## WHAT IS THE FREQUENCY OF THE TDR?

One of the first questions that comes up when discussing TDR equipment, is 'what is the frequency of the unit?'. The term 'frequency' in this case is misused, since TDR's actually operate with a bandwidth that contains a spectrum of frequencies. For the purposes of this document we will use the term 'frequency' instead of bandwidth, since this is the term with which most TDR users are familiar. Typical frequencies for TDR's used in production environments for controlled impedance testing are 2 Gzh, 7 Ghz, 10 Ghz, and 20 Ghz.

## WHY DO I NEED HIGH FREQUENCY?

Another question that often arises when comparing different TDR frequencies is 'why do I need a high frequency TDR, when my pcb circuit will be operating at a very low frequency (comparatively)?' The answer is that the frequency of the TDR determines how short a trace can be measured. The higher the frequency of the TDR, the shorter the trace that can be measured. So if the traces to be measured on the pcb are 4-6 inches long, then a 2 Ghz TDR would be capable of making these measurements. If the trace lengths go below 3 inches, then a 7 to 10 Ghz TDR would be a better choice. For traces below 2 inches, a 20 Ghz TDR would be necessary.

## ESD

It would seem that a higher frequency would always be better than a lower frequency for any TDR, but higher frequencies have one major drawback in controlled impedance testing. Traditional 20 Ghz TDR's have been more suceptible to ESD damage, to an extent that the expenses of creating an ESD safe environment for the TDR are more expensive than the TDR itself. Newer TDR's are now overcomming this limitation and can now withstand up to 30,000 volts at the probe tips.

## FINDING THE RIGHT FREQUENCY

Choosing the right frequency may look more difficult than it is. With a few simple questions, it can be a very straightforward decision process. Depending on the answers to these questions though, the frequency requirements dictate the answer.

1. How short are the traces I want to measure?
   < 4 inches - 2-7 Ghz
   < 3 inches - 7-10 Ghz
   < 2 inches - 20 Ghz

2. Do I need to do on-board testing of product pcb's?
   Generally requires 20 Ghz due to trace length requirements

## FREQUENCY VERSUS IMPEDANCE

The question often arises 'doesn't the impedance value of the test change with higher frequency?' The answer is that most of the really large pcb factories have been using 20 Ghz TDR's for decades, and have been comparing their numbers with the 2Ghz TDR's quite well. While insertion losses are frequency dependent, impedance measurments are not as affected by frequency within the 2-20 Ghz range. In cases where the higher frequency is used on very narrow traces, there are software algorithms that compensate for the impedance losses that occur - similar to how the 2 Ghz TDR's process these types of traces.

## IT'S ABOUT COST

The issues surrounding higher speed TDR's are really all about cost. What is the cost of the instrument? What is the cost to build ESD protection? What are the repair costs? What are the probe costs? High speed TDR's today are capable of making the widest range of production measurements possible, most particularly short length, on-board and insertion loss measurements, but they are more expensive to buy and maintain. However, new TDR's are now becomming available that reduce costs significantly in each of these areas. Operating costs for a 20 Ghz TDR can approach that of a 2 Ghz TDR.