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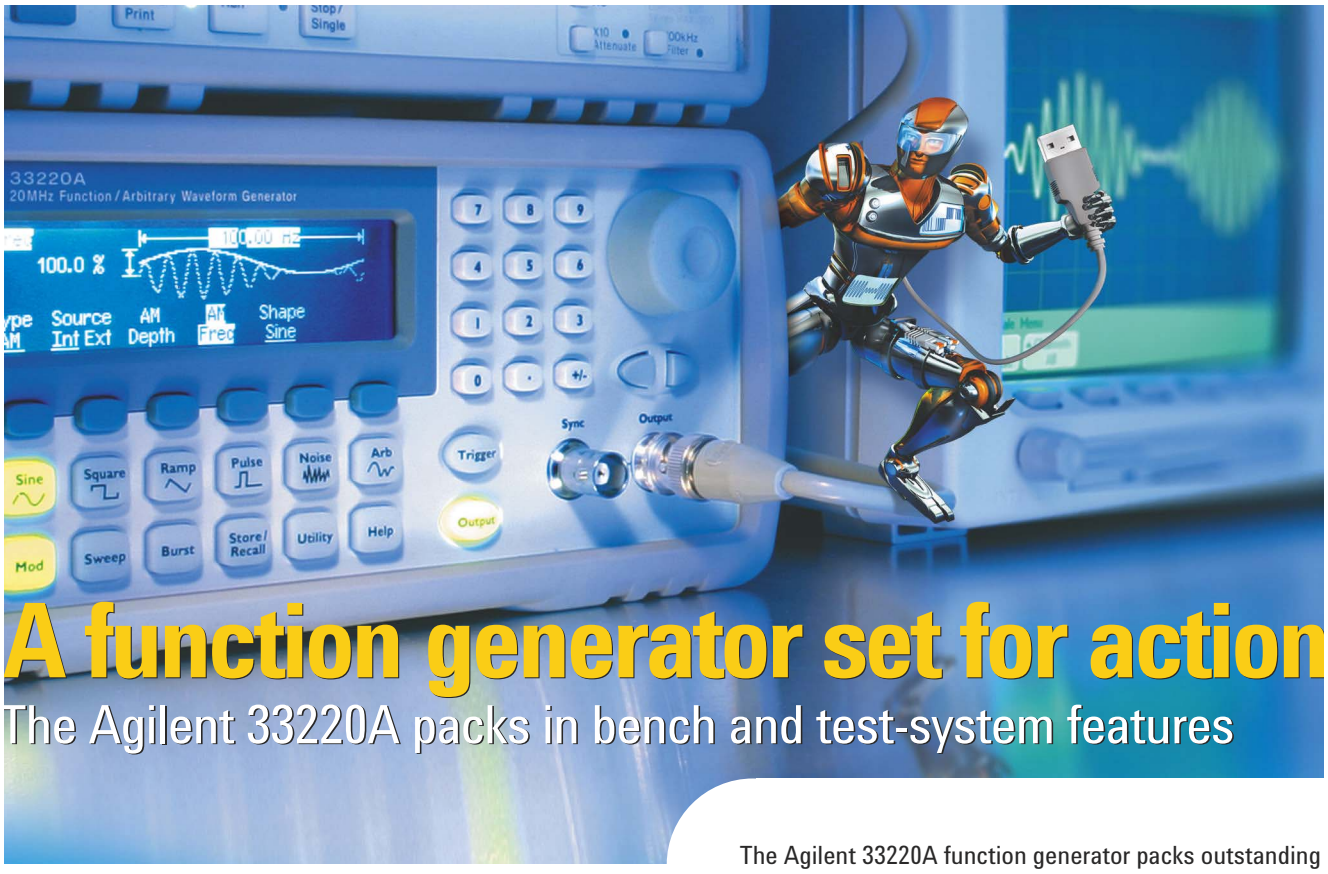

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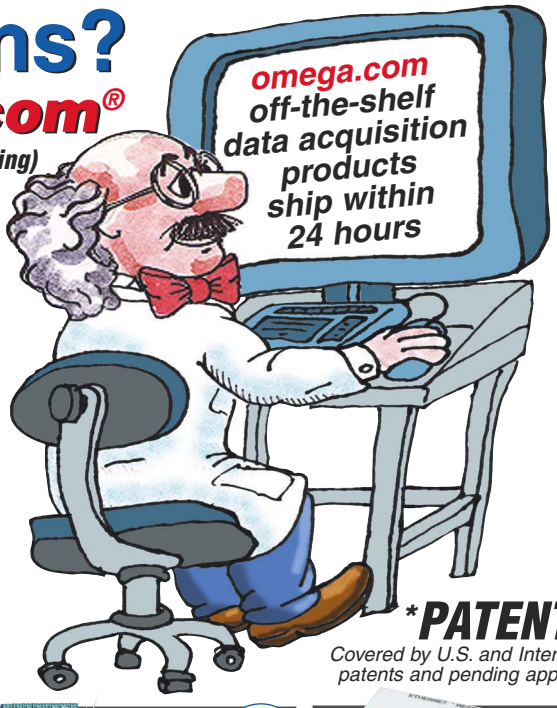

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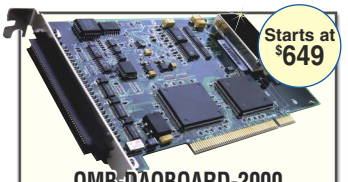

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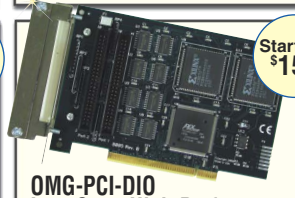

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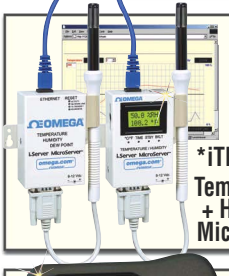

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Reed Electronics Group

25 years of test coverage

It has been 25 years since we launched the first issue of *Test & Measurement World,* setting out to serve the test, measurement, and inspection industries with reliable, unbiased information about test equipment and technologies. While a lot has changed since 1981, one thing that has not changed is the importance of the test engineer in delivering quality products to consumers and industry.

Throughout the past 25 years, we have stayed on top of a variety of technical advances and how they affected our industry. Consider the advances in machine vision. In

RUSS PRATT, PUBLISHER

1981, one contributor fretted that minicomputers didn't have the processing power to "process image data quickly enough to give real-time feedback" for effective location of visible shorts in thick-film circuits. Note the reference to *mini*computers. As for *micro*computers, the PC, in its IBM implementation, was born one month before *Test & Measurement World,* sporting 16 kbytes of RAM and optional 5¼-in. floppy drives—hardly the computing powerhouse necessary for automated inspection tasks.

We've grown up with the PC as it has evolved to handle the most challenging real-time test, measurement, and inspection tasks. And as it evolved, we, too, have developed a variety of ways to serve you better.

One thing that has not changed since 1981 is the importance of the test engineer in delivering quality products.

For example, advances in electronic media have helped us provide you with more timely information. No longer do we need to wait for our monthly print cycle to inform you about technology developments and standards updates. Using the Web and e-mail newsletters, we can bring you news on the day it breaks.

Of course, we continue to provide cutting-edge feature stories and editorial content in print, but we also offer a digital edition of the magazine, technology-specific test reports, a robust Web site (www.tmworld.com), interactive Webcasts, TMWSupplierSearch.com (a search engine that helps you locate products and companies), e-mail newsletters covering the worldwide test and inspection industry, and focused e-mail newsletters addressing specific topics. As technology continues to evolve, we will continue to look for ways to bring you information in whatever format best suits your needs.

Test & Measurement World thanks you for your loyalty, readership, and ideas for improvement. Without your support, we would not be able to provide the technical information you have come to rely on. As we venture into the next 25 years, expect and challenge us to continue to keep pace with technology. As always, if you have ideas on how we can improve our service to you, please let us know. T&MW

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If you're looking for outstanding value in a function generator, take a close look at the DS345.

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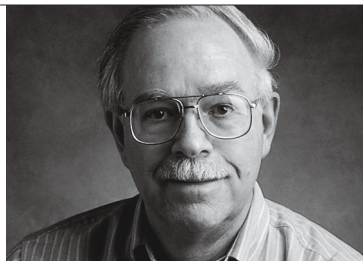

Here, kit, kit...

Do you remember Heath? No? Eico? Paco? If not, you're probably under 40 and have never practiced electronics as a hobby. Once upon a time, these three companies and others offered test instruments as kits of components. You—the buyer—provided assembly labor and quality assurance, honing your soldering and troubleshooting skills in the process.

Unfortunately, a combination of factors, including loss of free time, loss of interest in hobby electronics, economic pressures, and unfortunate management decisions, ended the days of mass-marketed instrument kits. You can't buy test equipment in kit form today...or can you?

Kits for instruments are indeed still available, but they differ from Heathkits in a number of ways. For starters, changes in technology made some kits obsolete—scratch tube testers and high-voltage power supplies—and regulatory and legal forces have influenced designs. Instead of jousting with safety agencies and bringing AC line voltage into a kit, contemporary kits' designers are likely to opt for battery or "wall wart" power. Fragile glass and high voltages inspire great caution in legal minds, and the CRT-based oscilloscope kit may be gone forever.

Documentation accompanying some of today's kits lacks the level of detail you'd find in Heathkit's gold-standard multipage assembly instruction manuals and may consist of only a few cryptically worded and sparsely illustrated pages.

You're also likely to encounter kits that consist of a printed-circuit board and bags of parts, but that don't include a case to house the completed board. Getting sheet metal enclosures designed and fabricated in quantity remains a major expense and a technical headache for a small-scale kit producer for whom a hundred kits constitutes a major production run. Vendors who do offer kits with cases use off-the-shelf, plastic enclosures that require minimal changes and are easily worked with basic shop tools.

Some of today's kits take advantage of low-cost and versatile microcontrollers. For example, one kit that I assembled can determine a three-leaded semiconductor's generic identity (i.e., FET, bipolar transistor, etc.) and measure a few of its parameters in seconds. Not bad for $50 and a few hours of my time.

The next time that you call, "Here, kit, kit," you just might be surprised by what answers. T&MW

KITS FOR THE HOLIDAYS

If you have a young person on your shopping list, why not give him or her an entry-level electronics kit, a few basic hand tools, a soldering iron, and most importantly, a few hours of your time as a mentor? Along with the kit, a young person can build self-confidence and a sense that technology is not only comprehensible but is also possible to master.

The following vendors offer entry-level or higher-level electronics kits. Note that the list isn't intended to be comprehensive or complete. If your gift recipient already has a hobby (e.g., model rocketry), check the ad pages of magazines that cover the hobby.

Velleman offers an interesting assortment of kits suited for many levels of skill: www.vellemanusa.com

Not much in the way of test instruments, but you'll find lots of radio kits: www.gibsonteched.com

Here are more educational kits: www.kelvin.com

Probably the most accessible source for electronic kits that don't require soldering: www.radioshack.com

For an overview of Heathkit's corporate history, go to: www.heathkit-museum.com

...and to view a PDF copy of Heathkit's October 1958 advertising flyer, see: www.heathkit-museum.com/features/hkflyer.shtml

To visit one surviving business entity that keeps the Heathkit name alive, visit: www.heathkit.com

For brief descriptions of Eico, Paco, and other lesser-known kit manufacturers, go to: www.qsl.net/kb7rgg

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Rohde & Schwarz dedicates R&D space; CEO to step down

Concurrent with Productronica 2005, Rohde & Schwarz held a dedication ceremony for a new 16,000-m^2 R&D facility at its headquarters in Munich, Germany. Friedrich Schwarz, company president and CEO, told the assembled gathering that the facility would create a work environment that supports the creativity of R&S employees. The 65-year-old executive also announced that he would step down from his positions in January.

In what represents a difference from typical operations in the high-tech industry worldwide, Schwarz said the billion-dollar company remains committed to keeping production close to home. About 90% of the manufacturing, he said, is done within 100 to 150 km of the Munich headquarters—close enough for quick response to manufacturing problems but far enough to discourage undue interference in production operations.

The new R&D space will help to house the 460 new employees the company has hired since its 2002/2003 fiscal year plus the 200 additional employees it expects to hire during its current fiscal year. Schwarz said the brisk pace of hiring is made possible by consistent year-on-year double-digit growth, even during the downturn following the burst of the Internet bubble. The company focuses on four areas: test and measurement, radio communications, broadcasting, and radio monitoring and location. www.rohde-schwarz.com.

Agilent acquires AFM maker

Agilent Technologies has acquired privately held Molecular Imaging, a manufacturer of nanotechnology-measurement tools. The acquisition counters a trend toward divestitures at Agilent, but it supports what Bob Burns, VP of Agilent's Nanotechnology Measurements Division, called a sharpening focus on Agilent's test-and-measurement roots.

Based in Tempe, AZ, Molecular Imaging is known for its PicoPlus family of modular atomic force microscopes (AFMs), which are used to measure the properties of materials at the nanometer scale. Because of ties between Molecular Imaging and Arizona State University, Agilent has no plans to move the Molecular Imaging operations. Financial details of the acquisition were not disclosed. www.agilent.com.

NIST aids in tests for crash-avoidance system

Researchers at the National Institute of Standards and Technology (NIST) are developing tests for a crash-avoidance system that should reduce the number of rear-end, road-departure, and lane-change accidents. NIST says that about 1,836,000 such accidents occur annually.

The crash-avoidance system is being developed under the auspices of the Department of Transportation (DOT). Called Integrated Vehicle-Based Safety System (IVBSS), the system is intended to simultaneously detect and warn drivers of any of three forms of crashes.

NIST has designed test procedures that are being used by a contractor to measure the performance of the safety

EDITORS' CHOICE

Software supports PXI RF digitizers

Aeroflex has released a new measurement suite for WLAN applications and has expanded the features of its existing GSM/EDGE measurement suite. Both suites enable users of the company's 3030 PXI RF digitizer family to speed up testing during the development and manufacture of WLAN and cellular devices.

The WLAN and GSM/EDGE measurement suites support spectrum, modulation, and power measurements with a single PXI test system. The WLAN suite analyzes 802.11a/b/g and PHY (physical layer) RF transmission parameters, and it enables the 3030 digitizer to perform OFDMA (orthogonal frequency division multiplexing access, or multiuser OFDM) and DSSS (direct-sequence spread-spectrum) power, spectrum, and modulation measurements in accordance with 802.11. The suite also analyzes 802.11 RF transmission parameters by using digital IQ data derived from the 3030.

The GSM/EDGE suite now includes receiver as well as transmitter testing, adding receiver-reference-sensitivity measurements to its ability to measure a transmitter's average RF power, burst profile, modulation quality (phase error or error vector magnitude), frequency error, and spectrum due to modulation and switching.

Prices: WLAN Measurement Suite for PXI—$3146; GSM/EDGE Measurement Suite—$3146. *Aeroflex,* WWW.AEROFLEX.COM.

system and its components, such as sensors and warning algorithms. The tests will determine the system's ability to warn drivers of a possible collision, detect a moving vehicle in adjacent lanes, and identify the presence of parked cars or other roadside objects and determine the available maneuvering room.

DOT will use the test data to decide whether the warning system performance is adequate to proceed with installing the system in about 10 vehicles for tests on the highway. DOT plans to complete the field operational test in approximately four years. www.nist.gov.

Test lab adds anechoic chamber

TUV Rheinland of North America, an independent testing and assessment service, has acquired a new 10-m fully anechoic chamber in its Santa Clara, CA, facility. With the chamber and its 4-m turntable, the company can perform tests on equipment weighing up to 8800 lbs. TUV Rheinland of North America says that almost any configuration of power can be supplied for the test, including three-phase AC power up to 100 A and 48 VDC up to 150 A for testing to EMC requirements such as FCC, VCCI, BSMI, CE Mark, and CISPR 11. www.us.tuv.com/testing.

CALENDAR

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

Measurement Science Conference, February 27–March 3, Anaheim, CA. Promotes education and professionalism in measurement science. 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.

EDITORS' CHOICE

Popular DMM meets its successors

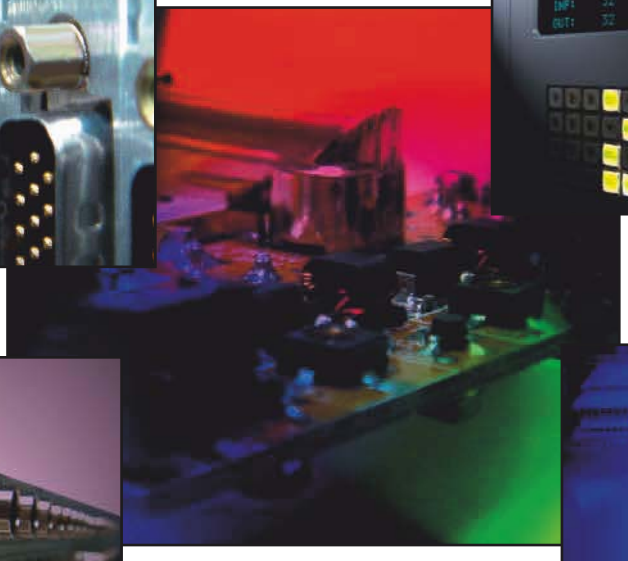
With the introduction of two new digital mulitmeters (DMMs), Agilent Technologies has expanded upon the features of its widely used 34401A DMM, which was released by Agilent's forerunner—Hewlett-Packard—in 1991. The new 6½-digit 34410A and 34411A (shown) improve reading speeds and system throughput by up to 50X over the earlier model, and they feature a dual display that lets you see two measurements, such as voltage and current or voltage and frequency, simultaneously.

In addition, the 34401A and 34411A can store far more measurements than their predecessor, which had a capacity of 512 readings. The new models can store 50,000 measurements in nonvolatile memory, and the 34411A can also store 1 M readings in volatile memory.

Where the 34401A could trigger only on a pulse or software command, the 34411A lets you trigger on signal characteristics such as signal levels, and you can set pre- and-post-triggers like you can with an oscilloscope. Other enhancements include a Web server and the addition of USB and Ethernet ports to the rear panel. Using the Web server, you can set the meter, get readings, and recall instrument settings with a browser. Because you can set up the DMM to log the instrument commands it receives from the server, you can use those commands in application programs when you need to automate measurements.

Prices: 34410A—$1595; 34411A—$1995. *Agilent Technologies,* WWW.TM.AGILENT.COM.

Switching?



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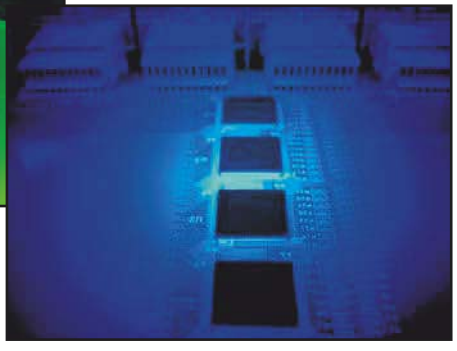

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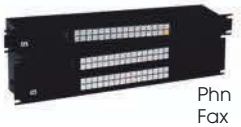

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Inspection and electrical-test products highlighted

> > > Productronica, November 15–18, Munich, Germany, sponsored by Messe München, www.productronica.de.

Viscom (www.viscom.de) debuted its S6056 automated optical inspection (AOI) system for printed-circuit boards, which adds a double-track capability and provides for parallel inspection of two PCBs. **Lloyd Doyle** (www.lloyd-doyle.com) announced the European release of its LD6000 range of automated optical test equipment for detecting faults during PCB manufacture. **Omron Electronics Europe** (www.eu.omron.com) launched its VT-RNS-ptH desktop AOI system, which employs the company's color highlight technology.

MVP (www.machinevisionproducts.com) displayed its high-speed AutoInspector Ultra II wire-bond inspection system. **VJ Electronix** (www.vjelectronix.com) exhibited its Model 1550 x-ray inspection system, which combines large-board (18x24-in.) inspection with automated motion control, measurement, and analysis.

Leica Microsystems (www.leica.de) highlighted its DM2500 M for inspecting circuit-board cross sections. **ViTechnology** (www.vitechnology.com) demonstrated five of its Vi-3K AOI systems, using different hardware and software configurations to show how the systems can be adapted for use at various stages of the PCB assembly line. **X-Tek** (www.xtekxray.com) highlighted its Revolution real-time microfocus x-ray system, which offers viewing angles of up to 75°.

Phoenix | x-ray (www.phoenix-xray.com) debuted its microme | x x-ray system for inspecting PCB assemblies. **Everett-Charles Technologies**' ATG Test Systems division (www.ectinfo.com) demonstrated the Eliminator integrated flying-probe test cell for high-throughput electrical measurements. The system handles conventional PCB panel test, IC package test, and PCB inner-layer electrical test. **BP Microsystems** (www.bpmicro.com) highlighted a single-lane tube feeder and loader and a 2-D inspection option for its device-programming systems.

Digitaltest (www.digitaltest.com) introduced the Lambda concurrent in-circuit/functional test system and described PXI functional test enhancements and a new fixture-lifting mechanism for its MTS300 hybrid test system. **Goepel electronic** (www.goepel.com) launched a series of low-cost boundary-scan controllers that will complement its high-performance ScanFlex line. **Seica** (www.seica.com) announced several new and enhanced products within its VIVA Integrated Platform, including the Strategy.sl automated in-circuit/functional bed-of-nails tester, the PilotVIP automated flying-probe tester for loaded boards, and the S24 BBT flying-probe tester for bare boards.

JTAG Technologies (www.jtag.com) demonstrated its recently introduced Gigabit Ethernet-compatible TapCommunicator, which is based on the TapSpacer technology from **Patria Advanced Solutions** (www.patria.fi). **Dage Precision Industries** (www.dage-group.com) introduced its 4000HS high-speed bond tester for measuring solder-bond reliability.

