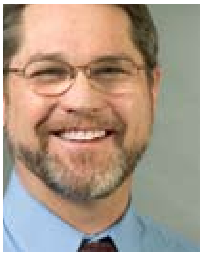

BY HOWARD JOHNSON, PhD

The nature of ESD

Alex Ching from BJ Pipeline Inspection Services in Canada designs large, complex digital systems. His product incorporates analog, digital-logic, battery, and chassis grounds, which connect at various "single-point connections" using wires, 100-kΩ resistors, and TVSDs (transient-voltage-suppression diodes). When he strikes the product with an ESD (electrostatic discharge), errors appear on sensitive internal LVDS (low-voltage-differential-signaling) data lines. Ching has sprinkled ESD-protection chips throughout the product in a fruitless attempt to control that problem. He says that, when an ESD event activates these protection chips, they are supposed to dump ESD currents into the digital-logic ground. From the digital-logic ground, he assumes that the currents flow through a single-point connection to the battery-ground network and, from there, through the parallel combination of a 100-kΩ, high-voltage resistor and an SMBJ5.0CA TVSD to the chassis. "Since the ESD-protection chips are so far from the chassis, ESD currents must travel a long distance on the digital-logic ground before passing through the battery ground to the chassis," Ching says. "Is this long ESD current path causing noise on my LVDS logic?"

Ching faces a common problem: In response to various noise issues that have emerged over the life of his product family, engineers have modified the grounding structure, probably several times, resulting in a "confused" grounding architecture. I cannot understand his whole system from this brief description, but I can perhaps discuss the general nature of an ESD transient.

ESD transient currents spread far and wide.

ESD is a fast event. As the ESD currents surge through your system, they follow, at each instant, what seems the best path available. If, for example, an ESD transient current reaches a junction of two wires, it splits evenly, half going down each wire, with no regard to where the wires lead. One path may lead to a good ground, whereas the other leads to an open circuit. The current cannot discern the better path to ground without first propagating to the ends of the two pathways. Only then, after considerable time and many reflections pass, do the lower-frequency elements of the ESD transient begin to recognize what you may think of as the best path to ground.

As a result of this behavior, the single-point ground connections in Ching's product do almost nothing to guide ESD transient currents. Once inside the product, ESD transient currents spread far and wide regardless of any ground jumpers, 100-kΩ resistors, and TVSDs that may exist. For example, ESD currents can easily jump directly from board to board through no connection other than the parasitic capacitance of one system element to another. In other cases, current flowing on one path can, through the action of mutual inductance, easily induce destructive voltages in an unrelated pathway.

To control ESD transient currents, you must design the system so that ESD events have only one clear path to ground at every point. For example, terminating a shielded cable onto a metal-shell connector with 360° shield contact around the connector and between the connector and the metal system chassis provides an adequate means of shunting ESD transients from a cable shield to the chassis. The transients have nowhere else to go.

Although TVSDs do a good job limiting the voltage across their terminals, they do not prevent current transients from entering your system. Once current passes through a TVSD, it must still return to ground. Generally speaking, if you mount the TVSD anywhere on your PCB (printed-circuit board), then you allow ESD current to flow on the PCB, and you may lose the war for that reason alone. The best designs shunt ESD currents back to earth before entering sensitive areas of the product.

Ching needs to properly diagnose his system before making any more changes. An engineer familiar with EMI (electromagnetic interference) can determine precisely where the ESD currents are flowing within the product and then design adequate means of protecting the product. Doug Smith of D.C. Smith Consultants provides some great tips on his Web site, www.emcesd.com, about diagnosing the flow of current from large, fast transient events. EDN

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