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# Test & Measurement World

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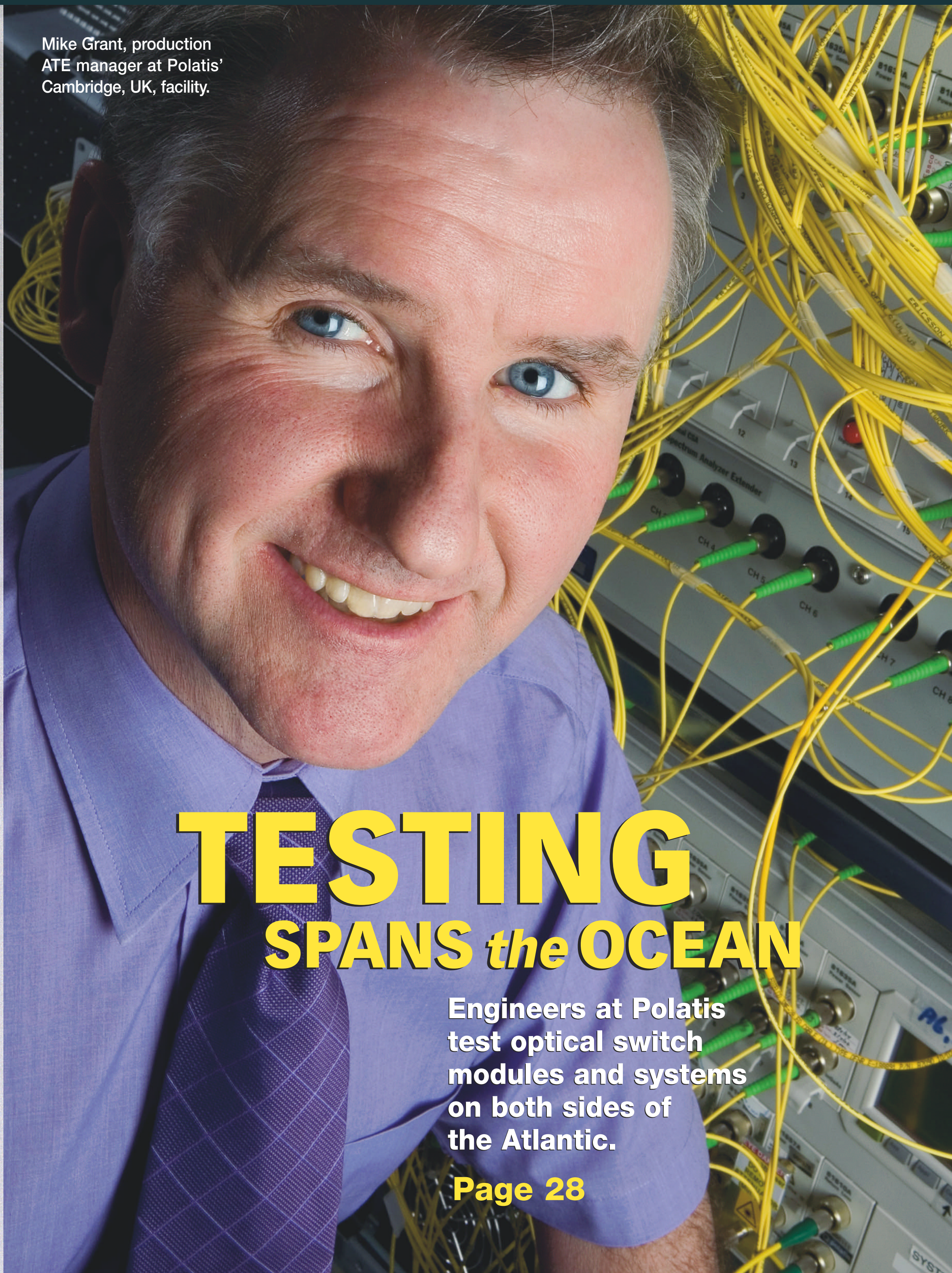

Mike Grant, production ATE manager at Polatis' Cambridge, UK, facility.

## TESTING SPANS the OCEAN

Engineers at Polatis test optical switch modules and systems on both sides of the Atlantic.

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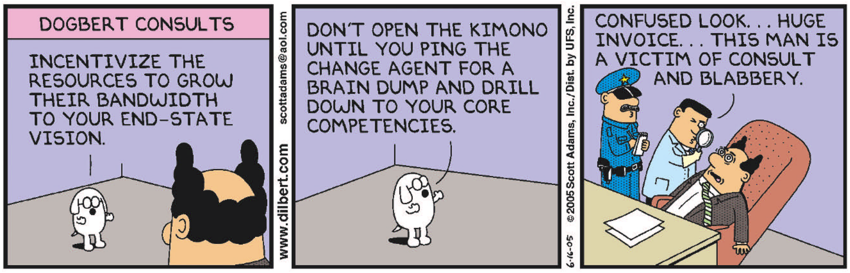


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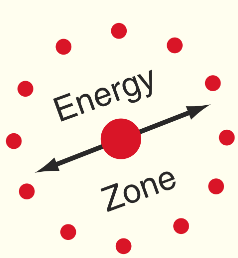


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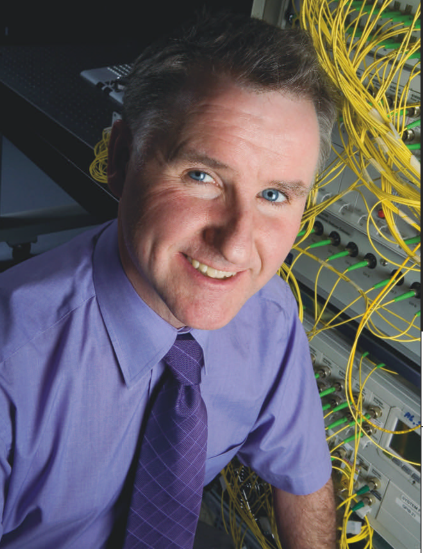
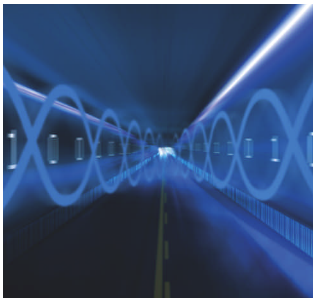


COVER BY: DANIEL LEVENSON



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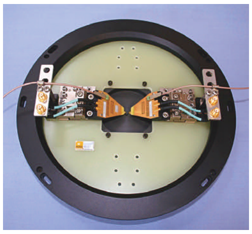

## TECH TRENDS



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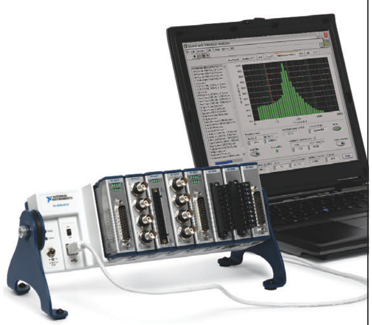




# www.tmworld.com

**> Check out these exclusive features on the *Test & Measurement World* Web site:**

## Automotive & Aerospace Test Report

- **Diesel engines drive T&M growth**

  Despite several false starts for diesel technology in the past, today's high fuel prices coupled with technical advancements provide the catalysts to propel a hesitant North American automotive industry into diesel production. In an exclusive interview, Larry Rinek, senior consultant on automotive technologies for market forecaster Frost & Sullivan, discussed the test and measurement aspects of diesel-engine production.

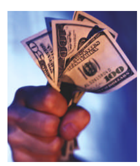
- **DAQ system records rocket engine test results**

  VI Engineering recently built a turnkey PXI-based test system that helps Wyle Laboratories capture test data when it tests rocket engines with thrusts up to 50,000 lb.

www.tmworld.com/aatr

## 2006 Salary Survey

- **Are you making enough money?**



To find out whether your salary is competitive with your peers', check out the results of *Test & Measurement World*'s 2006 Salary Survey. We asked subscribers to our magazine to tell us about their compensation, experience, education, job satisfaction, and workload. How do your benefits stack up?

www.tmworld.com/salary2006

## Blog commentaries and links

### NEW: "LXI: Instruments and Applications"

The LXI (LAN eXtensions for Instrumentation) standard is promising to bring the cost-effectiveness and simplicity of Ethernet interconnections to modular-instrument platforms. To make effective use of LXI, you'll need to familiarize yourself with application nuances involving triggering and other instrument-specific functions. Chief editor Rick Nelson is moderating this new blog to help keep you up to date and to let you ask questions and share your expertise. Recent posts:

- UK-based LXI resource
- Website demos three LXI instruments
- Europe showing increased interest in LXI

www.tmworld.com/blogs

## From the archives

- **Four ways to remove ambient noise**

  An open-area test site (OATS) for radiated-emissions measurements eliminates reflections, but it can introduce ambient RF signals. To compensate, you can tune out those interfering signals, shorten your measurement distance, employ signal substitution, or mathematically strip the ambient signal plus noise from your total signal. Read how in our August 2002 issue.

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[ EDITOR'S NOTE ]

# Test gains importance as perfection recedes

**Is the test engineer a hero or a villain?** That's a question I posed back in 2002, concluding that test adds as much value as any other aspect of a product's journey from concept to customer: Test is a vitamin (a healthy boost to the economical production of a quality product), not an aspirin (a treatment for some unforeseen illness).

**RICK NELSON,** CHIEF EDITOR

As I noted in my 2002 column, perfect designs and defect-free production are impossible goals, and efforts to approach them are prohibitively expensive. In fact, as designs become more complex, perfection is receding, not coming closer. Anne Gattiker, program chair for this year's International Test Conference and research staff member at the IBM Austin Research Lab, commented during a recent interview, "It used to be that people would do worst-case design. Designers would guarantee that their chips would work at all of the worst-case corners. But with increasing variability, they just can't afford to do that anymore. So, instead of trying to guarantee that 100% of their chips will work, they play a nasty trick on [test engineers] and only guarantee that 90% will work."

**Test must do more than separate good chips from bad chips.**

In addition, she said, "Technology has become so complex that we now have design and process interactions. There's so much pattern dependence and neighborhood dependence that it's almost impossible to get all the models right and all the test structures right the first time."

In such an environment, she said, "It's becoming more and more important for test not to just separate good chips from bad chips or good boards from bad boards, but to provide feedback to the fabrication process to help improve manufacturing yields, speed yield-learning ramp-up, and improve debug and time to market."

The theme of this year's ITC (October 24–26, Santa Clara, CA) is "Getting more out of test," and presentations will aim to help test engineers do more than separate good parts from bad parts. Getting more out of test, said Gattiker, will require efforts from EDA companies as well as test-equipment vendors. On the EDA side, she said, vendors need to enhance defect-localization and diagnosis software, while ATE needs to adapt to its role as a data-collection engine. Gattiker emphasized, "Only at test does the rubber meet the road. When you do a real test of your real product—that represents the first look you get with no modeling and no effort to be representative—it's the real thing."

The online version of this article (www.tmworld.com/2006_08) includes direct links to the interview with Anne Gattiker, to my 2002 column, and to more information about this year's ITC. T&MW

*Post your comments at www.tmworld.com/blog.*

[An exclusive interview with a test engineer]

## Flex those displays

DAN GUIDERA

Ed Bawolek is a test engineer at Arizona State University's Flexible Display Center (Tempe, AZ, flexdisplay.asu.edu), where engineers develop MOSFET arrays on plastic substrates that drive a display's pixels. Member companies such as General Dynamics and Honeywell integrate the displays with drive electronics and cases to form wearable displays. Initial applications are being designed for the US Army. Bawolek recently described his test responsibilities to senior technical editor Martin Rowe.

**Q: How is a flexible display made?**

**A:** We use a deposition process to build MOSFETs onto the plastic substrate. The substrate sits on a 150-mm silicon wafer that's used as a carrier. We deposit five to six layers of metal on the substrate to build the MOSFET array. We must run the process at a low temperature, typically 180°C, to avoid melting the plastic.

**Q: What's your role at the Display Center?**

**A:** I handle all the test responsibilities for the flexible displays. I make performance measurements on fabricated MOSFETS and provide feedback to the process engineers.

I provide data on drive current, threshold voltage, and channel mobility by measuring $I_{DS}$ vs. $V_{DS}$ and by performing $I_{DS}$ vs. $V_{GS}$ sweeps. The measurements are difficult because of the wide range of drive current—from microamps to femtoamps. That's nine orders of magnitude. (*Editor's note*: the online version of this article includes a downloadable plot of $I_{DS}$ vs. $V_{DS}$ for a MOSFET, www.tmworld.com/2006_08.)

I also measure the ratio of a MOSFET's $I_{DS}$ on current to its off current. Finally, I measure how the MOSFET responds to the polarity of $V_{GS}$. These devices have a hysteresis when the gate voltage swings from negative to positive and back to negative.

**Q: How do you make the measurements?**

**A:** I assembled an automated test station consisting of a semiconductor parameter analyzer and an old wafer probe station, built in 1986. Before I could use the probe station, I had to repair it and modify it to handle 150-mm wafers. It was designed for 100-mm wafers. The upgrade included replacing the original black-and-white cameras with color cameras. The system can photograph probe marks after testing a display to prove that it made good electrical contacts. I use the photographs as a process control for the test station.

A colleague wrote a new motion-control algorithm for the stages so I can control them from a PC. We also developed an alignment and pattern-recognition algorithm so the probes could land in the proper locations.

Next, I defined the tests and determined what data I needed to capture. We wrote code to capture data from the component analyzer and export the data to Excel for analysis and plotting.

The project took about three months to complete. I spent half the time on hardware, and a colleague spent six weeks writing the code. I've since made modifications to the code that adds functionality.

**Q: What were you able to accomplish with the automated test station?**

**A:** I spent the first 18 months of the project taking data that process engineers used to refine the fabrication process. We now have four stations in operation: two for production, one for electrical stress tests, and one for test development. The wafer probers range in age from 5 to 20 years.

We plan to move from 150-mm silicon wafers as carriers to 370-mm x 470-mm glass sheets, because the sheets let us build larger displays or test more displays at once. Now, we can produce transistor arrays on substrates for member companies. T&MW

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

# LXI delivers real benefits now, Plus flexibility for the future

*With its LXI products, Agilent Technologies offers engineers cost efficiency, performance and ease of operation*

**LXI is probably the biggest news to hit the instruments business in a generation. It promises across-the-board improvements in just about everything from performance, to cost, to ease of deployment.**

What makes LXI different? Economies of scale, for one thing. The LXI standard (LAN eXtensions for Instrumentation) is based on the most widely used local area network (LAN) technology, Ethernet. And Ethernet is the universal language of networking. Millions of engineers are already familiar with it, and it continues to improve, boasting speeds of up to 10 Gbits per second over copper wires.

LXI's roots in Ethernet mean you can count on automatic speed upgrades as commercial products continue to evolve. Furthermore, by building on standard technologies, industry experts predict that LXI-based instruments will be comparatively inexpensive, yet have a richer set of features and functionality.

But beyond those many strategic architectural advantages, LXI offers a large number of compelling and immediate benefits — benefits that can have a direct impact on costs, implementation goals, and ease of operation.

## Off to a quick start

For instance, right from the start, LXI is easier to set up than card cage systems and older, proprietary interfaces. There's just less to think about. The connections and interfaces are simpler. And there's less of a requirement for specialized knowledge. That translates into faster and cheaper implementation. Almost every major test & measurement supplier is participating in the development of LXI. This broad participation, combined with the technology's simplicity, mean LXI-based products are easier to integrate. That doesn't just apply to new systems. LXI is also oriented toward backward compatibility, and tools available from vendors such as Agilent Technologies ensure that this compatibility is as extensive as possible.

At the same time, LXI reduces overhead costs because it doesn't require a card cage, or a slot-zero controller. Nor does it demand proprietary interface cards and complex cabling. Instead, it's essentially "plug-and-play" because it leverages the available LAN port that is standard on almost all PCs. All that's needed is a LAN cable or a switch if multiple instruments are involved.

**LXI means you have maximum flexibility in many dimensions, including the size and configuration of the instruments you deploy. You can choose any combination of traditional bench or card-cage style, or compact/faceless.**

## Size doesn't matter

Similarly, LXI instruments can be deployed in any size or form factor, ranging from the classic bench "box" to faceless instruments, suited to compact or rugged duty applications in manufacturing or defense. Additionally, engineers can deploy sensors, amplifiers, filters, and attenuators in remote locations, such as in test fixtures.

Because LXI is based on familiar standards, you can take advantage of almost every kind of communication medium. In environments where large amounts of RF are being generated, you can rely on optical cable. Or, where hard wiring is too expensive or difficult, you can use wireless. The result is that instrumentation difficulties are less of a gating factor for whatever you are trying to accomplish.

For multiple instrument systems, LXI provides optional trigger standards that support easy and accurate synchronization of multiple devices, even if they are physically located miles apart. Indeed, you can set up tight synchronization over a wired LXI trigger bus that is functionally equivalent to a VXI or PXI backplane interconnection. The IEEE 1588 standard built into LXI enables instruments to share a common sense of time. So you can now implement start actions without a specific trigger requirement; synchronize instruments running at different rates; better correlate data; and, more easily troubleshoot both processes and instrumentation. LXI also enables direct communication between instruments, allowing you to minimize wait states in your programs and offload the PC.

### Make the connection

In short, LXI delivers the best of all worlds. Standard LAN components are inexpensive, so there are minimal infrastructure costs. LXI performance generally matches or exceeds previously available technology, and data throughput is tremendous, clocking in at 125 times the speed of GPIB. But above all, LXI offers flexibility. You can use as many instruments as desired, put them anywhere in the world, and trigger them precisely.

All this means that LXI is your path to the future, without undermining the investments you have already made. ■

**FOR MORE INFORMATION**
To learn more about LXI and products that incorporate it, contact:

**Agilent Technologies**
1-800-829-4444,
**www.agilent.com/find/tm-lxi**

**Agilent's LXI products are part of the Agilent Open Program.**
For more information, download the Agilent Open brochure at:
**www.agilent.com/find/open**

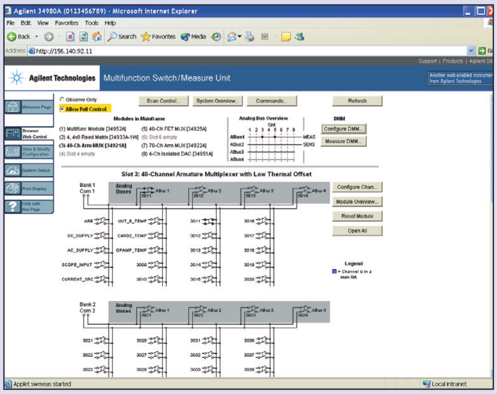
## LXI Done Right

A test system isn't what you need to worry about. Your product is. To make LXI test system development and operation more efficient and cost-effective, Agilent has developed Agilent Open, a program that simplifies test-system setup and integration with a versatile combination of test-system hardware, I/O, and software tools.

