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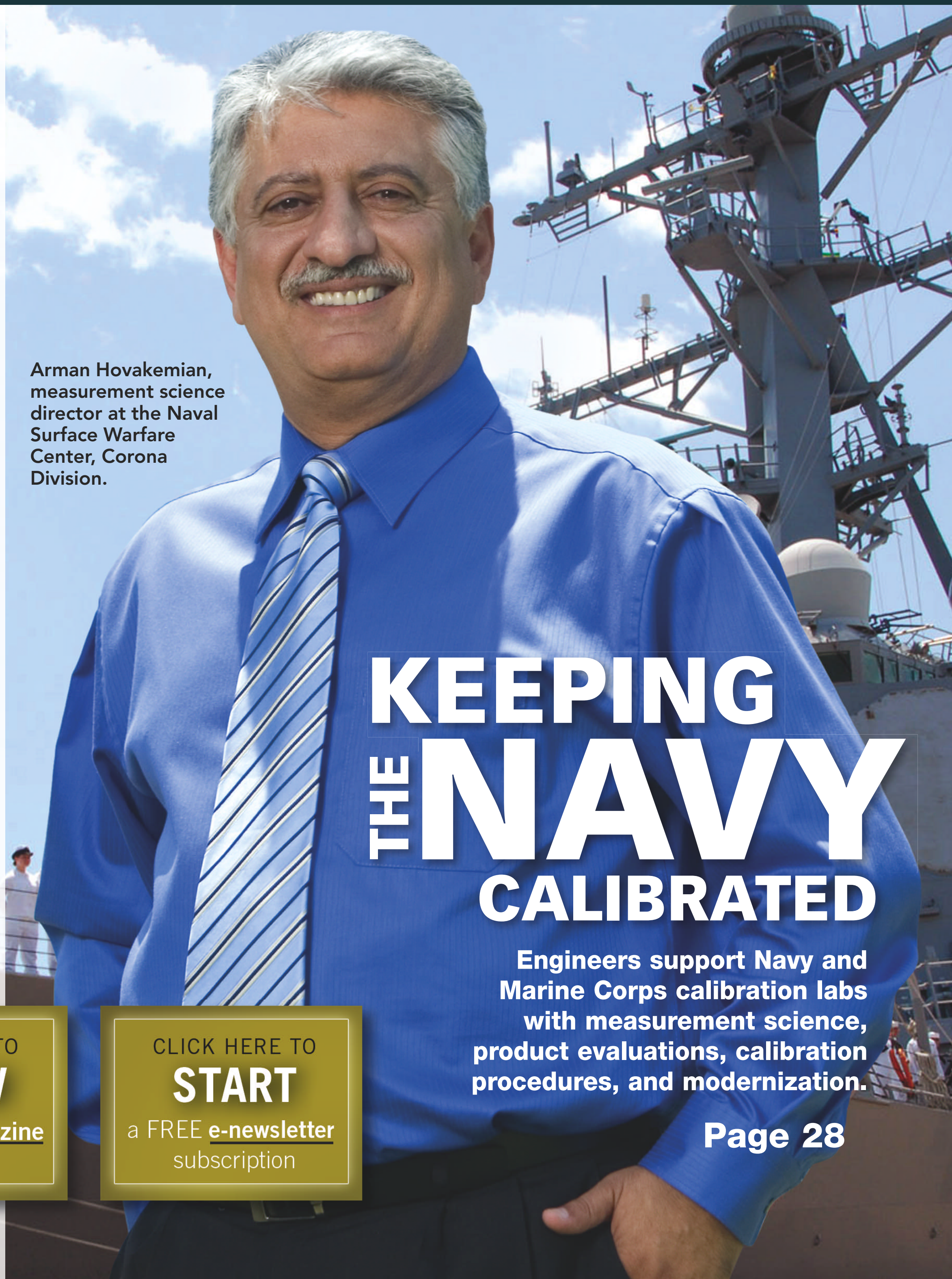

Arman Hovakemian, measurement science director at the Naval Surface Warfare Center, Corona Division.

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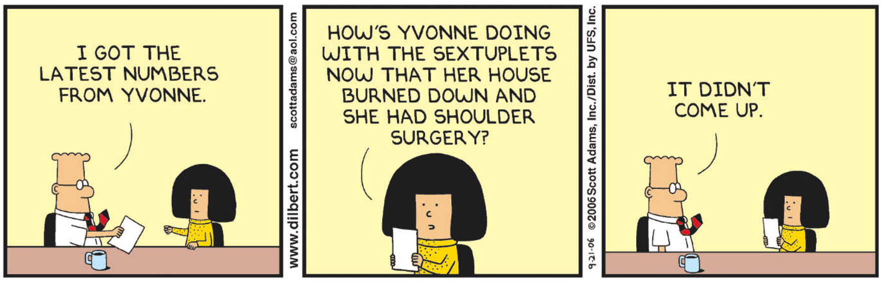

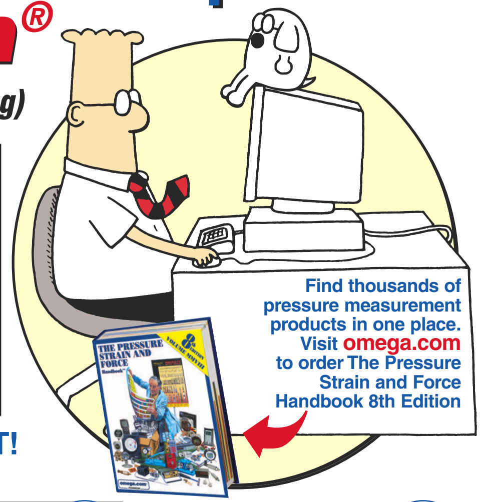

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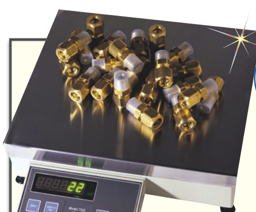

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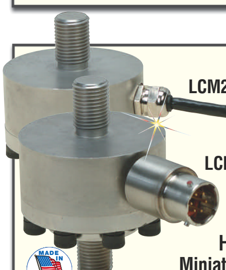

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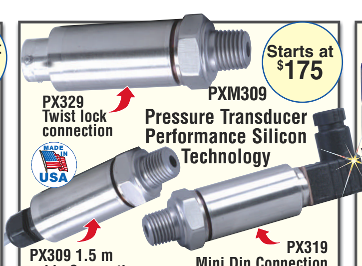

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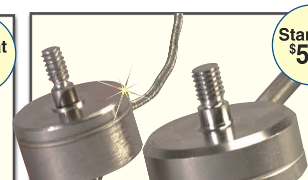

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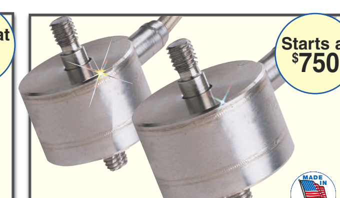

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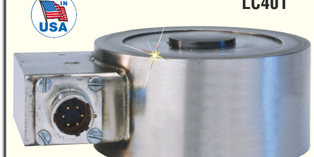

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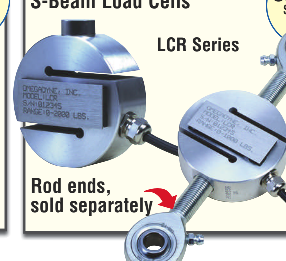

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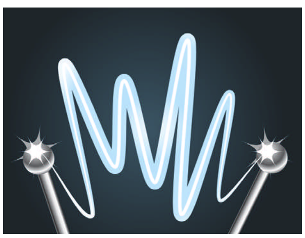

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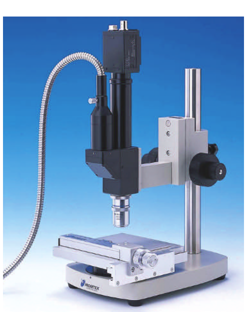

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Guest commentary

Multicore processors drive Instrumentation 2.0

In this fourth installment of a series about Instrumentation 2.0, David A. Hall, product marketing engineer at National Instruments, explains how multicore processors are helping engineers push their instrument systems to higher performance levels. Previous installments covered PCI Express and FPGAs.

www.tmworld.com/guests

How does your salary compare?

SALARY SURVEY 2007

Check out the results of our 2007 Salary Survey to find out whether your salary and benefits are competitive with the rest of the test-engineering industry. Plus, in "Testing in a frantic environment," contributing editor Lawrence D. Maloney notes that the concerns of engineers have shifted from worrying about job security to finding enough time to deal with an often overloaded plate of projects.

www.tmworld.com/salary2007

Blog commentaries and links

Taking the Measure

Rick Nelson, Chief Editor

- Beware the electronic dung heaps
- "Take this job and shove it"
- Should we stem the flow of funds to STEM?

LXI: Instruments and Applications

moderated by Rick Nelson, Chief Editor

- Podcasts recap LXI China meeting
- LXI to feature remote access demo at Autotestcon

Education and Careers

Amy Laskowski, Contributing Editor

- 9th graders are too set in their ways
- The school must help alumni if it wants alumni to help the school

Engineering Students at Work

Jessica MacNeil, Contributing Editor

- Industry experience in the classroom
- The industry needs you as much as you need it

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Not by STEM alone

STEM education in the US got a boost on August 9 when President Bush signed the America Competes Act. The act could provide up to $43.3 billion through 2010 for research and education programs in the STEM (science, technology, engineering, mathematics) subjects.

Would that be money well spent? Maybe not. The act has its share of skeptics, including the President himself, who expressed concern that the bill creates duplicative or counterproductive new programs while providing excessive funding for existing programs.

RICK NELSON, CHIEF EDITOR

Writing recently in the *Wall Street Journal*, Chester E. Finn Jr. and Diane Ravitch in "Not by Geeks Alone" go beyond criticism of specific programs to take issue with the current obsession with STEM education. They don't explicitly call for cuts in STEM spending, but they caution against letting STEM subjects overshadow literature, art, history, civics, and geography.

Americans with high-tech skills, they say, will always risk losing jobs to equally skilled people around the world willing to work for one fifth the salary. Further, they say, those who would de-emphasize the humanities are "misconstruing the true nature of American competitiveness and the challenges we face in the 21st century."

Will enough students be available to take advantage of STEM funding?

They suggest that the liberal arts are important even for those in high-tech fields: "Apple's iPod was not just an engineering improvement on Sony's Walkman. It emerged from Steve Jobs' American-style understanding of people's lifestyles, needs, tastes, and capacities." They go on to note that while Jobs dropped out of college, he went on to study philosophy and foreign cultures.

They warn against "turning US schools into test-prepping skill factories where nothing matters except exam scores on basic subjects," adding, "We need schools that prepare our children to excel and compete not only in the global workforce but also as full participants in our society, our culture, our polity, and our economy."

Apart from over-funding concerns on the one hand and the short-changing of equally important humanities subjects on the other, I'm concerned that the student power simply won't be there to take advantage of whatever STEM programs become available. According to a recent Princeton Review survey, engineering doesn't rank among the top 10 most popular majors in the US.

To improve that figure, it's important that some America Competes funding go into middle- and high-school programs—such as FIRST—designed to get American students interested in STEM subjects, and into college programs—such as EPICS—that will encourage university students to persevere. T&MW

See the online version of this article (www.tmworld.com/2007_09) for links to source material and to the programs cited.

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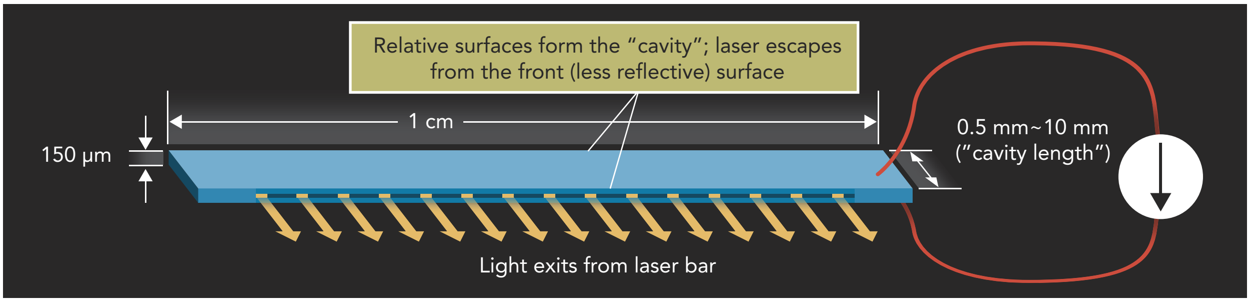


Diode-laser arrays emit light from one surface only and often require profiling.

Measured bars of light

Daniel Shi, a staff test engineer at Coherent (Santa Clara, CA), is responsible for metrology, calibration, and measurement-system analysis for production test of diode lasers, including single-emitter, bar, and stack products. These semiconductor devices produce light at levels from less than 1 W up to 1500 W. Coherent's diode lasers are used in industrial, medical, and military applications that require high power levels. Martin Rowe spoke with Shi by telephone to learn more about his work.

Q: What is a diode-laser bar?
A: It's an array of laser diodes that produce photons from electrical power. Bars can produce 100 W of light (we're developing higher-power bars). Each bar is cleaved from a semiconductor wafer, and a typical bar measures 1 cm long and 150 µm thick. The third dimension, normally referred to as "cavity length," varies from less than 1 mm to several millimeters. We can stack bars vertically or horizontally to increase the power of each packaged final product.

Q: What are your roles in test and measurement?
A: I'm responsible for three areas: metrology, calibration, and measurement-system analysis for production.

Q: Please differentiate between metrology and calibration.
A: Testing a laser bar involves measurements such as optical power, wavelength, and operational current. In my metrology work, I investigate instrumentation and procedures to best measure these properties. The ability to effectively measure these properties influences our internal operations from development to obtaining pass/fail decisions on the production line.

My calibration duty refers to correctly transferring known standards from outside sources such as NIST to dozens of production stations and carefully maintaining them to ensure measurement accuracy. I lead a group of technicians, equipment engineers, and manufacturing engineers to develop calibration procedures for production test stations. The measurement accuracy is important so that we meet customer expectations.

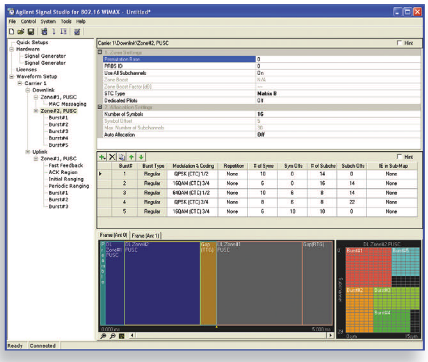
Q: How do you analyze measurement systems?
A: Often, if you repeat a measurement on the same station, the numerical results will slightly differ. While performing measurement-system analysis, I use statistical theory and analysis tools on test data to determine the performance and capability of test stations. I pick samples from a normal production stream and repeatedly run them through the targeted test station under controlled conditions.

I assess the sources of the discrepancies between measurements—the so called "uncertainty"—and determine how much error comes from equipment. From that data, I can determine if the station or the process needs improvement.

Q: How do you make production measurements?
A: We use a light-integrating sphere to make wavelength and power measurements. The sphere integrates the total output light, and we attenuate it by allowing only a small amount to reach a calibrated photo detector. We calibrate the photo detector with a NIST-traceable thermopile and optical meter. Their combined uncertainty is ±3%. Measurements also include a profile of a device's light output along the emitting surface [**figure**]. We call it "near-field measurement." T&MW

Every other month, we will publish an interview with an electronics engineer who has test, measurement, or inspection responsibilities. If you'd like to participate in a future column, contact Martin Rowe at mrowe@tmworld.com.

Agilent enhancements aid testing of WiMAX Forum Wave 2 profiles



Agilent Technologies has announced that its Vector Signal Analyzer (VSA), Signal Studio, and Mobile WiMAX Test Set products have been enhanced to facilitate testing of the WiMAX Forum's Wave 2 system profiles; these profiles specify options such as multiple-input, multiple-output (MIMO), a multi-antenna technology fundamental to Mobile WiMAX.

Agilent's 89601A VSA and N7615B Signal Studio measurement products support physical (PHY) layer signal generation and analysis for Wave 2 system profiles, including support for matrix A and matrix B signals, HARQ bursts, and uplink sounding zones. N7615B Signal Studio also provides MIMO fading embedded in a waveform, a capability that enables testing of MIMO receivers without the added expense of fading hardware or software.

The Agilent E6651A Mobile WiMAX Test Set incorporates flexible base-station emulation, IP traffic support, and the ability to make onboard RF parametric measurements. No external equipment is required to measure UL signals. The E6615A's Wave 2 enhancements include support for DL, STC, SM, and UL collaborative MIMO measurements. It also offers the protocols to support operating with the DUT in MIMO modes. www.agilent.com.

TUV Rheinland designated as conformity assessment body

TUV Rheinland of North America, a supplier of testing and certification services, has been recognized by the European Commission (EC) as a Conformity Assessment Body (CAB) for the Electromagnetic Compatibility (EMC) Directive 2004/108/EC. The company was given the designation under the US-EU Mutual Recognition Agreement (MRA) through the National Institute of Standards and Technology (NIST). A CAB reviews a product's documentation to ensure compliance to the EMC Directive and reports its findings to the EC.

The EMC Directive 2004/108/EC oversees the EMC compatibility of a wide range of products, including electrical and electronic appliances, systems, and installations. Effective as of July 20, the new version replaced the previous Directive 89/336/EEC. www.us.tuv.com.

JEOL completes microprobe installation

JEOL USA, a manufacturer of electron microscopes and scientific instruments for nanotechnology, reports that it has completed installation and acceptance of its first thermal field emission electron microprobe in the US. The microprobe was installed at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD.

An automated, high-throughput electron probe microanalyzer (EPMA), the JEOL JXA-8500F offers an analytical ability that surpasses that of scanning electron microscopes (SEM), according to the company. The ability to simultaneously use an energy-dispersive x-ray spectrometer (EDS) and

Editors' CHOICE

LabView runs across processor cores

The new LabView 8.5 adds several features that improve throughput in test applications. Taking advantage of multicore processors, LabView's multithreading ability automatically assigns program threads to processor cores. Previous versions let you perform up to four threads on single-core processors. Now, you can run four threads on *each* processor core.

