



TDR for signal integrity

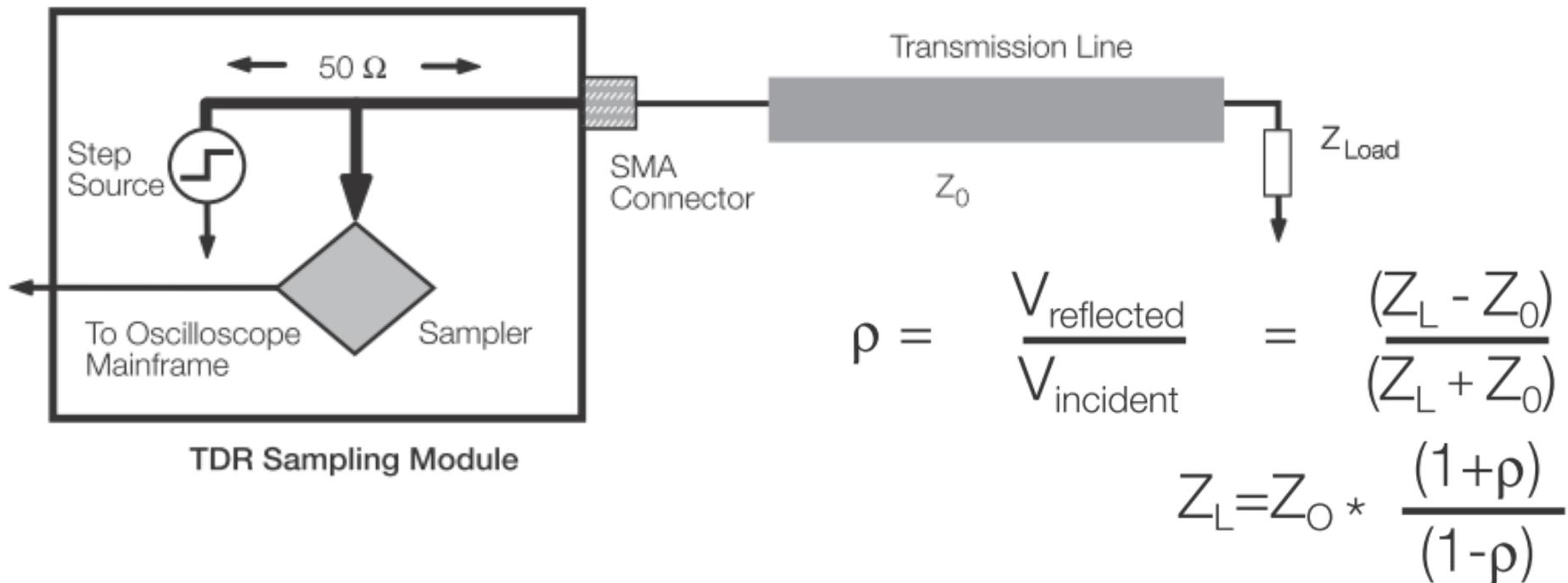
[Tektronix_TDR]

Time domain reflectometry

- To ensure signal integrity, it is necessary to understand and control impedance in the transmission environment through which the signals travel
- Mismatches and variations can cause reflections that decrease signal quality
- Methodology of choice for measuring impedances: Time Domain Reflectometry (TDR)
- TDR measures the reflections that result from a signal travelling through a transmission environment (a circuit board trace, a cable, a connector) *due to local changes in impedance*

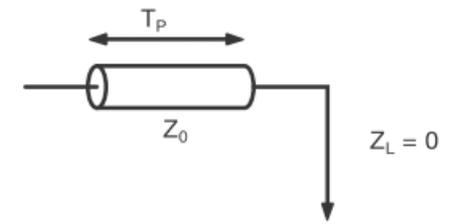
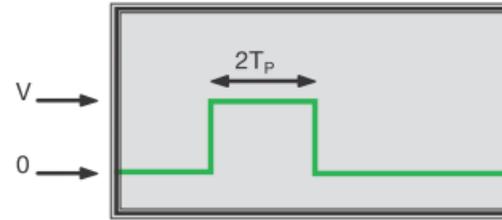
Time domain reflectometry