FineTech (www.finetech.de) highlighted its FinePlacer Micro HVR system for high-volume rework applications. **Pickering Interfaces** (www.pickeringtest.com) introduced an LXI switching chassis and power sequencer as well as PXI amplifiers and attenuators. **Rohde & Schwarz** (www.rohde-schwarz.com) introduced version 2.3 of its enhanced generic test software library (EGTSL) for its Compact-PCI/PXI test platform and also announced that it has optimized its new NGPL6/5 quadruple programmable power supply for mobile-phone production-line final test. T&MW

The Model 1550 x-ray inspection system combines large-board inspection with automated motion control, measurement, and analysis.
Courtesy of VJ Electronix.

More international than ever

> > > Vision 2005, November 8–10, Stuttgart, Germany, produced by Messe Stuttgart, www.messe-stuttgart.de/vision.

During Vision 2005, the **German Machine Vision Association** (VDMA; www.vdma.de) presented its latest market research, which forecasts that the market will exceed 1 billion euros by year's end. Exports, along with machine-vision consumption in the automotive and electronics and electrical industries, are expected to fuel growth through 2006 to just under 1.1 billion euros.

The newly formed **European Machine Vision Association** (EMVA; www.emva.org) also presented positive forecasts as well as two new industry standards. EMVA 1288, "Standard for Characterization and Presentation of Specification Data for Image Sensors and Cameras," is an initiative for defining a unified method for measuring, computing, and presenting specification parameters for cameras and image sensors used for machine-vision applications. The goal is to make it easier for customers to compare products from different manufacturers. *(continued)*

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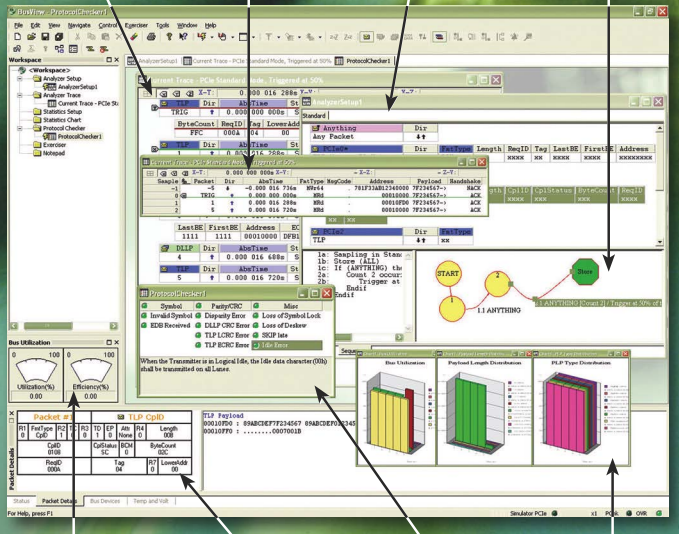

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The second standard, GenlCam Standard, aims to provide a generic programming interface for all kinds of cameras. The EMVA says that no matter what interface technology is being used, such as GigEVision or Camera Link, the application programming interface (API) should be always the same.

On the exhibit floor, which included more than 200 exhibitors from 19 countries. intelligent cameras dominated. **Basler Vision Technologies** (www.basler-vc.com) offered the eXcite intelligent camera and an embedded version of the MVTec HALCON software library. Celebrating its 10th anniversary, **Vision Components** (www.vision-components.com) presented 14 new smart cameras ranging from the VC2065 ($^1/_2$-in. CCD, 782x582, 45 frames/s, SVGA video output) to the VC4472 ($1^1/_8$-in. CCD, 1600x1200, 1-GHz DSP).

XenICs (www.xenics.com) presented the XEVA-FPA-320, a digital, software-configurable camera consisting of a 320x256 thermo-electrically cooled InGaAs array combined with control and communication electronics. **SICK/IVP** (www.sickivp.com) unveiled the IVC-2D and IVC-3D smart cameras and the Ruler E, which combines a camera with a built-in laser and optics for a predefined field of view.

Distributor **Stemmer Imaging** (www.stemmer-imaging.de) showcased products from DVT, Cognex, Pleora, and IPD. The company also exhibited its own Common Vision Blox software library for image processing. **MVTec Software** (www.mvtec.com) announced HALCON 7.1 for smart cameras; the new version of the software is being employed in cameras from manufacturers such as Sony, Philips, and Basler.

Pleora Technologies (www.pleora.com) announced GigE connectivity solutions with PC driver architecture for Ethernet connectivity and data flow. **Philips Applied Technologies** (www.apptech.philips.com/industrialvision) demonstrated the Inspector, an easy-to-use, smart-sensor system. The camera is preprogrammed, so users need to follow just five easy steps to get a system up and running.

Cypress Semiconductor (www.cypress.com) demonstrated its family of CMOS image sensors for machine-vision and motion-analysis applications. Schott Optics (www.us.schott.com/fiberoptics) displayed a line of fiber-optic light sources for machine-vision, microscopy, sensing, imaging, and automotive applications. Redlake MASD (www.redlake.com) displayed the MegaPlus II machine-vision camera for flat-panel and plasma-display-panel inspection. NeuroCheck (www.neurocheck.com) demonstrated the NeuroCheck image-processing software, a program that supports matrix and line-scan cameras in both monochrome and color formats. T&MW

(continued)

EDA and boundary-scan tools dominate ITC

> > > International Test Conference, November 8–10, Austin, TX, sponsored by the IEEE, www.itctestweek.org.

Cadence Design Systems (www.cadence.com) highlighted two Encounter Test enhancements. True-Time for bridges allows users to automatically generate delay tests that target the bridging faults common in nanometer designs. True-Time through RAM generates delay tests into and through nonscannable elements, including third-party RAMs.

Synopsys (www.synopsys.com) described enhancements to TetraMAX that provide designers with productivity gains for both automatic test-pattern generation and test-debugging tasks. **Mentor Graphics** (www.mentor.com) highlighted its new YieldAssist diagnostic tool, which is designed to quickly identify and isolate yield-limiting defects. **Magma Design Automation** (www.magma-da.com) demonstrated its Blast DFT, which features memory-BIST capabilities for 90- and 65-nm designs, including self-repair and routing-friendly architecture.

LogicVision (www.logicvision.com) exhibited ETCreate and announced that it has integrated the tool into Magma's Blast Create and Blast Fusion design flow. **Intellitech** (www.intellitech.com) introduced its next-generation System-BIST IC technology and demonstrated its support for JTAG-based testing of Serdes connections at speeds to 10 Gbps.

Mosaid Technologies (www.mosaid.com) unveiled its MS5205 sixth-generation test system targeted at engineering test, analysis, and bitmapping applications for semiconductor memories. **Goepel electronic** (www.goepel.com) introduced another I/O module for the ScanFlex boundary-scan hardware platform. The SFX1149.4 provides resources for the test of analog circuits based on the IEEE 1149.4 analog boundary-scan standard. T&MW

The MS5205 is designed for testing semiconductor memories.

Courtesy of Mosaid Technologies.

See the online version of this article for more ITC news and for information on next year's show. www.tmworld.com/2005_12.

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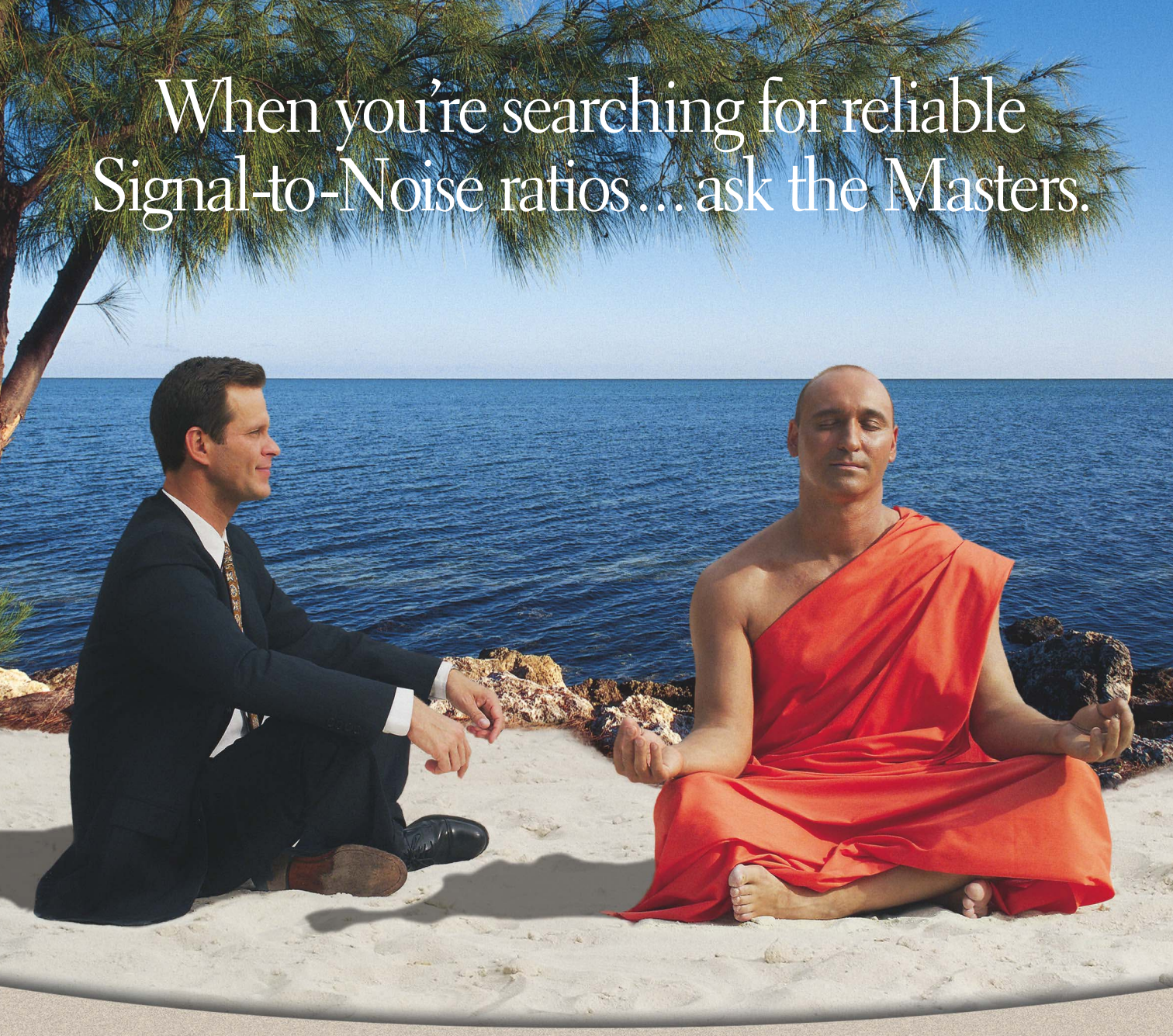

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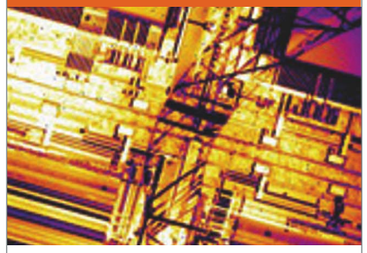
Infrared Signatures

An IR signature is the quantitative measurement of a target's apparent infrared brightness as a function of wavelength. Signature measurements are used to determine the appearance of a target to sensors under varying conditions of standoff distance and atmosphere, and to constrain the design of vehicle, sensor and camouflage systems.

High Speed/Stop Motion

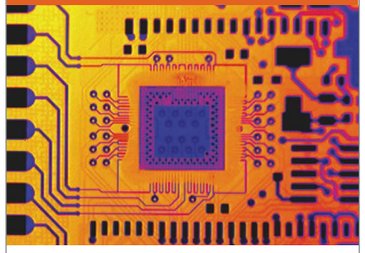
Advanced infrared sensors and data acquisition systems bring high-speed infrared imaging to a new level of performance, enabling microsecond exposure times to stop the apparent motion of dynamic scenes as well as capture frame rates exceeding 10,000 frames per second. Applications include thermal and dynamic analysis of jet engine turbine blades, supersonic projectiles and explosions.

Near Infrared (NIR)



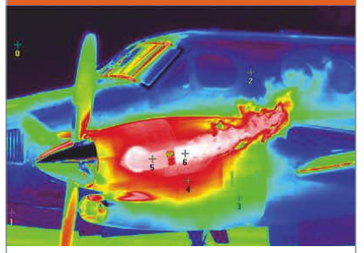
NIR light interacts with materials very differently from visible light or thermal IR. NIR imaging spectroscopy provides non-destructive quantitative analysis of crops, pharmaceuticals, agricultural products and lasers. Because NIR can penetrate many opaque materials, it can be used for imaging through haze, examination of art forgeries and questioned documents, semiconductor wafer inspection and many other applications.

Infrared Microscopy



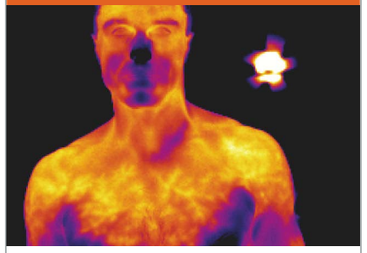
An infrared camera combined with a microscope becomes a thermal imaging microscope, capable of accurate temperature measurement of features as small as 10 microns. Electronics manufacturers can characterize the thermal performance of active and passive components as well as printed circuit traces in operation without physical contact.

Preset Sequencing



Preset Sequencing is the ability to capture image frames at 4 different integration times in rapid succession. The best pixel response from each image can then be selected and reconstituted into one dynamic image through a process called Dynamic Range Extension, producing an 18-20 bit image with superior thermal detail.

Research & Development



Infrared cameras enable characterization of the properties of materials in ways that complement many standard analysis techniques, as well as rapid non-contact temperature measurement in the most demanding conditions. The wide range of infrared sensor types and optics that are commercially available make infrared imaging capability an indispensable tool in many research environments.

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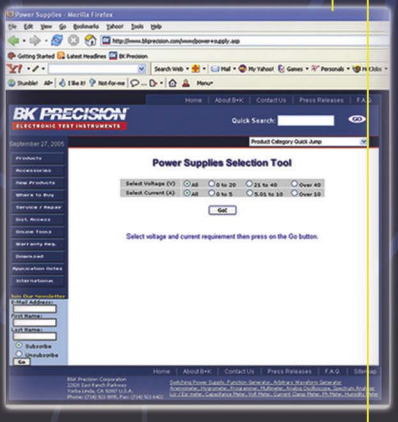

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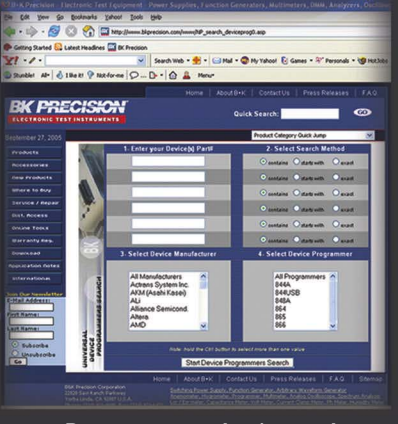

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The year of the waveform generator

I hereby declare 2005 "The year of the waveform generator" because of the unusually high number of product introductions. I've identified eight companies that have introduced function or arbitrary waveform generators this year: B&K Precision, Fluke, Geotest, Novatech Instruments, Signal Forge, Tabor Electronics, Tegam, and Tektronix. The prices range from less than $1000 to about $17,000.

"There's a clear movement from standard waveforms to arbitrary waveforms," said Bob Buxton, product line marketing manager for signal sources at Tektronix. "We expect a 9% growth in arbitrary waveform generators and zero growth in basic function generators industry wide." Tegam president Adam Fleder sees a similar trend, noting "The function/arbitrary waveform generator is replacing the classic function generator."

Fleder also noted a need for waveforms that simulate signals from sensors used in medical equipment and automotive systems. Hilton Hammond, Fluke's product manager, cited new technologies adopted in several industries, like automotive, as reasons his company introduced several waveform generators this year. "Engineers need to generate signals that simulate those found in technologies such as in braking systems and airbags," he noted.

Geotest and Tabor Electronics introduced waveform generators that replace discontinued models from Wavetek and Agilent Technologies (Hewlett-Packard). Geotest's GP1665 series replaces Wavetek and Agilent models, and Tabor has two models that replace two Agilent models.

There's even a new player in the function-generator market. Signal Forge introduced its first product, an 800-MHz sine-wave and square-wave source that uses a PC or terminal for its user interface. Priced at $985, it's in the same low price range as a new offering from B+K Precision that combines a function generator, counter, and power supply. In contrast, a top-of-the-line model in the Wonder Wave series of arbitrary waveform generators from Tabor is priced at around $17,000.

The most significant reason for the flurry of function/arbitrary waveform generator introductions is greater integration in direct digital synthesis (DDS) ICs. "DDS cores that were once used only in high-end equipment are now used in larger volume consumer, medical, and automotive markets," said Jeff Keip, senior product marketing manager at DDS IC supplier Analog Devices. Keip sees applications such as radio controllers for model planes, handheld wireless tag scanners, software defined radio, automotive radar, and impedance measurement for medical and industrial diagnostics creating economies of scale that drive DDS IC prices down. Tektronix, though, developed its own DDS IC for its AFG3000 series, which the company introduced in August. The IC integrates a DDS core with memory and a digital-to-analog converter. T&MW

The Wonder Wave series of arbitrary waveform generators consists of seven models, including the Model 2572, which operates at 250 Msamples/s.

Courtesy of Tabor Electronics

For more information about these recent waveform-generator introductions, see the online version of this article, which contains links to the product announcements. www.tmworld.com/2005_12.

RF and wireless dictionary

Keithley Instruments has published *Speaking RF: Wireless Communication Terminology,* a 30-page guide to many commonly used terms in RF and wireless technology. The guide also provides tables on topics such as watts versus dBm, communication standards, power supplies, and switching. www.keithley.com/pr/022.

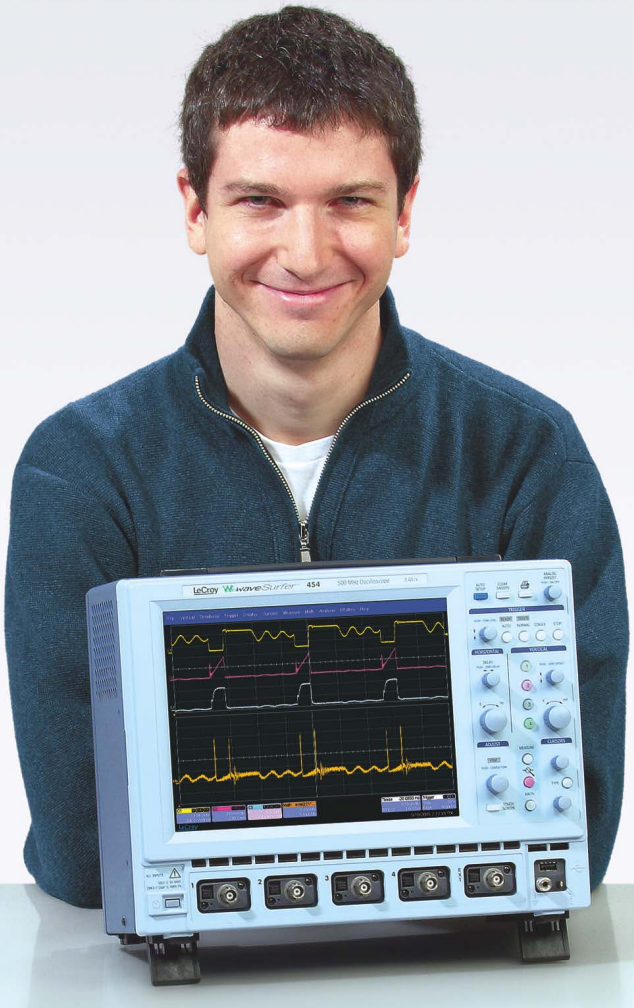
Fluke establishes online community

Users of Fluke test equipment now have a forum where they can share information and experiences. The Test & Measurement Tool Users Community lets you post messages to other members about DMMs, clamp meters, portable oscilloscopes, and calibration. www.flukecommunity.com

Kilogram moves closer to natural definition

Researchers at NIST and other institutions have made strides to replace the world standard for the kilogram with one based on physics and quantum standards. A watt balance makes kilogram measurements based on the relationship between mechanical and electrical power. www.nist.gov/public_affairs/releases/electrokilogram.htm.

Wow! Why?



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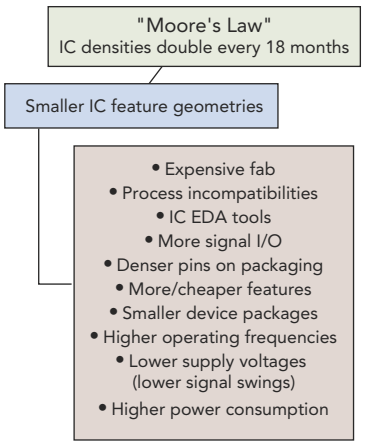
Workshop explores board test

On November 3–4, 2005, Agilent Technologies hosted the fourth annual IEEE Board Test Workshop at its facility in Fort Collins, CO. The brainchild of UK design-for-testability consultant Dr. R.G. "Ben" Bennetts, the conference explored various issues related to board test.

Five years ago—"aided and abetted by others"—Bennetts founded the Board Test Action Group, now known as the Board-Test Technical Activities Committee (BTTAC) of the IEEE Test Technology Technical Council (TTTC), to rekindle interest in board-level test at the International Test Conference. For a number of years, the ITC had concentrated primarily on device test.



Moore's Law affects technology at both the board and the device level.

"We held the first workshop at ITC in 2002," recalled Bennetts, "repeating the event in 2003. Because the ITC allows such hot-topic workshops to be associated with the conference for no more than two years, after that we had to strike out on our own."

