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Test & MEASUREMENT WORLD®

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Student Matt Hersh at the University of New Hampshire InterOperability Laboratory.

TODAY'S TESTING, TOMORROW'S ENGINEERS

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A function generator set for action

The Agilent 33220A packs in bench and test-system features

Agilent 33220A 20 MHz function/arbitrary waveform generator

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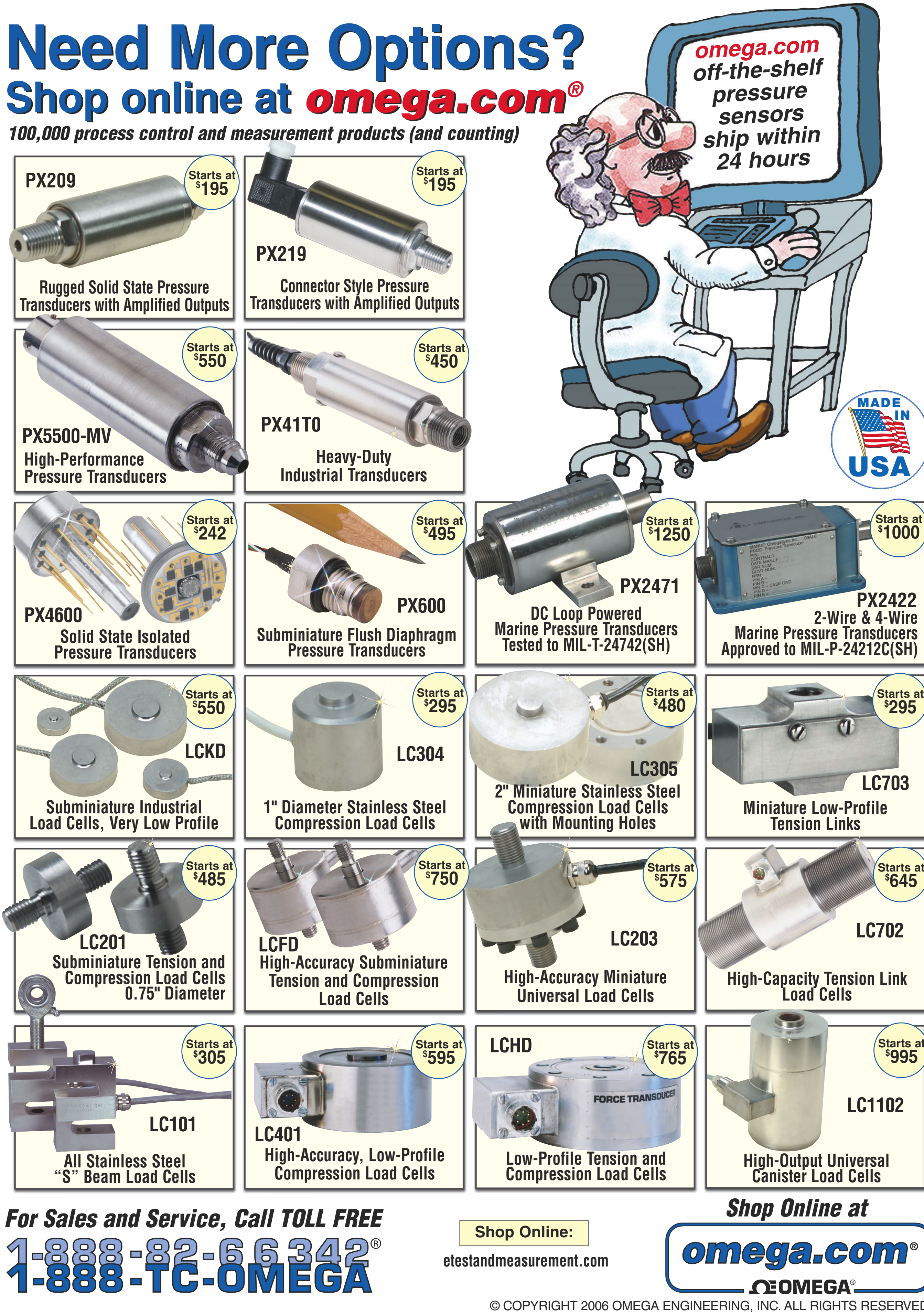
Agilent Technologies



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COVER BY: THOMAS AMES

Test & MEASUREMENT WORLD®

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C O N T E N T S

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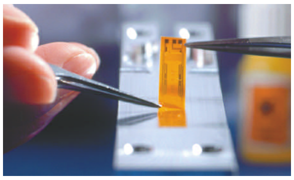
DEPARTMENTS

FEATURES



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TECH TRENDS

TEST DIGEST

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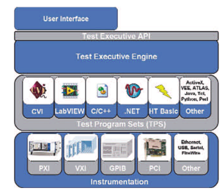
> **Check out these exclusive features on the *Test & Measurement World* Web site:**

Automotive & Aerospace Test Report

- **Raising the bar for EMI testing**
  In our exclusive interview with Jim Press of National Technical Systems, you will learn why the company upgraded three of its test facilities to handle 200-V/m electromagnetic interference (EMI) testing for electronics and avionics systems.

- **COTS software prevents ATE obsolescence**
  This feature explains how you can use commercial-off-the-shelf (COTS) tools and modular hardware to create long-lasting ATE systems that can both reuse legacy code and evolve to meet new testing challenges. One key? Use a test executive to manage your test program sets (TPSs).



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Compliance Test Report

- **Educating EMC engineers**
  We interviewed Dr. Todd Hubing, a professor at the University of Missouri, Rolla, to learn about current efforts to educate engineers about electromagnetic compliance (EMC). Dr. Hubing explained what the students are learning about EMC and electromagnetic interference (EMI), described the "hot topics" in academic research, and suggested topics for continuing education for established EMC engineers.

- **Shielded rooms go portable**
  If you have only an occasional need for a shielded chamber, you don't need to go to the expense of building a permanent structure. Several companies now offer custom-made, *portable* tent-like structures that offer the shielding you need for precompliance tests.

- **Keep your eye on RF risks**
  Along with the rise in the popularity of wireless communications has come an increased concern for controlling the safety hazards of RF energy—especially for handheld and wearable transmitters. Two guidelines from the FCC help manufacturers determine whether their products' RF emissions exceed the recommended limits.

www.tmworld.com/compliance

From the Archives

- **How does a Smith Chart work?**
  As relevant as ever, the online version of this popular tutorial from our July 2001 issue is still capturing clicks.

www.tmworld.com/archives

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Reed Electronics Group

Patent roulette

If anything good has come out of the settlement between BlackBerry maker RIM and patent holding company NTP (under which RIM will pay NTP $612.5 million), it's that the settlement is spurring a closer look at US patent law. It couldn't come at a more opportune time. Cognex, which has already done yeoman's work fending off a patent troll (Ref. 1), is once again going to battle—in this case, against Acacia Research and Veritec, who claim to hold a patent on a system for reading 2-D symbology. Cognex is seeking a declaration that the patent is invalid, unenforceable, and not infringed by either Cognex or its customers.

