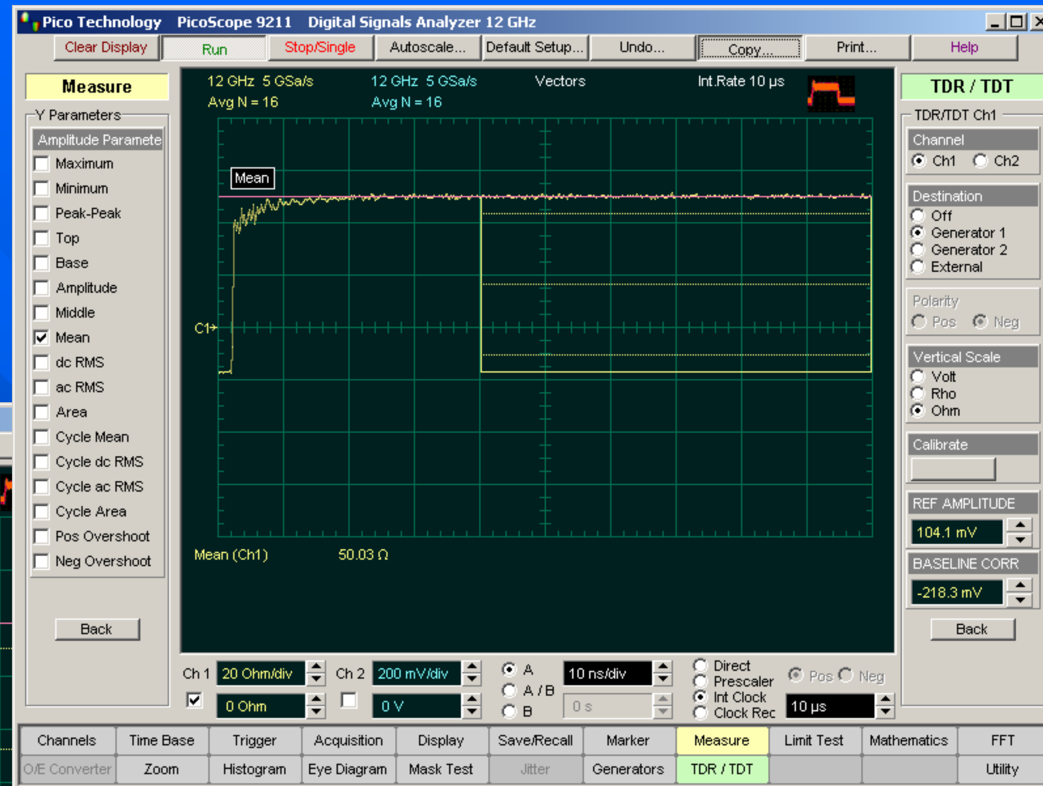
Rho
Reflection Coefficient is defined as follows: *Rho = Er / Eo*
where *Er* is the measured reflected voltage
Eo is the reflected voltage for the opened reference plane.
For open circuit: *Er* = *Eo* and Rho = 1
For short circuit: *Er* = *-Eo* and Rho = -1
For 50-ohm circuit: *Er* = 0 and Rho = 0