Agilent Open accelerates the creation of robust test systems that are easy to enhance and maintain by ensuring greater choice in measurements, connectivity and programming. This gives your team more time to focus on what matters most — the performance and reliability of your product.

The Agilent Open approach provides you with the ability to work within a choice of software development environments. For instance, IVI drivers available from Agilent work in all the most widely-used languages (Visual C++, Visual Basic, C#, and J#, as well as VEE Pro, Basic, LabVIEW and LabWindows CVI). Agilent Open also offers many other benefits:

- A rich web interface that goes beyond the functionality required by the LXI standard to support both monitoring and control.
- Software tools like the IO Libraries Suite that significantly reduces the time to set up your test environment, including connectivity tools across any common interface.
- Multiple interfaces and converters, such as LAN, USB and GPIB for general purpose instruments.
- Software tools to make it easier to use your test environment, including tools for the most common Microsoft environment (.NET).
- System ready instruments optimized for speed and ease of integration.




**With Agilent Open, you have the option of detailed, web-based "anywhere" control. In this example, you can control the switch matrix simply by clicking on the matrix crosspoints.**

And LXI from Agilent delivers real world benefits. For instance, a major automotive component manufacturer needed to improve the testing throughput for electronic control units (ECUs). The application demanded many changes to the bias voltage levels during testing, requiring the power supply to transition quickly to various voltages levels.

By adopting an LXI-compliant, Agilent Open N6700 modular power supply, the company was able to reduce test time from 20 seconds to 17 seconds, a 15% reduction for every device under test. This had an immediate impact on process throughput, saving time and money.

*For more information about Agilent Open, go to www.agilent.com/find/open.*

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## Sapphire D-40 debuts with RF capability


Credence Systems recently expanded its Sapphire test family with the addition of the Sapphire D-40, a tester that combines analog, digital, mixed-signal, and RF test instrumentation and leverages technologies first introduced in the Sapphire D-10. The new system also accommodates the company's Modulated Vector Network Analysis (MVNA) RF-measurement option, which adds wireless test capabilities for mobile phone, WLAN, WiMax, and Zigbee devices.

With its enhanced data-management and parallel test capabilities, the D-40 delivers four times the test performance of the Sapphire D-10 with only a 25% increase in platform footprint. "What we've done with the Sapphire D-40 is create a highly scalable data infrastructure, similar to that used on the Internet," said Dave Ranhoff, president and CEO of Credence. "Every time you add another module or instrument to the system, you add more data bandwidth."

With more than 2048 200-Mbps digital pins and high-density, mixed-signal instruments, the D-40 also features dedicated analog instruments and up to 32 ports of MVNA-enabled RF capability. According to Ranhoff, "The Sapphire D-40 offers both 16 and 32 port RF options, allowing our customers to move beyond the traditional dual and quad site test configurations common in today's wireless device testing." www.credence.com.

## AC voltages gain precise measurements

The National Institute of Standards and Technology (NIST) recently unveiled what it calls the first precision instrument for directly measuring AC voltages. NIST is testing the instrument for use in its low-voltage calibration service, where it could increase significantly the measurement precision of industrial voltmeters, spectrum analyzers, amplifiers, and filters.

The patented instrument is based on the Josephson junction technology used in NIST's DC voltage standards. When a fixed DC voltage is applied across a Josephson junction, the junction responds by generating an AC current that oscillates like a wave at a frequency exactly proportional to the applied voltage.

The new instrument uses arrays of junctions to generate AC pulses in precisely measured voltage units over a range of audio frequencies. Arbitrary waveforms can be generated at different voltage levels for different applications.

This calibration method would replace the current method, in which NIST performs AC voltage calibrations indirectly by measuring the heat delivered by an instrument to a resistor and then comparing that measurement to the heat delivered by a known DC voltage. At low voltages (such as 2 mV), the new AC Josephson junction voltage standard should improve measurement accuracy as much as one thousandfold.

Based on a concept that was co-developed by researchers at NIST and Northrop-Grumman in the mid-1990s, the AC instrument currently has a maximum output of 100 mV. NIST researchers hope eventually to increase that level to 1 V. www.nist.gov.

## RF spectrum analyzers

**Editors' CHOICE**

The 3280 series of 3-Hz to 3-GHz, 13.2-GHz, and 26.5-GHz spectrum analyzers achieve accuracies of ±0.15 dB up to 3 GHz. The instruments also provide better than –115-dBm/Hz local-oscillator (LO) phase noise at a 10-kHz offset from 1 GHz, and they offer +18-dBm third-order intermodulation performance. Digital IF resolution bandwidth ranges from 5 MHz to 1 Hz. Resolutions of 5 MHz to 300 Hz are available directly from the digital IF stage. Below 300 Hz, the instruments employ FFT calculations to generate filter bandwidths down to 1 Hz. The bandwidths are selectable in a 5-3-2-1 sequence

The 3280 series runs Windows XP and includes an internal hard drive and a built-in CD-ROM as well as a range of interfaces, including LAN, USB, RS-232, IEEE 488 (using the SCPI command set), VGA, and parallel printer ports. A 10.4-in. TFT LCD supports split-screen and multiple-windows-open modes. Three traces can be displayed per window, and as many as nine markers can be selected, with a marker table viewable in an alternate window.

Built-in functions include channel-power, adjacent-channel-power, occupied-bandwidth, spectrum-emission-mask, third-order-intercept, harmonic-distortion, X-dB-down, and phase-noise measurements. A tracking generator is optional.

Base price: $19,500. *Aeroflex, www.aeroflex.com.*

## IP engine helps NASA flight crew

Pleora Technologies reports that its iPORT PT1000-CL Internet Protocol engine and a camera from Adimec helped NASA assess the structural integrity of the Discovery space shuttle during its recent mission. The flight crew used the equipment, which was mounted at the end of the shuttle's 50-ft robotic arm, to visually inspect heat tiles for signs of damage before returning to earth.

The iPORT engine grabbed tile images from the camera and streamed them to a laptop inside the shuttle over a standard Ethernet link. Crew members controlled the camera via the engine as they inspected the shuttle's thermal-protection system.

"The iPORT engine worked as expected during the mission. Even though the Ethernet connection experienced mismatched impedance, ghosting, and crosstalk, the engine was able to overcome these problems and our flight software worked flawlessly," said Joel Busa, software lead for the shuttle's Integrated Sensor Inspection System, in a prepared statement. www.pleora.com; www.adimec.com.

## CALENDAR

**EOS/ESD Symposium,** September 10–15, Tucson, AZ. Sponsored by ESD Association. *www.esda.org/symposia.html.*

**Autotestcon,** September 18–21, Anaheim, CA. Sponsored by IEEE. *www.autotestcon.com.*

**International Test Conference (ITC),** October 24–26, Santa Clara, CA. Sponsored by IEEE. *www.itctestweek.org.*

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

## Editors' CHOICE

### I/Q modulation generator

The AFQ100A I/Q modulation generator produces the complex digital modulation waveforms required to evaluate the performance of wireless broadband communication systems. It combines a memory-clock rate that is adjustable from 1 kHz to 300 MHz and a memory depth of up to 1 Gsample to produce I/Q signals with an RF bandwidth of up to 200 MHz.


The AFQ100A is available with an output memory of 256 Msamples or 1 Gsample. Its unbalanced analog output level can be set between 0 V and 1.5 V, and its balanced output can be varied from 0 V to 3 V. Bias voltage from –2.5 V to +2.5 V can be superimposed on the signal at the balanced output. The AFQ100A also can be equipped with digital outputs that provide 16-bit resolution and a maximum data rate of 300 MHz. The unit has a signal-to-noise ratio of 83 dBc and a frequency response within 0.05 dB across its bandwidth.

The generator features several trigger functions and an output signal that can be adjusted to compensate for signal impairments. An internal equalizer can change the output signal to compensate for the variable frequency response of I/Q modulators. When used as an independent baseband source, the AFQ100A provides I/Q signals directly to the device under test. When accompanied by a vector-signal generator, it can produce the RF signals as well. Signals can be generated on a PC using Matlab or the supplied R&S WinIQSIM2 software, which provides test routines for many communications standards.

Base price: $28,770. *Rohde & Schwarz, www.rohde-schwarz.com.*

# From RF wafer probing to base-station testing

> > > International Microwave Symposium, June 11–16, 2006, San Francisco, CA, IEEE Microwave Theory and Techniques Society, www.ims2006.org.

**Suss MicroTec** (www.suss.com) demonstrated its new |Z| RF probe card for production test as well as its new SussCal Professional wafer-level high-frequency calibration software. **Rohde & Schwarz** (www.rohde-schwarz.com) introduced the FSUP, an instrument that combines a spectrum analyzer and phase-noise tester, and the AFQ100A, an I/Q modulation generator. The company also debuted enhanced Bluetooth and cable-measurement capabilities, test support for mobile WiMAX and WiBro, and code-domain-power test capability.

**Aeroflex** (www.aeroflex.com) introduced its 3280 series of 3-Hz to 3-GHz, 13.2-GHz, and 26.5-GHz spectrum analyzers, which achieve accuracies of ±0.15 dB up to 3 GHz. **Giga-tronics** (www.gigatronics.com) introduced its Panther 2500 series signal generators, which provide phase noise of –111 dBc at 10-kHz and 100-kHz offsets on a 10-GHz carrier frequency.

**Agilent Technologies** (www.agilent.com) announced several new design and measurement products for microwave and wireless research and development, including MIMO analysis capability and new network-analyzer options and its new 3-D electromagnetic design and verification software, EMDS.

The Panther 2500 targets high-resolution radar testing, RF and microwave component testing, subsystem testing, and local oscillator substitution.

Courtesy of Giga-tronics.

**Anritsu** (www.us.anritsu.com) introduced WiMAX capability for its Signature signal analyzer. The company also added an interference analyzer and channel scanner to its UMTS Master Node B analyzer and Spectrum Master handheld spectrum analyzer, debuted a low-cost 7.1-GHz spectrum analyzer, and combined the measurement features necessary for cell-site installation and maintenance into its BTS Master handheld base-station analyzer. T&MW

# Chip quality spans design, test, and inspection

> > > Semicon West, July 11–13, 2006, San Francisco, CA, SEMI, www.semi.org.

**Verigy** (www.verigy.com) made its trade show debut and announced that it is extending its joint development work with **Cadence Design Systems** (www.cadence.com) to optimize design and test links. **Nextest Systems** (www.nextest.com) introduced the Magnum Grande, which provides up to 7680 I/O pins deployed over 960 sites for flash test. **Advantest** (www.advantest.com) introduced a 16-channel mixed-signal module, dubbed the Base Band Waveform Generator Digitizer (BBWGD), for its OpenStar-compliant T2000 test system, while the **Semiconductor Test Consortium** (www.semi-test.org) highlighted OpenStar modules from Advantest and **Apria Technology** (www.apriatech.com).

**Suss MicroTec** (www.suss.de) introduced a field-upgrade capability for its BlueRay probe system. **Multitest** (www.multitest.com) demonstrated the InFlip MEMS strip-test module for three-axis low-g accelerometers. **Johnstech** (www.johnstech.com) highlighted gold-plated contacts for the Pad ROL200 contactor and announced its new Edge Test Contactor Division, which will address the memory-module market. **Eagle Test Systems** (www.eagletest.com) touted its announcement that **Linear Technology** (www.linear.com) has bought multiple ETS-364 systems. **GuideTech** (www.guidetech.com) teamed with **KVD** (www.kvdco.com) to demonstrate a low-cost test approach for devices with high-speed I/O.

**ALIS** (www.aliscorporation.com) demonstrated its LookingGlass LG-2 helium-ion microscope. **Cognex** (www.cognex.com) highlighted its In-Sight Explorer network automation software, which includes tools to manage a system of networked In-Sight wafer readers. **X-Tek** (www.xtekxray.com) announced the addition of computerized tomography to its Revolution system.

**Vistec** (www.vistec-semi.com), the former Leica Microsystems Semiconductor, highlighted the LDS3300 wafer edge and backside inspection system and its OEM microscope modules. **Rudolph Technologies** (www.rudolphtech.com) announced a repeat order for the NSX 115 macro defect inspection systems.

**UMD Advanced Test Technologies** (www.umdtech.com) exhibited burn-in and thermal-management products and also announced it has signed a letter of intent to merge with **Antares conTech** (www.antarescontech.com), a provider of sockets and connectors for the semiconductor industry. The combined company will be named Antares Advanced Test Technologies and will be headquartered in Vancouver, WA. T&MW

[SEMICONDUCTOR TEST]

RICK NELSON
CHIEF EDITOR
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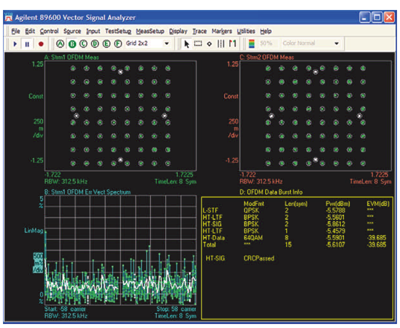
# RF test innovations target MIMO

Expected ratification of the IEEE 802.11n standard might be nearly a year away, but products embodying the multiple-input, multiple-output (MIMO) technology the standard specifies are already appearing. While some companies are waiting to develop "pre-n" chips until ratification comes closer, many others, such as Broadcom, have already entered the market, reports *Electronic News* (Ref. 1). Even those opposed to the so-called "pre-n" label, like Airgo Networks, are offering their own MIMO devices.




**Option B7Z provides developers with a graphical user interface and a set of signal-analysis capabilities pertaining to IEEE 802.11n MIMO and other RF applications.** Courtesy of Agilent Technologies.

Just as the chipmakers are moving forward on the MIMO front, so, too, are test-equipment vendors. Agilent Technologies, for example, has announced what it calls IEEE 802.11n MIMO modulation-analysis capability for its 89600 Series vector-signal-analysis software. The software option, labeled B7Z, provides a troubleshooting and evaluation tool set designed to address the challenge posed by the multiple orthogonal frequency-division-multiplexed (OFDM) signals that simultaneously transmit on the same frequency in 802.11n-like MIMO applications. It supports the IEEE 802.11n High Throughput (HT) draft spec, which calls for 20- and 40-MHz channels, as well as BPSK, QPSK, 16QAM, 64QAM, and 256QAM data subcarrier modulation formats.

Option B7Z can be used with Agilent's Infiniium digital oscilloscopes and 89600 Series VXI-based analyzers, which meet the IEEE 802.11n requirement for 36-MHz signal bandwidths. The Infiniium Series scopes, with a digitizing capability of up to 40 Gsamples/s, can measure 802.11n signals directly, without down-conversion.

Azimuth Systems has also announced a platform for Wi-Fi vendors wanting to test their draft 802.11n-based products. Called the "Azimuth MIMO Functional Test solution," the platform targets test of interoperability among MIMO products; performance, including maximum throughput; and backward compatibility to legacy devices.

Azimuth marketing director Graham Celine described the platform as a combination of software automation and hardware to support 802.11 tests, with the bulk of the product value in the software. It operates in conjunction with Azimuth's W-Series platform, which employs Azimuth's SmartMotion technology to simulate devices in motion, its testMAC technology to emulate golden devices, and its Real2Real architecture for system test.

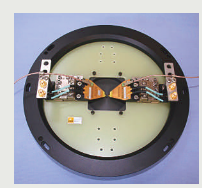
Celine noted that the MIMO Functional Test solution focuses on the aspects of MIMO that have limited channel dependence, while the company's ACE MIMO channel emulator serves for performance and range testing.

The Agilent and Azimuth products can test subassemblies and systems as well as chips, but as Celine pointed out, "Chipset vendors are the pioneers and as such are very actively involved in [802.11n] testing. We expect, as with all our other tests, that [the new platform] will be of huge value to the equipment manufacturers as well." T&MW

## REFERENCE

1. Deffree, Suzanne, "Draft 802.11n Misses Mark," *Electronic News*, May 3, 2006. www.electronicnews.com.

## Suss debuts RF probe card



The new |Z| RF probe card targets the need to extract S-parameters on the production floor to provide feedback for optimizing manufacturing processes. The card integrates MEMS-based contact technology to test up to 32 RF channels, and when configured with the company's Multi |Z| technology, it can test DC signals as well. Long, independent contact springs facilitate DUT contact despite variations in pad height. www.suss.com.

## Verigy goes public

In June, Verigy announced its initial public offering of 8.5 million shares of common stock, priced at $15 per share. Verigy, the semiconductor test business recently separated from Agilent Technologies, is listed on the NASDAQ National Market under the ticker symbol VRGY. Verigy's stock closed at $14.33 on July 21. www.verigy.com.

## DEI purchases Credence ASL

Credence Systems has announced that Device Engineering Inc. (DEI) has purchased a Credence ASL 3000 test system. DEI will use the ASL 3000 to test avionics interface ICs and ASICs. The ASL 3000 can support up to 31 instruments and provides greater than 1000 W at the device-under-test (DUT) environment. The system is also the basis for expanded digital and DSP-based instrumentation that will allow the ASL product family to test a range of mixed-signal devices. www.credence.com; www.deiaz.com.

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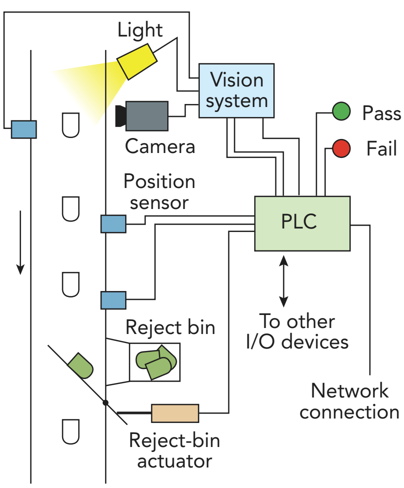
# Mind your I's and O's

VENDORS HAVE SIMPLIFIED camera- and software-configuration tasks so most test engineers can easily set up inspection routines. But when it comes time to use a vision system's I/O ports, engineers often wonder, "How do we use those signals to do useful things?"