RICK NELSON, CHIEF EDITOR

"Cognex firmly believes in the right of inventors and patent holders to seek licensing fees for legitimate, patented technology," said Dr. Robert J. Shillman, Cognex chairman and CEO, in a March 20 press release announcing Cognex's action. He continued, "But we strongly object when questionable patents are used to extort payments from companies that do not have the expertise to challenge the patents, or who, for business reasons, decide to submit to licensing demands rather than to undertake costly legal challenges."

RIM caved to the trolls, Cognex fights on.

I applaud Dr. Shillman for pursuing the fight and not caving, as RIM did. But companies like Cognex shouldn't have to be in the fight at all. What's needed is the reform of a US patent office that rubber-stamps the flimsiest patent filings and of courts and juries unable to comprehend the technical merits of patent claims. Illustrating the absurdity of the situation, *Jurassic Park* author Michael Crichton (Ref. 2) facetiously asserts patent rights to 257 facts about dinosaurs that you may not use in your own novel unless you pay him royalties.

There is hope. The US Supreme Court is hearing cases relating to medical tests and online auctions and may rule in a way that injects some common sense into the patent system. And many observers believe the RIM and NTP case will spur a backlash that leads to patent-law reform.

Bruce Sewell, general counsel for Intel, summed up the current situation succinctly in recent commentary on the RIM and NTP case (Ref. 3): "For NTP it was like winning the lottery, but for the rest of us, and for business in particular, it stinks."

It certainly does. Let's leave the gambling to casinos and state lottery commissions. American businesses, international businesses operating here, and legitimate patent holders all deserve better. T&MW

REFERENCES

1. "Court sides with Cognex," *Machine-Vision & Inspection Test Report, Test & Measurement World*, November 2005. www.tmworld.com/archives.

2. Crichton, Michael, "This Essay Breaks the Law," *The New York Times*, March 19, 2006.

3. Sewell, Bruce, "Troll Call," *The Wall Street Journal*, March 6, 2006.

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

[An exclusive interview with a test engineer]

Know your test hardware

John Slezia is a test engineer and a member of the technical staff at Cypress Semiconductor's manufacturing test group in Bloomington, MN. Cypress produces synchronous and asynchronous memories, first-in/first-out (FIFO) memories, and USB interface devices on 8-in. wafers. Slezia has held several positions in several locations since joining Cypress in 1983. He is employee number 44. Martin Rowe spoke with him on the phone.

Q: What are your responsibilities in the manufacturing test group?

A: My duties include monitoring the test floor for yield. I'm also responsible for test programming and test-time reduction on 100 test cells. Each cell contains an automatic digital IC tester. Most of the test cells contain purchased systems, but some were developed in-house. These test cells typically support as many as 50 devices on the floor at any time.

Q: What is the test process for testing devices while still on a wafer?

A: Wafers make three test passes, called sorts. In the first sort, we test parts with their temperature at 88°C and sort them into three categories: prime, repairable, and failed. We create an electronic map of the wafer that identifies failed and repairable devices—we don't drop ink on failed devices anymore.

We then use lasers to repair the devices and retest all prime and repaired parts at 88°C in the second sort. Those parts that pass the second sort get tested again at –40°C. These last two tests guarantee compliance to the Cypress Data Sheet.

Q: How long does it take to test all the devices on a wafer at each pass?

A: That depends on the device size and circuit complexity. Some wafers have as many as 20,000 parts while others have 200. Test time ranges from less than 1 s to 40 s per device. Average sort time is now 135 min per wafer. It used to be 221 min per wafer. A particular wafer that used to take 92 min to test now takes 18 min.

Q: How did you reduce test time so drastically?

A: I optimized the test programs to make them more efficient. I didn't remove any tests, but I did rearrange them to better utilize my test equipment and significantly reduce the cycle time of the tester. I did that because I have an intimate knowledge of how the test systems work. I identified a sensitivity in the tester's hardware that the manufacturer had to repair. As a result of the reduced test time, we were able to test more wafers in Bloomington instead of testing in Asia where we cut and package the wafers.

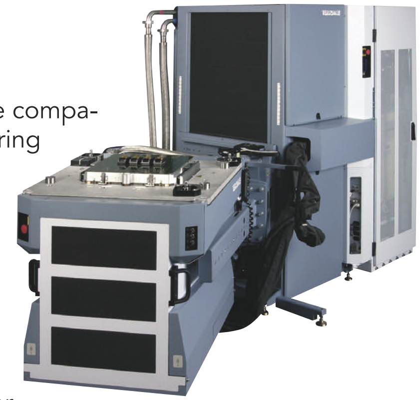
Q: What other changes have you made to make testing more efficient?

A: We monitor the test process in real time rather than test a batch of wafers and then analyze the data. We immediately analyze the data for every wafer, looking at 15 parameters. Because we test the devices in blocks of eight or 16 test sites, we can tell if a set of wafer probes is bad by analyzing what we call "site deltas." That is, we compare the data at the same relative site in each block. If the device in the same site in each block fails, we stop testing and fix the problem.

We analyze this data at the end of every wafer test using remote computers connected to the test on the company LAN. We then download the analysis to the tester while the next wafer is under test. If we find a problem, we stop the process, fix the problem, and retest the wafer in question. In the past, we would have tested 25 wafers before finding that the same site experienced a continuity problem. Now, we retest no more than one wafer. Some wafers may take hours to test, and we don't want to retest 25 wafers. 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.

Chinese operations select UltraFLEX, J750



Teradyne has announced the sales of semiconductor test systems to three companies operating in China. First, Shanghai-based Semiconductor Manufacturing International Corporation (SMIC) has selected UltraFLEX test systems for high-volume wafer testing. Teradyne reports that SMIC will use the UltraFLEX (**pictured**) to test audio, baseband, HDTV, high-speed-communications, and embedded-memory products.

Teradyne also announced that Actions Semiconductor, a fabless company in China, has purchased J750 test systems for MP3 and codec device test. Actions Semiconductor will employ the J750 as a dedicated engineering and production test system. Finally, Teradyne reported that ASAT, a provider of semiconductor package design, assembly, and test services, has purchased Teradyne FLEX and J750 systems for high-volume consumer-device test applications. The systems will be used in ASAT's new China facility located in Dong Guan. www.teradyne.com.

EMI standard underway for modules

Because existing standards governing electromagnetic interference (EMI) in electronic systems do not address systems that use replaceable electronic modules (REMs), the IEEE-SA Standards Board recently approved Project 1688, Standard for Module Electromagnetic Interference (EMI) Testing. The group will work to define susceptibility and emissions tests for radiated and conducted EMI on REMs.