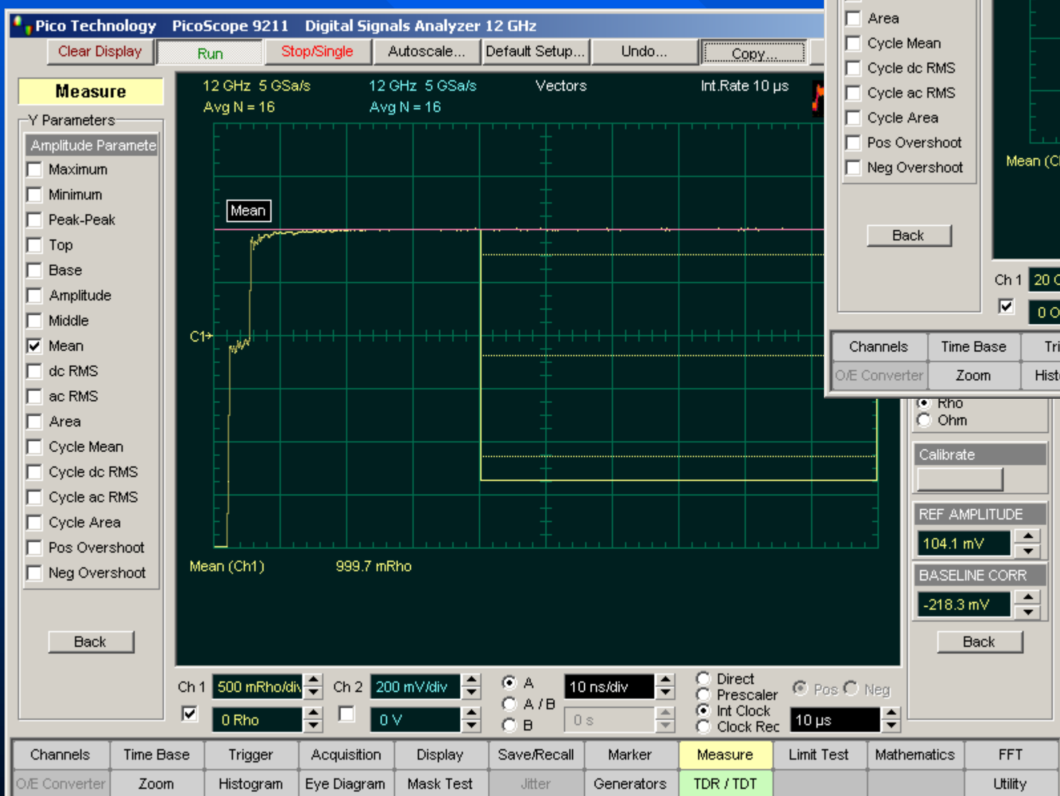
Ohm
Rho values can be converted to impedance values Z or back by using the following equations:
*Z = Zo * (1 + Rho) / (1 - Rho),*
Rho = (Z - Zo) / Z + Zo
where Z is the impedance of the DUT
Zo is the 50-ohm impedance of the transmission line
For open circuit when Rho = 1, Z = ∞.
For short circuit when Rho = -1, Z = 0.
For a 50-ohm circuit, Rho = 0 and Z = 50 ohm.

In addition to the voltage scale, TDT can also use **Gain** scaling. **Volt, Gain**
Gain
Gain is defined as follows: *GAIN = E / A*
where: E is the measured voltage
A is the amplitude of the TDT step.

Vertical Scaling in TDR/TDT (cont)

TDR Scale in Ohm





TDR Scale in Ohm

Horizontal Scaling

The selection is: Time, Meter, Foot, Inch

The Propagation VELOCITY or DIELECTRIC CONSTant controls let you specify the fraction of the speed of light at which the signal passes through your transmission line or network.

PROP VELOCITY and DIELECTRIC CONST apply only to axis units of distance, and do not apply if your horizontal units are seconds.