This year's sessions covered a wide range of topics. One presenter, independent consultant Bob Russell, explored z-plane deformations during flying-probe testing. He contended that resulting board warpage significantly threatens board quality and can lead to false failures.

A paper by Ken Parker from Agilent contended that Moore's Law presents no less a challenge at the board level than it does at the device level. Parker cited increasing reliance on lower operating voltages and optical signaling as high-priority concerns.

Bennetts and Agilent's Jeff Rearick presented status reports on the SJTAG and IJTAG initiatives, respectively. SJTAG looks at data languages and formats associated with boundary scan in multiboard system environments. IJTAG focuses on using the IEEE 1149.1 test access port as a common serial interface to access device-internal "instruments" for configuration, test, diagnosis, and debug. Bennetts explained, "Although the two initiatives come from opposite ends of the 'use of boundary-scan' spectrum, they may experience common problems and common solutions. So far, however, the two initiatives are proceeding down different paths."

Carlos O'Farrill, from contract-manufacturer Jabil Technical Services, offered a comparison between a low-cost in-circuit tester (manufacturing-defects analyzer) and more traditional high-end equipment. O'Farrill attempted to clarify the number of board-test failures caused by faulty devices and determine if the lower-cost machine could provide results comparable to those of its higher-priced sibling. A lively discussion ensued, centering around whether he had made a fair comparison and whether his methods could distinguish between a faulty device and a bad solder joint. Bennetts commented, "That type of interaction between the presenter and the audience adds to the intensity of the sessions." T&MW

The 2006 workshop will likely take place in September, although not under Agilent's auspices. To download the 2005 presentations, visit www.dft.co.uk/BTW2005.

SigmaQuest introduces service-oriented architecture

To ease integration with other software, SigmaQuest's SigmaSure 5.0 data-gathering and analysis tool has adopted a service-oriented (rather than an object-oriented) architecture, which provides loose coupling among interacting software agents. Version 5.0 also permits customers to restrict access to sensitive data and allows users to perform "what-if" analyses. www.sigmaquest.com.

Booklet touts benefits of boundary scan

JTAG Technologies has compiled a free 30-page guide that describes the benefits of adopting boundary-scan test and in-system programming as part of a product's development. Topics include requirements for implementing a boundary-scan design, embedded testing, and boundary-scan testing integrated with in-circuit test. www.jtag.com.

Thermal protection reduces board failures

In an effort to reduce potential board damage during manufacturing with lead-free solder, Cookson Electronics Assembly Materials has introduced Alpha Coolcap thermal protection devices. These reusable custom-fitted caps keep semiconductor packages below 260°C during high-temperature lead-free reflow and rework processes, reducing board warpage, "popcorning," and delamination. www.alphametals.com.

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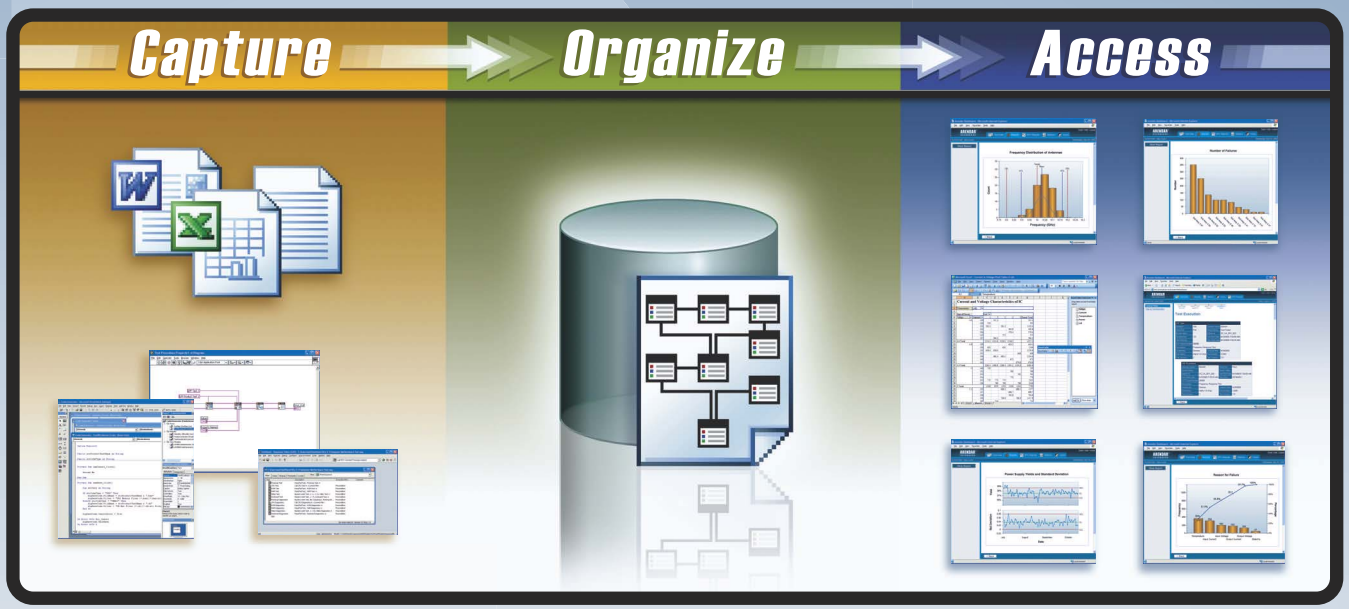

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Learn to apply LXI instrumentation

The LXI (LAN eXtensions for Instrumentation) Consortium—founded by Agilent Technologies and VXI Technology in September 2004 and joined by Keithley Instruments a month later—is entering its second year with more than three dozen members, who are beginning to introduce LXI-compatible instruments that you can integrate into existing test systems. In an October 19 Webcast (Ref. 1), representatives of the consortium's founding members explained why you might want to use LXI and how you can start to do so. (You can view the archived Webcast at www.tmworld.com/webcasts.)

FIGURE 1. Instruments with multiple types of interfaces can help smooth the transition to hybrid systems employing LXI. Courtesy of Agilent Technologies.

Scott Sampl, VP and GM of the Electronic Products and Solutions Group's System Products Division at Agilent Technologies, described LXI as a high-performance, compact, modular architecture that would ease the transition from R&D to manufacturing test by providing hardware and software compatibility. He described triggering and synchronization capabilities that would enable distributed test, with message-based triggering providing millisecond triggering accuracy and time-based triggering providing 10- to 100-ns triggering accuracy among globally distributed instruments. The standard also supports event-based triggering among instruments located close to each other.

Sampl noted that during the transition to LXI, it's wise to choose instrumentation with various interfaces (**Figure 1**) to help ensure compatibility with legacy equipment.

Jon N. Semancik, corporate marketing and business development manager for VXI Technology, described LXI as a natural fit for distributed data acquisition, with LXI supporting device connections over 100 m point-to-point, over 200 m with a router/switch, and over several kilometers using fiber.

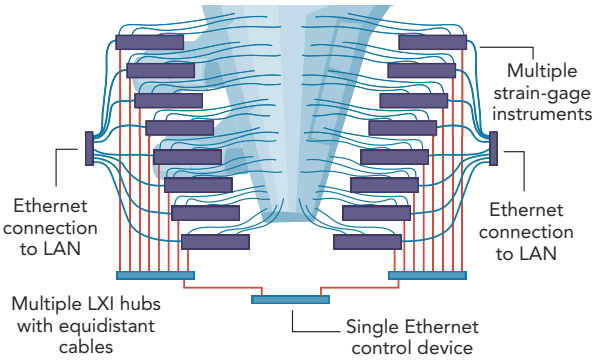


FIGURE 2. A data-acquisition system employing LXI technology provided 6000 channels of strain-gage measurements for a Boeing 787 Dreamliner. A single Ethernet control device enables acquisition.

Semancik described an application in which LXI equipment monitored strain gages located throughout a Boeing 787 Dreamliner (**Figure 2**). The application employed LXI trigger hubs and strain-gage conditioning and measurement instruments to monitor 6000 channels using hardware triggering.

Paul Franklin, a manager at Keithley Labs, provided a long-term look at LXI. He noted that in conjunction with the IEEE 1588 Precision Time Protocol standard, LXI will provide for precise synchronization and uniform time stamps.

Franklin cited several reasons why he believes LXI will avoid obsolescence,

Participants' questions

Here are some of the questions the panelists addressed during the Webcast, which is available for viewing at www.tmworld.com/webcasts:

- Are all instruments with a LAN port LXI?
- How do LXI instruments fit in with synthetic instruments?
- Is LXI compatible with wireless LANs or Power-over-Ethernet implementations?
- Is LXI compatible with VISA instrument drivers?
- Will IEEE 1588 synchronize LXI instruments over the Internet?
- Could a controlling computer have two separate networks connected—one for test instruments and another for a company network and the Internet?
- Will a separate PCI plug-in LAN card be required to get improved security and decent trigger/latency performance?
- What's the price premium for an LXI device compared with a GPIB device?
- Wouldn't multiple ports on instruments become redundant as the adoption of LXI takes hold?
- If I put an instrument without a front panel out on a LAN, how do I find its IP address?
- What is the relationship between LXI and XML?

Learn to apply LXI instrumentation *(continued)*

which he said occurs when something faster, better, and cheaper comes along or when the market served is too small to sustain the technology. LXI, he said, embodies the open, widely accepted Ethernet LAN standard; it serves a large market that is attractive to suppliers; new implementations will be backward compatible or support a simple and low-cost migration path; it avoids a rigid physical format that will allow packaging to evolve without devaluing the standard; and it focuses on interfaces, not implementations.

Rick Nelson, Chief Editor

REFERENCE

1. "Gaining the benefits of the LXI platform," produced by *Test & Measurement World* and sponsored by Agilent Technologies, Keithley Instruments, and VXI Technology, originally broadcast October 19, 2005. www.tmworld.com/webcasts.

ELECTROMAGNETIC INTERFERENCE

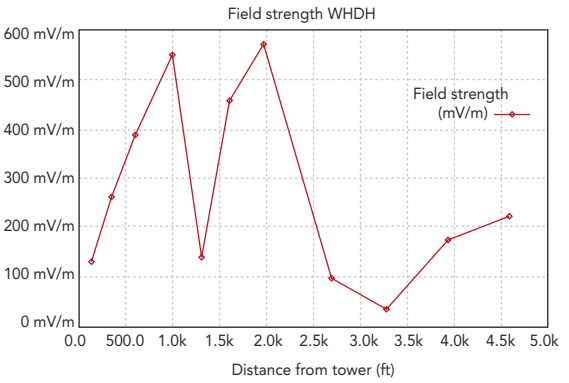
Car remotes vs. TV towers

Keyless automobile remote controls are rugged and run a long time between battery changes, but they can fail when in areas of strong electrogmagnetic fields.

Over the past few years, I have noticed that my car remote consistently fails in a certain shopping area. The problem? Interference from nearby TV and FM transmitters. All of Boston's TV stations and several FM radio stations use a set of four 1100-ft. towers located in a nearby suburb. The tower in this particular shopping area transmits analog on channel 7 (WHDH-TV) and digital on channel 42 (WHDH-DT).

What does it take to interfere with a keyless entry system? To find out, I asked the transmitter engineers at WHDH for field-strength measurements. The **figure** shows measurements for channel 7 at 11 locations near the tower. The first nine locations occur in the shopping area.

I ran some experiments and found that at distances of roughly 1000 to 2000 ft from the tower, my remote control would either not work at all or would work only within a few inches of the car door. At locations 3000 ft and beyond, the remote would work at distances of 15 to 18 ft. The plot shows a significant drop in field strength at about 1300 ft, but my remote control wouldn't work at that distance even though the field-strength data indicated that it should. But this was an unscientific experiment and I was not at the exact locations at which the field-strength measurements were made. Furthermore, the field-strength measurements were conducted at the channel 7 and channel 42 frequencies only. Other channel frequencies could have interfered with the remote.



EM field strength near a TV tower can interfere with remote keyless entry systems. Data courtesy of WHDH.

I didn't find an exact correlation between the field strength data and my experimental data, but I can still conclude that using a remote keyless entry system in areas of high EM fields will cause them to fail or to work only at reduced distances. Keep that in mind the next time you think a remote's battery has failed. *Martin Rowe, Senior Technical Editor*

NATIONAL INSTRUMENTS

THE DATA DETECTIVE

Mind Your I's and Q's

Most people who use cell phones, portable PCs, and other wireless devices understand the benefits of radio-frequency communications. Because consumers always expect more capabilities, designers must push communications to higher frequencies, use more sophisticated information encoding or modulation schemes, and transmit or receive at lower power. Often they require higher data throughput or higher bandwidths. Engineers refer to bandwidth rather loosely, though, which can cause confusion. Keep in mind two different types of bandwidth: A WLAN based on IEEE 802.11g, for example, provides a data bandwidth as high as 54 Mbits/sec. In the US, those transmissions take place between about 2.412 and 2.462 GHz, a signal bandwidth, or frequency range of about 50 MHz.

By modulating a carrier signal, we add information that others can receive and demodulate. There are three parameters of a signal that can be modified to convey information: amplitude, frequency anad phase.

In mathematical terms, think of modulation as:

$$\text{Signal} = A_c \cos(2\pi f_c t + \phi)$$

Where A equals amplitude, $2\pi f_c t$ equals frequency, and ϕ equals phase. The combined frequency and phase terms govern the "angle" described by the cosine term (Figure 1). Thus, by independently changing two components of a signal—its amplitude and its angle—you can increase a signal's information-carrying capacity and its immunity to noise beyond that of basic AM, FM, or PM signals.

Digital-communication techniques specify a set number of "states" for each type of digital modulation. A signal that employs 32-state quadrature amplitude-modulation (32 QAM), for example, allows 32 signal variations. Each variation conveys five bits of information ($32 = 2^5$). Instead of modulating phase and amplitude, the QAM technique modulates the *amplitude* of an in-phase carrier (I) and the *amplitude* of the carrier shifted one quadrant (Q), or 90 degrees (Figure 2). Combining the modulated I and Q signals produces a single signal in which the orthogonal I and Q components do not interfere with one another. Engineers have found it easier to modulate and demodulate the amplitude of two signals than to change the amplitude and phase of one signal. (An upconverter mixes the modulated baseband signal with a high-frequency signal to create the final RF transmission signal.)

A receiver splits the I and Q information, which in raw form looks like a Cartesian plot, often called a "constellation" diagram (Figure 3). Each dot represents one of the 32 values allowed in a 32 QAM signal. Think of the "vector" as a line that connects the origin and any dot. Note the relationship between I/Q and magnitude and phase. Because the combined I/Q signal produces a vector, engineers refer to instruments that generate and analyze I/Q-modulated signals as vector signal generators (VSG) and vector signal analyzers (VSA).

Test Your IQ

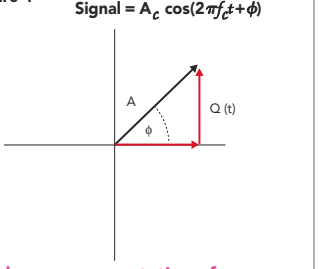
Jill has designed a circuit that demodulates a 32 QAM signal. When she looks at the data stream, though, she sees what seem like random bits—more like a noise signal than data.

Can you help Jill measure and analyze the signals to determine what has gone wrong?

http://rbi.ims.ca/4402-504

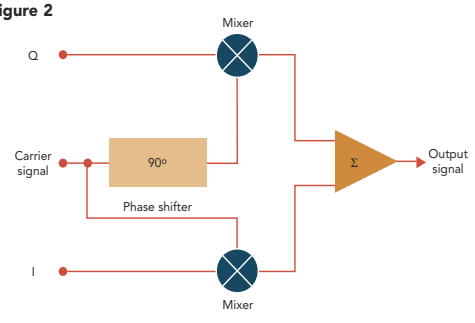
RF communications cannot occur without errors. So during vector analysis of communication signals, engineers quantify a modulation-error ratio (MER) and an error-vector magnitude (EVM). Both of which require acquisition of signal data, comparison with known-good data, and calculation of results. In short, MER calculates the peak or the rms value of the error vector between the ideal vector and the actual received vector for all points in a constellation diagram. EVM measures the difference between the ideal and the actual vector values in a transmission. Many vector signal analyzers can provide MER and EVM values, which help characterize the quality of a modulated signal.

Figure 1



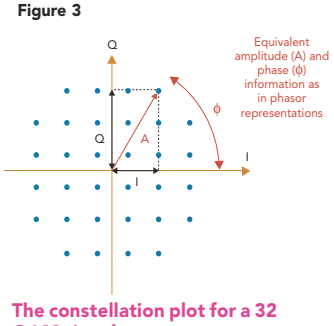
A phasor representation of a communication signal shows its amplitude and phase components.

Figure 2



A typical I/Q-modulation circuit.

Figure 3

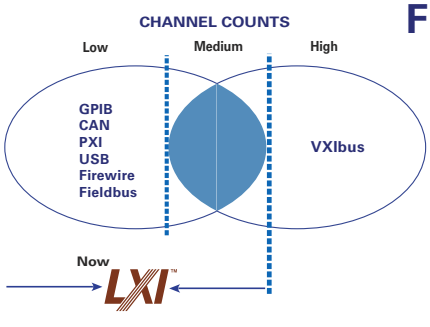


The constellation plot for a 32 QAM signal.

Go to http://rbi.ims.ca/4402-504 to solve the challenge!

A new idea is born.....

LAN eXtensions for Instrumentation (LXI™), founded by VXI Technology Inc. and quickly joined by over 40 MAJOR instrumentation suppliers, has become the fastest growing instrumentation platform in the world.



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- Sign up to attend a local seminar in your area
- Request our free engineering handbook

High-density Modular Instrumentation **www.vxitech.com**

VXI Technology™

FIBER-OPTICS TEST

The light and the distance

DEVICE UNDER TEST
Optical components that operate at 10 Gbps and are used in metro and regional networks to carry data, voice, and video.

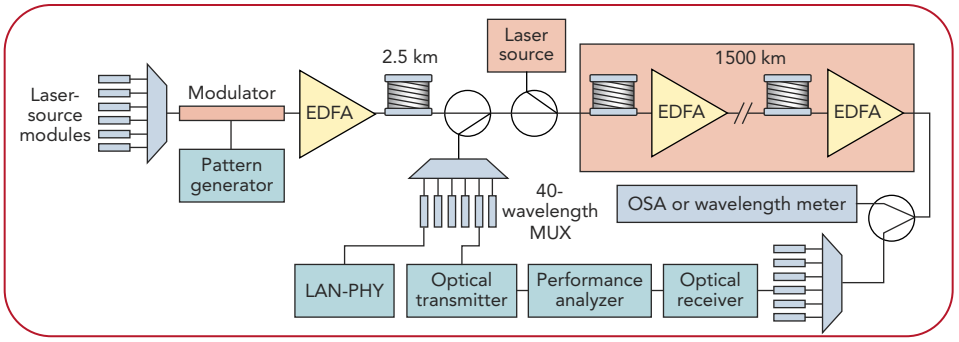
THE CHALLENGE
Verify that optical components will reliably transmit and receive data over 1500 km of optical fiber. Characterize the devices for optical signal-to-noise ratio (OSNR) and nonlinear effects to find the maximum reliable transmission distance if devices are unable to operate at 1500 km.

THE TOOLS
- Agilent Technologies: digital communications analyzer (DCA), multiwavelength meter, optical attenuator. www.tm.agilent.com.
- Ando (now part of Yokogawa): optical spectrum analyzer. www.yokogawa.com.
- Anritsu: pattern generator/bit-error-rate tester. www.us.anritsu.com.
- C-Cor: optical transmitters and receivers and erbium-doped fiber amplifiers. www.c-cor.com.
- ILX Lightwave: laser driver. www.ilxlightwave.com.
- Newport: laser driver. www.newport.com.
- Peleton: multiwavelength laser source. www.peleton.com.
- Spirent Communications: performance analysis system. www.spirentcom.com.

PROJECT DESCRIPTION

When C-Cor Access and Transport Group (Wallingford, CT; www.c-cor.com) acquired a line of optical transmitters and receivers, engineers needed to verify their performance at distances up to 1500 km. "We needed to understand the limitations, if any, of our components," said chief technologist Zoran Maricevic.

To characterize the components, Maricevic's team measured how optical signal-to-noise ratio (OSNR), chromatic dispersion, and nonlinear effects caused degradation in performance. They developed a test bed that simulates a transmission line where self-phase modulation (SPM), cross-phase modulation (XPM), stimulated Raman scattering (SRS), and stimulated Brillouin scattering (SBS) cause an increase in OSNR and a corresponding decrease in the bit-error rate (BER).



A test bed lets engineers measure how nonlinear effects on DWDM transmissions reduce transmission distance and increase bit errors.

Maricevic developed a test bed (**figure**) that contains 1500 km of optical fiber with erbium-doped fiber amplifiers (EDFAs) every 80 km. He made BER and OSNR measurements on each of 40 of 44 possible DWDM channels while keeping the other channels "dark." The measurements let him verify that the components worked and provided a measurement baseline. The components operate on optical channels 16–59 (191.6–195.9 THz). Next, Maricevic ran a frame-error test, using the performance-analysis system to send and receive Ethernet packets.

After verifying that single-channel transmissions met requirements, Maricevic ran tests with all channels turned on. He used C-Cor's optical transport modules to generate signals in 20 DWDM channels and used the multiwavelength laser source for the remaining channels. Nonlinear effects from adjacent channels cause BER and OSNR degradation.