LabView's Real-Time and FPGA add-ons also let you take advantage of multiple processors. Because real-time and FPGA applications don't run under Windows, the add-ons let you assign threads to processor cores, so you can build applications where one core acquires data and another performs analysis, filtering, signal processing, or datalogging. By assigning code to a specific processor core, you can run even more tasks in parallel. If you develop code for embedded systems, you can download multithreaded applications to an FPGA and run them independently of a PC.

One new module lets you build applications by using state charts that define user interfaces, communications protocols, controls, and other functions. State charts contain underlying LabView code that you can run or edit, but they provide a higher level of abstraction to your programs than writing your own code.

Base price: $1199, *National Instruments, www.ni.com/labview.*

up to five wavelength-dispersive x-ray spectrometers (WDS) increases speed for elemental analysis of nanometric sample areas. All but a few of the elements on the periodic table can be analyzed.

The JXA-8500F uses a Schottky-type field-emission gun. The probe diameter is 1/10th the size of conventional probes.

"This new FE gun allows us to analyze extremely small features by operating at low kilovolt and high beam currents," said Charles Nielsen, VP of JEOL USA. "The analytical ability of this instrument makes it possible to measure features and map them with a resolution approaching one hundred nanometers." www.jeolusa.com.

EADS distributes Tabor test equipment in US

EADS North America Defense Test and Services of Irvine, CA, now handles US sales and service for test equipment from Tabor Electronics. Tabor, based in Israel, manufactures pulse, function, and arbitrary waveform generators. EADS North America Defense is the former Racal Instruments, a manufacturer of PXI and VXI instrument cards and custom test systems. www.eads-nadefense.com; www.taborelec.com.

CALENDAR

International Test Conference (ITC), October 23–25, Santa Clara, CA. Sponsored by IEEE. www.itctestweek.org.

Automotive Testing Expo North America, October 24–26, Detroit, MI. Sponsored by *Automotive Testing Technology International* magazine. www.testing-expo.com/usa.

Vision, November 6–8, Stuttgart, Germany. Produced by Messe Stuttgart. www.vision-messe.de.

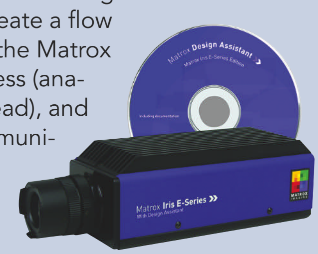
Productronica, November 13–16, Munich, Germany. Produced by Messe München. www.global-electronics.net/id/21310.

To learn about other conferences, courses, and calls for papers, visit www.tmworld.com/events.

Editors' CHOICE

Camera includes integrated software development package

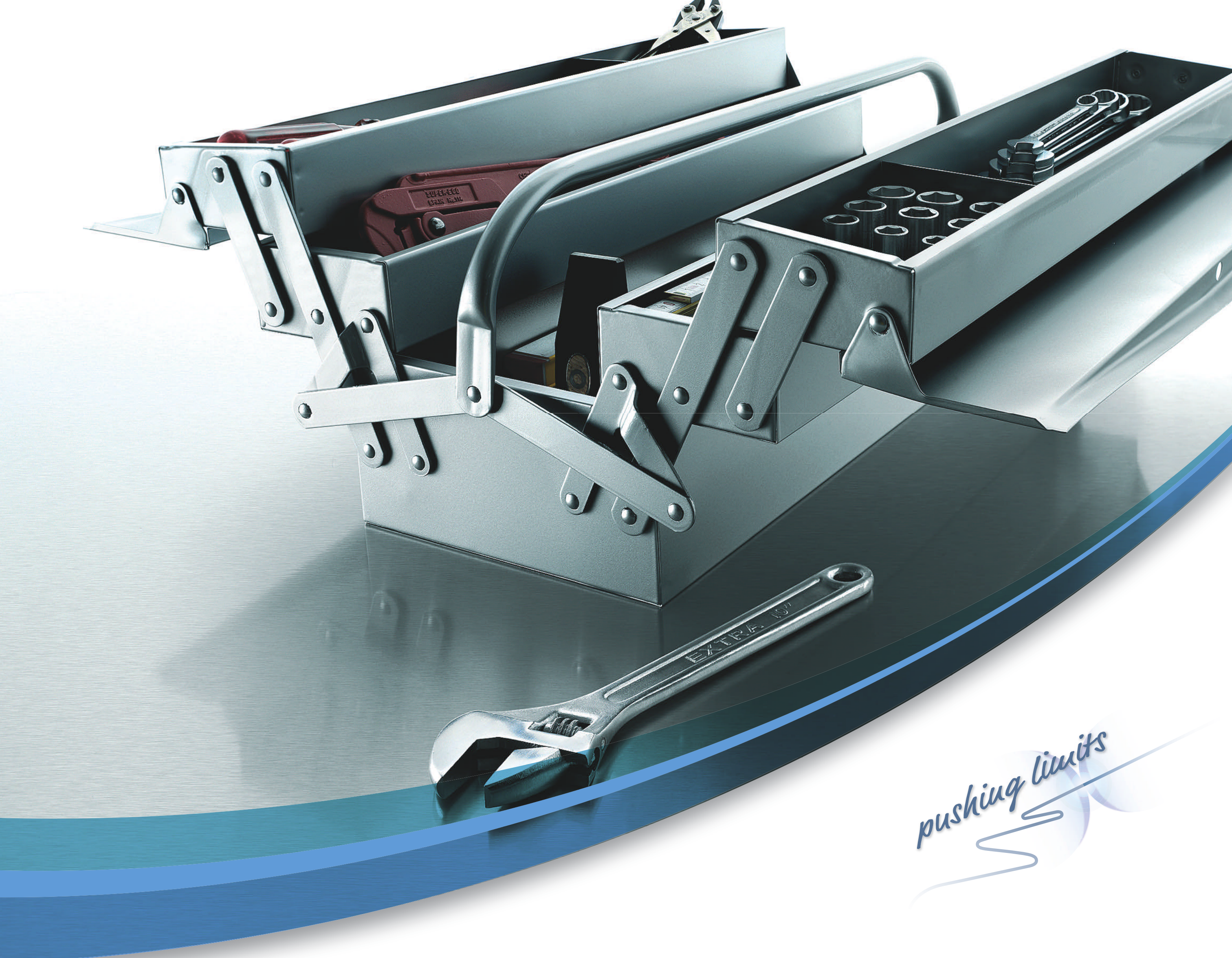
Matrox Imaging has announced the Matrox Iris E-Series with Design Assistant, a smart camera with an integrated development environment (IDE). With the Matrox Design Assistant environment's intuitive interface, users create a flow chart of an application that instructs the Matrox Iris E-Series camera to capture, process (analyze, identify, locate, measure, and read), and remotely display images and to communicate with external devices.



The development environment is fully self-contained for application development and deployment, and an integrated HTML editor and layout tool allows users to create custom Web-based views so operators can monitor applications.

The Matrox Iris E-Series smart camera includes an embedded Intel Ultra Low Power (ULP) Celeron processor, and it runs the Windows CE .NET real-time operating system. It is available as a single-body or remote-head-plus-processor design.

Base price: Iris E-Series camera with Design Assistant software—$2995. *Matrox Imaging, www.matrox.com/imaging.*



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Test, inspection get respect at chip show

> > > Semicon West, July 16–20, San Francisco, CA, SEMI, www.semiconwest.com.

Semicon West covered the gamut from design tools to rework tools. Included in this year's exhibits were yield-management software, electrical testers, environmental test equipment, and inspection components and equipment.

Synopsys highlighted its Odyssey and TetraMAX tools. Odyssey has traditionally supported correlation of fab, yield, and test data, and it now supports correlation of this data with TetraMAX circuit-failure data to help identify design or foundry problems. **Magma Design Automation** described the Passive Voltage Contrast (PVC) Checker simulation option for its Knights Camelot CAD navigation software. The company also highlighted its YieldManager software. **W.L. Gore & Associates** announced that it has added high-flex round cable to its High Flex Cable and Trackless Cable Configurator online tool.

Verigy introduced the V5000ep, which allows customers to perform quality assurance, characterization, and small-lot production at wafer sort and final test on memory devices as well as memory cards and multichip packages (MCPs). **Advantest** demonstrated its new integrated test cell (see p. 19).

Johnstech highlighted its new leaded ROL200 test contactors. **Nextest** demonstrated its Magnum Grande 7680-pin test system integrated with a Mirae Model 530 handler. Nextest also highlighted its Magnum SV 1024-pin test system and its Magnum iCP-EV 128-pin system. Members of the **Semiconductor Test Consortium** were on hand to discuss the STIX (Semiconductor Test Interface eXtensions) initiative.

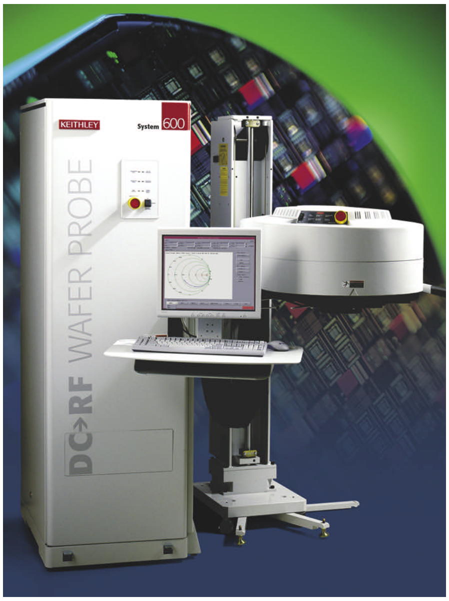
Keithley Instruments announced that it has enhanced its S600 parametric tester and said it has qualified FormFactor to manufacture high-performance parametric test probe cards for Keithley's semiconductor parametric testers. For its part, **FormFactor** highlighted its development of a MEMS-based probing contact technology capable of full area wafer probing of high-pin-density, ultra-fine-pitch devices. **Suss MicroTec** unveiled its new ProbeShield technology for wafer-level test.

Startup **Scanimetrics** launched its first product for the semiconductor test market: the Wi-TAP (Wireless Test Access Port) wireless noncontact "virtual probe." **Micromanipulator** highlighted its new P300J motorized, joystick-controlled probing station. **Data Translation** demonstrated a new release of Measure Foundry with the new Instrument Pack for Measure Foundry option, which supports LXI.

FEI highlighted its FIB tools as well as its new Phenom high-resolution desktop imaging tool with an optical camera. **Rudolph Technologies** demonstrated its wafer-inspection equipment. **FLIR Systems** highlighted its ThermoVision SC8000 MWIR infrared camera. **Point Grey Research** highlighted its Grasshopper series of IEEE 1394b cameras. **Vision Engineering** presented its Mantis Elite long-working-distance (4.41-in.) lens.

Olympus Integrated Technologies America demonstrated its FR3200 broadband Deep UV wafer-inspection and automated wafer-review system, which provides imaging in single or combined-multiple wavelengths. **Hyphenated Systems** highlighted its HS200A confocal microscopy system. **Vistek** highlighted its LDS3300 all-surface inspection tool, which enables front-side, back-side, and edge/bevel inspection.

In response to the growing demand for affordable high-end x-ray computed tomography (CT), **phoenix|x-ray** introduced its new microme|x CT system. **Carl Zeiss SMT** said it has shipped its first Orion helium ion microscope, to NIST. **Dage Precision Industries** highlighted enhanced computerized tomography capability for its XiDAT XD7600NT digital x-ray inspection system. **Temptronic** introduced its TP4500 ThermoStream system, which combines high thermal capacity and portability with a –45°C to +225°C temperature range. T&MW



The S600 parametric tester is migrating to Linux; firmware upgrades will provide throughput improvements compared to the earlier Unix-based systems.

Courtesy of Keithley Instruments.

See the online version of this article at www.tmworld.com/2007_09 for links to vendors and to our complete coverage of Semicon West.

EMC engineers convene in Hawaii

> > > International Symposium on EMC, July 10–12, Honolulu, HI, IEEE, www.emc2007.org.

The 2007 IEEE EMC Symposium took place in the 50th state to commemorate the 50th anniversary of the IEEE EMC Society. In her keynote address, Dr. Leah Jamieson of Purdue University, the IEEE president, expressed concern about the future of the engineering profession. "There will be a disconnect if education doesn't keep up," she said. She suggested that a bachelor's degree is becoming a "pre-engineering degree" and that a master's degree is almost a requirement.

In a session on EMC history, Hugh Denny, principal research engineer emeritus at the Georgia Tech Research Center, explained that EMC research began because of interference to military radios.

The exhibit floor offered several presentations in addition to a product exhibition. One demonstration featured probes designed to measure resistance in galvanized metal plates used as equipment enclosures.

Agilent Technologies demonstrated several recently released products, including the E4440A PSA series of spectrum analyzers and N9039A preselector. **Teseq** (formerly Schaffner EMC) introduced new products including the NSG 437, a lower-cost version of the company's ESD simulator. The company also introduced the NSG 4070, a conducted immunity tester that combines a signal generator, an amplifier, and control software.

California Instruments exhibited the Compact i/iX combination AC/DC power source and spectrum analyzer. **Kikusui** demonstrated its KHA1000 harmonic and flicker analyzer. T&MW

NIWeek sets record attendance

> > > NIWeek, August 7–9, Austin, TX, National Instruments, www.niweek.com.

NIWeek 2007 attracted more than 2400 attendees to Austin, where keynote demonstrations covered LabView 8.5 (see p. 11) and its ability to work with multicore processors. Other demonstrations included an FPGA-based audio recorder and a thought-controlled wheelchair.

Technical sessions included programming techniques for Windows Vista, bus comparisons, and oscilloscope selection. During the Vista presentation, NI's Noel Adorna asked if any audience members were using Vista and asked for comments. "It's a bit of a pain to upgrade, but it's more secure than Windows XP," said one attendee.

The exhibition hall featured numerous companies displaying camera and inspection equipment, including **Allied Vision Technologies, Basler, FLIR Systems, Hitachi, Navitar, New Electronic Technology, Princeton Instruments, Prosilica,** and **Sony.**

Test-system integrators were also on hand. **DAQtron** introduced the Trident Suite of digital video broadcast generators. **MicroLex Systems** exhibited a PXI-based video tester for baseband digital video streams. **Mindready** demonstrated configurable test systems for audio, RF, and functional test, including an RF signal record and playback system. **Boston Engineering** introduced an electronics platform consisting of a CPU board and a data-acquisition module. T&MW

See the online version of this article at www.tmworld.com/2007_09 for links to vendors and to our complete coverage of the EMC Symposium and NIWeek.

(ADVERTISEMENT)

HIGH-SPEED TEST

(Loop)back to the future

New test methods tackle ≥6.4Gbps data rates

Tom Vana, Member of Technical Staff
Credence Systems Corporation
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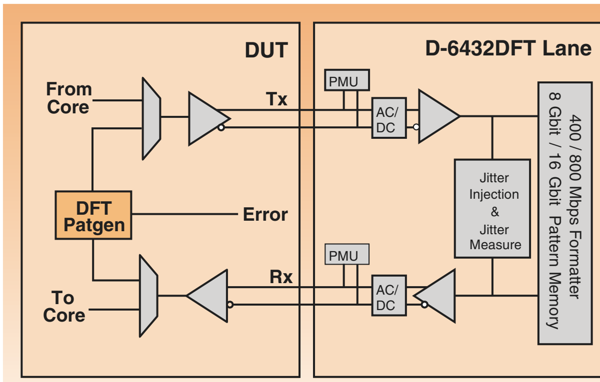
High-speed serial buses like PCI Express and HyperTransport introduce tough challenges for test engineers developing test sets with sufficient fault coverage at a cost of test the market will bear. Simple design-for-test (DFT) methodologies were implemented quickly at very low cost with limited fault coverage, while older "functional" test flows on high-end ATE platforms offered the most thorough fault coverage, but at increasingly prohibitive cost of test, test complexity and cycle times. Functional testing is becoming even less viable as cost per pin rises with bus speed in high-speed data applications, particularly in volume production test.

To meet the cost of test metrics that are established market realities, manufacturers have turned to loopback techniques (i.e., using the device to source the test data and receive it back into the device for recognition) for testing today's high-speed buses. Implementation of loopback is especially critical, considering the typical loss budget for high-speed signals. This loss budget typically has three components — contributed by the transmitter, receiver, and interconnect—all of which could degrade the signal "eye" over the loopback path and impact coverage.

Alternative DFT techniques like "near-end loopback" have already introduced cost efficiencies (via ease of programming and reduced capital investment in ATE) in testing devices for high-end consumer and computing applications. Near-end loopback techniques can be self-contained within the DUT with pathways created between the I/O pins. However, the inherent cost savings and simplicity carry stiff tradeoffs in terms of coverage. There are no parametric measurements, a lack of signal control, and lower likelihood of catching faults related to signal integrity or bit errors. For example, a simple internal or load board loopback would allow a marginal receiver to "hide" in the shadow of a robust transmitter and pass the loopback test screen. While these uncertainties can be worked around at lower speeds, compromising coverage at ≥6.4Gbps is simply too risky.

Far-end Loopback: Production-Level Testing at Lower Cost

Between the two extremes, innovative techniques such as far-end loopback combine the flexibility of DFT with the more in-depth diagnostics of functional testing. Lengthening the feedback path by placing the DUT in communication with a cost-effective, intelligent tester makes production-level testing of high-speed buses viable for the first time. Even more compelling, far end loopback with programmable signal degradation can be employed to cut costs and speed time-to-market while adding unprecedented fault coverage to loopback methodologies.



The Credence Sapphire D-6432DFT cost effectively tests high-speed buses such as PCI Express I & II, HyperTransport 1.2, 2.0 & 3.0 at data rates up to 6.4 Gbps.

Clearly, exponentially faster bus speeds are driving fundamental shifts across the board, from design through production. Innovative test methodologies like far-end loopback transform test into enabling technology and drive closer collaboration among the supply chain.

