

Thresholds for electrostatic discharge and electrical fast transients

By Mike Hertz

Industry standards in the areas of radiated immunity and conducted immunity testing require an oscilloscope for verification of pulse shape and pulse measurement parameters such as rise time, fall time and pulse width, on pulses created with electrostatic discharge (ESD) and electromagnetic coupling (EMC) generators. However, due to the pulse shapes used in the EMC testing standard, oscilloscope parameters have historically not been able to accurately measure these parameters. Traditional pulse measurements require the instrument to determine the steady-state high value of the pulse (top) and steady-state low value of the pulse (base). Top and base are determined from a voltage histogram that detects these two prominent modes. The threshold levels used to compute pulse parameters such as rise time, fall time, and pulse width are derived from the top and base values. For example, the thresholds used for a rise time measurement, defined as the time corresponding to a signal transition from 10% to 90%, is dependent on the 0% and 100% levels defined by base and top.

Consider the electrical fast transient (EFT) pulse (Figure 1). The pulse characteristics do not conform to the IEEE pulse parameter definitions because the EFT pulse does not have high and low steady-state values. After a fast linear rise to a sharp peak, the waveform then exponentially decays toward, but does not quickly reach, an asymptote. With no steady-state values, the EFT pulse would produce indeterminate top and base values. Because top and base must be determined in order to calculate the thresholds used for rise and fall times and pulse width, the measurements become invalid when using traditional oscilloscope pulse parameters.

EMC pulse measurements require the use of thresholds set to 0% and max, (where max is the peak voltage level of the waveform), instead of top and base, to meet the measurement specification. In the past few years, modern oscilloscopes have begun to allow for EMC pulse parameter measurements using threshold settings of peak-to-peak, 0% to max and 0% to min along with the standard absolute or percent levels.

In Figure 2, an electrostatic discharge waveform was acquired. The pulse width and rise time are measured with and without EMC thresholds applied. In parameter 1 (P1), the thresholds are set to 0% max, and the pulse width is measured correctly as 2.109 nanoseconds. In parameter 2 (P2), the thresholds are set to the standard scope threshold of 50% of top and base. In this case, the measurement is incorrectly reported as 50.348 nanoseconds—an error of 2287%. The width measurement was impacted so significantly that the 50% threshold between top and base actually produced a width measurement on the wrong pulse shape. Parameter 3 (P3) is set to the correct EMC threshold of 0% to max, producing a correct electrostatic pulse rise time measurement of 833 picoseconds. Notice that in parameter 4 (P4), the standard rise time is incorrectly reported as 873 picoseconds. When using standard pulse parameter measurements, erroneous values can be obtained. Note also, that in addition to correct measurement parameters P1 and P3 in Figure 2, the measurement parameters P1 and P2 displayed in Figure 1 were also calculated correctly using 0% max thresholds on the EFT pulse.

On a related note, because EMC pulses often have pulse perturbations on the falling edge of the pulse, these can result in false measurement readings when using standard parameters. For example, if the falling edge had ringing oscillations that repeatedly crossed the threshold, then multiple false width readings would be possible. For this reason, a measurement filtering capability that can limit the number of pulses the scope measures in an acquisition is needed. This

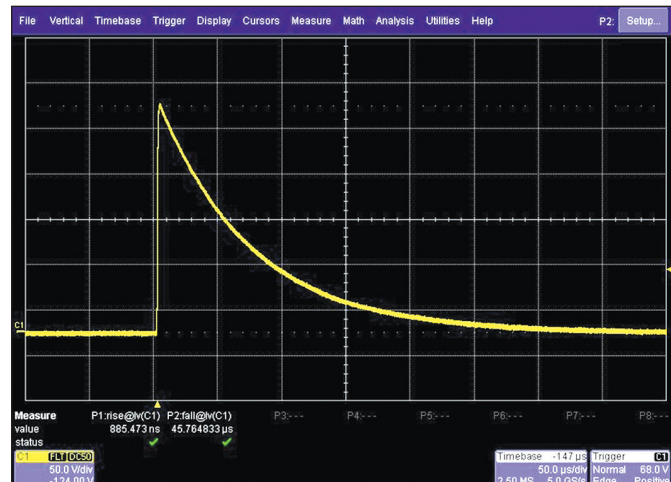


Figure 1. An EFT pulse does not have a clearly defined top and base.



Figure 2. Comparison of standard vs. EMC thresholds for pulse measurement parameters. Use of standard pulse thresholds produced more than 2000% error on this electrostatic discharge pulse.

measurement filtering capability, available on modern scopes, allows for pulse-like perturbations on the falling edge of a pulse to be ignored and excluded from the measurement results.

In conclusion, non-standard measurement capabilities are required to perform accurate pulse parameter measurements of electrostatic discharge, electrical fast transient, surges, voltage dips and interrupts. Selecting the correct measurement threshold can make a significant difference in the measurement accuracy of these signals. **RFD**

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