ESD Test Pulse Amplitude Stability in Device Testing

8/27/12 JEB

Resistance variation of resistors used in pulse forming circuits used in ESD testers has been ignored for many years. This includes both "short term" resistance variations during the HV test pulse and "long term" resistance variations of a resistor's stability. We can first examine the most egregious ESD test pulse variable produced in typical IEC guns originally designed for System level testing. The present concern is that this current waveform has become a pass/fail test for HMM testing of devices directly connected to the outside world. This test has been used to substitute Cable Discharge testing. Without a tester specifically designed for cable discharge testing of devices, the IEC gun became another wide tolerance ESD test. While it provides some level of certainty, it has major repeatability problems.

Excessive HMM failure level test variations have been formally identified by ESDA WG 5.6. It has standardized the test method for the industry. It has attempted to improve test repeatability with limited success so far for two basic reasons.

The first is the amount of excessive EM radiation that leaves gun without being part of the specified current waveform. For devices that have high speed sensitivities, the gun radiation can couple to DUT leads in the testing circuit and cause false triggering. EM radiation leaves the gun first because the current pulse takes a tortuous path to slow it down and form its shape. The high speed EM radiation is not part of the current pulse itself and has had no limits to its amplitude or time response. The EM threat primarily affects RF devices because interface IC's are simply used to operate I/O ports. Their ESD protection typically operates above 20 volts so they seldom contain sensitive gate oxides.

The second variable in HMM testing is that caused by inconsistent energy in the IEC waveform. Obvious variations occur between different testers with different waveforms. However variations can occur in any individual tester if the pulse forming elements are not stable. Too often non-pulse rated carbon composition resistors are used because their large bulk withstands the pulse energy much better than film resistors. However without obvious resistor burn-out carbon composition resistors used in HV pulse circuits develop instabilities after significant use. Short pulses of high energy applied multiple times in pulse shaping circuits often begin to show resistance instabilities at both low and high voltage operation.

Simply because a resistor will not burn-out after application of multiple high voltage pulses, does not mean that it will provide a reliable resistance function in the long term. Reliable HV pulse circuits which use resistors in the pulse forming circuit must use resistors which are rated for the specific pulse application. Such resistors are commercially available. Their use in pulse generating circuits greatly reduces variations in pulse amplitudes or shapes. To insure repeatable pulse generation over the use of the equipment, manufacturers can specify that pulse forming circuits are rated at some tolerance over the specified life of the circuit. This requires stability measurement by the manufacturer to insure that during its operating life it will insure immunity to changes from the application of HV pulses. This is not an unusual requirement in the pulse power industry, but such stability requirements have been ignored in ESD test equipment manufacturing. Use of stable resistors will greatly minimize the variations in the energy produced by ESD type pulse generators.

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While ESD testers may be rated for specific amplitudes and waveforms early in their life, it is their long term repeatability that affects ESD test results. Insuring resistance stability, both short and long term, insures that the pulses generated have constant amplitude. Many ESD testers deliver pulses which use resistors in the test pulse shaping circuit. For these testers, long term resistance stability ratings will insure that the pulse shape is consistent over time.

A different but also important variable in pulse generating circuits is voltage coefficient of capacitance. When the capacitance value is important to the pulse shape throughout the pulse commercial capacitors can be used which have inherently low voltage coefficients of capacitance. Capacitance stability at any voltage is just as important as resistance stability at any operating voltage in pulse forming circuits. As with resistors the coefficient of capacitors can also be measured to insure that they provide the same capacitance at all operating voltages.

Constancy and/or stability of these two simple circuit components seem to have been ignored in the design of some types of ESD test equipment. When we accept these variables we do so at the expense of constant and often frustrating efforts to improve ESD tolerances in DUT failure levels. Inherent manufacturing variations in device failure levels do not need additional variables in ESD tester variations.

Should we demand improved pulse stability in ESD test equipment, or continue fighting loosing battles, vainly searching for improvements in existing equipment?

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