Get your FREE copy of "High-speed Bus Fundamentals" at www.credence.com/loopback

RICK NELSON
CHIEF EDITOR
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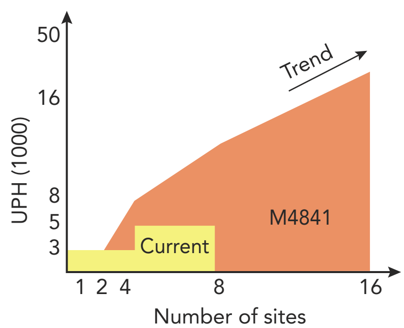
ATE firm responds to RF chipmaker's call

"We generate ideas, and those ideas eventually get made into silicon," said Octavio Martinez, director of test engineering at Qualcomm, during a session titled "Critical Issues in Test" at Semicon West in July. But, he said, the CDMA chipmaker is looking to ATE vendors to help address the challenges of testing cell-phone chips containing digital signal processors (DSPs), graphics processors, 1-GHz microprocessors, memory, and as many as 12 radios. He called for innovations ranging from design-for-test (DFT) enhancements to extended RF-capable multisite production-test capability.



Gary Fleeman says his firm's M4841 handler, integrated into a test cell, paves the way toward high-throughput multisite test for SOC and RF/mixed-signal devices. Courtesy of Advantest America.

One test vendor who responded to Martinez during the "Critical Issues in Test" session was Gary Fleeman, director of business development at Advantest America, who described a gamut of innovations ranging from design-automation software to materials-handling equipment. As for software, he said, firms are offering tools that support redundancy (for the internal repair of stuff that doesn't work), built-in self-test (for on-chip test generation), DFT (to reduce test hardware requirements), and diagnostics (to support yield learning).

Focusing on the test-equipment side, Fleeman described what he called a "honeymoon package—an arranged marriage of efficiency" between test resources and handling equipment. That marriage, he said, enables high-throughput (**figure**), cost-effective test solutions that can provide multisite test of stacked-die devices that combine high-speed digital circuitry, multicore processors, embedded flash and RAM, and multiple RF cores. Seamless integration of the test handler is critical, he said, because of the detrimental effects handler jam rates can have on throughput in systems that aren't seamlessly integrated. He presented a chart showing that a jam rate of just 1/2000 can reduce throughput from an ideal 30,000 units per hour (UPH) down to significantly less than 20,000 UPH.

On the Semicon West exhibit floor, Advantest demonstrated a T2000 LS mainframe linked to a M4841 dynamic test handler in an integrated system-on-chip (SOC) test cell. The Open-Star-compliant cell supports parallel testing of 16 high-pin-count BGA, CSP, QFP, and other consumer devices with throughput up to 18,500 UPH—a threefold improvement over its predecessor. It employs Advantest's Soft Touch handling using electro-pneumatic air pressure to avoid damaging miniaturized parts during touchdowns.

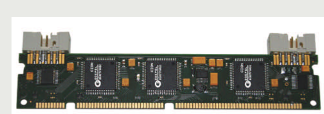
Fleeman concluded his "Critical Issues in Test" presentation by saying that seamless integration and parallelism coupled with streamlined software and development will lead to dramatic persite test cost reductions. That's in keeping with the conclusion of Qualcomm's Martinez, who emphasized that for him the bottom line is cost. Traditionally, he said, ATE capital expenditures have not been falling in concert with chipset average selling prices, adding, "ATE makers must keep up with relentless pressure to reduce cost of test." T&MW

Sapphire D-6432DFT combines loopback, jitter test

Credence Systems' Sapphire D-6432DFT instrument targets devices having PCI Express, HyperTransport, XAUI, XDR, RapidIO, InfiniBand, and other high-speed serial interfaces. It integrates at-speed loopback testing with jitter measurement and injection to permit serial-bus tests along with scan/functional and DC parametric tests in a single insertion. The instrument implements far-end loopback techniques that combine DFT functionality with an in-depth diagnostic capability. www.credence.com.

Module enables JTAG test of DIMM168 interfaces

Goepel electronic has introduced its CION Module/DIMM168, which makes use of the boundary-scan TAP to test all signal and voltage supply pins of JEDEC-standard-compliant DIMM168 connectors. Because the modules are equipped with a transparent TAP, several boards of the same or different types can be daisy-chained. The structural boundary-scan test of all DIMM168 signal and voltage-supply pins are executed by onboard CION ASIC ICs. www.goepel.com.



Microchip Technology selects Teradyne testers

Teradyne has announced that Microchip Technology has signed an agreement that extends through 2009 for the volume purchase of Teradyne J750 and FLEX test systems, which Microchip will use to test products such as its dsPIC digital signal controller (DSC). "The J750 and FLEX test platforms help us release new products quickly and meet our high-volume cost reduction goals," said Microchip VP Mathew Bunker. www.microchip.com; www.teradyne.com.

JON TITUS
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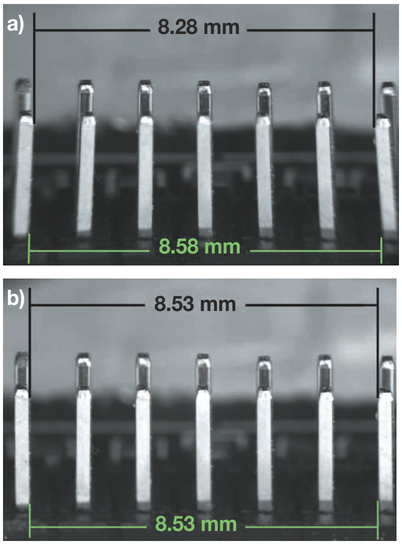
Telecentric lenses measure up

My July column ("Calibrate camera coordinates and colors") described techniques you can use to calibrate vision systems. In some cases, though, basic calibrations do not suffice. General-purpose machine-vision lenses produce perspective in images so that distant and nearby components of the same type appear to have different dimensions. In the same way, cars far down a highway appear to our eyes as smaller than cars just ahead of us. *We* know the cars didn't shrink,



a) This image shows different dimensions for pins on a PCB. b) This image, which was taken through a telecentric lens, provides accurate information.
Courtesy of Edmund Optics.

but vision software analyzing an image of them might think they did.

If components exist within a thin plane, perhaps on a printed-circuit board (PCB), minor distortions due to perspective may cause no measurement problems. But if manufacturing fixtures do not always place PCBs at the same distance from a camera or if components exist at different levels, say on a daughter card or subassembly, the accuracy of dimensional measurements can suffer.

To surmount this problem, vendors offer telecentric lenses that do not alter the dimensions of objects within the lens' depth of field—the distance through which it will properly focus. **Figure 1a** shows connector pins on a PCB as seen by a typical machine-vision camera and lens. The image of the same connector pins in **Figure 1b**, taken through a telecentric lens, reveals no perspective errors. It provides accurate dimensional information regardless of the pins' distance from the camera.

Because a telecentric lens accepts only parallel light rays, if the area you want to inspect increases, you will need a larger lens. A 16-mm-diameter telecentric lens used with a ⅔-in. CCD sensor, for example, offers an 11-cm horizontal field of view. As precision telecentric lenses get bigger, their cost goes up markedly. To reduce costs, you could use a small lens to inspect a product one section at a time rather than trying to inspect the entire product at once.

Although telecentric lenses overcome perspective errors, engineers also use them because of their overall accuracy. Greg Hollows, vision integration partners coordinator at Edmund Optics, explained that telecentric lenses have fewer lens-to-lens variations. Thus, if you need several lenses in a vision system, telecentric lenses help ensure you get comparable high-quality images from each lens. Lenses come with iris adjustments and may include a variable focus at slightly higher cost. And unlike general-purpose vision lenses that work with many camera-sensor sizes, telecentric lenses mate with only a few sensor sizes.

If you need dimensional accuracy over a given distance range, you should determine the dimensions of the area you want to inspect—the field of view—and then determine which lens and camera will work together. Lens suppliers can help match a lens to your requirements and equipment. Telecentric lenses come at premium prices because of their tight manufacturing tolerances and the small market for them. But better measurements can justify their cost. T&MW

Device inspects flat surfaces

The Moritex Super Optical Device 3 (SOD-III) includes an optical body that uses coaxial epi-scopic illumination to image flat surfaces. Compatible with various bright-field lenses and offering flexible mounting options, the SOD-III is appropriate for LCD and wafer-defect inspection and alignment, optical alignment, and automated inspection of small components. Peripherals include cameras and light guides. www.moritex.com.

Mini imager reads codes of less than 3 mil

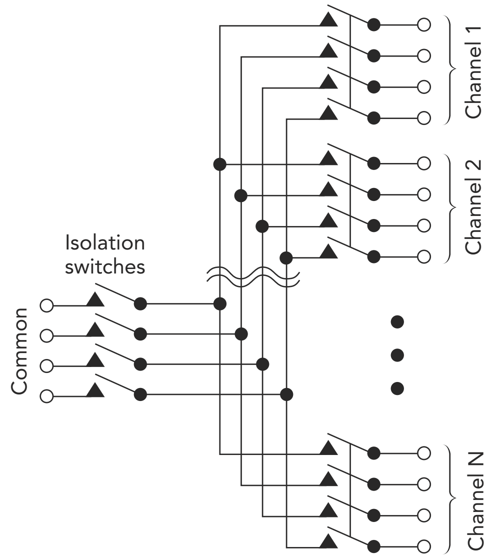
The Quadrus MINI 3 bar-code imager from Microscan Systems offers 3-Mpixel imaging and can read codes of less than 3 mil in size. Useful in tracking printed-circuit boards and semiconductors, the Quadrus MINI 3 has a wide field of view and can read up to 100 different codes in a single capture, including both long linear codes and small 2-D codes. www.microscan.com.

Platform offers vibration cancellation for SEMs

Technical Manufacturing has introduced the FloorPlatform PZT, an active inertial vibration-cancellation system for scanning electron microscopes (SEMs). The platform features sub-hertz vibration cancellation in an active hard-mount floor platform that fits most SEMs and is compatible with all internal vibration-isolation systems, according to the vendor. It is available with three or six degrees of freedom. www.techmfg.com.

WEBCAST

Webcast sheds light on switching systems



Switches range from simple SPST types to more complex configurations, such as this four-wire 1xN implementation.

Switching systems are probably among the most overlooked and misunderstood pieces of hardware in an ATE system, says Jeffrey Lum, Giga-tronics' CTO and president of the company's Ascor division. He sheds light on the subject of switching in the Webcast, "Designing good switching modules for ATE," in which he covers the need for switching, types of switching, design challenges, and available switching-module platforms.

Most test switches can benefit from switching, Lum explains, noting that switching systems help efficiently allocate tester resources to support one or more UUTs. Switches, he continues, come in a variety of formats, ranging from simple Form A single-pole single-throw (SPST) types to more complex configurations, such as the one shown in the **figure**. He describes multiplexer, or tree, configurations as well as star switches and cross-point matrices, explaining which ones best serve specific applications.

Lum provides details on how to avoid problems associated with long transmission lines, lack of shielding, and improper impedance matching. "Test your UUT, not your switching system," he advises, while providing hints on how to minimize reflections, eliminate ground loops, and avoid transmission-line stubs. He recommends that to keep your switch system invisible to your measurement resources, you should establish a chassis earth ground and maintain separate grounds for analog and digital signals.

Lum also provides advice on harnesses, noting that cables can be the "Achilles' heel" of a switching system, and he describes a harness-free switch design. He concludes with a detailed example of a star-switch design for 500-MHz signals.

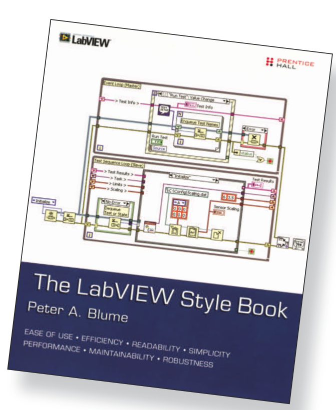
For more details, including insertion-loss data from signal-transmission examples, view the archived Webcast, sponsored by Giga-tronics and *Test & Measurement World,* at www.tmworld.com/webcasts.

Rick Nelson, Chief Editor

BOOK REVIEW

Use LabView with style

The LabVIEW Style Book, by Peter A. Blume, Prentice Hall (www.phptr.com), 2007. 372 pages. Hardcover: $89; downloadable PDF file—$71.20.



In this book, Peter Blume, a top LabView programmer and the president of Bloomy Controls (a National Instruments Alliance partner), shows you how to write clean, understandable graphical code. Other LabView style guides have been published over the years, but Blume's is the most comprehensive.

One feature of the book quickly jumped out at me: Even though LabView itself uses a lot of color, the diagrams in this book are printed in grayscale—apparently a decision that was made by the publisher. Readers who want to see the color images can purchase the downloadable version of the book.

In the early chapters, Blume provides examples of both clean code and messy code and explains why you should carefully plan your software project—advice that applies to all projects, not just those involving LabView. He also covers user interfaces, showing good and bad examples of user panels and stressing the need for simplicity and consistency. Chapter 4

Use LabView with style *(continued)*

shows you how to apply Blume's rules to streamline your block diagrams.

Chapter 5 covers icons, which indicate functions, operators, and sub-VIs (virtual instruments). Here, you'll learn conventions that can help you identify the functions contained within a VI. Blume stresses the use of color and symbols to differentiate and identify the function of code within an icon.

Instrument control and data acquisition generate a lot of data, and chapter 6 shows you how to choose the best data structure. For example, Blume recommends that you not use an alphanumeric string to represent an integer, because you'll waste memory and run the chance of introducing data errors.

In the last half of the book, Blume covers error handling and explains how to develop code that's not only readable, but efficient. He also dedicates a chapter to documentation, giving advice such as "Leave notes for the development team" and "Label each note in the left corner." Blume wraps up with a chapter on code reviews and describes processes and tools you can use to review and analyze your code.

Overall, this book is well worth the money for any LabView programmer.

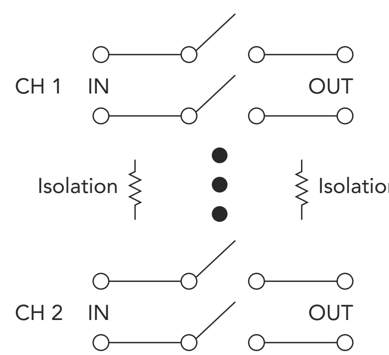
Martin Rowe, Senior Technical Editor

SWITCHING SYSTEMS

Avoid switching mistakes

Switching systems appear in many automated test systems used for both prototype evaluations and production tests. Even the most carefully planned switching designs can have issues that degrade performance.

Dale Cigoy, senior applications engineer at Keithley Instruments, helps engineers solve switching problems every day. He's written a paper called "Designing and Building the Perfect Switching Test System," which you can download from the online version of this article (www.tmworld.com/2007_09).



A switch card's channel-to-channel isolation represents how well it guards against signal crosstalk.

In his paper, Cigoy covers common issues such as contact resistance, settling time, channel-to-channel isolation (**figure**), and switch aging. He also discusses solid-state switches versus electromechanical relays, pointing out that solid-state switches have far greater life than relays, but by using them you pay a price in contact resistance.

"Trying to measure a few milliohms with upwards of 10 ohms of resistance in the circuit from the 'on' resistance would effectively bury the low-resistance measurement," warns Cigoy. He then points out that you can negate high resistance by using a "golden" channel and subtracting the resistance or by using four wires to separate system resistance from the measuring circuit.

Cigoy also discusses switch topology and compares multiplexed and matrix configurations. He covers full, partial, and blocking matrices and says, "The advantage of matrix configurations includes the absence of unterminated stubs, access to all channels, and similar path characteristics. Disadvantages include the need for extensive cabling and the use of many coaxial relays."

Martin Rowe, Senior Technical Editor

DATA ACQUISITION

Within the temperature range

DEVICE UNDER TEST
Gas-powered kitchen ranges that vary in width from 24 in. to 48 in. The standard kitchen range is 30 in. wide.

THE CHALLENGE
Automatically measure temperature at up to 1700 points to ensure safety compliance with ANSI Z21.1 "Household cooking gas appliances" (American National Standards Institute, www.ansi.org). Develop a test chamber flexible enough to accommodate all range sizes.

THE TOOLS
- Omega Engineering: thermocouples. www.omega.com.
- United Electronic Industries: Ethernet-based data-acquisition modules. www.ueidaq.com.

PROJECT DESCRIPTION

Whirlpool (www.whirlpool.com) designs and manufactures household appliances, including gas-powered kitchen ranges, under several brand names. All models must comply with industry standards for safety, including standards covering how much heat a range can emit.

To comply with ANSI Z21.1, technicians must test new ranges for external temperature. In the past, two or three technicians would manually make measurements by connecting each of 900 thermocouples to a temperature reader, one thermocouple at a time. A single set of measurements required several hours of a technician's time to set up and make. Later, engineers developed a semi-automated system where a technician could connect 50 thermocouples to a datalogger at once. That cut technician time to about 1 hr, but was still rather time consuming.

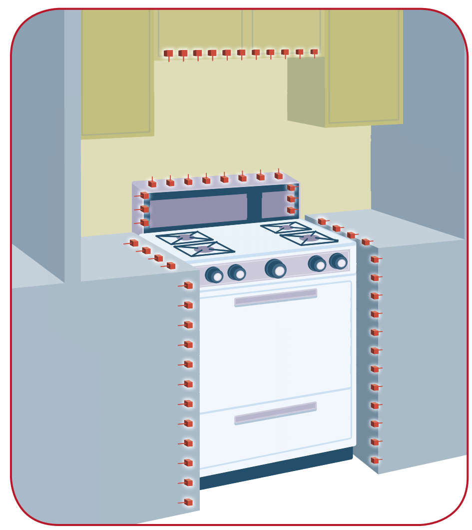
Today, technicians at Whirlpool's Edgewater Technology Center in St. Joseph, MI, including Johnny Isaacs, use a test booth that simulates a kitchen and lets them set up 1700 thermocouples in 2 min. The faster setup doesn't reduce the actual test time, which is defined in ANSI Z21.1, but it frees technicians to do other jobs while the test runs.

The test booth, 8-ft. square by 9-ft. high, has wood boards that simulate a kitchen counter and cabinets; the sides of the cabinet can be adjusted to accommodate ranges of different sizes. A rear panel, permanently in place, is large enough to accommodate the largest range. Boards surrounding the range and mounted above it contain the thermocouples mounted 3 in. apart (**figure**).

