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THE MAGAZINE FOR QUALITY IN ELECTRONICS

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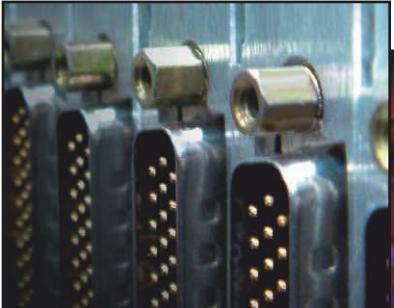


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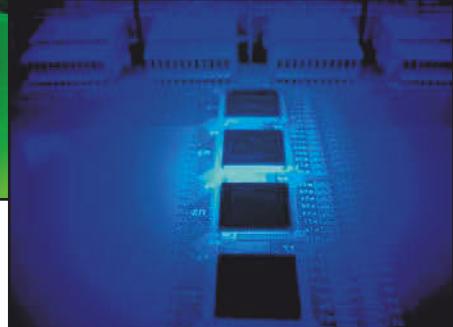
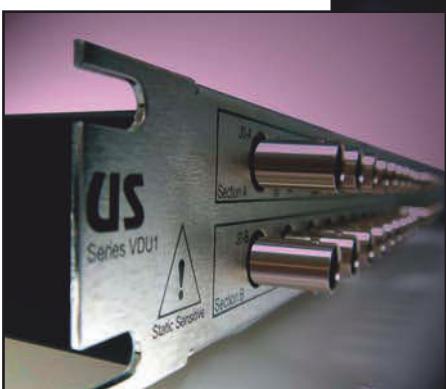
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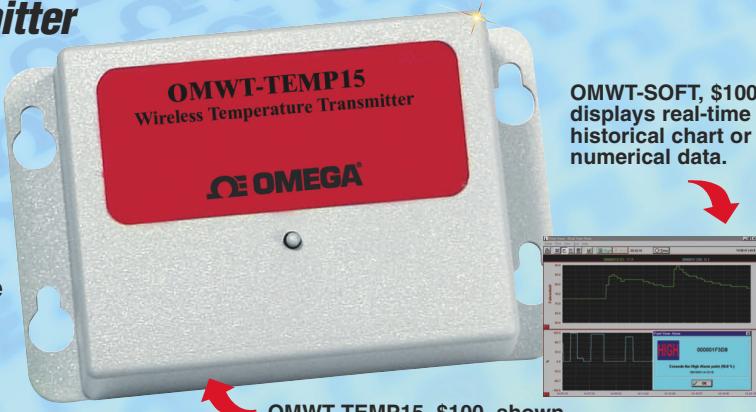


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► Learn to apply LXI

The LXI standard is paving the way toward modular test-system architectures that combine low-cost Ethernet technology with the measurement performance of GPIB instruments. The October 19 Webcast, "Gaining the benefits of the LXI platform," shows what the standard means to you and how you can begin deploying LXI systems. Check out the archived Webcast. www.tmworld.com/webcasts.

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EDITORIAL STAFF

Chief Editor: Rick Nelson
rnelson@tmworld.com
ATE & EDA, Inspection, Failure Analysis, Wireless Test, Software, Environmental Test

Managing Editor: Deborah M. Sargent
dsargent@tmworld.com

Senior Technical Editor: Martin Rowe
m.rowe@tmworld.com
Instruments, Telecom Test, Fiber-Optics, EMC Test, Data-Analysis Software

Assistant Managing Editor: Naomi Eigner Price
neprice@tmworld.com

Contributing Technical Editors:

Jon Titus, jontitus@comcast.net
Bradley J. Thompson, brad@tmworld.com
Steve Scheiber, sscheiber@aol.com
Greg Reed, editor@aatr.net
Richard A. Quinnell, richquinnell@att.net

Publisher:
Russell E. Pratt

Senior Art Director: Judy Hunchard
Senior Art Director/Illustrator: Dan Guidera

Director of Creative Services: Norman Graf
Manager/Creative Services: Gloria Middlebrooks
Prepress Manager: Adam Odoardi
Ad Layout Artist: Susan Jeune

Circulation Manager: LaGina Thomas
303-470-4328; lthomas@reedbusiness.com

Reprints: Reprint Management Services (RMS),
800-290-5460, ext. 149;
tandmw@reprintbuyer.com

List Rental: Julie Cronin, jcronin@dm2lists.com

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CEO: Jim Casella

President, Boston Division:
Stephen Moylan

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HOW TO CONTACT T&MW

EDITORIAL:
225 Wyman St., Waltham, MA 02451
Phone: 781-734-8423
Fax: 781-734-8070
E-mail: tmw@reedbusiness.com
Web: www.tmworld.com

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Needed: technology investment

The deteriorating state of science and technology expertise in the United States is the focus of a report issued October 12 by the National Academies. The congressionally requested report—written by a 20-member committee that included university presidents, CEOs, Nobel Prize winners, and former presidential appointees—notes that for the price of one engineer in the US, a company can hire 11 engineers in India.

Perhaps it's not surprising then that last year in India, 350,000 engineers graduated from institutions of

RICK NELSON, CHIEF EDITOR

higher education, while only about 70,000 did so in the US. In China, the figure was more than 600,000.

Here are some other facts cited in the report:

- In 1999, only 41% of US eighth-graders had a math teacher who had majored in mathematics at the undergraduate or graduate level or studied the subject for teacher certification.
- US 12th-graders recently performed below the international average for 21 countries on a test of general knowledge in mathematics and science.
- In 2001, US industry spent more on tort litigation than on research and development.

The potential consequences are dire. Committee chair Norman R. Augustine, retired chairman and CEO of Lockheed Martin, stated, "The building blocks of our economic leadership are wearing away. The challenges that America faces are immense."

The report does offer some helpful suggestions (short of recommending that all Americans prepare for law careers):

- Provide four-year scholarships to help top students obtain bachelor's degrees in science, engineering, or mathematics, coupled with a commitment to work for five years in public schools.
- Increase the national investment in basic research by 10% each year over the next seven years.
- Develop, recruit, and retain top students, scientists, and engineers from both the US and abroad.
- Establish an organization called the "Advanced Research Project Agency—Energy" that sponsors research to meet the nation's long-term energy challenges.
- Modernize the US patent system, realign tax policies to encourage innovation, and ensure affordable broadband Internet access.

All of these steps will require investment up front. Let's hope the political will can be found to make that investment. Without it, American engineers will have trouble achieving productivity levels that justify an 1100% salary premium. T&MW

See the online version of this article (www.tmworld.com/2005_11) for a link to the full report, "Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future."

Contact Rick Nelson at rnelson@tmworld.com.



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Safety society continues to expand

On January 1, 2004, the IEEE Product Safety Engineering Society (PSES, www.ieee-pses.org) came into existence. With roots dating to the late 1980s, PSES now offers product-safety engineers a forum for information exchange. PSES president Mark Montrose has been a part of the long process required for an ad hoc group of engineers to reach society status within the IEEE. Martin Rowe spoke with him at the 2005 IEEE Symposium on EMC in Chicago.

T&MW: Why was the PSES formed?

Montrose: It started in 1986 with Rich Pescatore, an engineer at Hewlett-Packard. The industry had problems getting products approved by the Canadian Standards Association (CSA) for safety certification. There were inconsistencies in policies and methods, even among the same manufacturer. Rich worked with the CSA and formed the CSA Users Group, to resolve problems. After about six months, the Users Group changed its name to the Product Safety Society (PSS). Within a year, the group had hundreds of members and a newsletter.

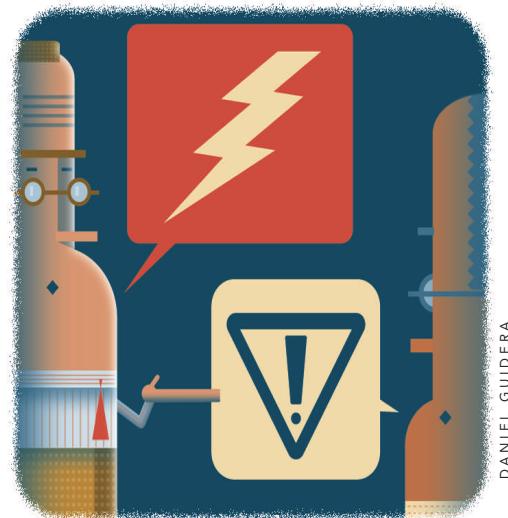
T&MW: Where did the members come from?

Montrose: Members came mostly from Silicon Valley. By 1988, several chapters had been formed: Santa Clara, Pacific Northwest, Denver, and New England. The New England chapter operated independently as the Northeast Product Safety Society (NPSS). In 2005, the NPSS became the Central New England Chapter of PSES.

T&MW: How did you become affiliated with IEEE?

Montrose: In 1989, the PSS applied to become an IEEE Society. But the IEEE wanted us to first have experience within an existing IEEE Society. In 1991, we became a Technical Committee, TC-8, the Electromagnetic Product Safety Technical Committee, within the IEEE EMC Society (EMCS). An unofficial subgroup was established for the PSS. In 1994, the IEEE said TC-8 violated IEEE policies governing how TCs function. A TC can have only a few members and can't have chapters or a newsletter. Essentially, TC-8 was operating as an unofficial society.

To get around this problem, we established a Working Group within TC-8, the Product Safety Technical Committee (PSTC). Working Groups may operate with members, funds, chapters, newsletters, and the like.



DANIEL GUIDERA

T&MW: If you already had the infrastructure of a society, why did it take so long to become one?

Montrose: Things take time in IEEE due to policies. For example, decisions can only be made three times a year at special meetings held among IEEE operational units. In 2000, the EMC Society Board of Directors asked me to spin off PSTC into an autonomous society. This became a formidable task to create a new society within IEEE, a feat that has not been accomplished in nearly 20 years.

To achieve society status for PSTC, two associates and I had to appear before the IEEE Technical Activities Board (TAB)—the governing body for all societies—and present a business plan to convince TAB that PSTC was ready to become a professional society.

We received preliminary approval to form a steering committee called the Product Safety Committee (PSC). The PSC's job was to develop a detailed business plan, write the constitution and bylaws, and develop a budget. I had to appear in front of 51 society presidents and division directors. They asked many difficult administrative questions, such as, "Where are you going to get revenue to support the operation?" "How can a virtual society exist without a conference or journal?" "What kind of support will you receive from academia?"

In June 2003, TAB approved the spin-off of the TC-8 from the EMC Society into the Product Safety Engineering Society. We began operation January 1, 2004. **T&MW**

To read the complete interview—and learn where PSES expects to go from here—see the online version of this article at www.tmworld.com/2005_11.

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.

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NI acquires IOtech

For the second time this year, National Instruments has acquired one of its competitors in the data-acquisition business. In May, NI reported that it had purchased Measurement Computing Corp., and in mid-October, the company announced its acquisition of IOtech. Terms of the acquisition were not disclosed.

IOtech, a long-time provider of PC-based data-acquisition and instrumentation products, will operate as an NI subsidiary out of its Cleveland, OH, offices and will continue to sell and support its products through its existing sales network.

Dr. James Truchard, NI president, CEO, and cofounder (pictured), released this statement about the transaction: "The acquisition of IOtech further strengthens our offering and reach of providing PC-based measurement solutions to engineers and scientists.

By combining IOtech's strengths in key areas, including portable, vibration measurement, and OEM products, with NI's software and worldwide data-acquisition leadership, we can further our acceptance of virtual instrumentation in applications for in-vehicle test, vibration measurement, and machine monitoring."

"For years we have had a prosperous relationship reselling NI DASYLab software, which was an important factor in the decision to join NI," said Tom DeSantis, IOtech president and founder. "IOtech's 20 years of experience, complementary product portfolio, and differentiated sales channel combined with NI's strong global presence and industry-leading NI LabView software will let us serve a broader set of measurement applications worldwide." www.ni.com.



SynTest gains patent for at-speed test

SynTest Technologies has announced that it was granted 33 claims on October 11 under US Patent #6,954,887 for a method of true at-speed testing of asynchronous multiclock, multifrequency designs using ATPG or logic BIST design-for-test (DFT) schemes. The company refers to its patented invention as "staggered skewed-load" or "staggered launch-on-shift."

The method provides ordered capture clocks to detect or locate faults within multiple clock domains and faults crossing clock domains in an integrated circuit during at-speed BIST or at-speed scan-testing. SynTest reports that the major benefit of this patented DFT scheme is the reduction in the number of ATPG patterns compared to the traditional one-shot DFT scheme for multiclock, multifrequency designs, resulting in test-vector compression of 3X to 10X. www.syntest.com.

Teradyne to sell Connection Systems

Teradyne recently reported that it has agreed to sell its Connection Systems division to Amphenol for \$390 million in cash (subject to a post-closing net asset value adjustment). Connection

Systems, based in Nashua, NH, is a supplier of high-speed, high-density connectors as well as high-performance printed-circuit boards and backplane interconnect systems. In

2004, the division accounted for 23% of Teradyne's revenue.

"The sale of Connection Systems will sharpen our focus on our core test businesses," said Michael Bradley, Teradyne

Portable 6-GHz spectrum analyzers

The Agilent Technologies CSA N1996A portable spectrum analyzers deliver 100-kHz to 3- or 6-GHz performance. The instruments each incorporate an internal VSWR bridge and tracking generator to allow you to characterize single- or dual-port devices such as filters, cables, and amplifiers. A card-slot architecture supports future performance and capability enhancements. Built-in measurement help, together with auto-tune, auto-scale, and auto-couple functions, leads you through each measurement task step by step. Key specifications include displayed average noise level of



-146 dBm in a 10-Hz bandwidth, 96-dBc dynamic range, and a +18-dBm third-order intercept point. Connectivity features provide support for functions such as remote control and firmware upgrades; the latter can be accomplished by transferring files from a USB memory stick. The instruments are compatible with the Standard Commands for Programmable Instruments (SCPI) syntax to support integration into existing test systems; LAN connectivity facilitates measurement automation over Ethernet.

Base prices: 3-GHz spectrum analyzer—\$8950; 6-GHz spectrum analyzer—\$12,250; 3-GHz tracking generator—\$3000; 6-GHz tracking generator—\$4000; 3-GHz preamplifier—\$1500; 6-GHz preamplifier—\$2,000. *Agilent Technologies*, WWW.AGILENT.COM.

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CALENDAR

APEX, February 5–10, Anaheim, CA. APEX focuses on electronics assembly processes and equipment. Sponsored by IPC. www.goapex.org.

Measurement Science Conference, February 27–March 3, Anaheim, CA. Designed to promote measurement science and related disciplines. Sponsored by The Measurement Science Conference. www.msc-conf.com.

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

president and CEO, in a statement released to the press. "That concentration will strengthen our ability to do what we do best—provide our test customers with better products and services that meet their evolving needs. This strategic move also increases our financial flexibility to support our growth plans in our core test businesses." www.teradyne.com.

Tera Probe selects FormFactor

FormFactor has announced that Tera Probe has chosen FormFactor as its strategic partner for wafer probe-card technology. Tera Probe, a testing-service venture formed by Advantest, Kingston Technology, Powertech, and Elpida Memory, combines its founders' respective test equipment, assembly and testing services, memory products, and wafer technology to serve Elpida and other semiconductor manufacturers.

FormFactor reports that a major cost factor in system packages is the time and costs to package and test die that are ultimately identified as "bad," and adds that wafer-level final test prior to pack-

aging to verify known good die (KGD) can help control costs. "Not only does FormFactor share our vision for KGD, its proven products and its commitment to further enhancements of KGD-yielding technology promise the lowest risk for us as we put our strategy into action," said Masahide Ozawa, president of Tera Probe. www.formfactor.com.

LabView 8 distributes processing power

National Instruments' venerable LabView application development software is now at version 8. As with previous LabView releases, National Instruments has addressed the needs of both the novice and expert LabView programmer.

The most significant new feature in LabView 8 is its ability to perform "distributed intelligence." This feature lets you develop programs that run on numerous microprocessors, FPGAs, and DSPs. You can develop code on a PC, then compile and download your code. The shared-variable feature lets distributed processors share data in real time over a network.

Deterministic Ethernet minimizes latency. LabView 8 also supports Bluetooth, so you can develop applications that run on PDAs.

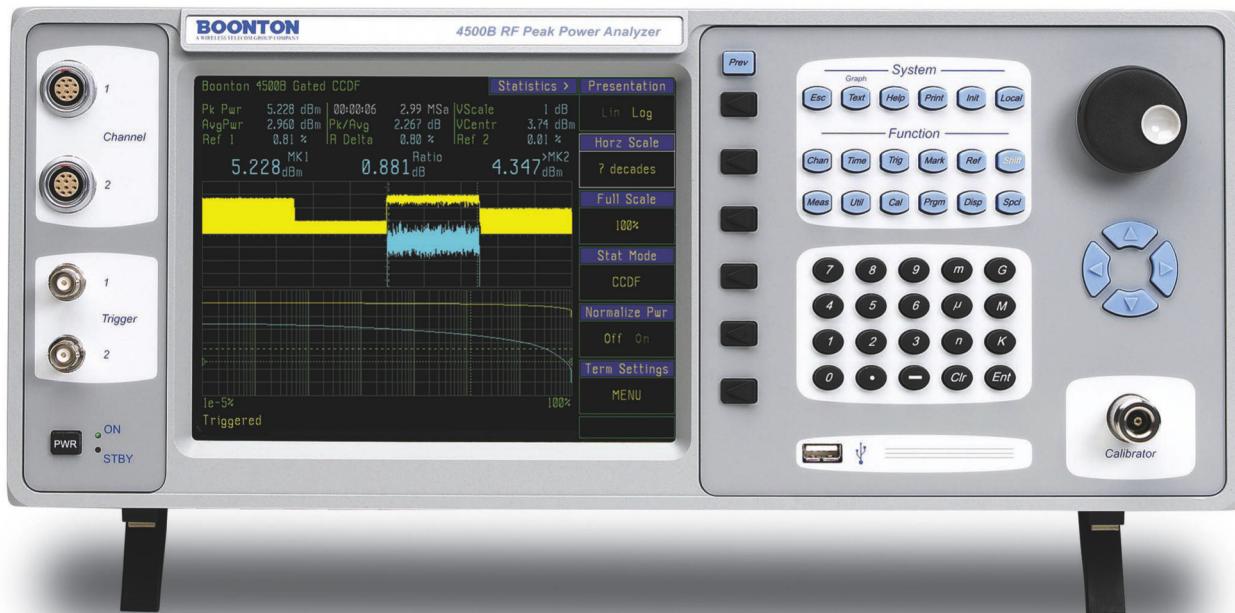
The project feature helps you manage large development projects. It lets you navigate and organize an entire system—LabView code, external code modules, drivers, documentation, and hardware. It also gives you a system view of an application.

LabView 8 features an instrument-driver finder that lets you find a driver on your system or from the National Instruments Web site. When you locate a driver, you can right-click on it to install it into your programming palette. If you can't find a driver, you can use LabView 8's driver-development wizard.

Base price: \$995. National Instruments, WWW.NI.COM/LABVIEW.

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Device programming, boundary scan presented

>>> Assembly Technology Expo, September 27–29, Rosemont, IL,
Sponsored by Assembly Magazine, www.atexpo.com.

On the in-system-programming (ISP) front, **CheckSum** (www.checksum.com) was on hand to announce expanded device support for its MultiWriter ISP system, which now supports microcontrollers from companies such as Freescale. MultiWriter operates in conjunction with the CheckSum Analyst in-circuit test (ICT) platform.

Data I/O (www.data-io.com) announced its ImageWriter-300, designed specifically for ICT integration. The ImageWriter line enables device programming inside a test fixture; the first configuration, ImageWriter-200, is a PC-driven programmer for manufacturing test environments with PC-based test programs. Image-

Writer-300 can perform fully embedded programming without a PC. The company also introduced its PS588 automated programming system, designed for use in programming centers operating at high volumes—more than 1400 devices per hour.

BP Microsystems (www.bpmicro.com) demonstrated its 1710 universal engineering programmer and described its Model 2710 concurrent programming system. Highlighting boundary scan, **Digitaltest** (www.digitaltest.de) was on hand to demonstrate its Condor flying prober with new boundary-scan support from **Corelis** (www.corelis.com). **T&MW**



The PS588 automated programming system can serve in programming centers, operating at rates to more than 1400 devices per hour. Courtesy of Data I/O.

Exhibits span lenses to frame grabbers

>>> International Robots & Vision Show, September 27–29, Rosemont, IL,
Sponsored by the Automated Imaging Association, www.machinevisiononline.org.

Imperx (www.imperx.com) announced the addition of Gigabit Ethernet interfaces to its line-up of Lynx cameras, complementing the previously available Camera Link interfaces. **Luminera** (www.luminera.com) announced the release of a new line of 2-Mpixel USB 2.0 digital cameras for industrial markets. The Lw230 employs a 1616x1216-pixel CCD sensor.

Cognex (www.cognex.com) debuted its In-Sight 5400S stainless-steel vision sensor that can sort objects, read linear and 2-D codes, and count products. Cognex also described a new software development kit for its In-Sight sensors.

JAI Pulnix (www.jai.com) highlighted its new CV-L107CL three-CCD line-scan camera, which features 3x2048-pixel resolution, a 19-kHz line rate, flat-field and shading correction, and optional individual exposure times for each of its R, G, and B channels. **Point Grey Research** (www.ptgrey.com) announced the release of an enhanced version of its Dragonfly digital board-level IEEE 1394a camera, the Dragonfly2, which doubles the original's frame rate. It's available with one-third-inch progressive-scan CCDs running 60 fps at 640x480 pixels or 30 fps at 1024x768 pixels in monochrome or color.

Tattile (www.tattile.com) highlighted the new JPEG-compression capability for its line of 13 TAG digital cameras, which support the Gigabit Ethernet standard. The company also highlighted its cooperative efforts with **MVTec Software** (www.mvtect.com) to introduce an interface between MVTec's Halcon software and the Tag family of cameras.

Active Silicon (www.activesilicon.com) highlighted its Phoenix Camera Link frame grabbers, which now operate over the industrial temperature range as a standard feature. The frame grabbers are available as part of an image-acquisition package, which combines a Phoenix frame grabber with a **Photonfocus** (www.photonfocus.com) CMOS color camera. Active Silicon also highlighted an LFG4 frame grabber that now supports the Mac OS X operating system.

Matrox Imaging (www.matrox.com) announced PCI Express support for its Solios family of frame grabbers. PCI Express is available with the Camera Link-compatible Solios eCL and with the analog Solios eA. **View Engineering** (www.vieweng.com) highlighted its Benchmark 300 metrology system, which combines optics, illumination, image-processing



A new line of large-format lenses are compatible with leading-edge 12-kpixel cameras and can provide an image space resolution of up to 100 line pair/mm. Courtesy of Edmund Optics.



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capability, and an optional through-the-lens laser to provide a 300x150x150-mm measuring range. In addition, the company announced enhancements to its Elements software suite.

Edmund Optics (www.edmundoptics.com) described new large-format lenses compatible with 12-kpixel cameras; the lenses can achieve up to 100 line-pair/mm image-space resolution and can accommodate 5-micron pixel sizes and sensors up to 90 mm; applications include LCD and plasma flat-panel inspection. **Moritex** (www.moritexusa.com) highlighted its new SOD-10X micromachine lens for applications including semiconductor and LCD alignment and inspection. The lens features a 1.5-micron spatial resolution. SOD-10X lenses feature telecentricity to maintain magnification and view angle to any part under inspection that remains within the lenses' depth of field.

Shock and awe in Orlando

>>> **Autotestcon, September 26–30, Orlando, FL, Sponsored by the IEEE, www.autotestcon.com.**

Autotestcon 2005 delivered plenty of firepower for both military and commercial test technologies. In his keynote presentation, Lieutenant General Donald J. Wetekam (US Air Force) detailed test-engineering services, logistics, and readiness for aircraft and missile maintenance across multiple stateside installations. The plenary sessions consisted of six presentations from Marine, Army, Navy, and Air Force personnel who related combat readiness case histories for test equipment delivery as well as field functionality, performance, and maintenance during recent theaters of engagement from Desert Shield and Desert Storm through current ground and sea installations supporting troops in Iraq.

On the exhibit floor, **Elgar Electronics** (www.elgar.com) introduced the ReFlex Power military ATE power supply. **Pickering Interfaces** (www.pickeringtest.com) rolled out its 60-100 LXI modular switching chassis. **Teradyne** (www.teradyne.com) dis-

StockerYale (www.stockeryale.com) introduced its Model 12 SFVI (Spherical Fluorescent Vision Illuminator) HemiLite for machine-vision applications including PCB component inspection. The company also highlighted its Model 6 CFVI (Circular Fluorescent Vision Illuminator)—a low-profile, industrial-grade fluorescent lighting system powered by a 25-kHz driver—and demonstrated its ML Series fluorescent backlight panels. In addition, StockerYale announced that it has extended its COBRA (Chip-On-Board Reflective-Array) family to include models having 125-mm, 250-mm, and 500-mm lengths and to include versions emitting red, blue, and UV (395-nm) light. The company also introduced a COBRA line-scan backlight version, debuted its Model 21DC fiber-optic illuminators, and introduced its Lasiris Magnum II high-power laser-diode line generator. **T&MW**

played its Di Series of VXI digital test instruments for military and aerospace applications.

Acqiris (www.acqiris.com) released its DC152 and DC122 10-bit PXI digitizers that operate up to 4 Gsamples/s. **Hypertronics** (www.hypertronics.com) announced the availability of its new HyperRel line of MIL-DTL-38999 rugged connectors for military applications.