- The TDR display is the voltage waveform that returns when a fast step signal is propagated down a transmission line
- The resulting waveform is the combination of the incident step and reflections generated when the step encounters impedance variations

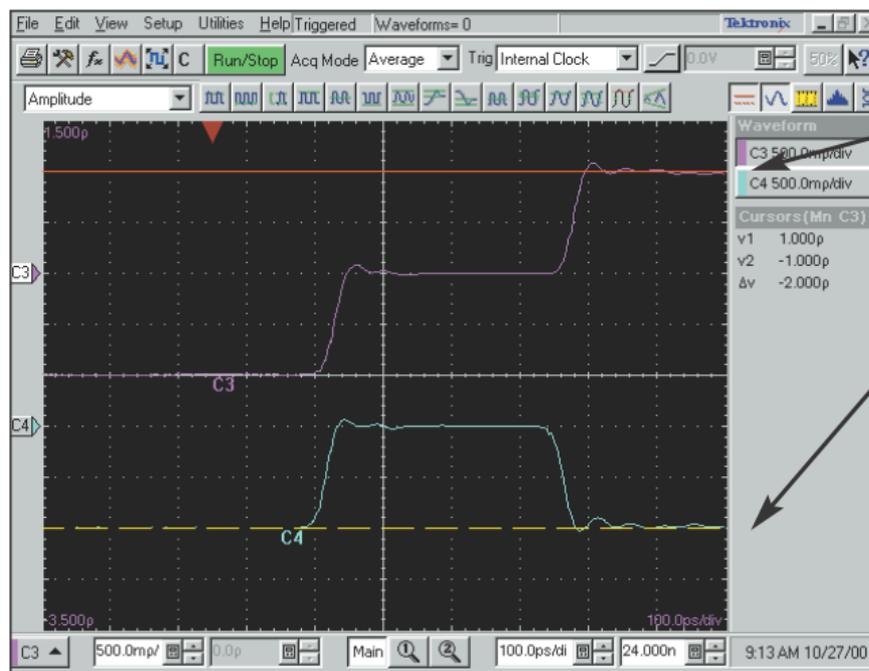
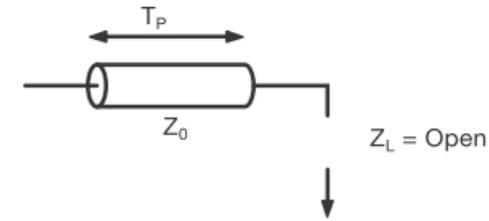
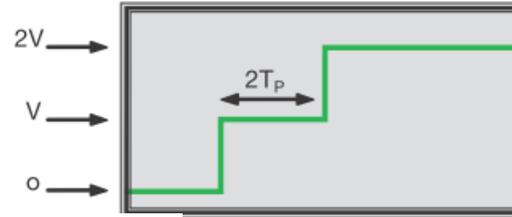


Some examples

- Short Circuit Termination



- Open Circuit Termination



Open
Circuit

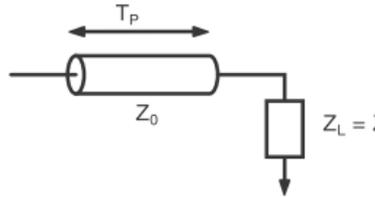
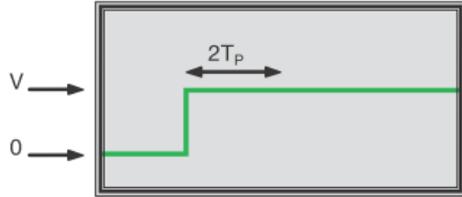
Short
Circuit

Figure 2. Time domain measurement shows a step with an open and a short circuit.

