TDR Resolution Comparison

Time Domain Reflectometers (TDRs) are used in the pcb industry today primarily for controlled impedance testing of pcb traces. Historically, TDRs did not have the pulse rise times necessary to test short traces on raw pc boards that would actually go into end products, and so tests were performed on coupons placed around the edges of pc board panels. These coupons had probe point geometries, and trace lengths that were well suited to the capabilities of existing TDRS.

Today, there is an increasing demand from pcb customers for testing of the pcb traces on the raw pc boards themselves (on-board testing). This demand has increased as the size of the pc boards have decreased, and the capabilities of TDRs has increased. Newer high bandwidth TDRs are now capable of measuring much shorter trace lengths with good resolution, and new high bandwidth probe configurations are making it possible to probe on-board geometries , such as BGA pads, directly.

The first TDR requirement for on-board testing of short PCB traces is a fast pulse rise time. The relationship between pulse rise time and minimum required trace length is well understood, and has been clearly specified in the IPC Test Method 650 standard. This standard states that the resolution of the TDR (based on pulse rise time) determines the minimum trace length that can be measured accurately (see Table 4-1 below from IPC-TM-650). This assumes that the measurement is done at 50 ohms single-ended, or 100 ohms differential, which matches the impedance of the TDR, cables, probe, and trace under test. When measurements are made on traces with values outside this matched impedance, the minimum required trace length will only increase.

Table 4-1 (from IPC-TM-650)

TDR System Risetime	Resolution	4X Resolution
10 ps	5 ps / 1 mm [0.04 in]	4 mm [0.16 in]
20 ps	10 ps / 2 mm [0.08 in]	8 mm [0.31 in]
30 ps	15 ps / 3 mm [0.12 in]	12 mm [0.47 in]
100 ps	50 ps / 10 mm [0.39 in]	40 mm [1.57 in]
200 ps	100 ps / 20 mm [0.79 in]	80 mm [3.15 in]
500 ps	250 ps / 50 mm [1.97 in]	200 mm [7.87 in]

Table 2

TDR	**Rise Time**	**Minimum Trace Length**
CITS800	200	80 mm
CITS800s	200	80 mm
ST600	75	30 mm
ST808	20	8 mm
Tektronix	20	8 mm
Agilent	20	8 mm

Table 4-1 is a description of what is possible for a TDR with a given rise-time, so long as the rest of the system does not get in the way. It is also the line beyond which the TDR does not have even the theoretical possibility of resolving consistently to accurate numbers, and at which point the measurements are not within IPC standards.

Table 2 shows the current rise time numbers for several TDR manufacturers, and their model numbers. These numbers are theoretical best numbers, since there are many additional factors that

can degrade this performance, such as cable and probe losses, probe point discontinuities, mismatched impedances between the system and the trace under test, etc. These rise times are graphed below.