AMREL/American Reliance (www.amrel.com) introduced a new 1.2-kW Model SPSE programmable switching power supply, which has a fully functional keypad as well as an embedded Ethernet interface. **WinSoft** (www.winssoft.com) demonstrated the new Multi-WISE (WinSoft Instrument System Emulator) unit, a 1U-size emulator module that supports the replacement of multiple instruments regardless of the manufacturer, communication interface (including GPIB, USB, and TCP/IP), or programming language. **T&MW**

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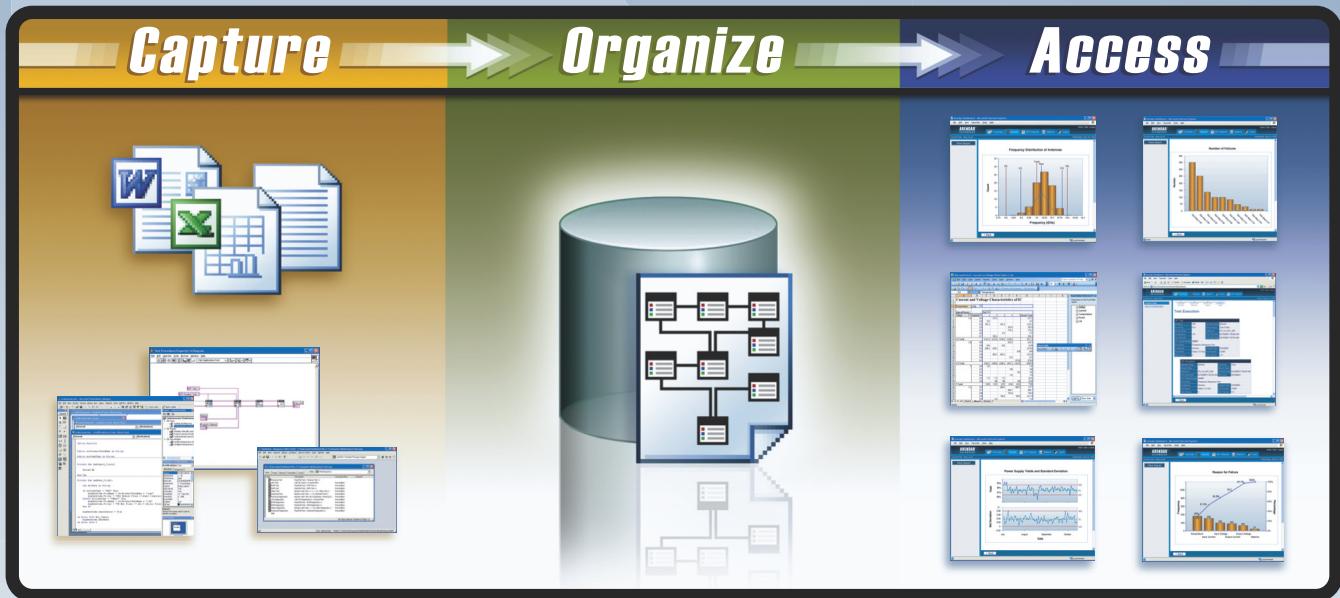
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Bench instruments to the rescue for RFIC design and test

Logic designers can employ DFT tools and dedicated desktop debuggers to get their devices up and running, as described in our October cover story, "Design meets test." RF engineers don't have that luxury, though,

as the RF arena suffers from a dearth of formal DFT methods and tools.

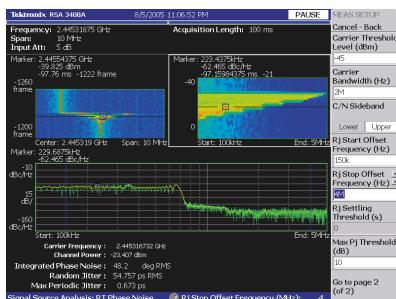
Consequently, RF designers—as well as logic designers dealing with gigahertz clock rates beyond the reach of normal logic-design tools—need to develop their own test approaches and configure their own RF instrumentation. It was the need for flexible, cost-

Hiebert, director of marketing for real-time spectrum analyzers, reported that the latter helps to address customers' efforts to comply with relevant RFID standards, while the signal-source analysis suite arose in part to satisfy requests of designers of phase-locked-loop and voltage-controlled oscillators who wanted to see how the phase noise of their devices varies over time. The software generates what the company calls a Noisogram, which shows phase-noise amplitude with respect to offset and time.

Applications for the signal-source analysis suite extend beyond traditional RF areas like phase-noise measurement. "RF is everywhere now,"

Hiebert said, adding that the clock speeds now running on backplanes correspond to what used to be known as microwave frequencies. To meet the needs of digital designers dealing with RF effects, Tektronix engineering manager Akira Nara pointed out that the company's real-time spectrum analyzers and software can plot jitter vs. time—a characteristic that's mathematically related to phase noise vs. time but that is more readily understandable to a digital design engineer.

Just as digital designers are increasingly facing RF and microwave challenges, RF engineers are facing a new threat: software bugs. "A bad line of code in a DSP can lead to bad RF behavior," Hiebert said. Consequently, RF instruments and software need to address the needs of traditional RF and microwave engineers as well as digital hardware—and even software—designers. **T&MW**



This real-time spectrum-analyzer display includes a Noisogram (upper right) showing phase-noise amplitude with respect to offset and time. See the online version of this article for a larger image, www.tmworld.com/2005_11.

Courtesy of Tektronix.

effective instrumentation that led IC designer Steve Robalino to develop a \$1000, 1-GHz signal generator, available from startup Signal Forge, where Robalino now serves as chief technical officer. The company offers application notes describing the use of the instrument in measuring parameters such as amplifier gain, 1-dB compression point, and third-order intercept point.

Help is also coming from a traditional instrument maker in the form of software suites that Tektronix offers to complement its real-time spectrum analyzers. Most recent are its signal-source analysis suite, introduced last month, and an RFID measurement suite, introduced in September. Bob

Amkor, Jennic buy RF-capable 93000s

Agilent Technologies has announced that Amkor Technology and Jennic have purchased Agilent 93000 SOC series RF-capable test systems. Amkor is using its system in Singapore to test devices such as RF tuners. Fabless semiconductor company Jennic is installing its system at its Sheffield, UK, headquarters to help validate and develop tests for its wireless microcontrollers. www.agilent.com.

Prototyping adapter

Design engineers using 0.5-mm-pitch, 84-position µBGA ICs can employ the Ironwood Electronics PA-BGA84C-P-Z-01 prototyping adapter, which can interface a 0.100-in.-center pin-grid array with a 10-GHz socket. Contact resistance is normally 10 mΩ. The bottom interface of the adapter is constructed with gold-plated machined terminal pins; the adapters can be optionally supplied with wire-wrap pins. Price: \$516. www.ironwoodelectronics.com.



Flex to test Atheros RF SOCs

Teradyne has announced that Atheros Communications has purchased a Flex test system with the full range of Teradyne Gen4 microwave instrumentation. The system will be used for quad-site production test of Atheros' portfolio of RF system-on-a-chip devices, including the AR1900 single-chip cellular device for Personal Handyphone System (PHS) handsets. www.teradyne.com.

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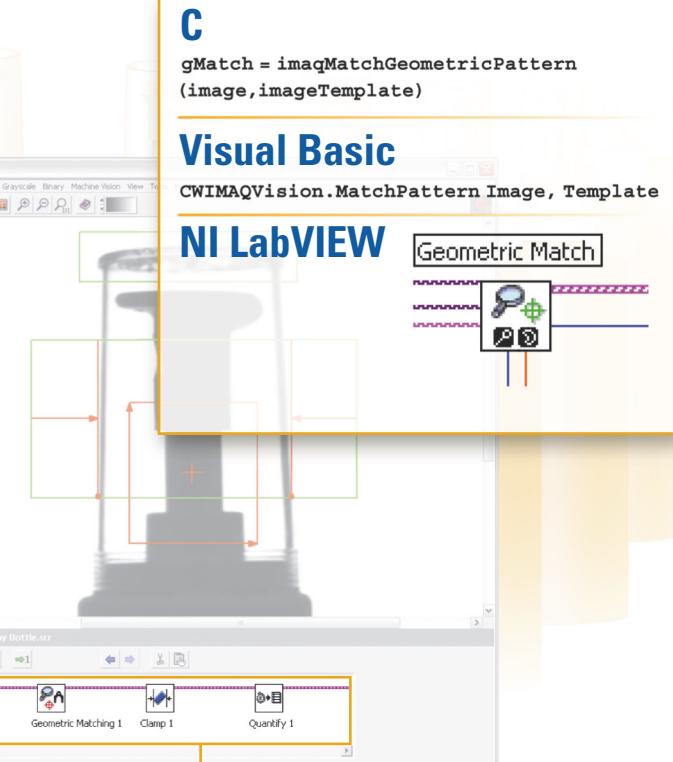
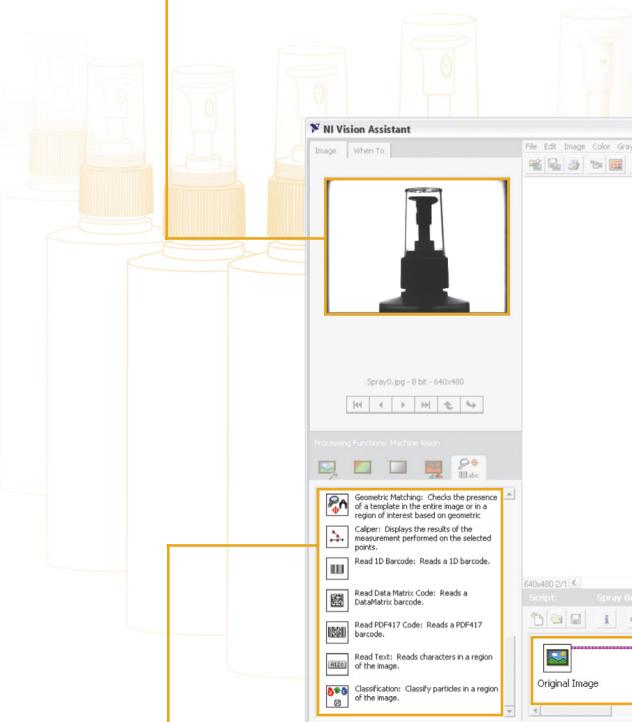
```
gMatch = imaqMatchGeometricPattern  
(image,imageTemplate)
```

Visual Basic

```
CWIMAQVision.MatchPattern Image, Template
```

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Will CMOS sensors catch up?

Engineers who design inspection systems may wonder why cameras based on popular CMOS sensors haven't appeared in large quantities in the machine-vision market. After all, CMOS area-array sensors

serve well in consumer devices such as cell phones and digital still cameras. In addition, CMOS technology offers several advantages over charge-coupled devices (CCDs). The CMOS fabrication technologies lend themselves to the inclusion of timing circuits, analog-to-digital converters (ADCs), and other functional blocks within an area image sensor. Cameras that employ CCD sensors must include discrete circuits that provide those functions.



Image-sensor manufacturers offer CCD and CMOS detectors in a variety of formats, most of which aim to satisfy the needs of consumer products.

Courtesy of Dalsa.

Unfortunately, most commercial CMOS sensors lack a critical feature—a “global” shutter—inherent in CCD sensors. A CCD sensor will simultaneously reset all its detectors (pixels) and, after an exposure, will transfer the accumulated charges to a shielded area. The CCD sensor then shifts out the charge for each pixel. This type of technology goes by the name interline transfer, or ILT. The simultaneous action at all detectors prevents image distortion during an exposure and readout.

Most CMOS sensors, though, use an electronic “rolling” shutter that can lead to distorted images when significant motion occurs in an image during an exposure. A CMOS sensor sequentially charges rows of detectors, waits a

short exposure time, and then reads the exposure information row by row. Think of how a flat-bed scanner operates and you'll get the general idea. Move a scanned paper during a sweep, and you see a skewed image. So, images acquired with a CMOS-based camera on a fast-moving production line may appear distorted.

But don't count out CMOS sensors. Terry Guy, a product marketing manager in the Image Sensor Solution Group at Eastman Kodak, explained that some designers employ a strobe light to illuminate an object. They produce a light pulse that lasts only as long as the CMOS camera's exposure time. Thus, the camera “sees” the object only during the strobe period, which eliminates distortions. Guy also noted that generally, CMOS sensors offer less sensitivity and introduce more noise than CCD sensors. He expects, though, that technology advances will eventually let CMOS sensors catch up with CCDs.

According to Dave Litwiller, VP at Dalsa, a supplier of sensors and cameras, many CMOS-sensor manufacturers have concentrated on building devices for consumer products that don't require a fast shutter. After all, a slight skew in a picture-phone image doesn't matter. So far, these manufacturers haven't seen enough of a machine-vision camera market to offer CMOS devices with better shutter characteristics. Litwiller thinks the emergence of global shutters in CMOS sensors, the advantages of integrating functions within the sensors, and CMOS sensors' low power demands make these sensors increasingly attractive to machine-vision camera designers. **T&MW**

For an animated description of the ILT technique, visit: micro.magnet.fsu.edu/primer/digitalimaging/concepts/interline.html.

Sensor withstands rough treatment

The Cognex In-Sight 5400S vision sensor operates in industrial applications that may subject it to chemical washes and submersions. Industrial equipment that sorts objects, verifies label text, reads linear and 2-D codes, and counts products can benefit from using this sensor. The In-Sight 5400S includes vision software, built-in Ethernet communications, and tools that simplify application development. www.cognex.com.

Ethernet connects cameras and code

MVTec Software and Tattile now offer the TAG interface, which lets users of MVTec's Halcon software directly interface application code with Tattile's line of TAG Gigabit Ethernet cameras. Software developers can add a few lines of code to their Halcon programs to acquire gray-scale and RGB images. The interface software also lets developers program all TAG camera capabilities through a network connection. www.mvtc.com, www.tattile.com.

Imager scans 1-D and 2-D codes

To operate the Quadrus Mini code reader, you simply plug it in, point it at a symbol, and push the EZ button. The unit automatically focuses and sets exposure time, gain, and illumination intensity before it reads linear bar codes and 2-D codes. The Mini can decode 2-D marks that move at up to 100 ft/s on a production line. www.microscan.com.



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SOFTWARE

Free program helps you design filters

At one time or another, you'll probably need to design an analog filter. Despite an abundance of digital filter design tools (for example, the excellent FDA-Tool bundled with Matlab's Signals toolbox), there are few general-purpose GUI tools for synthesis of arbitrary active analog filters.

To help students and the engineering community, I developed Analog Filter Design (AFD), an intuitive active analog filter design tool. Four universities currently use it as a teaching tool. AFD lets you design, analyze, and simulate Bessel, Butterworth, Chebychev I and II, and elliptic filters up to the 8th order of arbitrary passband gain using more than 10 different circuit topologies (see **figure**). It runs under one master GUI as a Matlab toolbox.

AFD simulates the frequency and time-domain responses of

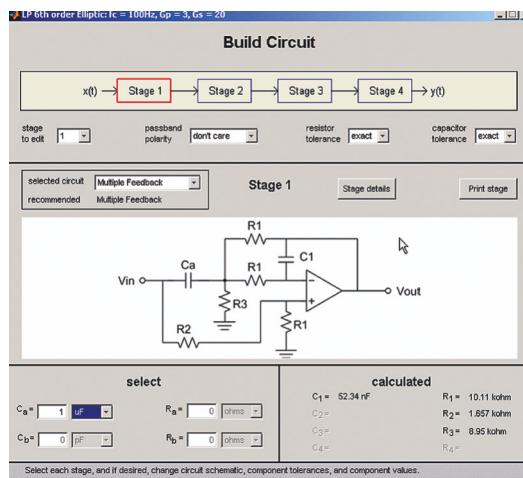
the filter built with both idealized and standard-value components to a variety of standard test waveforms. It can also load a sampled user waveform and simulate its time-domain and frequency-

domain performance both pre-filtering and post-filtering.

To facilitate stage-by-stage debugging and tuning, you can independently analyze each filter stage in the frequency domain and in the time domain. You can compute the sensitivity of filter characteristics to changes in component values. Although it can implement the filtering stages using a variety of circuits, the program suggests the circuit most suitable for the particular stage's gain and Q.

The AFD download (a .zip file) includes a full user manual and installation instructions. You can download the AFD tool from academics.vmi.edu/ee_js/ (click "research" then on "Active Filter Design for Matlab" to download the program).

James Squire,
Virginia Military Institute



A free Matlab application lets you design and analyze active analog filters.

BOOK REVIEW

Measuring 65-nm circuits

Overcoming the Measurement Challenges of Advanced Semiconductor Technologies, 1st ed.,
Pete Hulbert, et al., Keithley Instruments (www.keithley.info/semihandbook), 2005. 140 pages. Free.

As process geometries shrink below 90 nm, material and device innovations—rather than traditional process scaling—are driving semiconductor advances. That's the contention the authors make to introduce Keithley's new handbook on parametric measurements of semiconductor devices. They go on to demonstrate in detail what those material and device innovations are and what they mean to engineers trying to make measurements on devices employing them.

For example, the authors describe why gate-oxide layers are getting thinner, how the change affects capacitance-voltage measurements, and what demands it puts on the instruments

used to make those measurements. They also explain why high-dielectric-constant gate materials are being employed (to reduce gate leakage) and how to characterize the reliability of these materials—specifically, by using a charge-pumping technique to make charge-trap-ping measurements.

A section describes RF wafer tests that don't require big-iron ATE systems, providing details on factors such as probe-card control. A related chapter describes statistical-process-control techniques that manufacturers can apply



to wireless device manufacturing in order to meet known-good-die goals for the RFICs destined for cell phones.

An extensive section covers reliability testing, touching on subjects including wafer-level reliability testing, high-throughput gate-dielectric reliability tests, and a cylindrical stress test applied to improved thermal stability of copper vias. A concluding section describes femtoamp DC leakage tests for devices aimed at low-power mobile applications.

This book is free, so it's not surprising that there's the occasional word from the

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DATA TRANSLATION

Measuring 65-nm circuits (continued)

sponsor, such as that a particular Keithley system "provides the lowest cost of ownership available." Also not surprisingly, the book uses Keithley instrumentation in its measurement example.

Nevertheless, the authors provide more than enough generic information to make the book a worthwhile read regardless of whose instruments you use.

Rick Nelson, Chief Editor

SOFTWARE

Create your own data plots

Engineers often need to plot and analyze data. While Microsoft Excel covers many data-analysis applications, it doesn't always let you set up a plot the way you want. Enter gnuplot, a free plotting program available at www.gnuplot.info. Currently at version 4.0, gnuplot is a command-line-driven program that lets you plot data in two or three dimensions from just about any data set.

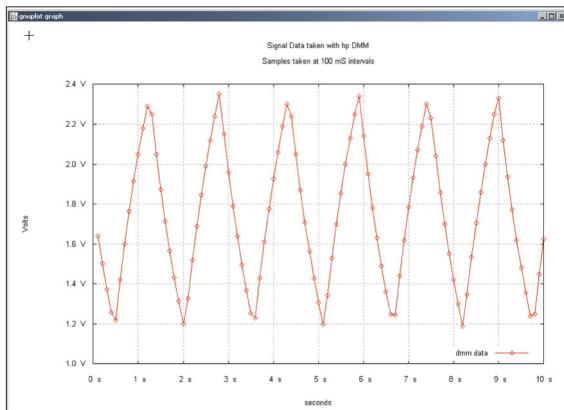
To create a plot, you enter a series of commands that set up the plot's parameters and tell gnuplot where to look for the data. For example, if you type

```
plot [-30:30]
sin(pi*x)/(pi*x)
```

into the command line, gnuplot will plot $\sin x/x$, where x covers the range of -30 to +30. If you'd prefer not to type each command separately, you can combine a series of commands into a script and then call the script from the command line.

The **figure** shows a sample plot. Using a DMM, I took 100 samples at 10 samples/s of a 1-Hz waveform and saved the data in a text file. The script defines the graph and tells gnuplot where to find the data. You can download a zip file containing the data set and the script I used from the online version of this article (www.tmworld.com/archives/2005_11).

The following sample from the gnuplot script defines the plot's x axis:



The gnuplot plotting software lets you write scripts and plot data.

```
# These format statements
# indicate what the numbers
# will look like on the
# graph.
set format x "%0.0s %cs"
set format y "%0.1s %cV"
```

The first command line sets values in the x axis to display no digits to the right of the decimal point with the value followed by "s". The "%cV" in the second command line sets up each value in the y axis to have one decimal place followed by "V".

If you browse gnuplot's documentation, you'll see that it's a powerful plotting tool. You'll have to spend some time learning to use the command-line syntax, but as an engineer, you can handle it.

Martin Rowe, Senior Technical Editor

ACKNOWLEDGEMENT

Thanks to Ron Simonson, product engineer at Analog Devices (Beaverton, OR), for writing the gnuplot script used in this article.

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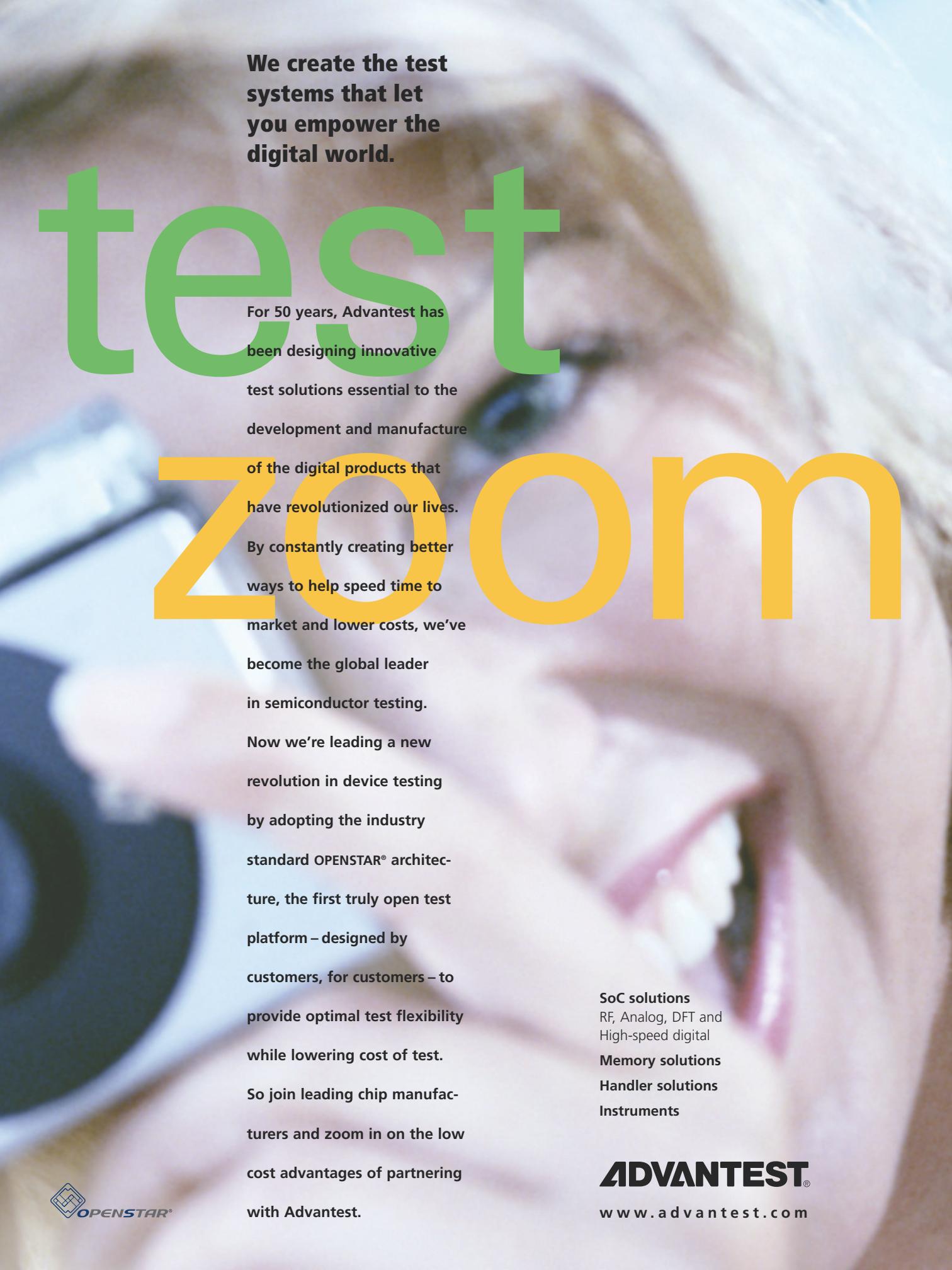
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PROJECT PROFILE

INSTRUMENTS

Sometimes, analog is better

DEVICE UNDER TEST

Quad- or dual-channel zero-threshold matched-pair MOSFET arrays. Each MOSFET features a low threshold voltage, about $0.0\text{ V} \pm 2\text{ mV}$. The device's nearly zero-threshold gate voltage (V_{GS}) lets it operate with lower power-supply voltages than most other MOSFETs.

THE CHALLENGE

Shorten test time because using computer-controlled test equipment takes too long to find the threshold voltage (V_{GS}) required to fully turn on the device. Design an analog circuit that lets a bench DMM accurately measure V_{GS} while reducing test time.