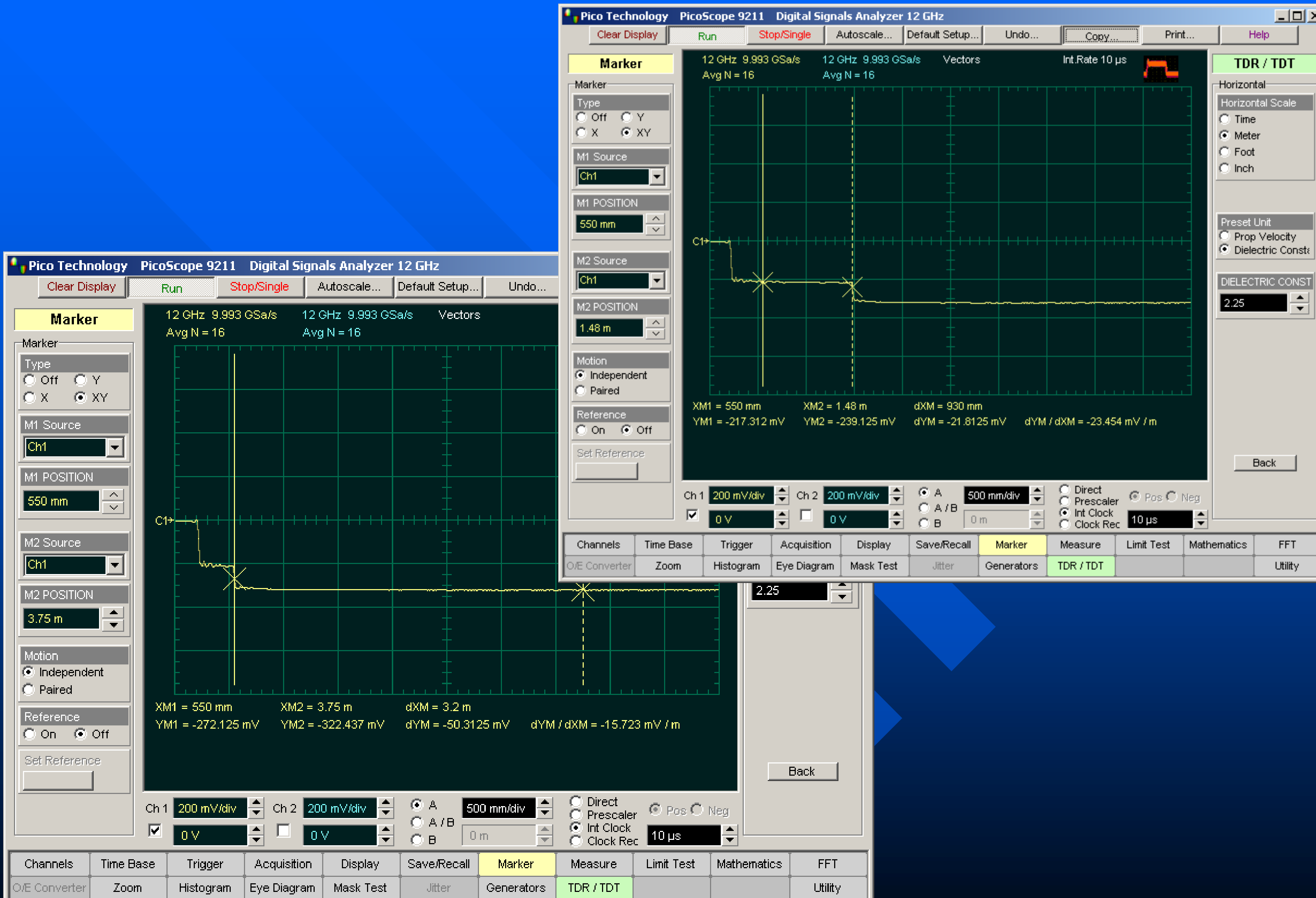
Propagation velocity is relative to an air-line transmission cable, so a setting of 1.0 indicates that your transmission line or network passes signals at the same speed as an air-insulated cable. The default value of 0.7 applies to most 50-Ohm coaxial cables with plastic dielectric.

You can change the value of propagation velocity from 0.1 to 1 in 0.005 steps, or the value of dielectric constant from 1 to 100 in 0.01 steps.