Light from a digital "1" can degrade a transmission in the transmission's channel, causing SPM, or it can interfere with transmission in neighboring channels, causing XPM. XPM causes 6 dB more interference than SPM. The engineers measure XPM in a channel near the center of the frequency band, a location at which XPM interference occurs from both above and below the channel's frequency. "You also need to run live traffic on at least the two most adjacent channels on either side of the channel under test," explained Maricevic. He performed his tests on channel 39 (193.9 THz) with live traffic from the performance analyzer on channels 37, 38, 40, and 41. The remaining channels carried either live traffic or unmodulated light from the laser source.

LESSONS LEARNED

C-Cor engineers learned the value of having clean eye diagrams at transmitter outputs (measured with the DCA). They also learned that you must make optical spectrum measurements everywhere in an optical transmission line. The company reports that the performance of its PLEXiS platform exceeded customer requirements. "I can't overemphasize availability of quality, reliable test gear for gathering test results and verifying all the assumptions made," said Maricevic.—*Martin Rowe, Senior Technical Editor*

The online version of this article contains links to more information about SRS, SBS, and XPM: www.tmworld.com/2005_12.

The Best in Test

Each year, *Test & Measurement World*'s editors present the Best in Test awards to products we think are particularly innovative or useful. Here, we present the 2006 Best in Test winners as well as 18 products worthy of honorable mention (p. 36). *T&MW*'s editors narrowed this year's field from scores of deserving products, nominated by vendors, that were introduced between November 1, 2004, and October 31, 2005.

You can help determine which of the 12 Best in Test products will become the Test Product of the Year. To make your voice heard, visit www.tmworld.com/awards and cast your electronic ballot by January 18, 2006. We will announce the winning product in February and publish a description of it in our March 2006 issue.

In addition to the products described in this Best in Test section, keep in mind other worthy products identified by *Test & Measurement World* editors throughout the year in our Editors' Choice columns and Product Update features. You can read about these products at www.tmworld.com/product_showcase.

> > > VOTE ONLINE for the Test Product of the Year

WWW. TMWORLD.COM/AWARDS ☆ DEADLINE: JANUARY 18, 2006

> Review more editors' selections for 2005: www.tmworld.com/product_showcase

BOARD & SYSTEM TEST

ScanFlex boundary-scan platform

GOEPEL ELECTRONIC, WWW.GOEPEL.COM

Created to extend boundary-scan tests beyond the capabilities embodied in the traditional IEEE 1149.1 standard, the ScanFlex platform supports IEEE 1532 for in-circuit programming, IEEE 1149.4 for analog boundary-scan test, and IEEE 1149.6 for AC boundary-scan tests. The modular ScanFlex supports serial scan-pattern rates to 80 MHz on as many as eight independent test-access ports (TAPs).

A ScanFlex system includes a boundary-scan controller, TAP transceiver modules, and optional I/O modules to support additional test instruments. Prices start at $4000 for a configuration having two independent programmable TAPs plus support for 32 dynamic digital I/O signals, two analog I/O signals, three static digital I/O signals, and three trigger lines.

SPECTRUM ANALYZER

RSA3408A real-time spectrum analyzer

TEKTRONIX, WWW.TEKTRONIX.COM

The RSA3408A can display frequency-domain plots over time, a feature that lets you see how the frequency content of a signal changes. That's important for viewing signals on devices such as cell phones, wireless LANs, radars, and RFID products that operate in several modes. The real-time feature lets you trigger an acquisition based on frequency anomalies that occur within any 36-MHz frequency range, and the analyzer can store any frequencies that occur within that range. Once it captures a series of signals, the RSA3408A lets you view them as time-correlated plots, so you can find which condition caused a particular frequency to occur. Prices start at $49,800.

X-RAY INSPECTION

XStation MX and ClearVue inspection system

TERADYNE, WWW.TERADYNE.COM

ClearVue 3-D x-ray imaging technology employs a patented off-center tomosynthesis imaging technique to enhance the detection of PCB solder and quality defects. ClearVue uses a stationary x-ray source and detector, avoiding rotating mechanical parts that can induce image errors with laminography and other 3-D x-ray techniques that employ a steerable x-ray beam in synchronization with a moving image detector and board under test. Teradyne reports an improvement in image clarity that enables users to achieve false failure rates of less than 500 joints per million inspected, with false calls reduced up to 40 times despite faster cycle times. A Teradyne XStation MX inspection system equipped with ClearVue technology costs from $500,000 to $600,000.

DATA ACQUISITION

PXI-5922 digitizer

NATIONAL INSTRUMENTS, WWW.NI.COM

Digitizing applications from audio to RF can take advantage of the PXI-5922 single-slot PXI card. Using NI's FlexII ADC, the card can change its resolution with sampling rate. For example, the card can change from 16 bits at 15 Msamples/s to 18 bits at 10 Msamples/s to 24 bits at 500 ksamples/s. Starting at $6495, the PXI-5922's FlexII ADC uses a 6-bit sigma-delta ADC that oversamples incoming signals at 120 Msamples/s. The multibit converter reduces noise and increases sampling rates over single-bit delta-sigma ADCs. A proprietary linearization technique results in the ADC's wide dynamic range at the high end of its frequency range.

> > >

SEMICONDUCTOR ATE

Sapphire D-10 test system

CREDENCE SYSTEMS, WWW.CREDENCE.COM

Built around a high-speed switched data network instead of a conventional bus-based implementation, the Sapphire D-10 leverages high-density CMOS integration combined with FPGA-based flexibility to provide a cost-effective test platform that performs wafer sort and final test for microcontroller, wireless-baseband, display-driver, and other low-cost consumer mixed-signal devices.

Priced from $169,000 for a digital system and ranging to $550,000 for a fully loaded configuration, the air-cooled system moves data between instruments and processors at sustained rates to 500 Mbyte/s. The Sapphire D-10 supports up to 768 digital pins and a full complement of analog and mixed-signal instruments—including industry-standard CompactPCI instruments as well as Credence in-house-developed implementations.

OSCILLOSCOPES

DL9000 series oscilloscopes

YOKOGAWA, WWW.YOKOGAWA.COM/TM

Yokogawa's DL9000 1.5-GHz and 1-GHz digital oscilloscopes let you adjust the sampling rate and waveform memory to match the needs of your application. With a starting price of $10,995, the scopes are available with 2.5 Msamples of waveform memory on each of four channels, with an "L" version containing 6.25 Msamples on each channel. You can also select the number of acquisitions the instrument sends to the screen each second. In accumulate mode, the scope overlays up to 2000 acquisitions on the screen (at 2.5 ksamples per acquisition) that you can scroll through to look for signal peculiarities. The scopes have an array of analysis functions that include mask tests and eye-pattern measurements such as jitter.

RF & WIRELESS TEST

ZVT 8 vector network analyzer

ROHDE & SCHWARZ, WWW.ROHDE-SCHWARZ.COM

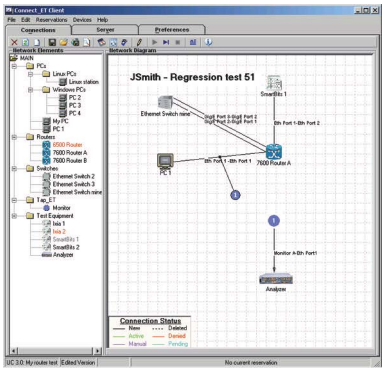
The world's first eight-port vector network analyzer operating to 8 GHz, the R&S ZVT 8, supports multiport and balanced-device measurements. Equipped with up to four independent sources, it can quickly perform swept multitone and intermodulation measurements on amplifiers and mixers. All ports can be driven in parallel, enabling simultaneous measurement of several DUTs or several paths of one DUT.

The ZVT 8's designers managed to integrate the multiple sources and receivers while maintaining high isolation to achieve a dynamic range greater than 120 dB. Other features of the instrument, priced from 36,380 euros, include an output power of at least 13 dBm at all test ports and an electronic level sweep range of 50 dB.

SOFTWARE

Lab Manager 4.1 software

EDENTREE TECHNOLOGIES, WWW.EDENTREETECH.COM



Lab Manager lets you automate test beds used for testing optical and RF networks and their components. It works with a variety of optical and RF switches from Apcon, Calient Networks, Gillerglass, Racal, Universal Switching, and others so you can reconfigure test networks without having to remove and reinstall optical or copper cables. Price varies with number of switches supported, with typical prices from $60,000 to $100,000. You save time and money switching from one UUT or series of tests to another. Lab Manager communicates with switches through an Ethernet link, sending commands to each switch for connecting the appropriate ports. The software hides the specific commands from you, letting you configure switches from its user interface.

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POWER

eLOAD series electronic loads

AMREL/AMERICAN RELIANCE, WWW.AMREL.COM

Designed especially for testing fuel cells, batteries, power supplies, solar arrays, and super capacitors, AMREL's eLOAD line of electronic loads offers closed-case calibration, so you can calibrate the units from the front panel instead of returning them to the factory. The eLOADS are available with operating voltages up to 1200 V, current dissipation to 5000 A, and wattage to 150 kW. An oscillation protection circuit slows the load to eliminate oscillations, and it compensates for long lead lengths and connections that contribute to the inductance. The AMREL eLOAD uses a bus plate instead of a bus bar to cancel out the unit's internal inductance. Prices start at $1675.

WIRELINE

OBR reflectometer

LUNA TECHNOLOGIES, WWW.LUNATECHNOLOGIES.COM

Luna Technologies' OBR optical backscatter reflectometer is the first component-level and module-level reflectometer with backscatter sensitivity. It lets you diagnose fiber-optic components and assemblies. You can measure minute reflections with 125-dB sensitivity and 40-micron spatial resolution. This year, Luna enhanced the $90,000 instrument, enabling it to test components connected with up to 300 m of optical fiber with submillimeter resolution. The long length lets you interrogate long, complicated optical networks such as runs between amplifier modules. You can adjust the instrument's dynamic measurement range from 0 dB to –130 dB. Software provides for data storage and manipulation.

FAILURE ANALYSIS

NC-1 noncontact probe system

SUSS MICROTEC TEST SYSTEMS, WWW.SUSS.COM

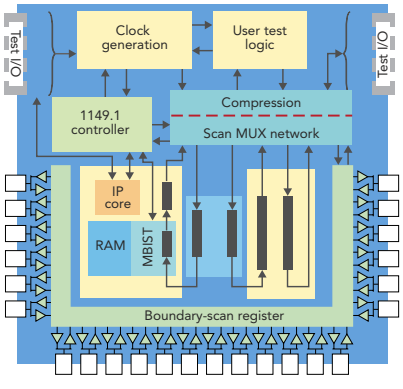
With the NC-1, Suss MicroTec has developed a patented system to acquire voltage and timing information from a DUT without physical or electrical contact. This system enables no-load, in-circuit probing of functional devices without the use of optical emissions for detection and acquisition, thus promising continued functionality well beyond the 65-nm range.

The NC-1 also makes unnecessary the addition of probe points via focused ion-beam (FIB) structures, which, even with the use of active probes, can alter circuit performance. The system, with a base price of $750,000, can function from the top side or backside of a device through a barrier oxide layer. The resulting data is presented graphically as a voltage-over-time trace.

ELECTRONIC DESIGN AUTOMATION

Encounter Test Architect software

CADENCE DESIGN SYSTEMS, WWW.CADENCE.COM



Employing a unified compiler-based approach to full-chip test, Cadence Encounter Test Architect allows design and test engineers to specify, compile, and verify all of the test structures for an entire chip using a single environment. Encounter Test Architect supports scan, compression, memory BIST, on-product clock generation, boundary scan, and I/O test to address designs containing multiple cores, hundreds of memories, and a complex hierarchy of RTL blocks.

Customers will benefit from Encounter Test Architect, priced at $250,000 per seat per year, with increased productivity, accelerated time to tape-out, reduced cost of test, and improved end-product quality. It makes unnecessary the use of disparate tools and homemade scripts to insert test structures into designs, thereby avoiding the costs and potential DFT errors that can affect traditional approaches.

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HONORABLE MENTIONS

Fetura zoom imaging platform

THALES OPTEM, WWW.THALES-OPTEM.COM

Driven by a supercharged optomechanical engine, the Fetura zoom module covers a 12.5:1 zoom range in 500 ms flat—10 times faster than conventional cam-driven zoom lenses. An onboard microprocessor and patented lens encoders significantly improve repeatability through closed-loop feedback, eliminating optical backlash and magnification approximations. The self-contained design of Fetura also reduces external wires to just one, while RS-232, FireWire 1394A, and USB connectivity options further streamline OEM integration. Engineered to withstand the forces of accelerated automation and positioning, Fetura performs reliably to 1 million zoom cycles. Base price: $4000.

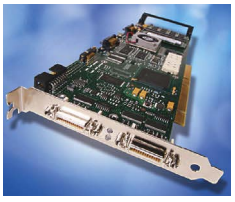
4500B peak power analyzer

BOONTON ELECTRONICS, WWW.BOONTON.COM

With the 4500B peak power analyzer, you can capture, display, and analyze RF power in both time and statistical domains. The analyzer's 8.4-in. color TFT LCD lets you view up to two live RF channels, two live trigger channels, two stored memory channels, and one live math channel simultaneously. It also offers 100-ps time-base resolution and more than 60-dB dynamic range to improve TDMA, GSM, and RF amplifier linearity testing. Base price: $17,825.

XRI-1200 digital image-processing board

DALSA CORECO, WWW.DALSA-CORECO.COM



Plugged into a computer's PCI-X slot, the XRI-1200 digital image-processing board meets the requirements of demanding x-ray imaging applications where images often contain motion artifacts and exhibit low-contrast, high-noise characteristics. The FPGA-based board performs image capture, shading correction, gamma correction, lens correction, motion detection, noise reduction, edge enhancement, and rotation with an arbitrary angle on a 1024x1024-pixel, 12-bit image at frame rates in excess of 30 frames/s. It is bundled with a dedicated software development kit and a suite of calibration and configuration tools that accommodate a variety of standard and custom data formats, including LVDS and Camera Link. Price: $3500 in OEM quantities.

MultiWriter ISP device programmer

CHECKSUM, WWW.CHECKSUM.COM

Increasing throughput and lowering costs, MultiWriter programs up to 24 serial in-system-programmable (ISP) devices simultaneously per board or multi-board panel at high speed. This in-circuit-test-based system handles virtually any serial bus protocol without the addition of new tester hardware and achieves programming speeds equivalent to those cited in the part's data sheet. MultiWriter is available as part of a CheckSum-developed application package that includes a bed-of-nails test fixture and associated test program operating on a CheckSum Analyst in-circuit test system. Price: less than $20,000 for an average fixture and program with 2000 points and MultiWriter ISP functionality.

YieldAssist DFT tool

MENTOR GRAPHICS, WWW.MENTOR.COM

Part of Mentor's design-for-test product portfolio, the YieldAssist diagnostic tool allows semiconductor manufacturers to harvest device failure information from the wafer-sort phase of manufacturing test. By identifying both systematic and random defects, YieldAssist speeds root-cause failure analysis and improves device yield. YieldAssist also provides a critical link back into the design process for improving design for manufacturability as well as for adaptively improving the quality of the manufacturing test itself and reducing defect per million (DPM) rates. Base price: $126,000 per year for a term-based license.

VNA Master vector network analyzers

ANRITSU, WWW.US.ANRITSU.COM

Lightweight and portable, the VNA Master MS2024A and MS2026A handheld vector network analyzers perform vector-corrected one-port and one-path/two-port measurements over a frequency range of 2 MHz to 6 GHz. The analyzers' RF immunity rejection of up to +17 dBm ensures high-accuracy measurements when used to deploy, verify, and troubleshoot military/defense and commercial wireless networks. High and low power settings for two-port measurements eliminate the need for external attenuators. Base price: $15,645.

Versatest V5500 memory tester

AGILENT TECHNOLOGIES, WWW.AGILENT.COM

The Versatest V5500 enables single-insertion testing of multichip package (MCP) devices containing multiple memory types (flash, DRAM, and SRAM), as well as discrete flash memory. What's more, the V5500 offers an optional programmable interface matrix that provides 16,384 pins per test head. Using the matrix, you can obtain up to four times the parallelism at final test—for up to 320 NAND flash devices in parallel or up to 256 NOR flash and MCP devices in parallel. Base price: $1.3 million for a system capable of testing 256 devices in parallel.

UltraFLEX production test system

TERADYNE, WWW.TERADYNE.COM

As a member of the FLEX test platform, the UltraFLEX system offers the digital speed and pin count needed for multisite testing of complex, high-performance devices used in computing, graphics, audio/visual, and networking. The system provides background DSP processing to reduce overall test time. It can be configured with digital, AC, and DC test resources, and it provides full synchronization and control of each test instrument on a vector-by-vector basis. The FLEX platform employs a universal-slot test head and high-density instrument design so you can match system configurations to changing production requirements right on the test floor. Base price: less than $1 million.

BERTScope CRU 12500A clock recovery unit

SYNTHESYS RESEARCH, WWW.BERTSCOPE.COM

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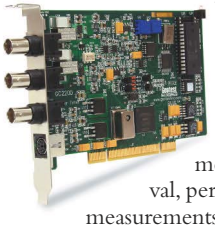
according to the manufacturer, the widest loop bandwidth available for jitter testing on the market today. The CRU 12500A also allows full control of key parameters, including loop bandwidth, peaking/damping, and roll off. You can recover full rate clocks—including spread-spectrum clocks used in Serial ATA (SATA), Serial Attached SCSI (SAS), PCI Express, and Fully Buffered DIMM (FB-DIMM) applications—for signals at data rates from 150 Mbps to 12.5 Gbps. Base price: $29,000.

GC22x0 PCI universal time-interval counters

GEOTEST—MARVIN TEST SYSTEMS, WWW.GEOTESTINC.COM

The GC22x0 series of universal time-interval counters consists of three 3U PCI boards capable of measuring frequencies



up to 2 GHz. In addition to adjustable input trigger levels, these boards provide A and B channels for ratiometric measurements, as well as interval, period, and frequency measurements. The GC22x0 series achieves a frequency resolution of 10 digits in just 1 s and resolves time measurements to 100 ps. Prices: $1850 to $3850.

N4903A serial bit-error-rate tester

AGILENT TECHNOLOGIES, WWW.AGILENT.COM

The N4903A high-performance serial bit-error-rate tester (BERT), which offers complete calibrated jitter tolerance testing (J-BERT) in a single instrument, can perform BER tests on popular serial buses such as PCI Express, SerialATA, Fibre Channel, and Gigabit Ethernet. The N4903A also performs eye contour and mask testing, spectral jitter decomposition, and error-location capture, and it features 20-ps transition times and 50-mV analyzer sensitivity. With all jitter sources calibrated in one box, the unit shortens development time, so even engineers without jitter expertise can have the unit running within minutes. Base prices: 7-Gbps version—$120,000; 12.5-Gbps version—$160,000.

Model 1281 arbitrary waveform generator

TABOR ELECTRONICS, WWW.TABORELEC.COM

This single-channel arbitrary waveform generator packs 1.2-Gsamples/s sample clock performance, large waveform memory (8 Mbytes standard, 16 Mbytes optional), and a powerful sequence generator into a small, half-rack case that is just 2U high. The Wonder Wave Model 1281 lets you create very large, complex waveforms up to 400 MHz with 12 bits of resolution for less than $15,000. It also provides square wave transition times of less than 700 ps. Calibration and updates are computer controlled through the GPIB, LAN, or USB 2.0 port. Base price: $14,175.

WaveExpert sampling oscilloscope

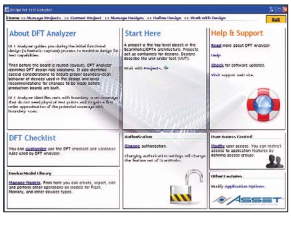
LECROY, WWW.LECROY.COM

What LeCroy calls a "near-real-time oscilloscope," WaveExpert combines the high bandwidth and accuracy of a sampling oscilloscope with the speed and flexibility of a real-time instrument. The WaveExpert series offers up to 100-GHz bandwidth, as well as signal acquisition speeds that are 100 times faster (10 Msamples/s) and memory depths 125,000 times deeper (512 Mpoints) than conventional sampling scopes. A coherent interleaved sampling mode enables the capture and display of long serial data waveforms without the need for an external pattern trigger. WaveExpert also produces time-domain reflectometry (TDR) pulses that have 20-ps incident rise times. Base price: $21,500.

DFT Analyzer boundary-scan test software

ASSET INTERTECH, WWW.ASSET-INTERTECH.COM

Comprising three tools that are employed at different stages in product development, the DFT Analyzer validates the boundary-scan (IEEE 1149.1/JTAG) design-for-test features of a circuit-board design before prototypes are assembled. It determines the extent of a design's boundary-scan test coverage and recommends changes that would increase coverage. The final output of DFT Analyzer is a complete boundary-scan description of the design that can be imported directly into the boundary-scan test-generation tool in ScanWorks, the company's JTAG system. Base price: $10,000 for limited-term licensing.