For a 48-in.-wide range, the system uses all 1700 thermocouples installed in the booth. For smaller ranges, the outermost thermocouples aren't used. PC software, written by senior technician Kirk Boyd, lets technicians select which thermocouples to ignore for the smaller ranges.

The thermocouples connect to 16 data-acquisition modules, each of which can accommodate 108 thermocouples. A test takes 9 hrs to complete. Technicians run the oven in cleaning cycle, which runs the oven's internal temperature to 860°F, for 4½ hours. If at any time the thermocouples closest to the range detect an outside temperature higher than 194°F (117°F above the lab's 77°F ambient temperature), the system will notify technicians to end the test.

If the temperature remains within tolerance, the system records the last temperature measurements before the cycle ends. A technician then lets the oven cool for 30 min, which drops the chamber temperature low enough to enter the room and open the oven door because the oven automatically



Up to 1700 thermocouples—connected to 16 data-acquisition modules—monitor the temperature around a gas range during a product evaluation.

locks its door when internal temperature exceeds 600°F. This action tests that the oven's automatic locking works. Then, technicians close the door and repeat the test. This time, they turn on the burners (four or six, depending on the model) 3½ hours into the test.

LESSONS LEARNED

"Flexibility is key," said Isaacs. "As Whirlpool's ranges went beyond the standard 30-in. width, we needed a flexible test booth. We can't have a dedicated test booth for every range size." Technicians use the test booth nearly every day because of the number of new products in development.

Martin Rowe, Senior Technical Editor

ENGINEERS SUPPORT NAVY AND MARINE CORPS CALIBRATION LABS WITH MEASUREMENT SCIENCE, PRODUCT EVALUATIONS, CALIBRATION PROCEDURES, AND MODERNIZATION.

KEEPING THE NAVY CALIBRATED

STEVE LABADESSA

Bob Fritzsche leads the METCAL in-service assessment group, a team of engineers who support instrumentation on ships and on the ground.

BY MARTIN ROWE, SENIOR TECHNICAL EDITOR

NORCO, CA—When Navy pilots use night-vision goggles, they trust that the goggles will provide the proper sensitivity. When Navy personnel use radios, they expect the radios to operate on the correct frequency. And everyone aboard a Naval ship relies on instrument gauges to accurately indicate quantities such as temperature and pressure.

FIGURE 1. **The NSWC Corona Measurement Science Department consists of five divisions that handle all aspects of equipment specifications, calibration procedures, standards, automation, and purchases.**

To ensure that these and other weapons systems perform as expected, defense contractors develop specialized test and measurement equipment. But who tests the testers?

The answer is the Navy itself. Technicians on land-based and ship-based calibration labs test and calibrate the Navy's more than 1.7 million pieces of test equipment, performing more than 525,000 calibrations per year.

The Navy has more than 5000 active calibration procedures in use around the world. All calibration procedures (manual and automated), test-equipment evaluations, and measurement analysis, as well as some calibration standards, originate in the Measurement Science Department at the Naval Surface Warfare Center, Corona Division (NSWC Corona, www.corona.navy.mil).

Headed by measurement science director Arman Hovakemian, the Measurement Science Department is the Technical Agent for the Navy's metrology and calibration (METCAL) program. More than 250 engineers, scientists, and technicians support 409 calibration labs, 242 on ships and 167 on the ground. The work force is entirely civilian. Most of the staff are government employees, but some are Navy contractors. **Figure 1** shows the hierarchy of the five divisions that report to Hovakemian:

- *Measurement Requirements Assessment (MS10).* Assesses measurement requirements for Navy and Marine Corps weapon systems associated with acquisition programs. It also develops calibration support plans.
- *METCAL (metrology and calibration) In-Service Assessment (MS20).* Assesses measurement reliability and readiness for Navy and Marine Corps test equipment that supports operational systems. Staff members also provide technical support to calibration laboratories and Systems Command.
- *Metrology Engineering Assessment (MS30).* Develops calibration procedures for test equipment, provides technical requirements for calibration facilities, performs metrology training, and produces specifications for calibration standards. Three technical

subgroups focus on DC/low frequency, microwave and electro-optics, and physical and mechanical measurements.

- *Advanced Measurement Systems (MS40).* Assesses new weapons-system measurement requirements and performs metrology R&D in cooperation with the Air Force and Army. Staff members coordinate with the National Institute of Standards and Technology (NIST) to transfer Navy-designed calibration standards to industry.
- *Strategic Systems Evaluation (MS50).* Performs assessment and procurement of general-purpose test equipment and calibration standards.

STEVE LABADESSA

Arman Hovakemian manages the measurement science department, which provides measurement assessment and calibration procedures to Navy and Marine Corps calibration labs.

The need for standards

To the military, "calibrate" means "compare" rather than "adjust." Navy technicians on ships and on land will verify that a weapons-system tester is within tolerance and adjust it only when it's out of tolerance.

To perform a calibration, the technicians need calibration standards. When you think of a calibration standard, you probably think of a high-end digital multimeter (DMM) or multifunction calibrator, but the Navy refers to anything used to calibrate anything else as a standard.

Aviation electronics technician Sheridan Lee calibrates a pair of night-vision goggles aboard a ship. NSWC engineers wrote the calibration procedure that Lee follows. Courtesy of US Navy.

In many instances, the engineers in the Metrology Engineering Assessment (MS30) group determine that a basic DMM or oscilloscope can become the standard that technicians use to calibrate weapons-systems testers. In cases where the Navy needs a calibration standard with better uncertainty than is available in commercial off-the-shelf (COTS) equipment, the NSWC Corona engineers develop their own standard.

One example involved night-vision goggles. "In the early days of night vision," said metrology assessment manager Jeff Walden, "there were many challenges. The Navy decreed that night-vision goggles must be tested before each use. Thus, the tester must be accurate. It must emit a known, low level of light that the goggles must detect to pass a test."

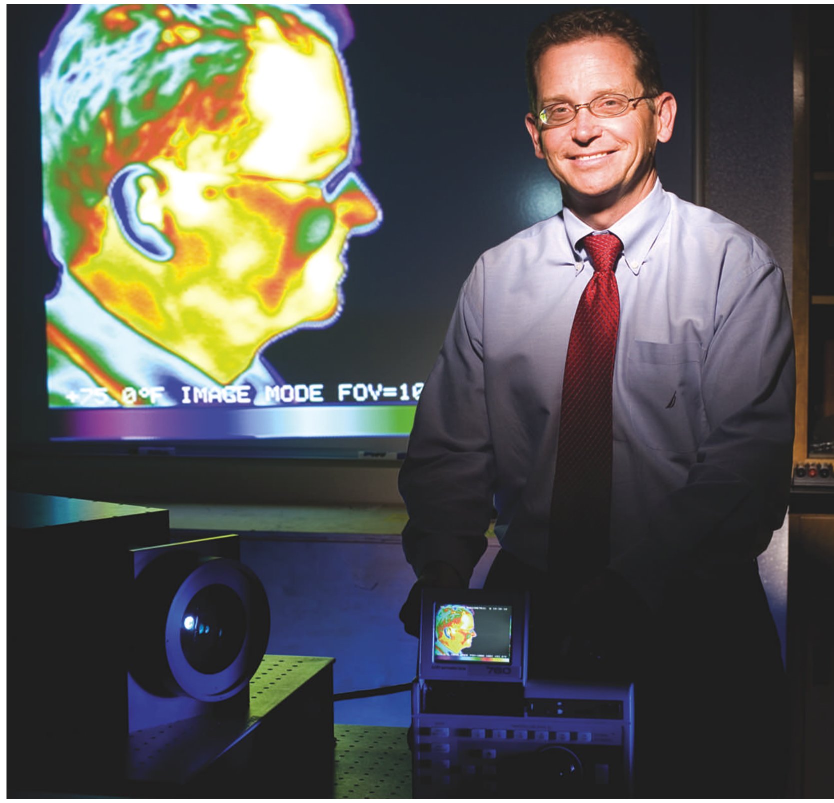
To ensure that the tester emits the proper light level, NSWC Corona engineers developed a photometer that measures the light levels from the tester, and they transferred the design to the contractor that builds the goggles and their testers. The engineers also wrote the procedures that Navy technicians use to calibrate the goggle testers.

Navy pilots rely on infrared cameras to help them find targets. The camera detects spatial frequencies that correlate to temperatures. A camera tester uses a blackbody source that produces a bar pattern. To verify the blackbody source, technicians use an infrared detector developed at NSWC Corona.

Procedural process

When engineers in the Measurement Requirements Assessment (MS10) group determine that a weapons system needs testing, they also determine if the test system needs calibration. If it does, an engineer in Walden's MS30 group will develop a calibration procedure for a tester. Testers and their calibration procedures must satisfy the technical requirements that MS10 engineers specify. The technical nature of the calibration (electrical, electro-optic, or mechanical) determines which MS30 engineer will write the procedure.

Because all Navy and Marine Corps calibration procedures originate at NSWC Corona, technicians around the world calibrate test equipment the same way. "Corona is the organization assigned the task of developing, reviewing, approving, and distributing calibration procedures for the Navy and Marine Corps. Centralizing that function helps to create standardization of format, content, and technical approach across the Department of the Navy." said METCAL (MS20) manager Bob Fritzsche. *(continued)*



STEVE LABADESSA

Jeff Walden leads engineers who assess the Navy's metrology and calibration needs.

"A test procedure will include all the information that a technician needs to perform a calibration," added Walden. "That includes calibration standards, logistics, safety precautions, and special facility requirements."

The Measurement Science and Technology Laboratory, which houses the Measurement Science Department, has a lab that engineers use to evaluate calibration procedures and to develop automated calibration systems. Engineers at NSWC Corona perform few calibrations on test equipment—calibrations take place in the field.

After an engineer writes a calibration procedure, called an "Instrument Calibration Procedure" (ICP) by the Navy, he or she will take the procedure to the appropriate calibration lab to verify the procedure's integrity. Then, an ICP will go to one of six metrologists, or "subject-matter experts," for a quality technical (QT) review.

In a QT review, a subject-matter expert looks for details such as test-uncertainty ratios between the equipment under test and its calibration standard. **Figure 2** shows the process for developing and verifying an ICP. (The online version of this article contains detailed flowcharts of each box, www.tmworld.com/2007_09.)

Following a QT review, an ICP goes through a practical review. "One of our engineers will bring a procedure to a Navy or Marine facility and perform a bench test on the procedure with one of the laboratory's technicians," said Fritzsche. "The engineer will update the procedure to incorporate the inputs from the technician."

ICPs also receive a quality formatting (QF) review. ICP process manager Julie Cunavelis explained that Navy contract support personnel edit ICPs for formatting consistency. They correct details such as typing errors, line widths, and spacing. "Following a QF review, someone will perform a final bench test of the ICP," she said. "Bench tests take place at NSWC Corona or at another Navy lab by someone other than the ICP writer. Even with all those reviews, we still find glitches."

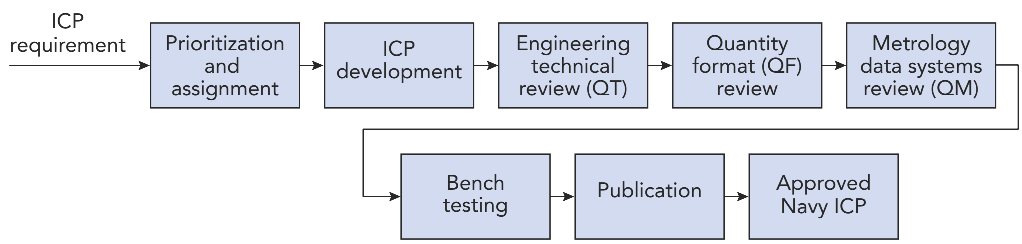


FIGURE 2. Instrument calibration procedures (ICPs) require several major process steps during their development. Courtesy of NSWC Corona.

When an ICP reaches final approval, Cunavelis' group will convert the written procedure to a PDF version that will be reviewed by someone from the METCAL group. Cunavelis will also give the ICP one more review. When it's ready, the approved ICP goes onto the monthly CD-ROM update. Each month's CD-ROM contains all in-service Navy test procedures. Upon receiving a new disk, technicians at each calibration lab destroy the previous edition.

The monthly CD-ROM update contains more than just test procedures. It contains a database of calibration intervals for each piece of test equipment. Calibration intervals may change even when a test procedure doesn't, so labs always work from the latest CD-ROM.

Internal analysis

To determine calibration intervals, engineers at NSWC Corona constantly receive and analyze calibration results from calibration labs. Because of the vast numbers of Navy test instruments, NSWC Corona engineers have perhaps the most calibration data of any organization in the world. Engineers study the data, usually over a three-year period, and recommend changes to calibration intervals. *(continued)*

If a particular instrument is consistently within tolerance, engineers may lengthen a calibration interval, which reduces the Navy's cost of ownership. If a particular instrument model is found out of tolerance, however, engineers will look at the impacts that an out-of-tolerance instrument has on testers and ultimately on weapons systems. They may recommend reducing calibration time or they may look for the cause of the condition and correct it, possibly by modifying the test procedure.

Night-vision goggles require testing before each use. NSWC-Corona engineers developed a standard to calibrate night-vision goggle testers. Courtesy of US Navy.

Data analysis is just one of the activities that NSWC Corona undertakes to reduce calibration costs. Hovakemian explained that the measurement science department has embarked on an automation and modernization program. "Just because we need something doesn't mean we get it, so we have to save money," he said.

Fritzsche emphasized this point when he added, "The Navy needs to spend money to purchase and update its bombs, planes, and ships. Thus, maintenance dollars to support those systems are often hard to find, and funding for calibration, which is essentially the maintenance of the maintenance equipment, is even more scarce."

Perhaps the most significant cost-cutting project involves automating selected calibration procedures. Richard Schumacher, an engineer in the Advanced Measurement Systems (MS40) group, demonstrated an automated calibration on an Agilent Technologies function generator and DMM. Navy engineers have selected 30 calibration procedures to automate, based on workload and level of difficulty.

"We automated a DMM calibration first because it was easy," said Schumacher, "but it's not a good test. So, we then developed a procedure for one of the most difficult instruments to calibrate, an RF test set, which uses 15 calibration standards. This instrument used to take 12 hours to calibrate by a highly trained technician. Now, a lesser-trained technician can calibrate it in about 3½ hours."

The automated system, called METBENCH, consists of an embedded computer module that doesn't have a hard drive. For security reasons, the operating system—a custom version of Linux—and the calibration software reside on a bootable USB thumb drive. Technicians at shore-based labs get the calibration procedure from the Navy's computer network, while ship-based technicians get procedures from a satellite link. (The monthly CD-ROM contains instructions on how to use the automated procedure.) Calibration results will also go on the USB thumb drive. NSWC Corona engineers deployed the first automated calibration procedures on a ship-based lab.

Schumacher explained that NSWC Corona engineers chose Linux for security, its small core, and no license fees. The computer connects to instruments through a USB-to-IEEE 488 interface.

"We developed a software tool that lets us develop automated calibration procedures without programming," said Schumacher. "We try to develop a single procedure that can automate the calibration of more than one instrument. We used to develop manual test procedures for each instrument model. Now, we can have one automated procedure for a class of instruments, such as DMMs." The system supports SCPI-based instruments and pre-SCPI instruments.

To perform a calibration, a technician logs into the system. Technicians have access only to those procedures that they are authorized to perform. The system then polls the instrument bus to find connected instruments, which includes equipment under test and those instruments used as calibration standards. A user log records every command sent to and response received from all instruments. Thus, the Navy can prove that an instrument was calibrated, and it has a time-stamped record of the entire procedure.

Schumacher and his colleagues in the MS40 group are also automating instrument management. A Web-based application lets lab technicians and managers locate any instrument or tester that requires calibration. A bar-code system records information on every person who handles an instrument. A technician's log-in information determines how much information he or she will see.

Automation can greatly reduce calibration time, provide greater repeatability, and provide a channel for NSWC Corona engineers to retrieve test results. An equipment-modernization program spanning a three-year period should further cut costs.

Replacing equipment

When it is time for the Navy to update its systems and calibration procedures, the MS30 group is responsible for evaluating replacement equipment. Brennan Heglar manages the physical and mechanical group. "We're looking to replace aging and obsolete calibration standards," he said. "Electronic standards have a five- to seven-year life while mechanical standards last 15 years or more."

The engineers look not only to replace standards but also to reduce the number of standards they must support. For example, a lab may use different standards for voltage, current, and frequency. The engineers may try to replace those three standards with one instrument.

"Electronic instruments make many measurements," said Fritzsche. "Time on the bench counts, so using a standard that produces several signals cuts test time over using multiple standards. Plus, from a logistics and cost perspective, we have fewer calibration standards to support."

The MS30 engineers base their decisions to replace instruments—whether they're used for testing weapons systems or used as calibration standards—on calibration and usage data. By looking at which systems use a particular standard, the engineers can determine the impact

that a new standard will have on equipment maintenance. They look at recurring costs of existing standards versus the purchase cost and maintenance costs of buying new standards. A replacement instrument must have, at most, a five-year payback period.

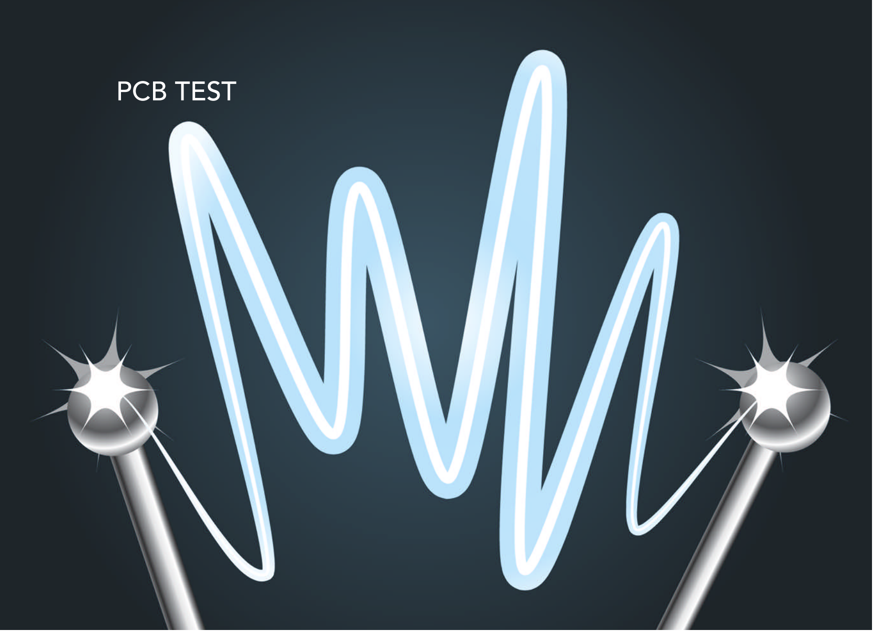
Navy engineers will use commercial off-the-shelf (COTS) equipment wherever possible. "COTS is key," said Heglar. Unfortunately, a replacement instrument isn't always available. Take, for example, the HP8902A RF measuring receiver. NSWC Corona engineers have to use three instruments to get comparable measuring capabilities. "We're working with test-equipment manufacturers to develop a replacement instrument," said Schumacher.