They may think they can connect solenoids, motors, and sensors on a production line directly to a vision system's I/O connectors. But vision systems don't operate autonomously within a manufacturing plant. Instead, they serve as part of a complete production line, overseen by one or more programmable logic controllers (PLCs).




**The design of a real vision system requires a thorough understanding of the types and uses of various I/O signals.**

Kyle Voosen, product manager for vision at National Instruments, explained, "System integrators often use a programmable automation controller to broker communication between vision systems and industrial I/O. This way, engineers can easily test all I/O operations independent of the vision system. It would be impractical or impossible to simultaneously test all the I/O devices on a manufacturing line if it ran directly to a vision system."

The I/O ports on vision systems operate with 24-V levels and 5-V TTL signals and may provide uncommitted NPN and PNP transistor outputs. You can use a variety of signal types to interface with external devices, but you'll most likely use a PLC, even if you need to turn on simple pass/fail lamps. Inputs also originate from a PLC, which can tell a vision system when a part reaches a set position, what types of inspections to run, and so on.

I/O operations get complicated when a camera operates on a production line some distance from sensors and actuators. The vision system may "see" a defective product, but because the product must travel farther down the line to reach the reject-bin actuator, the vision system cannot command a PLC to immediately push the part into the bin. Instead, the vision system or the PLC tracks the part and signals the actuator to push it in the bin at the proper time.

Tracking may require that system designers use sensors to detect the movement of parts and establish time delays to synchronize operations. After all, several good parts may have to pass the reject-bin actuator before a failed part arrives.

This example involves combinations of devices that connect to the camera and to the PLC and that must operate in sync with each other. Even if engineers master the use of the individual I/O signals, they still must get all the I/O devices to work together.

In cases when a vision system must produce and sense "local" signals, engineers must understand how to control I/O lines that don't involve a PLC as well as controlling those that do. Local signals, for example, can control light sources and sense the arrival of a part for inspection. It makes no sense to run these signals through a PLC, which would skew their timing. Although I/O signals seem easy to understand in theory, their application can get quite complicated. T&MW

## Wafer-metrology systems

Rudolph Technologies' S3000 (300-mm) and S2000 (200-mm) ellipsometry-based metrology systems are designed to provide high-throughput measurements of thin transparent films throughout the semiconductor device fabrication process. The systems employ Rudolph-proprietary and Cognex PatMax geometric pattern-matching technology for patterned wafer applications. www.rudolphtech.com.

## PCI Express video board

The Euresys Picolo Alert video capture board now comes in a PCI Express version. This 16-video-input board features a 1-lane (x1) PCI Express interface that is compatible with all PCI Express connectors. The Picolo Alert has a total digitizing power of 200/240 frames/s, shared among the 16 channels. Capture and preview functions are simultaneously available for each camera. The board includes a watchdog circuit and nine I/O lines. www.euresys.com.

## PCB laser marking

The ELM-700A laser-marking system from Eunil engraves bar codes, product model numbers, and logos on PCBs ranging in size from 50x50 mm to 430x350 mm. The system also accommodates board thicknesses from 0.5 mm to 2.0 mm. The PC-controlled ELM-700A can process both PCB and plastic materials with a maximum adjustable conveyor speed of 200 mm/s. Options include a bar-code reader, a 15-in. LCD touch-screen monitor, and a host connection. www.eunil.com.

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EMC

# Scan for ESD-induced errors

An electrostatic discharge (ESD) from a person touching an electronic device or system can produce thousands of volts and several amperes, which can easily damage or destroy an integrated circuit (IC). A damaged device is often easy to find with a visual inspection, but ESD can produce secondary effects that are difficult to troubleshoot. A team consisting of Professor David Pommerenke and two students at the University of Missouri-Rolla's EMC Laboratory (www.emclab.umr.edu) developed a tool that can measure the impact of secondary electromagnetic interference (EMI) effects from ESD. The scanning system can help engineers find where and how secondary ESD events cause bit errors in digital systems (Ref. 1).

An ESD event produces radiated EMI in the form of E-fields and H-fields. The fields can then couple into printed-circuit board (PCB) traces and IC pins, turning back into current. Current in a PCB trace can produce a voltage sufficiently large enough and long enough to cause a bit error without damaging an IC. A PCB with an embedded processor, for example, may continue to function after the bit error, or it may crash, requiring a restart.

Finding the point or points where induced current couples into a system is difficult because radiated fields can travel anywhere within a system's enclosure. To identify EMI-susceptible areas on a PCB, the UMR scanning system scans a probe across a PCB, producing localized EMI and tracking the PCB's response. The system can use an E-field probe, vertical and horizontal H-field probes, and a direct-contact probe to inject a localized disturbance into the PCB. The E-field and H-field probes produce fields from an ESD pulse and radiate them into PCB traces and IC pins, whereas the direct-contact probe injects an ESD pulse directly to the point of interest. As the system scans the probe across the PCB and produces EMI or ESD, software monitors the effects of the disturbances and plots them on a map using color to indicate the intensity of an error (**Figure 1**). The system is, in effect, the opposite of a radiated EMI scan that measures radiated emissions from a PCB.

To create the localized EMI or ESD, the system generates a series of transmission-line pulses (TLPs) as it scans across a PCB. A TLP generator produces rectangular pulses with a 900-ps rise time and a peak voltage of up to 5000 V. TLP pulses hold their peak level longer than the Human Body Model (HBM) pulses produced by handheld ESD simulators (Ref. 2). TLP generators also produce more repeatable pulses (**Figure 2**). Measured at a 50-Ω terminated trace, the pulse is about 200 ns wide at the half-amplitude point.

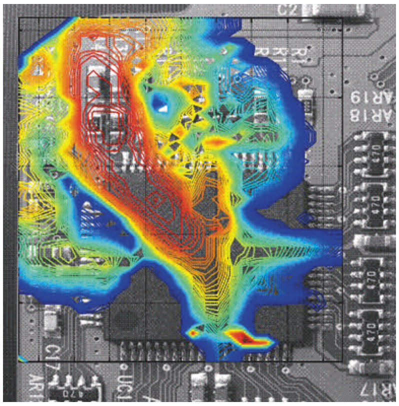

**FIGURE 1. A PCB scan indicates areas that are susceptible to secondary ESD effects. Red indicates highest susceptibility.** Courtesy of University of Missouri-Rolla.

The researchers discovered that ESD-induced EMI can affect a system even on signal lines that carry slow digital signals such as status lines. PCB designers usually use short traces to carry high-frequency signals such as clocks and serial data streams, but they may use longer runs for slowly changing signals. Unfortunately, the longer the trace, the better it acts as a receiving antenna for stray EMI. The research team learned this lesson when a scan revealed a trace that, when subjected to pulse EMI, caused soft errors to occur. They fixed the problem by adding an R-C filter to the trace. The filter removed energy from the ESD-induced EMI. It also slowed the wanted signals, but not enough to affect system operation.

*Martin Rowe, Senior Technical Editor*

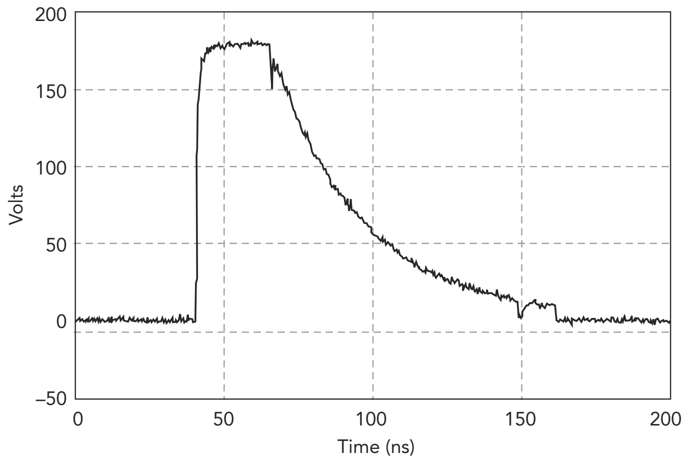


**FIGURE 2. A TLP generator produces a repeatable pulse for ESD testing.**
Courtesy of University of Missouri-Rolla.

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1. Pommerenke, David, Jayong Koo, and Giorgi Muchaidze, "Finding the root cause of an ESD upset event," DesignCon 2006, International Engineering Consortium, Chicago, IL. web.umr.edu/~davidjp/paper/Pommerenke_DesignCom2006.pdf.

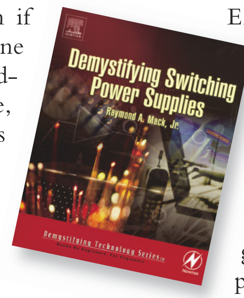
2. Rowe, Martin, "TLP testing gains momentum," *Test & Measurement World*, September 2002. p. 37. www.tmworld.com/2002_09.

BOOK REVIEW

# Learning to specify and buy power supplies

*Demystifying Switching Power Supplies*, Raymond A. Mack, Jr., Newnes (books.elsevier.com), 2005. 323 pages. $49.95.

Switching power supplies are ubiquitous in many types of test equipment, so it might behoove you to know something about them, even if you don't propose to design one yourself. In fact, from a test-and-measurement perspective, knowledge of power supplies can be invaluable, because they may be the source of problems in the equipment you are trying to test. Often selected as an afterthought, a power supply may not deliver the power or regulation a design requires, it may contribute unacceptable levels of jitter through crosstalk, or it may emit troublesome levels of EMI.




The author's stated goal with this book is to help you understand how a switching power supply works, how to intelligently specify a custom supply, and how to design one if need be. He succeeds at the first two goals, but with respect to helping the reader design a supply, he provides enough detail to suggest that design be left to power-supply professionals. You may feel you've come away with a sufficient understanding of the circuitry, but you're very unlikely to want to have to deal with the litany of EMC and safety standards you would need to comply with.

Mack takes you from the basics ($v = L di/dt$, plus buck, boost, inverting boost, buck-boost, and other supply circuit topologies) on through the details of passive component selection and semiconductor selection. Of particular note are his treatment of control circuits and their effect on ripple levels and electromagnetic compatibility. He provides a step-by-step test sequence for evaluating power-supply response using a variable load, an oscilloscope, and a function generator.

Mack concludes with two solid examples: a true sine-wave inverter uninterruptible power supply and a personal-computer power supply. (Disclosure: The book's publisher is owned by *Test & Measurement World*'s parent company.)

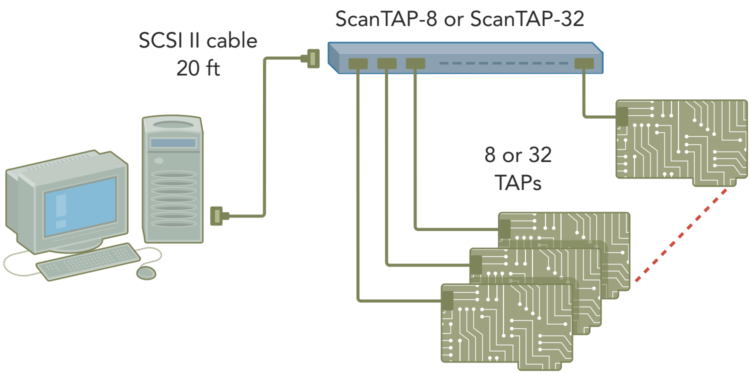
*Rick Nelson, Chief Editor*

COMMUNICATIONS TEST

# Boundary scan accelerates VoIP test

As more new processors and communication electronics are designed to include boundary-scan chains, boundary-scan testing of multiple circuit boards in parallel is becoming a way to cut both time and costs out of the test cycles of product manufacturing. A single operator can test multiple boards simultaneously from a single PC. With these new boundary-scan (JTAG) tools, it takes the same amount of time to test four boards as 1000.

Zultys Technologies, a maker of VoIP products, is embracing boundary scan as the company acts to take advantage of enterprise-level VoIP applications that are predicted to grow at 20% annual rates through 2009. To meet its time-to-market, costs, and quality requirements, Zultys is employing Corelis boundary-scan hardware to perform concurrent testing and programming of multiple units without operator intervention. With the Zultys implementation, Test Access Ports (TAPs) on a remote test pod have a dedicated pin on the JTAG interface connector that can detect the presence of the target board. The software monitors the state of this signal to detect both the presence of the target




**A simple test setup involves connecting the test controller to a PC through a PCI, USB, LAN, or cPCI interface, then to multiport TAP pods to accommodate the UUT.**

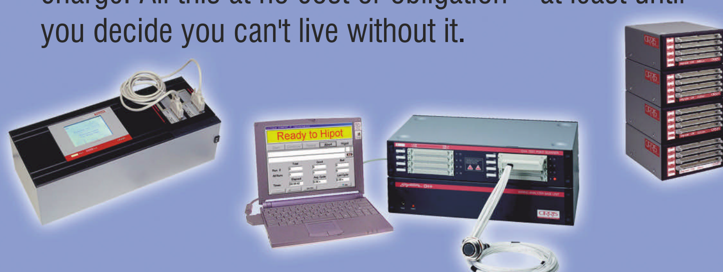
device as well as the proper insertion of the test cable.

The hardware applies simultaneous test vectors and in-system programming (ISP) patterns to each board, and it performs individual, simultaneous verification. Any failure of one board will be logged but doesn't prohibit the continuation of testing on all the other units under test (UUTs). From there, additional hardware choices fan the connection out to accommodate more and more units at once.

The details of how Zultys applies boundary scan in its "push-line" conveyer-belt assembly process are available in a paper at www.corelis.com/products/WhitePapers.htm#zultys.

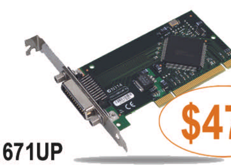
*Karla May, Manager of Strategic Accounts, Corelis*















INSTRUMENTS

# All the right switches

**DEVICE UNDER TEST**
Avionics control panels used in the Boeing 787. The panels consist of switches, potentiometers, and indicators that control and monitor various aircraft functions in the cockpit and main cabin. Panels range in complexity from two to 22 switches, one to eight indicators, and one to 12 potentiometers.

**THE CHALLENGE**
Develop a system that functionally tests the panels for switch closures, indicator light illumination, and potentiometer settings. Design an interface board that provides a single connector for use with numerous cable harnesses. Develop an easy-to-use user interface for test operators.

**THE TOOLS**
- Geotest: PXI 3U/6U mainframe; controller; two-channel, 0–30-VDC power-supply card; 75-channel relay cards. www.geotestinc.com.
- National Instruments: PXI CAN bus controller cards; graphical programming language; test executive. www.ni.com.
- Signametrics: 6½-digit PXI DMM card. www.signametrics.com.

## PROJECT DESCRIPTION

Korry Electronics (Seattle,WA, www.korry.com) manufactures control panels for the Boeing 787 aircraft. With the 787, Boeing is incorporating a new generation of panels. Traditional control panels consist of switches and indicators, each with its own set of wires that come out to a connector. The 787 control panels reduce wiring by incorporating a controller area network (CAN) bus for switch control and indicator status.

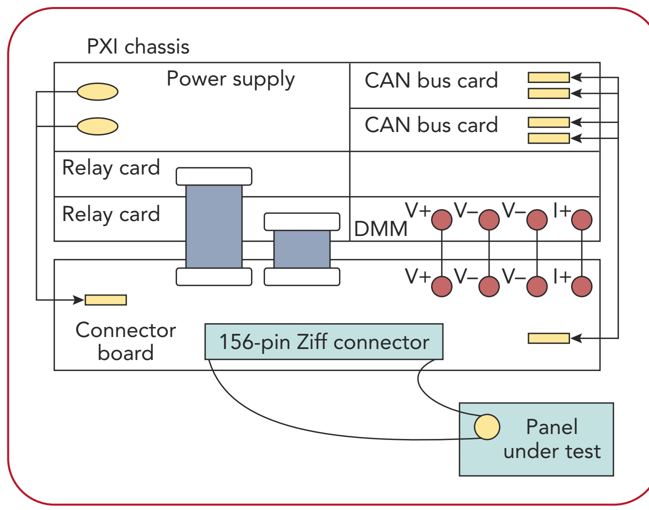
The test station's PXI chassis (**figure**) supplies power for testing a panel's switches, potentiometers, and indicators. Two relay cards route power from the DC power supply to the panel, and they connect a digital multimeter (DMM) card when applicable. Software sets the power supply to 28 V, the voltage used in many aircraft systems. Two dual CAN-bus interface cards connect bus channels from the PXI chassis to the individual switch panels.

Test engineer Allen Cutler designed an interface board that routes power to a panel's components. He used a single 156-pin Ziff connector in his custom interface panel so a test operator can connect any of several cable harnesses to the board. Circular military-style connectors bring the signals to the panel. Each type of panel has a unique cable assembly.

Before applying power to the panel, the system verifies integrity of the switch panel power circuitry. After applying power to the panel, the system measures the current it draws. If the current is within limits, the system tests switches by connecting the power supply to each switch. The discrete switches are hard wired, and the digital switches are monitored by the CAN bus. The DMM, connected between the switch under test and ground, verifies switch closure when it senses the power-supply voltage. For manually controlled switches, the system informs a test operator to close the appropriate switch, after which the system verifies switch closure.

To test a potentiometer, the system connects the power supply across the part, then connects the DMM's voltage input from the wiper to ground and measures the wiper voltage. The system instructs the test operator to adjust the potentiometer from end to end, which should produce a voltage from 0 V to 5 V. "We prefer to measure voltage instead of resistance," said Cutler. "It's more accurate."

For an indicator test, the system sends a command over the CAN bus to illuminate each indicator. The system applies power to an indicator and instructs the test operator to verify that the light is on. A set of check boxes appears on a PC monitor, and an operator checks the boxes for passed indicators.




**A PXI chassis provides power, relays, a CAN-bus interface, and a DMM for testing avionics control panels.** Courtesy of Korry Electronics.

## LESSONS LEARNED

During this project, Cutler learned the value of preparation. "Do a good evaluation of your test needs so you'll have the right resources," he said, "and use common connectors whenever possible."

"Use modular code as much as possible," he added. "I use many subroutines across multiple panels. Each relay has its own routine that the software calls as needed, regardless of which panel is under test." He also reuses code written for applying power and measuring power-supply current in each panel.

*Martin Rowe, Senior Technical Editor.*

# TESTING SPANS

## Engineers at Polatis test optical switch modules and systems

> Mike Grant is the production ATE manager at Polatis' Cambridge, UK, facility.

DAVID LEVENSON

BILLERICA, MA—Optical switches are fast becoming a component of choice for telecom engineers who develop reconfigurable networks. With optical switching, you don't have to convert optical signals to electrical signals and back just to configure a network. Skipping the conversion reduces network costs and maintains data rates.

