Keep pc-board testing from harming low-voltage ICs

Teradyne's new "SafeTest" technology prevents test from creating the very problems it aims to solve

"First, do no harm." This fundamental tenet of physicians' Hippocratic oath might well apply to the testing of printed-circuit boards. That's because when you attempt to test today's pc boards with yesterday's in-circuit testers, you run the risk of causing serious damage to the chips. Result: waste for your company, irate customers for your boards, or even fatalities when defects show up later in a host of applications, ranging from consumer goods to medical and industrial products.

In large part, the problem can be traced to the relentless trend toward miniaturization in electronics. By shrinking the size of the features that they etch into semiconductor dice, IC manufacturers achieve lower costs, while improving speed and building in more functionality. However, this move toward smaller features has led to lower breakdown voltages and ultimately more defects in pc-board testing. The chief reason: Testers designed for boards that traditionally operated with a power-supply voltage of 5V are still being used on new generation ICs, which operate on 2.5V, 1.5V, or even 0.8V. These new chips require more accuracy and safety features than are available on conventional pc-board testers. Without improvements in testing, the only alternative for companies is to use older components, which fail to meet customer expectations.

Teradyne's solution: SafeTest

To solve this growing problem, Teradyne is leading the way with new in-circuit technology that it calls "SafeTest." It is available only on Teradyne TestStation in-circuit machines, which are priced from $140,000. SafeTest involves much more than merely scaling down the voltages that the test system applies to the boards. Preventing IC damage is only one of SafeTest's objectives; another is improving test accuracy. Even when they don't damage devices, outmoded testers can produce misleading information. For example, good boards can appear to have failed tests that they actually passed. In other instances, customers are shipped defective boards because testing failed to detect problems it should have caught.

"Few fields undergo changes as rapid as those in electronics," says Alan Albee, product manager of Teradyne's TestStation in-circuit products at the company's North Reading, MA, facility. "It's important that PCB manufacturers around the globe understand what features are required to accurately, reliably, and safely test low-voltage technology."

To understand what makes SafeTest technology so effective, first consider the operation of a typical tester. Most in-circuit-test systems rely on bed-of-nails fixtures that give the instruments within the test system electrical access to every node (or net) of the pc board. Using this access, the tester takes a divide-and-conquer approach, testing each component on the assembled board.

To perform powered-up testing of digital components, the tester uses driver/sensor circuits capable of driving a device's input pins to the required logic states and sensing the output pins' resulting logic states. The digital pin drivers can typically supply or sink currents of 600 mA or more. The driver momentarily forces nodes on the board to the logic levels the test requires. Temporarily overdriving component outputs to force a node to its opposite logic state is called *backdriving*.

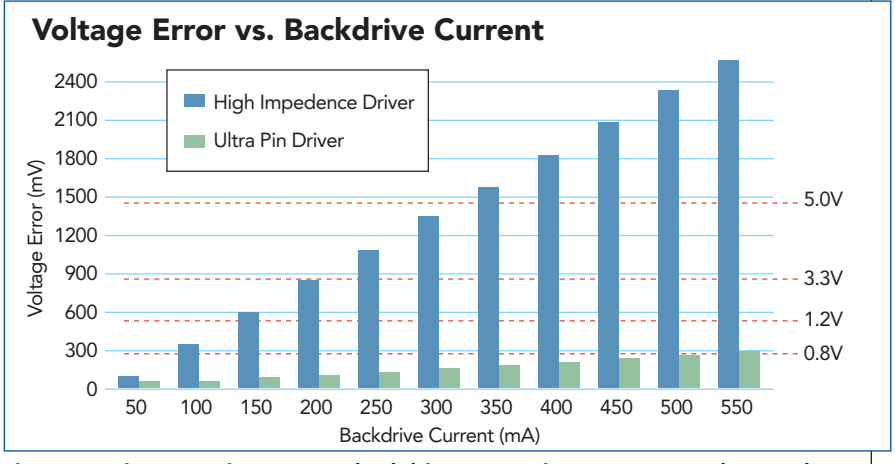
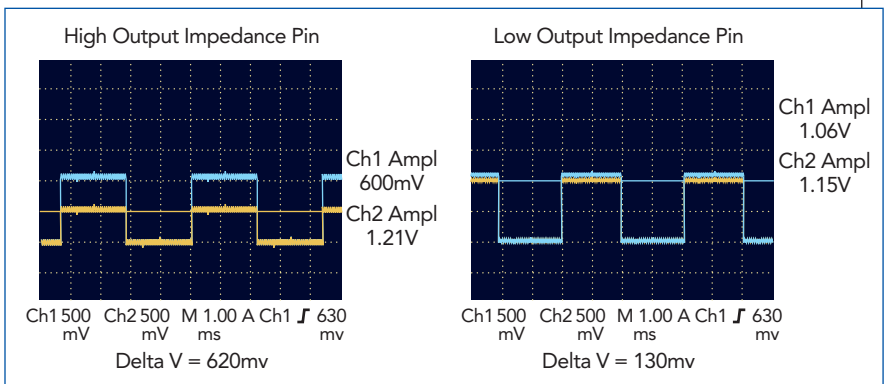