Part of the IEEE EMC Society, the P-1688 group hopes to develop a draft standard in time for the 2006 IEEE EMC Symposium (August 14–18, Portland, OR). The project team is headed by Fred Heather, Joint Strike Fighter Electromagnetics Effects Lead. mailto:heatherf@ieee.org.

ASAT, HKSTP select 93000 Pin Scale platforms

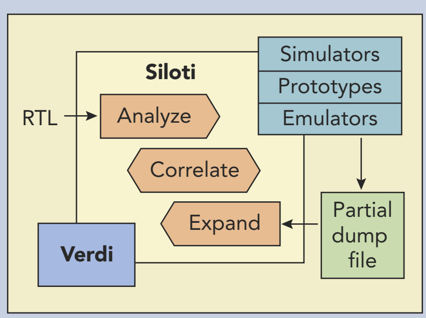
Agilent Technologies reports that ASAT, a subcontract manufacturer in China, and Hong Kong Science Technology Park (HKSTP), Hong Kong's IC development support center, have each selected an Agilent 93000 Pin Scale system with Audio/Video 8 functionality.

ASAT will use the system for testing high-volume mixed-signal and digital devices at its new production facility in Dong Guan, China. "Many of our customers have requested that we adopt the 93000 Pin Scale system to support their device testing requirements," said John Ritchie, senior director of testing operations and engineering at ASAT. "The 93000 Pin Scale tester allows ASAT to flexibly support the varied test demands we receive from different mixed-signal device applications, using one test platform. This will help us to

Editors' CHOICE

Visibility enhancement for IC debug

The Siloti family of software tools addresses the problem of decreasing visibility into the functional operation of complex ICs during late-stage verification and system validation. They aim to overcome the problems of limited signal observability in near- and post-silicon applications with patent-pending visibility-enhancement technology. Siloti can serve in simulation, emulation, first-silicon prototyping, and silicon debug. The Siloti tools are tightly integrated with their vendor's Verdi automated debug system to bring RTL debug to visibility-challenged environments.



The underlying Siloti visibility-enhancement technology analyzes limited signal data, automatically derives missing information, and correlates complex low-level representations with RTL descriptions. Initial products in the family include the Siloti SilVE and SimVE offerings, which work with third-party simulation, emulation and FPGA-based prototyping tools, as well as with emerging DFD tools and test environments. The Siloti SilVE product works with emulators, prototypes, and DFD-enabled chips to optimize observability of signals. The Siloti SimVE product works with standard HDL simulators to make regression simulation more efficient.

Base price: $65,000 for an annual license. *Novas Software, www.novas.com.*

meet our production test goals in our new China facility."

Agilent says that HKSTP will use the Agilent 93000 Pin Scale system for testing high-speed and mixed-signal devices used in mobile consumer electronics and personal computers. "We selected the 93000 Pin Scale system and the A/V8 because of the system's cost-effective per-pin upgrade capability and high performance in high-speed, mixed-signal multisite test," said Ir. S.W. Cheung, VP of business development and technology support at HKSTP. "In addition, Agilent's knowledgeable application engineers are able to complement the skills of our internal resources by providing advanced support for our tenants and customers." www.agilent.com.

Firms plan WiMAX plugfest

Trendsmedia and CWLab are joining forces at the WiMAX World Europe Conference and Expo, slated for May 22–24, 2006, in Vienna, Austria, to produce a special preconference WiMAX performance plugfest. The program is geared to network operator attendees who are currently evaluating the best WiMAX and pre-WiMAX equipment. Vendors sponsoring the plugfest will have their equipment or services tested and results featured at the WiMAX event. Plugfest results will be presented in a half-day program at the conference. www.wimaxworldeurope.com.

CALENDAR

Vision Show East, May 9–11, Boston, MA. Sponsored by Automated Imaging Association. *www.machinevisiononline.org.*

Sensors Expo & Conference, June 5–7, Rosemont, IL. Sponsored by Questex Media Group. *www.sensorsexpo.com.*

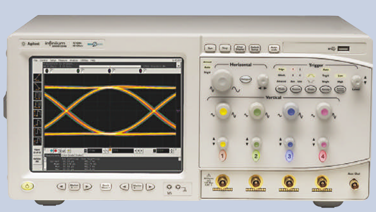
MTT-S/International Microwave Symposium, June 11–16, San Francisco, CA. Sponsored by the IEEE Microwave Theory and Techniques Society (MTT-S). *www.ims2006.org.*

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

Editors' CHOICE

Scope drops noise floor

Agilent Technologies' DSO80000B series of four-channel, 2-GHz to 13-GHz oscilloscopes, which includes eight models, improves on the noise floor of the DSO80000A series. The lower noise floor lets you use a higher-bandwidth scope than you could with previous models. By moving to a higher bandwidth, you can capture high-frequency harmonics and produce a more accurate picture of a waveform. The DSO80000B series also let you upgrade a unit's bandwidth without returning it to the factory. Thus, you can buy just enough bandwidth for your current applications and upgrade as your signals gain speed.



The DSO80000B adds the Infiniiscan option, which lets you post-process signals and sets triggers based on waveform characteristics. With this $4995 option, you get a menu that lets you select from several categories of triggers. The measurement category, for example, lets you trigger the scope based on parameters such as rise time or pulse width. It also lets you trigger on frequency, jitter, and a combination of voltage and time characteristics.

Prices: $30,000 to $115,000. Bandwidth upgrades—$9000 to $19,500. *Agilent Technologies, www.agilent.com/find/dso80000b.*

IPTV under discussion at OFC/NFOEC

> > > OFC/NFOEC 2006, Anaheim Convention Center, March 5–10, Anaheim, CA, www.ofcnfoec.org.

During OFC/NFOEC 2006, a panel of industry experts met with the press to discuss the status of TV carried over IP networks (IPTV). Chris Rice, executive VP of network planning and engineering at AT&T, said that his company has deployed some IPTV over 1-Gbps Ethernet passive optical networks (PONs), but it is waiting for GPON standards to mature. GPONs, which should bring 2.5-Gbps bandwidth to homes, are needed because MPEG-2 video streams don't have enough compression to handle high-definition TV and because MPEG-4 decoders that offer the necessary compression are still too expensive for widespread deployment.

ON THE EXHIBIT FLOOR

SyntheSys Research (www.bertscope.com) showed its physical-layer analyzers that perform BER analysis and display eye diagrams. The company also introduced the BERTScope CR 12500A clock-recovery instrument that recovers clocks for optical networks such as 10 GigE, Fibre Channel, and SONET. **Agilent Technologies** (www.tm.agilent.com) introduced three bit-error rate (BER) testers including the N5980A, a 3.125-Gbps serial BER tester that connects to a PC through an Ethernet link.