Like any optical device or system, optical switches must be tested for various forms of power loss. Engineers at Polatis (www.polatis.com), which has a location in the UK as well as one in Massachusetts, measure parameters such as optical power insertion loss (IL), return loss (RL), polarization-dependent loss (PDL), and wavelength-dependent loss (WDL), all over a range of temperatures. The engineers make these measurements on identical systems in both locations, thus providing for consistency across the Atlantic.

A Polatis switch system consists of a switch-fabric core manufactured in Cambridge, UK. Inside the core, piezoelectric devices steer beams of light from one port to another. (See "Beam steering," p. 32, for a description of how the Polatis switch works.) **Figure 1** shows a map of how the components come together to form a complete switch system. Testing takes place at the module level and at the system level.

Following assembly, a core switch module requires extensive testing, even in production. After testing, a core module may ship to the Billerica, MA, facility for integration into a complete switch system or it may stay in Cambridge. The Polatis staff assembles a complete system by inserting a switch module into a case, adding a power supply, and in some instances, adding optical power meters into the system to provide power detection and optical attenuation.

To learn about how Polatis tests both its core switch modules and complete switch systems, I visited the Billerica facility where I met Tim Glenn, senior lead engineer, and Aaron Bent, VP of marketing. To learn about the capabilities in Cambridge, I spoke with production ATE manager Mike Grant by phone.

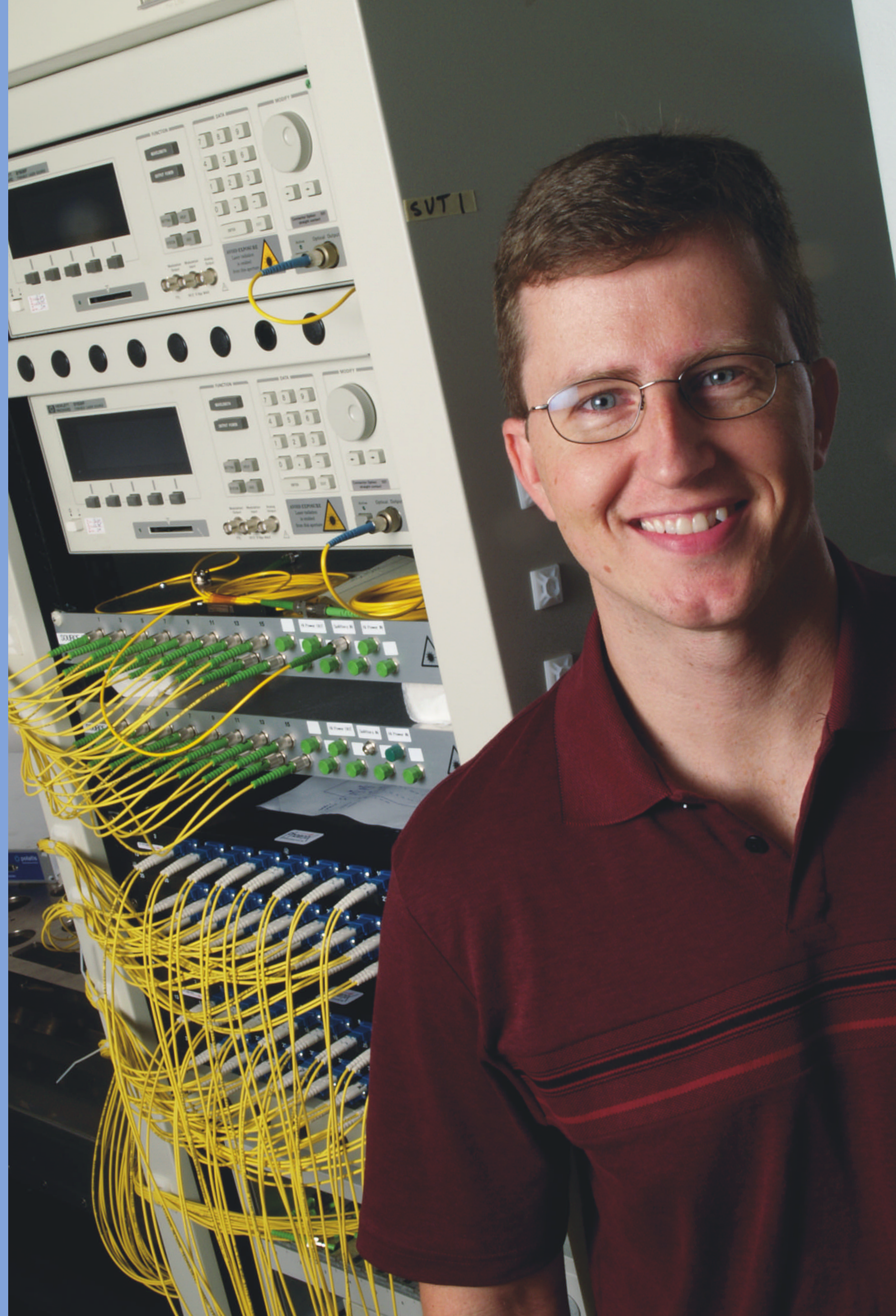
### Testing the core

At the Cambridge facility, Grant oversees testing of the optical core switch module, which consists of the piezoelectric actuators, optical collimators, and control electronics. A core switch module typically has 16x16 optical ports (256 possible crosspoints), or 32x32 optical ports (1024 possible crosspoints).

Optical testing begins with an automated inspection of the piezoelectric subassemblies, which move the collimators and steer beams of light. An inspection system consisting of a Pulnix CCD camera and a National Instruments PCI frame-grabber card measures the lateral displacement of the light beam when a voltage excites the piezoelectric device. LabView software captures and stores the characteristics of each actuator subassembly.

Following inspection, the beam-steering assemblies, control electronics,

MARK ALCAREZ




> Tim Glenn is senior lead engineer at Polatis' Billerica, MA, facility.

# THE OCEAN

## on both sides of the Atlantic.

MARTIN ROWE, SENIOR TECHNICAL EDITOR

and collimators are assembled into a core switch module. The completed module goes through a series of calibrations to ensure that it properly steers light to the correct ports.

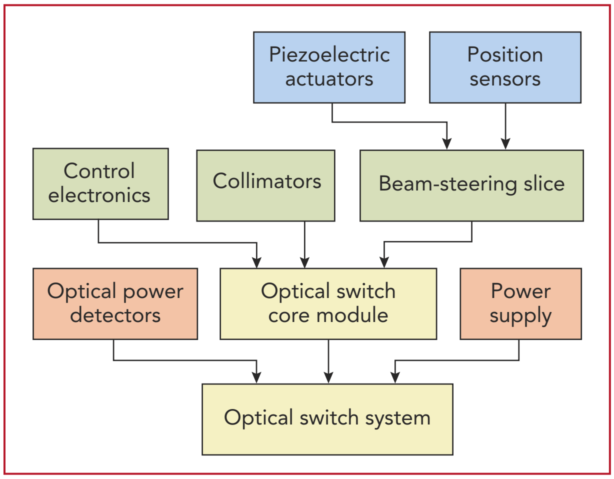



**FIGURE 1. An optical switch system uses a core switch module to switch signals to optical ports.**

Calibration starts at room temperature on a test system consisting of 1550-nm laser source and detector, housed in a custom-built 1U tray (**Figure 2**). "We use our own switches to connect the laser source and power meter to the switch module under test," said Grant. "It's essential that the test system be absolutely stable during the tests. Otherwise, the calibration of the beam-steering mechanism will be invalid."

Software automates the testing. A peak-power-search algorithm finds the position of maximum optical power. The software then records the position of the collimator as measured by an analog-to-digital converter (ADC) attached to the position-sensing electronics. The sense value is stored in the controller's memory, pending adjustments from thermal cycling.

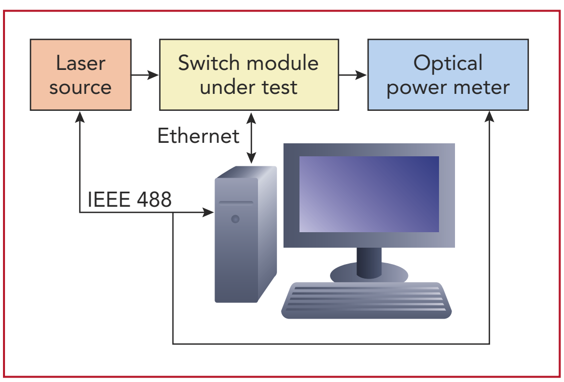



**FIGURE 2. An optical power meter measures the switch module's output power, while a peak-power-search algorithm calibrates the switch's optical paths.**

Once operational, a core switch module moves to a thermal calibration station. A Sharetree temperature chamber that lets engineers calibrate the actuators from 0°C to 60°C. The engineers use the chamber to rerun the peak-power-search algorithm at the temperature extremes. By locating the beam position and measuring the output power, the system adds temperature-compensating digital offsets to the control board. Once calibrated, the switch module loses less than 1.0 dB of optical power from the entering light beam.

Testing of the core switch module doesn't end with calibration. A module must still prove that its temperature-dependent loss and repeatability meet Polatis' requirements. Following the temperature calibration, the module must demonstrate a stability of less than 0.5 dB change in insertion loss over the entire temperature range. Polatis engineers measure loss through the core switch over the entire 0°C to 60°C operating range. They measure loss at 0°C, 25°C, 60°C, and several other temperatures. A temperature stability value of 0.1 dB is typically achieved.

Repeatability tests take several hours to perform, so the Polatis engineers usually run them overnight. "We run tens of thousands of switching cycles over a range of 0 to 60°C to check the operation of the switch, which generates tens of megabytes of data," explained Grant. Switch repeatability is measured with 100 scans of every input port/output port combination. The test uses an Agilent Technologies or Yokogawa amplified spontaneous emission (ASE) light source operating in the 1500-nm wavelength region to minimize amplitude noise in the measurement system. The test lets engineers verify that a switch module has a repeatability of ±0.05 dB.

The final acceptance test for a switch module involves measuring insertion loss, optical return loss, and crosstalk. In this test, engineers use the three-patchcord technique that complies with ANSI/TIA/EIA-568-B.3-2000 and other standards (Ref. 1). The patchcord is a reference for insertion loss by which Polatis engineers can compare a connectorized switch module's insertion loss.

To make the measurement, engineers first insert the reference patchcord into their test network and measure insertion loss with either a 16-channel or 32-channel Agilent or dBm Optics power meter. They also use an ASE source (an Agilent or a New Focus tunable laser) to drive the patchcord. Then, they substitute the switch module for the patchcord and measure again. Each of the switch outputs connects to a separate channel on the power meter, a setup that permits simultaneous measurement of insertion loss on the illuminated output and of leakage optical power, or crosstalk, on the "dark" outputs.

Polatis engineers also measure polarization-dependent loss (PDL) and wavelength-dependent loss (WDL) in the C-band (1530–1560 nm) and L-band (1565–1625 nm). To make the PDL measurement, engineers use an Agilent polarization controller and dBm Optics component spectrum analyzer. The Agilent 8169A polarization controller is under the control of the dBm Optics component spectrum analyzer for this test, and the system automatically measures loss over a matrix of polarization states. To make the PDL measurement, engineers use the patchcord to measure PDL of the test network, then they replace the patchcord with a switch module. The difference in PDL represents the switch module's PDL.

### On to integration

When a switch module passes acceptance testing in Cambridge, it's ready to become the core of an optical switch system. Integration takes place in both the Cambridge and Billerica locations. A complete switch consists of the core

switch module, a network interface management card, a power supply, a case, and optional power monitors.

Calibration of the core switch modules in Cambridge ensures that the maximum amount of light reaches the intended output. Sometimes, though, users need to reduce optical power to a controlled level. By deliberately detuning a switch—by misdirecting the light beam—users can control the amount of optical power at an output port. This detuning lets a switch operate as a variable optical attenuator (VOA), an option on Polatis switch systems.

Users can configure the switch system for constant output power or for constant attenuation. To attain a constant output power, the switch system monitors the output power and adjusts attenuation in real time. For constant attenuation, the system measures both incoming and outgoing power, adjusts the amount of attenuation, and then holds the attenuation. Power monitors installed into a switch system make controlled attenuation possible, but these power monitors need calibration. "We need to perform the power-monitor calibration because each optical detector's responsivity differs slightly," said Glenn.

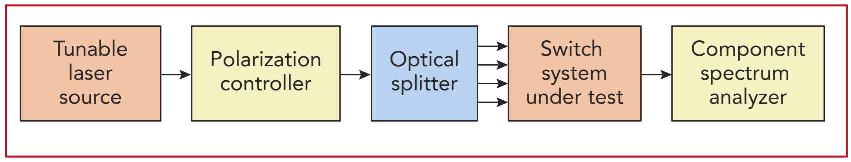



**FIGURE 3. Engineers use this system to measure IL, PDL, RL, and WDL in an integrated switch system.**

Polatis calls an integrated switch system with power monitors a VOA switch tray (VST). After a VST is assembled in the integration room, Glenn and others test it with a rack of instruments consisting of a dBm Optics component spectrum analyzer, a New Focus tunable laser source, and an Agilent polarization controller. "After integration, we repeat many of the measurements done in Cambridge," said Bent. "We compare RL, PDL, and WDL measurements of the integrated system against those done in Cambridge on the core switch module before we calibrate the optical monitors." **Figure 3** shows the test setup in the integration lab.

Following integration and initial testing, a completed VST moves from the integration room to the calibration and final-test room. The room contains two test stations, each using a Thermotron environmental chamber. One station performs calibration of the optical power monitors, and the other performs final test.

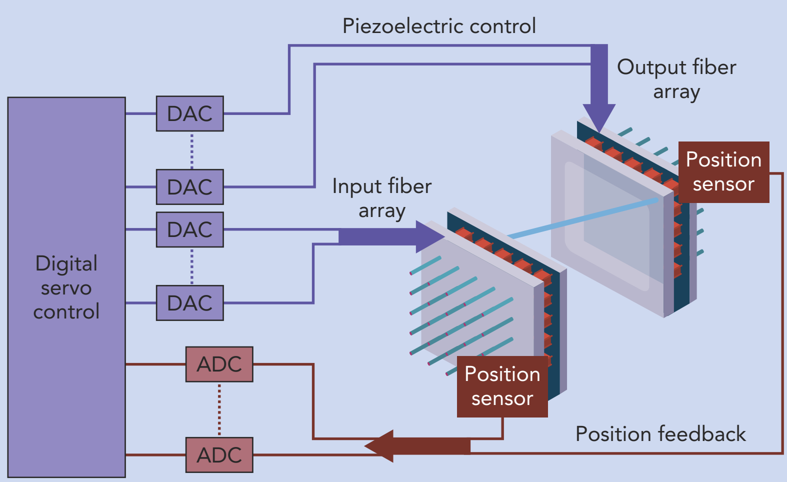
The calibration station uses a rack of instruments that include laser sources and power sensors. Three Agilent tunable laser sources and one Agilent fixed laser source generate the light. The fixed laser source (1550 nm), along with an EDFA and JDSU attenuator for controlling power over a large range, lets engineers perform initial functional test and calibration. The tunable lasers vary the wavelength during a wavelength-dependency calibration. A polarization controller minimizes uncertainties caused by PDL of the test system and polarization-dependent responsivity (PDR) of the integrated power monitors.

An Agilent 8166A lightwave multichannel system populated with 33 optical power sensors measures optical power

## Beam steering

Polatis' switch fabric uses piezoelectric technology to steer beams of light through free space by moving optical collimators so a transmitting and receiving collimator correctly align with each other (see **figure**). Capacitive angle sensors track the position of each collimator. The collimators, piezoelectric devices, and capacitive sensors reside in a sealed core switch module, which prevents stray light from interfering with the switched optical beams.

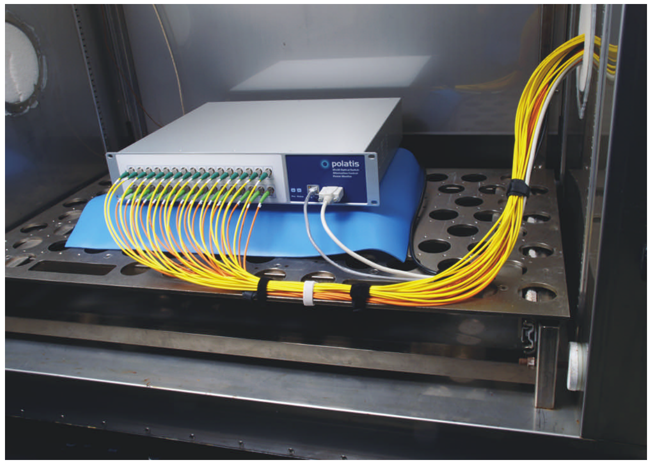
A control-electronics board in the core switch module contains digital-to-analog converters that produce analog voltages to drive the piezoelectric devices. Position sensors produce analog voltages that represent the collimator's position. Analog-to-digital converters on the control board digitize the voltages, which the controller uses to maintain a tight feedback loop that keeps the collimators pointing at their targets. The architecture is "non-blocking"—any optical input can connect to any output. Because the core switch module uses electrical signals in the control loop, it can switch "dark" fiber.—*Martin Rowe*




**Piezo controls and position sensors steer light between the input and output fiber arrays.**

as it enters and exits a VST under test (**Figure 4**). Up to 32 power sensors connect to the output ports for output power measurement. The additional power sensor is used as a reference for measuring input power. A standard Polatis switch connects the laser sources to the polarization controller. Test signals then travel to the VST under test.

Light that exits the VST under test travels to the calibration station's power sensors, which serve as references for the power monitors in the VST. Once calibrated, the power monitors achieve accuracy of ±0.25 dB, or ±5% of range. "During a specific calibration measurement," explained Glenn, "we hold all variables such as temperature, power, and wavelength constant except one, namely the one variable whose impact on detector responsivity is being characterized during the measurement. For example, we hold wavelength constant at 1550 nm and temperature at 25°C, while we calibrate over a wide range of input power: –30 dBm to +24 dBm."




An optical switch under test in a thermal chamber.

MARK ALCAREZ

To perform a calibration, the system software written in LabView compares the readings from the VST's optical detectors to those from the calibration station's optical sensors and records the differences. The system repeats the measurements over the full ranges of temperature, wavelength, and optical power, changing only one variable at a time. From the measurements, the software creates a look-up table and stores the table's values in the VST. During normal operation, the VST applies the table values to its power measurements, which brings them into line with those of the external optical sensors. The optical detectors become NIST-traceable through their calibration with the external power meters.