NSWC Corona engineers can also reduce costs by negotiating multiyear buys with equipment manufacturers. "We were able to buy an instrument for $10,000 per unit through a contract rather than pay $70,000 without a contract," said Walden. "We also combine our buys with those from the Army and the Air Force, which can reduce costs."

Besides coordinating equipment purchases with the other military services, NSWC Corona engineers confer with their Army and Air Force counterparts to share technical information, including calibration procedures when possible. "We work with other services," said Hovakemian. "We regularly hold meetings with the Air Force and Army where we look for ways to avoid duplication of calibration procedures or facilities. If the Navy needs a calibration and the nearest lab is run by the Air Force, we'll use that lab."

NSWC Corona engineers also participate in technical conferences such as the Measurement Science Conference (www.msc-conf.com) and the NCSLI Conference and Symposium (www.ncsli.org/conference). In fact, Fritzsche served as 2007 Measurement Science Conference president. He and others also work closely with NIST on metrology issues such as traceability to national standards.

Recently, Hovakemian and others in the Measurement Science Department have partnered with two local universities—University of California at Riverside and at Irvine—on educational programs to get engineering students to consider careers in metrology. T&MW



To avoid device damage, engineers must minimize backdrive currents and the length of time a circuit must endure them.

The BACKSTORY *on* BACKDRIVING

BY ANTHONY SUTO, TERADYNE, AND JOHN MCNEILL, WORCESTER POLYTECHNIC INSTITUTE

Since the introduction of in-circuit test (ICT) more than three decades ago, manufacturers of printed-circuit boards (PCBs) have debated whether overdriving devices during test can damage them. Research on the subject surfaced out of Bell Laboratories in the early 1980s (Ref. 1). Its conclusions were somewhat limited.

The Bell research involved CMOS parts featuring the large geometries, thick oxides, and 5-V power supplies of that era's state of the art. Since then, the battle to reduce heat dissipation and power consumption in a world of ever-higher speeds and shrinking circuit features has forced voltage levels dramatically lower, until today's V_{CC} barely tops 1 V.

Achieving higher device performance at lower supply voltages has required manufacturers to reduce gate-oxide thickness, yet thinner oxide makes a circuit more vulnerable to damage from electrical overstress (EOS).

Backdriving during in-circuit testing causes particular concern. Some circuits suffer damage from EOS when diodes are subjected to current levels that exceed manufacturers' specifications. More robust devices can guard against this damage, but they typically exhibit a higher shunt capacitance and therefore cannot achieve the switching speeds necessary for many applications.

Damage can take several forms. Reverse-biased junctions that are subjected to EOS can avalanche and fail. More often, forward-biased diodes fail because the high current leads to high temperatures that cause damage. Metallization layers that connect to the protection circuits can also succumb to Joule heating.

Devices may not malfunction immediately. Instead, parts with latent defects may pass all normal

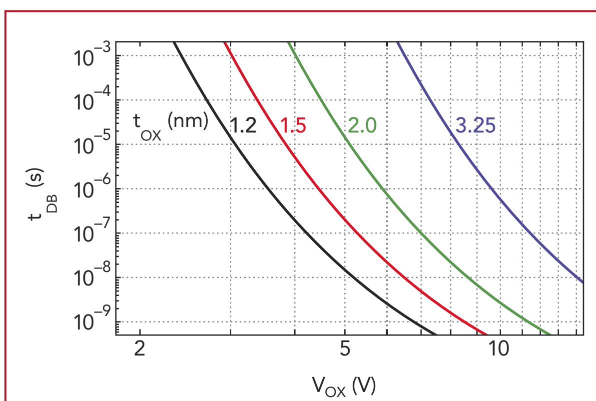


FIGURE 1. This graph shows mean time to dielectric breakdown (t_{DB}) as a function of voltage stress (V_{OX}) across the gate oxide for various gate oxide thicknesses (t_{OX}).

production tests, only to deteriorate over time and fail at the worst possible moment—in the hands of the customer. To ensure such failures don't occur, you need to understand the relevant failure mechanisms and how you can safely apply in-circuit test techniques.

CMOS latchup and TDDB

CMOS latchup occurs when I/O voltages exceed the power-supply voltage or fall below the nominal IC ground by more than about 700 mV. Such conditions can turn on the parasitic bipolar transistors Q_{npn} and Q_{pnp} in CMOS processes, heating up the bond wires as well as the rest of the die to temperatures that can exceed 200°C. More common on 12-V CMOS devices made two decades ago, this type of damage still presents a significant problem in submicron-geometry devices.

Time-dependent dielectric breakdown (TDDB) begins with an overvoltage condition that exhibits either a large amplitude for a short duration or a smaller amplitude for a longer duration. Resulting hot carriers accelerate to velocities high enough to enter the gate-oxide layer and create electron-hole pairs. The pairs, in turn, trap charges in the transistor's dielectric layer. These traps attract other trap sites and accumulate to form a silicon filament that eventually shorts a gate to a channel. As with diode damage caused by EOS, latent versions of these defects can escape all electrical tests during production only to fail later on.

Researchers have proposed two models for predicting gate-oxide reliability as a function of electric field E. For high values of E, an anode-hole injection, or "1/E" model agrees fairly well with experimental results. A thermochemical—or "E"—model works better at low field levels.

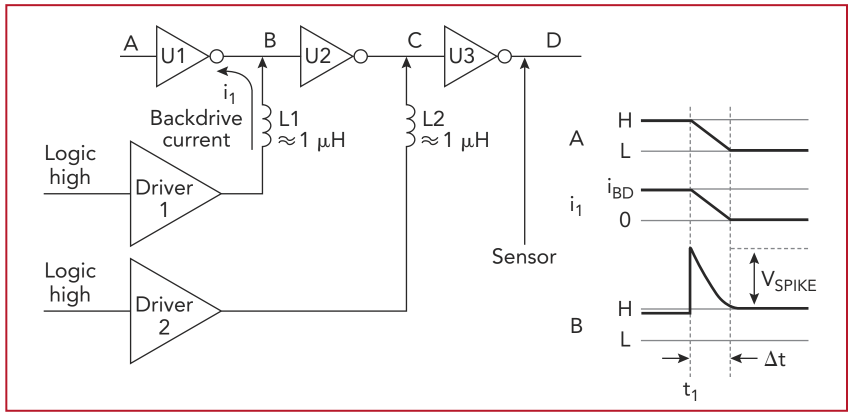


FIGURE 2. This example shows the backdriving of device U1 necessary to test device U3.

The 1/E model predicts a mean time to breakdown of

$$t_{BD} = C_1 \exp(C_2/E_{OX})$$

In this equation, C_1 is a technology-dependent empirical time parameter that represents a best fit with available data. Its value in this case is $5.6\text{x}10^{-13}$ s. C_2—the field-acceleration parameter—equals $4.3\text{x}10^{+8}$ V/cm. E_{OX} represents the electric field in the oxide, determined by

$$E_{OX} = V_{OX}/T_{OX}$$

where V_{OX} represents the voltage drop across the gate oxide caused by the applied voltage, and T_{OX} is the oxide thickness in centimeters. **Figure 1** graphs these parameters for various oxide thicknesses.

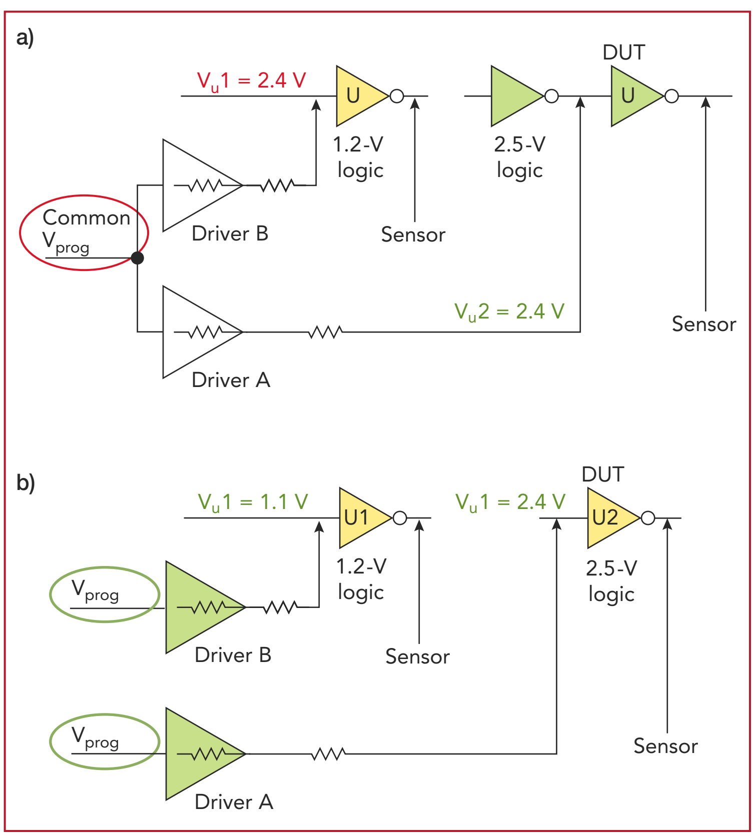


FIGURE 3. (a) A tester with a single voltage level for both Driver A and Driver B may not provide a safe environment for both devices. (b) In this tester design the two drivers can be programmed independently to minimize stress to the lower-voltage part.

Enter the in-circuit tester

An in-circuit tester must often force inputs to a logic state opposite to their "natural" states. This "backdriving" can induce currents of several hundred milliamps as well as overvoltage transients.

In **Figure 2**, U3 is the device under test. Its input at node C is forced by pin driver Driver 2. To ensure that Driver 2 sees a constant load and that the device produces a stable output, the tester prevents the U2 output from changing state during the test. To achieve this isolation, Driver 1

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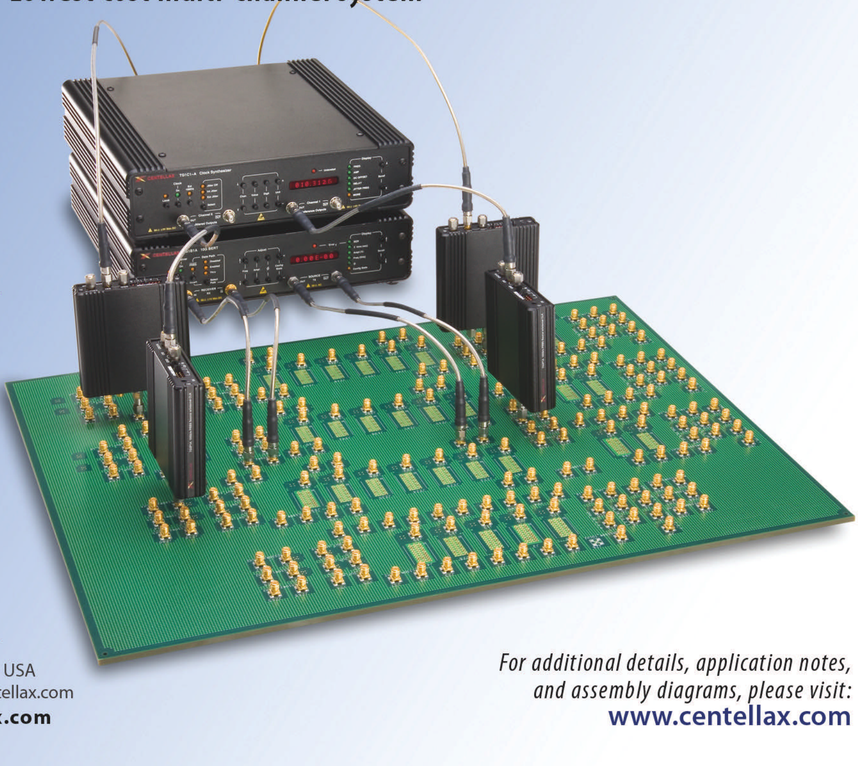

***SP10 SYSTEM** shown measuring BER of differential 20-inch 'victim channel' through FR4 backplane, with four single-ended aggressor channels interfering.*

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forces node B high. Since U1's input remains free, Driver 1 does not see a constant load.

The current level (i_1) required to maintain the desired state at node B depends on the node A logic level. If node A is high, U1 tries to drive node B low. To maintain the high, Driver 1 must supply a substantial backdrive current (i_{BD})—from 50 mA to 500 mA, depending on the device architecture. If node A is low, then node B is already high, and Driver 1 needs to supply little or no current during the test.

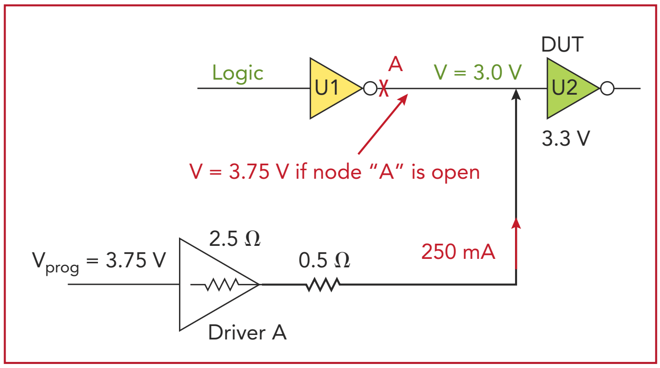

FIGURE 4. This test configuration exhibits an IR drop of 750 mV due to a 250-mA backdrive current through a 2.5-Ω driver output resistance and 0.5-Ω fixture and board resistance. Driver accuracy is ±100 mV, enabling V_{prog} to rise as high as 3.85 V.

If node A transitions from high to low during the test because of activity elsewhere on the board, the necessary backdrive current changes from i_{BD} to 0 over a very short time period (Δt). The sudden change in current and the inherent inductance between the driver and node B—typically 1 to 10 µH—causes a voltage spike at node B that can be severe enough to damage devices connected to that node.

Consider a backdrive current of 100 mA, a Δt of 10 ns, and an inductance (L) of 1 µH. The transition produces a voltage spike:

$$V_{SPIKE} = 1\ \mu H\ (100\ mA/10\ ns) = 10\ V$$

For faster logic families, the problem is even more severe. Their lower output impedance requires higher backdrive currents and lower transition time.

Certain characteristics of in-circuit tester architecture will aggravate a device's susceptibility to overvoltage failure. **Figure 3a** shows conventional in-circuit shared logic-level assignments that input a single voltage level to both Driver A and Driver B. In this case, Driver A has been programmed to an input voltage of 2.4 V, the level necessary to drive device U2 to a logic high. Because Driver B is slaved to that same voltage, it will subject U1's 1.2-V logic to overvoltage.

Testers designed specifically to serve low-voltage technologies, as in the schematic in **Figure 3b**, permit engineers to program the logic level independently for each pin. Each driver has its own programmable voltage for both high and low logic levels. Driver A delivers 2.4 V, while Driver B is programmed to apply only 1.1 V.

Inaccurate high-impedance tester drivers can also subject devices to overvoltage stress. The test configuration in **Figure 4** applies 250 mA of backdrive current to force the output of U1 to a logic high. This driver has an output impedance at 2.5 Ω and a path impedance of another 0.5 Ω, producing an IR drop in the test circuit of 750 mV. In addition, the driver has an accuracy specification of ±100 mV.

To accommodate the IR drop and to achieve an input voltage of 3.0 V at U2, you would need to program the input to Driver A above U2's 3.3-V nominal level to 3.75 V. With a driver accuracy of 100 mV, the programmed voltage could be as high as 3.85 V. If the output of U1 is open, the backdrive current is no longer required, and the tester drives the input of U2 to 3.85 V—an overvoltage condition.

If you replaced the high-impedance driver with a driver with an output resistance of only 0.05 Ω and an accuracy of ±15 mV, the tester will still push 250 mA of backdrive current, but the IR drop would be only 138 mV. Providing a 3.0-V input at U2 in this case would require you to program a voltage of 3.125 V. The driver error means that the actual voltage may be as high as 3.14 V. Therefore, even if the output of U1 is open, the voltage at U2 does not exceed safe levels.

Excessive current can also compromise device quality. In a worst-case scenario, the tester has to backdrive multiple outputs on the same device. In that circumstance, the ground bond wires or the power bond wires inside the chip have to carry backdrive currents from

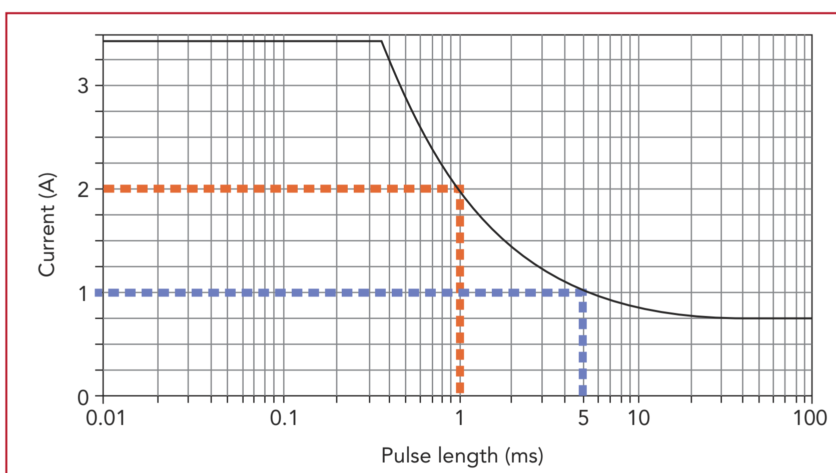

FIGURE 5. The curve represents what the UK Ministry of Defence has found to be safe backdrive current levels and pulse durations that will limit the temperature of a 1-mil-diameter aluminum bond wire to 210°C. A device with one ground bond carrying 2 A allows a pulse lasting only 1 ms (red dashed line). Adding a second ground bond to share the current permits a 5-ms pulse (blue dashed line). The values assume a 25°C ambient temperature and a 39-ms cooling-off period between pulses.

all backdriven digital outputs at the same time.