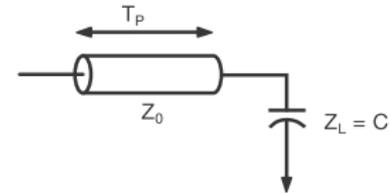
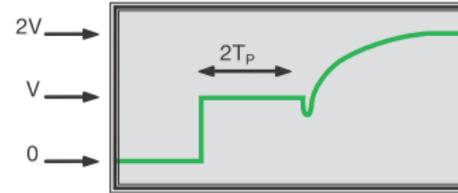
The short circuit is measured as -1ρ (rho) and the open circuit (infinite ohms) results in a ρ of $+1$.

Some examples

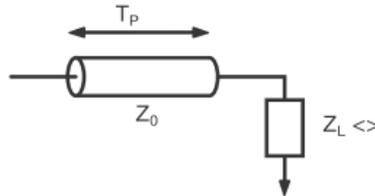
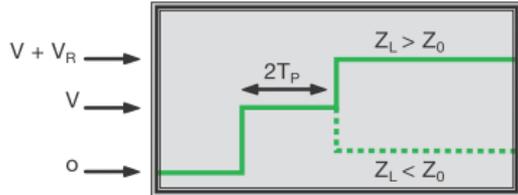
- Matched Load Termination



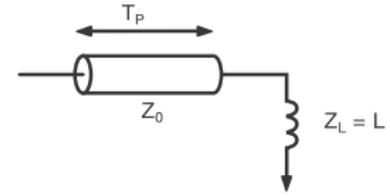
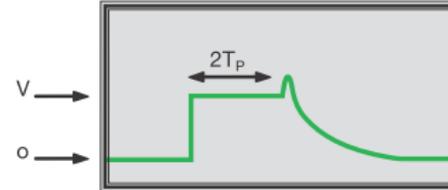
- Capacitor Load Termination



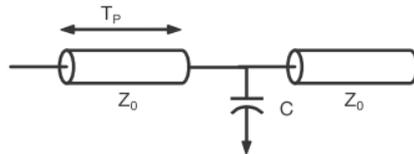
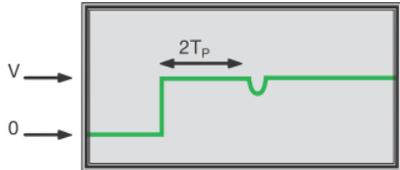
- Mismatched Load Termination



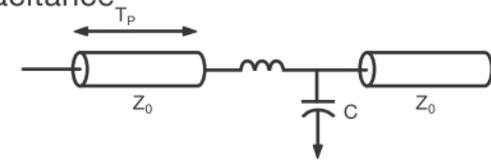
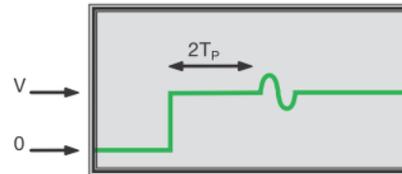
- Inductor Load Termination



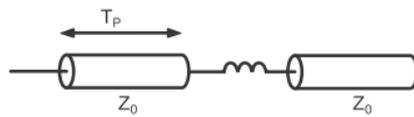
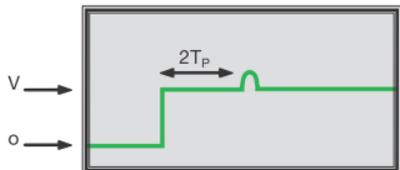
- Shunt Capacitance Discontinuity



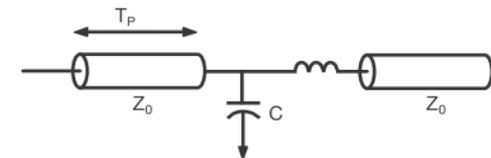
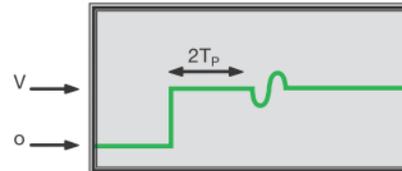
Series Inductance - Shunt Capacitance