The optical cables used in the calibration and test systems are critical to producing a switch that meets its specifications for loss and power-monitor accuracy. Losses in the fibers between the test instruments and the VST under test are negligible, but insertion losses from the connectors must be minimal and consistent. Cleaning of the optical connectors and the quality of the connection are critical to proper performance. "If someone else cleans the connector bulkheads and makes the connections," Glenn emphasized, "I run an initial set of measurements. I know from experience how well the system performs. If it doesn't meet my requirements, I'll remake the connections."

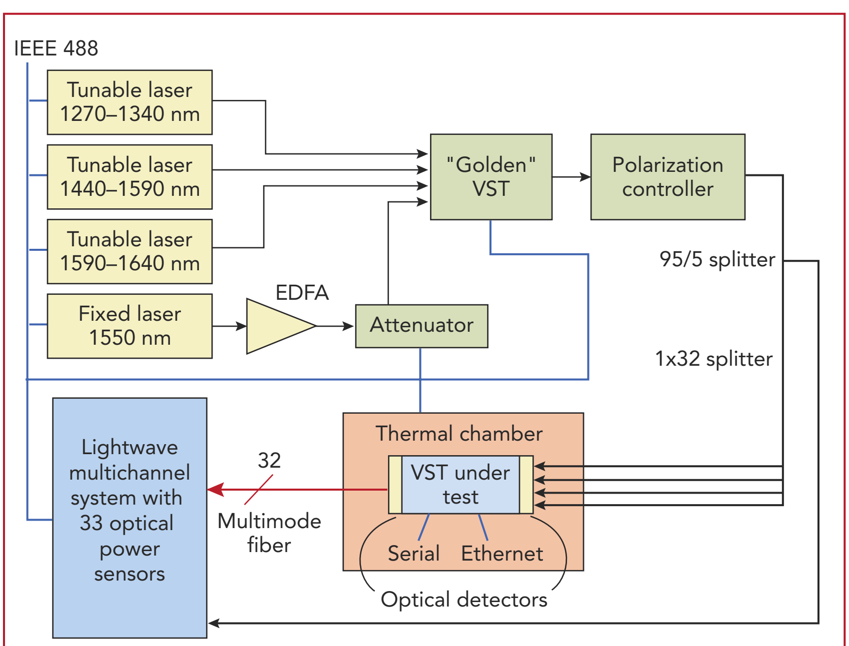



**FIGURE 4.** Calibration of power detectors takes place with the switch (VST) in a thermal chamber.

Alignment of optical fibers in connectors is also critical. To minimize loss uncertainty, Glenn designed the tester to use multimode fibers on the VST's output ports—other paths use single-mode fibers. Multimode fibers have a 50-µm core diameter, whereas the single-mode fibers used inside the VST have 8-µm core diameters. That difference in diameter essentially eliminates the chance of misalignment, which dramatically improves measurement accuracy. Each multimode cable essentially becomes an extension of the corresponding reference power sensor. In effect, the power sensor's "large-area detector" now resides at the front panel of the switch, where calibration of the internal power monitors is specified.

Following calibration, VSTs move to a final-test station where engineers measure IL, RL, PDL, WDL, and repeatability. They make all of these measurements over the VST's operating temperature range. Repeated testing at the module and system levels assure users that a Polatis switch meets its tight specifications for power loss and repeatability. T&MW

## REFERENCE

1. ANSI/TIA/EIA-568-B.3-2000, "Optical Fiber Cabling Components Standard," Telecommunications Industry Association, Arlington, VA, April 2000. www.tiaonline.org.

# Detective WORK finds board failures

Analysis of board failures requires standard lab tools as well as engineering insight and intuition.

THOMAS PAQUETTE, INSIGHT ANALYTICAL LABS

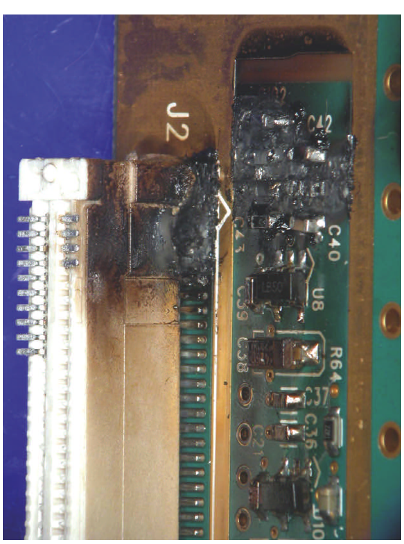



**FIGURE 1.** A burned PCA shows charring near the J2 label. Note the damage to the component area. The high temperature in this area melted solder and let several components fall off the PCB.

As the complexity of printed-circuit assemblies (PCAs) increases, so do the demands placed on failure analysts and analysis labs. The use of BGAs, buried vias, and global component sources challenges analysts who seek the source of board failures. Through careful "detective" work, these analysts examine clues on failed PCAs and test components to home in on the sources of failures.

At our lab, the analysis of one typical PCA failure followed this sequence: A customer sent us a PCA with a burned area (**Figure 1**). Some ICs and discrete components had fallen off the board, and the customer sent those, too. We also received the unit's schematic diagram and printed-circuit board (PCB) layouts, along with a known-good PCA for comparison.

A failure analyst familiarized herself with the PCA's original condition by reviewing the layout and schematic. Next, she inspected the PCA and noted the condition of the board surfaces as well as any visible damage to internal layers. Evidence of missing traces and damage to the top and bottom of the board also provided useful clues to the source of the failure. Examination of the charred area let the analyst better understand how the high heat had spread.

The analyst also determined where loose components had been attached to the burned PCA. In this case, several components showed severe damage and only a few were missing. By comparing the state and location of the damaged components to equivalent parts on the known-good PCA, the analyst began to conclude excess current caused the failure.

The PCA's burned section provided the overall system with only one direct signal—an output that passed through a connector. But neither the PCB trace nor the connector appeared damaged. So, perhaps a *damaging* current did not flow on this conductor, although *excess* current might have led to the failure.

While a technician tested discrete components removed from the burned area (they all passed), the analyst examined possible current paths, one of which included the output signal's CMOS driver. This IC might have experienced a voltage spike that triggered a latch-up event. The chip did not appear damaged, so the analyst removed it from the PCA and checked its DC electrical characteristics, which met specifications. Finally, she decapsulated the IC and examined its die, which showed no damage.

Of the missing components, only one—a tantalum capacitor—seemed like a good suspect. The missing capacitor could have provided a low-resistance path between the PCA's power-supply buses and ground, which would generate excessive heat.

To test this hypothesis, the analyst used an infrared imager to display the PCA's surface temperatures as she replaced the same capacitor on the known-good PCA with various resistors and powered the board (**Figure 2**). Results showed a 10-Ω resistance in the missing capacitor would have caused the damage found on the original PCA. (A shorted tantalum capacitor, though, would produce even less resistance and allow more current to flow, at least temporarily.) The circuit's signal levels did not exceed the capacitor's data-sheet specs, so the analyst concluded that either the circuit designer underestimated power-bus voltage spikes or the PCA assembler may have used a defective capacitor.

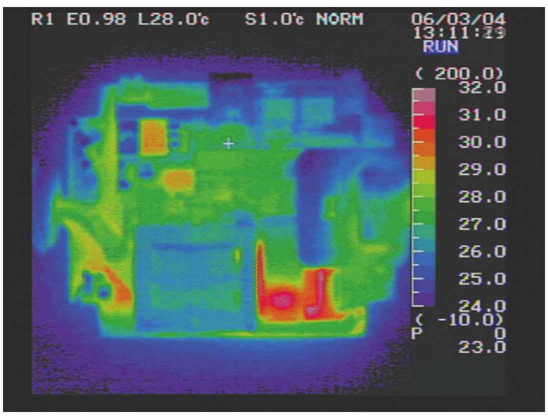



**FIGURE 2.** This infrared image shows two hot areas (red and pink) and cooler areas (purple) on a PCA. Analysts use such images to locate abnormally hot areas that may indicate or cause failures.

In this example, detective work focused on a defective passive component. Other problems, such as the increasing numbers of counterfeit components, the use of fine-pitch ball-grid arrays (BGAs) and buried vias on PCBs, and damage caused by electrostatic discharge (ESD) or electrical overstress (EOS) events, also lead to board failures that require careful analysis in order for their source to be tracked down.

## Components wear disguises

Board failures, such as the one described above, may arise from a problem of increasing proportions—the inclusion of counterfeit parts from distant vendors in the supply chain. Engineers and managers often cite the use of counterfeit ICs as a growing problem that affects the quality and reliability of electronic equipment. But counterfeiters also produce more mundane discrete parts such as resistors and capacitors. The unsuspecting use of such parts, which can cost only a few tenths of a cent each, can cause manufacturers to spend hundreds of thousands of dollars on recalls and corrective actions.

Detection of counterfeit parts may require that analysts involve component manufacturers in their investigations. Recently, after we performed an analysis of a capacitor failure for a customer, the customer returned the defective capacitor to its supposed manufacturer, only to learn he had purchased a counterfeit device. From the exterior, the fake capacitor appeared identical to a legitimate component. An x-ray inspection of the fake's interior showed major differences between its construction and that of legitimate products.

These days, failure analysts who work on PCAs must consider the possibility that one or more counterfeit component exists on a failed board. And although a counterfeit part might not fail outright, it could start a chain of events that causes a catastrophic failure.

## BGAs keep contacts out of sight

Individual components do not have to fail to cause a PCA failure. Often, electrical contacts are the culprits. Complex surface-mount ICs often demand the use of BGA packages that offer a dense matrix of solder-bump or solder-ball contacts. We frequently hear of a circuit problem that engineers have temporarily "solved" by pressing down on a BGA or exposing the BGA to a temperature change. To a failure analyst, this type of stress-related defect usually indicates poor solder-ball adhesion between BGA and PCB solder pads.

Additional BGA-related problems include bump-to-bump shorts, micro-cracks in solder, and poor contact coplanarity. To find such defects, PCA analysts need a way to view the small solder balls, sandwiched between the BGA's underside and a PCB. Relying upon their experience with PCAs, analysts may be tempted to use a vision system employing acoustic microscopy, x-ray inspection, or visual inspection to reveal defects, yet each technique has limitations that make it generally unsuitable for examining BGA problems.

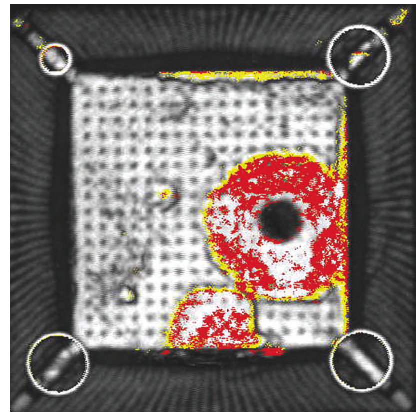


**FIGURE 3.** The red area in this acoustic-microscopy image shows delamination (separation) of the die and the packaging material. The large black dot indicates carbonized plastic caused by excessive heat.

Analysts can use acoustic microscopy to "see" delaminations, voids, and damage within a packaged device (**Figure 3**), but components inside a BGA usually disrupt the sound waves and prevent good imaging of the solder balls. Likewise, acoustic-microscopy images of the solder balls taken through the board from beneath a BGA yield poor results. A PCB's woven fiberglass and the layers of metal and vias, not to mention the components on the

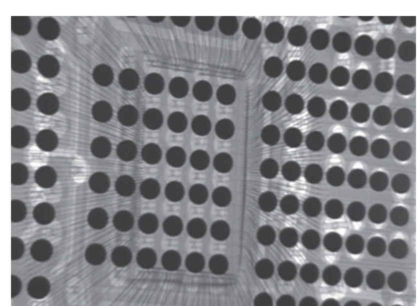
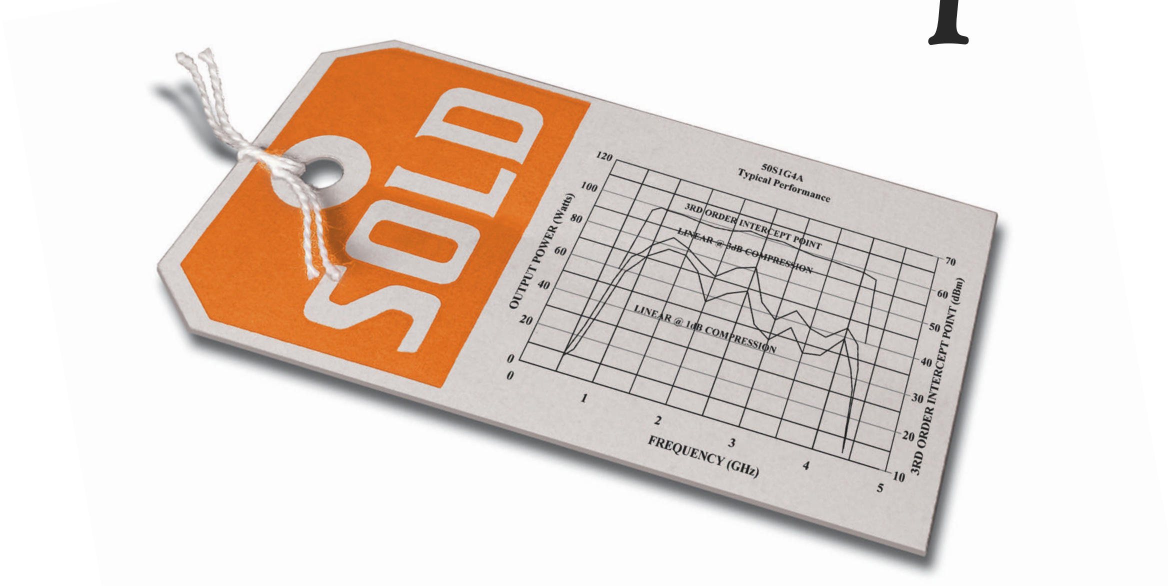


**FIGURE 4.** An x-ray view taken at an angle through a BGA shows individual solder balls and wire bonds but reveals little about micro-cracks and corrosion on PCB solder pads.

# Promises Made, Promises Kept!

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PCB's bottom side, attenuate and diffuse the sound waves.

X-ray techniques can produce images of BGA solder balls, but analysts can determine only the shape of the balls, their opaqueness, the presence of voids in the solder, and signs of solder "wetting" (**Figure 4**). Analysts will not see problems caused by micro-cracks in the solder and by "black pad," a form of corrosion. And analysts can only infer the presence of cold-solder joints from x-ray images.

Visual inspection of BGAs with a fiber-optic camera system lets an inspector see many of the solder balls. But this type of inspection proves ineffective when analysis requires inspection of hundreds of solder balls to find one or two defects.

Generally, electrical testing still provides the best way to identify open solder joints or shorted solder balls as well as opens and shorts within a BGA. Testing also has drawbacks, though, because it requires electrical access to the BGA connections, either through test pads on the PCB's component side or test pads placed on the back of the PCB to duplicate the BGA's solder-ball pattern. This type of access comes at the cost of extra "real estate" on the PCB. So, although analysts may request extra test points, the test points may cost too much to include.

**FIGURE 5.** Liquid dye placed between this BGA and the PCB it was soldered to penetrated a space that existed between the center solder ball and its solder pad. The other balls were soldered properly to their respective pads, so no dye penetrated these junctions.

As a last resort, when all other techniques have failed and analysts have no other option, they may use the "dye and pry" technique, which relies on a liquid dye that penetrates into existing micro-cracks or under open solder balls. After analysts let the dye dry, they pry the BGA off its PCB and inspect the solder balls for the presence of the dye and investigate problems the dye reveals (**Figure 5**). Unfortunately, this method destroys a PCA its owner might have hoped to salvage.

## Vias remain in the dark

Contact failures also may originate within a PCB. Complex designs may include 20 or more metal layers, sandwiched deep inside a PCB. That type of construction makes it difficult to connect test probes to some internal conductors. Designs that employ densely packed components with small lead pitches require the use of smaller vias—the contacts created through a layer to connect conductors. PCBs may include buried, or blind, vias (those that do not come to a PCB's surface) as well as high-aspect-ratios vias (those with a narrow diameter for a given layer thickness). The use of smaller and buried vias can cause failures attributed to incomplete plating, cracks, and contamination from materials used in manufacturing (**Figure 6**).

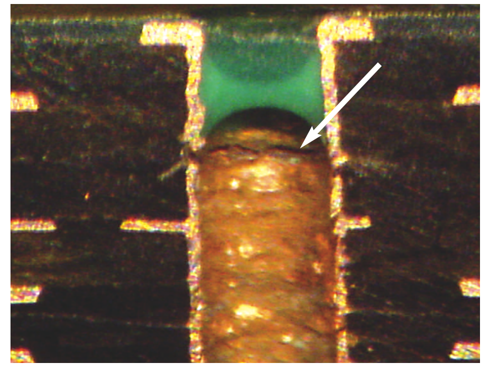

**FIGURE 6.** This cross-section image of a PCB via shows a crack that caused an open circuit. Stress, contamination, or insufficient plating might have caused the crack.

The inclusion of an increasing number of vias and metal layers seems to make tracing a short circuit exponentially more difficult. To start an analysis of short circuits, analysts require PCB layout files and a schematic diagram. With this information in hand, they can follow a "brute force" approach.

First, analysts identify possible areas in which a short may occur, and they then probe surface points. When possible, they isolate specific conductors. Some analyses require cutting into the PCB to expose internal conductors for probing. Or, analysts may need to cut into a board to sever an internal conductor so they can isolate a circuit. As a last resort, they can saw through a PCB to gain access to conductors along the side of the cut.

## ESD events trigger problems

If the cause of a board failure still remains elusive, analysts look for possible damage within ICs. ESD and EOS events still cause the most IC failures. Analysts can determine why individual devices fail, but analysis of an IC as it relates to the circuits and conductors on a "host" PCA may lead them to the origin of the ESD or EOS event. An analysis of the IC itself can show which pins an overstress event affected. Then, the circuit diagram and PCB layout can help analysts identify the path and source of a damaging voltage.

Such analyses can lead manufacturers to redesign their PCAs and circuits to improve reliability. Analysis of overall IC failures in conjunction with PCA failures also may point to production equipment or to a handling procedure as a cause of ESD or EOS problems.

In some cases, even a known-good IC can cause a failure. Subtle differences in processing can make a component from one IC manufacturer more susceptible to problems in a given environment than a pin-for-pin replacement from a different manufacturer. In other cases, a specific production lot of ICs may cause higher numbers of failures.