THE TOOLS

- Advanced Linear Devices: quad SPST analog switch, dual comparator, dual op amp, timer, dual and quad MOSFET arrays. www.alldinc.com.
- Agilent Technologies: source-measure unit and DMM. www.agilent.com.
- Keithley Instruments: source-measure unit. www.keithley.com.

PROJECT DESCRIPTION

Advanced Linear Devices (ALD, Sunnyvale, CA, www.alldinc.com) recently introduced the ALD1108 zero-threshold MOSFET. To characterize a device, ALD engineers must apply a gate voltage of -5 V to $+5\text{ V}$ and find V_{GS} at the point where V_{DS} is $100\text{ mV} \pm 1\text{ mV}$ and I_{DS} is $1\text{ }\mu\text{A}$. The engineers need a way to accurately measure V_{GS} , V_{DS} , and I_{DS} .

When the first devices were available for engineering evaluation, ALD engineers used source-measure units to apply the gate voltage and the $1\text{ }\mu\text{A}$ of drain current (I_D). "We started by programming the source-measure units to apply an ever-increasing voltage to the gate and to measure V_{GS} and V_{DS} and I_{DS} ," said ALD president Bob Chao, "but finding V_{GS} took over one minute on each device, which was too long."

The delays occurred because the source-measure unit had to increment its output voltage in 1-mV steps across the $+5\text{ V}$ to -5 V span and take an I_D measurement at each step until I_D reached $1\text{ }\mu\text{A}$ with V_{DS} at $100\text{ mV} \pm 1\text{ mV}$. A computer programmed the source-measure unit to produce each value of V_{GS} and make the measurements.

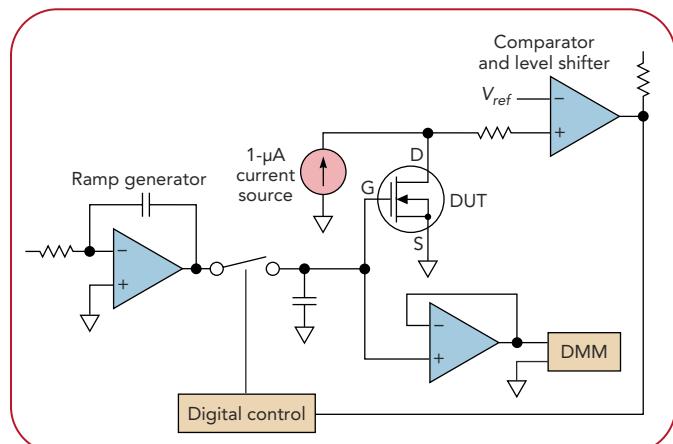
To solve the problem, ALD engineers designed a simple analog circuit from op amps, comparators, MOSFETs, a timer, and an analog switch (ALD manufactures all of these devices), as well as several passive components from other manufacturers. The **figure** depicts a simplified schematic.

The circuit uses a ramp generator that applies a voltage from -5 V to $+5\text{ V}$ to the device under test's (DUT's) gate. A current source pumps $1\text{ }\mu\text{A}$ into the DUT's drain. When the ramp voltage reaches the DUT's threshold voltage, the DUT turns on, which lets current from the source pass through.

A precision comparator monitors the drain voltage through a resistor. When I_D reaches the

full $1\text{ }\mu\text{A}$ and the drain voltage reaches $100\text{ mV} \pm 0.2\text{ mV}$, the comparator changes state, causing a switch on the ramp generator's output to open. The polypropylene capacitor holds the gate voltage long enough for a high-resolution DMM to measure it. A power supply or source-measure unit provides a reference voltage for the comparator.

A second comparator (level shifter) converts the precision comparator's output to standard logic levels. The digital-control circuit uses the



An analog circuit finds the value of gate voltage that produces the full $1\text{-}\mu\text{A}$ drain current at a drain voltage of 100.0 mV . (You can download a detailed schematic from the online version of this article at www.tmworld.com/archives/2005_11.)

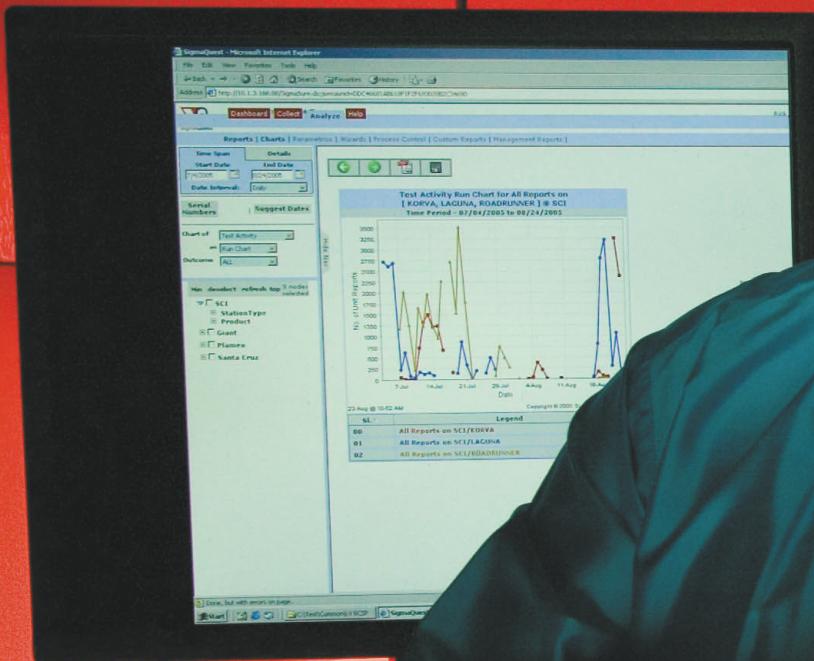
level-shifter's output to start and stop the test. To start a test, an engineer pushes a button that starts the timer. The timer forces the switch closed, which connects the ramp generator to the DUT. When the comparator and level shifter change state, indicating $I_D = 1\text{ }\mu\text{A}$, the level-shifter's output signal resets the timer, opens the switch, and lights an LED indicating that the measurement is complete.

LESSONS LEARNED

ALD engineers learned that using computer-controlled test equipment isn't always the best solution to a measurement problem. With off-the-shelf active and passive components, you can sometimes build a simple supplementary circuit that, in conjunction with automated test instruments, can cut test time and improve measurement accuracy.

Martin Rowe, Senior Technical Editor

Rick Frier, senior manager of global test engineering at Plantronics, employs SigmaQuest database management software to complement his CS50 wireless headset as he communicates with production-test operations in China and Mexico.



Bringing home **THE DATA**

SANTA CRUZ, CA—Plantronics headsets are everywhere: in homes, offices, contact centers, and airplanes. They've traveled as far as the moon, and today they're roaming wherever their wireless-phone-chattering wearers care to go.

But Plantronics test engineers themselves are striving for a less peripatetic life. To that end, they're bringing up to speed software that should minimize their need to travel to far-flung manufacturing facilities. With the software's Web interface, the engineers can sit at their desks at Plantronics headquarters here and view detailed test activity at remote locations.

The test engineering team's ultimate goal is to ensure the quality of a broad mix of products produced in high volume in locations including Mexico and China. The engineers assemble rack-and-stack test systems at the company headquarters and deploy them, along with test programs, at the remote manufacturing facilities. For optimum results, the engineers must build test systems that are accurate, remain calibrated, and correlate well with each other. Further, they need to ensure that each test approach optimally balances instrumentation and labor resources and that production technicians apply the systems properly. To perform their jobs effectively, the Plantronics engineers need lots of data, which hasn't always been easy to obtain.

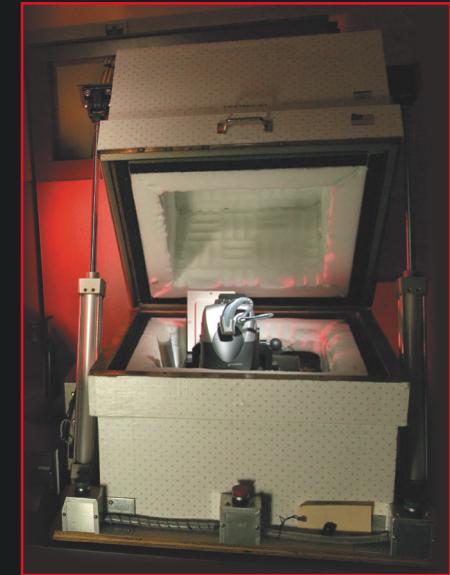
Responsibility for the test-engineering function ultimately rests with Rick Frier, senior manager of global test engineering. Frier got his engineering start in the medical business, where he designed fail-safe circuitry for hospital pumps that deliver fluids to patients. Then, he entered the disk-drive business, where, during a 20-year stint, he gained database experience that he's been able to apply at Plantronics.

Defining the test requirements

Frier's three years at Plantronics, he said, have introduced him to an expansive test-engineering role, as his responsibilities have included product development, process engineering, and manufacturing. At Plantronics, he explained, product development spans a three-stage process, with stage 0 defining the specifications to embrace the basic design concept, stage 1 defining radio and acoustic performance and physical configuration, and stage 2 involving actual fabrication of the products. "We get involved right at stage 0 to make test requirements clear. We need to ensure we can test the boards in a large-scale manufacturing environment, and of course, we need sufficient access to perform a final test of our products in plastics."

Plantronics is now focusing on wireless products that employ Bluetooth and DECT (digital enhanced cordless telecommunication) RF communications, such as the Voyager 510 Bluetooth headset and CS50 900-MHz DECT wireless office headset system. The combined audio and RF technologies of such products complement Frier's interests as a ham radio operator, but the combination also complicates the test process by adding RF functionality to the acoustic features the company has long been known for.

"Now, there are a lot more and varied devices on our boards than we had with just regular acoustics," said Frier. "So, when we start manufacturing these boards at high run rates, it's not surprising that we might initially experience higher fallout rates. Initially, it was difficult for us to understand what specific problems were occurring at our contract manufacturers, because it took us days or weeks to get the information we needed to try to identify critical failure modes. And



Custom enclosures hold products under test while providing acoustic and RF isolation to eliminate the effects of ambient noise and interference from nearby test systems.

Database software helps Plantronics test engineers manage far-flung manufacturing and test operations from the comfort of their US headquarters.

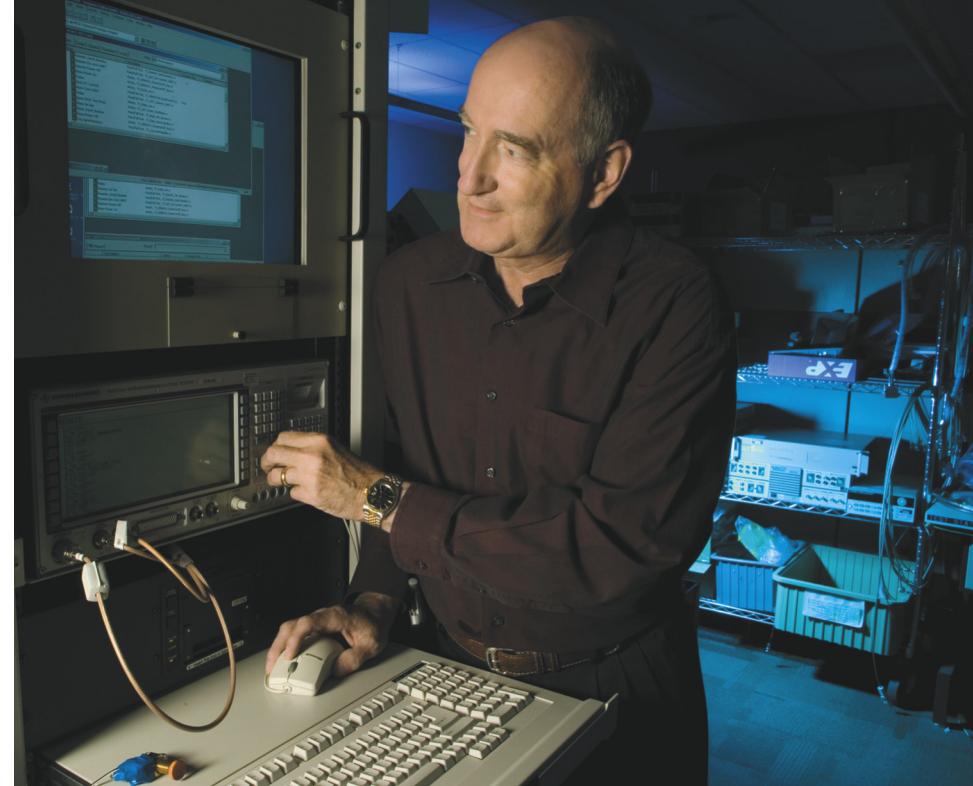
Rick Nelson, Chief Editor

when we did get the data, we couldn't always be certain of its accuracy."

Getting data out of China is particularly difficult, Frier said. "Much of it is entered by hand, some may be in Chinese, and it can take a week of evening calls to understand what a report is saying. It's often quicker to put an engineer on a plane and send him over there." The result might be the uncovering of a simple problem that could have been solved quickly and cheaply had appropriate data been available. Or, the engineer initially dispatched might learn the problem isn't one he's best qualified to solve, requiring that yet more people from headquarters make the journey.

And even when remote facilities did provide timely, accurate data, it was rarely in a format that engineers could easily use to visualize how well a facility was operating. "When we're ready to begin manufacturing a product, we do pilot runs to gather information," Frier said. "We often had to put data by hand into Excel to generate the charts that would let product engineering visualize upper and lower limits, for example, and look for good distribution within those limits." All in all, Frier said, it had been a very painful and expensive process.

As a consequence of this painful process, Frier said, "it became challenging to get yields to a point where we were satisfied." In addition, he said, his staff was



Terry Walters, senior VP of operations, adjusts a rack of equipment that will test DECT wireless products.

spending too much time on planes and too little time developing and optimizing new test systems and programs. Frier explained that these issues were key to justifying the development of a database that could track each manufacturing facility, each product line, and each test system.

The test systems themselves are made up of commercial products—instrumentation such as Anritsu Bluetooth testers, Brüel & Kjaer artificial mouths, and Rohde & Schwarz DECT testers as well

as National Instruments LabView and TestStand software—plus custom fixtures and cabinets that Plantronics designs and builds. An effective test-system design will have to take into account labor costs at the target facility—Chinese facilities, with lower labor costs, can accommodate more operator intervention than can Mexican facilities, Frier said. In addition, the setup needs to make effective use of instrumentation; for example, to prevent a \$60,000 RF DECT instrument from sitting idle

Adapting a commercial software system

SigmaQuest CEO Nader Fathi commented on his company's work with Plantronics. On top of existing SigmaQuest reporting capabilities, he said, Plantronics requested high-level management reports and custom engineering reports that were highly specific to the Plantronics environment. But two functions—"what-if analysis" and "push-button reporting"—that SigmaQuest developed with Plantronics have been integrated into SigmaQuest's SigmaSure commercial software suite for the real-time capture, aggregation, and analysis of functional test results.

Fathi described SigmaSure as a database with a business (or real-time analytics) layer on top. It consists of an application program interface (API) for extracting data from test systems in an XML format and for delivering software—such as the latest version of a test program—to test systems. SigmaSure also includes components for collecting and analyzing data and for the remote control of test systems.

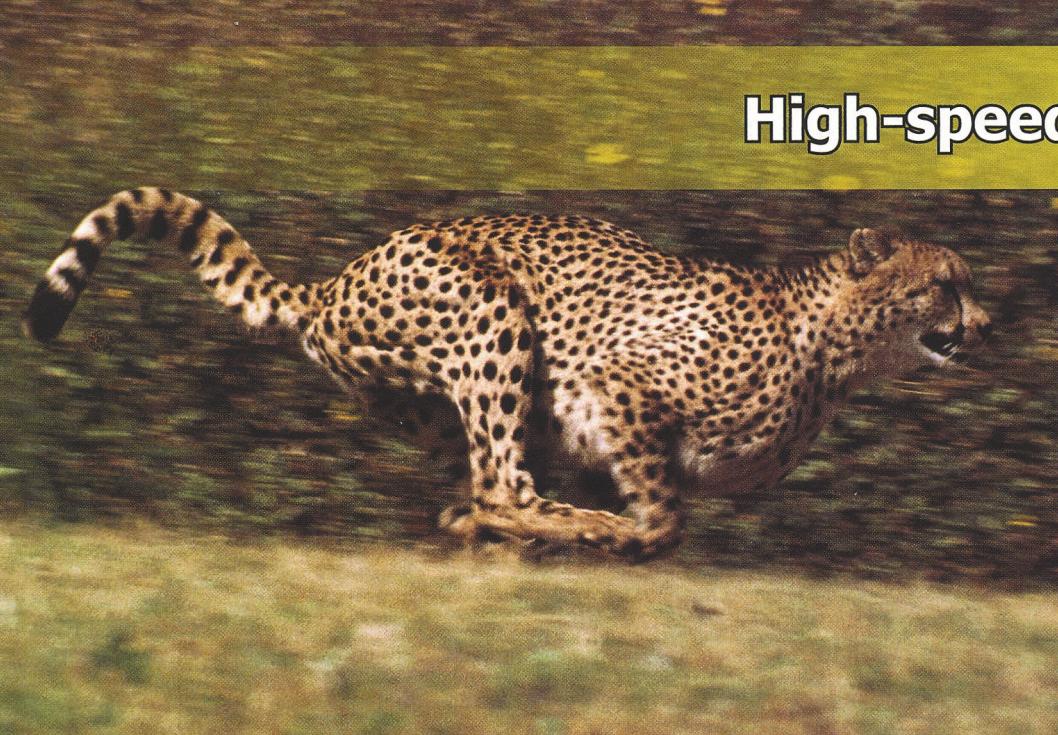
In initial work with Plantronics, Fathi said, "We found out that Plantronics engineers at times worked on week-

ends generating product-performance reports for Monday-morning engineering staff meetings." The push-button reporting function, he said, allows them instead to use the SigmaSure real-time dashboard to schedule and automatically convert relevant data to word-processing documents, making manual report generation unnecessary. As for the "what-if" analysis, Fathi said it helps decision makers instantly explore scenarios by letting them change parameter values or limits on the fly and see the overall impact on yield or other factors.

Fathi noted that the majority of SigmaQuest's customers use the SigmaSure suite directly off the shelf, although some may employ custom translators instead of the SigmaQuest API to get test data into SigmaQuest XML format. He added that SigmaQuest data can be exported for additional analysis using third-party packages.

His advice to prospective database implementers: Don't try to reinvent the wheel and create a custom solution with a high long-term cost of ownership. And make sure your database is globally scalable.—Rick Nelson

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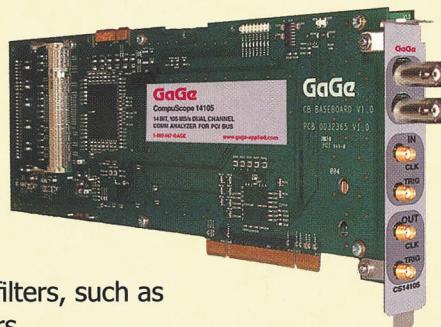
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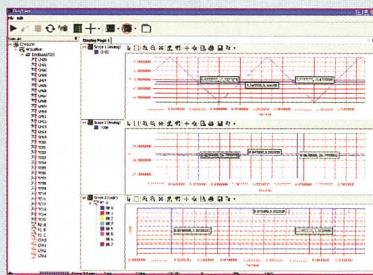


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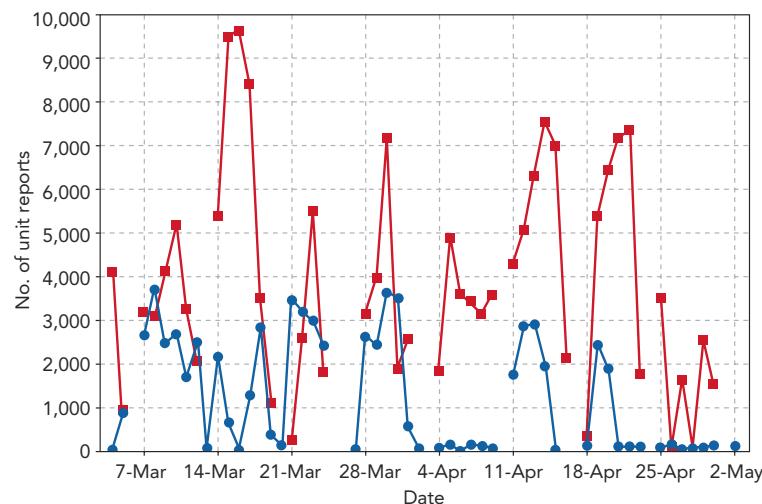
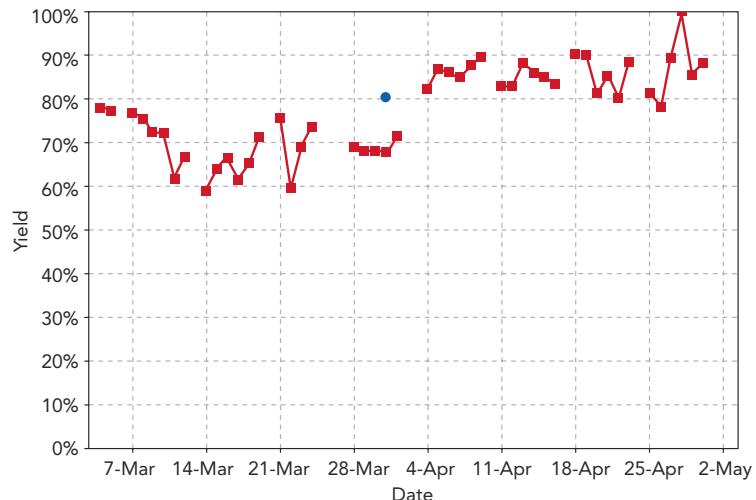
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SOFTWARE

during DUT handling, the test setup could employ a dual-well test chamber that lets an operator change out DUTs in one well while tests proceed in the other.

The goal that Frier envisioned for a database implementation was to acquire and deliver accurate, timely data from these test systems and to make it available at headquarters in formats useful to engineers as well as managers. Frier's background in databases—he has a master's degree with an emphasis on management of engineering and technology, which included database development, and he has developed two databases for the disk-drive industry—enabled him to envision an optimal implementation for Plantronics: "We required two significantly different modes—one for engineering-level analy-

The Plantronics implementation of the SigmaQuest database presents data in a variety of formats. The top chart illustrates yield increases resulting from an April 1 engineering change order. The bottom chart shows daily production levels at a contract manufacturer in Mexico (red) and in China (blue). (The SigmaQuest charts have been altered here to disguise proprietary information.)



Rick Frier readies a test chamber and fixture for the test of a CS50 DECT headset.



Rick Frier readies a test chamber and fixture for the test of a CS50 DECT headset.

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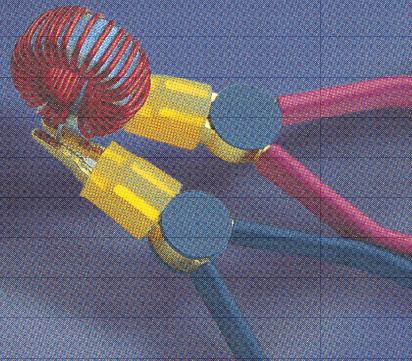
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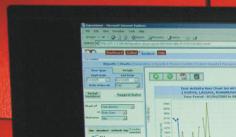


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sis and one for management. At the engineering level, we wanted to see the details of the units run to understand Cpk [process capability index] and to see the actual test limits and the spread of failure modes. Are failures catastrophic or marginal, and if marginal, what's going wrong? Is it the test limits, is it the original specification, or are we getting bad parts? We need to be able to drill down and answer these questions."

At the management level, Frier said, "I want to be able to look at a screen each morning and get an overview of what's happening across all product lines at all my manufacturing plants and look at factors such as how well all my test equipment correlates."

Frier noted, "When we actually got into reviewing different commercial databases, we found nobody had exactly what we needed to present our RF and acoustic test data in the formats we wanted to see. We had to find somebody who would be willing to work with us to develop a database that would present the data in the manner we needed to have it presented in." Sigma-Quest was an attractive partner in that regard, Frier said, because the company offered price advantages in exchange for being able to integrate functions it developed for Plantronics into its standard products (see "Adapting a commercial software system," p. 32).

Frier said he was pleased to help identify functions that would be applicable to firms other than one that made headsets. "It helps SigmaQuest and it helps us, because we obviously want SigmaQuest to be successful and stay there and continue to support us."

Getting CMs on board

All of Plantronics' PCBAs are made at contract manufacturers. "We just build the test equipment and support the CMs with our test equipment. For final assembly into plastics, we do have a facility—called Plamex—in Tijuana, Mexico, which assembles probably about 80% of our products. We have a CM in Guadalajara, Mexico, and three in China, which build our PCBAs, so we have five facilities that I need to set up the system on. We've taken it a step at a time on the way to getting 100% of our test equipment up and running with the database—I was very hesitant to just roll it out quickly across all lo-

cations because I wanted to avoid having our system crash their systems. I wanted to make sure we did it very smartly and cautiously to make sure we got the information we needed without interfering with the CMs' operations."