HPB-5B high-power burn-in system

MICRO CONTROL, WWW.MICROCONTROL.COM

Able to test logic and memory devices up to 150 W, the HPB-5B burn-in system leverages individual pattern zones per burn-in board with individual temperature control for each device. The system

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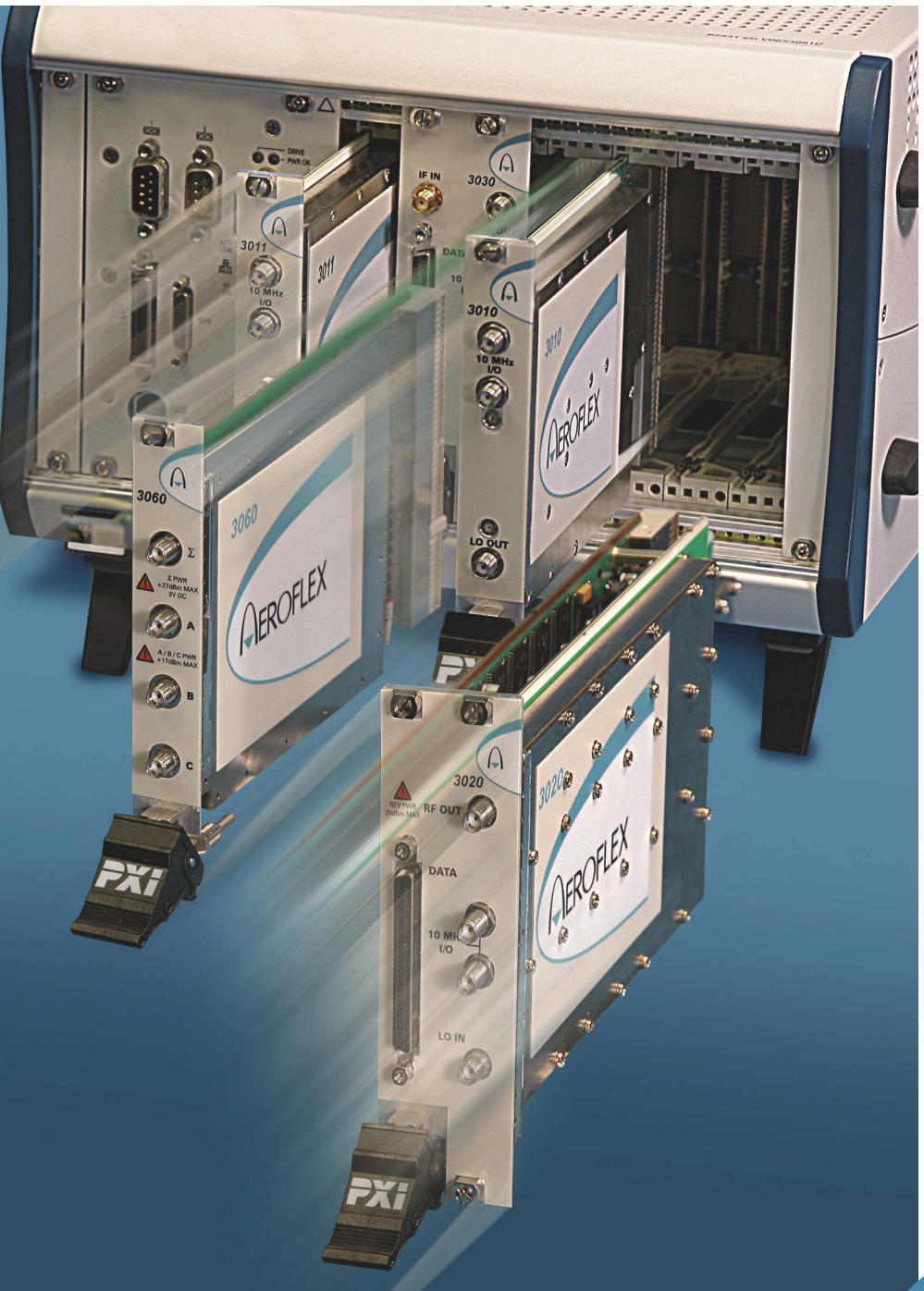

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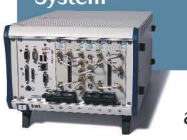

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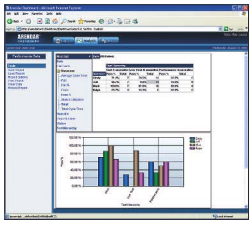
VI TECHNOLOGY, WWW.VI-TECH.COM

Arendar 2006 software offers a scalable solution to collecting, organizing, and extracting valuable information from your design, validation, and manufacturing test data through a standard Web browser. Drag-and-drop multidimensional test-performance analysis leverages online analytical processing (OLAP), data cube, and business intelligence technologies to allow you to view product test information from an unlimited number of perspectives, such as by date, by test station, by product, by product line, by operator, and by test revision. Arendar uses Microsoft SQL Server and Oracle databases to safely store and retrieve data without requiring a database administrator or IT expert. Price: Arendar Desktop—$3995; Arendar Enterprise Server—from $9995.



Series 2600 System SourceMeter instruments

KEITHLEY INSTRUMENTS, WWW.KEITHLEY.COM

Based on a high-throughput source measure unit (SMU) in a modular instrument form factor, the Series 2600 System SourceMeter platform provides multichannel scalability for cost-effective testing of electronic components and semiconductor devices. The single-channel Model 2601 and dual-channel Model 2602 can be used as stand-alone SMUs or seamlessly integrated into systems of virtually any channel count through TSP-Link, Keithley's 100-Mbps serial bus for communication and trigger coordination. An embedded test script processor lets you program a sequence of test commands and execute high-speed automated test sequences independently of a PC operating system. Base price: Model 2601—$5495; Model 2602—$7995.

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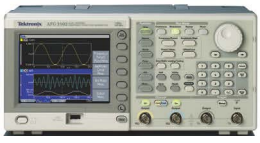
Combining an arbitrary waveform generator, function generator, and pulse generator into a single compact instrument, the AFG3000 Series focuses on usability, simplicity, and performance at an affordable price. The six-model series offers frequencies up to 240 MHz and sampling rates up to 2 Gsamples/s. Dual-channel models allow independent selection of waveforms and frequencies. A 5.6-in. display shows all relevant waveform parameters and graphical waveform shape at a single glance. Shortcut keys provide direct access to frequently used functions and parameters, while a USB connector on the front panel enables waveform storage to a memory device. Prices: $1780 to $8500.



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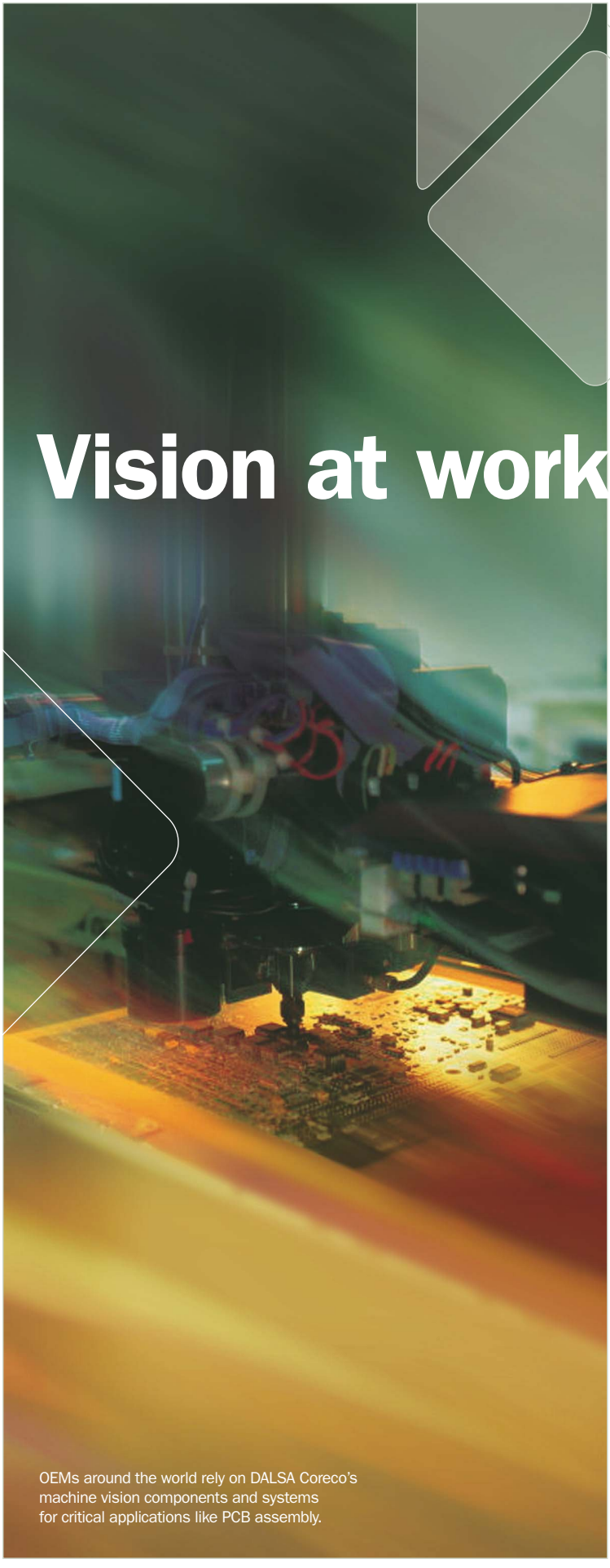

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PROCESS CONTROL KEEPS FAULTS IN CHECK

PAMELA LIPSON, IMAGEN AND LANDREX TECHNOLOGIES,
AND LYLE SHERWOOD, SYNQOR

Most electronic assembly lines produce some defects, or faults. For example, solder-paste printers may deposit excess, smudged, or insufficient quantities of solder, and component pick-and-place equipment may improperly place or orient components. Such faults reduce first-pass PCB-assembly yields, sometimes over short periods, but more typically over extended times (**Figure 1**).

To catch these defects, many manufacturers use automated optical inspection (AOI) equipment to identify problems that workers then fix at the end of the assembly line. This tactic is fine when a company can absorb the cost of rework and field failures, but for PCB manufacturers who compete in a market with small profit margins, these costs can be unacceptable.

PCB manufacturers would be wiser to use AOI to help line managers acquire quantitative inspection information that they can use to adjust their processes and reduce defects in the first place. First-pass production of PCBs with fewer defects cuts costs, saves time, and reduces the need for rework employees. By using an AOI system to perform process monitoring, manufacturers can:

- identify quality problems that develop during the startup of a new production line,
- maintain high-quality production on an existing line, and
- shorten setup times required by changes.

For example, one manager who used an AOI system to acquire and analyze data from 1 million PCBs, assembled during a five-month period, decreased defects tenfold. AOI data let the manager adjust production variables as they occurred and before they could cause defects. These slight process corrections consistently kept the number of defects low.

AOI data can also help a line manager stabilize the assembly of a new PCB type so PCBs are assembled properly the first time. We have heard from managers who report a 50% reduction in the time needed to stabilize production of a new type of PCB as a result of acquiring and analyzing inspection information.

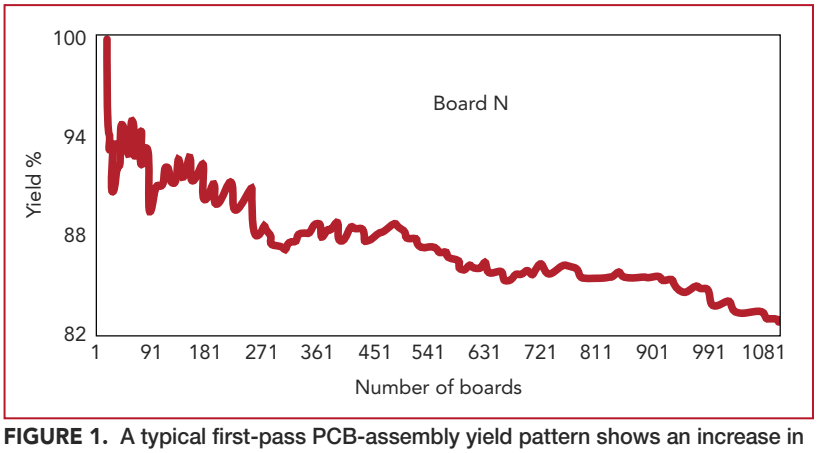

FIGURE 1. A typical first-pass PCB-assembly yield pattern shows an increase in defects over time.

Catch the drift

To uncover the root cause of defects and take corrective action, a line manager must determine whether defects occur at random or as the result of production-system problems. Using an AOI system, a manger can gather quantitative optical-inspection data that illuminates patterns and pinpoints the source of problems.

Many engineers know about optical-inspection attribute data that produces "go/no-go" decisions, but they may misunderstand the need for variable data, which comes from quantitative measurements of solder volume, part placements, and so on. To provide useful results, an AOI system must supply variable data with a tenfold increase in repeatability and accuracy over that found in assembly equipment, such as a pick-and-place machine. A post-placement AOI system installed to inspect for the placement drift of a 0402-size SMT device, for example, must offer a precision of 100 µm and a repeatability of ±10 µm. That ratio represents a Gauge Repeatability and Reproducibility (GR&R) value of 10%.

During the past seven years, we have used the Optima 7200 AOI system from Landrex Technologies to profile the PCB-assembly processes and analyze the post-placement processes at many companies. The analyses encompass many types of PCBs, such as those used in cell phones, PCs, and servers. The Optima 7200 operates as a post-placement inspection system that provides attribute data, such as missing part, wrong part, and wrong label. The system also precisely measures component positions to furnish variable data. Careful analysis of the data, at several "levels," can quickly improve first-pass PCB production yield.

Until recently, though, many companies that assemble PCBs have not collected this type of data. Data collection and analysis take time, talent, and money. Often, production-line managers and AOI experts spend so much of their time trying to keep a production line up and running that they have little time to gather data for subsequent systematic analysis. Newer AOI systems, though, offer high-precision measurements that will help line managers translate accurate inspection information into lower PCB defect rates and higher profits.

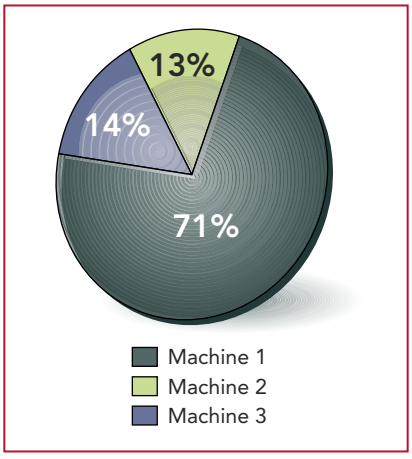

FIGURE 2. By relating defects to a specific machine, line managers can make corrections and increase yield quickly.

Our work has confirmed that the use of optical inspection of PCBs during production can reduce defects. These five examples illustrate ways in which PCB manufacturers used AOI to increase yield:

- **Machine-level analysis.** Even a simple analysis of AOI data can reveal "macro" defect patterns. During a case study, a production-line manager inspected 1 million PCBs assembled by three separate parts-placement machines. After analyzing assembly defects—based on attribute data—over several months, the manager found one placement machine caused 71% of the defects (**Figure 2**). When the production staff adjusted the machine to reduce the defects, the first-pass yield increased. In this case, the AOI system tracked specific defect types and their sources.

- **Part-level analysis.** Sometimes, the root cause of a decrease in PCB-assembly yield relates only to a few parts. During a two-week period, we analyzed the AOI data from a run of PCBs. This attribute data indicated the proper vs. improper positioning of components on a PCB. The Pareto chart (**Figure 3**) shows that three parts—the MICRO8 ball-grid-array (BGA) package, the 0805C-CT tantalum capacitor, and the EMT3-x small outline transistor (SOT)—caused the most defects. When line managers adjusted the production equipment to properly place these three components, PCB-assembly defects declined by 80%.

- **Part-level analysis on one board.** During inspection, we acquired variable data for the positions of the same components used to plot the Pareto chart in Figure 3. An analysis of the data revealed details about the expected position of the components and the positions at which the AOI equipment found them. In this

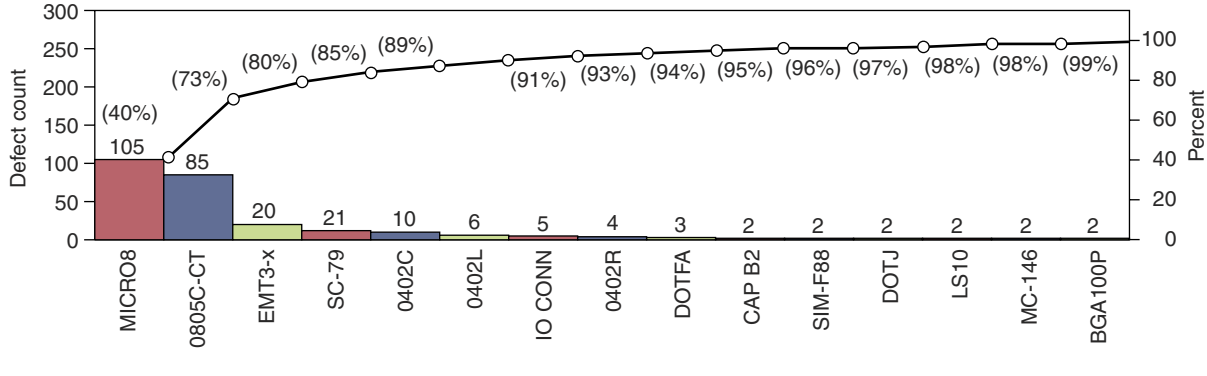

FIGURE 3. A Pareto chart plots defect types from largest to smallest numbers so managers can solve problems in order of how they affect quality.

case, we reviewed all the part-placement information for one type of PCB. A scatter-plot diagram (**Figure 4**) shows the difference between the expected and the actual part locations. (The scatter plot shows PCB reference designations rather than package types.)

Each red dot on the chart represents a component on the PCB, and each rectangular label calls out a specific component class. The inner and outer rings indicate the 4-mil and the 8-mil process limits, respectively. From the plot, you can see five component classes—H11, U2, J5, U4, and C33—cause the most defects. Production equipment placed one or more of these parts more than 8 mils away from its expected position.

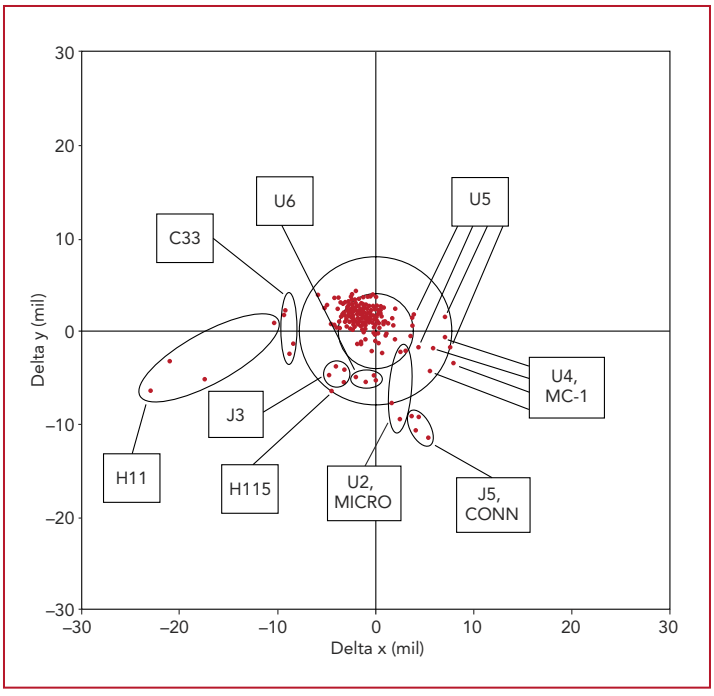

FIGURE 4. A scatter plot shows the difference between expected and actual part position as measured by AOI equipment for one board.

If you look closely at the plotted data, you will see components labeled J3, U6, U5, and H115 do not yet cause gross defects during PCB assembly because they fall within the 8-mil process-control limit. But component-placement equipment has put them more than 4 mils away from their expected positions. Without any corrective action, placement of these components may drift outside the 8-mil limit, which will cause assembly defects.

The chart in Figure 4 also shows that the component-placement equipment puts the majority of parts off center. If managers do not correct this centering problem, they soon may experience many more defective PCBs as placements drift farther from the center "target" position. Although not plotted here, analysis of data acquired from several of the same PCBs produced the same variable-data "signature," which indicated a system-level production problem.

• **Part-level analysis across boards.** Although the plot in Figure 4 suggests a centering problem, information such as this may not tell the whole story. Further investigations showed the component-placement equipment always placed an SOT "off pad" in what seemed like a random manner. When we examined the Δx and Δy positional data for the SOT on many PCBs, however, we saw something different: The production equipment placed the SOT at a constant displacement in a

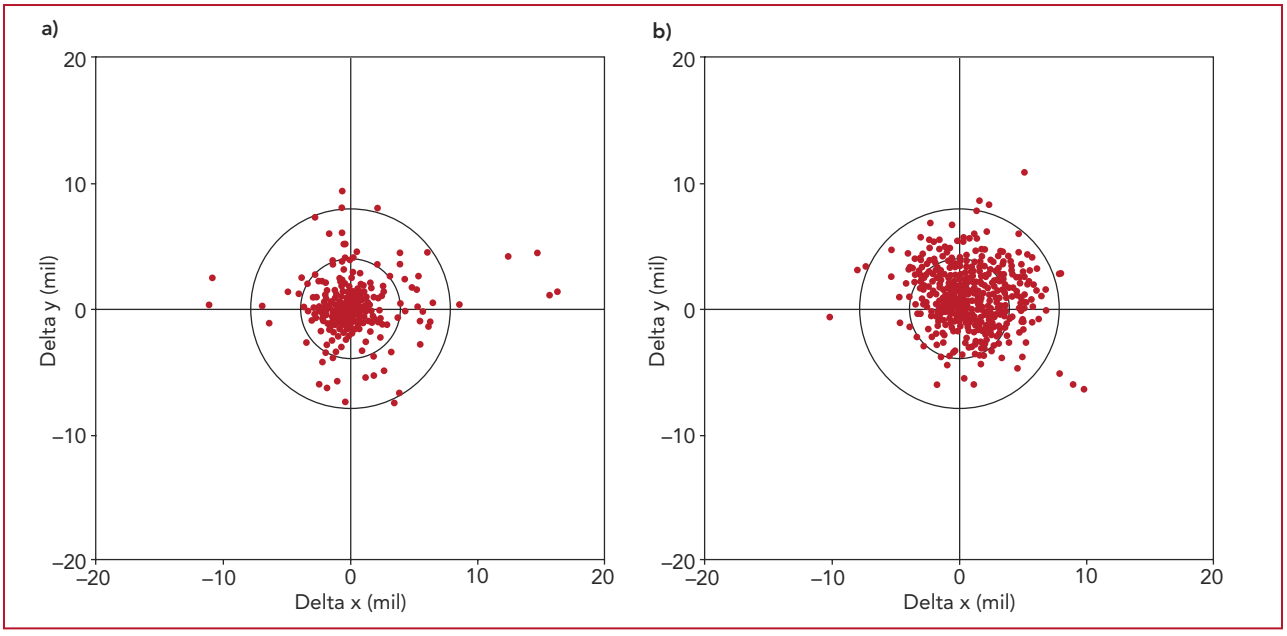

FIGURE 5. a) Production Line 1 showed many defects, but most part placements took place within the 4-mil target. b) By comparison, Line 2 showed fewer overall defects, but poorer parts-placement accuracy, which may cause more defects in time.

radial direction around its target position. To production managers, this "signature" indicates a bent nozzle used to place the component. (A bent nozzle will place a part a fixed distance from its intended location, but at a different radial position that depends on the rotation of the nozzle at the time of placement.) After we identified the root cause of the defect, the line manager quickly solved the problem.