Visual inspection, infrared imaging, acoustic microscopy, and other tools can help failure analysts investigate circuit failures and their causes. But failure-analysis detective work also requires good engineering skills and intuition about how circuits and components fail and the damage these failures can cause. T&MW

## ACKNOWLEDGEMENT

Thanks go to my colleague Chris White for his help with this article.

**Thomas Paquette** *is president of Insight Analytical Labs, a company he founded. He has a BSEE from Clarkson University and has worked in the electronics field for over 30 years. He specializes in analysis of PCAs, discrete semiconductors, and IC failures.*

# PCI EXPRESS: BEYOND MINIMUM COMPLIANCE

**You'll need to go beyond the basics embodied in the PCI-SIG committee's software if you want to best your competitors in the PCI Express arena.**

MIKE LI AND RICH VIGNES, WAVECREST

A compliance testing software package available for free download from the PCI-SIG committee is an excellent, simple tool for preliminary demonstration of a product's compliance to PCI Express 1.1 standards. Indeed, that package was the predominant tool used to demonstrate product compliance at a PCI Express plugfest held in San Jose, CA, December 5–9, 2005.

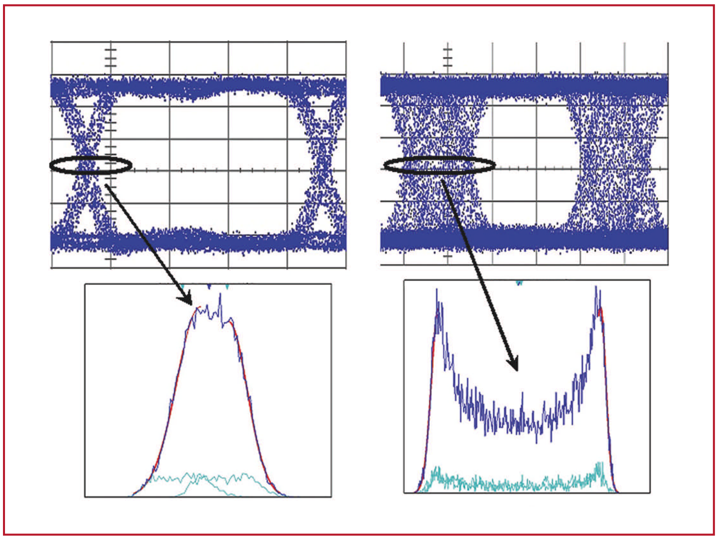

FIGURE 1. The top right eye diagram indicates degraded performance relative to that depicted in the top left diagram. The corresponding histograms suggest the lack of a PCI Express-compliant clock.

You should note, however, that this software was designed to provide a "snapshot" of minimum compliance and was never designed to be a complete compliance tool for PCI Express. The SIG software measures and reports on just four parameters ($V_{TXA}$, $V_{TXA\_d}$, $T_{TXA}$, $T_{TXA\text{-}MEDIAN\text{-}to\text{-}MAX\text{-}JITTER}$), while the specification for full compliance requires manufacturers to measure and report on a total of 30 parameters, in accordance with the PCI Express, Revision 1.1 Base Specification and Card Electromechanical Specification (Refs. 1 and 2). **Tables 1** and **2** show differential transmitter output specifications and differential receiver input specifications, respectively. In addition, reference clock peak-to-peak phase jitter must not exceed 86 ps for a $10^{-6}$ BER or 108 ps for a $10^{-12}$ BER. (See "REFCLK phase jitter specifications" accompanying the online version of this article at www.tmworld.com/2006_08).

The PCI SIG software is useful for customer demonstrations, but more-robust commercial compliance-test packages, which are available from a variety of vendors, address the comprehensive list of parameters called out by the PCI Express specifications. You can take advantage of these commercial packages to create products that are not just compliant, but that have higher design margins and improved production yields.

When evaluating commercial packages, you should compare their capabilities with respect to the PCI Express specifications to find the package that performs the tests you need. You should also take the time to understand the methods each package uses for the underlying measurements, as these measurements are used to derive other results during parametric (jitter, noise, and BER, also termed JNB) testing.

The best test methods, test instruments, and software packages to use are those that come closest to taking direct measurements for the parameters that apply to your products. You may need to use several instruments and methods—each one providing a "best method" for some portion of the list of parameters to be measured and reported on.

Using the right compliance tools is not a "nice to have" capability but a matter of maintaining competitiveness in the marketplace. Passing parts that have limited design margins can cause serious business issues. While such parts may pass the minimum compliance tests, if they later fail in the field, they will affect the bottom-line profits of a product line or business unit.

## Table 1. Differential transmitter output specifications

| SYMBOL | PARAMETER AND DEFINITION | 1.1 SPEC |
|---|---|---|
| UI | Unit interval | 399.88 ps (min)<br>400.12 ps (max) |
| $V_{TX-DIFFp-p}$ | Differential peak-to-peak TX voltage swing | 0.8 V (min)<br>1.2 V (max) |
| $V_{TX-DE-RATIO}$ | De-emphasized differential output voltage (ratio) | –3.0 dB (min)<br>–3.5 dB (nominal)<br>–4.0 dB (max) |
| $T_{TX-EYE}$ | Minimum transmitter eye width | 0.75 UI (min) |
| $T_{TX-EYE-MEDIAN-TO-MAX\_JITTER}$ | Maximum time between the jitter median and maximum deviation from the median | 0.125 UI (max) |
| $T_{TX-RISE,\ TX-FALL}$ | D+/D– TX output rise/fall time | 0.125 UI (min) |
| $V_{TX-CM-ACp}$ | RMS AC peak common-mode output voltage | 20 mV |
| $V_{TX-CM-DC-ACTIVE-IDLE-DELTA}$ | Absolute delta of DC common-mode voltage during I/O and electrical idle | 0 mV (min)<br>100 mV (max) |
| $V_{TX-CM-DC-LINE-DELTA}$ | Absolute delta of DC common-mode voltage between D+ and D– | 0 mV (min)<br>25 mV (max) |
| $V_{TX-IDLE-DIFFp}$ | Electrical idle differential peak output voltage | 0 mV (min)<br>20 mV (max) |
| $V_{TX-RCV-DETECT}$ | Amount of voltage change allowed during receiver detection | 600 mV (max) |
| $V_{TX-RCV-CM}$ | TX DC common-mode voltage | 0 V (min)<br>3.6 V (max) |
| $I_{TX-SHORT}$ | TX short-circuit current limit | 90 mA (max) |

## Table 2. Differential receiver input specifications

| SYMBOL | PARAMETER AND DEFINITION | 1.1 SPEC |
|---|---|---|
| UI | Unit interval | 399.88 ps (min)<br>400.00 ps (nominal)<br>400.12 ps (max) |
| $V_{RX-DIFFp-p}$ | Differential input peak-to-peak voltage | 0.175 V (min)<br>1.2 V (max) |
| $T_{RX-EYE}$ | Minimum receiver eye width | 0.4 UI |
| $T_{RX-EYE-MEDIAN-to-MAX-JITTER}$ | Maximum time between the jitter median and maximum deviation from the median | 150 mV (max) |
| $V_{RX-CM-ACp}$ | AC peak common-mode voltage | 0.4 UI (min) |

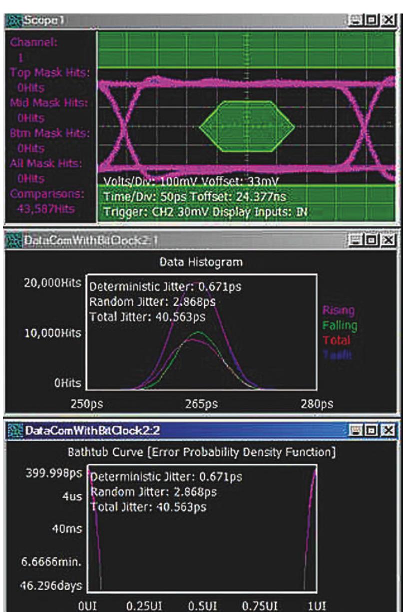


**FIGURE 2.** An eye mask (top) enables go/no-go testing, while a histogram (middle) indicates the jitter of rising and falling data edges relative to the clock signal. The bathtub curve data enables derivation of DJ, RJ, and TJ values using a tail-fit algorithm.

### Analyzing failures

You should also look for a PCI Express compliance tool that can perform failure analysis when a part fails on the production line or is returned from the field. Since compliance tools, by definition, are used to measure designs *after* they are complete, many packages provide limited or no diagnostic tools to aid a developer in isolating the root cause of the failed parameter. But if you use a tool that does offer failure analysis, you can quickly isolate the source of a problem and find a solution. Faster resolution of incidents results in improved customer satisfaction and overall better performance in the marketplace.

Robust packages provide diagnostic tools for both clock *and* data. Without first verifying the clock signal is accurate, you are at risk for propagating relatively small errors into very large errors.

Here are some examples of detailed views used for diagnostics. **Figure 1**



shows the test results of a PCI Express data signal with and without using a compliant clock. **Figure 2** shows an eye diagram, a jitter histogram, and bathtub measurements on a PRBS $2^{23}-1$ pattern. The Wavecrest TailFit algorithm (Refs. 3 and 4) applied to the jitter histogram yields RJ, DJ, and TJ results in about 1 s, measuring a signal from a pattern generator.

Other functions that can help evaluate PCI Express compliance include marker tools that can indicate jitter characteristics in several formats, including fast Fourier transforms (FFTs). In addition, clock/PLL tools can help isolate the cause of a Serdes problem that stems from a faulty reference clock or PLL. The online version of this article shows graphical examples of marker and clock/PLL tools and illustrates, for example, how you can use FFT and 1-sigma vs. span views to identify sources of jitter such as crosstalk or power-supply noise in order to find and eliminate problems (www.tmworld.com/2006_08).

A final example demonstrates the importance of diagnostic tools. Consider the test results for a transmitter that has been tested for compliance to PCI Express. **Figure 3** depicts the transmitter signal/jitter output test results for the full-swing eye (Figure 3a), de-emphasis eye (Figure 3b), and BER cumulative distribution function (CDF) and associated TJ at BER = $10^{-12}$ (Figure 3c).

In this figure, the measured eye-opening is 0.694 UI (or TJ = 61.2 ps). The minimum specification for the transmitter eye opening is 0.75 UI; therefore, this PCI transmitter marginally fails the compliance test.

**Figure 4** shows the data-dependent jitter (DDJ) distribution, PJ, and RJ power-spectrum density (PSD) for the same transmitter. Transmitter jitter output diagnostics test results measure DDJ as a function of the UI span. The DDJ histograms are reviewed for rising (green) and falling (purple) edges, respectively. The lower left diagram depicts a "zoom in" for the worst-case DDJ locations. The lower right diagram shows both PJ and RJ PSD shape.

These diagnostic views provide valuable information for determining the major jitter contribution. In this example, a PJ value at 5 MHz with a magnitude of 20.9 ps was the underlying problem. Had this PJ been identified and removed early in the development cycle, the transmitter would have passed the compliance test with high design margin. The DDJ in this case is 20.76 ps, and RJ rms is 1.4 ps, and both were determined to not be the major contributing factors.

Once you choose a software package for your PCI Express compliance tests, you should use the same instruments and test methodology throughout the entire product cycle. This will permit a seamless transition from development to design characterization to high-volume production, which will save time, reduce test costs, and improve time-to-market for your company. Using a single methodology in all cases will eliminate the confusion that could arise from measured values that were generated by different methods and platforms. T&MW

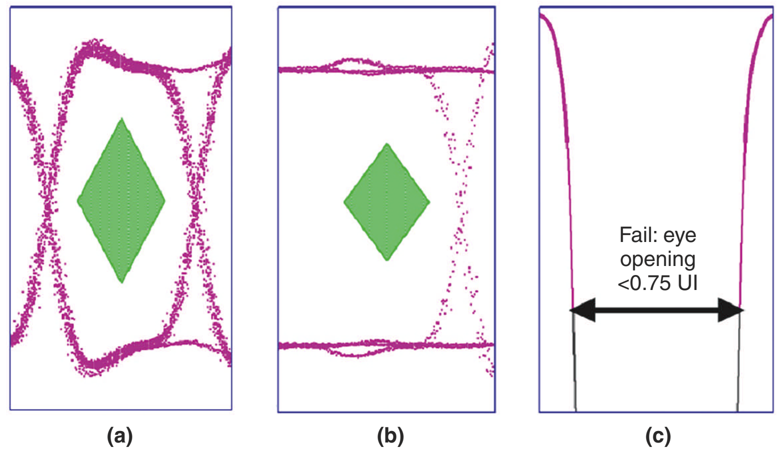


**FIGURE 3.** These images show the test results for a transmitter's signal/jitter output and associated TJ at BER = $10^{-12}$: (a) full-swing eye, (b) de-emphasis eye, and (c) BER CDF bathtub curve.

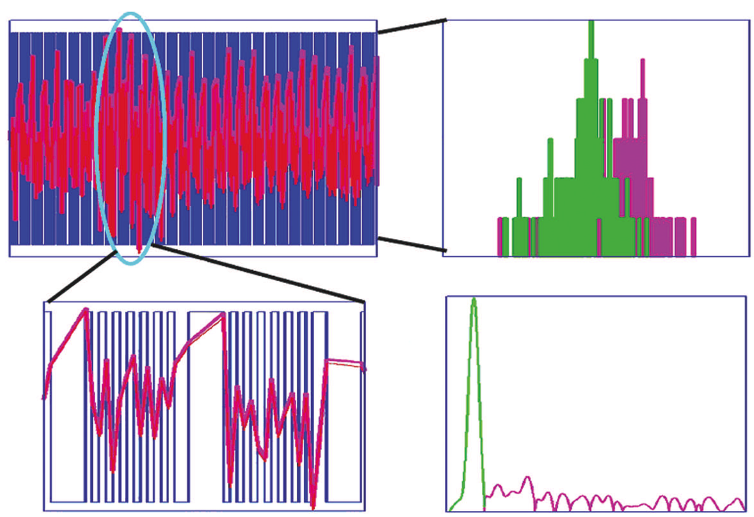

**FIGURE 4.** Shown here are data-dependent jitter (DDJ) distribution and PJ and RJ power-spectrum density (PSD) for the transmitter that failed the compliance test in Figure 3. The DDJ histograms are reviewed for rising (green) and falling (purple) edges, respectively. The lower left diagram depicts a "zoom in" for the worst-case DDJ locations, and the lower right graph shows both PJ and RJ PSD.

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2. "PCIe Card Electromechanical Specification 1.1," PCI SIG, 2005, www.pcisig.com/specifications/pciexpress/base.

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## ACKNOWLEDGEMENTS

The authors would like to thank Dennis Petrich of Wavecrest for his assistance.

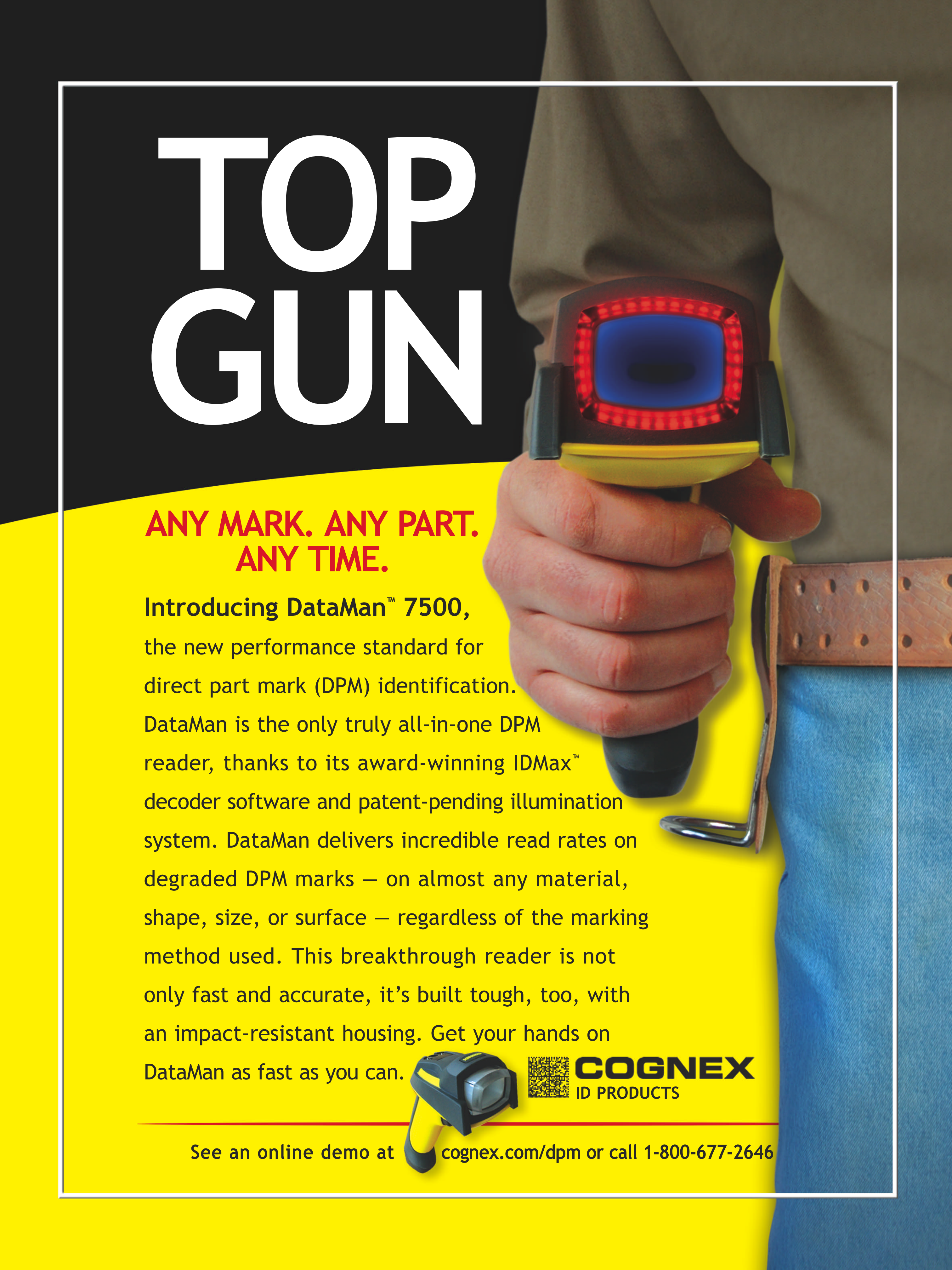


**Dr. Mike Li**, *chief technology officer for Wavecrest, pioneered the tail-fit jitter separation method and has been involved in setting standards for jitter, noise, and signal integrity for serial data communication. He has more than 15 years experience in high-speed instrumentation for both electrical and optical communication. He has a BS in physics from University of Science and Technology of China, and he has an MSE in electrical engineering and a PhD in physics from the University of Alabama in Huntsville. He has done post-doctorate work at the University of California, Berkeley. Dr Li has published more than 70 papers and has filed nine patents, with two granted and seven pending.*

**Rich Vignes**, *director of marketing for Wavecrest, has 20 years experience in business development, product marketing, and product management. He has formed numerous strategic partnerships and alliances to facilitate bringing whole solutions to the market. He has a BSME degree from the University of Minnesota and has two patents pending.*


### ON THE WEB

Various tools can help you evaluate a product's compliance to PCI Express. The online version of this article shows graphical examples of marker and clock/PLL tools and illustrates how you can use FFT and 1-sigma vs. span views to identify sources of jitter such as crosstalk and power-supply noise. **www.tmworld.com/2006_08.**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# Programming without code

*Steve Scheiber, Contributing Technical Editor*

Programming an effective inspection regimen is one of the most demanding aspects of setting up a vision system, as developers often need to write a new program for each product type. And with innovations in electronics technology making extreme product customization more practical, manufacturers may have to dramatically increase their programming efforts to cope.