Success of the database project requires acceptance on the part of Plantronics'

CMs. "The CMs are supportive and not supportive. Some of the facilities have jumped into it pretty willingly; some have been hesitant, imposing delays and not returning phone calls. In those cases, we have just said, 'look I know you guys don't really want us there, but we are going to come, so you are going to have to get used

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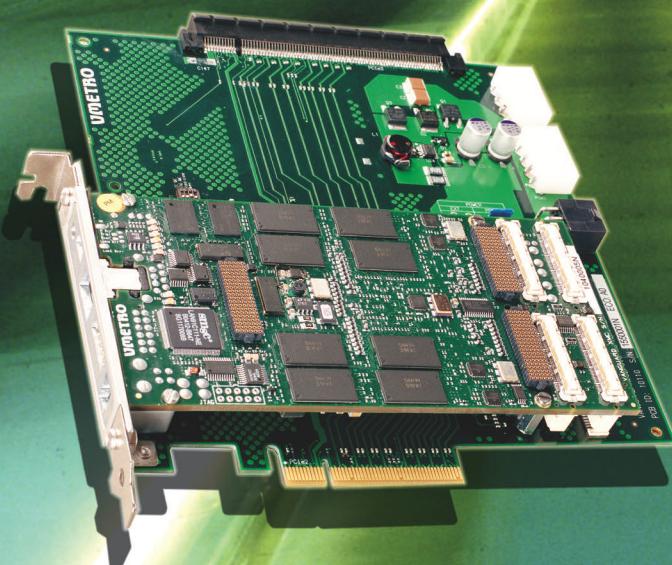
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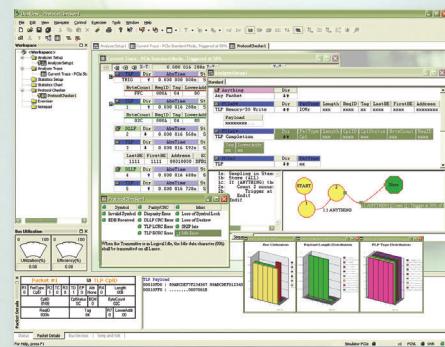
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to us.' I think that what they are concerned about is that we will have a lot more control and understanding of what's really happening on their manufacturing floor. It hasn't proved to be to their disadvantage yet, but I think they would prefer it if they remained totally in control."

He cited one example where a CM's control might be inappropriate: "To a manufacturer, it's a big deal in terms of money if a product isn't yielding. If yield is poor on one tester, an operator might be tempted to bump a lower limit down a tiny bit or an upper limit up a tiny bit in an effort to get the tester to correlate better with others."

He noted that there can be several causes of correlation problems: A test system's acoustic or RF shielding might be degraded by repeated opening and closing of its test chamber, for example. "If there's a correlation problem, we want to know about it and solve it ourselves," by repairing or replacing a fixture or taking other appropriate action. "We don't want the operator changing limits. But before implementing the database, we had no way to tell if he was doing that short of stationing a test engineer on the floor with him."

Access to data

The CMs that are supportive, he added, realize that the timely acquisition of accurate data will ultimately help improve their production processes, allowing Plantronics engineers to respond promptly and effectively to correlation or yield problems. When asked if the CMs themselves will have direct access to the data, Frier said, "That's still in discussion. What level of access do we give CMs? I can't see any disadvantage to letting them view the data. Of course, we won't let them change anything, but if they can look, they may be able to identify problems themselves and solve them before those of us in Santa Cruz get to our desks in the morning."

The level of support is evident in the access the CMs provide to their IT infrastructure. "Some let us set up our equipment [the servers on which the data resides] in their air-conditioned IT rooms; some say we can set up on the production floor next to our test equipment—that's the most we will give you.' Either way works fine for us, but of course, I'd rather be in their IT room because the equipment located there should be more reliable. And in time, maybe even the reluctant CMs will see more of the benefit of the system and be more willing to work with us on that level."

No matter where the physical installation, there have been the typical IT issues to resolve: establishing firewalls that protect both Plantronics and the CMs and

eliminating viruses on the test systems. Some operators do surf the Internet using the test equipment, Frier said, making anti-virus protection necessary. "We will tell the CMs that this is completely unacceptable, but what message does the operator get? Maybe, 'Just don't do this when the customer is here.'"

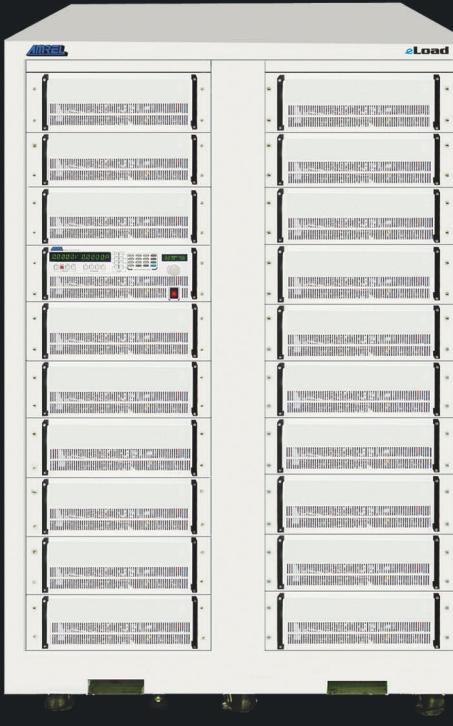


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CMs aren't the only ones who need to accept the database—so, too, do Frier's co-workers. He said, "It's been interesting how people within Plantronics react to the system—some people have been enthusiastic from the beginning and some not. By now, though, most realize the benefits of seeing real, live data quickly.

The ability to see what firmware version a product is using and to look at actual test-limit files is something that demonstrates its value very quickly."

He noted ways in which several constituencies can use the system. "Failure-analysis people can run the system from here to try to identify root causes. Man-

agement can look at data in a variety of formats. A manager can look at one day, which is useful when just starting production, or he can look at rolling weekly averages, which might be more useful for monitoring the long-term performance of a production line." Quality-control people, he added, want to look at yields on a daily basis to look for problems that might be due to different component batches.

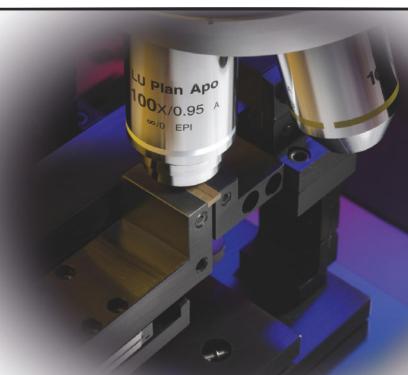
"And software engineers can confirm that proper firmware versions are being installed. We used to e-mail firmware updates to our CMs but had no way to ensure they were updating all the test systems until products came back." In addition, he said, "Hardware engineers can get a detailed understanding of what's happening on the production floor. They can look at histograms of frequency-tuning performance or offset and drift or any other characteristics."

Of course, each person has particular ideas of what data should be available and what format it should be presented in. "I knew that was going to happen because it's happened to me in the past," Frier said. "Everyone who looks at a system will say, 'well this is great but it doesn't do exactly what I want.' So, we sat down with everyone who would use the system to compile a wish list."

Ultimately, the key selling point that got Plantronics executives on board was the money the system would save. Frier expects the system to pay for itself within eight months—mostly in engineering hours spent traveling to manufacturing facilities or entering data by hand. "Now, I can pull the data out and look at it in a format that makes sense to me in 10 or 15 minutes. That used to take as long as a week."

Frier emphasized that the savings in his calculations represent real savings and are not based on the intangibles that he said some database companies focused on in their presentations to Plantronics. His calculations, he said, are based on actual engineering time spent and production downtime avoided, all documented with accounting records. Factors like customer satisfaction, he said, "are very important, but I can't confidently assign a hard number to them. And I didn't need to in order to justify the purchase of the system. Improvements in customer satisfaction and so forth are bonuses on top of the hard savings I documented."

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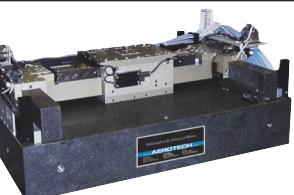
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A new method for creating faster-than-at-speed tests can detect small delay defects in all circuit paths of 130-nm devices.

BEYOND AT-SPEED

MARTIN AMODEO, CADENCE DESIGN SYSTEMS, AND BRUCE CORY, NVIDIA

Traditional scan-based at-speed delay tests attempt to check for transitions at the system clock speed. For chips designed at 130-nm nodes and below, at-speed tests are no longer sufficient for detecting small delay defects in many of a design's paths. You can, however, employ a new method for creating faster-than-at-speed delay tests that are able to detect small delay defects in all circuit paths, as evidenced by the results we obtained by applying the technique on an Nvidia 130-nm chip.

As feature sizes have decreased, and as processes have changed (as exemplified by the industry-wide move to copper), the importance of structural delay test has increased greatly. Defects that cause increased delay, such as resistive opens, have become more common.

These defects are difficult to detect with single-clock (stuck-at-fault) patterns, because they don't tend to affect the overall logical results of a circuit. Some of these defects can be observed with I_{DDQ} patterns (for example, bridging defects between power and ground), but faults detected this way are difficult to isolate and diagnose. Moreover, relatively high background leakage

currents in newer designs even make I_{DDQ} detection difficult. At-speed functional patterns offer a possible solution, but they are difficult to create and are not necessarily robust enough for high test coverage.

To detect delay defects effectively, the industry is migrating toward structural delay tests. We have found, however, that the quality of such patterns depends on the slack in the paths over which a fault is propagated and ultimately observed. Too much slack from a small physical defect to its observation point can make the defect impossible to observe, because the slack will allow extra time for the fault-induced slow transition to settle out to the expected value.

At-speed delay tests

Delay-test-generation algorithms based on controllability and observability estimations tend to generate test patterns down the easiest and most accessible paths; these algorithms test for transitions at the system clock speed. The paths these algorithms select also tend to be either the shortest paths or the ones with the greatest amount of slack when running the clocks at system speed.



If a pattern generator marks off a fault effect as “tested” down one of these short paths, the generator won’t attempt to evaluate that fault again to observe it down a longer path. Therefore, small defects can escape, even though they were nominally “detected” with the pattern set.

For example, in **Figure 1**, assume there is a defect at location A. A typical test-generation algorithm will test for this defect down the shorter path on the bottom because it is far easier. Yet, a small defect would have a much higher chance of detection down the longer path on the top.

Random fill and serendipitous fault mark-off present a similar problem, because faults are marked off with no regard to the amount of slack in the paths through which they were observed. This again leads to higher nominal coverage, but the quality of that coverage is neither determinable nor guaranteed.

To work within the constraints of existing test software (and its tendency to observe and mark off faults down short, noncritical paths) and eliminate the slack down these paths (removing the possibility of test escapes), you can use a new technique that tests chips at faster-than-system speeds.

Faster-than-at-speed delay tests

A fairly straightforward way to address the problem of slack is to create patterns with as much of the slack removed as possible. Assuming you make no changes to the test-generation or fault-simulation algorithms, increasing the clocking speed of the test patterns removes slack.

In other words, this method will still test the short paths, but it will test them at higher speeds. To use this method, you must determine a range of appropriate clocking speeds that will permit a majority of the paths on the part to be mea-

sured with as little slack as possible. You can determine this range by getting a distribution of path lengths in the circuit for each clock domain.

Once you determine the frequency range, you need to generate test patterns

to run at these various speeds. You must choose an interval between each frequency gradation as well. These intervals can re-introduce the problem of slack, but you can choose intervals that are small enough to keep slack to a minimum. Ideally, the test generator will automatically create tests for each transition with the minimum possible slack.

frequency interval—and no other factors—will determine the maximum slack value. It will also guarantee that any serendipitous fault mark-off that occurs will be down paths with the desired amount of slack, since all others will be measuring X.

One way to automate the generation of faster-than-at-speed tests is to use circuit-timing knowledge to both generate the faster-than-at-speed tests for the shorter paths and mask off the longer paths as required. The timing information can be made available to the automatic test program generator (ATPG) engine from the Standard Delay Format (SDF) timing data from any industry-standard timing-analysis tool. The ATPG engine can internally “time” the patterns and determine which flip-flops are fed by paths that do not meet the required timing. It can then automatically mark these flip-flops to measure X in the pattern set.

The test-generation algorithm should first create the patterns that have the fastest frequencies, followed by slower frequencies. The test coverage is accumulated as the test generation progresses. In this way, faults are marked off as tested at the highest frequency at which they can be observed, and subsequent test-generation runs do not attempt to test these faults down slower paths, saving test-generation and simulation time.

Sample implementation

We conducted a study using this test method on a 130-nm graphics processor. We generated approximately 27,000 two-clock delay test patterns, achieving 85% transition fault coverage. These patterns were

run at functional speed. Despite using this robust set of patterns, we still found some failures at system-level test.

We ran a static delay analysis to determine the slack (assuming a clock running at system speed) per unique path on this chip, within the main clock domain; the results are shown in **Figure 3**. Note that

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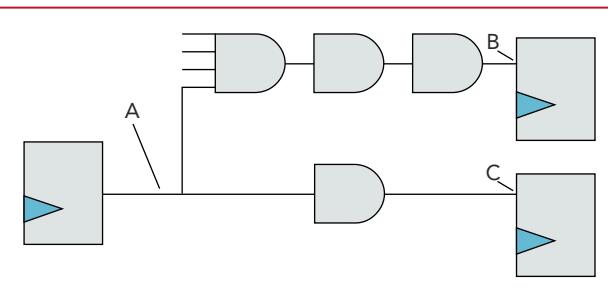


FIGURE 1. The effects of a fault at location A could be observed at location B or C. An automatic test-pattern generator would most likely choose the easier, short path to C, but slack in that path may hide the defect.

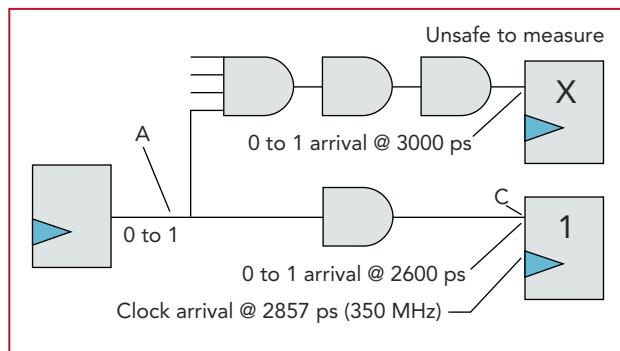


FIGURE 2. Faster-than-at-speed testing removes slack along the path from A to C and permits detection of a fault at A. For this testing to succeed, however, flip-flops on longer paths must be masked.

Figure 2 demonstrates that in order to create patterns at various speeds that work on real silicon on a tester, the flip-flops fed by paths that cannot operate at these faster-than-system speeds must be instructed to measure Xs (don’t care states). This will harm fault coverage, but it will guarantee that your choice of fre-



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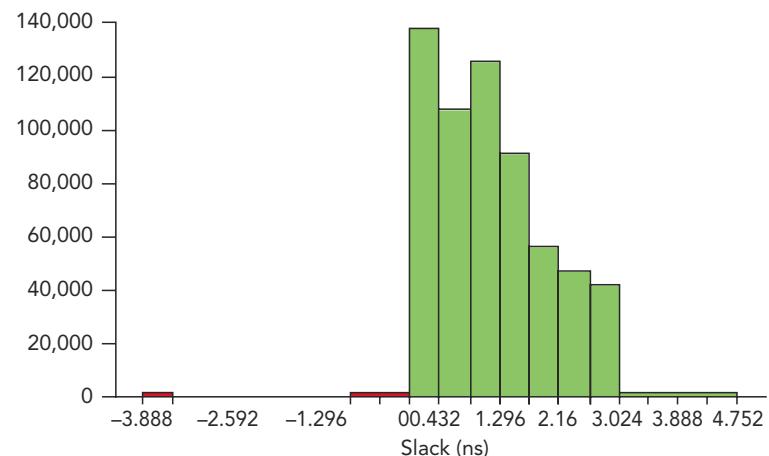


FIGURE 3. The distribution of path slacks on a 130-nm device shows that about half the paths have slack in excess of 1 ns, making the device a good candidate for evaluating a faster-than-at-speed test approach.

about half of the paths have a slack in excess of 1 ns. This chip made a particularly good candidate for these experiments because so many of the paths have a high degree of slack. Having numerous short paths increases the odds that a fault effect can feed both a short path and a long path.

One (among several) of these chips was found to fail system-level test, referred to here as chip X. Chip X passed the robust set of 27,000 at-speed delay test patterns, in spite of its relatively high fault coverage. We'll refer to this as pattern set P1. An additional 1000 test patterns, pattern set P2, were timed to just over 2X the functional clock speed (detecting somewhere in the neighborhood of 13% of delay faults).

We fault-simulated pattern set P2 on top of the coverage marked off from pattern set P1, and showed no additional faults marked off. This shows that pattern set P1 had tests for all of the faults that are covered by pattern set P2, so the main difference between the two pattern sets is the speed at which the patterns can be run on the tester.

We created pattern set P2 using an SDF file generated for the worst-case corner—low voltage and high temperature. The actual tester conditions were not as poor as the conditions governing the creation of the SDF (lower temperature and higher voltage), so we scaled the delay data linearly until the test patterns began working on the real silicon

at their rated speeds. This information had to be calibrated correctly so that the flip-flops that could not be measured at the rated speed could be masked. Empirically, the SDF data, created for conditions of 1.08V and 125°C, successfully approximated the test conditions (1.1V to 1.6V, 110°C) when we scaled the data to 95% of its values.

Once we achieved good correlation on the timing information for a known-good part using this linear scaling, we applied the patterns with confidence to the failing part, chip X.

Implementation results

Overall, the results from our example implementation showed that pattern set P2 was able to detect the failure mode that was detected at system-level test, but that

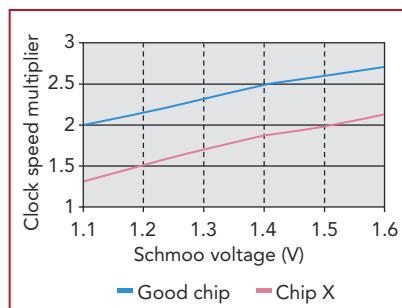
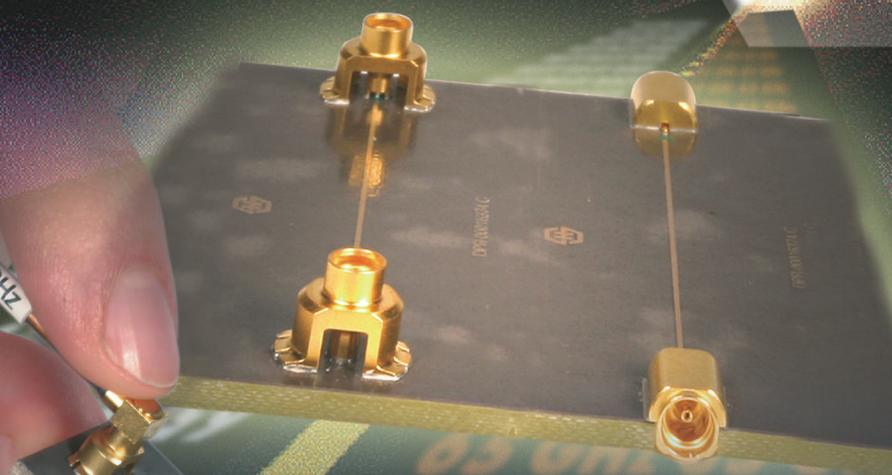


FIGURE 4. A delay defect on chip X caused it to begin exhibiting failures at 1.7X the clock frequency at its 1.33-V nominal operating voltage. A good chip tolerated a 2X clock even at 1.1 V.

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pattern set P1 running at system speed did not detect the failure mode. The fault or faults that model the physical defect in chip X must have been marked off as tested down a short path (faster than functional speed, with enough slack to make the defect unobservable) in pattern set P1. Pattern set P2 also tests for the defect down a short path, but this pattern runs at a higher speed so the delay defect can be observed.

Pattern set P2 started detecting the failure at approximately 1.7X the functional clock speed at nominal voltage (1.33V). The defect was determined to be a region of the chip that added approximately 500 ps of extra delay to any transition passing through it.

Figure 4 shows the difference in performance of a good chip and chip X running pattern set P2. The lines are the thresholds at which the chips begin to fail. This illustrates the relative delay that is added to a path through the defective area of the chip.

The implementation of this test method on a real device experiencing system failures has demonstrated that running faster-than-at-speed tests will detect test escapes from at-speed tests. Running only a robust set of at-speed transition test patterns is not adequate to achieve the desired product quality. In addition, our implementation demonstrates that you need test pattern timing information in addition to the test coverage percent metric to gauge how well the delay test can detect defects. **T&MW**

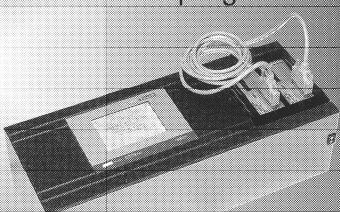
Martin Amodeo is a product engineer on Cadence's Encounter Test team, specializing in delay test applications. Prior to joining Cadence, he worked on the IBM test team as a developer for delay-test ATPG. He has a BS in computer engineering from the Rochester Institute of Technology.

Bruce Cory is the group manager of nVidia's design-for-test methodology group, which focuses on developing techniques to help increase chip margins and reduce the cost of manufacturing test while maintaining quality.

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THE DATA DETECTIVE



Fourier Rules in the Frequency Domain

The widespread design of wireless devices forces many engineers to move from the time domain into the frequency domain. An instrument such as a spectrum analyzer and a tool such as the Fourier transform can present frequency-domain information in easy to understand formats.

Still, frequency-domain measurements require a bit of explanation, starting with the discrete Fourier transform (DFT), an algorithm that operates on discrete time samples acquired by an analog-to-digital converter (engineers often call a discrete Fourier transform a fast Fourier transform, or FFT). A DFT produces information about the average frequency content of a signal during the period sampled. Thus, the DFT serves well when frequency content remains constant.

A DFT plots both "positive" and "negative" frequencies on either side of a 0-Hz (DC) reference. The negative information is redundant, but it represents half the power in the signal. So, a DFT routinely doubles the power represented at each positive frequency value. In effect, this power represents the root-mean-square (rms) amplitude of the sine-wave component at a given frequency.

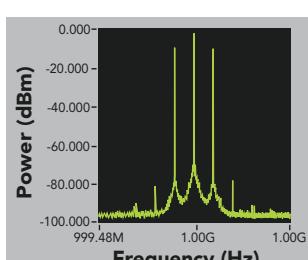
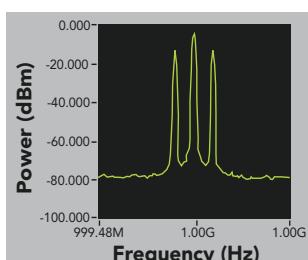
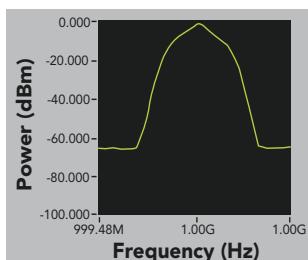
The frequency range and resolution a DFT provides depend on the sample rate (F_s) and the number of data points acquired (N). The DFT puts out frequency information between 0 Hz and $(F_s/2) - (F_s/N)$. The frequency lines, or bins, occur at intervals of F_s/N . Thus, the sampling frequency deter-

mines the frequency range or the bandwidth. The number of sampled points determine the frequency resolution, also called the resolution bandwidth (RBW).

As you lower RBW, a DFT better resolves signals, so individual frequency components become visible (see figure). Notice that decreasing the RBW also lowers the displayed noise floor. But, the finer frequency resolution and lower noise come at a price; longer acquisition times, which mean you must take more samples. Thus, data-transfer and computation times increase and overall measurement throughput decreases.

The lower noise floor effectively increases dynamic range, but this situation applies only for narrowband signals, such as pure sine waves. The bandwidth of such signals fits entirely within one frequency bin. Observe caution when measuring modulated signals. Their power spans several frequency bins, and you'll observe their average power reduced by an amount that equals the observed noise-floor reduction due to decreasing the RBW. Thus, the dynamic range for these signals remains constant. Reducing RBW does not improve the dynamic range for broad-band modulated signals.

You also can use a preamplifier to help an RF analyzer measure signals that may remain hidden beneath the instrument's noise floor. Suppose you apply signals with -110 and -145 dB amplitudes to an analyzer with a -140 dB noise floor. The latter signal falls below the noise floor, so the analyzer cannot detect it. A preamp with a 30 dB gain would boost the two signals to -80 and -115 dB, which raises the weaker signal above the noise floor. The analyzer's software then "lowers" the measured spec-



By taking more samples over a longer time, you can decrease the resolution bandwidth and separate nearby signals from one another. The better resolution comes at the cost of longer processing times, though.

Who's Got the Spur?

Phil's production-line test instruments indicate a signal source produces one or more spurs that shouldn't exist in good products. But Jane, an engineer in the development lab, can't detect and measure any spurious signals.

Can you suggest ways Jane could improve her measurements to determine whether the spurs do exist?

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trum by 30 dB. In effect, the two signals now exist at their original levels of -110 and -145 dB and the noise floor moves down by 30 dB to -170 dB. Obviously you cannot change the actual noise floor, but the relative difference between the signals is correct due to amplification of the signal. In effect, you can increase the effective sensitivity of the analyzer and lower the noise floor in relation to the signals.