• **Board-level analysis across assembly lines.** One common hypothesis holds that two production lines outfitted with the same equipment and set up to build the same PCB should yield similar results. To test this hypothesis, we ran an experiment that placed two identical AOI machines on two seemingly identical production lines that assembled the same PCB design. Based on the acquired data, we characterized the manufacturing process on each line.

The two production lines, Line 1 and Line 2, produced different defect profiles that resulted from different causes. Overall, Line 1 produced about three times as many defects as Line 2. The plotted data for a series of boards shows equipment on Line 1 (**Figure 5a**) placed the majority of the parts well within the 4-mil tolerance window. In contrast, Line 2 (**Figure 5b**) produced a few defects just outside the 8-mil tolerance window, but all parts showed a high variability of placement. Line-2 production equipment placed the majority of components 2–6 mils off center, so this line does not adequately control the component-placement process.

Although Line 1 may seem more problematic, because of the number of far-ranging defects it produced, you can expect Line 2 to produce more problems in the long run due to the wide variations of placement differences. But this cloud has a silver lining: You can use the variable-process data to catch and correct large and subtle defect trends before you end up with a lot of incorrectly assembled PCBs.

These examples show how production-line managers have taken a strategic approach to process control. By combining their knowledge of manufacturing processes and quantitative trend information from inspection equipment, they can keep PCB-assembly lines under control, which in turn reduces defects and manufacturing costs. T&MW

Pamela Lipson *launched Imagen (Cambridge, MA) after receiving a PhD from MIT in 1997. Her company develops computer-vision technology for a variety of different consumer and industrial fields including the automated inspection of electronic products. She also serves on the Landrex Technologies Board of Scientific Advisors. lipson@imagen-inc.com.*

Lyle Sherwood *works as a senior manufacturing engineer at SynQor (Boxborough, MA). During his career, he has spent more than 10 years developing new machine-vision technologies. He earned his BSE in bioengineering at the University of Illinois.*

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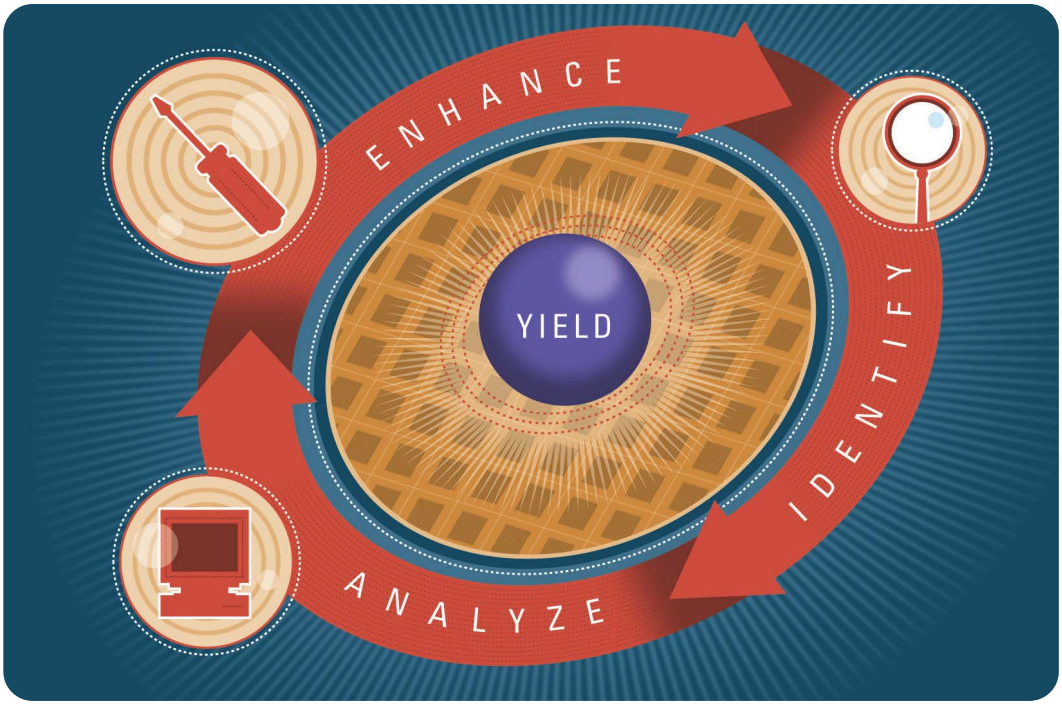

SCAN TEST DRIVES YIELD

TEST FAILURE DATA PROVIDES A TREASURE TROVE OF INFORMATION THAT CAN IMPROVE SEMICONDUCTOR PRODUCTION PROCESSES AT 90 NM AND BELOW.

MARK CHADWICK, MENTOR GRAPHICS

Yield enhancement has taken on added significance as IC feature sizes shrink below 90 nm, especially in the area of effective test methodologies. In fact, in the most recent version of the International Technology Roadmap for Semiconductors (ITRS; http://public.itrs.net), all of the most difficult challenges for yield enhancement are directly related to test methodologies and defect identification.

Yield enhancement can basically be broken down into a three-step process:

- isolating failing devices,
- determining what caused the failure, and
- implementing corrective changes to improve yield.

Traditionally, production test has focused primarily on the first step—isolating failures—but recent advances in scan-based test have expanded production test's role to include the other two steps as well. For example, failure-diagnosis tools are determining the cause of device failures, and design-for-manufacturing (DFM) tools are focusing on implementing corrective changes.

More workload for scan test

The past 10 years have seen a dramatic shift from functional testing to scan-based test techniques that provide high fault coverage with concise metrics for gauging relative test quality. Until now, the primary focus of scan test has been to minimize test escapes—those parts that pass all manufacturing tests but end up failing in the field. Determining why the parts fail has been of secondary importance: Essentially, the scan tests have been pass/fail. To uncover possible causes of failures, semiconductor manufacturers have employed in-line inspection and failure analysis on a small subset of devices.

Devices that end up in the failure bin offer a gold mine of information, but taking time to analyze only a small sample of the failed devices delays the implementation of corrective action and leads to lost profits while your yield remains low. Scan test gives new life to defective devices by letting you analyze them as part of the test process to determine the exact cause of the failure and gain insight to yield improvement.

It is scan test's methodical nature that makes it effective for isolating defects. Because each structural element of the logic design is targeted during automatic test-pattern generation (ATPG), the tester can use failure information to find the logical location of the defective behavior. In a sense, scan-test failure-diagnosis algorithms reverse the process of ATPG to find offending logic that causes a scan test to fail.

Figure 1 outlines the basic operation of scan-test failure diagnosis. When a device fails on the manufacturing automated test equipment (ATE), the tester generates a log file that indicates what test patterns failed, which scan chain contained the failure, and which bits differed from what was expected. A scan-test failure-diagnosis tool correlates this information with the test-pattern stimulus and expected results. The tool uses the logical gate-level netlist to derive the suspected locations that caused the test failure, and it uses both failing and passing patterns to further isolate the suspected location.

Unfortunately, ATE normally has a relatively small buffer for logging failure data during manufacturing test, so the information is often truncated. This lack of data puts a heavier burden on the diagnostic tool. One solution is to rerun the test off the production line, but this method can be difficult to implement because you need to replicate all of the production-line test conditions.

Failure diagnosis can be further complicated by test-vector compression techniques that make diagnosis difficult, if not impossible. Therefore, you should use a test-compression approach that permits diagnosis directly from the truncated production test failure logs, without requiring any special patterns (Ref. 1).

The output from a scan diagnostic tool is shown in **Figure 2**. Because individual defects can cause multiple test failures, the tool groups the defects into "symptoms." Each symptom can be caused by one or more "suspects," depending on the complexity of the failure and the amount of failure-log information collected. Using advanced diagnostic algorithms, the tool classifies the suspects into different types. As an example, a bridging defect (the symptom) between two logic signals will likely have at least two suspects—one for each side of the bridge. Likewise, an open defect could be caused by multiple suspects due to the disconnection of pins.

The report shown in Figure 2 only deals with the logical location of the suspects. To determine the location and type of the actual silicon defect, physical information must be correlated to the logical location. The physical characteristics of the failing logical locations can help determine the type of defect. For example, an investigation of the physical view can determine whether a suspected bridge in the logical domain is possible physically.

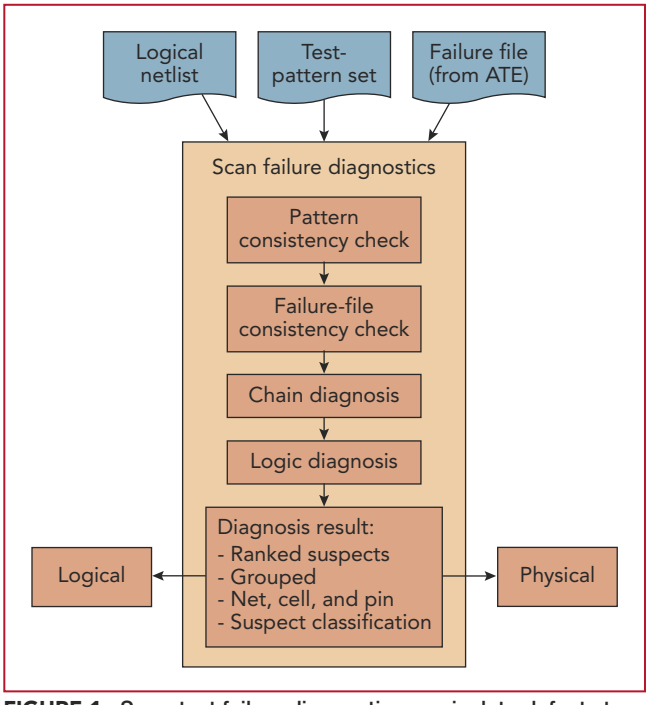

FIGURE 1. Scan-test failure diagnostics can isolate defects to logical and physical levels based on netlists, test patterns, and ATE failure data.

Targeting failures

ATPG tools have typically focused on achieving the highest fault coverage with the minimum number of patterns, a practice that made sense because of the test-time and pattern-count limitations that ATE imposed. To keep the number of patterns low, pattern sets were not optimized for isolating defects in the event of test failures. Fortunately, test-pattern-compression technology now offers compression ratios up to 100X, which has eased most test-time and pattern-count concerns. Compression permits the addition of scan tests that can target particular defect types, thereby providing for more accurate failure diagnosis. Here again, the physical layout information can be used, but this time to help to optimize the test-pattern generation itself.

As an example, look again at bridging failures. To target bridges during ATPG, you can use a two-pronged approach. First, you can use the physical layout to determine which nets are most susceptible to bridges, and you can generate tests that target those bridges.

Then, because it is nearly impossible to develop rules that target all possible bridges, you can apply a second step—focused in the logical realm that augments the conventional fault models. In this, called the multiple-detect method, a traditional ATPG tool generates patterns targeting each fault multiple times in order to increase the probability of detecting nonmodeled defects without using layout information. With this method, each net is activated multiple times (Ref. 2). With other nets being set to opposite logical values, the probability of uncovering different bridges increases.