Cognex recently announced enhancements to its VisionPro product line that aim to reduce the amount of programming required of system developers. A graphical programming tool permits users to create vision programs without actually writing code. I asked Steve Cruickshank, Cognex product manager, to discuss the implications.

**Q: How will these new features help users on the factory floor?**

**A:** We targeted the solution at customers who don't want to do all of their own programming. At the same time, for manufacturers who still want to write code to get the vision systems to perform inspection, we include a complete set of programming tools. The intent is to give users a point-and-click alternative to writing code, and to provide both capabilities on the same system.

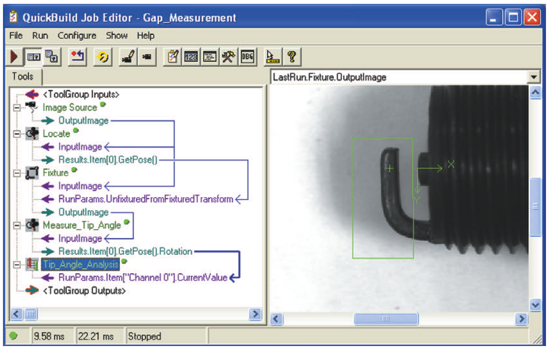
**Q: How does this differ from what people have done in the past?**

**A:** We divide the development into two complementary tasks that involve people with different skill sets. Programmers can take advantage of a full Visual Basic toolkit to construct operator interfaces and perform complex database interactions, for example. The people who train the system using the graphical tools do not need to know how to program at all. An interactive vision development environment called QuickBuild (**figure**) is used to define an object's edges and other features with simple mouse clicks. Turning over much of the development to users who can complete the task graphically frees programmers for other projects, which maximizes programmer productivity.

In addition, in a conventional setup, if you wanted to find a feature in an image, you had to begin with a known-good image for comparison. Our approach includes the PatMax geometric pattern matcher so that users can train the system without ever generating an actual image. They even have the option of starting the process by reading information directly from a CAD file.

**Q: How does the interactive tool work?**

**A:** The QuickBuild environment is used to set up the vision piece. Which cameras do you use? How do you trigger them? How do I decide between "pass" and "fail"? From the output, the application wizard creates an operator interface that can be delivered directly to the factory floor. It works with Visual Basic, but most of the VB activity goes on behind the scenes.




**Graphical tools permit users to create inspection programs without writing code.** Courtesy of Cognex.

Despite the VB content, users don't need a VB license. We've written the software on top of a Microsoft .NET environment, and we have included a compiler. The vision system offers a lot of hardware flexibility. For example, we support a wide range of frame grabbers and direct-connect acquisition techniques.

Our goal has always been to make our systems as easy as possible to use to allow our customers to work faster and more easily and thereby reduce inspection costs. These new features help further that effort. □

## INSIDE THIS REPORT

EDITOR'S NOTE

## Inspection makes some noise

*Steve Scheiber, Technical Editor*

No one would contend—as some "experts" did 40 years ago—that lasers are an interesting curiosity with no practical application. Today, they drive everything from the telecom infrastructure to post-paste PCB solder-pad inspection. Yet, the recent announcement of the acoustic analog to lasers—sound amplification by stimulated emission of radiation, or SASER—is provoking a response similar to the one that first greeted lasers.

The technology has been around for several years, but a practical demonstration announced in *Physical Review Letters* (June 2, 2006) has brought the concept much closer to reality. SASERs produce coherent sound in packets of sound vibrations called phonons. The new version from Anthony Kent at the University of Nottingham and scientists at the Lashkarev Institute of Semiconductor Physics uses a superlattice of thin semiconductor layers to perform the amplification efficiently and economically. SASER wavelengths are in the nanometer range. One of the first proposed uses for the technology ("A Little Big Noise," *The Economist*, June 8, 2006) is for inspecting faults in microelectronic circuits.

It is easy to dismiss such developments as impractical and confined to the distant future. As with lasers, however, the future has a habit of catching up with us faster than we expect. Failure to anticipate it will inevitably leave us behind. □

*Contact Steve Scheiber at sscheiber@aol.com.*

HIGHLIGHTS

## Rudolph ships wafer-inspection system

Rudolph Technologies has announced the first shipment of its all-surface macro-defect detection system to a US-based manufacturer of flash memories. The system, which will be installed in a quality-assurance environment, combines the wafer front-side inspection capability of the AXi 935 Macro Defect Inspection tool with the edge inspection capability of the recently introduced E25 Wafer Edge Inspection module.

"The combination of the AXi 935 and E25 on a single platform accommodates automatic inspection of both the front surface and edge of the wafer in a single system without significantly impacting inspection throughput. The inspection data can be fed forward for automatic disposition of both wafers and die for quality assurance." said Ardy Johnson, VP of marketing for Rudolph.

The E25 Wafer Edge Inspection module includes several new features, including increased surface coverage, simplified recipe creation, and an improved detection algorithm for edge chips and cracks. Modules are also available for wafer backside inspection. www.rudolphtech.com.

## Cognex unveils In-Sight software

During Semicon West (July 11–13, San Francisco, CA), Cognex highlighted its In-Sight Explorer network automation software, which includes tools to manage a system of networked In-Sight wafer readers. The software provides controls for remote setup of wafer readers, for managing access-level permissions, and for handling network, I/O, system backup and restore, and other system-management tasks.

In addition, the company announced that the In-Sight 1721 wafer reader now includes a Microsoft .NET-based graphical user interface that provides the look and feel of the company's 1700 Series models. The 1721 can be retrofitted into existing equipment.

"With In-Sight Explorer software, virtually every task is easier," said Justin Testa, Cognex senior VP for ID products. "As our fab customers continue to move toward fully automated wafer traceability, these new tools will make it easier for them to achieve higher yields by centralizing control of multiple wafer readers on the fab network." www.cognex.com.

## Firms shorten image-processing design time

Celoxica and GiDEL are joining forces to reduce the design time for high-end image-processing and machine-vision applications. Using programmable logic as a low-power coprocessor to accelerate system performance, the firms have integrated Celoxica's ESL design environment and video IP libraries with GiDEL's high-performance FPGA+ modular digital signal processing (DSP) platforms.

Celoxica's tools enable developers to implement their C algorithms directly into FPGA hardware, where they can be augmented with libraries of video IP. With Celoxica's open API software and board-support packages, users can create imaging applications independent of board-level detail and compile their applications to program the FPGAs on GiDEL platforms, which offer VGA, DVI, and Camera Link interfaces. www.celoxica.com; www.gidel.com.

## CALENDAR

- **Vision 2006**
  November 7–9
  Stuttgart, Germany
  *Produced by Messe Stuttgart*
  *www.vision-messe.de*

# Understanding Camera Link specs

*Steve Scheiber, Contributing Technical Editor*

Comparing different aspects of electronics technologies requires that you compare them on the same basis—apples to apples, so to speak. In the February "Machine-Vision & Inspection Test Report," I discussed standard methods for transferring image data from a video camera to an analysis system (Ref. 1). In the process, I looked at the specifications for Camera Link, GigE Vision, Gigabit Ethernet, FireWire, and USB. Since the article appeared, several questions have arisen, in particular questioning the raw speed of Camera Link.

Courtesy of Imperx.

All of the sources I spoke to—whichever standard they preferred—classified Camera Link as the fastest of the alternatives. Their calculations of the actual speeds, however, did not always match. Some sources quoted the maximum Camera Link bandwidth at 7.14 Gbps. Others used 6.12 Gbps or 5.5 Gbps. Why the confusion?

I recently went back to Steve Kinney, product manager at JAI Pulnix and a former chair of the Automated Imaging Association's Camera Link Committee, for clarification.

The Camera Link standard employs chipsets that run at 40, 66, or 85 MHz. A base configuration uses a single Camera Link connector carrying one 28-bit video channel. Including a second connector adds two additional 28-bit channels. A medium configuration uses two of the channels, and a maximum configuration employs all three.

Therefore, with the 85-MHz chipset, some sources report the maximum base-configuration speed at 2.38 Gbps, medium configuration at 4.76 Gbps, and maximum configuration at 7.14 Gbps. According to Kinney, however, those numbers overstate the case.

Those specifications assume that all Camera Link configurations use all 28 bits per channel. Kinney contends that only 24 bits per channel actually transfer data. The first channel's remaining four bits provide camera timing. The extra bits on the second connector provide four lines for camera control and four lines for bidirectional serial communication.

At 85 MHz, then, the maximum speeds reduce to 2.04 Gbps for 24 bits, 4.08 Gbps for 48 bits, and 6.12 Gbps for 72 bits. Ironically, a proponent of GigE Vision, not Camera Link, provided the higher numbers.

Other sources reported the Camera Link bandwidth at 5.5 Gbps. Kinney suggested that specification is also based on 28-bit channels, but uses a maximum chipset speed of 66 instead of 85 MHz.

When comparing specifications for making engineering decisions, be sure that the numbers translate accurately to the real world and directly to your specific application. The criteria around which they are established must be the same for all the alternatives. Otherwise, the decisions you make may not achieve the performance you are looking for. □

## Reference

Scheiber, Steve, "Camera Link and GigE improve image speeds," Machine-Vision & Inspection Test Report, *Test & Measurement World,* February 2006. p. 52. www.tmworld.com/2006_02.

# Converting analog to digital with GigE

*Steve Scheiber, Contributing Technical Editor*

Many magazine and Web articles have compared the capabilities of digital vision buses such as Gigabit Ethernet (GigE), Camera Link, and FireWire. Yet, rather than learning how digital buses compare to each other, many manufacturers are more interested in learning how these buses compare to their analog counterparts. When manufacturers select a digital bus, they are generally replacing outdated analog equipment, and they want to know what improvements a digital bus can offer.

Compared to analog systems, digital systems can be less expensive and easier to set up. Eric Carey, manager of the smart-products group at Dalsa, recently explained how his company helped a customer adopt a GigE-based system to replace its analog setup.

## The situation

The customer uses machine vision to inspect assembled PCBs in-line, primarily looking for component presence or absence and alignment. The analog installation included four monochrome cameras—two looking down at the board, and one on each side at an angle—connected to a frame grabber (**Figure 1**).

Strobe lights synchronized to the cameras provided illumination. The frame grabber coordinated image acquisition from the four cameras. A part tracker sent a signal to the frame grabber that a board was in place. The frame grabber then fired the strobes, captured the images, digitized them, and sent them over a PCI bus to image memory.

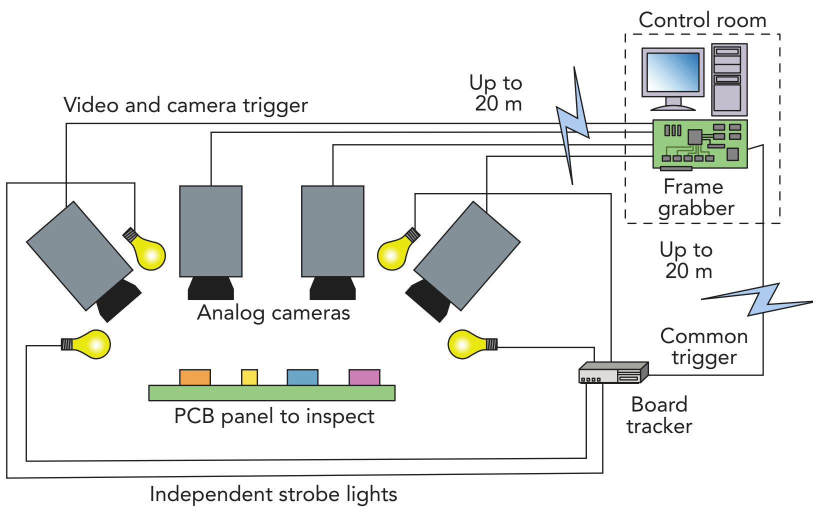



**Fig. 1 The analog setup included two cameras above the board under test, along with a camera on either side. Strobe lights provided illumination, and a frame grabber digitized the images.** Courtesy of Dalsa.

The image data was then sent from the camera over an analog cable to a PC in a control room 20 m away. There, analysis software compared the images with known-good versions, identifying any deviation above a set threshold. The system processed a maximum of 2000 images/min, not counting board-positioning time.

The manufacturer wanted to replace the equipment with more up-to-date equivalents, both to reduce costs and to set the line up for future migration to color imaging. Modernizing the production line also had marketing advantages when the company presented its production capabilities to customers and prospects.

Although acquisition costs for analog and digital cameras were about the same, not needing the frame grabbers for the digital installation cut the cost dramatically. In addition, the line resolution necessary for the application meant that moving to analog color cameras would have required RGB rather than composite color cameras. Each analog RGB camera would have needed its own frame-grabber input for each color (red, green, blue), so an analog color system would need a total of four frame grabbers along with the accompanying cabling and software. Because in the new setup the cameras themselves digitized the acquired images, migrating to RGB color simply meant replacing the cameras and the software.

Digital imaging provided additional benefits. Because there is no cabling (and therefore no signal loss) between the image acquisition and the digitization step, direct digital images tend to have higher resolution and experience less noise. Filtering out the noise in an analog signal reduces resolution at image edges.

## The conversion

For the digital system, Dalsa used GigE Vision as the communication protocol because of its 1-Gbps bandwidth and the fact that it could carry signals all the way to the control room without the need for repeaters. In this configuration, the cameras group image data in packets, each packet generally representing a small number of lines of data from an area-scan or line-scan image.

The system labels the packets as it creates them to ensure an accurate reconstruction of the image at the other end. Packets do not always arrive at the receiver in the correct order, because an interrupted or garbled packet must be re-sent.

Dalsa selected monochrome VGA cameras with a 10-µm² pixel size to permit resolution comparable to the analog setup. The company replaced the PC interface with an Intel network card.

In higher-bandwidth data situations, the system might have required a network card for each camera, but GigE Vision's bandwidth proved sufficient to allow using an Ethernet switch that included a port for each camera and one port connected to a single network card at the PC. The switch was placed a few feet from the cameras, minimizing cable lengths on that side, and an Ethernet cable connected the switch to the PCs in the control room. **Figure 2** diagrams the new setup.

Removing the frame grabber required the developers to find a new way for the system to handle the pulses that triggered the strobes and the cameras. In the new configuration, the part-detection circuitry that was already in place had to drive the trigger pulse on each camera. It required four separate outputs from the part-detection hardware to furnish enough current to drive the optocoupler at the trigger input of the cameras and to ensure simultaneous triggering. The part-detection circuitry also continued to control the strobe firing as it had done under the analog scheme.

An Ethernet solution adds a small image-acquisition latency compared to a frame grabber. Because the camera starts to expel image packets as soon as each packet is full, however, this effect does not generally cause any problem. The added latency in this case was less than 1 ms.

Any control that must be performed in real time should be handled directly at the camera. The new system uses the trigger pin of the cameras for that purpose. This approach keeps the delay between the trigger pulse and the start of the exposure below 20 µs. To prevent any false pulse detection on the optocoupler camera inputs, the integrators set the trigger-pulse debouncing to 2 µs. That is, the cameras are set to ignore any pulse shorter than 2 µs.

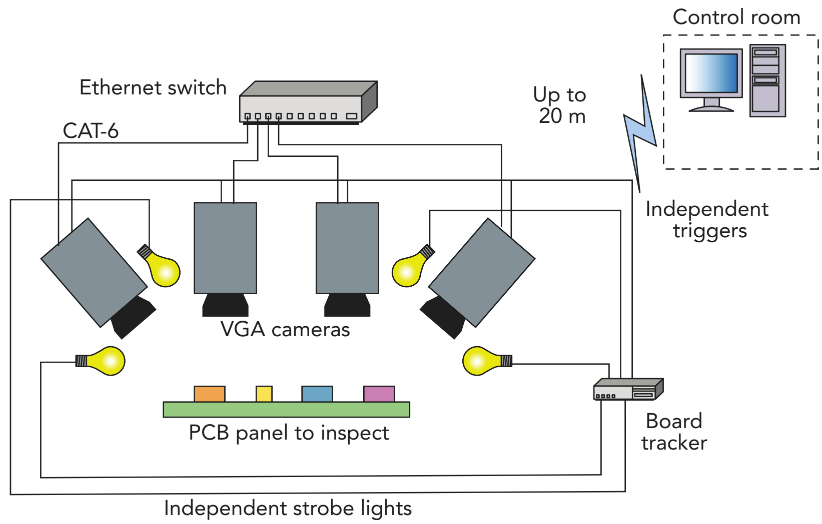



**Fig. 2 The digital setup did not require the frame grabber. Each of the four cameras digitized its own images before sending them through an Ethernet switch and Ethernet cables to the PC in the control room.**
Courtesy of Dalsa.

An optimized GigE Vision packet processing driver reassembles the streaming packets into image files, a task that the frame grabber performed before. In this case, the extra step increased the load on the CPU by less than 6% for simultaneous acquisition by the four cameras. Since the PC in the control room contained a dual-core hyperthreading microprocessor running at more than 3 GHz, the extra load did not unduly burden the image-processing step.

