Measure Cable Properties Using TDR

Low cost, portable, oscilloscope connected TDR

Measuring cable properties using Tektronix oscilloscopes and the Picotest J2151A PerfectPulse® TDR

A time-domain reflectometer, or TDR, can be used to measure cable properties such as dielectric constant, velocity factor, dielectric loss, skin effect, and rise time degradation. A variable output pulse train with 1kHz, 10kHz, 100kHz, 1MHz, and 10MHz square wave makes it easy to measure long cables. The TDR is usually a large expensive instrument that includes a high-speed edge pulse and a sampling oscilloscope. The National Institute of Standards and Technology (NIST)-certified J2151A along with Tektronix oscilloscopes can be used to make these measurements with excellent accuracy. More information can be found here: https://www.picotest.com/measurements/MeasuringPCB.html

Measuring cable dielectric constant (D_k) & velocity factor (V_f)

The D_k and V_f of a cable can be measured using

$$D_k = \frac{34.875 \cdot (t_{ns})^2}{(Length\ in\ inches)^2}$$

$$V_f\ (in\ percentage) = \frac{1}{\sqrt{\mathrm{Dk}}} \cdot 100$$

A known length of the cable can be cut to measure the round trip time (t_{ns}) which is in turn used in the D_k calculation.

Measuring cable length

There are cases when a cable is not accessible for measurement. The length can be measured using a TDR, employing the following

$$Length = \frac{11.81 \cdot t_{ns}}{2 \cdot \sqrt{D_k}} inches$$

where t_{ns} represents the round-trip time in the oscilloscope and D_k is the dielectric constant, which can be measured by cutting a small known length of the cable. Theoretically, the J2151A at 1kHz can measure up to 198km depending upon the cable losses and the sensitivity of the oscilloscope if the cable velocity factor is 0.66.

Measuring cable impedance

$$R_{DUT} = \frac{2 \cdot R_{GEN} \cdot V_{SCOPE}}{V_{GEN} - 2 \cdot V_{SCOPE}} = \frac{12.5}{V_{SCOPE} + 0.25} - 50$$

where R_{DUT} is the impedance of the device under test (DUT), R_{GEN} is the generator output impedance (50 Ω), and V_{SCOPE} is the voltage received in the oscilloscope (-500 mV).

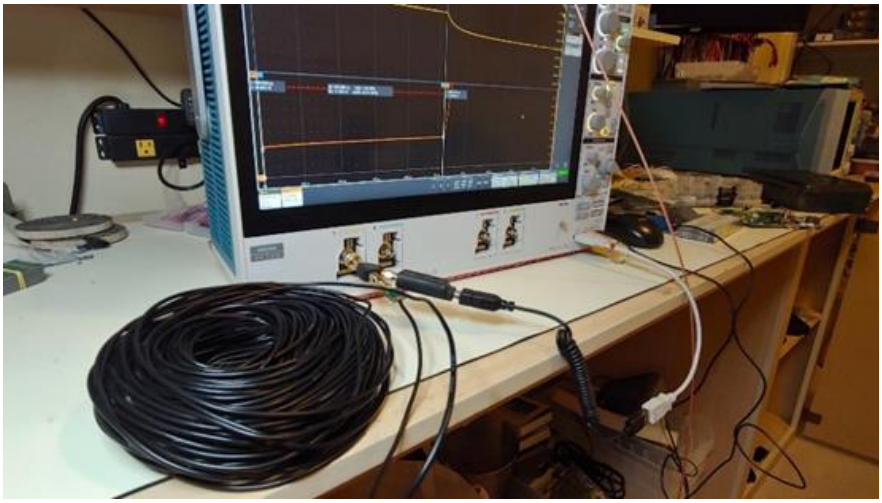
Picotest J2151A PerfectPulse® pocket TDR

Tektronix 5/6 series MSO

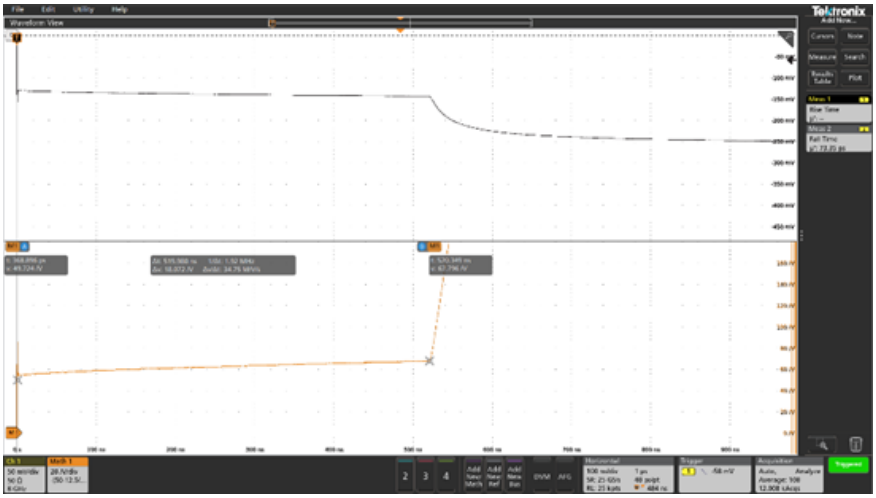
Sample TDR Test Board that comes with the J2151A. Trace 1 is a 50 Ω trace. Trace 2 is a "Beatty standard." It generates a significant reflection and can be used to get the dielectric and loss parameters of the circuit board. Trace 3 is 50 Ω with markers 3" apart to measure the speed of the signal relative to the speed of light. The ratio is related to the dielectric constant of the circuit board. The second "dip" is much shallower than the first because the edge was slowed by the trace discontinuity. Trace 4 is a shallow impedance step of roughly 5% (50 Ω to ~52.5 Ω).

PICOTEST

Long Cable Measurements Using the J2151A



Measurement setup of the J2151A capturing the reflection from 50m cable which is kept open at one end and connected to the TDR at the other end. The measurement can extract the dielectric constant, velocity factor, length, and impedance of the cable as described above.



The TDR response captured from the reflection measurement of 50m cable. The cable is a low pass filter and the cable attenuates the high frequencies in the TDR signal. The rise time and fall time are degraded due to the cable losses.

Picotest Products

J2151A	PerfectPulse® Fast Edge TDR
FRA BUNDLE	J2100A injection transformer, J2120A Line injector
J2150A	USB Harmonic Comb Injector
P21B01	1-Port and 2-Port Probes and DC Blocks
J2180A	Ultra-Low Noise 0.1Hz-100MHz Amplifier
VRTS03 Voltage Regulator Test Standard	supported tests – PSRR, Bode plot, Non-invasive stability, Load step, Noise density

To learn how this solution can address your specific needs please contact Picotest:
877-914-7426
info@picotest.com
www.picotest.com

PICOTEST

INJB05 - J2110AS Solid State Injector, J2111AS Current Injector, J2101A Injection Transformer 10Hz - 45MHz, J2102B Common Mode Transformer, J2120A Line Injector, J2130A DC Bias Injector, J2140A Attenuator, J2170B High PSRR Power Adapter

PWR100 Power Integrity Bundle includes the Bode 100 and INJB03

Picotest provides products that are designed to simplify measurements while providing the ultimate resolution and fidelity.

PICOTEST