The combination of both of these steps greatly increases your likelihood of un-

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lot_id=1245
wafer_id=5961
tracking_info_end
#symptoms=3 CPU_time=21.39sec fail_log=fail_logs/X59Y61.log.nochain.mentor
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symptom=1 #suspects=1 #explained_patterns=5
suspect  score  type    value  pin_pathname  (cell_name)  (net_pathname)
-------------------------------------------------------------------------------
1        100    STUCK   0      /a0/m_1/m_55/B  (NR2M2D)    (/a0/m_1/pi26)
-------------------------------------------------------------------------------
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-------------------------------------------------------------------------------
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-------------------------------------------------------------------------------
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4        64     BRIDGE_2WAY  0      /a0/m_1/m_3/A (NR2M2D) (/a0/m_1/m_3/pi16)
-------------------------------------------------------------------------------
```

FIGURE 2. A scan-test failure-diagnostics output report groups defects according to symptoms that may be exhibited by one or more suspects.

covering bridge defects during scan test and being able to identify the location of the bridge during failure diagnosis.

Adopting a diagnosis strategy

Implementing a scan-test failure-diagnosis methodology can require significant planning across multiple organizations, each using a variety of tools. To begin, the design-for-test (DFT) engineer creates the scan-pattern test sets. Then, these test-pattern sets are converted to an ATE program by a test engineer. Failure logs from the ATE must be gathered after manufacturing test. These logs need to be converted to a format readable by the scan failure-diagnosis tool. At the time of diagnosis, the tool will need to read the failure log, the logical netlist, the test patterns, and possibly the physical layout.

The coordination of all this data can span across different groups within one organization, over months or years, and can even involve different companies. Ensuring the consistency of the data during the entire process can be a significant challenge, so it is helpful if you use a diagnostic tool that can determine data consistency and assist in troubleshooting.

Putting scan-test failure diagnosis into the manufacturing flow requires efficient data collection and rapid analysis. The resulting information from diagnosis will have to be fed into larger manufacturing databases and also sent to failure-analysis equipment for subsequent deprocessing and defect isolation.

Tools are now available that extend scan test's application to failure diagnosis and analysis. These tools look at the problem from a failure-analysis (FA) engineer's point of view, thereby reducing the need for being a "DFT expert" in order to get meaningful results.

As yield improvement takes center stage, scan-test failure diagnosis is proving to be a key component for monitoring manufacturing defects and enabling rapid corrections to systematic yield loss. As the ITRS has indicated, the industry must still overcome significant challenges before this failure diagnosis is integrated into the overall process. The development of scan-failure diagnosis tools is helping manufacturers meet these challenges. T&MW

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Mark Chadwick *is a product marketing manager for Mentor Graphics' DFT Division in Wilsonville, OR. He has worked in EDA and DFT for more than 17 years, most recently at Credence Systems before joining Mentor Graphics. He has a BSEE from the University of Wisconsin.*

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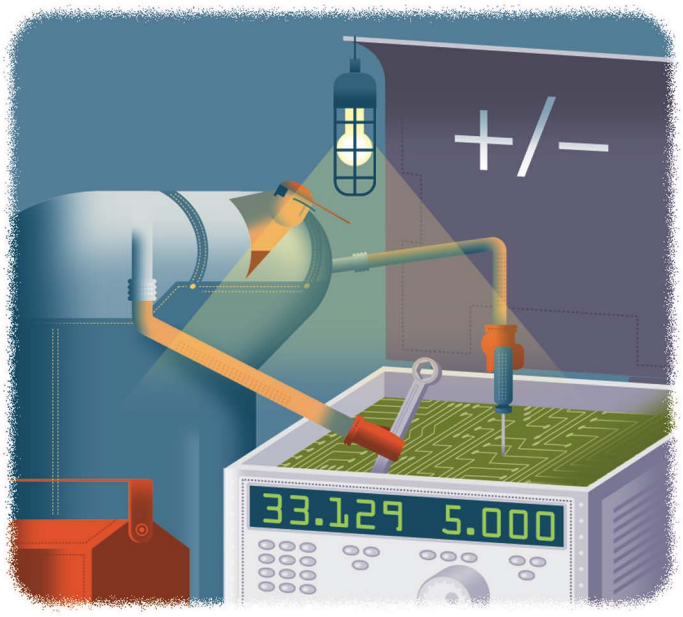
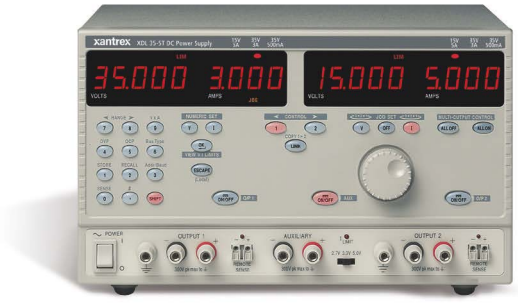


DANIEL GUIDERA

Manufacturers follow different procedures when calibrating variable DC power supplies.

Ensuring power supply ACCURACY

MARTIN ROWE, SENIOR TECHNICAL EDITOR



Dual displays measure output voltage and current. Courtesy of Xantrex.

Front-panel controls and a communications bus let you control a system power supply's output. Courtesy of Kepco.

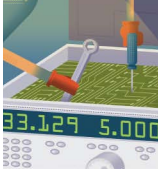
Every day, you count on programmable system and bench DC power supplies to deliver voltage and current to products under test. You expect these supplies to deliver outputs that cover wide ranges while remaining within specified tolerances. To ensure their DC power supplies fulfill such expectations, manufacturers calibrate the instruments before shipping them to customers, yet no two manufacturers follow an identical calibration procedure.

Why calibrate?

In adjustable supplies, a reference voltage sets the output, and it's that voltage that requires calibration. For many years, power supplies used potentiometers to set their outputs. Some supplies still do, but mechanical potentiometers tend to drift. Digital potentiometers replaced mechanical ones in many supplies, which improved stability.

New power-supply designs use digital-to-analog converters (DACs) to produce voltages from digital signals that originate from a front panel or an external communication bus. A DAC's output becomes the reference voltage that controls a power supply's output. DACs are more stable than potentiometers, but they still require initial and periodic calibrations. Programmable, DAC-based power supplies, unlike their potentiometer-based predecessors, don't need their cases opened for calibration.

Because of component tolerances, a given reference voltage won't result in an identical output voltage in every unit that comes off the assembly line. To compensate for those differences, each supply's DAC must produce a slightly different reference voltage for the same output setting. A power supply's processor applies correction factors, called calibration constants, that alter a DAC's input, which in turn alters its output. Manufacturers calculate those constants by taking measurements on a supply's output during calibration. Mark Edmunds, director of engineering at Xantrex, reports that his company's power supplies are typically accurate to within 2% prior to calibration and to within



0.5% after the calibration constants are applied

A test setup for a programmable power supply consists of an isolation transformer, a variable AC power source, switches, loads, a DMM, and a computer that automates the procedure (**Figure 1**). Some manufacturers also include an oscilloscope for measuring output ripple and noise. (The online version of this article contains links to more detailed test setup schematics from Kepco and Xantrex, www.tmworld.com/2005_12.)

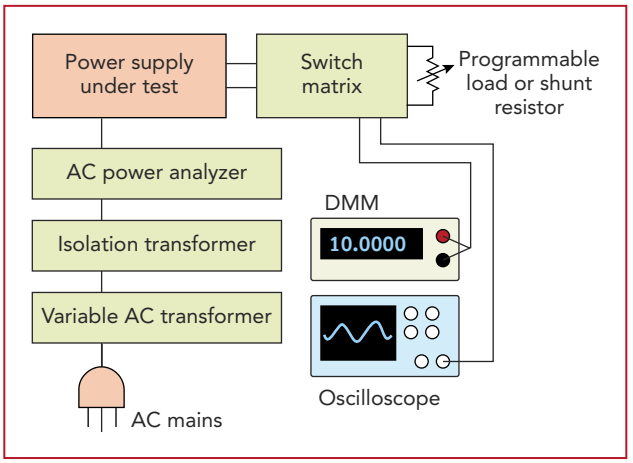


FIGURE 1. A switch matrix connects measurement instruments and loads to a power supply under test.

The use of an isolation transformer eliminates ground loops that cause errors and create safety hazards. A variable power source lets engineers and technicians test a supply at its high and low AC voltage limits, called a line-regulation test. By using programmable electronic loads, manufacturers can use the same test setup for numerous power-supply models. (See "Loads need calibration, too," below.) Some test setups also contain an AC power analyzer that lets engineers test a power supply under known power conditions. Xantrex's Edmunds, for example, uses an AC power analyzer to record input voltage, current, power, and power factor on a UUT's AC input.

The key instrument in a power-supply calibration and test setup, though, is a DMM. The DMM measures a supply's output voltage and also measures its output current by measuring the voltage across a shunt resistor. Power-supply manufacturers use a bench DMM with at least 5½ digits of resolution, because they need to detect small voltages such as 1 mV out of 30 V. Some manufacturers, however, use 6½-digit DMMs, and Agilent Technologies uses its 8½-digit DMMs.

The switches in the test setup serve various functions. An automated calibration setup needs switches to connect the load to the UUT. Other switches may connect a DMM and a scope to a supply's output. Some DMMs include switches that can connect them to a UUT's output or load. Engineers at Kepco built a test fixture that includes switches to make the load and instrument connections; the switches are programmable though an IEEE 488 port.

Different procedures

Although the test setups are similar, the calibration procedures for voltage levels and load conditions vary among power-supply manufacturers. Some manufacturers perform two-point calibrations on unipolar power supplies with their supplies at 0 V and at full scale. Others perform two-point calibrations at 10% and 90% of full-scale settings from which they calculate gain and offset calibration constants ($mX+b$).

The two-point calibration isn't a universal practice, though. "We calibrate our Sorensen line of low-power DC supplies at five points," said Elgar application engineer

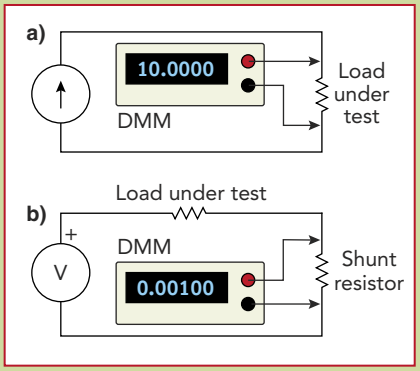
Loads need calibration, too

Calibrating an electronic load is essentially the inverse of calibrating a power supply—only more so because loads can operate in constant voltage, constant current, constant resistance, and constant power modes. "Calibrating an electronic load takes about four times as long as calibrating a power supply," said Javier Camarillo, applications engineer at AMREL.

To calibrate a load, an AMREL technician will use a DC power supply to provide a voltage or current to the load, depending on the mode. For constant voltage, a technician applies a known current to the load and measures the voltage across the load with a DMM, entering the measured values into the load that become the calibration constants (see **figure**). For constant current, a technician applies a voltage to the load through a shunt resistor (0.01 Ω ±0.005 Ω), measures the voltage across the shunt, calculates the current through the shunt, and enters that value into the load. Both constant voltage and constant current modes need two calibration points. AMREL uses 10% and 50% of full scale, said Camarillo.

Constant-resistance and constant-power calibrations require a known voltage and a known current. A technician measures both voltage across and current through the load and enters those values into the load to get the calibration constants. He or she makes four pairs of measurements—one each with the known voltage and current in both high and low settings (10% and 50%).

Martin Rowe



a) To calibrate a power supply's constant-voltage mode, a DMM measures the voltage across the load. b) To calibrate the constant-current mode, the DMM measures the voltage across the shunt to calculate current in the load.

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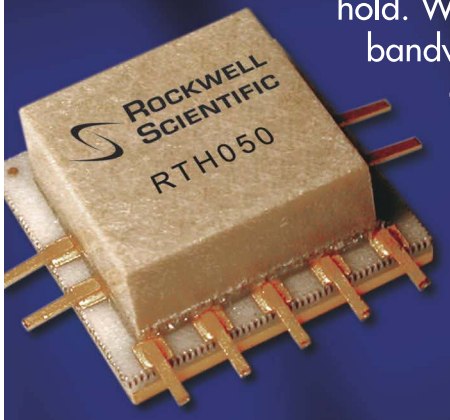

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Lyle Hilden. "We measure voltages at 10%, 25%, 50%, 75%, and 90% of full scale, then apply five calibration constants to each supply. A five-point calibration improves linearity over a two-point calibration." Elgar performs the five-point calibrations for both a supply's constant voltage and constant-current modes.

Manufacturers that perform two-point calibrations will add a third point for bipolar-output supplies. Service technician Nick Karafotis at B+K Precision noted that he calibrates at 0 V, positive full scale, and negative full scale for bipolar power supplies. Karafotis will, upon request, take measurements at other settings. "Some customers need calibration data. For those that require test data, we check a supply's output at several points. For example, we might take voltage measurements for a 0-V to 30-V supply at 0 V, 1 V, 5 V, 10 V, and 30 V."

The loads on power supplies during calibration also vary. Some manufacturers perform voltage calibrations with open circuits (no load), while others calibrate their supplies at 50% current output (half load) and at 100% (full load). Those that calibrate at no load will check a supply's output accuracy at full load. Hilden reports that Elgar performs the calibration with the DMM as the only load (essentially an open circuit, given a DMM's high input impedance). After applying the calibration constants, a technician tests each supply under full or partial load to check its load regulation. Most manufacturers use a calibrated electronic load set to provide a constant resistance during these tests.

In addition to operating as constant-voltage sources, a DC power supply also operates as a constant-current source, another feature that needs calibration. Typically, a manufacturer inserts a current shunt in series with a UUT's output, then measures the voltage across the shunt with a DMM (**Figure 2**). Manufacturers must accurately know the value of the shunt resistor. Some measure it with a DMM while others send their resistors to an outside lab for measurement. "We use a calibrated and cooled shunt resistor," said Liviu Pascu, senior engineer at Kepco, "and a 6½-digit DMM to measure the voltage across the shunt." Cooling is often necessary, because self-heating can cause a shunt resistor's value to change. A stable temperature also minimizes errors introduced by thermocouple effects in the wires.

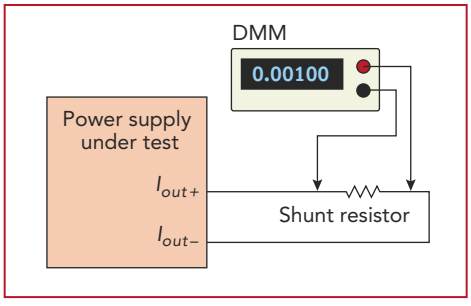

FIGURE 2. Current calibration uses a DMM to measure voltage across a shunt resistor.

Feedback calibration

Because programmable power supplies report the voltage and current they supply through digital displays and to a host computer through a communications bus, they need to measure their own outputs. Programmable power supplies have analog-to-digital converters (ADCs) that digitize their outputs. No power-supply calibration is complete, therefore, without calibration of the unit's readback circuits. After calibrating a supply's output, a test setup will set the output to a known value (typically 0 V and full scale, but that can vary) and measure it with a DMM. The test setup's computer then requests measurements from the DMM and from the supply under test. If the difference isn't within tolerance, the test setup will calculate $mX+b$ and store those constants in the supply's nonvolatile memory. It can then apply those calibration constants to the ADC. T&MW

POWER-SUPPLY MANUFACTURERS

For a list of programmable power-supply manufacturers, visit **www.tmwsuppliersearch.com** and enter "programmable power supplies" in the search field.

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TEST REPORT

ENGINE TEST

Diesel's new demands

Greg Reed, Contributing Technical Editor

Engine manufacturers are on target to introduce new, cleaner diesel engines in 2007 in order to meet stricter diesel engine emission standards issued by the US Environmental Protection Agency. Testing is critical to the design and development of advanced fuel-injection systems, which allow engine manufacturers to comply with stricter US regulations for passenger-car emissions. Current emissions standards require that each fuel system component be carefully tested for performance prior to being assembled into an engine.

Given the high cost of diesel fuels, testing for even more efficient diesel combustion engines has assumed a heightened priority among engine manufacturers. During a recent phone interview, I discussed the state of diesel engine testing with Michael Schena, president of Michigan Custom Machines (www.mcm1.com).

Q Would you please provide some background on the 2007 standards?

A Back in 1978, early passenger car diesels were known for their poor performance and belching smoke all to the tune of a clattery noise under the hood. Since then, a lot of work has been done in Europe and in the US off-highway industry to further the evolution of diesel engine technology.

The last regulation change took place in 2002. The next change occurs in 2007 and holds much more stringent requirements, while the 2010 standard will actually merge the emission standards for gasoline and diesel engines alike.

Michael Schena, president of Michigan Custom Machines.

The biggest key to meeting these goals is in the fuel system. By going to higher pressures at the fuel-injector nozzle, the fuel can be atomized into finer droplets in the cylinder, giving more surface area and a cleaner burn.

Q What is common rail injection?

A Common rail injection is a type of diesel fuel system. Common rail consists of a high-pressure fuel pump capable of 2000 bar (about 30,000 psi) that feeds a heavy cast-iron vessel called the "common rail." Some engines have one or two rails depending on configuration. Special heavy-duty fuel lines feed the injectors that are actuated by an individual solenoid or set of solenoids in the injector.

Pressure in the rail can be controlled by the pump itself or by a relief valve on the rail itself. The beauty of this system is that it is very responsive and can electronically deliver fuel as often as engine revolution requires.

Q What are some special requirements mandated by your customers?

A Split-injection measurement is a big one. This is a feature of fuel injection that requires not only precise actuation, but also precise measurement. It is possible for a fuel injector to not properly dispense the correct amount of fuel for one of the splits, which would lead to poor engine performance in final testing if not caught early on. On a smaller scale, the remanufacturing and after-market industries rely on similar testing to meet OEM requirements and satisfy that "out of warranty" customer.

Q What primary challenges lie ahead for makers of engine test and measurement equipment?

A The requirements for handling higher pressure with thin, low lubricity fluids is always a challenge. These pressures will continue to increase to further improve fuel atomization. The sophistication of the fuel-injector actuation is always a challenge. Some injectors are actually using two solenoids to turn on and turn off the injection event, and in some cases, these solenoids are actually replaced by stacks of piezo crystal wafers that respond much faster than conventional magnetic devices. Of course, driving these types of actuators is totally different from conventional means. We constantly work to stay in pace with these challenges, so we can provide the best turnkey solutions for our customers. □

For the complete interview, see the online version of this article. www.tmworld.com/aatr.

INSIDE this issue

EDITOR'S NOTE

Biodiesel brings testing into focus

Greg Reed, Technical Editor

Recent soaring energy costs have created intense interest in non-petroleum-based energy sources. One alternative fuel source, biodiesel, offers a homegrown solution for the diesel engine industry. For test providers, the testing associated with diesel engine efficiency and emission particulates could translate into a windfall.

The US Environmental Protection Agency (EPA) has signed a final rule implementing in-use testing requirements for heavy-duty diesel engines. Under a new program, manufacturers will measure gaseous and particulate exhaust emissions from diesel engines using portable emission measurement systems (PEMS) installed onboard the vehicle. Following a pilot highway truck program, the in-use testing will become mandatory in 2007 for highway engines.

Globally, similar diesel test programs exist in Europe, Asia, and South America. Additional diesel retrofit and test programs exist in California and Japan.

The advent of alternative fuels and the accompanying resurgent interest in diesel engines offers engineering firms growing opportunities in test and measurement. Whether testing for engine efficiency, emission particulates, or other performance diagnostics, reliable test data will hasten adoption of alternative energy practices while reducing dependence on foreign oil. □

Contact Greg Reed at editor@aatr.net.

NEWS

Mindready acquires Radical Systems

CANADA'S Mindready Solutions has acquired Alabama-based Radical Systems to bolster its automated test, measurement, data-acquisition, machine-vision, and process-control systems operations for its defense, aerospace and automotive, and transportation customers. "This acquisition provides us a strong entry into the defense/aerospace and automotive/transportation test engineering markets and a solid business with a diversified list of blue chip customers," said Claude Delage, president and CEO of Mindready. www.mindready.com.

dSPACE models broaden HIL simulation business

A SUPPLIER OF hardware-in-the-loop (HIL) simulators for testing electronic control units (ECUs) has widened its scope to offer complete solutions for automotive applications. dSpace's newly developed automotive simulation models include models for vehicle dynamics, diesel engines, and gasoline engines. Specialized software allows users to view the structure of the models and modify them independently. A graphical user interface facilitates definition of essential vehicle parameters, road profiles, driver behavior, and driving maneuvers. www.dspaceinc.com.

NTS expands satellite test capability

NATIONAL TECHNICAL Systems has announced availability of several specialized tests for satellite and launch vehicle systems and components at its facilities in Los Angeles and Santa Clarita, CA. The launch simulation tests combine extremely high-level acoustic noise, vibration, and thermal shock to detect failure modes that could impair a launch or result in functional failures in space. Also, atmospheric tests expose test specimens to gases known to cause long-term degradation of certain materials; these tests are combined with thermal shock and solar radiation over long periods to evaluate the survivability of satellite components and systems designed to operate for many years in space. www.ntscorp.com.

Endevco partners with UK firm

ENDEVCO REPORTS that it has entered into a partnership with Cambridge Vibration Maintenance Service (CVMSL) through which CVMSL will provide calibration and repair services for Endevco accelerometers and pressure sensors in the UK. "This is one more step forward in increasing our customer support in Europe, and CVMSL is a logical partner based on their experience and knowledge of our customers' service requirements," said Rob Meyer, president of Endevco.

CVMSL provides customers with support for vibration testing needs, supplying spare parts as well as complete vibration test systems. The partnership with CVMSL complements the network of Endevco technical support centers that are already in place in London, Barcelona, Paris, and Nuremberg. www.endevco.com.

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Aerospace Testing Expo
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Hamburg, Germany
www.aerospacetesting-expo.com

SWITCHING

10 tips for building a switch system

Luke Schreier, Product Marketing Manager, Switching, National Instruments

Manufacturers of automotive and aerospace components face the challenge of developing complex test systems that must last for decades. As technologies converge in increasingly elaborate devices, a test system's capabilities may extend from basic voltage, current, and resistance measurements to audio, video, and RF measurements, and the tester may be expected to have a 10- to 20-year life span. These factors put a huge burden on the switch system to manage and route each pin on a device under test (DUT).

Most manufacturers have added capabilities to their switch systems that make it easier to implement advanced switching topologies with extended lifetimes. It is important to take advantage of these capabilities, but you also need to watch out for the traditional "gotchas" in switch-system development. Here are 10 tips that can help you develop a "future-proof" switch system that will last as long as you need it.

1. Rethink your choice of relay

In the past, armature relays were the only option for high-power signal switching, but they were physically large and had short life spans. These relays have improved during the past decade as new manufacturing techniques have reduced their sizes and increased their lifetimes to approach 1 billion cycles, but they are no longer your only option.

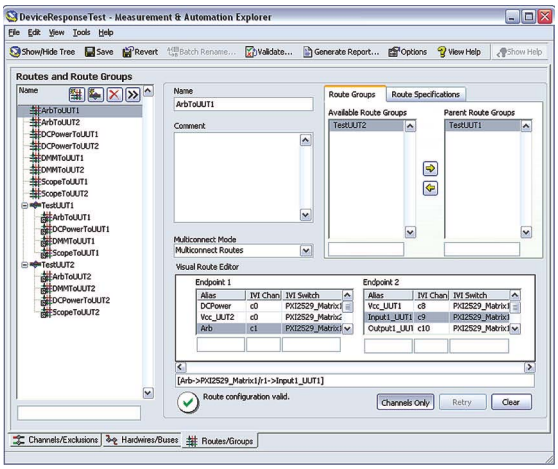
Reed relays have become an acceptable option for high-voltage switching and are typically an order of magnitude faster than armature relays. Solid-state relays and field-effect transistors (FETs), which have typically been used in infinite-life, low-power switching systems, are also another option for high-power systems with low on-resistance implementations.

Rethink what you knew previously about relays, and you are likely to find a better solution.

2. Understand safety considerations

Government programs typically require levels of certification for all commercial off-the-shelf hardware, and switch systems are no different. When selecting a switch system, consider only those products that comply with emissions, immunity, CE, and high-voltage safety (UL, VDE, and others) standards.

Also, when you need to connect switching signals to mains supply circuits (for example, wall outlets), pay attention to the module measurement category rating, or CAT rating, because supply circuits can have transients far above their working voltages. A CAT II rating is required for switching any 120-V/240-V wall outlet signal.



Routing databases like NI Switch Executive make it easier to manage hundreds or thousands of switch channels.

3. Decipher specifications accurately

Look past the marketing description of a product to find out how it compares to the competition. This is especially true in RF switching applications, where the term "bandwidth" is often interpreted differently. While 3 dB may be the right way to rate a digitizer's bandwidth, often 1 dB or 1.5 dB is more appropriate for the insertion loss of a switch (although not every vendor specs in that way). And even if a switch has excellent insertion loss, the voltage standing wave ratio (VSWR) or crosstalk spec may not be acceptable at the rated "bandwidth."

4. Use a routing database

Many switch systems can have hundreds of channels in each module. The system programming will be greatly complicated if you refer to each channel by its hardware name or a binary representation, and future maintenance will be almost impossible.

Use a database or look-up table to store route information and provide aliases for rows, columns, and channels. NI Switch Executive (**figure**) is one example of switch-management software that can store all of the channel aliases and routes in a system.

5. Take advantage of debugging options

Most vendors provide some simple way to close a relay without requiring you to write a program, whether it is through a Web interface, simple application software, or front-panel controls. Take advantage of these interfaces to verify functionality or to monitor relay states during execution. The shorter your "time to first click," the faster you can set up and debug a switch system. *(continued)*

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6. Choose a mass interconnect

It can be aggravating to find the perfect switch configuration in the form factor you want only to learn you can't connect the signals to the DUT in the way you expected. Generally, the higher the switch density of the module, the more challenging the connectivity becomes. You can take advantage of commercially available mass interconnect solutions from vendors such as Virginia Panel and MAC Panel to improve the lifetime of your connectors (and the cleanliness of the connections).

7. Track relay lifetime

Mechanical relays often are rated in excess of 1 billion cycles. Instead of attempting to keep track of expected lifetimes through a calculator or ignoring the number of cycles completely, choose a vendor that includes relay lifetime counting in the switch hardware. Then, with a simple function call, you can find out how soon you will need preventive maintenance.

8. Maintain your switches

Once your relay approaches the end of its rated lifetime, how easy is it to replace? You should be able to easily swap out an old relay for a new one, so make sure your vendor provides the methodology to do this, especially on high-density modules that may have complicated assemblies.

9. Combine the switch and test platforms

The advantages of using relay modules in the same platform as measurement hardware are well-known: smaller physical size, common bus connectivity, and reduced cable lengths between instruments and switches. You can reduce large amounts of integration work by using a common platform such as VXI or PXI. VXI has long been successful as a modular instrument and switching platform, and the growth of PXI over the last five years ensures a common multivendor platform on which to build an ATE system.

10. Plan for the future

Whichever platform you choose, assume your test system will not last forever. You will likely need to either upgrade or augment portions of it through multiple product iterations, so make sure the switch vendor has the breadth of switch offerings to get you through future projects. You can lose valuable time learning how to set up, program, and maintain switch hardware, only to have to start all over again with a new vendor the next time. □