Because Dalsa provided the image-control software for both the analog and digital camera installations, the impact of the change on the image-processing software was minimal, which reduced the system setup time. The engineering effort focused on replacing the hardware components.

The migration to the digital system presented a particular challenge, because when the project began, the GigE Vision specification had not been finalized. Close collaboration between Dalsa application engineers and the team operating the original analog system facilitated the updates and maintained software compatibility.

"This system was an excellent opportunity for GigE Vision, because of the cable length required to reach the control room," said Dalsa's Carey. "Customer cooperation allowed field-testing this new technology before we started system deployment. Field testing required some training to understand networking concepts and their impact on the vision system. The digital changeover proved a huge success." □

## For further reading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Scheiber, Steve, "Camera Link and GigE improve image speeds," Machine-Vision & Inspection Test Report, *Test & Measurement World*, February 2006. p. 52. www.tmworld.com/2006_02.

Titus, Jon, "Tech Trends: A need for speed," *Test & Measurement World*, February 2006. p. 16. www.tmworld.com/2006_02.

Titus, Jon, "Tech Trends: Vision meets Ethernet," *Test & Measurement World,* April 2006. p. 20. www.tmworld.com/2006_04.

# 10 worthwhile Web sites

*Steve Scheiber, Contributing Technical Editor*

In the dim past—October 2002 to be precise—Jon Titus reported that he typed "machine vision" into a search engine and got 150,000 hits (Ref. 1). Type that same phrase into a search engine today, and you'll get millions of hits. Since you probably don't have time to visit them all, here are a few sites that really stand out.

### CV Online: The Evolving, Distributed, Non-Proprietary, On-Line Compendium of Computer Vision

homepages.inf.ed.ac.uk/rbf/CVonline

This site with the jawbreaker title serves as both a basic and a comprehensive resource for anyone who wants to learn more about machine vision. Established and maintained by Robert Fisher of the School of Informatics at the University of Edinburgh, Scotland, it presents summaries and links on a few (actually about 700) of the central topics in the field. Set up as an interactive site, it invites people with experience in the field to make their own contributions.

### Computational Vision at Caltech

www.vision.caltech.edu/publications/publications.html

Students and faculty at the California Institute of Technology present a wide range of publications that address machine vision's computational foundations. Concentrating primarily on image recognition, topics include recognition and learning, human-machine interfaces, 3-D reconstruction, and motion. The site even offers several complete PhD theses.

### AI topics: Vision

www.aaai.org/AITopics/html/vision.html

The vision section of the American Association for Artificial Intelligence (AAAI) Web site contains hyperlinks to textbooks and references as well as other knowledgeable Web sites. It provides introductory information under the banner "Good places to start," and for visitors already familiar with the topic, the site provides links to the latest research.

### University of Adelaide Computer Vision Publications

www.cs.adelaide.edu.au/~vision/publications

This bibliography lists some of the latest work by faculty and students at the University of Adelaide, Australia. As with many other research institutes, the primary consideration revolves around qualitative and quantitative image recognition and pattern matching. In addition to the bibliographic information, some entries provide links to PDFs of journal or conference papers.

### Introduction to Computer Vision and Image Processing

www.netnam.vn/unescocourse/computervision/computer.htm

This textbook from Luong Chi Mai of the Institute of Information Technology in Hanoi presents many of the basic concepts of machine vision, then carries them through to more advanced topics. Aimed at an undergraduate or graduate student, the text does not assume any prior knowledge of the subject, but it does require a basic understanding of statistics and mathematics, computer programming, and elementary data structures.

### PASCAL: Pattern Analysis, Statistical Modelling, and Computational Learning

eprints.pascal-network.org/view/subjects/MV.html

The PASCAL project was established to create a Europe-wide distributed institute providing access to a large amount of information on topics related to pattern analysis, statistical

modeling, and computational learning. This page contains 236 conference and workshop publications specifically about machine vision, many of which are available as PDF files for download. The list includes such topics as edge detection, image recognition, scene classification, and multivariate analysis.

### Image Science and Machine Vision

www.ornl.gov/sci/ismv/publications.shtml

The publications on this page reflect the wide range of research from the Oak Ridge National Laboratory in Oak Ridge, TN. One paper, for example, explores interferometry considerations in semiconductor wafer inspection and metrology. Papers can be downloaded as PDF files.

### David Vernon: Automated Visual Inspection and Robot Vision

homepages.inf.ed.ac.uk/rbf/BOOKS/VERNON/vernon.htm

This entire classic textbook is now available online. Entries in a hyperlinked table of contents take you to a series of PDF files. Although aimed at high-end undergraduates and graduate students, and now more than a decade old, this comprehensive resource contains a wealth of information and explanation, from the rudiments of the subject to the most advanced ideas.

### European Machine Vision Association (EMVA)

www.emva.org

The stated purpose of the EMVA is to strengthen the position of its member companies as well as European machine-vision technology. It also offers a European platform for information exchange and joint action. The Web site contains information about the 1288 and GenICam standards, articles on machine-vision topics, a database of member companies, and links to product information and case studies.

### Automated Imaging Association (AIA)

www.machinevisiononline.org

The AIA oversees both the Camera Link and GigE standards and also produces The Vision Show each year. The organization's Web site provides information about Camera Link and GigE, articles on numerous vision topics, announcements of members' new products, and data on worldwide vision markets.

**PLUS, A BONUS SITE:**

### *Test & Measurement World*

www.tmworld.com/ins

Don't forget to visit the Machine-Vision & Inspection page of the *Test & Measurement World* Web site. Here, you'll find the latest news about the vision industry, archived articles from both the main magazine and the Machine-Vision & Inspection Test Report, and links to related articles from other Reed Business Information publications. You'll also have an opportunity to sign up for our monthly Machine-Vision & Inspection e-mail newsletter. □

### Reference

1. Titus, Jon, "17 vision Web sites worth a visit," Machine-Vision & Inspection Test Report, *Test & Measurement World,* October 2002. p. S3. www.tmworld.com/archives.



## PRODUCTS

### FPGA system with Camera Link

Used as a stand-alone board for embedded applications or connected to a PC, the RTG005 from Hunt Engineering leverages a user-programmable FPGA with an embedded PowerPC processor and a Camera Link interface for image acquisition. The system supplies 128 Mbytes of DDR SDRAM, 16 Mbytes of flash memory for PowerPC code storage, and a USB 2.0 port.

The embedded PowerPC processor allows the user to combine hardware processing programmed in VHDL with software processing programmed in C. Hunt furnishes VHDL support to permit concurrent access to the DDR memory from both the PowerPC and the VHDL design. The system comes with a sample imaging design that performs many standard imaging functions and streams data to a host PC for display. The FPGA can be configured via the USB port, a Xilinx JTAG cable, or from onboard PROM.

The RTG005 comes with a USB cable, I/O cables, power-supply unit, and CD containing all documentation, tutorials, software tools, and samples. *Hunt Engineering, www.hunteng.co.uk.*

### Frame grabbers

Matrox Imaging has announced new configurations of its Solios frame-grabber family. The Matrox Solios XCL-B and Matrox Solios XCL-F support a single base or a single full Camera Link camera, respectively. Both models are also available for PCI Express. In addition, the XCL-F features an optional, customizable processing core based on the Altera Stratix FPGA family to accelerate specific routines in an application. The Altera Stratix devices are available with or without memory (SDRAM or SRAM). *Matrox Imaging, www.matrox.com.*

### CMOS camera system

Consisting of a compact camera and an external power supply, the pco.1200 hs camera system from Cooke records images at 1 Gbyte/s. The 10-bit CMOS camera features a 1280x1024-pixel resolution and can transfer image data to a computer over the FireWire, Camera Link, or Ethernet bus. Exposure times range from 1 µs (50 ns optional) to 5 s. *The Cooke Corporation, www.cookecorp.com.*

Read about more machine-vision and inspection products on the *T&MW* Web site:
www.tmworld.com/ins



Test & Measurement World

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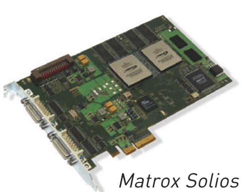
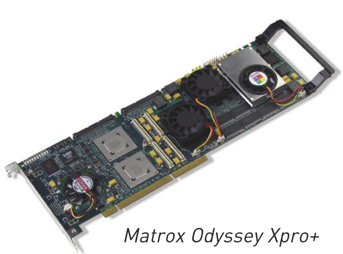


*Matrox Solios eCL*



*Matrox Odyssey Xpro+*

## Data-acquisition module

Data Translation's DT9841-VIB Sleek Box combines eight analog inputs, two analog outputs, and 16 digital I/O lines with a 32-bit floating-point digital signal processor. Connected to a PC over USB, the module's simultaneously sampled analog inputs feature 24-bit resolution and a 100-ksamples/s acquisition rate per channel. The DT9841-VIB also provides excitation (programmable 4-mA current source), signal conditioning (AC or DC coupling), and filtering (10-kHz Butterworth filter) for integrated electronics piezoelectric (IEPE) accelerometers.

DSP software support includes Texas Instrument's Code Composer Studio as well as Microsoft Visual Studio. You can also use MEscope from Vibrant Technology for post-processing of captured data.

Price: $5690. *Data Translation, www.datatranslation.com.*

## Analog signal generator

The Agilent E8663B analog signal generator provides what the vendor describes as the best close-to-carrier phase-noise performance available in an off-the-shelf signal generator with frequency ranges up to 3.2 or 9 GHz. The fully synthesized signal generator achieves typical phase-noise performance of –130 dBc/Hz or lower at a 1-kHz offset from a 1-GHz carrier. It provides output power up to 21 dBm and can operate over a frequency range of 100 kHz to either 3.2 or 9 GHz.

The close-to-carrier phase-noise performance of the instrument makes it possible to characterize high-resolution radar and electronic warfare systems and components.

The Agilent E8663B analog signal generator replaces the discontinued HP or Agilent 8662A and 8663A signal generators. The E8663B provides lower phase noise than its predecessors as well as enhancements in level accuracy and harmonic distortion. This analog signal generator is code-compatible with the Agilent 8662A and 8663A, ensuring seamless operation in ATE applications using the 8662A/63A and the Agilent E5500 phase-noise test system.

Base prices: 100-kHz to 3.2-GHz frequency range option—$41,500; 100-kHz to 9-GHz frequency range option—$47,500. *Agilent Technologies, www.agilent.com.*

## 7.1-GHz spectrum analyzer

The MS2717A spectrum analyzer delivers 100-kHz to 7.1-GHz performance and offers optional W-CDMA/HSDPA RF test and W-CDMA detailed demodulation measurements for characterizing wireless Node B transmitter components. Despite its low cost, the MS2717A offers typical phase-noise performance of –110 dBc/Hz (SSB phase noise) at 10-kHz offsets up to 6 GHz. Typical dynamic range is 100 dB, and the instrument's 8-MHz capture bandwidth supports optional W-CDMA/HSDPA RF measurements and W-CDMA demodulation. A W-CDMA demodulator option supports code-domain-power and error-vector magnitude (EVM) measurements. The MS2717A measures 242x372x339 mm and weighs 5.6 kg.

Base price: less than $12,000. *Anritsu, www.us.anritsu.com.*

## Compact test chamber

The MicroClimate 3 reach-in test chamber from Cincinnati Sub-Zero simulates a full range of temperature and humidity conditions for testing small components and products. This upright 3-$ft^3$ chamber covers a temperature range of –73°C to +190°C and a humidity range of 10% to 95% RH. The MicroClimate 3 operates from a standard 115-V supply and features a programmable controller, an RS-232 interface, a 2-in. access port, and a demineralizer filter for water purification. Humidity models include an electronic humidity sensor.

*Cincinnati Sub-Zero, www.cszindustrial.com.*

## Device programmer software upgrade

BP Microsystems has improved the speed of its 7th generation automated programming systems with the release of BP Win 4.60. By altering the site sequence prioritization routine to allow the autohandler to pick and place parts more efficiently, the 4710 and 4700 programmers are now able to program up to 1400 devices/hr, an increase from 1200 devices/hr. In addition, the 3710 and 3700 programmers are now able to program up to 1100 devices/hr, an increase from 950 devices/hr.

*BP Microsystems, www.bpmicro.com.*

## Multifunction data-acquisition module

The SeaI/O-470 multifunction module can handle applications such as process control, data acquisition, broadcast automation, and facility management. The module provides 16 single-ended or eight differential 12-bit analog inputs, two 12-bit digital-to-analog (D/A) outputs, eight optically isolated digital inputs, and eight open collector digital outputs. The analog-to-digital (A/D) inputs are independently software selectable for 0–5 V, 0–10 V, ±5 V, and ±10 V ranges and can be configured for measuring 0–20-mA current loop. The D/A channels are independently jumper selectable for a 0–5-V or a 0–10-V output range. Eight digital inputs are rated for 5–30 VDC and provide 300-V external isolation, while the SeaI/O-470's eight open collector outputs can be used to switch 24-V devices found in industrial control applications. The module can be connected to a host device via Ethernet, USB, RS-232, or RS-485.


Base price: $469. *Sealevel Systems, www.sealevel.com.*

## Multichannel USB module

Compatible with both USB 1.1 and USB 2.0 ports, the USB-3101 from Measurement Computing provides four channels of 16-bit analog voltage output, eight digital I/O connections, and one 32-bit event counter. The device is powered by the +5-V USB supply from a computer. InstaCal plug-and-play software simplifies installation and calibration of the USB-3101 under Windows 95, 98, ME, NT4, 2000, and XP. The USB-3101 also works with Measurement Computing's other software programs, including Measurement Studio MCC Edition, SoftWire graphical programming interface for Visual Studio .NET 2003, and DasyLab, as well as National Instruments' LabView.

Price: $299. *Measurement Computing, www.mccdaq.com.*

> > > > > > >

## Upgrades to boundary-scan system

Corelis has added direct I²C and SPI-based device programming capabilities to its ScanExpress boundary-scan system. Since the I²C and SPI interfaces are independent of the JTAG test interface, the user can use a single JTAG controller to test the board and perform direct programming of serial EEPROM and flash memories without removing the JTAG connector or switching to a dedicated programmer. With the new direct programming port, serial flash/EEPROM devices can be programmed at speeds up to the device's theoretical programming time. Corelis customers can upgrade their old controllers to include the new function.

*Corelis, www.corelis.com.*

## Safety tester interface card

Associated Research has released a data/interface card for its Omnia and HypotUltra III series electrical safety testers that provides a choice of communication protocols as well as an efficient method for logging test data. The card includes an RS-232/RS-485 serial port, a data-collection port, and a PS/2 input port. Its internal flash memory stores up to 100,000 test results, and its data-collection port works with a supplied 256-Mbyte flash memory stick. Test data is automatically stored at the end of each test.

*Associated Research, www.asresearch.com.*

## Signal-conditioning cards

Designed for use with Omega's data-acquisition products, the OMB-DBK207 and OMB-DBK207/CJC signal-conditioning boards can be configured with up to 16 OM5 (5B) isolated analog-input modules. These modules can be mixed in any combination to measure temperature, strain, voltage, current, and frequency. Each input module provides 500 V of isolation from the system, as well as from other channels.

Prices: OMB-DBK207—$249; OMB-DBK207/CJC—$399. *Omega Engineering, www.omega.com.*

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**BRIAN DOODY**
CEO
Dalsa
Waterloo, ON, Canada

Brian Doody became CEO of Dalsa in 2006, with responsibility for overseeing all of the company's internal operations, including both the Digital Imaging and Semiconductor businesses. He joined the company in 1985 and has since served in multiple roles, including VP of manufacturing and engineering and VP of operations, as well as president of Dalsa Digital Imaging, where he was responsible for the firm's $100 million digital imaging business. A professional engineer, Doody has a BSEE from Queen's University and an MS from the University of Waterloo.

In an exclusive interview with *T&MW*, Doody discussed the challenges facing manufacturers of vision systems.

# From plug-and-play to high performance

**Q: What are the big challenges you face in developing vision systems?**

**A:** One major challenge is ease of use. Customers need to get up and running on our products as fast as possible. A second consideration is price versus performance. Dalsa has traditionally focused on high-performance solutions, but we need to balance that with cost considerations. Finally, customers demand high-quality service, whether they are technicians on the factory floor or design engineers working on OEM systems.

**Q: How do your recent new products address these concerns?**

**A:** The new Genie Series for Gigabit Ethernet are area-array-based cameras that eliminate the frame grabber. That's a big advantage, of course, in ease of setup, since all you do is plug the camera into an existing network port. Our new line-scan series of cameras, called Spyder GigE, provides similar advantages, and both lines of cameras automatically start up the appropriate drivers when plugged in. So, it's really a shrink-wrapped, plug-and-play solution.

Among other new products, the Sapera Essential Software toolkit bundles board-level acquisition and control with advanced image processing—and also offers a new geometric search tool. For the high-end performance, such as mask and wafer inspection, we offer the X-64 frame grabber that delivers the processing power and image acquisition speed that are critical in those billion-dollar fabs.

**Q: Which vision applications are growing the fastest?**

**A:** We see a great deal of interest in the area of identification. This field requires the addition of very advanced pattern-recognition algorithms. Applications are very broad, ranging from security and surveillance to automated microscopic identification of defective cells in medical diagnostics. We also look for growing end markets where vision is becoming more dominant and more critical. A good example is flat-panel displays. To get costs down, manufacturers have been increasing the size of substrates to get more screens out of the process. This requires the addition of higher-resolution automated inspection, and that creates more opportunities for our products.

**Q: Which video-acquisition standard seems to be winning out today, Camera Link or Gigabit Ethernet?**

**A:** It's a little early to declare a winner. GigE is still a new technology, compared to Camera Link. Each really represents different markets and applications.

Gigabit Ethernet really targets applications where ease of use and cost reduction are big considerations. For example, customers can eliminate frame grabbers. On the other hand, GigE is limited by data transfer rates, about 100 Mbytes/s, and that assumes that you have complete control of the Ethernet and have no other data running on it.

But many of the applications that we serve in the high-performance market operate at much higher data transfer rates. Here, we rely on Camera Link, which not only can be readily expanded, but also offers constant access to, and control of, the data path in both directions.

Still, for lower speeds—for example, 60-frames/s VGA—GigE will become a dominant player. I compare GigE to the RS-170 analog standard that was used everywhere in the first applications of machine vision back in the late 1980s and early 1990s. Gigabit Ethernet will be the solution that replaces that analog standard. T&MW

Brian Doody comments on plug-and-play systems, product-development approaches, market opportunities, and other topics in the online continuation of this interview: www.tmworld.com/2006_08.

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