Yokogawa (www.yokogawa.com/us) introduced the AQ6370 optical spectrum analyzer (OSA), which performs frequency sweeps 10 times faster than its predecessor and adds high-speed IEEE 488, Ethernet, and USB interfaces. **Apex Technologies** (www.apex-t.com) displayed the AP2440A OSA, which measures both optical power and phase. **Luna Technologies** (www.lunatechnologies.com) showed an OSA that measure insertion loss, polarization-dependent loss, polarization-mode dispersion, chromatic dispersion, and group delay in optical components and networks.

LeCroy (www.lecroy.com) exhibited its SGA100G serial data analyzer with 100-GHz bandwidth. **Anritsu** (www.us.anritsu.com) introduced the MP1800 series of modular signal quality analyzers. The series consists of three mainframes and a 12.5-Gbps synthesizer, a pulse pattern generator, an error detector, and a 128-Mbit test-pattern memory.

Arroyo Instruments (www.arroyoinstruments.com) introduced three products for testing laser-diode modules. **ILX Lightwave** (www.ilxlightwave.com) displayed laser-diode controllers, diode current sources, temperature controllers, and mounting fixtures.

Analog Devices (www.analog.com) introduced the ADN2865, a loop-timed SerDes IC for PONs at data rates up to 2.5 Gbps. **Exfo** (www.exfo.com) exhibited the PPM-352B-EG PON power meter, which measures and displays pass/warning/fail analysis of all signal types. The company also displayed test modules for its SONET/SDH testers.

Tempro (www.tempro.textron.com) showed its line of optical time-domain reflectometers. **dBm Optics** (www.dbmoptics.com) exhibited the Model 2004 component spectrum analyzer, which tests components for polarization-dependent loss and other parameters. **Thorlabs** (www.thorlabs.com) exhibited systems that measure polarization-mode dispersion and polarization-dependent loss in optical fibers.

Fiberpro (www.fiberpro.com) exhibited the Model CI 4000 acoustic fiber cable identifier. It uses noninvasive tapping to produce audio and visual representations of the fiber's signals. **CEYX Technologies** (www.ceyx.com) announced the LightSmart X100 digital laser control system that can monitor itself and compensate for temperature and age.

Circadiant Systems (www.circadiant.com) released the Hydra system for testing long-reach multimode (LRM) components and systems to the IEEE 802.3aq standard. **Glimmerglass** (www.glimmerglass.com) demonstrated the System 600, a low-profile, high-density optical-switching system. **Inphi** (www.inphi-corp.com) displayed the 2080MX, a 20-Gbps 4:1 multiplexer IC designed for use in SONET test and measurement equipment. **Polatis** (www.polatis.com) introduced the OMB series of CompactPCI optical switch modules that can be configured in combinations from 1x15 to 8x8.

JDSU (www.jdsu.com) introduced several products, including the SmartClass testers that let telecom carriers test broadband access networks such as ADSL 1/2/2+. The SmartClass OTS-55 optical test set tests for dark fiber installations. **Peleton** (www.peleton.com) displayed the TM 2530 series of tunable lasers and its TM3050C 96-channel laser source. **Promet** International (www.promet.net) displayed an interferometric fiber-optic connector testing system. T&MW

The SmartClass tester is designed for testing broadband access networks.

Courtesy of JDSU.

The N5980A is a 3.125-Gbps serial BER tester.

Courtesy of Agilent Technologies.

> > >

Calibration standards get updates

> > > Measurement Science Conference, February 27–March 3, Anaheim, CA, www.msc-conf.com.

Panel discussions at the 2006 Measurement Science Conference covered updates to critical calibrations standards. In "Proposed Revisions RP-1: The Establishment and Adjustment of Calibration Intervals," Don Wyatt of Diversified Data Systems described the reasons for updating the 10-year-old document. For example, it's now possible to perform complex analysis on large data sets that were impossible to do in 1996, simply because of the improvement in inexpensive computer power. As a result, the next revision of RP-1 will recommend that cal labs keep more data on an instrument's calibration history.

In the Z540 panel session, "Calibration Requirements for M&TE, The Revision of ANSI/NCSL Z540-1," Paul Nelson of Raytheon discussed the current standard and the proposed new standard, Z540.3. The new revision sets out to control access to an instrument's calibration constants by forcing manufacturers to lock out users from the calibration data.

In his keynote address, Philip Coyle, senior advisor to the president of the Center for Defense Information, spoke of the importance of measurements in the field of battle. He attributed the accuracy of laser and GPS-guided missiles to the quality of the measurements used in their design and manufacture. "Shooting down an enemy missile with another missile against the backdrop of space is like trying to score a hole-on-one when the hole is moving at 17,000 miles per hour," he said. "The defense missile needs to distinguish between the real missile and any decoys."

ON THE EXHIBIT FLOOR

Several companies demonstrated software for calibration management and automated instrument calibration. They included **Anmar** (www.anmar.com), **AssetSmart** (www.assetsmart.com), **Diversified Data Systems** (www.dds-inc.com), **Edison Mudcats** (www.edisonmudcats.com), **Integrated Sciences Group** (www.isgmax.com), **Northrop Grumman** (www.surecal.com), **Fluke** (www.fluke.com), **Norvada** (www.norvadallc.com), **One RedX Software** (www.1redx.com), **On Time Support** (www.ontimesupport.com), and **SanSueB Software** (www.sansueb.com).

The Model 5901 triple point of water cell has an uncertainty of 0.0001°C.

Courtesy of Hart Scientific.

Fluke (www.fluke.com) demonstrated calibration standards and multifunction calibrators, and its **Hart Scientific** subsidiary (www.hartscientific.com) exhibited the Model 5901 triple point of water cell. **Symmetricom** (www.symmetricom.com) exhibited its cesium-based time and frequency references. **Guildline Instruments** (www.guildline.ca) exhibited its 6622 resistance bridge. The bridge uses current to measure resistances up to 100 kΩ and voltage (up to 1000 V) for higher resistances.

Tektronix (www.tektronix.com) exhibited its recently announced DPO4000 and DPO7000 line of oscilloscopes. **Rigol** (www.rigol.com) exhibited a line of two-channel, 100-MHz low-cost oscilloscopes. **Yokogawa** (www.us.yokogawa.com) exhibited its latest oscilloscope offering, the DL9000. **Agilent Technologies** (www.tm.agilent.com) exhibited high-end RF spectrum analyzers and power meters for calibrating equipment and components. T&MW

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RICK NELSON
CHIEF EDITOR
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DRAM test: At the crossroads?

DRAM technology has reached a juncture requiring significant revisions in test approaches—unless, of course, it hasn't. ATE powerhouses Advantest and Agilent Technologies have staked out significantly different positions on what emerging DRAM technologies will require.