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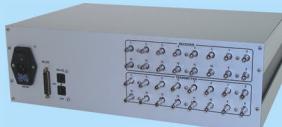
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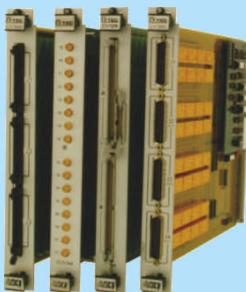
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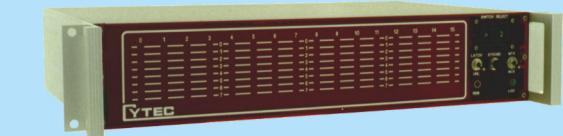
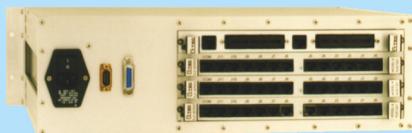
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TEST REPORT

AVIONICS

Keep 'em flyin'

Steve Scheiber, Contributing Technical Editor

High-reliability, low-volume products, such as avionics and vectronics (space and other vehicle electronics), present different challenges from more familiar consumer products. They demand zero failures—either perfect manufacturing and test processes or sufficient redundancy to compensate for any system faults that emerge during operation. No one wants an airplane's guidance system to fail over the Atlantic or a communications satellite to stop serving its customers.

One way to increase reliability—reducing parts count—relies on a few complex parts rather than many simpler ones and introduces its own test challenges. Kamill Hilberth, CTO at Superior Electronics, a contract manufacturer and independent test-program developer for military and other high-reliability applications, explained, “Testing the parts on a complex board can produce diminishing returns, discouraging comprehensive functional test as well as bed-of-nails test. In addition, component cost and complexity represent a powerful incentive for introducing noninvasive verification to avoid damaging them

[the parts] during test.” So, manufacturers of high-value boards—like others in the industry—rely increasingly on inspection.

“Because machine vision deals with structure rather than function,” said Hilberth, “it can find faults hidden even to customized solutions like built-in test.”

Yet, inspection of such PCBs also presents challenges. Double-sided PCBs containing multichip modules and other complex components thwart attempts at manual or automated optical inspection. Manufacturers of these systems rely heavily on thermal and x-ray techniques. Avionics, because of low manufacturing volumes and frequent design and engineering changes, can permit much wider variations of “acceptable” than more conventional products do.

“Under these circumstances,” Hilberth said, “matching observed images with reference files resembles human signature recognition. No two signatures will be identical. Nevertheless, we need to develop accept/reject criteria through extensive image libraries and special filtering algorithms.”

Designers must find ways to balance decision criteria to avoid failing good boards or passing faulty ones. To improve fault coverage, inspection systems must generally produce higher-resolution images.

Because increasing image resolution requires acquiring more information—a narrower field-of-view and more “snapshots,” for example—inspection often involves trading off between test time and comprehensiveness. In high-volume applications where throughput is critical, manufac-



turers might risk missing a fault during inspection and finding it later. Avionics and other high-reliability products encourage the opposite approach. A “failure is not an option” strategy means accepting higher costs and longer test times to ensure that no failures survive to the final product.

Hilberth also advocates incorporating corresponding noninvasive inspection steps into field and depot testing and into so-called “health management systems”—monitoring techniques that report on the mission readiness of electronics during normal operation or as part of field maintenance. To employ inspection in this way requires a common fault database between the two venues to allow the manufacturer to correlate results and thereby more easily detect patterns or trends. Inspection can also reduce the number of hidden faults during manufacturing, making health-management decision engines more effective.

Manufacturers of avionics and vectronics must address the same issues as their more traditional counterparts. Although boundary conditions, quality criteria, and economic benefits differ dramatically, inspection increasingly provides viable solutions. □

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EDITOR'S NOTE

Heating up

Steve Scheiber, Technical Editor

As optical and x-ray inspection techniques continue to improve, we sometimes lose sight of other technologies that could add to our quality arsenal. Infrared inspection has enjoyed a mixed history at best. Although infrared inspection is still used to inspect bare boards for shorts, its entry into loaded-board manufacturing proved less successful, suffering as much from a lack of corporate enthusiasm as from any drawbacks to the method itself. Circumstances encourage taking another look.

One of the challenges of increasingly powerful components is their heat dissipation. Concern has arisen that normal operating temperatures of some components can create "hot spots" on the board that approach tolerance limits of board substrates and other components.

As with visible-light and x-ray products, the resolution and sensitivity of infrared inspection hardware and software have improved dramatically in recent years. Although it might be argued that identifying locations with heat problems on boards during full-scale production would constitute closing the barn door after the horse has bolted, incorporating infrared inspection into prototype, pre-production, and initial ramp-up can minimize problems once full production begins.

Readers of this space will no doubt recognize that my fascination with this technique is far from new. Nevertheless, it could offer solutions in some situations where more conventional inspection techniques fall short. □

Contact Steve Scheiber at sscheiber@aol.com



NEWS

AIA reaches record membership

DURING THE 2005 International Robots & Vision Show, the Automated Imaging Association (AIA) announced that its membership is at a record high of 240 companies from 25 nations. "It's quite gratifying to see the growth of our industry and trade association, from a handful of companies with minimal sales in the early 1980s to a multibillion dollar global marketplace filled with hundreds of successful companies," said AIA executive director Jeffrey A. Burnstein. www.machinevisiononline.org. □

Dalsa receives major contract

DALSA HAS ANNOUNCED that it has received a contract valued at \$1.7 million in Canadian dollars (about \$1.44 million US) from an Asian scientific research facility. Under the terms of the contract, Dalsa will design a custom CCD image sensor chip and deliver follow-on production units throughout 2006. The Ontario-based company also has the potential to receive subsequent orders from the customer

upon the successful completion of this project.

Savvas Chamberlain, CEO of Dalsa, released a statement saying, "I am very pleased that Dalsa technology continues to make successful inroads into Asia. This contract is yet another excellent example of how leadership in technology enables Canadian companies to successfully expand into new world markets." www.dalsa.com. □

Court sides with Cognex

COGNEX REPORTS THAT on September 9, the US Court of Appeals for the Federal Circuit affirmed an earlier lower court decision that the claims of 14 machine-vision patents asserted by the Lemelson Partnership are unenforceable for reasons of prosecution laches (or delays in asserting a legal right or claim). In this case, Cognex says that Lemelson delayed prosecution by up to 39 years after the filing of the original patent.

"This ruling confirms Cognex's belief that Lemelson abused the patent system when he obtained his so-called 'machine-vision' patents. And the ruling also helps to give credit for the development of machine vision to

Firms unveil scalable GigE vision products

NETHERLANDS-BASED Quest Innovations has announced that it has signed an OEM licensing agreement with Pleora Technologies for Pleora's iPORT PT1000-VB In-Camera IP Engine. The agreement allows Quest to develop scalable processing units and smart cameras with Gigabit Ethernet (GigE) interfaces.

"Through this agreement, we are incorporating GigE interfaces into our scalable machine-vision processing hardware," said Richard Meester, president and CEO of Quest Innovations, in a prepared statement. "We will release our first GigE camera with processing capabilities in November at the machine-vision show in Stuttgart [Vision 2005, November 8–10]. We'll also launch a new high-precision—10 micron—laser-scanning system based on our Raptor camera that reduces object scanning times dramatically compared to current systems on the market." www.quest-machinevision.com; www.pleora.com. □

those who truly deserve it...the many highly skilled engineers at Cognex and elsewhere who have spent years inventing, developing, and manufacturing the machine-vision products that serve industry so well today," said Dr. Robert J. Shillman, chairman and CEO of Cognex, in a prepared statement. www.cognex.com. □

View acquires Micro-Metric

VIEW ENGINEERING recently announced that it has acquired privately held Micro-Metric, a manufacturer of high-magnification, non-contact critical dimension and coordinate nanometrology systems. View Engineering provides large-area video and laser-based coordinate measuring systems.

Vijay Patel, president of View Engineering, released a statement saying, "Micro-Metric brings technological expertise in high-magnification microscopy and submicron feature measurement to our strengths in high-speed, large-area metrology systems. Micro-Metric extends our technology roadmap for micromachined and microelectronic component metrology into the nanoscale realm." Micro-Metric will continue to operate from its headquarters in San Jose. www.viewengineering.com.

Omron to establish base in Shanghai

OMRON PLANS TO establish a vision sensing and control development center in Shanghai, China. The center, to be named "Omron Institute of Sensing & Control Technology (Shanghai) Co.," will be located in Zizhu Science Park, Shanghai, and is scheduled to open in October 2006. It will form one of Omron's core R&D facilities and will concentrate on vision-sensing technology, particularly object and shape recognition, including human faces.

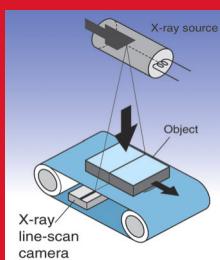
www.omron.com. □

Matrox supports PCI Express

TO MEET the needs of customers migrating from PCI and PCI-X, Matrox Imaging has announced that its Solios family of frame grabbers

will now support PCI Express. The protocol is included on both the Camera Link and analog variants of the Matrox Solios, Matrox Solios eCL, and Solios eA, and both versions are designed for four-lane (x4) PCIe. www.matrox.com/imaging. □

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TECHNOLOGY

Machine vision looks good

Ben Dawson, Dalsa Coreco

Machine-vision technology has been used for more than 30 years, yet is perceived as being difficult to set up. This perception comes from vision products that were difficult to use, often underpowered, and required a vision expert. Fortunately, a new generation of vision products are changing this perception and bringing wider acceptance for vision technology.

Figure 1 shows an assembly process for electric drills. A conveyor moves printed-circuit boards from manufacturing to the machine-vision system, which detects the board, checks that each board is the correct type, checks for missing components, and reports the board's position and orientation to a robot arm controller for correct insertion into the drill assembly. A few years ago, this task would have required an expensive vision system and extensive development.

Most machine-vision systems have a way to position the parts in the camera's field of view (the conveyor belt here), a "part-in-place" sensor to detect that a part is present, lighting, a camera, a vision computer to do the inspection, and some outputs based on the results of the inspection.

Hardware

The part-in-place sensor has developed from the lowly photocell to be smarter and easier to use. Sensors are now available for specific types of materials, such as reflective or matte surfaces. Some "smart sensors" include simple processing that, for example, allows them to detect and sort different colored parts.

In the past, vision systems used cameras designed for surveillance or television. These cameras were unsuitable for making fast and accurate measurements of part dimensions. Machine vision now uses specially designed cameras that are fast and provide the high-quality images needed for inspection and measurement.

while particles catch the light and appear bright white.

The advent of intense, inexpensive, uniform, and reliable LED lighting has made setting up a machine-vision system much easier. You can find hundreds of lighting products specifically designed for machine vision. Most lighting vendors will recommend appropriate lighting for your machine-vision task, so you don't have to be an expert.

The vision computer can be a specialized processor inside the camera—a "smart camera"—or a separate, specialized computer, typically based on personal computer technology (Figure 2). The advantages of this approach include increased computational power and a huge base of available software and experienced programmers.

For advanced applications that call for data rates of tens of megabytes per second, you can turn to faster, more powerful dedicated vision-processing boards. Although such boards are not new, today's versions use DSPs and FPGAs for extraordinary computational power.

Most vision computers—from smart cameras through high-end processor boards—include some form of digital I/O. Lower-end computers generally provide one or two input lines to trigger image acquisition and two or three output lines to drive part sorting. More capable hardware features more I/O lines and additional I/O protocols, such as Ethernet, FireWire, USB, and serial and parallel ports.

Some newer vision computers integrate what amounts to a small programmable logic controller (PLC) into

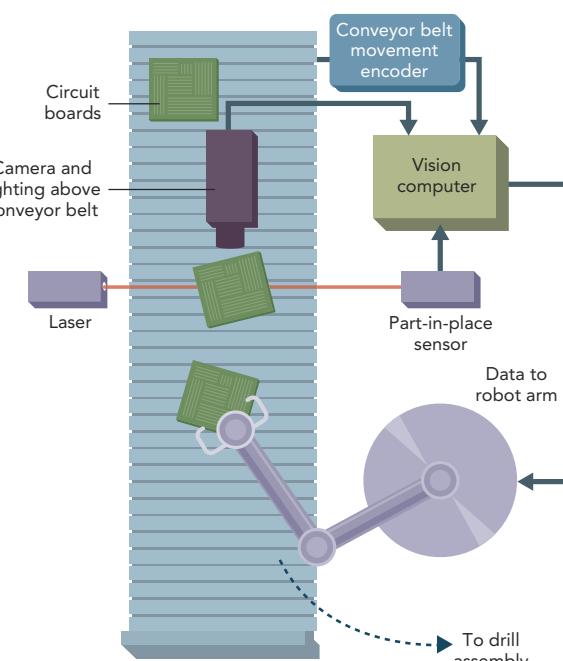
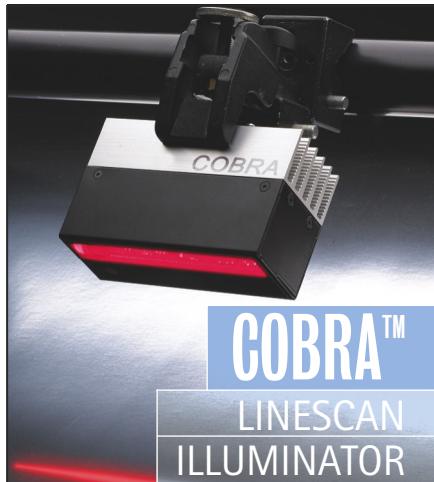


Fig. 1 In this electric-drill assembly process, a conveyor moves printed-circuit boards from manufacturing to the machine-vision inspection system.

Lighting is a key component in a machine-vision system—you can't inspect or measure something you can't see. Carefully designed lighting enhances the features in a part that you want to inspect or measure while suppressing visual features that interfere with the inspection or measurement. For example, to find and count small particles on a surface, you can use a ring of lights pointing nearly parallel to the surface. This "dark field" illumination makes the surface black



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Machine-Vision & Inspection TEST REPORT

Machine vision looks good • from page M5 the vision computer. For example, our vision computers provide separate logic that delays the part-sorting output signals.

Standardization

An increasing number of standardized machine-vision components are making it easier for vision designers to assemble a machine-vision system. Components for part positioning are standardized already, and lighting, optics, and sensor (camera) components are fast moving in that direction. Standard vision components reduce deployment efforts—you get a familiar mechanical or electrical interface.

Vision application engineers understand an inspection system's lighting, optics, algorithms, and computation capability, but they don't necessarily understand the unique characteristics of a particular task. System development often bogged down while the vision application engineer educated you about the system's capabilities and you educated him or her about what you wanted to accomplish. Standard-component specifications embody much of this specialized knowledge and so facilitate this communication.

Algorithms

In addition to the many hardware advances, sophisticated machine-vision algorithms are also improving vision-system performance. For example, most machine-vision programs start by locating the part within the image, which they accomplish using a search algorithm. Machine-vision vendors are competing to improve the ease-of-use, speed, accuracy, and robustness of their search algorithms. **Figure 3** shows a search algorithm setup screen from Dalsa Coreco's Sapera Processing software. Speed and accuracy are easily quantifiable. Robustness is somewhat more elusive.

One measure of "robustness" is how well a vision system ignores acceptable variations. Manufactured parts exhibit such variation, and "naturally manufactured" parts, such as apples or oranges, have even more. Robustness also indicates how well the system tolerates "distractions," such as changes in lighting conditions, unexpected objects in the field of view (an operator's hand, for instance), or changes in a part's reflectance. These conditions depend on the individual situation.

The more robust an algorithm is, the easier it is to use. If, for example, the algorithm can tolerate or compensate for some changes in lighting, then less effort is needed to shield the vision system from stray light and to control variations in system lighting.



Fig. 2 A compact, PC-based vision computer, such as this one from Dalsa Coreco's ipd group, can perform complex image analysis.

The user interface

Perhaps the most important factor in ease-of-setup is how the hardware capabilities, such as inputs and outputs, and the processing algorithms are presented to the user. Algorithms such as search or convolution (for spatial filtering, pattern matching, edge detecting, and so forth) have always been encapsulated into subroutine libraries. A well-designed subroutine library offers high execution speed, compact memory, and consistent execution time—important in real-time applications that press the limits of hardware performance. A major disadvantage is the modest-to-long learning curve required to use a library, and a subroutine library can contain only a limited amount of prior knowledge about a particular machine-vision application.

A key advance in ease-of-setup was the development of graphical programming packages. These packages present the vision system's software

components in a graphical user interface so that you can design your application by connecting components rather than by programming. Not having to write code and having help online greatly reduces the system development time. For example, library-based applications typically take months to set up, while ones based on Dalsa Coreco's Wit or Sherlock packages, for example, can be done in weeks. There are still high-performance vision applications, such as inspecting large LCD panels, that require the performance of a subroutine library, but most applications can be implemented more quickly with a graphical programming package.

The latest and, in my opinion, hottest development in vision software is to tailor it for specific classes of applications. For example, our iN-spect vision appliance is designed for inspection requiring single or multiple views of a part, while the iLabel vision appliance inspects labels on boxes, bottles, cans and similar items. Limiting the problem domain allows the embedding of a large amount of application-specific knowledge into each product.

Embedding functionality in this way can permit a much simpler user interface to the algorithms and hardware resources. Each specialized product's interface consists of panels, somewhat similar to a Windows wizard, that walk you through the problem (Figure 4).

By precisely matching system and application, you can often set up and verify a vision application in hours and with minimum help, although you may still need help with lighting and

lens selection. These specialized products are designed so that users who are not vision experts can quickly build test and measurement setups.

Machine vision is becoming an increasingly important component in test strategies. The technology is being

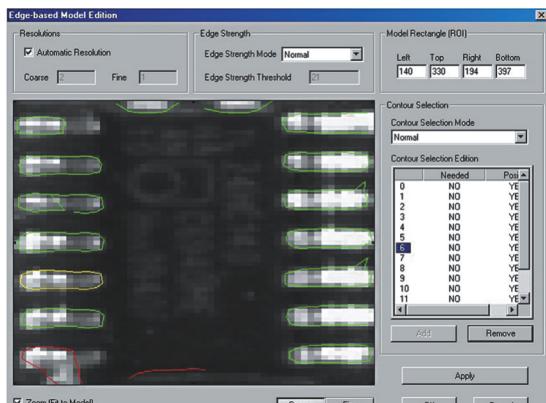


Fig. 3 A search-algorithm interface should combine ease-of-use with speed, accuracy, and robustness.

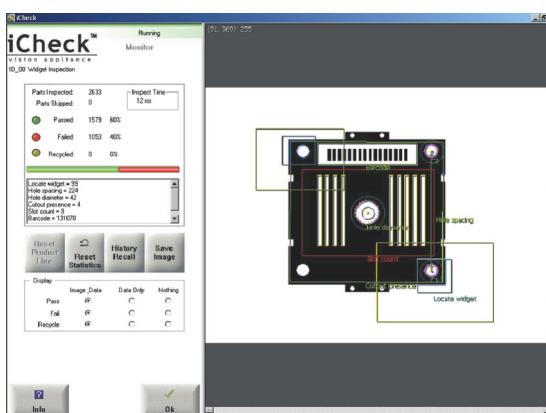


Fig. 4 An application-specific interface can walk you through system setup.

driven by processor performance levels, the challenge to improve algorithms, and the creation of standardized products. System development has recently started to emphasize ease-of-setup, as this is a critical factor in using machine vision for efficient and effective manufacturing. □

Ben Dawson earned his MSEE and PhD from Stanford. He was on the research staff at MIT and served as director of research and development for Imaging Technology. He is now director of strategic development at ipd, a Dalsa Coreco group.



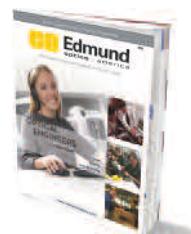
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ECONOMICS

Justifying inspection in a test strategy

Steve Scheiber, Contributing Technical Editor

When examining the role of inspection in manufacturing test, you must look at both its costs and its benefits. Managers are notoriously unwilling to authorize the purchase of capital equipment without some assurance that the expenditure can be justified.

As bed-of-nails access continues to decline in many products, manufacturers must increasingly rely on functional test, hot mockup, and creative use of self-tests to verify that a circuit works. Developing comprehensive test programs for such situations is challenging, and the resulting fault reports may flag a board as bad but often cannot pinpoint the exact failure location closer than a particular section or logic block. Diagnostic techniques such as guided probing must zero in on the actual fault.

Government demands to eliminate lead from components and solder complicate the situation further. Higher melting points and other inherent characteristics of lead-free solder will ensure higher defect rates, at least at the beginning.

Also, because lead-free solder is more brittle than its tin/lead counterpart, companies may limit physical probing on faulty boards for fear of creating problems rather than correcting them. In that case, it is very likely that more boards will be scrapped rather than repaired.

Inspection to the rescue

An effective inspection step can dramatically reduce the cost and quality penalties introduced by these manu-

facturing trends. Because inspection "looks" at the board to determine whether it was built correctly, it can more easily identify the exact culprits for the faults that it finds.

Automated optical inspection can spot bent and broken leads, solder shorts, and other faults on visible nodes. Techniques like x-ray inspection will see missing or misplaced balls under ball-grid arrays, bad solder joints, and other problems hidden from more conventional techniques. Adding inspection to a test strategy will ensure that more boards can be repaired successfully and fewer end up as scrap.

The impact of fix vs. scrap is far from trivial. Most economic analy-

number of defect opportunities as the sum of the number of components and the number of solder joints. You can calculate expected yields with this equation:

$$\text{Yield} = \left[1 - \left(\frac{\text{DPMO}}{1,000,000} \right) \right]^N$$

where:

DPMO = defects per million opportunities

N = number of defect opportunities

Running the numbers

To justify investing in an inspection system, you need to calculate the number of faulty boards you produce and the expected savings from

repairing them rather than scrapping them.

Consider a board with a manufacturing cost of \$400 that contains 550 components and 4450 solder joints—a total of 5000 defect opportunities—built with a process that produces a DPMO of 75. Using the equation above, yield from assembly (before any test or repair) would be 68.7%.

Assume that without an inspection step, you can identify and successfully repair half of the defective boards. In that case, the effective yield after test and repair is 84.35%. To ship 160,000 good boards per

year, you would have to build 189,686 boards. At \$400 per board, the scrap costs the operation almost \$12 million (Table 1).

Suppose you add an inspection step to diagnose the failures more effectively so you can repair more boards. Assume that fixing the

Table 1. Scrap cost with no inspection

Number of components	550
Number of solder joints	4450
Defect opportunities	5000
Nodes	500 to 1500
Yield from assembly (before test or repair)	68.7%
Repaired boards, as a result of test only	50% of failures, or 15.65% of board starts
Yield from test and repair (no inspection)	84.35%
Number of boards planned to ship per year	160,000
Board starts, including scrap, needed to reach planned shipment	189,686
Cost per board	\$400
Value of scrapped boards, 15.65% of board starts	\$400 x 29,686 boards = \$11,874,400

ses will show that if there is more than a small amount of scrap, its cost overwhelms all other costs.

Manufacturers often measure process quality in defects per million opportunities (DPMO). Stig Oresjo, senior test strategy consultant with Agilent Technologies, presents the

Justifying inspection • from page M9
 boards costs 25% of their value. If inspection allows you to repair even half of the previously scrapped boards, the cost picture would look like the "Fix 50% of boards" column in Table 2.

The inspection and repair steps reduce the number of board starts required to ship 160,000 boards to 173,583 and saves more than \$5 million. The need for fewer board starts also increases the effective capacity of the production line and can postpone the need for labor overtime or new production facil-

bers like these go a long way toward convincing company controllers that inspection systems will pay for themselves in short order.

Increasing the benefits

For many boards, especially expensive ones, the average repair cost is much less than 25%. Repairing a board worth \$2000 would rarely exceed a few hundred dollars, reducing the total repair cost and making inspection an even more attractive option.

The calculations in Table 2 hinge on meeting a 75 DPMO specifica-

ability applications requires recoating the boards after repair, so the cost of fixing them may also exceed their value. In these cases, scrapping the boards remains the most economical alternative.

Getting there from here

The object of any test strategy is to ensure that you ship good products to customers. With the advent of lead-free solder, which has a higher melting-point and is more brittle, you also need to be reasonably sure that merely shipping the products will not make them fail.

Table 2. Savings by adding inspection

REPAIRING BOARDS THAT WOULD HAVE BEEN SCRAPPED AFTER TEST ONLY		
	Fix 50% of boards	Fix 90% of boards
Number of boards planned to ship per year	160,000	160,000
Yield from assembly (before test or repair)	68.7% of board starts	68.7% of board starts
Repaired boards, as a result of test only	50% of failures, or 15.65% of board starts	50% of failures, or 15.65% of board starts
Yield after test and repair (no inspection)	84.35% of board starts (leaving 15.65% scrap)	84.35% of board starts (leaving 15.65% scrap)
Repaired boards as a result of inspection	50% of scrap, or 7.825% of board starts	90% of scrap, or 14.085% of board starts
Yield after test/inspection and repair	92.175% of board starts	98.435% of board starts
Board starts needed to reach planned shipment of 160,000	173,583	162,544
Number of scrapped boards per year	13,583	2,544
Cost per board	\$400	\$400
Value of scrapped boards	\$5,433,200	\$1,017,600
Cost of repairing extra boards as a result of inspection (\$100 each)	\$1,358,300 (\$100 x 13,583 boards, or 7.825% of board starts)	\$2,289,400 (\$100 x 22,894 boards, or 14.085% of board starts)
Value of scrapped plus extra repair	\$6,791,500	\$3,307,000
Savings over no inspection ("Value of scrapped boards" from Table 1)	\$5,082,900	\$8,567,400

ties, representing huge potential additional savings.