- Series Inductance Discontinuity

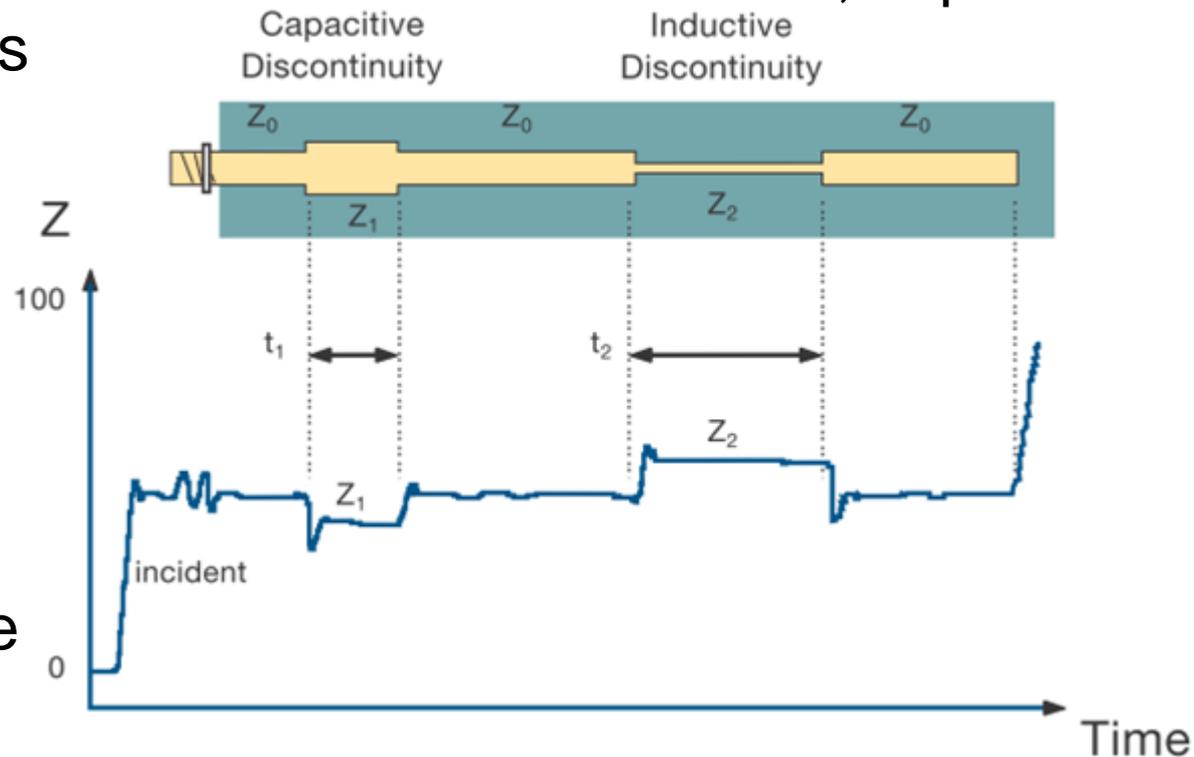


Shunt Capacitance - Series Inductance



In PCBs...

- PCBs typically have impedance-controlled microstrip and stripline transmission lines
- Components, vias, connectors and other “interruptions” create impedance discontinuities
- These discontinuities can be modeled as inductors, capacitors and transmission lines



- The waveform can be analyzed to determine how much the impedance deviates from the nominal value

Measurement system

A TDR sampling module

- produces a very accurate controlled pulse with fast rise time and minimal aberrations
- offers math functions that calculate
 - actual component values
 - physical distance to points of interest along the transmission line