Debbora Ahlgren, an Agilent Automated Test Group VP & GM, believes that XDR (extreme data rate) and GDDR (graphics double data rate) DRAMs will require new test approaches to ensure high quality at low cost of test (Ref. 1). She cited the type of faults appearing in memories fabricated in 65- and even 45-nm processes as one reason for the new test requirements. Such devices are subject to random defects, including delay defects that, she said, require an at-speed tester-per-pin architecture to be reliably detected.

The T5501 is well positioned to test devices through GDDR4, according to Gary Fleeman, director of product engineering. Courtesy of Advantest.

To address what Ahlgren sees as the emerging demands, Agilent in February introduced the 93000 HSM. Available in 2.2-Gbps and 3.6-Gbps versions, it supports 16-site XDR or 32-site GDDR DRAM test in a single test head, offers parallel eye-finding source/synchronous capability, and supports at-speed capture of failure data to facilitate yield learning. Ahlgren said the 93000 HSM addresses memory test challenges by enabling single-insertion test of high-speed memory cores as well as I/O.

In contrast, Gary Fleeman, director of product engineering at Advantest, doesn't foresee any near-term challenges that will be insurmountable to the installed base of memory testers, including his firm's T5501, which targets multisite test of DDR and GDDR devices. He said the T5501, which operates at 2.133 GHz in DDR mode, is well positioned for DDR3 devices as well as for GDDR4.

He did note that the ever-increasing I/O speeds of graphics memory will ultimately challenge the installed base, and he suggested that his firm's 6.5-Gbps digital module, which initially targeted Serdes test (Ref. 2), will play a role in at-speed test of memory interfaces. In fact, in highlighting the module at Semicon Japan in December, Advantest specifically cited its applicability to DDR and XDR DRAM test.

The Advantest 6.5-Gbps module plugs into the company's T2000 SOC tester. But Fleeman doesn't see the T2000 evolving into a single-insertion memory-test platform. In fact, he said, "I don't see anybody's 6.5-GHz pin electronics becoming part of single-insertion memory test approach. It is absolutely the case that all mainstream memory test today is dual insertion, and emerging new parts are not going to be core tested at I/O speed. The industry has clearly settled on a structural core-test insertion with long test times and then an at-speed I/O test. We've already started down that road, and we are not looking back."

I'll look back in a few months to see which memory-test roads are well traveled. T&MW

REFERENCES

1. Nelson, Rick, "93000 platform takes aim at DRAM final test," *Test & Measurement World,* "Test Industry News," February 21, 2006. www.tmworld.com.

2. "Advantest T2000 Module Targets Serdes Test," *Test & Measurement World,* "Test Industry News," July 12, 2005. www.tmworld.com.

SV Probe gets K&S wafer-test assets

SV Probe has announced that it has completed the acquisition of the wafer-test assets from Kulicke & Soffa Industries. The transaction, announced on January 24, was completed on March 3. SV Probe said it will provide continuous service to K&S's existing customers for blade, cantilever, vertical, and advanced-vertical probe-card products and wafer-interface products. www.kns.com, www.svprobe.com.

QuickLogic taps Sapphire D-10

Credence Systems has announced that QuickLogic will use the Credence Sapphire D-10 for the development and production of its next-generation, low-power field-programmable gate arrays (FPGAs). Optimized for 200-Mbps probing, the D-10 accommodates analog and mixed-signal instruments as well as up to 768 digital pins. www.credence.com.

TUG heads for Florida

The Teradyne Users Group will convene May 1–3 in Ponte Vedra Beach, FL. TUG 2006 topics will include production efficiency, memory test, multisite test, fast time measurement, revision control, RF test, program conversion, and test program sets. Bradley J. Carlson, propulsion systems engineer at NASA, will present a keynote address. He currently works at the Kennedy Space Center supporting safety and mission assurance for Space Shuttle propulsion integration. www.teradyne.com/tug.

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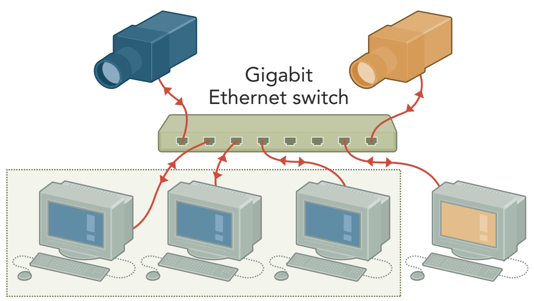
Vision meets Ethernet

THE EMERGENCE of protocols such as EtherNet/IP for industrial equipment and LXI for instrument control reveals a trend for using Ethernet for more than business communications and Web surfing. So, it comes as no surprise that vision-equipment vendors also have hoisted the Ethernet banner: The new GigE Vision protocol will use standard Gigabit Ethernet hardware to link cameras and PCs.

The Automated Imaging Association, which oversees the GigE Vision standards committee, expects approval of this new protocol by the organization's May Vision Show East gathering in Boston. But users of machine-vision equipment may ask, "We already have RS-170, USB, FireWire, and Camera Link, so why add another vision standard? And what does GigE Vision offer equipment users and developers?"



A single Ethernet switch can route GigE Vision images from one camera to a host PC and from one camera to several PCs. Courtesy of Pleora Technologies.

A great deal, it turns out:

- Ethernet implementations require little new computer equipment. Most PCs come with Ethernet ports, and vendors offer high-performance network switches at low cost. If you have only a few cameras, you can make direct camera-to-PC connections without going through a switch. Of course, applications will require new GigE Vision-compatible cameras. And software will need new drivers and a new Ethernet stack. The current Microsoft Windows Ethernet stack would cause a communication bottleneck.
- The GigE Vision standard will rely on a discovery process to obtain XML-coded data from networked devices. This information will identify camera types, characteristics, and options, so networked devices can operate in a plug-and-play fashion. Although USB and FireWire devices offer a similar capability, they suffer from distance limits that keep cameras close to computers.
- Developers who have had experience with Ethernet in industrial environments will find they can add GigE Vision hardware to existing networks without much effort. In some cases, developers will be able to mix vision and nonvision equipment on a network, although bandwidth may suffer.
- Ethernet protocols include error-detection mechanisms that can automatically request a retransmission of a defective data packet. Granted, USB communications include error checking, too, but those communications cannot reach the bandwidth of a Gigabit Ethernet link. And few consider USB to be an industrial network.
- Ethernet communications can occur over longer distances than those permitted for USB, FireWire, or Camera Link interfaces. A run of Ethernet Cat-5 cable, for example, can easily reach 100 ft.