PRODUCTS

VXI digital test instruments

Compatible with Teradyne's M9-Series, the Di-Series of VXI-based digital test instruments leverages 64 single-ended or 32 differential-pair programmable channels to address military, aerospace, and avionics test requirements. Performance enhancements include the ability to test differential logic, such as high-speed LVDS. *Teradyne, www.teradyne.com.*

Impact testing software

Version 3.0 of Impulse data-acquisition and analysis software for instrumented impact testing improves test setup, data analysis, and reporting. Version 3.0 also lets you integrate deflection measurement data directly with Impulse test results and analyses. *Instron, www.instron.com.*

Rad-hard accelerometers

Two high-temperature, radiation-hardened accelerometers are designed for shock and vibration measurements in extreme environments. The 357B53 and 357B54 charge-output devices operate in temperatures ranging from –95°F to +500°F (–71°C to +260°C) and survive accidental shock inputs to ±2000 g. *PCB Piezotronics, Vibration Division, www.pcb.com.*

Motion-analysis software

Virtual.Lab Motion Rev. 5 adds an auto-recursive solver and extra modeling capabilities to eliminate the calculation bottleneck when simulating the behavior of timing chains, belts, and tracked vehicles. Rev. 5 also computes the contact forces and deformation of a flexible body intermittently hitting rigid spheres, such as sunroofs, roller bearings, and telescopic shafts. *LMS International, www.lmsintl.com.*

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Hands-free cell-phone development kit

Helping designers of hands-free cellular phones for automobiles deliver high-quality audio and enhanced tuning capabilities is the goal of the Texas Instruments Hands-Free Kit (HFK). A DSP-based development platform, the kit provides flexible real-time voice and audio-enhancing algorithms. It includes Acoustic Technologies' SoundClear audio software—a combination of patented algorithms for acoustic echo cancellation, noise cancellation, sound enhancement, and full-duplex control. The kit also includes Acoustic's RAPID-HFK tuning tool, which allows manufacturers to tune their designs quickly and efficiently.

The kit includes a TMS320C5407 DSP motherboard, the SoundClear and RAPID-HFK software, a 120-day trial version of TI's Code Composer Studio integrated development environment, Code Composer Studio library examples, a JTAG connector, line-out and microphone jacks, an onboard microphone, a user-programmable interface including three LEDs and three pushbuttons, and an expansion peripheral connector.

Price: $495. *Texas Instruments, www.ti.com/hfkpr. Acoustic Technologies, www.acoustictech.com.*

MIMO channel emulator for Wi-Fi test

The Azimuth Channel Emulator (ACE) 400NB reproduces 4x4 multipath environments with channel correlation to test multiple-input-multiple-output (MIMO) or single-input-single-output (SISO) wireless-LAN implementations. It is a stand-alone testing platform that can be used with current 802.11a/b/g devices and future 802.11n devices.

The ACE 400NB emulates real-world conditions in a repeatable, controlled manner for efficient real-time performance testing of chipsets, clients, and access points. It includes bidirectional 4x4 multipath channel emulation with correlated channels; built-in support for six real-time channel models for typical Wi-Fi scenarios; direct connections to 802.11 devices (no external RF devices required) to simplify setup; a GUI-based configuration to select the channel model; TCL script control with one mouse click; and Azimuth's patented SmartMotion attenuation system for precise measurement of performance over range.

Base price: $159,220. *Azimuth Systems, www.azimuthsystems.com.*

USB module samples 12 channels

Data Translation has released the latest in its series of USB data-acquisition modules. The DT9836, a 16-bit analog input model, is available with either six or 12 single-ended channels. Each module contains a dedicated analog-to-digital converter (ADC) for each channel, so you can sample all channels simultaneously at 225 ksamples/s. All channels sample within 5 ns of each other.

The module also provides two 500-ksamples/s analog outputs, 16 digital I/O channels, two 32-bit up/down counter/timers, and three quadrature decoders (for x-y positioning applications). Analog input ranges are ±10 V and ±5 V.

Each module comes with a CD containing drivers for Windows 2000/XP, and you get oscilloscope and datalogger application software. The datalogger application includes source code. You also get LabView drivers and an evaluation copy of DT Measure Foundry for application development.

The DT9836 is available in a board-only OEM version or in an enclosure version that uses BNC connectors for analog inputs and outputs, triggers, and external clocks. Two D subconnectors provide access to digital I/O, counter/timers, and quadrature encoders.

Base price: $1295. *Data Translation, www.datatranslation.com.*

LTX introduces Fusion MX

Targeting high-throughput, multisite testing of highly integrated devices, the Fusion MX offers 40 universal instrument slots, enabling a range of configurations. Capabilities include a portfolio of mixed-signal instruments, including multiple synthesizers and digitizers as well as RF, DC, and power test options; a suite of Serdes test options offering performance to 12 Gbps; digital performance to 400 Mbps with time-measurement-per-pin capability; and a flexible memory architecture.

The MX accommodates the same test programs, instrument cards, and DUT boards as other Fusion X-Se-

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ries testers, including the EX for complex, high-volume ICs such as digital-consumer and baseband-communications devices; the CX for lower pin-count, high-performance analog and mixed-signal devices; and the DX desktop SOC test system. *LTX, www.ltx.com.*

Flexible multifunction tester

The 5800 series multiconfiguration, multifunction ATE system from Aeroflex provides a modular test environment that allows users to combine low-cost analog in-circuit testing (to a maximum of 3456 test points) with functional and system testing in a single test environment. Taking advantage of PXI hardware, the tester is available in three styles—bench, floor standing, and rack-mount—and each has a 21-slot rack as well as power and utility cards. Available: March 2006. *Aeroflex, www.aeroflex.com.*

50-MHz function generators

Two 50-MHz waveform generators offer powerful operating features to meet the requirements of bench test and automatic test equipment applications in consumer and industrial

electronics, biomedical applications, and automotive manufacturing. The Model 80 combines a function generator, a linear and logarithmic sweep generator, and a phase-lock generator with DC output. The Model 81 provides a function generator, a pulse generator with leading and trailing edge timing control, and a phase-lock generator, in addition to a built-in counter/timer that automatically detects external reference frequencies in the PLL operating mode. Price: Model 80—$4495; Model 81—$5590. *Fluke, www.fluke.com.*

USB-to-serial servers

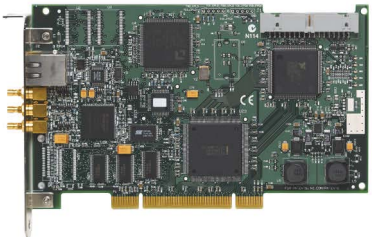
Offering 16 independent serial ports, SeaLINK+16 devices connect multiple peripherals to any USB port. The serial ports on each device appear as standard COM ports to the host system to enable compatibility with legacy software. Both the SeaLINK+16/232 and the SeaLINK+16/485 are housed in rugged 1U rack-mount metal enclosures. The SeaLINK+16/485 offers RS-232/RS-485 selectivity through cabling. Two USB 1.1 downstream connections allow daisy chaining SeaLINK devices or interfacing standard USB peripherals. Base price: $729. *Sealevel Systems, www.sealevel.com.*

Camera Link interface adapter

For use with VMETRO's Xilinx Virtex II Pro-based PMC-FPGA03 module, the CAML-MOD3 Camera Link adapter captures video from two base-mode cameras or one base-mode, medium-mode, or full-mode camera. The CAML-MOD3 uses the emerging Mini Camera Link (MiniCL) HDR26 connector and is compatible with conventional Camera Link equipment employing the MDR26 connector. Operating at the maximum Camera Link clock rate of 85 MHz, the CAML-MOD3 transfers data in real time at sustained data rates of up to 680 Mybtes/s into the user-programmable Virtex II Pro FPGA (full mode). Price: $995. *VMETRO, www.vmetro.com.*

IEEE 1588 PCI interface

The PCI-1588 interface board synchronizes clocks and events for multiple distributed devices with submicrosecond precision using the IEEE



1588 precision time protocol (PTP). You can use the board for developing synchronized data acquisition systems, as well as for synchronizing IEEE 1588-capable industrial control and test and measurement devices, including future Class A and B LXI devices. The PCI-1588 synchronizes other IEEE 1588-capable devices through a built-in Ethernet port. It also offers three general-purpose I/O pins and RTSI bus connection. *National Instruments, www.ni.com.*

Benchmark filter design kit

Modelithics' filter simulation and design kit includes everything you need to simulate, design, construct, and compare common low-pass, high-pass, and band-pass filters. All models and layouts are included to support your EDA software. Using Global Models to represent each component, you can generate accurate simulations that enable first-pass design success. You can validate the results by measuring the pre-assembled sample filters, and you can create similar filters using the bare boards supplied with the kit. *Modelithics, www.modelithics.com.*

CDMA 2000 protocol analyzer

Allowing both real-time and off-line analysis, GL's CDMA 2000 protocol analyzer works in conjunction with GL's Ultra T1 and E1 PCI bus cards, portable T1 and E1 analyzers, and Ethernet access interfaces. You can

use the software to capture, decode, and perform various tests on CDMA protocols across A (A1), Ater (A3, A7), Aquinter (A9), and Aquater (A11) signaling interfaces. It also captures and decodes Ethernet-based protocols (across Aquinter and Aquater interfaces), ATM-based protocols (across Ater interface), and HDLC-based protocols (across A interface). What's more, the software allows customized filtering and searching of the captured data. *GL Communications, www.gl.com.*

Rack-mount frequency converters

Accepting 50-Hz, 60-Hz, and 400-Hz input and yielding a fixed 50-Hz or 60-Hz output, the ED Series of frequency converters delivers reliable AC power ranging from 3 kVA to 5 kVA. The converters easily accept wide input variations and remain at their designed voltage and frequency, allowing connected equipment to continuously operate during extended brownouts to 88 VAC. Complete with integrated battery modules, the 3-kVA and 4-kVA models weigh just 94 pounds and 95 pounds, respectively. The 5-kVA model weighs 105 pounds. Base price: $8450. *Falcon Electric, www.falconups.com.*

SS7 SUA test application

Spectra Release 5.2 software adds the ability to emulate, test, generate, and evaluate networks and network elements that support the SS7 SCCP User Adaptation Layer (SUA) running over Steam Control Transmission Protocol (SCTP). Running on the Spectra network diagnostic tool, the SUA tester application generates SS7 SCCP and TCAP signaling traffic to stress test application server processes (ASPs) and signaling gateways (SGs). It also performs functional and conformance testing for ASPs, SGs, and application servers, as well as evaluates SUA protocol performance across SGs, ASPs, and application servers. *Tektronix, www.tektronix.com.*

High-input-channel USB modules

The DT9813-10V and DT9814-10V USB 2.0 data-acquisition modules offer 16 and 24 analog input channels, while reducing per-channel measurement costs by as much as 55%. Each module provides 12-bit resolution, a 50-ksample/s throughput rate, two analog outputs, and a bipolar input range of ±10 V. The DT9813 also supplies eight digital I/O lines. Price: DT9813—$349; DT9814—$399. *Data Translation, www.datatranslation.com.*

Multifunction I/O boards

Plugged into the PCI bus, the OME-PCI-1800 series of plug-and-play I/O boards allows continuous 330-kHz analog data acquisition under DOS and Windows. The half-size boards provide 12-bit resolution, 16 digital input channels, 16 digital output channels, three external trigger modes, and an onboard FIFO buffer. The OME-PCI-1800H and OME-PCI-1800L furnish 16 single-ended or 8 differential inputs. The OME-PCI-1802H and OME-PCI-1802L provide 32 single-ended or 16 differential inputs.The suffix "H" denotes a high-gain model and the "L" denotes a low-gain model. Base price: $575. *Omega Engineering, www.omega.com.*

32-channel 1024-QAM lasers

Targeting CATV DWDM networks, K2 Optronics' 32-channel, 1550-nm wavelength, 1024-QAM lasers increase the digital capacity of QAM transmitters by up to four times to support the growing demand for interactive applications. At the same time, the lasers provide a twofold increase in the packaging density of QAM transmitters. *K2 Optronics, www.k2optronics.com.*

Portable USB acquisition devices

Outfitted with screw terminals for direct signal connectivity, the usbDAQ/108 and usbDAQ/109 USB-powered data-acquisition devices are built for portability, efficiency,

and flexibility. The usbDAQ/108 offers eight analog input channels with 12-bit resolution and a maximum sampling rate of 10 ksamples/s. The usbDAQ/109 provides eight analog input channels with 14-bit resolution and a maximum sampling rate of 48 ksamples/s. Additionally, each module furnishes two analog outputs, 12 digital I/O lines, and a 32-bit counter. Price: usbDAQ/108—$145; usbDAQ/109—$245. *Capital Equipment, www.cec488.com.*

Arbitrary waveform generators

The CompuGen family of PCI arbitrary waveform generators offers 12-bit resolution at digital-to-analog conversion rates of up to 1 billion samples/s. The CompuGen 11G, CompuGen 4300, and CompuGen 8150 provide one, four, and eight channels, respectively, with conversion rates of 1 billion samples/s, 300 million samples/s, and 150 million samples/s. Each comes with 4 Msamples of onboard memory (up to 16 Msamples on the CompuGen 8150). Free software for creating, editing, and generating waveforms is included, along with development kits for C/C++, MATLAB, and LabView. Base price: $4495. *Gage Applied Technologies, www.gage-applied.com.*

Motor control starter kit

A new version of the AK-ST7FMC starter kit accommodates single-phase, bi-phase, and three-phase AC motors (including permanent magnet AC motors) and three-phase DC motors in various control topologies. Based on STMicroelectronics' ST7FMC microcontroller, the kit includes a motor control board with 10-A inverter stage; a 24-V three-phase, permanent-magnet brushless DC motor; an in-circuit debugger board; and an optoisolation board. Price: $695. *SofTec Microsystems,* www.softecmicro.com.

Digital signal conditioner

Boasting a TEDS-Tag identification system for automatic load-cell identification, the CellMite Model 4325B digital signal conditioner connects to a standard strain gage, load cell, extensometer, or pressure sensor. It simultaneously generates a serial output for connection to a PC, as well as a ±10-V analog output. CellMite's TEDS-Tag system reads the serial number of the load cell and stores both the serial number and calibration data in nonvolatile memory. TEDS-Tag also reloads the calibration data automatically. *Electro Standards Laboratories, www.electrostandards.com.*

Handheld color meter

This handy battery-operated meter measures color and illuminance/luminance of light sources in the field or lab. The HCT-99-D measures color chromaticity coordinates x,y and u',v', lux, and candela per square meter, as well as correlated color temperature. The new Delta-UV function shows the deviation of the measured x,y color coordinates from the blackbody radiator locus. Other features include a high-contrast LCD with backlighting and computer control via a USB interface. Price: $2270. *Gigahertz-Optik, www.gigahertz-optik.com.*

Temperature calibrator

Accurate and portable, the MicroCal T500 enables temperature calibration in a variety of working environments. The unit covers a temperature range from ambient to 1020°F with a stability of ±0.11°F. It provides five test holes at a depth 7.3 in., two high-accuracy input channels, resolution of 0.01°F, and an RS-232 serial interface. The MicroCal T500 delivers a cooling time of 50°F/min and a heating time of 40°F/min. Software programs allow automatic calibration and documenting in compliance with ISO 9000 standards. *E Instruments Group, www.einstrumentsgroup.com.*

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Low-cost ICT

The Analyst *ems* provides the capability to test assemblies for manufacturing defects, such as opens and shorts and incorrect, missing, or misoriented components. These faults make up the majority of problems encountered in the manufacturing flow. In-circuit test systems measure continuity, capacitors, resistors, inductors, voltages, semiconductor junction voltages, and SMT connections for opens. *CheckSum, www.checksum.com.*

Low-cost USB DAQ

The usbDAQ/108 and 109 modules from CEC ship with a free TestPoint application to get you up and running in minutes. The devices have multifunction capabilities with eight channels of 12- or 14-bit analog inputs, two analog outputs, 12 digital I/O lines, and one counter. You simply load drivers and plug the modules into your USB port. Base price: $145. *CEC, www.cectp.com/tmw.*

Ethernet-to-vehicle network interface

The Model AVT-418 is an Ethernet-to-vehicle network interface that supports all popular in-vehicle networks. All networks are included; there are no additional modules to buy or install. Used by test engineers worldwide, the interface is easy to set up and use. *Advanced Vehicle Technologies, www.AVT-HQ.com.*

204 frames per second

The Silicon Video 642M and 642C camera systems offer 640x480-pixel resolution at up to 204 frames/s. Rates with windowing exceed 19,600 frames/s. A global shutter provides sharp images. Available configurations can capture for seconds, minutes, or hours. Applications for the systems include inspection, kinematics, collision studies, sports analysis, and biological imaging. Price: $1495. *Epix, www.epixinc.com.*

Measurement suites for network test

As cellular phones and PDAs become capable of connection into wireless local-area networks (WLAN), Aeroflex is releasing a new measurement suite for WLAN and expanding the features of its existing GSM/EDGE suite. Designed for the company's PXI modular RF platform, these suites help speed testing during the development and manufacture of WLAN and cellular devices using a single Aeroflex system. *Aeroflex, www.aeroflex.com.*

Calibration-management software

Fluke MET/CAL Plus version 7.1 calibration-management software helps you manage and calibrate your workload more efficiently. It includes MET/CAL software for automated calibration and the MET/TRACK system for managing test and measurement assets. It is a complete software solution for calibration professionals. *Fluke, www.fluke.com.*

Full-featured true AWG

The Tabor Model 2571/2 is a powerful true arbitrary waveform generator. At 250-Msamples/s, it outputs signals to 125 MHz at 16 bits to 16 Vp-p. It can be single or dual-channel and includes a 16-bit LVDS digital-pattern output, modulation, frequency hopping, sweep functions, and GPIB, LAN, and USB 2.0 interfaces as standard features. *Tabor Electronics, www.taborelec.com.*

Product guide 2006

The latest product guide from B+K Precision lists high-current rack-mounted power supplies, new USB device programmers, new frequency counters, and an 8.5-GHz spectrum analyzer. You can confidently select the instruments and accessories that are just right for you. The company says its distributors can be relied on for their service and assistance, making it easier to buy B+K products. *B+K Precision, www.bkprecision.com.*

500-MHz logic analysis

The LogicPort logic analyzer offers timing analysis to 500 MHz on 34 channels. Priced at just $369, the USB-powered unit also includes 200-MHz state and transitional sampling, multilevel trigger capability, and a +6V to –6V adjustable input threshold. The easy-to-use software includes I²C, SPI, and RS-232 interpreters. *Circuit Specialists, www.circuitspecialists.com.*

Soft-sided cases

Fieldtex Products manufactures a line of soft-sided cases that are available in 18 standard sizes. The cases have optional modular divider systems that adjust for many different applications, and the sides are supported with stiffener to add support and protection. *Fieldtex Products, www.fieldtexcases.com.*

Solid-state pressure transducers

Designed to withstand vibration and shock, Omega's PX209 (cable style) and PX219 (connector style) transducers deliver consistent accuracy in small, stainless-steel cases, with either 0- to 5-VDC, 0- to 10-VDC, or 4- to 20-mA outputs. A four-active-arm bridge sensor accounts for high performance, employing a micromachined diffused silicon diaphragm, proprietary thin-film media, and dielectric isolation barriers. *Omega Engineering, www.omega.com/Pressure.*

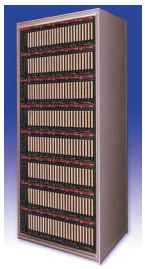
High-resolution line-scan lenses

Edmund Optics has introduced new large-format lenses designed for line-scan and area-scan cameras. These high-performance imaging lenses are compatible with leading-edge cameras and provide twice the amount of light throughput of comparable lenses. Typical applications include web inspection, flat-panel (LCD, plasma) inspection, factory automation, and food and beverage inspection. *Edmund Optics, www.edmundoptics.com.*

2006 test and measurement catalog

Keithley's free 2006 catalog offers details and specifications on the company's general-purpose and sensitive sourcing and measurement products, DC switching, RF switching and measurement, data-acquisition solutions, semiconductor test systems, and optoelectronics test hardware. Tutorials simplify the selection of products for specific applications. *Keithley Instruments, www.keithley.com/at/268.*

Wire-harness analyzer



The easy-wire CH2 high-voltage wiring tester offers test voltages to 1500 VDC and 1000 VAC in a modular system that can expand to 20,000 test points. The CH2 can also be used as a zero-defect wiring assembly aid, guiding the operator step-by-step through the assembly process with on-screen connector graphics and red and green LED indicators. *Cirris Systems, www.cirris.com.*

Fibrous dust test system

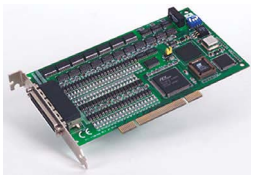
The DT-550 from Compatibility Products performs accelerated fibrous dust testing. The effect of fibrous dusts on high-efficiency air-cooled systems is critical. Real-world dust contamination contains both dust particles and fibers. By testing for fibrous dust environments, you can avoid thermal problems and customer dissatisfaction. *Compatibility Products, www.compatibilitypro.com.*

Catalog on CD

A CD catalog from Krohn-Hite includes full data-sheet information on all products, customer-support information, application notes, and more. Products include tunable active filters, DC voltage and current calibrators, wideband power amplifiers, distortion analyzers, precision phasemeters, precision resistors, ultra-low distortion oscillators, and a function generator. *Krohn-Hite, www.krohn-hite.com.*

PCI DAQ card

The PCI-1758UDI is a 128-channel ultra-density isolated digital-input data-acquisition card that has a universal PCI connector for both 3.3-V and 5-V PCI slots. It has a robust I/O design with 2500-VDC ESD protection and 70-VDC overvoltage protection for industrial applications. *Advantech, www.eautomationpro.com/us.*



Programmable power products

AMREL/American Reliance manufactures one of the widest ranges of power products on the market. The eLoad programmable air- and water-cooled loads range from 800 W to 100+ kW, 600 VDC/1500 A. The ePower programmable linear and switching power supplies range from 20 W to 900+ kW, 800 VDC/2700 ADC. Both lines include closed-case calibration and USB and Ethernet interfaces. *AMREL/American Reliance, www.amrel.com.*

Test drive software on Web

SigmaExpress, hosted by SigmaQuest, enables you to automatically upload and analyze your product, manufacturing test, and repair data using an ordinary Web browser. Details such as real-time yield comparisons and marginal measurements between multiple sites and lines, along with analyses, are provided in the form of real-time, Web-based dashboards and discovery wizards. *SigmaQuest, www.sigmaquest.com.*

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[An exclusive interview with a technical leader]

HANS BAKA
Managing Director
Digitaltest
Stutensee, Germany

Hans Baka started to work for Digitaltest in Stutensee in 1994 as marketing and sales manager and became managing director in 1997. He is now responsible for quality and financial management as well as sales and marketing for all worldwide subsidiaries, distributors, and agents. Before joining Digitaltest, he held sales-management positions at other ATE companies in Germany. Educated as an engineer in electronics, Baka's background is in electronics as well as in CAD design and quality management.

▶ *Baka comments on boundary scan, geographical differences in manufacturing-test requirements, and the future of the PCB in the online version of this article:*

www.tmworld.com/2005_12

Concurrent test points way to PCB quality

Digitaltest is concluding its 25th anniversary year as a supplier of turnkey solutions for electronic manufacturers, including hardware, software, and fixturing as well as global support and application service. Chief editor Rick Nelson spoke with Hans Baka at Productronica 2005 and followed up with an e-mail interview.

T&MW: What makes Digitaltest unique among printed-circuit-board test equipment makers?
Baka: Digitaltest offers a complete family of test systems from small and inexpensive 19-in. testers up to high-speed in-circuit testers and flying probers. All the systems run under the same software environment, and all hardware modules are compatible across all systems, thereby enabling customers to choose the best solutions for their test requirements while substantially reducing the cost of spare parts.

T&MW: We were saddened to note the passing of founder Dr. Grant Boctor during this anniversary year for the company. Could you describe his importance to Digitaltest and to the automated test industry?
Baka: Dr. Boctor was a great visionary. His inventions made him well-known in the industry, and even our competitors have respected him. The electronic industry has lost an important contributor, and we all will miss him as a colleague and a friend.

T&MW: How will the company evolve with Dr. Boctor's passing?
Baka: His family feels responsible for his dream and is running the company in his name. His enthusiastic spirit continues in his wife, daughter, and son. The employees' experience averages 10 to 20 years, and the knowledge they have acquired will stay within Digitaltest and will be continuously developed. With this experience and dedication, despite the great loss, we see a bright future ahead.

T&MW: "Concurrent Test" is a strategy that Dr. Boctor has championed. Will Digitaltest continue to focus on concurrent-test techniques?
Baka: Yes, at Productronica 2005, we demonstrated the new concurrent-test concept, which was completed this year and is based on his ideas. We are sure concurrent test will have a major impact on electronic production, as our nonmultiplexed tester with integrated functional test resources unblocks end-of-line production bottlenecks. With the nonmultiplexed pin architecture, Digitaltest offers emulation software and hardware that provide compatibility with fixtures and test programs from our competitors. A customer can continue to use existing fixtures when changing to our systems—no additional costs are involved.

T&MW: Are there any particular strategies other than concurrent test that the industry as a whole needs to adopt?
Baka: The time of the old dinosaurs is definitively over. Our industry does not need the very complex system that can manage everything. The price for those machines is too high. Digitaltest has developed a range of testers that can be fitted to customer needs.

T&MW: Is lead-free solder posing any special problems for board test, and if so, how is Digitaltest addressing them?
Baka: It doesn't seem so. To initially prove new lead-free processes, the industry will do more test, but after a period of adjusting those processes, we will see a swing back to regular test. The transition period, though, will present a good opportunity for our flying prober, which can economically expand test capacity without requiring additional expensive fixtures. T&MW

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