Repairing a larger proportion of the boards improves this picture further. If you can repair 90% of the previously scrapped boards, as in the third column of Table 2, effective yield increases to 98.4%.

The number of board starts drops to 162,544. The total cost for board scrap and repair now totals only \$3,307,000, so you save more than \$8.5 million in a single year. Num-

tion. If the number of defects were even double that, first-pass yield drops to 47.2%. You would need to build almost 340,000 boards to ship 160,000, and the other costs would skyrocket as well.

Of course, adding an inspection step is not always cost-effective. Repairing very simple, inexpensive boards could actually exceed the cost of scrapping them.

Similarly, repairing boards that are conformally coated for high-reli-

Incorporating inspection can alleviate some of those concerns. But convincing company managers to spend what can be a significant sum on capital equipment requires numbers to show how the purchase will ultimately benefit the company's bottom line.

Fortunately, generating convincing numbers is not difficult. The only task remaining is selling those numbers to the managers who must sign the checks. □

PRODUCTS

Intelligent camera

The Impact T22 from PPT Vision is an intelligent camera designed as a drop-in replacement for obsolete or under-powered vision systems. An extension



to the Impact T-series, the T22 has an image-processing computer inside the camera, enabling it to be deployed

without the additional image-processing hardware typically found in older machine-vision systems. With a 1/2-in. CCD, the Impact T22 is interchangeable with older, camera-based vision systems, enabling manufacturers to upgrade older vision engines to achieve 100% real-time inspection while reusing existing optical and lighting components. The Impact T22 is a suitable replacement for both analog and digital systems. *PPT Vision, www.pptvision.com.*

Image-processing board

The XRI-1200 from Dalsa Coreco is a PC-based digital image-processing board designed for x-ray imaging applications in which images contain motion artifacts and exhibit low-contrast, high-noise characteristics. The new board performs adaptive image processing to reduce noise in both still and dynamic images, significantly improving image quality and contrast. An FPGA-based image-processing engine performs real-time digital image processing in three dynamic stages, improving measurement and diagnostic accuracy. The real-time image-processing engine employs adaptive frame averaging to reduce noise while compensating for sensor non-uniformity and lens distortions.

The XRI Software Development Toolkit (SDK) includes tools, utilities, and installation scripts to promote rapid application development, diagnosis, and

deployment. The XRI-SDK imaging libraries permit users to control all aspects of the image-acquisition process and image-storage function on both the local and host computers. Price: \$3500 (OEM qty). *Dalsa Coreco, www.imaging.com.*

Smart cameras

The VC40xx series of smart cameras from Vision Components provides VGA monitor output, fast trigger input and



output, and four digital inputs and outputs. Each model in the series supports both serial and Ethernet interfaces. The cameras use the C64 DSP from Texas Instruments, which delivers computational

power as high as 3200 MIPS. The 128-Mbyte SD card provides additional storage and can be accessed much faster than the 16-Mbyte MMC card available in the company's VC20xx series. At the high end in the series, the Model VC4066 provides 1024x768 pixel resolution at 30 full frames per second. *Vision Components, www.vision-components.com.*

Sensor software

Cognex has released version 1.2 of the Intellect software for DVT vision sensors. The new version features improvements to the user interface and increases object sorting efficiency by allowing a single tool to identify and count multiple shapes or colors. Intellect 1.2 also includes faster image updates, a new optical character verification tool, custom drivers for robotic applications, and a preconfigured tool

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Products • from page M11

for label position and gross defect inspection. A free download is available at the company Web site. *Cognex*, www.cognex.com/dvt.

Fluorescent light source

The Exfo X-Cite 120 fluorescent source has a light spectrum similar to that of conventional mercury lamps, but lasts much longer, providing a 1500-hr bulb life. The integrated Intelli-Lamp system provides safe operation, ensuring that the light source cannot be switched off while the lamp is still hot. The light is directed to the microscope via a flexible liquid guide. The intensity of the light emitted by the Exfo X-Cite 120 can be controlled with an optional iris-diaphragm. Alignment-free adapters are available for Olympus BX2 and IX2 series microscopes. *Olympus*, www.olympus-europa.com.

Infrared camera

The ThermoVision SC6000 scientific-grade infrared camera from Flir Systems offers simultaneous and independent analog and digital output data



streams—a feature that allows for the sending of corrected imagery to a video monitor while uncorrected data is sent to a digital recording system. The new camera also features fast and user-adjustable frame rates with a camera output of 50 Mpixels/s. It supports analog video during windowing operations and offers advanced synchronization features. Optional software provides the tools for users to automate data acquisition, advanced analysis, or custom programming for easy integration with other software applications. *Flir Systems*, www.flirthermography.com.

Test & MEASUREMENT WORLD

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Test & Measurement World
225 Wyman St., Waltham, MA 02451
tmw@reedbusiness.com

Editorial Staff

Chief Editor
RICK NELSON
rnelson@tmworld.com

Technical Editor
STEVE SCHEIBER
sscheiber@aol.com

Advertising Sales

Publisher
RUSSELL E. PRATT
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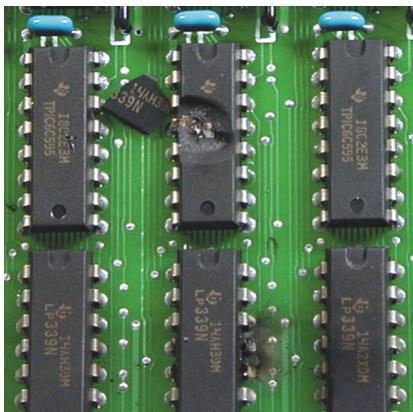


FIGURE 1. Overtvoltes applied from live cables to sensitive tester inputs can result in ICs exploding within instrument cases. To prevent this type of damage, keep power sources away from cable-test benches.

Voltage transients and equipment damage can prevent a cable-harness tester from operating properly—and can have a direct impact on your business. Without a viable tester, you can't certify incoming cable and harness assemblies before adding them to your inventory. Similarly, you may be unable to certify the quality of your own products, and thus will be unable to ship them.

The major threats to a tester's proper operation come from electrical and mechanical hazards, but cable testers can also be damaged by other factors (see "Component failures," p. 52, and "Software threats," p. 54). Regardless of the source, you can take preventive steps and develop repair procedures to keep your cable-harness testers in working order.

Attachment of a "live" cable

Each of the 100 or more test points in a typical cable tester connects directly to an integrated circuit (IC) used in applying or measuring test signals. Although various means of overload protection can be built into each point, it becomes economically impractical to isolate the test points from more than a few volts higher than the maximum test voltage. Should the operator inadvertently connect a live cable to the tester, severe damage may ensue.

If the overvoltage from the live cable is considerably above the test voltage, breakdown of the affected IC may transmit the overvoltage through the power bus, reaching many interconnected ICs and rendering the circuit board unrepairable. ICs may actually explode leaving a blackened crater on the inside of the case (Figure 1).



CABLE TEST

Preventive measures:

- Do not allow any power sources on the test bench.
- Keep the work area clutter-free and uncrowded.
- Disconnect any unused interface cables from nearby computers or other equipment.
- When testing long cables, ensure that both ends are labeled, and include in the test procedure a positive confirmation that both ends are detached before attaching the cable to the tester.
- Ensure that any batteries that may be attached to the cable, or built into the cable, are disconnected.
- If you test harnesses built into an equipment cabinet, ensure that all conductors and the shield conductor (if tested) are isolated from ground during testing. Ground differential voltage may cause the test to fail or damage the tester.

Static discharge

Another potential source of electrical hazard is static discharge that can enter the test-point terminals. Taking the usual precautions of working on a grounded work-bench with dissipative mats, grounding the test equipment, and wearing a wrist strap may not be sufficient to protect the cable tester from static damage. Charge may develop on the insulation of long cables as a result of frictional motion when the operator coils or uncoils the cable while moving it to the test bench. Charge on the insulation can then attract opposite charge on the copper conductors just under the insulation. This in turn forces charge to the cable endpoints where it remains trapped (**Figure 2**).

A properly grounded operator can pick up the cable by its connector, which is insulated from the outer jacket and conductors, and unknowingly discharge the copper conductors into the test equipment at the moment he or she attaches the connector. The volume of charge released may overload clamping diodes built into the tester's ICs, causing damage to the circuitry. Generally, cables longer than 10 ft (3 m) pose increased risk, especially cables with rubber insulation.

Preventive measures:

- Work with a humidity level of 60% or higher (although this is not usually possible during winter months).
- Equip the tester with transient suppressor boards in which special high-speed Zener diodes protect each point from transients higher than the test voltage and less than ground.
- Attach a grounding plug to the cable momentarily before connecting it to the test equipment. The grounding plug consists of a mating connector in which all pins are connected together and tied with a single wire to an earth ground.

Power-line transients

You also need to protect your cable-harness tester from power-line transients. A 1-s power interruption may disrupt batch testing and cause a loss of log data or batch reports, requiring a supervisor to restore normal operation and possibly requiring the need to repeat a test. Power surges and switching noise risk damage to equipment as well as stored data.

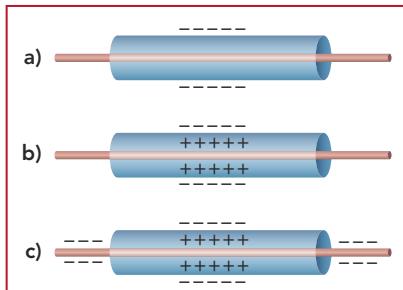


FIGURE 2 a) Friction can develop a negative charge on cable insulation, which attracts a positive charge to the b) copper conductor. That positive charge, in turn, c) drives negative charge toward the ends of the cable, which can result in tester damage, particularly for cables 10 ft long or more.

Preventive measures:

- Use a 600-W to 1000-W uninterruptible power supply (UPS). Such a UPS should be sufficient protection for most workstations, and it represents a small fraction of the cost of the equipment it protects. (A UPS typically costs less than \$100 for the tester alone, or less than \$200 for both the tester and computer.)
- If your facility provides building-wide uninterruptible power, add a surge suppressor to the tester's power input.

Conductive debris

The final electrical hazard that you should worry about is debris that can conduct electrical charges. Wire clippings, metal punch-outs, metal dust, or spilled beverages may cause unintentional connections between test points, or they

Component failure



Not all failures are externally induced.

Under normal circumstances, equipment will ultimately fail given enough time and use. The "mean time between failure" spec statistically predicts how long you can expect normal operation, on average, before failure occurs. While end-of-life wear-out cannot be avoided, you need not invite it prematurely.

Turn off computers and test equipment at the end of the workday or when they are not being used. Fans and other mechanical components wear predictably while powered-up during periods of disuse, and semiconduc-

tors age faster when powered-up because of heat and current flow. You can use timers or remote network control to manage end-of-day shutdown and beginning-of-day startup, or you can simply assign this job to a specific employee.

You can also prevent overheating by regularly cleaning filters, vacuuming vent holes, and locating equipment away from known heat sources. And be sure to block unauthorized use by untrained personnel; you should require passwords for computer-controlled equipment, and you should lock power sources when other access controls become impractical.—Christopher E. Strangio



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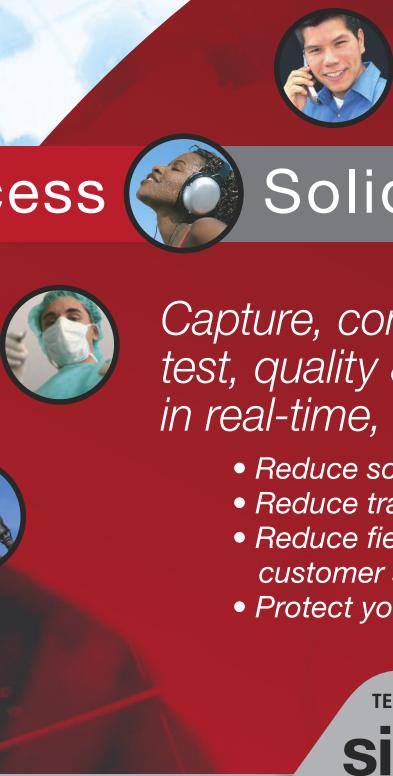
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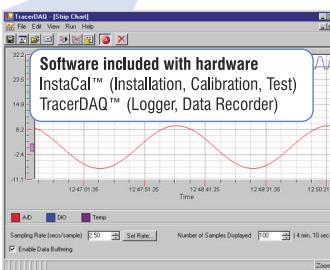
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CABLE TEST

may work their way onto the circuit board and introduce shorts. Coffee and soda are highly conductive when liquid, and they leave conductive residue when dry, creating a difficult repair problem—especially for testers measuring isolation resistance above 1 MΩ.

Preventive measures:

- Do not permit cable assembly or repair in the vicinity of the test equipment.
- Do not permit food or drink at the test station.
- Place a dust cover over the test equipment when it is not in use.
- Avoid situating the test equipment in the same room as grinding or metal-working machines.

Defective connectors

A cable tester can also become inoperable as a result of mechanical hazards, such as defective connectors. If the physical characteristics of connectors used on your cables are slightly out of specification, they may deform or in other ways damage the mating connector on your cable tester.

For example, plastic RJ45 modular plugs sometimes have excess unremoved flashing from the mold, or sharp edges, which catch the wire pins on sockets. When unplugged from the tester, the wire pins may hang up on the flashing

and become bent upon removal, permanently damaging the socket. Note that the same problem may damage your customer's connectors and you may be held responsible.

Preventive measures:

- Carefully inspect sample parts before committing to a supplier.
- Require a quality certificate from the supplier before accepting incoming parts.

Connector wear out

Even high-quality connectors, though, can eventually cause problems. The natural wear caused by the friction of inserting or removing connectors from mating sockets cannot be avoided. Some simple precautions will prevent premature failure and quickly restore equipment to a functioning condition.

Preventive measures:

- Use connector isolators (also known commercially as "connector protectors" or "connector savers"). These small adapters insert between the cable tester and cable connector to absorb the force and wear of repeated insertions. They may be easily unplugged and changed when necessary and are widely available for D subminiature connectors.
- Require that the mating connectors on your test equipment have solid metal



Software threats

Software threats can come from either internal or external sources. Inadvertent erasure of valuable data, malicious action, or internal hardware failure may expunge critical programs, procedures, scripts, and log files. No other process failure yields as easily to correction or risks such adverse consequences. The best way to protect your equipment against the loss of key data is to perform regular backups.

Schedule daily automatic backups of your computers, being sure to include cable databases, scripts, log files, and written procedures. Various commercial software packages offer daily networked backup of specified machines without human intervention. End-of-day backup scripts may include automatic equipment power-down when complete. Be sure to keep an off-site backup, refreshed weekly or monthly, to protect against the catastrophic loss of a facility.

You should also write-protect your data to prevent inadvertent erasure or malicious damage. Establish a log-in procedure for your cable tester software to ensure that ill-trained employees do not apply a tester's learning capability to a faulty cable to force a defective work lot to pass.

Christopher E. Strangio

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pins, not stamped pins, and include gold plating.

Improper insertion

Test technicians can also be a source of connector problems. Technicians who apply excess force off-axis from the insertion direction may bend the pins or shell of a mating connector.

Preventive measures:

- Provide proper training and written procedures for test technicians.
- Situate the cable tester, connector boards, or panel so that the force applied during insertion easily aligns with the connector axis.
- Ensure that keying marks or other indicators of orientation appear clearly on the mating connectors.
- Some cables have intentionally plugged holes in female connectors to prevent backward insertion. Expressly mark the technician's work sheet or procedure if hidden orientation keys exist in the test cable.

Improper storage

You also need to take proper care of a tester's ancillary components. Most cable testers use plug-in connector boards to accommodate many different connector styles. When boards are detached from the tester, connectors may be damaged if not properly stored.

Preventive measures:

- Store boards in a rack so the connectors do not make contact with other boards during storage.
- Use a dust cover over large or fragile connectors, or put boards in bubble bags.
- Store filled racks in closed cabinets.

Our dependence on complex systems in manufacturing leaves us vulnerable to process failures that may have expensive consequences. By taking well-thought-out precautions, you may avoid the preventable accident that can extract a heavy cost in time and inconvenience. T&MW

Christopher E. Strangio is the president and founder of CAMI Research and holds degrees in electrical engineering from Villanova University and MIT. He has been awarded two patents, developed CAMI's CableEye PC-based cable and harness test system, and is a senior member of the IEEE.



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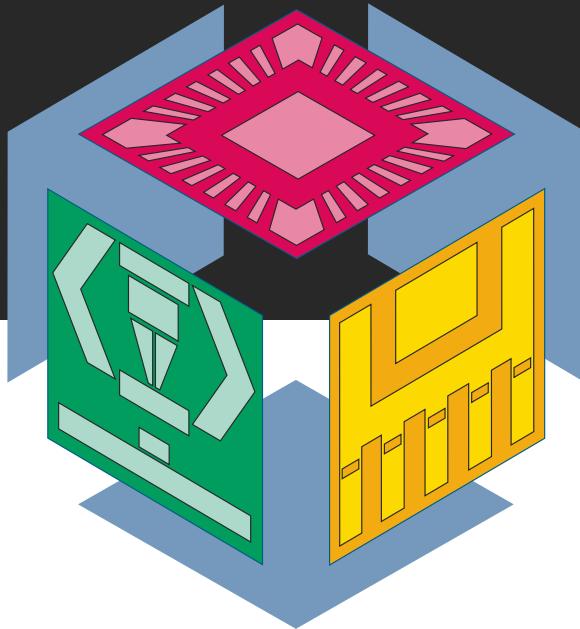
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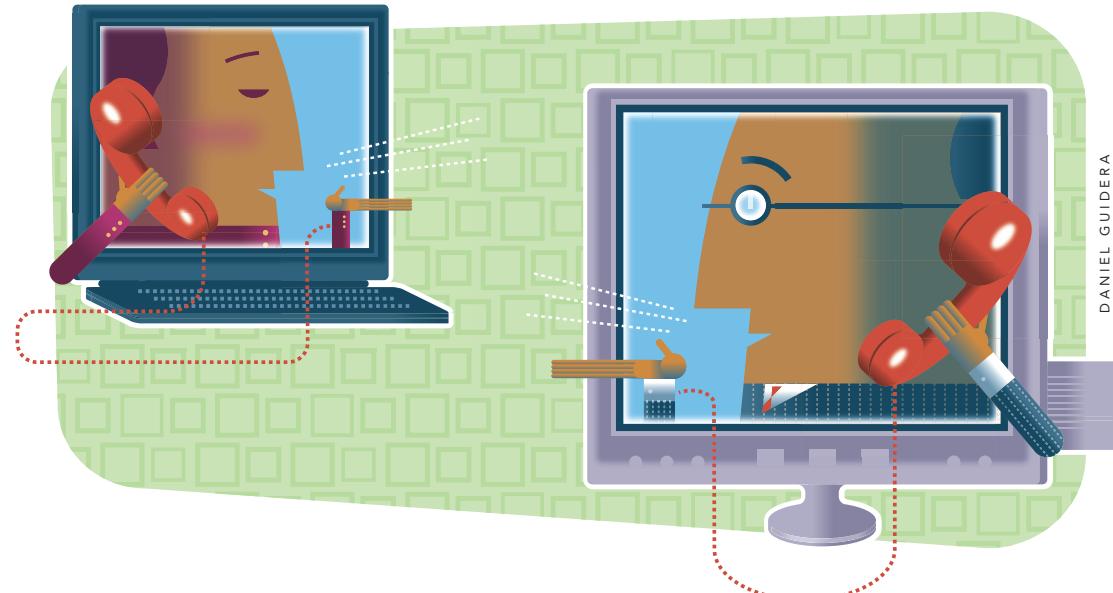
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DANIEL GUIDERA

VoIP complicates TEST

With VoIP systems now receiving serious attention, communications test must embrace increasingly complex demands.

Recovering from a false start in the mid-'90s, voice over Internet Protocol (VoIP) has re-emerged as a viable contender for telephony applications. Transmitting time-critical voice traffic over the data-centric Internet Protocol has required the development of complex protocols, which in turn has led to dramatic changes in network communications test.

One of the changes that VoIP is bringing to communications test is a huge growth in the market for VoIP test equipment, according to analysts Sankara Jambulingam and Olga Yashkova of market research firm Frost & Sullivan. In their report, "World VoIP Test Equipment Markets," the analysts foresee the market blooming from \$215.8 million in 2004 to nearly \$640 million in 2008, an annual growth rate of more than 30%.

The market expansion includes R&D and manufacturing equipment, but Yashkova said that the biggest growth is in system monitoring and troubleshooting equipment, a market that should expand by more than 50% each year. Jambulingam explained, "As the size of VoIP networks expands, the scalability limitations of open source tools has come to light. Unlike data communications, which can tolerate delay and changing data rates, anything that goes wrong with voice is instantly felt by the user." This sensitivity to timing makes monitoring and troubleshooting large networks critical to providing the quality of service (QoS) that users have come to expect from telephony systems.

Test equipment challenges

Test equipment vendors participating in this growing market face significant challenges, according to the analysts. Because standards for VoIP are still evolving, test equipment must be capable of interpreting a variety of protocols and must also be able to detect interoperability issues arising from differing imple-

RICHARD A. QUINNELL, CONTRIBUTING TECHNICAL EDITOR



COMMUNICATIONS TEST

mentations of protocols. In addition, the analysts noted, the equipment needs to be relatively easy to use. Voice applications are highly complex uses of the network that cannot be treated as simply another application, they said. The more the equipment can simplify delving into that complexity, the better.

Test engineers also face a challenge: blending VoIP systems with traditional time-division multiplexed (TDM) switched-circuit systems telephony. Handling blended systems will require the use of traditional audio telephony and data network test equipment as well as an understanding of both SS7 and Internet Protocol, according to Bahaa Moukadam, VP of IP telephony at Spirent Communications. "One thing we are seeing everywhere, both on the VoIP equipment side and the telephone carrier side," said Moukadam, "is that they [engineers] have in-depth knowledge only of their side. Merging VoIP and switched-circuit telephony needs a deep understanding of both."

To meet that need, Moukadam says, VoIP developers are turning to their test equipment suppliers. "More and more customers are saying that they need help with expertise as well as tools," he said. He added that customers are also asking for help in creating test plans and test methodologies.

System test demands scalability

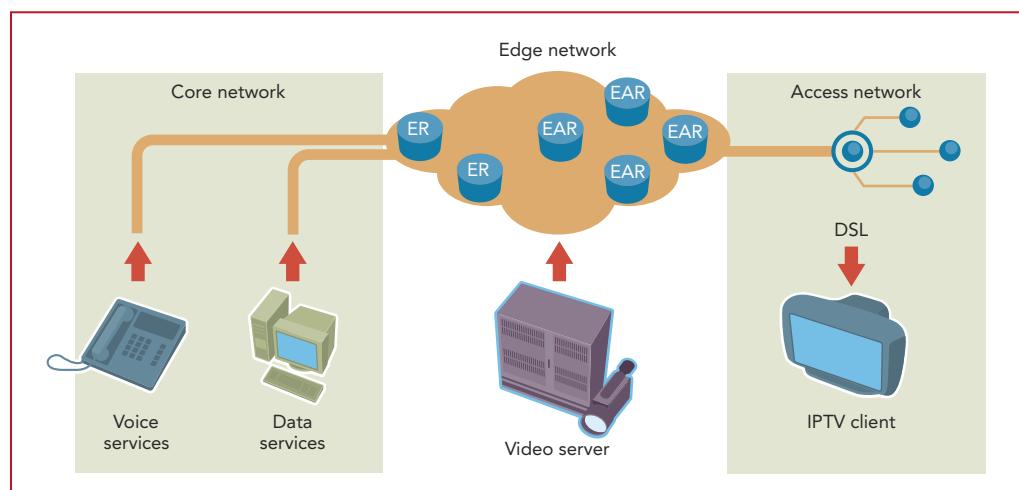
Regarding the needs of VoIP test equipment, Moukadam agreed with the Frost & Sullivan analysts. An ability to handle both protocol variations and scalability is essential, he said, particularly scalability. He noted that testing must be able to simulate an entire network of mixed traditional and VoIP telephony along with data communications, all at varying load levels. This requirement implies that some VoIP

test equipment will need high performance if it is going to help evaluate equipment targeting a large enterprise environment. Spirent, for example, offers its Abacus 5000 test system, which handles analog, TDM, and VoIP calls with 50,000 IP phone calls under test.

Moukadam also commented that VoIP test equipment must go beyond simply testing against the protocols and must include evaluation of their voice

More challenges await

Yet, even while test equipment vendors are embracing the need to test blended systems, new applications and challenges are arising. One is the "triple-play" combination of data communications, VoIP telephony, and Internet television (IPTV). As with voice, video signals require sophisticated protocols in order to generate a user experience comparable to that of conventional cable and satellite



Full evaluation of VoIP and IPTV designs will require testing in a complete system environment in order to ensure that the customer experience will be as desired. Courtesy of Spirent Communications.

quality. "To test voice applications by looking only at the IP level is not enough," he said. "QoS tests need to evaluate the subscriber experience."

Blended-nature telephony systems are likely to be in place for a long time as VoIP slowly replaces traditional telephony, first for enterprise customers and then working outward to replace telephone systems for residential customers. In order to provide the kind of user-level-experience testing that Moukadam recommends, test engineers will need a full suite of both VoIP and analog test equipment for conducting end-to-end tests in a blended system.