Some users of GigE Vision equipment will simply connect one or more cameras to a host PC. But system designers may establish complex networks that route images through switches and networks not dedicated to vision applications. People in this latter group should consult with GigE Vision equipment and software vendors about bandwidth and latency issues as well as real-time response times. Although GigE Vision will simplify vision systems, it won't eliminate every headache. T&MW

Sensors combine analyses

The PresencePLUS P4 Omni and P4 Omni 1.3 vision sensors combine gray-scale, blob, edge, and object analysis tools in a single package; a bar-code reader is optional. A remote "teach" function operates without the need to connect to a PC; a built-in live video output allows users to view the sensor's inspections in real time and to view failed inspection images without a PC. The sensors offer 10/100 Ethernet or RS-232 interfaces. www.bannerengineering.com

Software hones x-ray image inspection

A Windows XP-based x-ray image processor, VIPx from FocalSpot, offers advanced SMT/BGA inspection capabilities and image-enhancement tools for upgrading almost any PC-based x-ray inspection system. VIPx increases inspection productivity through algorithm-based inspection modules that automatically find solder connections and perform measurements and defect detection by operator-defined pass-fail analysis criteria. www.focalspot.com.

CCD cameras offer Mpixel resolution

Basler's eXcite intelligent camera series now includes four new megapixel-resolution CCD models. The new variants are equipped with 1.45- and 2.0-Mpixel CCD sensors and are available in monochrome and color versions. At full resolution, the new cameras can capture images at 17.8 and 14.0 fps. www.basler-vc.com.

LXI: Modular instrumentation for today and tomorrow

Agilent Technologies offers a test and measurement system that combines the best features of LAN technology and rack-and-stack instrument packaging

Modular instruments have become increasingly popular for building custom test systems. In a wide variety of settings—R&D, manufacturing, quality assurance, service and repair—these systems implement key setups for verifying, debugging and characterizing the designs of new products.

A few years ago, Agilent and VXI Technology (www.vxitech.com) became concerned about the limitations of the two leading modular-instrument packaging technologies—the venerable VXI (VME extensions for instrumentation) and the newer, and usually smaller, PXI (PCI extensions for instrumentation). PXI is based on CompactPCI, an embedded-systems packaging standard that is a ruggedized version of PCI (peripheral-component interconnect), which is widely found in desktop PCs.

Despite their popularity, those modular-instrument standards are hampered by several shortcomings that seem destined to become more onerous as time passes. First, both feature parallel buses that are becoming obsolete and that limit how far you can locate the modules from one another. Second, both are based on expensive shared power supplies and card cages responsible for cooling the modules that reside within the cages. Both also require that each card cage incorporate a costly Slot-0 module or system controller. Most important, although VXI and PXI rely on computer-industry buses, they have evolved into specialized standards that derive little benefit from the computer industry's high unit volumes.

Best of both worlds

What emerged from the discussions about modular instruments is LXI (LAN extensions for instrumentation). LXI combines the best of modular and rack-and-stack instrument packaging and brings other benefits of LAN technology to test and measurement. For example, LXI features Ethernet as the method for interconnecting rack-and-stack instruments in systems, instead of the venerable IEEE 488, a cabled parallel bus, also known as GPIB (general-purpose instrumentation bus).

IEEE 488 has served the T&M industry well over three decades, but its speed is no longer adequate for many applications. It is also routed through durable but large and expensive connectors and thick, balky cables. In contrast, Ethernet, operating at speeds to 10 Gbps, transmits its bus signals serially over thin, flexible, relatively low-cost cables terminated in inexpensive plastic-bodied RJ-45 connectors that snap together.To achieve physical consistency, the LXI standard begins with standard IEC (International Electrotechnical

Agilent Synthetic Instruments - LXI Class A (shown here).

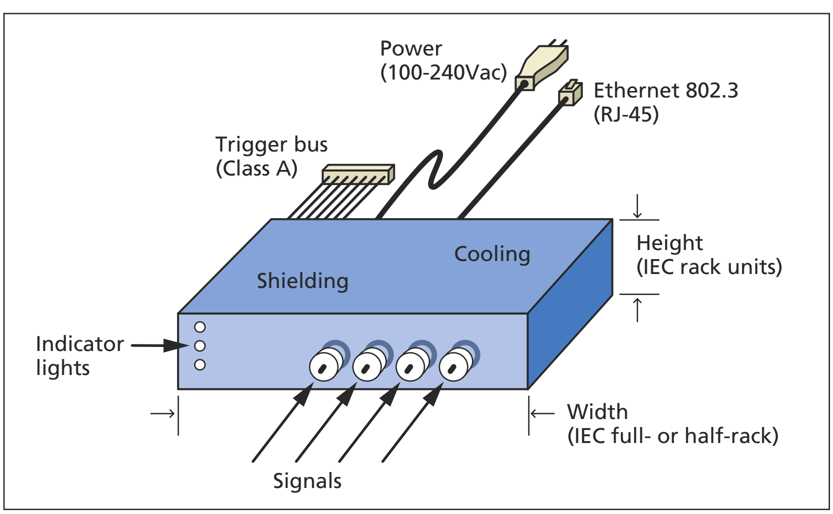


Figure 1. The LXI standard strives for physical consistency that simplifies system integration and implementation.

Commission) rack dimensions, but also defines an additional smaller instrument size of 1 LXI unit (1U high—that is, 1.75-in.-and ½-rack wide). The standard also recommends the placement of various connections (Figure 1). For example, compliant instruments use the front panel for signal inputs and outputs, plus indicator lights for LAN, power, and IEEE 1588 (synchronization). The rear panel contains connectors for hardware triggering, power input, and Ethernet communication. Each LXI module must meet worldwide standards for cooling and EMI (electromagnetic-interference) shielding. LXI modules receive operating power either from the ac line or, by use of POE (power over Ethernet) technology, from the network connection.

By specifying the interaction of proven, widely-used standards such as Ethernet, Web browsers, and IVI (interchangeable virtual instrument) drivers, LXI enables fast, efficient and cost-effective creation and reconfiguration of test systems. Other benefits include: compact size and higher test throughput than are found with rack-and-stack instruments or caged instrument modules. Agilent and the more than 40 corporate members of the LXI Consortium believe that these LXI-based test systems are "future proof." They won't become obsolete any time soon.

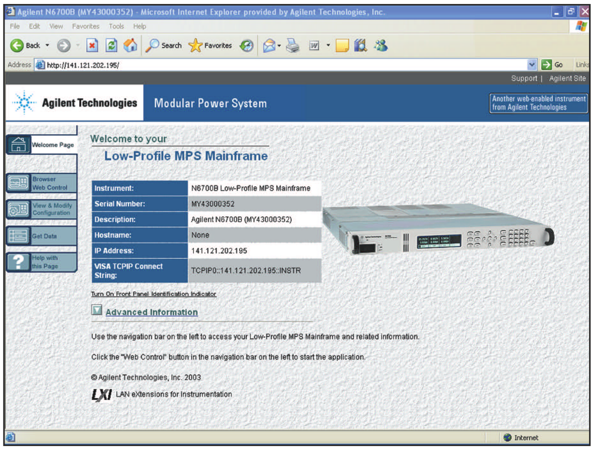


Figure 2. LXI specifies an informative instrument page that engineers can access with a standard Web browser.