If you don't know the velocity but you know the dielectric constant of the transmission medium, you can convert its dielectric constant to a velocity using the following equation:

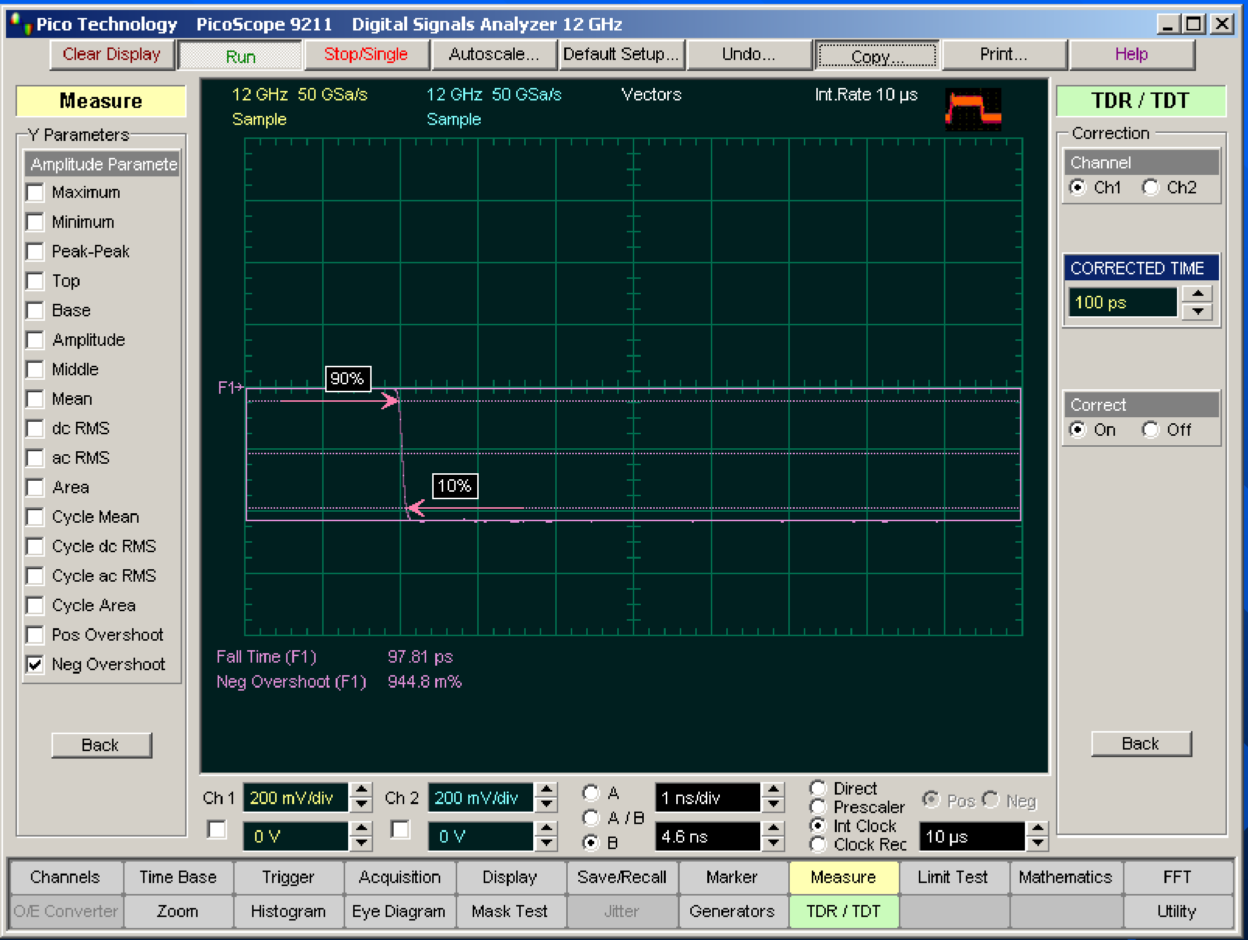
$$Velocity = \frac{1}{\sqrt{Dielectric\,Constant}}$$

Distance Measurements (cont)