The 74AC244 bus driver, for example, features eight outputs, each requiring about 250 mA to backdrive, as well as a single power pin and a single ground pin. If there is only one bond wire between the ground pin and the die, then as much as 2 A could be flowing through that wire. If, instead, the pin and die were double-bonded—two bonded ground wires in parallel—then 1 A of current would flow along each of those paths.

Figure 5 illustrates what the UK Ministry of Defence (Ref. 2) has found to be safe operating parameters for backdriving on a 1-mil-diameter aluminum bond wire. According to the graph, with all eight outputs backdriven on a 74AC244 along a single bond wire carrying 2 A, a backdrive pulse longer than 1 ms would risk damaging that bond wire. A part from another vendor that featured two parallel bond wires could endure a backdrive pulse of 5 ms before experiencing the same level of stress.

How much backdrive?

We analyzed one manufacturer's test-related backdrive on a PC motherboard. Our analysis showed the following:

- 17 out of 17 digital bursts included backdriving conditions;
- 217 backdrive events exceeded 50 mA;
- the test exposed 96 nets on the board to backdrive conditions, 28 of them more than once;
- the mean backdrive current was 131 mA with a median of 87 mA;
- the maximum current was 543 mA; and
- the longest backdrive pulse width was 258 ms.

The manufacturer's staff claimed that by using design-for-manufacturing and design-for-test methods, they had diligently optimized the test program. They said they had not subjected the board to backdriving conditions and were quite surprised when we showed them our results.

Uncontrolled backdriving can be caused by a number of factors. For example, the test program may inadequately isolate devices from transients during the test, and incorrectly programmed drive levels can exceed input compliance limits, accidentally turning on ESD structures. At one point in our analysis of the PC motherboard, the test program applied 2.5 V to a 1.2 V device. A test program may also connect bidirectional output bus drivers to pin drivers before switching the chips to input mode.

In some board topologies, the program may accidentally backdrive not the gates themselves but discrete small-value resistors connected between a long run of two digital devices communicating with one another. These resistors, typically with values of 22 Ω or 33 Ω and generally four to a pack, reside in the circuit to minimize transmission-line effects. They don't have a very high power rating, so backdriving can damage them when pins on either side are forced to different logic levels.

Last, it is not uncommon to see incorrect code loaded onto programmable devices. That type of error could, for example, backdrive an output that is supposed to be an input.

Figure 6 shows a screen from a debug environment that features real-time backdrive information to help programmers identify potentially harmful conditions. This type of information allows you to go back to the program and to the board schematic to identify alternate test steps that prevent such dangerous conditions.

Backdrive measurement circuitry can also save manufacturers money during production. Here, the debug tool can reveal incorrect device programs, open or faulty enable pins, and incorrect isolation vectors. The tool looks for backdrive durations of 500 ns to 25 ms and currents of 15 mA to 500 mA—parameters that users can set depending on the specific situation.

Thus, to avoid device damage, you must minimize backdrive currents and the length of time a circuit must endure them. By invoking all available tools—including new software debug tools—you can reduce test-vector execution times and ensure that logic devices do not accidentally change state during backdrive conditions. T&MW

```
DEVICE LABEL: U33_B1: (NAND tree Test)
DEVICE NAME: U33
DEVICE TYPE: 82801 (I/O Controller Hub-3V)

PIN   NODE            NAIL     BACKDRIVE
A3    PICH_HLCOMP      106      79.06 mA
G1    LAN_RXD1         640      73.79 mA
R21   RSMRST_           90     131.76 mA
W11   PCLK_ICH         105      84.33 mA
Y20   OVCUR_1          147     469.08 mA
R22   FERR             614      76.42 mA
C12   CPUINIT_         743     450.64 mA
D11   SB_A20M_         575     563.95 mA
Y17   SUS_STAT         531      73.79 mA
      GGNT_             61     171.29 mA
      RBF_              67     237.18 mA
      SBA0             122     176.56 mA
```

FIGURE 6. New debug software can show real-time backdrive information to help programmers identify harmful conditions.

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FOR FURTHER READING

Technical papers that provide a discussion of backdriving can be found at www.teradyne.com/atd/resource/type/technical_papers.html.

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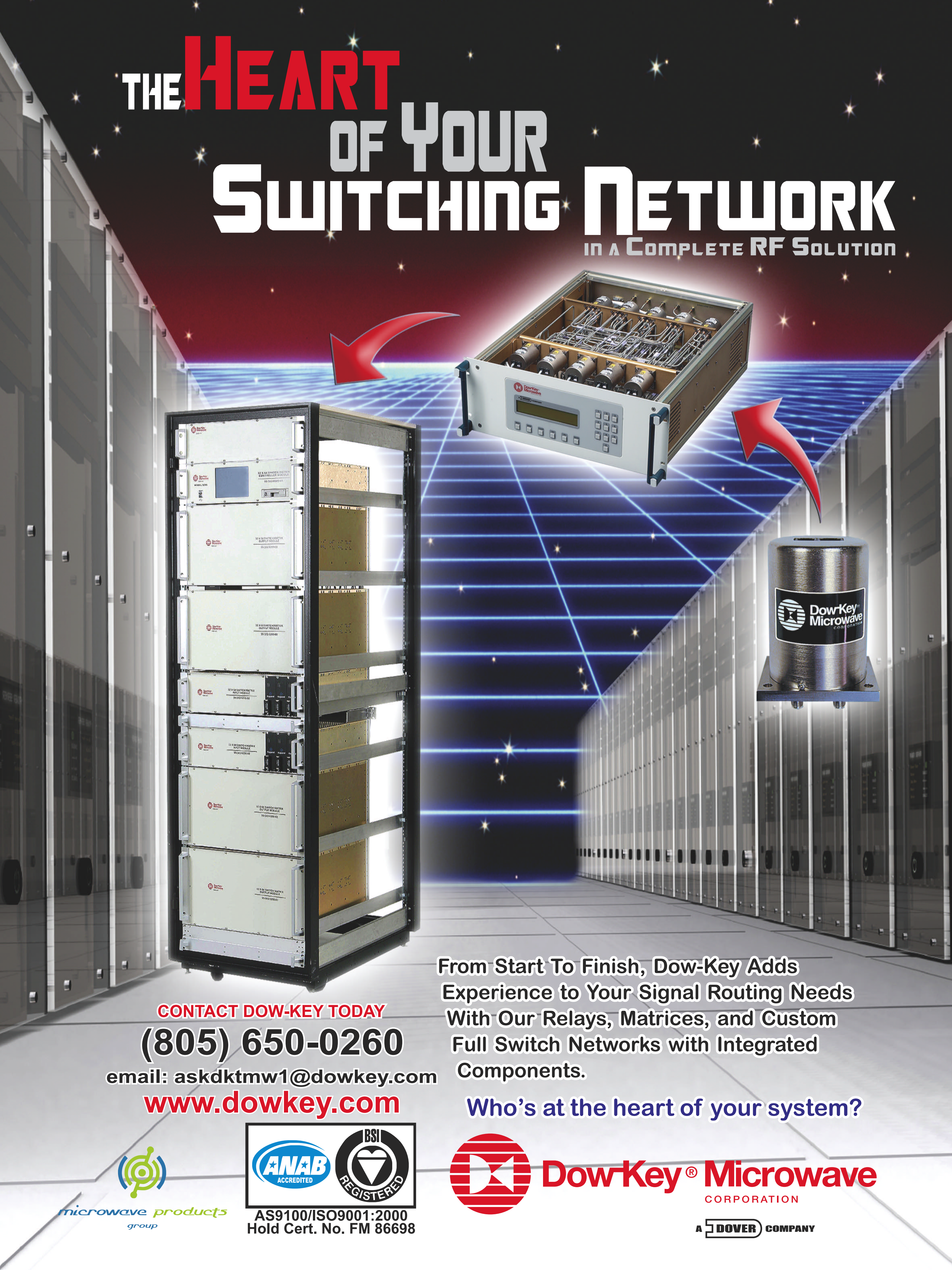
Tony Suto *is chief scientist at Teradyne (North Reading, MA), and* **John McNeill** *is associate professor at the Electrical and Computer Engineering Department at Worcester Polytechnic Institute (Worcester, MA).*



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Agilent Technologies

MAKING THE CONNECTION between VXI and LXI

Test-system designers can leverage the power of LXI and Ethernet without sacrificing the capabilities of VXI technology.

BY TOM SARFI, VXI TECHNOLOGY

LXI instrumentation is making inroads in the test and measurement industry, especially in small- to medium-channel-count applications. Yet, despite the growing popularity of LXI, demand continues for the combination of density and performance that VXI instrumentation provides. In addition, VXI has a significant installed base of systems that will retain their usefulness for the foreseeable future.

By combining the strengths of the LXI and VXI platforms, engineers can build systems for acquiring data over long distances, such as from strain gauges distributed along an aircraft runway. Similarly, engineers also can combine the technologies to build a high-throughput system, such as a 24-channel system that can acquire data at up to 64,000 samples/s.

Merging VXI and LXI

Both VXI and Ethernet—the bus used in LXI instruments—have long histories of development while maintaining compatibility with earlier versions. The VXIbus is based on the VME architecture introduced in 1981, while Ethernet has been evolving for more than 25 years. In addition, Ethernet has inherent benefits that have made it the interface of choice for test system designers and instrumentation suppliers:

- It is an established, high-speed bus that continues to evolve;
- It offers a stable architecture;
- It is computer-platform and operating-system independent;
- It is a low-cost interface that works with low-cost cabling and accessories; and
- It supports up to 10-km separation between host and target device.

For these reasons, the LXI (LAN eXtensions for Instrumentation) Consortium selected Ethernet as its communications backbone. The initial LXI specification was released in September 2005 and was quickly adopted by more than 40 suppliers. Despite this movement, many system engineers want to maintain their investment in VXI for higher-channel-count requirements, although they are willing to integrate

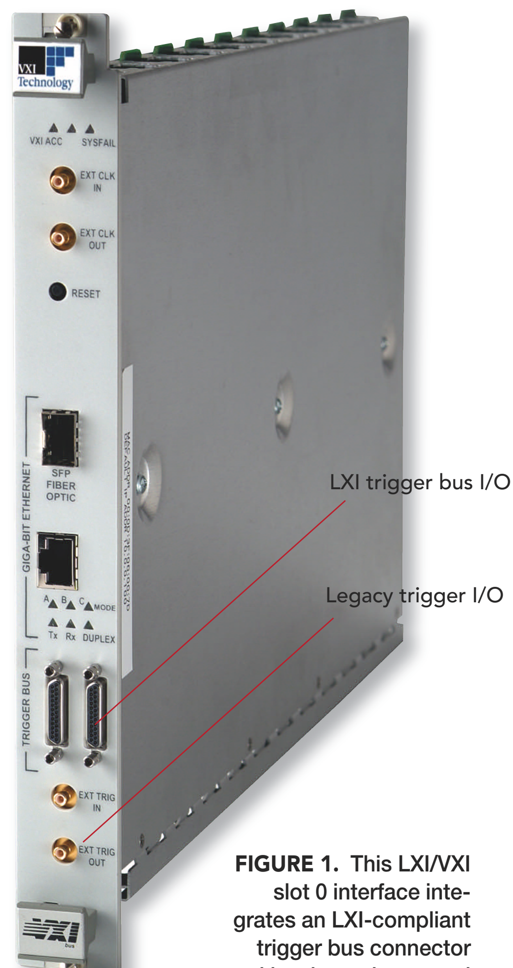


FIGURE 1. This LXI/VXI slot 0 interface integrates an LXI-compliant trigger bus connector and level translators and drivers to enable the interface to accommodate the different logic levels of a legacy bus.

LXI-based products as they become available. This means that LXI and VXI products must work together seamlessly in hybrid systems.

By incorporating an LXI/VXI slot 0 Class A compliant bridge device, VXI instruments can be tightly integrated with instruments residing on an LXI instrument network. Merging LXI instruments and VXI devices in this way allows designers of test systems to take advantage of the strengths of each platform. It also enables them to build powerful instrumentation networks capable of addressing nearly every functional-test and data-acquisition need.

LXI Class B compliance requires that an instrument include the IEEE 1588 Precision Time Protocol, which defines a precision clock-synchronization method for distributed networked devices. A VXI system can become time synchronous with LXI devices on the test LAN if the slot 0 interface incorporates IEEE 1588.

For more deterministic synchronization and handshaking between networked devices in close proximity, the hardware triggering required by LXI Class A-compliant devices should be used. The LXI specification incorporates a separate eight-line LVDS trigger bus that can map directly to the VXIbus TTL trigger bus.

To implement the bridge between trigger buses, the slot 0 interface must integrate an LXI-compliant trigger bus connector and level translators and drivers to accommodate the different logic levels of each bus. **Figure 1** shows the front panel of a typical LXI/VXI slot 0 interface.

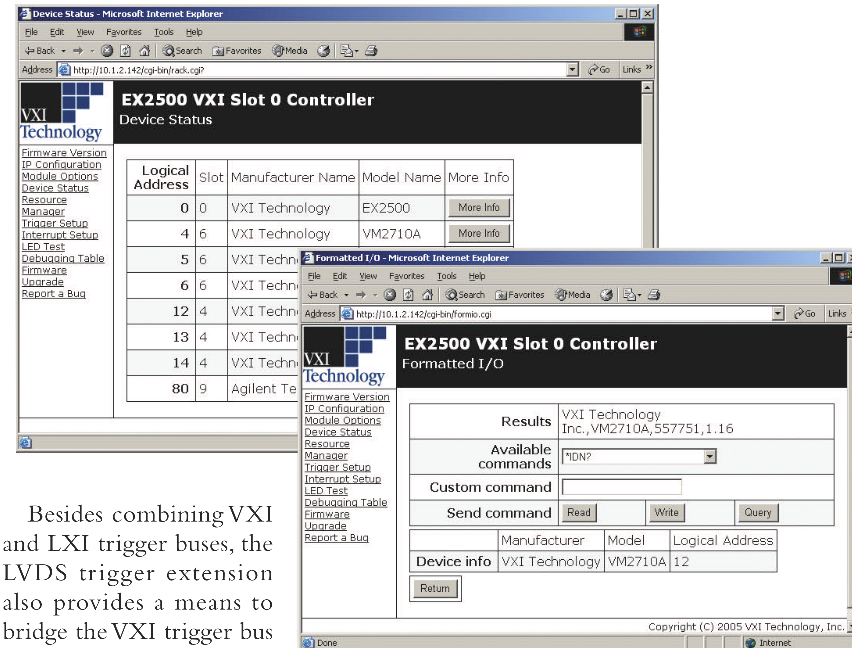


FIGURE 2. An LXI-compliant Web interface can support VXI instruments.

Besides combining VXI and LXI trigger buses, the LVDS trigger extension also provides a means to bridge the VXI trigger bus across multiple mainframes. This was not possible with previous serial slot 0 interfaces.

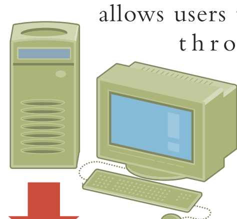
The LXI specification also states that LXI-compliant instruments must include an embedded Web page to allow direct communication to instruments through a browser. The LXI/VXI slot 0 interface now makes this tool available to VXI system users. The Web page (**Figure 2**) provides a GUI that allows users to control devices through common browser applications such as Internet Explorer or Firefox.

Many VXI slot 0 interfaces do not embed the VXI resource manager on the module. Rather, it is hosted on the remote PC and must be executed prior to communicating with any devices on the backplane. In contrast, the LXI/VXI slot 0 interface embeds the resource manager on the module and executes it automatically at power up. This eliminates the need for a separate software utility on the host.

More importantly, an HTML-driven interface like the one in Figure 2 can be designed to act as an interactive control panel. The control panel resides on the host controller and permits register or message-based communication to be done through the browser. This capability simplifies software installation and setup.

Distributed applications

VXI was initially designed to handle high-channel-count or high-mix functional-test and data-acquisition systems. Applications requiring the distribution of measurement channels across long distances were typically left to small, low-



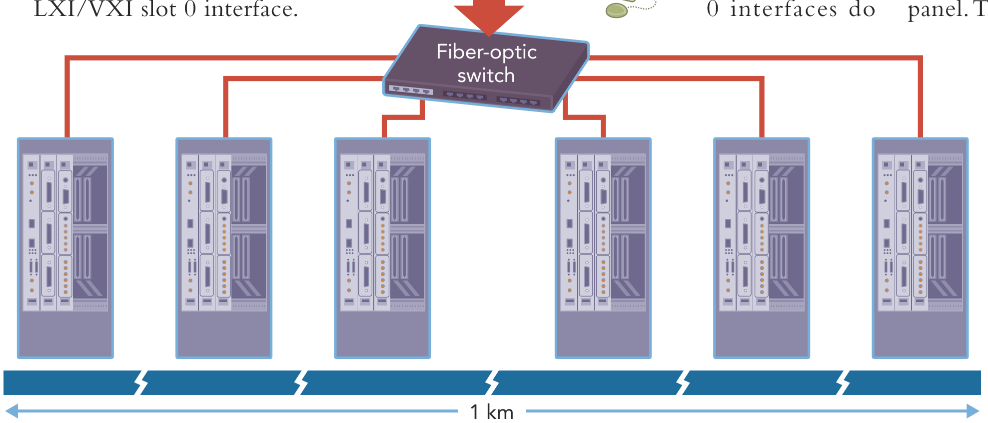


FIGURE 3. In this distributed application, each mainframe handles six groups of strain gauges and contains a VXI/LXI slot 0 interface, which costs about one-third the price of an embedded slot 0 controller.

performance modules linked together with proprietary buses. When higher channel counts or measurement quality demanded the performance provided by VXI devices, the options were limited to costly embedded controllers or bus extenders that were not always reliable.