More than just a LAN port

Although many current-generation instruments include LAN ports, LXI is the next logical step in the evolution of LAN-based instrumentation. It includes classic "box" instruments, modular instruments without panel-mounted controls and displays, and functional building-block modules (synthetic instruments). Even when space is at a premium, you don't have to sacrifice capability, accuracy, or performance. Best of all, you can use the same instruments—and leverage the same test-system software—across R&D, design validation, manufacturing, and service. Using the same hardware and software in these disparate activities not only cuts test-development time, but it also results in more consistent measurements and less time wasted in trying to correlate measurements made by different people in different places.

Every LXI-compliant device must also be able to serve its own Web page. This page provides key information about the device, including its manufacturer, model number, serial number, description, hostname, MAC (media-access control) address and IP (Internet Protocol) address (**Figure 2**). The standard also requires a browser-accessible configuration page that allows the user to change parameters such as hostname, description, IP address, subnet mask, and TCP (transfer-control protocol)/IP-configuration mode. Accessing these Web pages is as simple as typing the instrument's IP address into the address line of any standard Web browser.

Many of Agilent's LXI-compliant instruments go beyond the LXI requirements, providing monitor and control capabilities in their Web pages. For example, you can set up a DMM (digital multimeter), command it to start making measurements and then read the results. The ability to control an instrument through a browser interface opens a realm of new possibilities for test engineers who need a simple way to access test systems from virtually anywhere in the world.

Triggering options

One especially intriguing aspect of LXI is its triggering and synchronization capabilities. By harnessing the capabilities of the LAN and the IEEE 1588 time-synchronization protocol, LXI provides a variety of triggering modes that are not available in GPIB, PXI, or VXI.

The three classes of LXI devices—Classes C, B, and A—implement these capabilities to an increasing degree. Class C provides the basic capabilities associated with LXI instruments. Class B adds LAN triggers and time-based triggers using the IEEE 1588 precision time protocol (both over LAN). In addition, Class A features a hardware trigger bus that enables triggering of LXI instruments in close proximity. The trigger bus is similar to the backplane bus of VXI. It is an eight-pair, differential-voltage bus that enables 5-nsec/m timing accuracy for co-located instruments. Synthetic instruments are expected to comply with Class A.

Combine this triggering flexibility with such benefits as high performance, compact size, and web-based control, and it is easy to see why LXI is increasingly becoming the engineer's best option for effective modular instruments. ■

FOR MORE INFORMATION

To learn more about LXI and products that incorporate it, contact:

Agilent Technologies
1-800-829-4444,
www.agilent.com/find/tmw-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

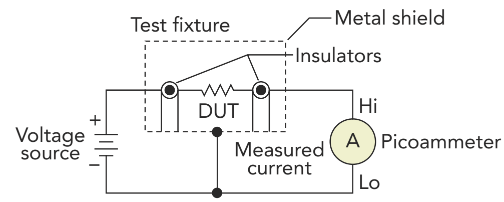
BASIC MEASUREMENTS

Cut noise from high-resistance measurements

Noise in circuits reduces measurement accuracy, which reduces the effective resolution of an instrument as well. Electrostatic coupling is the most common source of noise in resistance measurements above 10 MΩ.

Electrostatic interference occurs when an electrically charged object comes close to an uncharged object. At low-impedance levels, the effects of the interference are negligible, because the charge dissipates rapidly. High-resistance materials, however, don't let the charge decay quickly, and the interference may result in unstable measurements. Delays could be in the range of tens of seconds to several minutes, depending on the application. To reduce the effects of electrostatic interference, it's important that you use both shielding and guarding when making high-resistance measurements.

Shielding a circuit with a metallic enclosure prevents electrostatic interference from affecting a high-impedance circuit (**figure**). Noise current generated by the electrostatic voltage source and the coupling capacitance flows through the shield to ground rather than through the signal conductors.



A metal shield and guard circuits reduce noise in high-impedance measurements.

The easiest shield to make is a simple metal box or mesh screen that encloses the test circuit. Connect the shield to the low-impedance point on the measurement instrument. If this point floats above ground, you should observe special safety precautions to prevent any shock hazard. You should also use shielded cables to minimize noise.

Guarding adds a low-impedance conductor, maintained at the same potential as the high-impedance circuit, to intercept any interfering voltage or current and divert it to ground. Connect the guard to the instrument's guard terminal, if available, or use an external buffer amplifier. A guard does not necessarily provide electrostatic shielding, but it will reduce noise from other sources.

Dale Cigoy, Applications Engineer, Keithley Instruments

WEB TOOLS

Online calculator aids test-asset management

"What if we could design a way to bring new profitability and speed to our test-related functions?" That's a question posed by Paul McNamara, CEO of the Sente Group, which offers an online worksheet and calculator that can help manufacturers see their own potential for improvement.

McNamara says he has seen telecom and defense companies improve profitability by tens of millions of dollars by focusing on what he describes as *the* dynamic that drives test-related activities: the interdependence of people, practices, and tools. Streamlining relationships among these groups, he says, can lead to measurable improvements in engineering cultures.

McNamara cautions that engineering, financial, operations, and quality personnel should not settle for 5 to 10% improvements. Most asset-management efforts, he explains, aim low and simply deploy asset-tracking software in an effort to foster equipment sharing. But such software, he says, doesn't account for how engineers behave in the real world: They fail to properly sign out equipment, and they hoard it to ensure it's available the next time they need it.

TCO calculator values

STEP	
1	Number of active instruments turned on and performing tests
2	Number of inactive instruments (can be turned on and hooked up)
3	Utilization percentage
4	Number of pieces of equipment owned
5	Annual test-equipment spend
6	Purchase savings
7	Ownership and maintenance savings
8	Engineering direct-labor savings
9	Total savings

Input entered by user (steps 1, 2, 4, 5) — Output from calculator (steps 3, 6, 7, 8, 9)

The key to asset-usage improvement, McNamara says, lies in the realization that assets are inanimate objects that don't need management. Assets never have agendas, never are in bad moods, and never engage in office politics. People, however, must be able to manage, be managed themselves, and be satisfied that they can get their jobs done, he says, adding that a program can only be successful if it satisfies users.

McNamara advises starting with practices that will earn the trust of users and build that trust over time by delivering the technology they need, when they need it, without fail. Early success, he says, builds momentum for continuing and expanding an initiative.

The stakes are high. A large OEM, McNamara says, may have 10,000 pieces of discrete test equipment, each having an average acquisition cost of $9500 and achieving utilization rates hovering

Online calculator aids test-asset management *(continued)*

around 15%. Without an effective asset-management approach, he says, capital spending on test equipment will be 50 to 75% higher than it needs to be.