Many pieces of the puzzle are available, as some manufacturers have begun to offer equipment for voice quality and network testing as well as network analysis in VoIP systems. In addition, you can also find an array of Ethernet analyzers and traditional telephony test equipment products on the market.

television. Emergence of the IPTV application will continue and compound the challenges faced by test equipment vendors.

Nor will the challenges stop there. There is also a move within the industry to combine wired and wireless communications systems. This blending of two approaches will affect test equipment in an exact parallel to the effect that blending voice and data has on wired networks. Test engineers will need to develop familiarity with both types of networks, which are substantially different, and test equipment vendors will need to be there to help.

The impact of all these changes will be an expansion of requirements for communications test. Lab equipment, field equipment, and test engineers will need to stretch their capabilities to be able to cover the diversity of equipment and protocols involved in communications. This, in turn, represents a tremendous opportunity for those with enough reach. **T&MW**

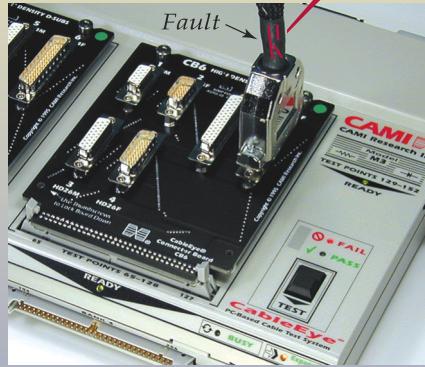
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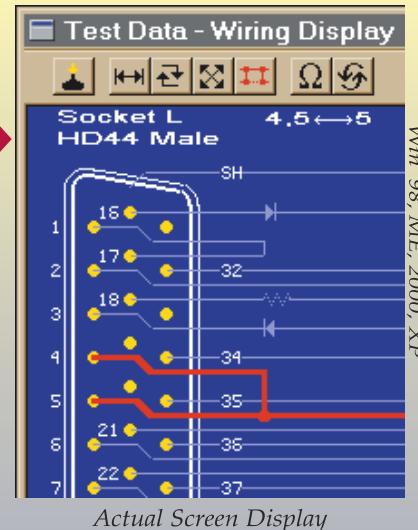
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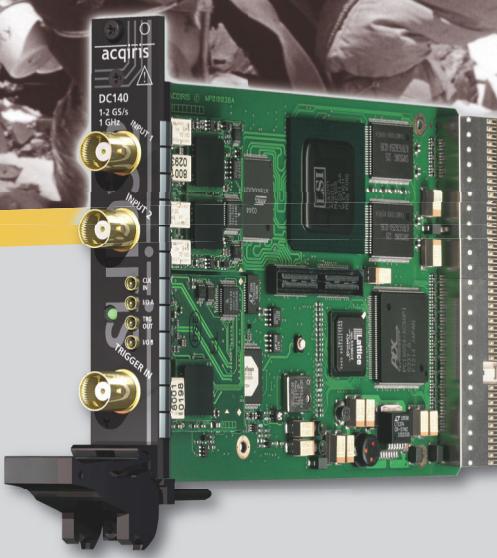
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Bud expands enclosure line

The Style G line of Plasticase enclosures features rounded corners and edges as well as a four-piece construction, which makes each of the component parts easier to machine, compared with two-piece models, according to the vendor. Plasticase Style G is constructed of self-extinguishing ABS plastic material with a UL94-5VA flammability rating. The exterior features a mar-resistant textured surface with the base attached to the cover with four color-matched screws. Standard color for the Plasticase Style G is black with other colors, top configurations, and modifications available. The Plasticase Style G is also equipped with internal PCB mounting bosses. External dimensions range from 5.00x3.80x1.50 in. to 6.75x6.25x1.63 in.



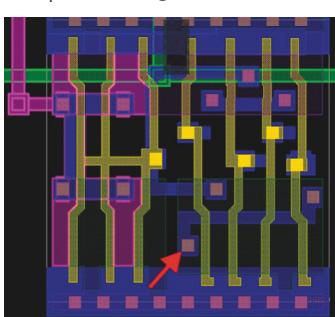
Base price: \$6.75. *Bud Industries, www.budind.com.*

Mentor expands DFM strategy with YieldAssist

Mentor Graphics' YieldAssist diagnostic tool for enhancing semiconductor yield aims to quickly and accurately identify and isolate yield-limiting defects. YieldAssist expands Mentor's design-for-test (DFT) product portfolio beyond classical test generation and defect detection.

YieldAssist is based on the premise that failing devices from the wafer-sort phase of manufacturing test can provide a gold mine of information. YieldAssist allows semiconductor manufacturers to harvest this information through its ability to directly read failure logs from compressed test patterns and identify both systematic and random defects to drive failure analysis and yield improvement. It also provides a link back into the design process for improving design for manufacturability as well as for adaptively improving the quality of the manufacturing test itself.

The vendor positions YieldAssist as a product that addresses one key area—rapid high-volume diagnosis—out of three necessary for an effective overall yield-learning strategy. The other two areas include manufacturing test, which the company's TestKompress or FastScan automatic test-program generation tools



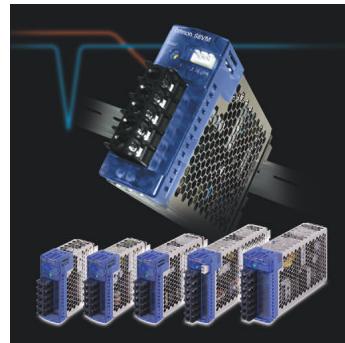
address, and defect isolation, which the company addresses by providing a link between YieldAssist and the firm's Calibre results viewing environment, which in turn provides a physical layout view that helps users isolate defects to particular physical locations—see the red arrow in the accompanying figure.

Base price: \$126,000 per year for a term-based license. *Mentor Graphics, www.mentor.com*

Lead-free supply offers undervoltage alarms

The Omron S8VM power supply features an undervoltage alarm that signals when voltage falls and indicates the cause, facilitating troubleshooting by onsite operators. Combinations of LEDs indicate whether voltage loss is due to a momentary power interruption, an overload, or a drop as the power supply itself loses voltage due to aging.

The S8VM is 40% more compact than earlier Omron models and is currently available in ratings from 15 to 150 W at voltage levels from 5 to 24 V. It can operate at 100% load temperatures to 50°C. Versions rated from 300 to 1500 W will be released in 2006.



The S8VM meets global environmental and safety standards; it contains no lead in order to meet with the requirements of the RoHS directive effective in July 2006.

Base prices: 15-W model—\$59; 150-W model—\$154. *Omron Electronics, www.omron.com/oei.*

Boundary scan for analog

The JTAG Technologies STA476 graphical software tool supports use of the SCANSTA476 analog voltage monitor from National Semiconductor; it works with an evaluation board from National containing the SCANSTA476.

The STA476 utility allows selection of any of the eight analog inputs on the evaluation board. DC measurements can then be conducted on the selected channel or channels using a JTAG Technologies controller to initiate the test and access the results over a standard IEEE 1149.1 boundary-scan interface.

Base price: free to JTAG Technologies customers. *JTAG Technologies, www.jtag.com.*

> > > > > >

PMC sports Camera Link interface, FPGA

The CAML-MOD3 Camera Link adapter module for the VMETRO's Xilinx Virtex II Pro-based PMC-FPGA03 PCI mezzanine card (PMC) can capture video from two base-mode cameras or one base-,

medium-, or full-mode camera. The CAML-MOD3/PMC-FPGA03 combination merges data acquisition with the benefits of a local user-programmable FPGA.

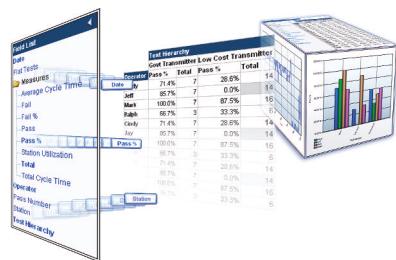
The FPGA can be used to implement functions such as edge detection, FFTs, digital filtering, and correlation to serve applications

including target tracking, feature recognition, and real-time filtering. The CAML-MOD3 uses the Mini Camera Link (MiniCL) HDR26 connector standard and is compatible with traditional Camera Link equipment employing the MDR26 connector. In base mode, up to two cameras can be attached via separate cables; in medium and full modes, a single camera connects via two cables. Sample firmware and host software for capturing Camera Link data, provided in VHDL and C++, respectively, allows developers to concentrate on implementing their own proprietary processing.

Price: CAML-MOD3—\$995. VMETRO, www.vmetro.com.

Arendar adds data analysis and reporting

Arendar test-data-management software has several new features in its 2006 version. Arendar 2006 uses online analytical processing for data analysis and reporting. With that feature, you can quickly analyze

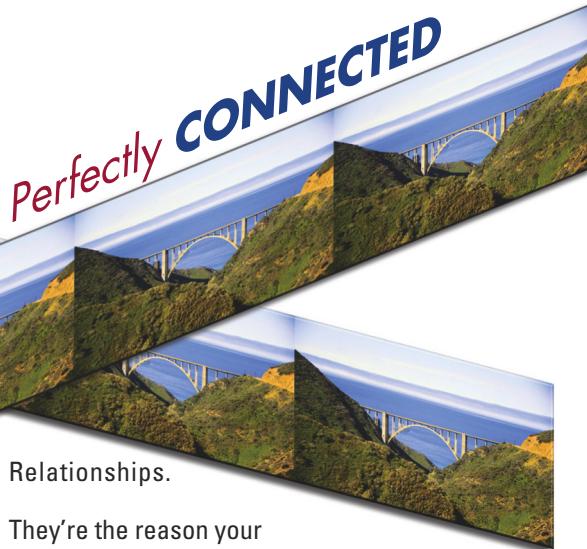


data through an unlimited number of perspectives, such as by product line, product, date, or operator. Thus, you can quickly spot trends in performance.

Arendar 2006 lets you organize data using familiar folders, allowing you to isolate specific test data and administer security rights. You can set viewing, modification, and access to data folders for each user through a security log-in box.

The Arendar software lets you import data from test applications written in numerous languages. It has direct hooks to LabView and TestStand, making it a test-data management tool for storing, viewing, and analyzing data on a single workstation or across a network.

Prices: \$1995 for the desktop edition; \$9995 for the server edition. VI Technology, www.vi-tech.com.



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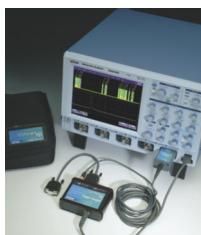
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Scope decodes CAN bus symbols

LeCroy's Vehicle Bus Analyzer (VBA) is an oscilloscope and protocol decoder for the CAN bus. The VBA is based on the Waverunner scope platform. It lets you see electrical signals on the CAN bus, and it decodes the signals into bus symbols, eliminating the need for a protocol analyzer. Because the VBA has four



scope channels, you can view and decode the bus while looking at other signals such as those from sensors or engine control units. Or,

you can view and decode up to four CAN buses at once. You can set up triggers based on CAN bus symbols to isolate events.

LeCroy offers two VBA models: the VBA 6050 (\$18,900) is a 500-MHz scope with 2 Msamples of waveform memory on four channels or 4 Msamples on two channels. The VBA 6100 (\$23,990) has 1 GHz bandwidth. It can interleave both sampling rate and bandwidth to achieve 10 Gsamples/s and 4 Msamples/channel on two channels.

LeCroy, www.lecroy.com.

Sentaurus extends TCAD physical modeling

Synopsys has announced the availability of its Sentaurus Technology CAD (TCAD) tool suite, which now combines core TCAD products for multidimensional process, device, and system simulation into a single user interface.

Created by combining existing Synopsys products with those acquired with the Synopsys acquisition of ISE, Sentaurus provides calibrated physical models and 2-D and 3-D modeling capabilities to address future challenges in semiconductor development while maintaining continuity with customers' existing software installations.

The application space of Sentaurus spans the complete range of semiconductor technologies, covering deep-submicron-logic, memory, power, compound-semiconductor,

mixed-signal, optoelectronic, and RF devices. The Sentaurus tool suite enables customers to explore and optimize a range of process and device alternatives, optimize performance and manufacturability, and improve parametric yield. Through proper calibration with prototype wafers, TCAD can predict the behavior of

silicon in the manufacturing line for new technology nodes. The company cites a 2004 International Technology Roadmap for Semiconductors (public.itrs.net) estimate that the use of TCAD will provide as much as a 40% reduction in technology development costs.

Synopsys, www.synopsys.com.



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Multifunction USB devices

Equipped with a 1-MHz, 16-bit analog-to-digital converter, the Personal Daq/3000 series offers a variety of synchronous, multifunction I/O in a single USB-based device. Each of the three models in the series provides eight differential or 16 single-ended analog inputs with seven programmable input ranges from ± 100 mV to ± 10 V full scale. By attaching an optional PDQ30 module, you can expand inputs to 32 differential or 64 single ended. Models also include up to four 1-MHz, 16-bit analog outputs; 24 digital I/O lines; 4 counter inputs; and 2 timer outputs.

Prices: \$899 to \$1099. [iotech](http://www.iotech.com), www.iotech.com.

Digital storage scopes

Two new models join the TDS1000 and TDS2000 series of digital storage oscilloscopes, offering cost-effective choices for design and devel-

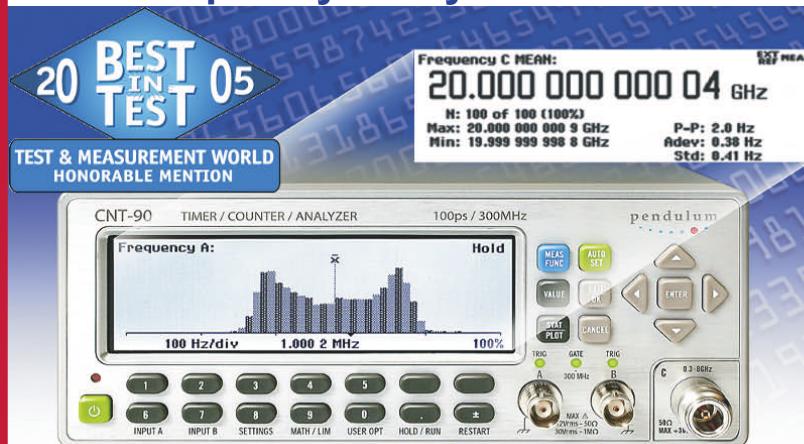
opment, service and repair, manufacturing, and education applications. As an entry-level model, the TDS1001 provides two channels, 40-MHz bandwidth, and a monochrome display. The TDS2004 furnishes four channels, 60-MHz bandwidth, and a color display.

Price: TDS1001—\$850 MSRP; TDS2004—\$1600 MSRP. [Tektronix](http://www.tek.com), www.tek.com.

DC/DC converters for ATE

Vicor's "E grade" line of second-generation DC/DC converter modules and VIPAC arrays (which operate from -10°C to $+100^{\circ}\text{C}$) cost approximately 15% less than "C grade" versions (which operate from -20°C to $+100^{\circ}\text{C}$). Targeting ATE, communications, defense, and aerospace applications, the converters are available in four input ranges, seven output voltages, and three package sizes (quarter, half, and full brick).

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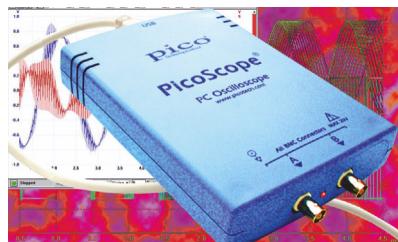
pendulum

Different base-plate and pin options are available. High-frequency ZCS/ZVS (zero current and zero voltage switching) provides for high power density, low noise, and high efficiency, which ranges from 80% to 90% depending on output voltage. Customers can configure the modules and VIPAC arrays using design tools available at the vendor's Web site.

Base price: \$0.29 per watt in quantities of 1000. Vicor, www.vicor-power.com.

PC oscilloscope

Connecting to a PC through a USB 2.0 port, the PicoScope 3224 two-channel oscilloscope boasts 12-bit resolution, a 20-Msample/s sampling rate, and a large 512-ksample memory buffer. The USB 2.0 interface also powers the unit, eliminating the need for an external power supply. A 72-dB dynamic range enables the scope to detect low-level harmonics when used in spectrum



analyzer mode. It also offers 1% voltage accuracy and 100-ppm time-base accuracy. PicoScope 3224 comes with both PicoScope and PicoLog software applications, a 32-bit Windows driver, and support for numerous third-party applications. Pico Technology, www.picotech.com.

Power quality monitor

Capturing up to eight channels of input data to an internal hard drive at a fixed sample rate of 6250 Hz, the Dash 8Xe lets you monitor a variety of power events, such as interrupts, swells, sags, harmonics, unbalance, and power factor. It

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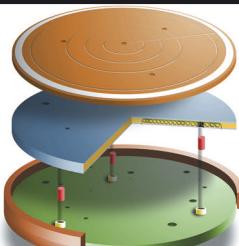
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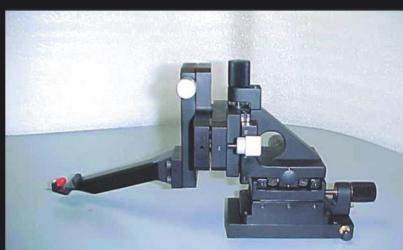
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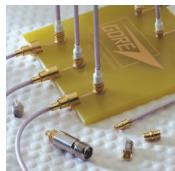
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permits harmonic analysis up to the 50th harmonic, while maximizing the duration of an acquisition stored on the 36-Gbyte hard drive. In transient mode, the Dash 8Xe captures high-speed glitches and other anomalies at a sample rate of 200 kHz per channel. The unit is equipped with a 15-in. monitor with touch-screen control for real-time data viewing and analysis. Base price: \$12,000. Astro-Med, www.astro-med.com/power.

DDS function generator

Useful for many general-purpose test and bench troubleshooting applications, the Model 271 10-MHz function generator creates a wide



variety of standard and arbitrary waveforms using direct digital synthesis to achieve exceptional accuracy and stability. The Model 271 features extensive modulation capabilities, including sweep, AM, gating, trigger/burst, FSK, and hop. Price: \$1495. Fluke, www.fluke.com.

Industrial multimeter

Intended for heavy-duty use, the 500 Series of industrial multimeters is waterproof to IP67 standards and drop-proof to up to 6 ft. All three models in the series carry a safety rating of CAT IV 600 V and CAT III 1000 V. Each meter measures voltage, resistance, electrical and electronic frequency functions, and DC/AC current. In addition, units feature 1000-V input protection for all functions, dual-sensitivity frequency functions, and diode open circuit voltage of 2.8 VDC. Other features include true RMS measurements with capacitance and Type-K temperature, peak hold, 6000-count LCDs on the EX510 and EX520, and a 44,000-count LCD on the EX520. Extech Instruments, www.extech.com.

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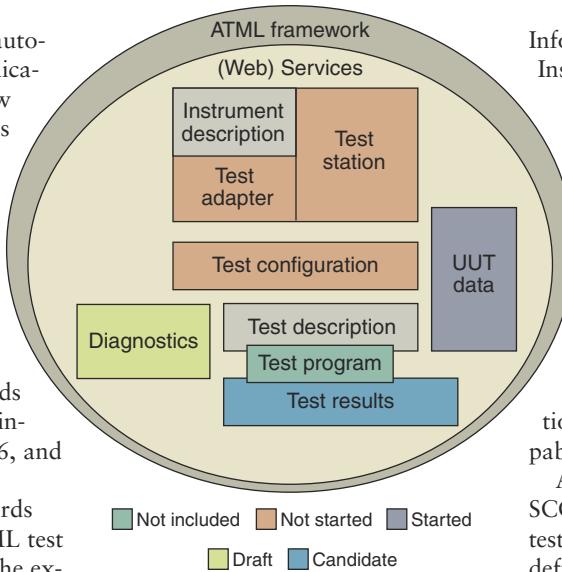
IEEE sets in motion dual ATML test standards

Greg Reed, Contributing Technical Editor

Test engineers working on automotive and aerospace applications can expect a couple of new tools to arrive soon. The IEEE is developing two standards—IEEE P1671.1 and IEEE P1671.2—that cover the use of automatic test markup language (ATML) for exchanging descriptions via XML technology on both the test performed and the instruments evaluated. Work on the standards is already well underway; final internal ballots are ready for 2006, and delivery is expected in 2007.

In addition, these two standards support the IEEE P1636.1 ATML test results standard, which covers the exchange of test results via XML technology. All three standards come under the aegis of the IEEE's Standards Coordinating Committee (SCC) 20—Test and Diagnosis for Electric Systems group.

The IEEE P1671.1 standard is titled, "Trial-Use Standard Automatic Test Markup Language (ATML) for Exchanging Automatic Test



The automatic test markup language (ATML) will facilitate an open exchange of test data among industry, academia, and government.

Courtesy of IEEE.

Information via XML: Exchanging Instrument Descriptions." This related standard focuses on the test and diagnosis of electronic systems by describing common instrument descriptions shared across various automatic test systems. In practice, an XML-based format exchanges the static description of an instrument to permit more dynamic instrument descriptions to fill such functions as test configuration descriptions and instrument capability descriptions.

According to Les Orlidge, IEEE SCC 20 chairman, "IEEE P1671.1 test description will add the facility to define test requirements suitable for use within a test executive and/or diagnostic reasoner system, allowing portable test descriptions to be specified to augment the existing test results. IEEE P1671.2 instrument description will provide a foundation to allow full instrument comparison over the Internet or direct inclusion of instrument details into an integrated test system."

The IEEE's SCC 20 working group hopes to expedite international adoption of these test procedures through agreements and alliances with key international test equipment providers and users. Once in place, the standards will facilitate an open industry-backed approach to exchanging test information promoting interoperability, scalability, and supportability required by the testing community. □

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Equipment and Test Information via XML: Exchanging Test Descriptions." It employs XML to define a format for exchanging information on test performance and conditions as well as the diagnostic requirements involved. Moreover, it facilitates the use of test descriptions to locate, align, and verify the proper operation of a unit under test; helps in preparing and documenting test programs; and provides a common description for automatic test systems (ATS) in the automotive, semiconductor, aerospace, and military sectors.

The second new standard, IEEE P1671.2, is named, "Trial-Use Standard Automatic Test Markup Language (ATML) for Exchanging Automatic Test Equipment and Test

Further information about these standards is available on the IEEE Web site, standards.ieee.org.

EDITOR'S NOTE

Advancing test interfaces

Greg Reed, Technical Editor

Recent documents issued by the PXI Systems Alliance (PXISA) and the LXI Consortium detail the latest developments of PXI and LXI test communications interfaces and promulgation of corresponding standards. Each organization has good reason to be optimistic about success.

The PXISA released the PXI Express specification, which integrates PCI Express and CompactPCI technology into the PXI standard. PXI Express gives users expanded bandwidth (up to 6 Gbytes/s per system) while preserving compatibility with existing PXI products.

The LXI Consortium has released its first technical specification. The document intends to advance system integration by inclusion of functional areas, a unified trigger model, and application of IEEE 1588 for test and measurement.

PXI, based on PC technology, and LXI, based on Ethernet connectivity, offer advancement potential beyond traditional backplane buses. Today, PXI is well-entrenched with 65 member companies and more than 1150 products. Although still new, LXI has already signed on 20 members and counts several products in the marketplace.

Any successful technology advancement requires more than elegant design concepts. While we see tangible proof of PXI advancements and some initial success for LXI, future new product introductions with "PXI inside" or "LXI inside" will truly prove the direction of test interface advancements. □

Contact Greg Reed at editor@aatr.net.



NEWS

IPC and JEDEC to host "lead free" conference

IPC AND JEDEC have announced that they will host the 11th International Conference on Lead Free Electronic Components and Assemblies in Boston, MA, from December 6 to 8. The goal is to help the industry prepare for such issues as new alloys and materials evaluations, inspection changes, tin whiskers, reliability, and increased assembly costs.

Workshop topics will include protocols for WEEE and RoHS compliance, best practices in implementing lead-free assembly, and strategies for ensuring the reliability of solder attachments, PCBs, and components.

Conference topics will include case studies in RoHS compliance, aerospace industry response to the global transition to lead-free solder, impact of RoHS compliance on exempt industries, and lead-free assembly and miniaturization.

Additional lead-free conferences are planned for 2006 at locations in the US (Santa Clara, CA, and Austin, TX), Sweden, Singapore, and Germany. www.ipc.org/leadfreeNA. □

Aerospace firm reduces noise levels

WITH THE AID of the NASA-funded Space Alliance Technology Outreach Program (SATOP), operations at Smiths Aerospace's Long Island facility are now much quieter. When redesigning its manufacturing floor, Smiths, which produces aircraft power and control system components, wanted to reduce the noise level resulting from vibration testing in the environmental stress screening test lab. The company followed the recommendations of a SATOP partner and installed special acoustic noise-reducing panels that have solved the problem.

The walls of the lab were constructed of hollow framing with sheet rock panels, which could not reduce or suppress noise transmission. "The ESS shock tests range from 3 to 6 GRMs at frequencies ranging from 1 to 3 kHz, and the noise output ranged from 70 to 110 dB....We tried to minimize the noise by upgrading the ceilings in adjoining areas. Unfortunately, this tactic didn't help at all," explained Ben D'Cruz, technical services manager at Electronic Systems of Long Island, a division of Smiths Aerospace.