A LAN-based slot 0 device allows multiple mainframes to be connected to a single host controller up to 100 m away with standard copper cable and an Ethernet switch. Fiber-optic cables and switches permit distances to 10 km. If the slot 0 device implements LXI Class B synchronization techniques, measurements can be synchronized to a high degree of resolution (tens of nanoseconds) across the instrumentation network.

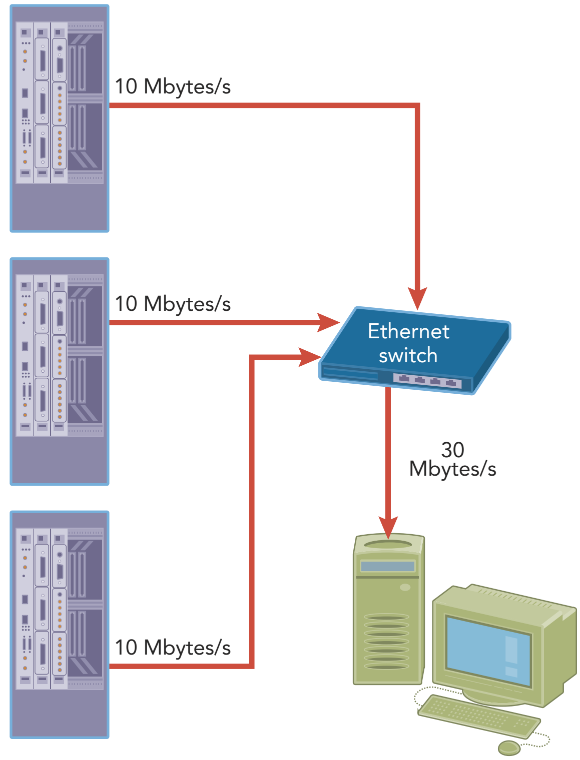


FIGURE 4. This system aggregates data from three VXI mainframes via a 1-Gbps Ethernet switch.

As an example, consider a system constructed to acquire data from six groups of strain gages distributed across 1 km of concrete pavement, with each group consisting of 192 channels. The strain gages measure the stresses on the pavement, which is subjected to repeated loading to simulate the landing of large commercial aircraft.

The high channel count and integrated signal conditioning required for this installation were best handled by a VXI architecture. The original system incorporated six mainframes with six embedded controllers. Each controller independently managed data acquisition from the channels in its mainframe and passed the data over an Ethernet connection to a remote PC, where a complex program post-processed and synchronized the data.

System designers found, however, that this architecture was susceptible to faults due to the number of independent processors involved. The LXI/VXI slot 0 interface provided an opportunity to consolidate control and data processing on a single host, greatly reducing complexity. In addition, because the LXI/VXI slot 0 implements LXI class B synchronization, channel-to-channel skew has been reduced considerably, and data samples acquired across mainframes (and distances) have tight time correlation. **Figure 3** illustrates the topology of the new implementation.

Increasing data throughput

Perhaps one of the most significant aspects of adding Ethernet capability to VXI is the ability to increase overall data throughput by using the speed of the bus coupled with the fundamental nature of an Ethernet switch. Large-channel-count, high-speed systems can push the limits of even the fastest slot 0 interfaces because the single pipeline back to the host is bandwidth limited. Further, the acquisition device often becomes a bottleneck if cycle times (the speed at which a block of data can be placed on the bus) are constrained by factors such as onboard processing.

This is illustrated by a 16-channel, 16-bit acquisition device capable of

sampling data on all channels simultaneously at a maximum rate of 100,000 samples/s. An onboard digital signal processor (DSP) runs the data through intense algorithms prior to putting a block on the bus for retrieval, and a single module is limited to about 12-Mbytes/s throughput to the backplane. If the slot 0 interface can support transfer rates greater than 12 Mbytes/s from the backplane to the host, then the instrument module can be a bottleneck. If the slot 0 interface cannot support 12-Mbytes/s transfer rates, then the interface itself may become a bottleneck. In either case, the instrument faces the prospect of overflowing its buffer because it cannot be emptied fast enough to keep up with the amount of data acquired.

In a recent application, 240 channels of data were simultaneously and continuously sampled at a rate of 64,000 samples/s. The amount of data to be processed by the entire system can be calculated from

$$R_{DI} = R_S DC$$

where R_{DI} is the data-in rate, R_S is the sample rate, D is the number of bytes per sample, and C is the number of channels. For the 16-channel, 16-bit system described above, R_{DI} = 30.7 Mbytes/s.

Because the data input rate exceeded the 12-Mbytes/s rate at which a module could be emptied, an overflow was certain to occur, and significant amounts of data would be lost. Further, even the fastest slot 0 interfaces could not alleviate this problem, because the data transfers occurred across a single bus connection back to the host. For example, a 1-Gbit LXI/VXI slot 0 interface supports block transfers in excess of 40 Mbytes/s, but this would not increase the aggregate data rate through a single pipeline.

The only acceptable way to address this application was to split the acquisition modules across three six-slot VXI mainframes (five modules per mainframe) and interface back to the host controller using a 1-Gbit slot 0 interface and a multiport 1-Gbit Ethernet switch as shown in **Figure 4**. While the path from the switch to the host PC is across a single connection, the keys to successfully meeting this challenge revolved around the bandwidth of the bus (1-Gbit Ethernet is roughly 100 Mbytes/s) coupled with the intrinsic ability of the switch to manage and buffer the large amount of data passing through each of the three ports.

These examples illustrate effective deployment of combinations of VXI and LXI technology that take advantage of the promise offered by LXI while ensuring that the installed base of VXI systems continue to pay dividends. T&MW

Tom Sarfi *is business development manager at VXI Technology (Cleveland, OH) and president of the VXIbus Consortium.*

LXI switches go high voltage and low loss

Pickering Interfaces has added two models to its line of LXI-based switch systems: the high-voltage Model 60-310 and the low-thermal-EMF Model 60-510. The Model 60-310 can hot-switch 500-VDC signals or cold switch 1000-VDC signals through a 300x2 two-pole switching matrix that resides in a 2U-size enclosure. You can use the Model 60-310 to perform insulation tests on cable harnesses and PCBs as well as to perform breakdown testing on semiconductor devices, relays, and switches. The switch module uses rhodium-plated reed relays and is also available in 100-switch and 200-switch versions.

The Model 60-510 contains a 56x33 matrix that can switch 150-VDC signals with current up to 1 A. Also housed in a 2U-size enclosure, the 60-510 uses ruthenium-sputtered contacts. Typical loss from thermal EMF is less than 2.5 mV.

Base prices: 60-310—$12,155; 60-510—$11,295. *Pickering Interfaces, www.pickeringtest.com.*

Analog signal generator offers 6-GHz performance

The SMB100A analog signal generator from Rohde & Schwarz comes in four models with measurement coverage from 9 kHz to 1.1, 2.2, 3.2, and 6 GHz. Output is +18-dBm specified (+25 dBm in overrange mode); flatness is ±0.5 dB up to 3 GHz and ±0.9 dB above 3 GHz; and setting time is less than 3 ms for frequency and less than 2.5 ms for level.

In list mode, the instrument can store and automatically run up to 2000 pairs of frequency and level settings, reducing setting time to less than 1 ms. At 1 GHz, phase noise with a 1-Hz measurement bandwidth is typically –128 dBc/Hz at a 20-kHz carrier offset, nonharmonic suppression is –70 dBc at a 10-kHz offset, and wideband noise is typically –152 dBc.

The SMB100A can serve aerospace and defense applications such as radar system (pulsed signal) testing. In addition to the instrument's standard AM, FM, and phase modulation, a pulse generator and pulse modulator are available as options.

Other features include reverse power protection of 50 W at 1 GHz, 25 W up to 2 GHz, and 10 W at 6 GHz; broadband-frequency modulation with a maximum deviation of 16 MHz above 3 GHz; VSWR of less than 1.8:1; measurement repeatability of ±0.02 dB; and an internal low-frequency generator that delivers sine-wave signals up to 1 MHz and square-wave signals up to 20 kHz.

Base price: $6350. *Rohde & Schwarz, www.rohde-schwarz.com.*

Store a world of test data

Data-acquisition systems used in aerospace testing may have hundreds of channels, which means they generate a lot of data. The Big River LTX2 data recorder from Conduant can help in such applications, as it holds up to sixteen 2.5-in., 250-Gbyte disk drives, enabling it to store up to 3.2 Tbytes of data. It can also accept SATA solid-state drives.

The recorder has several digital interfaces for connection to data-acquisition systems. Interfaces include a front-panel data port (FPDP), a 32-bit TTL bus, and a serial FPDP (a serial optical interface based on Fibre Channel). It also supports Star Fabric—which gives the recorder access to a PCI bus—as well as LVDS and Camera Link.

The Big River LTX2 can operate as a stand-alone recorder, or you can connect it to a PC though its Ethernet port. You can write your own control software or use the recorder's built-in Web server to control it with a browser. The LTX2 is designed for field applications and runs on 12-VDC power.

Price: $28,000 for a 1.6-Tbyte system. *Conduant, www.conduant.com.*

JTAG module streamlines TestStation integration

JTAG Technologies has announced the availability of its JT 2147 Custom Function Module (CFM) for use with its Symphony 228xPLUS integration package for Teradyne's TestStation in-circuit testers (ICTs). With the availability of the JT 2147 CFM, existing TestStation and previous-generation 228x systems can be upgraded with a JTAG Technologies boundary-scan controller to handle test and in-system programming demands.

> > > > > > >

The JT 2147 CFM provides a means of incorporating a boundary-scan TAP pod into the ICT system. Two CFMs can be installed on the Teradyne Custom Function Board (CFB), which provides ground isolation and also contains a switching matrix to route TAP signals to pins on the test fixture.

The JT 2147 module is the product of a cooperative effort between engineers at Teradyne and JTAG Technologies.

Base price: Symphony 228xPLUS—less than $15,000 for a complete upgrade package, including one CFM module. *JTAG Technologies, www.jtag.com.*

Noise modules have bandwidths up to 10 GHz

Wireless Telecom has added two modules to its family of amplified noise sources: the Noise Com NC1127A and NC1128A. With their white Gaussian noise distribution, the modules can be used as random jitter sources for many applications, including PCI Express, Infiniband, 10 GigE, and IEEE 802.3ap backplane Ethernet testing.

The NC1127A operates from 10 MHz to 5 GHz and provides output power of –20 dBm at –117 dBm/Hz and output flatness of ±2.5 dB. The higher-frequency NC1128A covers a range of 10 MHz to 10 GHz and provides output power of –17 dBm at –117 dBm/Hz and output flatness of ±2.5 dB. Both devices operate over a temperature range of –35°C to +100°C.

The output of each noise source connects to an RF amplifier that boosts power to the desired output. NC1000 modules can be used for a wide variety of applications that require the injection of noise at high levels, including CATV equipment, secure communication channels, and military jamming systems.

Wireless Telecom Group, www.noisecom.com.

Strategic debuts 125-MHz PCI Express I/O boards

In addition to a choice of 16-bit, 32-bit, and 64-bit TTL port widths, Strategic Test's UF2e-7000 series of digital I/O boards for the PCI Express bus provides a maximum clock rate of 125 MHz on 32 channels and 60 MHz on 64 channels. The four-board series can synchronize up to 127 boards, including digitizers and arbitrary waveform generators.

The UF2e-7020 and UF2e-7021 are also able to record and replay simultaneously. Each board furnishes external clock and trigger connectors, as well as 64 Mbytes of on-board memory, which can be expanded to 4 Gbytes. In FIFO mode, the boards can stream data to and from a PC at 150 Mbytes/s. All boards come with SBench software for recording or replaying digital waveforms.

Strategic Test, www.strategic-test.com.

CATALOGS & PRODUCTS

The following write-ups were supplied by advertisers in this issue.

Product information CD

A product CD offers a virtual tour of all AR products, including RF and microwave amplifiers, amplifier modules, EMI receivers, and RF test accessories. It also includes application notes, advertisements, brochures, and press releases. *AR, www.ar-worldwide.com.*

6½-digit DMM

Keithley's Model 2100 6½-digit USB digital multimeter has a special introductory price of $795 plus a 30-day no-risk evaluation. You can learn about its precision, features, and speed at the company's Web site. *Keithley Instruments, www.keithley.com/at/469.*

In-circuit tester

CheckSum's new Agilent 3070-compatible ICT test system includes the hardware and software to reuse existing 3070 test fixtures, even with TestJet, at a much lower cost. *CheckSum, www.checksum.com.*

Push-pull connectors

A catalog from Lemo describes the company's B and S Series connectors, as well as the watertight K and E Series. A wide variety of plugs, sockets, and couplers are available in different contact configurations. *Lemo, www.lemo.com.*

High-voltage power

Spellman's Bertan 210 Series HVPS provides regulated outputs from 1 to 50 kV at 125 to 225 W. The low-noise, linear topology results in extremely low output ripple. The 210 Series instruments are reversible, providing negative or positive polarity. *Spellman High Voltage Electronics, www.spellmanhv.com/bertan/tmw.*

Improved RF switching

Pickering Interfaces offers 3-GHz RF PXI switching modules with high density and high performance. Typical VSWR is 1.2, and insertion loss is below 1 dB. Models include SPDTs, muxes, and 2x2 matrices. *Pickering Interfaces, www.pickeringtest.com/radio.html.*

Poster explains WiMAX

A new poster from Agilent is designed to help engineers understand the WiMAX communication standard by describing and contrasting fixed and mobile WiMAX technologies as well as describing some tests that engineers will need to make as they develop WiMAX products. *Agilent Technologies, www.agilent.com/find/wimaxposter.*

Test and measurement

Data Translation's product guide offers details on USB, PCI, and LXI data-acquisition test and measurement products, including Measure Foundry application builder. You can choose from low-cost, simultaneous, high-performance, and DSP hardware and software. *Data Translation, www.datatranslation.com/productguide.*

Spectrum analyzer

The R&S FSU67 from Rohde & Schwarz extends the upper frequency limit in spectrum analysis from 50 GHz to 67 GHz, making external waveguide mixers superfluous and simplifying the test setup. *Rohde & Schwarz, www.rohde-schwarz.com.*

IP network simulator

IPNetSim simulates the conditions of real-time IP networks, including latency, jitter, bandwidth, congestion, packet errors, and bit errors independently in both directions at speeds of up to 100 Mbps (or 1 Gbps per link). *GL Communications, www.gl.com/ipnetsim.html.*

PCIe data acquisition

Spectrum offers PCI Express digitizers and data-acquisition cards ranging from 100 ksamples/s up to 200 Msamples/s. The cards include up to 4-Gbyte onboard memory, eight input ranges, and drivers for Windows and Linux. *Spectrum, www.spectrum-instrumentation.com.*

Interface converters

Omega's miniature IC11 converters provide high-quality interfaces in a miniature package and at a low cost. The IC11 intelligent RS-232-to-RS-422/485 converter can be selected for half or full duplex, and it allows transmission distances of up to 1220 m (4000 ft). *Omega Engineering, www.omega.com.*

Rack and panel connector

iCon, a high-performance rack and panel connector, combines signal, power, and coaxial modules in one device. It is designed for high-density applications, mating up to 320 signal contacts. *Virginia Panel Corp., www.vpc.com.*

Catalog adds imaging lenses

Edmund Optics recently added seven lines of Schneider imaging lenses to its Website and catalog. The products include three CCD lenses, F0.95 fixed-focal-length lenses, telecentric lenses, and compact VIS-NIR lenses. *Edmund Optics, www.edmundoptics.com.*

Clock extraction for BERT

If you need clock extraction for BERT synchronization, a Centellax Clock Recovery Unit can help. When a direct clock signal isn't available for your BERT error detector, the Centellax CRU (with rates from 622 MHz to 13.5 GHz) extracts a clock signal from your data stream. *Centellax, www.centellax.com.*

Mixed-signal oscilloscopes

Yokogawa has expanded its line-up of 16- and 32-bit mixed-signal oscilloscopes targeted at applications that require simultaneous measurement of both logic and analog waveforms. Yokogawa's MSOs also offer serial-bus triggering and analysis. *Yokogawa, www.yokogawa.com/tm.*

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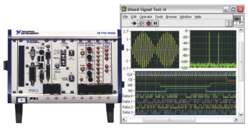

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NATIONAL INSTRUMENTS™

PXI systems aid manufacturing test

By Richard Quinnell, Contributing Technical Editor

Despite its heavy investment in LXI as the foundation of its next-generation manufacturing test systems, Agilent Technologies has been expanding its presence in the PXI market. In December 2006, the company acquired PXI Instrument Technologies (PXIT) and Acqiris, and in the spring of this year, it reaffirmed its new acquisitions' memberships in the PXI Alliance and became a member of the alliance in its own right in May.

Neal O'Gorman, Agilent's PXIT product manager, cleared up this apparent contradiction by explaining that the company remains committed to its current PXI customers and that going forward, it plans to work with customers to find the best solution for a given application, regardless of the technology platform.

Until LXI truly takes off, though, Agilent and its customers need to rely on other modular technologies when building comprehensive manufacturing-test systems. Fadi Daou, former CTO of PXIT and now consultant to Agilent on product strategy, spoke with me by phone to explain PXI's role in manufacturing test.

INSIDE THIS REPORT

Q: What kinds of products did the acquisition of PXIT bring to Agilent?

A: Our focus was on high-value instruments, mostly for electro-optical transceiver signal testing. Products included a 8.5-Gbps digital communications analyzer, bit-error-rate testers (BERTs), and derivative products such as pulse generators. We addressed the manufacturing test area where no one else had the right solution for the market.

Q: What does the right solution for manufacturing test involve?

A: There are three key needs in manufacturing test: throughput, cost, and size. PXI addresses all of these well. In throughput, for instance, you might need a minute to run a test using an R&D-type bench instrument. With a manufacturing-test instrument, you would want to run that test in 5 s.

Q: How does PXI help engineers shorten test time?