Figure 1: Driver error increases as backdrive current increases. Note the very low error rate in the low-impedance driver used in Teradyne's SafeTest technology.



At left, a high-impedance driver produces a 620 mV voltage error when driving a node that requires 150 mA of backdrive current. In contrast, a SafeTest low-impedance driver, right, limits the error to 130 mV.

This backdriving effect occurs quite commonly-because of the board's circuit design, the fault conditions on the board, or missing isolation code in the test program. What's more, the pin-driver electronics design can increase the likelihood of backdrive-induced device damage, as well as reduce the accuracy with which the tester imposes the intended conditions on the device under test. To prevent these problems, SafeTest relies on a low-impedance driver architecture, which maintains high accuracy under high-current backdrive conditions. In addition, SafeTest features high-speed control circuits, which shorten the duration of backdrive, further reducing the possibility of device damage.

Case in point: PC-motherboard test

To see how SafeTest performs versus conventional technology, take the example of a typical in-circuit-test program for a personal computer motherboard. Here, backdriving occurred in 17 of the 56 digital-device tests. During program execution, backdrive currents exceeded 50 mA 156 times. The median backdrive current was 176 mA, the highest-current event required 600 mA, and the longest backdrive duration was 2.5 msec. On conventional in-circuit testers that use high-output-impedance rail drivers, backdriving of this magnitude can cause serious problems. For example, as the backdrive current increases, the pin driver's voltage error increases dramatically, causing the tester to apply to the device under test voltages that differ substantially from those the test engineer intended. Figure 1 demonstrates the relationship between backdrive current and driver error. Note the very low level of voltage inaccuracy in SafeTest's low-output-impedance pin-driver design.

Teradyne's TestStation LH in-circuit pc-board test system incorporates the groundbreaking SafeTest low-voltage-test technology.

Still another harmful effect of excessively high backdrive currents in low-voltage ICs is overstress of ESD (electrostatic-discharge) protection diodes. Some device manufacturers warn that ESD diodes should not carry currents higher than 100 mA. Exceeding these ratings can cause ESD-diode damage that factory testing doesn't detect. However, identifying and avoiding ESD-diode overstress is impossible for most in-circuit testers. Teradyne emphasizes that only testers that embody SafeTest technology can measure real-time backdrive currents, report where backdriving is occurring on a board, and program maximum backdriving current and time limits.

Teradyne engineers also view SafeTest as an effective safeguard against a failure mechanism known as latchup, which occurs in CMOS (complementary metal-oxide silicon) devices when a pair of transistors forms a PNPN or NPNP SCR (silicon-controlled-rectifier) structure. When the SCR turns on, it establishes a low-impedance path from the power-supply terminal to ground. High current in the path can destroy the device or cause it to malfunction. Latchup usually results from applying a rapidly rising or falling voltage spike that exceeds the maximum or minimum voltage specifications of a CMOS device input pin. In many cases, latchup occurs because of electrostatic discharge or during in-circuit testing when an output suddenly changes its logic state while it is being backdriven.

Such voltage spikes can adversely affect the reliability of the test and the device itself. Teradyne recognized that preventing these potentially harmful spikes during digital in-circuit testing required multiple-level digital-isolation, a feature incorporated into SafeTest. This isolation capability ensures that all outputs on a net are controlled and are in a known state before connection of a digital driver. Some in-circuit testers isolate only outputs that are directly connected to device-under-test inputs. But this approach doesn't prevent potentially troublesome spikes on nets that aren't directly connected to the device under test.

Because SafeTest solves so many of these problems, Teradyne sees strong potential for the new technology throughout the world of low-voltage pc-board test. The company notes that not only are the costs of the new testers comparable to traditional technology, but customers stand to reap greater benefits from fewer defects and improved customer satisfaction. Since the technology was introduced in early 2003, applications for the new tester have spread rapidly to include handheld devices, medical products, and large boards used in servers and telecommunications systems. ■

FOR MORE INFORMATION

To learn more about SafeTest technology, visit:
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