D'Cruz turned to SATOP for help and was referred to a SATOP alliance partner, OSHEX/Environmental Safety Associates. OSHEX recommended that Smiths install panels made of Barrier Septum Composite, a non-reinforced loaded vinyl noise barrier sandwiched between two layers of fiberglass. The panels did the job, and according to D'Cruz, "The resulting noise reduction was immediately apparent in the adjacent work centers." www.spacetechsolutions.com. □

VTI delivers accelerometers to Korean automakers

Finland's VTI Technologies has been selected by automakers in Korea as a supplier of low-g accelerometers for electronic stability control and active suspension systems. Deliveries of VTI's SCA610 and SCA620 single-axis accelerometers have already begun.

"We have cooperated with Korean part manufacturers and system suppliers for several years. Our first applications were for ABS systems, and these new applications are in vehicle stability and suspension. The Korean car manufacturers are implementing new features into their car models very fast. They rely on proven technology for the most critical parts, like sensors, as well as on global suppliers like VTI," said Hannu Laatikainen, VP of sales and marketing for VTI Technologies. www.vti.fi. □

CASE STUDY

Mini-subassembly borescope ensures integrity

Greg Reed, Contributing Technical Editor

For many automotive industry suppliers, testing products against regulatory standards is an integrated part of production. As a result of this need for advanced product testing, CAR Engineering, a multidisciplinary engineering and machine shop, has experienced a boost in requests for pre-tested products.

Recently, a manufacturer of remote visual inspection equipment asked the company to design a miniature-sized borescope with improved performance and efficiency. Used for detecting subtle irregularities within castings and complex assemblies, an optical borescope offers a nondestructive test mechanism that can ensure the struc-

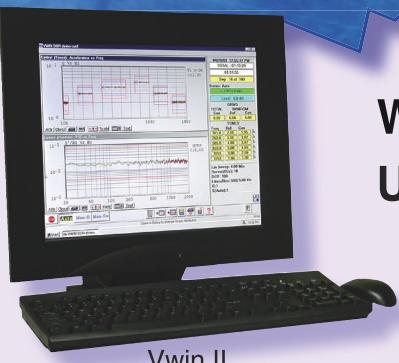
tural integrity of a complex aircraft engine or can diagnose a simple cause of an automobile squeak. Smaller components often mean additional cost and loss of precision, so the challenge for CAR was to meet quality specs in a cost-effective manner.

CAR selected Kerk Motion Products as a partner for miniaturizing the borescope. The engineering backbone of the resulting borescope consists of Kerk's mini series of lead screws, which are made of 303 stainless steel. With its small-diameter lead-screw components, the mini series provides reliable precision motion control at as little as 1/10th the cost of miniature ball screws.

The new borescope uses four lead screws simultaneously, resulting in both a clockwise and counterclockwise direction within the subassembly, thus loosening one or two of the positioning leads and tightening the balance. This variability accommodates the high-load capacity, high speeds, and smooth motion necessary for the borescope's operation.

The borescope lens now provides 25% more articulation, and the size of the motion control subassembly has been reduced by about 50%. The final product is in its last build and is expected to be in full production, with about 2000 units annually, by April 2006. □

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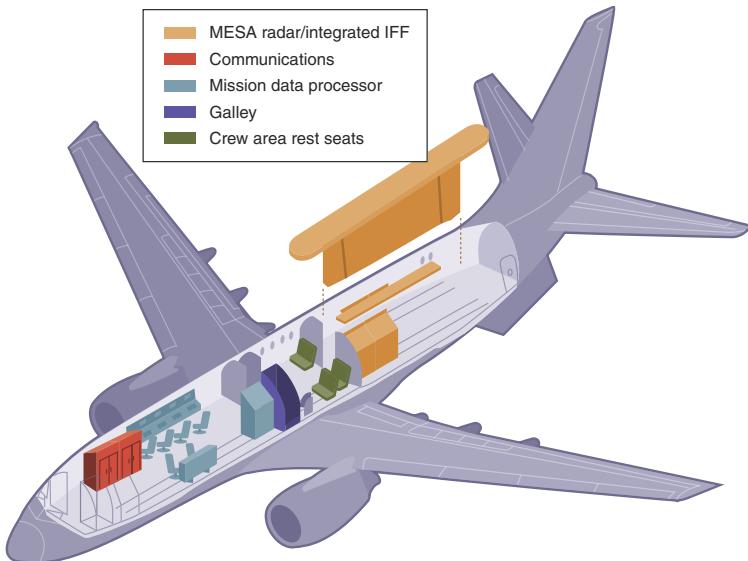
Structural test verifies radar dome

Greg Reed, Contributing Technical Editor

When a major aerospace manufacturer won a contract for producing a radar dome to sit atop the Boeing 737-700 aircraft, the company turned to KineticSystems for help in developing the necessary structural test. The radar dome project, known as "Project Wedgetail," includes an airborne early warning and control (AEW&C) device equipped with multi-role electronically scanned array (MESA) radar housed within a dome structure (figure). Tests for Project Wedgetail needed to include structural analysis as well as stress testing of the sensitive radar and antenna electronics inside.

KineticSystems conducted initial ground testing with software that simulated air performance conditions on the Wedgetail module in isolation from the aircraft. Later, the company verified the Wedgetail's structural integrity by performing further simulated structural testing of the dome mounted on the aircraft. Eventually, in-flight tests fully confirmed the structural stability of the radar dome.

To simulate flight conditions, KineticSystems used a system of actuators linked to hydraulics to apply various loads to the Wedgetail module. A system of strain gages and



This diagram shows components of the early warning and control system. The MESA radar component is located inside the dome structure. Courtesy of KineticSystems and Gage Applied Technologies.

transducers measured additional forces encountered during flight. The company used a data-acquisition system to process information gathered from all testing processes in real time and then analyzed the results using Excel files and data plots. The setup allowed operators to change parameters and zoom in on specific test processes, such as the aerodynamics profile.

The testing revealed failures that necessitated design modifications until both the module and the aircraft were deemed reliable under all flight conditions. To ensure all components remain reliable, the aerospace manufacturer will continue to conduct fatigue testing periodically throughout the life of the module and aircraft.

As a result of the structural lab testing, the manufacturer was able to develop a radar dome with a low aerodynamic drag profile while meeting the requirements of fore and aft coverage on Boeing's 737-700 aircraft. Along the way, the electronics test procedures also led to enhancements to the reception of radar data.

Bernie Spear, at KineticSystems-West observed, "The Wedgetail project presented significant test challenges, but the test team verified a structurally sound module within the dome which meets all flight requirements." Today, the airworthy radar dome system accounts for 360° coverage and a range of 200 nautical miles. □

Structural test toolset

KineticSystems used the following tools and subsystems to perform structural tests on the Wedgetail radar dome:

- Motorola VME processor host with a VME target computer for control and PC-based load control system terminal display (made by Cyber-System) with operator stations.
- KineticSystems-Cyber FM 7000 load-control system using 40 channels of the National Instruments PCI-7030RT series boards as a servo controller.
- KineticSystems-Cyber Versaplex data-acquisition system with a strain-gage signal conditioner, a low-level multiplexer, and a 50-kHz 16-bit ADC interfaced to a load control system computer display.
- Structural test instrumentation (customer installed) with strain-gage transducers, deflection transducers, and hydraulic actuators controlled by the KineticSystems-Cyber load control system.

PRODUCTS

Bidirectional digital I/O card

Built on a 3U PXI card, the GX5641 provides 64 bidirectional TTL or differential channels, for 128 individual digital inputs or outputs. The card's channels can be predefined to convert TTL to differential or vice versa. You can operate the GX5641 I/O card independently or control it through software. *Geotest-Marvin Test Systems*, www.geotestinc.com.

HALT/HASS controller option

A configuration option for the Synergy controller allows it to take complete command of an environmental chamber's temperature and vibration systems for highly accelerated life testing (HALT) and highly accelerated stress screening (HASS) to accelerate prod-

uct reliability and throughput while reducing costs. Outfitted with a color touch screen, the two-channel Synergy controller offers total programming of



temperature, humidity, altitude, and vibration versus time. It also provides six event outputs for special applications. Communication capabilities include built-in 10/100 BaseT Ethernet, RS-232/485, GPIB, and Web-based remote control. Base price: \$2755. Delivery: 4 to 6 weeks. *Tidal Engineering*, www.tidaleng.com.

Sensor processing system

The recently upgraded daqPC data-acquisition, storage, and network system now achieves a sustained, continuous recording and playback speed of 600 Mbytes/s. Available in rack-mount and portable versions, the PC-based sensor processing system employs ICS and third-party boards for applications that require acquisition, processing, and archiving of analog input signals. Maximum storage capacity of the daqPC in a 7U high chassis is more than 2.8 Tbytes. *Interactive Circuits & Systems*, www.ics-ltd.com.

CAN/LIN validation software

Used in conjunction with the TDS5000B and TDS7000B digital phosphor oscilloscopes, the TDSVNM program enables efficient testing and debugging of low-speed serial buses, including CAN-based and LIN-based



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Editorial Staff

Chief Editor
RICK NELSON
781-734-8418; rnelson@tmworld.com

Technical Editor
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networks. The application software performs CAN and LIN timing and protocol analysis, measures oscillator tolerance and propagation delay, aids in setting the optimum sample point, and simultaneously decodes time-correlated CAN and LIN messages. It also allows you to set trigger conditions based on the content of a CAN message. *Tektronix, www.tektronix.com.*

Up-time optimization services

Automotive component manufacturers, machine builders, and others seeking faster test-intensive assembly operations can now access InterTech Development's Uptime Optimization consulting service. The service details how to incorporate online calibration and validation of test technology, automation of temperature compensation during testing, and similar engineering that minimizes or eliminates previous needs to shut down test-centric assemblies for recalibrations. InterTech estimates that a combination of solid-state capabilities for online calibrations can eliminate up to 60 min. of assembly downtime in each 8-hr shift using machines with leak testing stations. *InterTech Development, www.intertechdevelopment.com.*

6-GHz PXI RF test modules

When used with the Aeroflex 3010 RF synthesizer, the 3025 and 3035 PXI modules allow high-speed testing of RFICs and other devices intended for WLAN and WiMax applications as well as for satellite TV broadcasting and military communications. The 3025 digital signal generator (\$15,000) covers a frequency range of 86 MHz to 6 GHz. The 3035 6-GHz digitizer (\$8000) works with the 3010 RF digitizer to provide vector signal analysis of RF signals. *Aeroflex, www.aeroflex.com.*

EUI functional tester

The Pro One EUI, a universal electronic unit injector (EUI) functional test machine, lets you test fuel injector performance by automatically comparing

a range of performance measurements against acceptance criteria. By changing the profile and fixturing, you can set up the machine to accommodate several different product envelopes. All measurements are automatic and traceable with the proper

calibration. The Pro One EUI uses a programmable fuel injector module capable of generating the appropriate waveforms for virtually all solenoid-based diesel injectors on the market today. *Michigan Custom Machines, www.mcm1.com.*

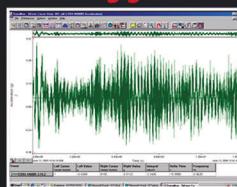


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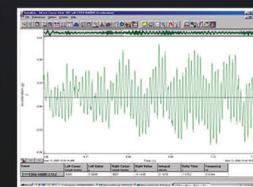
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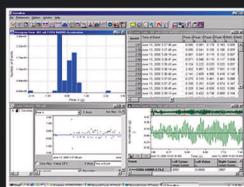
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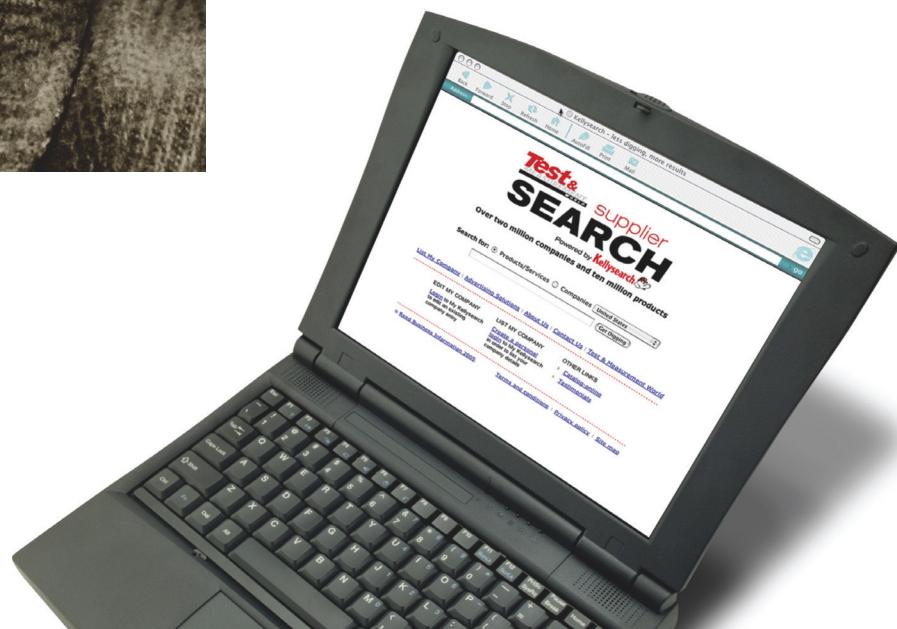
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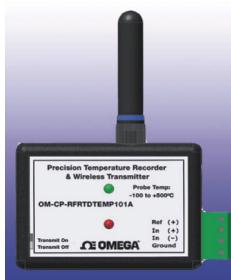


CompactPCI subsystem

This 4U rack-mount CompactPCI enclosure comes with a 64-bit, 8-slot 6U backplane and redundant power supplies. The backplane dedicates one slot to the system CPU board and seven slots to peripheral boards. Designated the cPCIS-6418U, the high-availability subsystem supports a PICMG 2.5-compliant H.110 CT bus; front-access, hot-swap cooling system; and hot-swap 500-W and 200-W redundant power supplies with universal AC input. Price: \$2695. *Adlink Technology*, www.adlinktech.com.

Temperature transmitter

Small enough to fit almost anywhere, the OM-CP-RFRT-DTEMP101A temperature recorder and wireless transmitter measures and records up to 5461 temperature readings. When enabled, the battery-powered device transmits readings back to the host computer where the data can be analyzed in real time. Readings are also logged to internal memory for added data security. Price: \$449. *Omega Engineering*, www.omega.com.

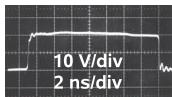


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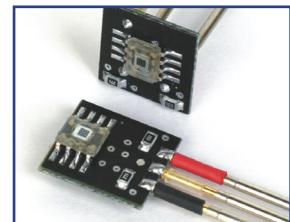
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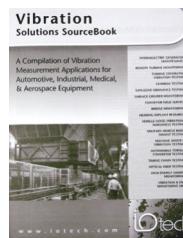
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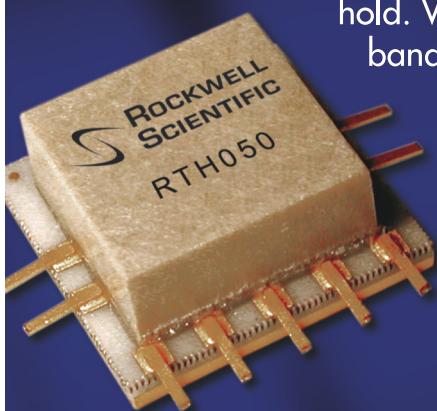
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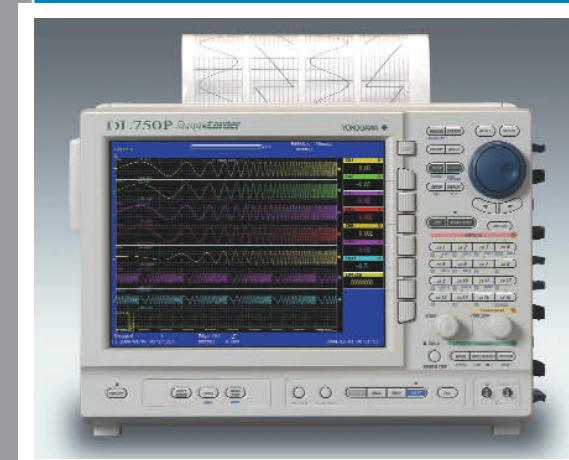
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Publisher: Russell E. Pratt
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Marketing Manager: Laura Koulet
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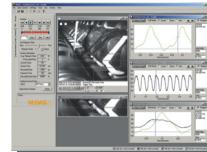


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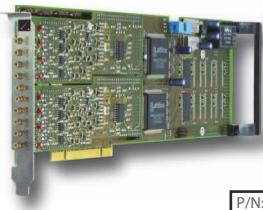


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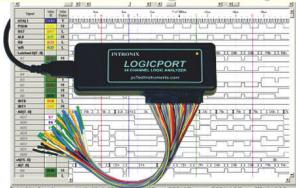
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Richard House is president of VI Technology, a company specializing in test data management, automated test products, and professional services. House has nearly 20 years of experience in engineering, marketing, and corporate operations in the test and measurement field. Prior to joining VI Technology in 1999, House held the positions of director of engineering and strategic marketing manager at National Instruments.

► The online version of this article includes more Q&A showing examples of successful Arendar installations, as well as information on engineering services offered by VI Technology.

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Find your way through the data maze

At more and more companies, engineers are drowning in test data, says Richard House of VI Technology. In a recent interview with *Test & Measurement World*, the test-industry veteran assessed the problem and suggested some solutions.

T&MW: To what extent have the number and complexity of tests increased at OEMs?

House: Very significantly. Taking automated measurements used to be difficult and time consuming, but new, off-the-shelf test equipment and software have made the process much easier and faster. Combine that with cheap hard-disk space, and there's little pressure on engineers to cut down on tests. New sequencing software also allows for very complex tests, such as sweeping measurements over various voltage and temperature ranges, or it can enable a test step to be repeated many times until it passes. Engineers also know that the repercussions of not getting enough test data can be very costly. Tests may have to be revalidated, which can be very expensive, or engineers may need to regain access to test equipment that they share with other departments. Engineers look bad if they have not performed all the tests needed. The problems come when they need to retrieve that data.

T&MW: What is the impact of poor test data management on companies?

House: Higher costs, longer time to market, missed opportunities, poor product quality, and dissatisfied customers. Productivity is lost, too. Engineers complain that they have better things to do than hunt for lost data. At one communications company we worked with, it took over 24 hours before engineers could get a report back. A semiconductor firm held a frustrating meeting every Friday in an attempt to standardize nomenclature for test files. At still another company, one group feared that its funding would be cut because of difficulties in retrieving data and generating required reports.

T&MW: How does your Arendar software address these problems?

House: In essence, it creates a system for managing test data from the very start of product development. Most engineers are not skilled in creating databases and networks. They also hesitate to get IT involved, for fear it will slow the testing process and cause costs to soar. Arendar eliminates these problems. Deploying this software is as simple as using an installer, and the cost is comparable to that of test-development software—under \$10,000 for the server and about \$2000 for each station.

T&MW: When in a product's life cycle is Arendar most useful?

House: It is primarily a tool for managing tests during the design and manufacturing stages of a new product. However, companies also use Arendar to track field tests on products that have been returned because of problems. They will then compare these incoming field tests with original tests. This analysis can help them spot trends in failed products that can then trigger needed changes in design or manufacturing.

T&MW: What are some other benefits for customer companies?

House: Arendar makes test data universally acceptable and useful. It helps companies capture data from test software, as well as legacy data files, and organizes it in a Microsoft SQL Server or Oracle database. Engineers can then access the data through a standard Web browser, through their interactive analysis software, or over a network. In essence, we are bringing enterprise-class software to test engineers at a very low cost. **T&MW**

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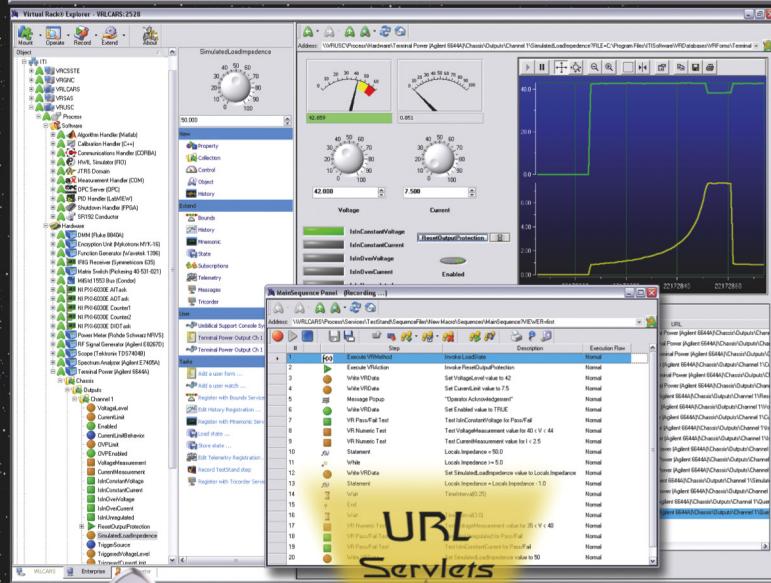
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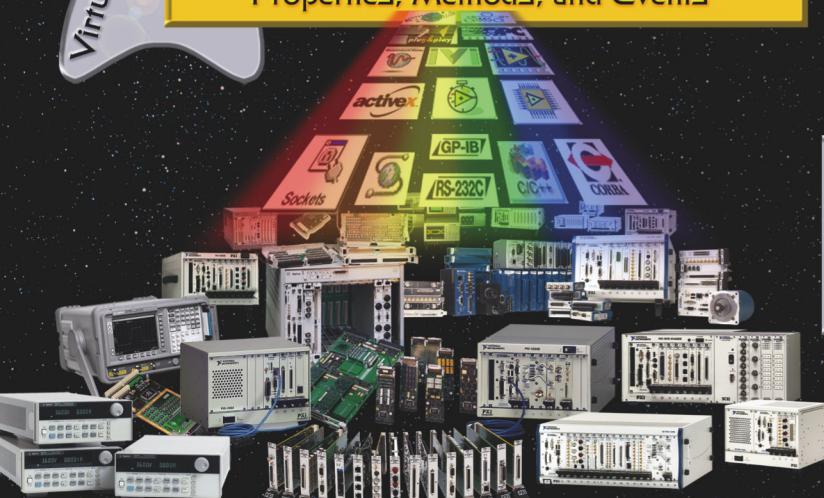
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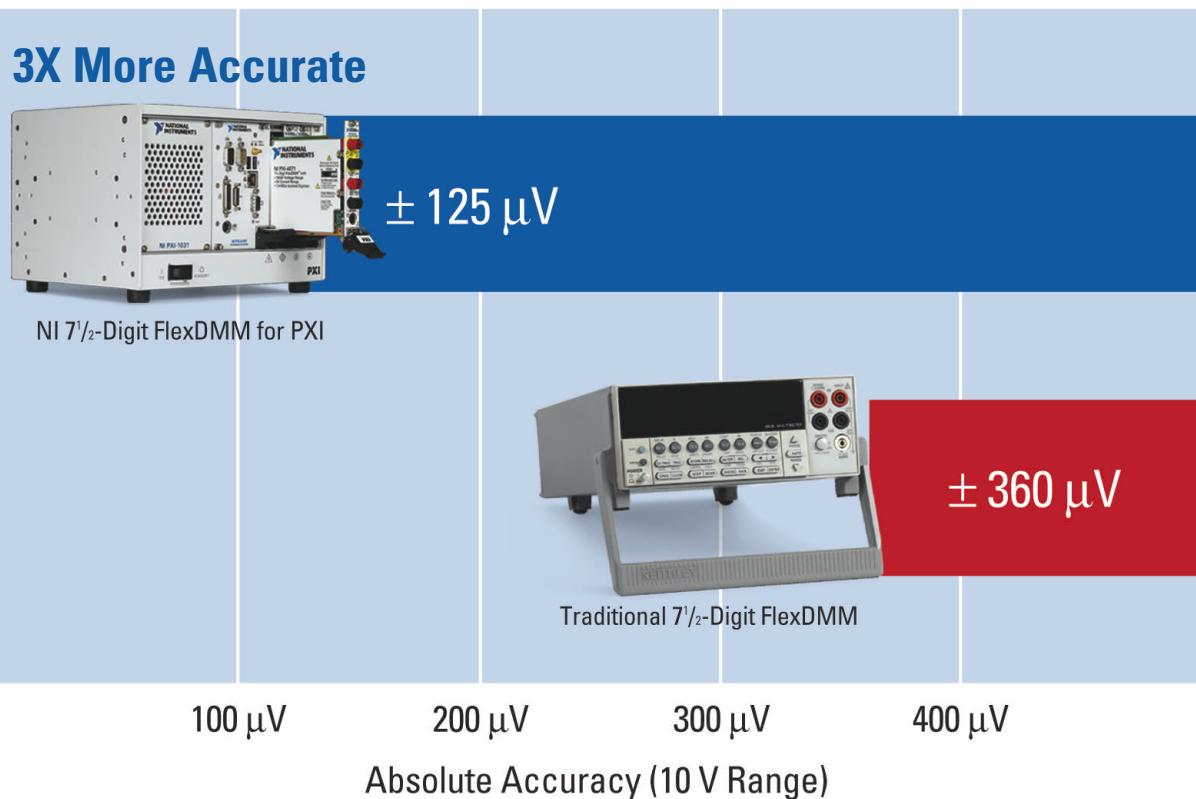
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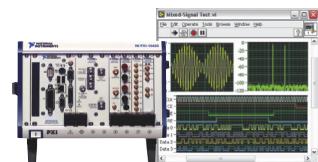
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