A: R&D test equipment lets the engineer make adjustments so he can measure signals to establish design margins and the like. In manufacturing test, you need to make only a limited set of measurements and only need a pass/fail response or simple metrics. That goes a lot faster.

With PXI, instrument setup is handled by software with no front-panel knobs to turn, allowing the system to move from one test to the next quickly. That also helps prevent people from making changes that might upset the test.

Fadi Daou
Former CTO of PXIT;
Consultant to Agilent Technologies
Courtesy of Agilent Technologies

Q: Any other benefits?

A: PXI supports virtual instrumentation and allows you to get many instruments in the same chassis. This helps reduce size and cost of the instrument, which is critical for manufacturing test where users may need to establish and run many manufacturing lines in parallel in one location. With PXI, Agilent can sell an instrument for typically half of what an R&D instrument would cost.

A final important factor is that users can get PXI products that come from a single design team so they can ensure compatibility and offer optimized communications between the units. Even if from one company such as Agilent, R&D instruments of differing types come from different design groups addressing different needs. PXI permits one design team to create all the key instruments for an application. □

EDITOR'S NOTE

Wireless PXI?

Richard A. Quinnell, Technical Editor

With just about everything going wireless, I've started wondering when PXI will join the parade. A wireless link to an instrument module certainly seems to hold promise. Eliminating wires can help prevent ground loops, inductively coupled EMI, and common-mode noise

while providing high-voltage isolation and eliminating the need for connector accessibility. The move would also stimulate development of unforeseen applications.

But PXI is more than just a data bus. The synchronization and trigger buses, or at least their functional equivalent, would also have to be made wireless. And timing is much harder to control in a wireless connection.

Wireless connections have many undesirable attributes as cable replacements. One concern is the variability of signal-propagation time. Cables and backplane traces have fixed and predictable lengths, but wireless links can be any size up to the radio's range limit. Because the speed of light is around a nanosecond per foot, even movements of a few inches can have a significant impact on system timing. Any wireless PXI proposal will need to provide a means for calibrating or constraining timing signal-propagation times or find a way to eliminate the effects of variable signal paths.

Other challenges exist with wireless links, including providing data security, handling interference and signal loss, and dealing with multiple, simultaneous signals. But challenge is what engineers thrive on. Is wireless PXI worth the effort? □

Contact Richard A. Quinnell at editor@aatr.net.

HIGHLIGHTS

Pickering announces new RF switching modules

Pickering Interfaces has expanded its PXI RF switching line with the introduction of four new single-slot modules that offer RF performance to 3 GHz with low insertion loss. Each module is available in partial-build configurations, allowing users to specify the number of switching elements they need, and each is available with a choice of MCX or SMB connectors.

The 40-870 provides up to six-off SPDT switches; the 40-872 offers up to four-off four-way multiplexers; the 40-874 includes one or two eight-way multiplexers; and the 40-877 provides a single or dual 2x2 matrix with loop-through connections that permit users to construct larger matrices.

David Owen, business development manager for Pickering Interfaces, commented, "The new RF modules are the start of a new generation of high-density and high-performance RF cards. They use novel construction methods that offer lower loss, lower VSWR, and higher density than competitive PXI solutions." www.pickeringtest.com.

Cards gain software examples

Strategic Test is now providing free LabWindows/CVI examples for its UltraFast line of PCI Express, PCI, PXI, and CompactPCI instrument cards. The examples demonstrate how to integrate the UltraFast Windows DLL with LabWindows/CVI so that mixed-mode test systems can be configured using Strategic Test's digitizer, arbitrary waveform generator, digital I/O, and pattern generator boards.

The examples include a soft oscilloscope, a function generator, a signal generator, digital recording and playback, and digital pattern generation. Users can modify the examples for their own applications. www.strategic-test.com.

Oscilloscope development kit supports Vista and Linux

ZTEC Instruments has released a free software development kit (SDK) and driver package for its PCI, PXI, and VXI-based modular oscilloscopes. The SDK and drivers for ZTEC's C-Class and M-Class oscilloscopes add support for Windows Vista and Linux 2.6.x. Class-level drivers provide the hooks you need to control the oscilloscopes through C, LabView, LabWindows/CVI, COM, Visual Studio, and Matlab. Class-level instrument drivers let you use the same programming interface for all instruments of the same class. That consistency helps you avoid changing code when changing instruments, computing platforms, or bus architectures.

ZTEC customers can upgrade to the new software, which makes it possible to use the ZScope soft front panel on Windows Vista, XP, and 2000. (If you don't have a ZTEC oscilloscope, you can still download the software and evaluate the ZScope interface.) The company plans to release ZScope for Linux and native Mac in the near future. ZScope lets you control all ZTEC scopes of the same class. You can view captured, computed, and reference waveforms, and you can save waveform data and instrument settings. With a single ZScope application, you can switch between multiple instruments and view and control instruments within a test system.

The SDK, instrument drivers, and ZScope application are available at no cost as a download. www.ztecinstruments.com/download-software.

PXI Express brings streaming to test

By Richard A. Quinnell, Contributing Technical Editor

PXI Express can be a foundation for streaming-data instrument design using a chassis such as the PXIe-1065. Courtesy of National Instruments.

Bus bandwidth has always been the primary bottleneck in modular test instrumentation. The advent of PXI Express, however, has created possibilities for the high-speed streaming of data both within and outside of the chassis. With bus data rates capable of reaching billions of bytes per second, the question now is how to handle all that data.

When instruments first began communicating along a bus, they could handle only the most basic data traffic. GPIB, for instance, topped out at about a 1-Mbps data rate. Further, experience showed that system overhead and bus sharing limited the rate for sustained data transmission to about 30% of peak bus bandwidth. As a result, instruments that were gathering data needed to either process it themselves or save it to a buffer for later transmission to another instrument for post-processing. Neither option was ideal.

For one thing, having the data-acquisition board process the data itself reduces the benefits of synthetic instrumentation, according to Robert Lowdermilk, Scientific and Engineering Fellow at BAE Systems. "The idea is to separate processing from data acquisition to allow use of the best available technology for each." Lowdermilk noted that processors double in performance every 18 months while data acquisition doubles every three years, so a board that incorporates both functions faces continual redesign.

But the alternative—buffering data for post-processing—also has limitations, the most obvious being that you can't perform real-time data analysis or interpretation. In addition, buffer sizes can be limited because of the cost of high-speed memory, and this narrows the time window that a test engineer can peek into. To configure an instrument to capture the right time window, you need to develop elaborate triggering mechanisms.

With the advent of the PXI bus, however, a third alternative for processing data became available. PXI data bandwidth can be as great as 132 Mbytes/s—enough capacity in some applications to allow the streaming of information from a data-acquisition module to a processing module. The ability to stream data minimizes the need for buffering and allows for real-time data processing.

Still, the instrument bus remained a limiting system element. Data-acquisition sample rates and bit widths that continue to climb and a trend toward multichannel data acquisition have kept the bus a bottleneck for high-end applications, requiring that instruments continue to buffer their data. Further, the rising acquisition rates mean either that users must increase expenditures on memory to increase the size of the buffer or that the capture window must shrink to prevent the buffer from filling so quickly.

The introduction of PXI Express (PXIe) and chassis that support it has turned the situation around. Each lane of a PXIe link runs at 2.5 GHz and can handle more than 300 Mbytes/s. Designers can bundle lanes together to achieve data rates to many gigabytes per second. Further, the links are point-to-point, so unlike with conventional PXI, the bus bandwidth of a PXIe link does not need to be shared among all the system's data transactions.

Future systems promise to be even faster. The second generation of PXIe links, likely to be available in the next year or two, is expected to handle 5 Gbps per lane, and the third generation should handle 10 Gbps. But even with the current PXIe, test engineers have access to a data bus that can stream many channels of data at the fastest sample rates and bit widths available. The result, according to Lowdermilk, is that the CPU in a PXIe system is now the bottleneck. *(continued)*

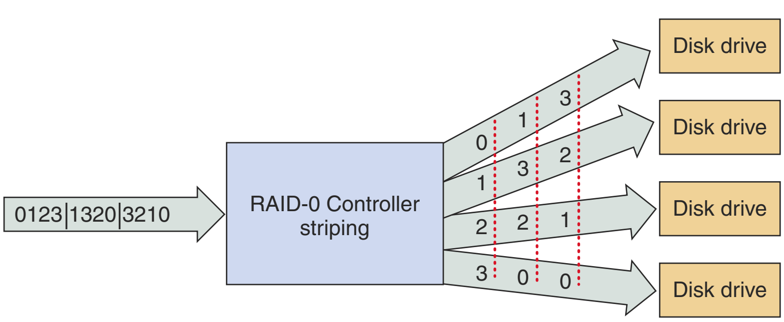

Fig. 1 Streaming data on PXIe can outstrip the ability to record data, although partitioning the data across a RAID array can increase storage speeds. Courtesy of National Instruments.

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To store or to process?

Designers of test systems have two options for handling the streaming data that PXIe supports. One is to record the data to a low-cost, mass-storage system. The other is to increase the processing power available for real-time handling of the data stream.

Recording data in a mass-storage system, such as a redundant array of independent disk drives (RAID), differs from buffering the data in on-board memory. The cost of mass storage is much lower than SRAM, and capacities as high as a terabyte are attainable. Thus, the time window that can be affordably captured and examined expands from fractions of a second to potentially hours.

Having access to terabytes of data does create a challenge: How do you manage that much data? Faced with hours of recorded information, engineers will need tools for previewing the information and quickly accessing the details of interest. Still, the benefits are compelling. A large time window provides independence from the need to set elaborate triggering conditions; users simply set the recording in motion and wait for the fault or other critical event to occur. An additional advantage is that the recorded data includes the full lead-in to the event, making it easier to find the causes.

Another benefit is that captured data can be streamed back through the system in real time. This allows engineers to develop their tests with captured field data rather than synthesized signals, resulting in a more thorough evaluation. The ability to stream recorded data is also useful in the design of manufacturing-test systems, where it is used to reduce the per-pin memory needed in testers.

The main performance limitation when streaming data to RAID systems comes from the drive's write speed, but automatic partitioning of data to several disks can increase record speed (**Figure 1**). Such arrays will soon be available for PXIe systems. Conduant, for example, is scheduled to release its PXIe-416 StreamStor product, capable of recording more than 3 hrs at 600 Mbytes/s, later this year.

Parallelism enhances processing power

Given that PXIe streaming and data acquisition can now quickly overwhelm conventional processors, test engineers who need real-time data analysis will need to enhance their processing power. Eventually, processor performance will catch up to data rates, but in the meantime, some form of parallel processing will be needed.

To that end, BAE Systems is working with Phase Matrix and National Instruments to develop a 26.5-GHz synthetic instrument based on PXIe. The proposed synthetic instrument uses a 26.5-GHz downconverter from Phase Matrix and IF digitizers from NI to capture the data. BAE Systems is handling the data processing using FPGAs with PCI Express (PCIe) interfaces built in. The parallel structures of the FPGA allow design of a data-processing engine that can handle multiple samples simultaneously, thus keeping the required device clock speed manageable.

Whether processed in real-time or sent to mass storage, streamed data in a PXIe instrument represents a powerful capability in test instrument design. It opens applications once requiring proprietary instrument designs, such as military signal intelligence, to commercial off-the-shelf (COTS) equipment. It can free engineers from hours of effort developing triggering schemes by trial-and-error and reduce the memory cost of instrument design. For engineers with applications that can take advantage of it, streaming data is a valuable new technique. □

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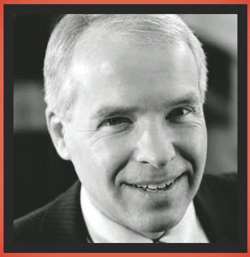

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PRODUCTS

Adlink introduces eight-slot PXI chassis

Adlink Technology has unveiled two eight-slot 3U PXI chassis, each of which features one system slot and seven peripheral slots as well as smart chassis status monitoring and control and an operating temperature of 0–55°C (32–131°F). Both models, the PXIS-2508 and PXIS-2558T, include a control board that monitors and manages the chassis status including the fan speed, system voltages, and internal temperature. The PXIS-2558T also offers an integrated 8.4-in., 800x600 resolution LCD touch-panel display.

Adlink Technology, www.adlinktech.com.

Four modules test optical transceivers

Agilent Technologies has released four new modules in its PXIT series that are designed to help manufacturers test optical transceivers.

The four-slot N2100B PXIT 8.5-Gbps digital communications analyzer module (pictured) helps manufacturers perform eye-diagram analysis to characterize the quality of transmitters from 1 Gbps to 8.5 Gbps. The three-slot N2101B PXIT 10.7-Gbps bit-error-rate tester includes a high-accuracy clock source, a data-pattern generator, and an error detector.

The two-slot N2102B PXIT 11.1-Gbps pattern generator enables complete coverage from 622 Mbps to 11.1 Gbps with improved jitter and transition times. And the two-slot N2099A PXIT synthesizer covers a 2-GHz tuning range and is available at center frequencies of 5.25 GHz, 9.4 GHz, and 10.5 GHz. Agilent says that the

N2099A is a suitable clock source for the N2101B and N2102B modules when an external clock is required.

Base prices: N2100B—$27,000; N2101B—$35,000; N2102B—$17,500; N2099A—$8000. *Agilent Technologies, www.agilent.com.*

PXI multimeter offers 6½ digits

Delivering 6½ digits of resolution at up to 10 readings/s and up to 3000 readings/s at lower resolutions, the PXI-4065 multimeter from National Instruments makes it possible to develop high-channel-count datalogging measurement systems based on the

PXI bus. You can combine the multimeter with more than 150 available NI PXI switch configurations in the PXI-1033 chassis with integrated controller to create datalogging systems for $3500 with up to 48 channels and for $12,000 with up to 784 channels. For further system expansion, you can add 3000 channels with each additional 18-slot PXI chassis.

The PXI-4065 digital multimeter provides isolation of ±300 VDC/VRMS, current measurements up to 3 A, and two-wire or four-wire resistance measurements. With the NI-DMM driver software that comes with the PXI-4065, you can build high-channel–count systems using National Instruments' LabView SignalExpress. For automated test systems, the multimeter is also compatible with NI TestStand, LabView, LabWindows/CVI, and Measurement Studio development environments, offering a variety of options for defining and controlling measurement applications.

National Instruments, www.ni.com.

Development software gets new Service Pack

Geotest—Marvin Test Systems has released a new Service Pack for its ATEasy 6.0 application-development environment. Service Pack 1 incorporates several new features, including enhanced support for WinSocket interfaces, an expanded driver library for PXI, LXI, and GPIB products, and extended support for the .NET framework.

Geotest—Marvin Test Systems, www.geotestinc.com.

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JIM TUNG
MathWorks Fellow
The MathWorks
Natick, MA

Jim Tung has more than 25 years experience in the technical computing software field. A 19-year veteran of The MathWorks, he held the positions of VP of marketing and VP of business development before assuming his current role, which focuses on business and technology strategy and analysis. Tung previously held marketing and sales management positions at Lotus Development and Keithley DAS, a pioneering manufacturer of PC-based data-acquisition systems. Jim earned a bachelor's degree from Harvard University.

Contributing editor Larry Maloney interviewed Jim Tung at the *Test & Measurement World* offices about the use of software tools for test applications.

Let modeling solve test challenges

Q: Where does The MathWorks fit in the world of engineering?

A: The company was founded in 1984 around our Matlab software, so technical computing is a strong suit: bringing in data and analyzing it and developing and deploying algorithms and technical applications. Over the last 15 years, another key area has been model-based design, which is changing the way engineers develop, test, and verify components and systems.

Q: How are engineers using Matlab for test and measurement?

A: One of the strengths of Matlab for test is its ability to analyze and model data gathered from hardware and software. Increasingly, vendors of bench and ATE equipment are incorporating Matlab in their products as instrumentation and test systems become more PC-based. This enables engineers to use Matlab on the instrument to construct custom filters or modulation waveforms or to add analysis routines.

We've also developed several modules for Matlab targeted for test and measurement. These include the Data Acquisition Toolbox that connects Matlab to data-acquisition boards on the PC and the Instrument Control Toolbox that links Matlab to test hardware through GPIB, RS-232, and other interfaces. Also very important is our SystemTest tool. It helps engineers working in Matlab or Simulink, our block-diagram modeling environment, to start building test routines early in the development process.

Q: Why the big focus on modeling?

A: Modeling tools, such as our Simulink family, are becoming a core part of the design and verification process. System design increasingly involves creating models of physical components that affect system behavior—the mechanics, electronics, controls—as well as the environment. In an automotive suspension system, for example, that environment includes the road surface, weather conditions, and the driver. Finally, the model includes the algorithms or logic used in the system.

You can also automatically generate embedded software from the algorithm models for your system, and with our new Simulink HDL Coder tool, you can even generate Verilog or VHDL code for digital electronics. This saves a huge amount of time and money, versus creating multiple physical prototypes and manually writing the code. Meanwhile, the model allows continuous validation and verification of your design, and it can be leveraged to design an ATE or hardware-in-the-loop setup that includes the behavior of the system in operation.

Q: How does your Simulink family make system modeling easier?

A: Simulink enables engineers to accurately model, simulate, and implement the behavior of a variety of continuous or discrete time systems. These systems include controls, signal processing, image processing, communications, and physical objects. Our users have created whole libraries of Simulink models that other engineers can use to accelerate the development process.

Q: What impact is modeling having on the test-engineering function?

A: Traditionally, the test engineer tended to be at the end of the line, designing tests based solely on product or system specs. Now, test engineers are increasingly using design models as the basis for designing their tests. We also see more design engineers doing some test work early in the process, such as running Monte Carlo simulations or hardware-in-the-loop tests. In fact, The MathWorks is trying to accelerate this trend with the a new product called Simulink Design Verifier. T&MW

Jim Tung provides more specifics on his company's products and test applications, as well as its development strategies, in the online version of this interview: www.tmworld.com/2007_09.


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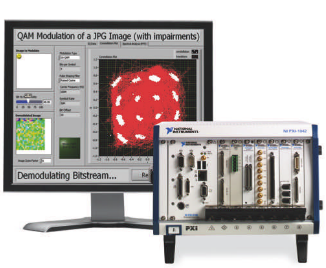

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