TDR/TDT Correction

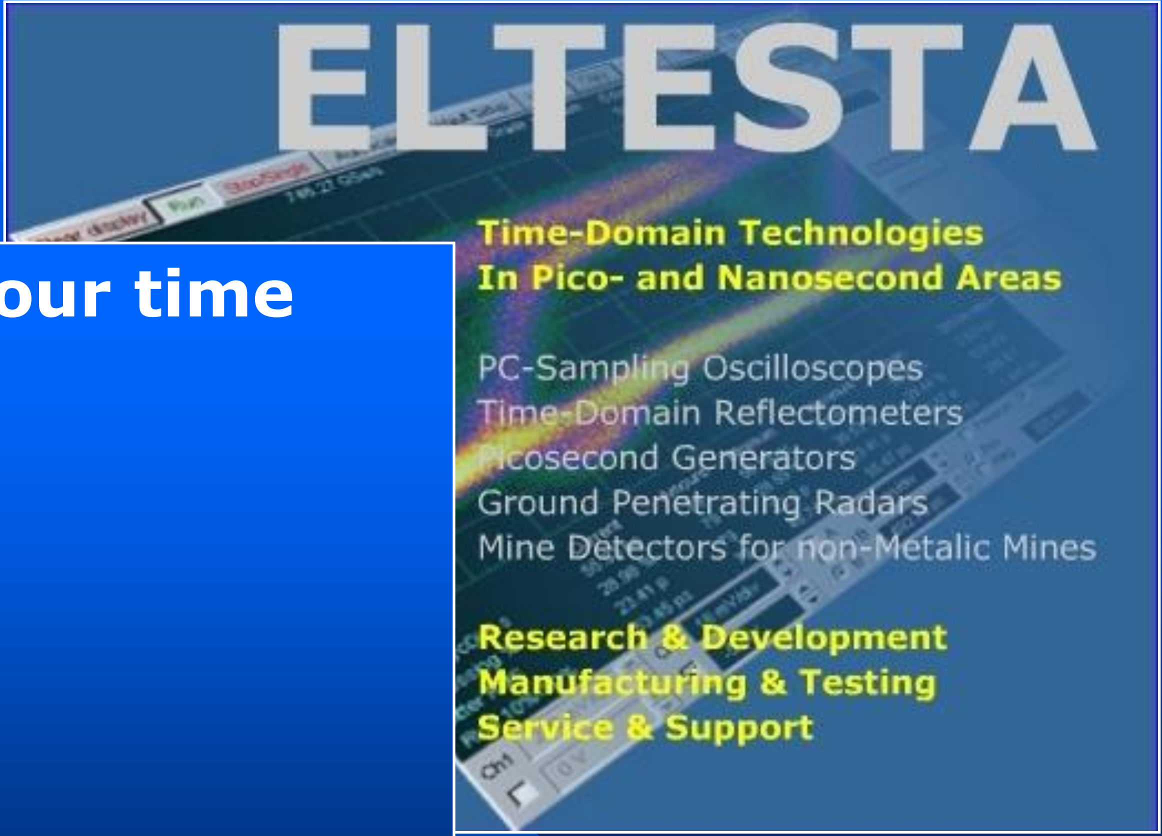
The Correction allows you to change the rise time of the corrected step for TDR or for TDT on each of the channels, and also to turn on or off the display of the normalized TDR or TDT trace (function).



The Correction allows you to change the rise time of the corrected step for TDR or for TDT on each of the channels, and also to turn on or off the display of the normalized TDR or TDT trace (function).
Correction procedure corrects for sources of measurement errors concerned with TDR response. By using correction, the results become more reliable, repeatable, and accurate. In addition, performing a correction allows the instrument to simulate stimulus steps with different effective rise times. This allows you to view the effect of actual signal rise times on the magnitude of reflections from discontinuities.

The measurement results show 97.81 ps corrected fall time and 0.9448% negative overshoot.

The End



Thank You for Your time

Questions?

info@eltesta.com

Application Notes available @ www.eltesta.com