To read a paper by McNamara detailing his approach and to find a link to the Sente Group's online total-cost-of-ownership calculator, based on the company's proprietary TCO model, see the online version of this article at www.tmworld.com/2006_04.

Rick Nelson, Chief Editor

INSTRUMENT CONTROL

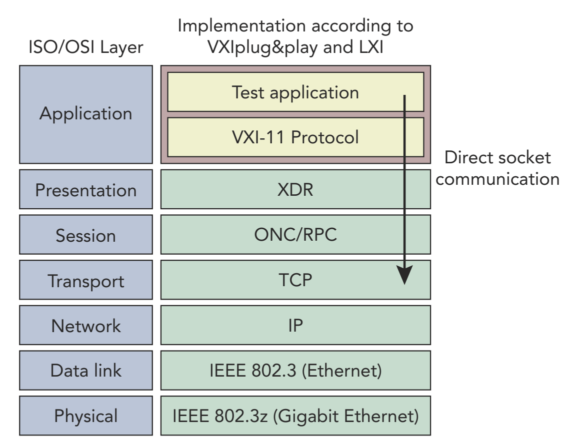
Linux controls instruments through Ethernet

Because every PC built in the last several years has an Ethernet port, the bus has become popular for controlling instruments—you can connect test equipment directly to the PC without the need for an interface card. In addition, many manufacturers provide instrument drivers for the Windows operating system, making it easy for engineers to set up and run an Ethernet-based test system.

But if you prefer the Linux operating system, setting up a test system is slightly more difficult. Instrument drivers are not as commonplace for Linux, so you need to find another way to communicate with instruments through the Ethernet port. You have two communication software options: the Virtual Instrument Software Architecture (VISA) driver or a direct communication through a transmission control protocol (TCP) socket.

Developed by the VXIplug&play Alliance, VISA has an extension called VXI-11 that lets application programs communicate with instruments over Ethernet. The advantage of VISA and VXI-11 is that you can use the same code that you use for IEEE 488 communication. You just have to change one line of code to tell VISA to communicate over Ethernet. LAN Extensions for Instrumentation (LXI) enhances VISA, but you can use VISA with any instrument that has an Ethernet port. The **figure** shows the protocol stack for VISA and VXI-11. Your test application and VISA reside at the application layer and must communicate through all seven layers to reach your instrument.

Your second option is to bypass the session and presentation layers by communicating directly to the TCP layer using direct socket communication. Socket communication requires less code than using VISA, but the code isn't compatible with VISA or IEEE 488.



You can use VISA and VXI-11 or direct socket communication to control instruments over Ethernet.

To learn more about using VXI-11 and direct socket communication, you can download "Using Linux to control LAN-based instruments," by Stefan Kopp of Agilent Technologies, from the online version of this article at www.tmworld.com/2006_04. The paper includes source-code examples for VISA and socket communication. You'll also find a link to "Migrating to Ethernet" from the October 2004 issue of *Test & Measurement World*.

Martin Rowe, Senior Technical Editor

INSTRUMENTS

Car stereos get benched

DEVICE UNDER TEST

Automotive stereos returned to a stereo manufacturer's service center for repair. Stereos include several models installed into numerous vehicles from several manufacturers.

THE CHALLENGE

Automate testing of stereos. Replace analog meters and stand-alone instruments with an integrated, computer-controlled system. Perform some 30 measurements on AM, FM, and weatherband (WB) carrier frequencies. Measurements include 3-dB limiting sensitivity, signal-to-noise ratio (SNR), total harmonic distortion (THD), and intermediate frequency (IF) rejection ratio. Eliminate manual setups of test equipment, automate measurements, and provide test reports.

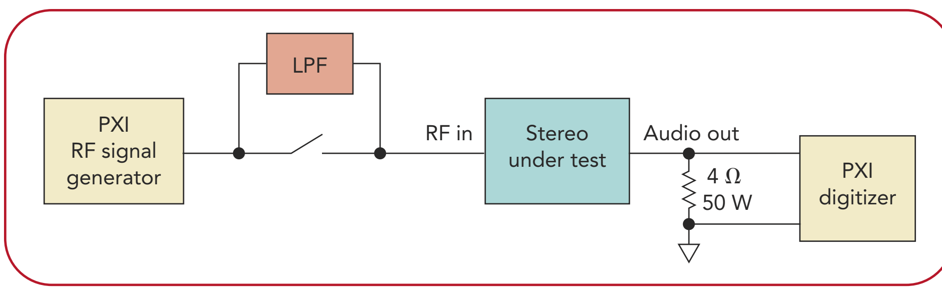
THE TOOLS

- Mini-Circuits: passive low-pass filter. www.mini-circuits.com.
- National Instruments: PXI instrument chassis with embedded controller, PXI RF signal generator module, PXI dynamic signal analyzer module, PXI RF switch module, graphical programming language, test executive. www.ni.com.

PROJECT DESCRIPTION

When a car stereo experiences trouble, a dealer's mechanic will replace it and send the defective unit to the manufacturer's service center. For years, technicians at one stereo manufacturer's service centers tested stereos manually, using an RF signal generator to create modulated signals for the stereo's antenna input. They used DMMs or analog dial meters to measure the audio output power. The technicians performed all the tests by hand, adjusting analog RF signal characteristics (including carrier frequency and power level), adjusting the meter ranges, and recording the measurements.

When the stereo manufacturer wanted to automate the tests, it turned to Bloomy Controls (www.bloomy.com) to develop a test system. Bloomy engineers developed a PXI-based system (**figure**) that generates RF signals and measures audio outputs. The signal analyzer measures audio signals in rms volts across a 4-Ω, 50-W resistor.



A PXI chassis contains all the instruments needed to test automotive stereos. (The online version of this article includes a photograph of the system. www.tmworld.com/2006_04.)

One of the tests measures the stereo's 3-dB limiting sensitivity. The RF generator produces an FM-modulated signal at a simulated radio-station frequency, say 98.1 MHz, at 60 dBμV. A technician pushes the stereo's seek button, which causes the stereo to scan until it finds the signal.

Once the stereo stops scanning, the technician adjusts the stereo's volume control until the system measures 2 Vrms. The system then gradually drops the stereo's RF signal power until it detects a 3-dB drop in audio power. The RF signal power that causes the 3-dB decrease in audio output is the 3-dB limiting power.

LESSONS LEARNED

While the limiting-sensitivity test requires a custom algorithm, others such as signal-to-noise ratio (SNR) and total harmonic distortion (THD) can take advantage of preprogrammed functions. The system also measures the stereo's IF rejection ratio, which produced some unexpected results.

During the IF rejection test, the system sets the RF signal's carrier frequency to the stereo's 10.7-MHz IF frequency with the stereo still tuned to 98.1 MHz. A discrepancy appeared between the audio response measured by the new system and that measured by the old system. RF signals from the analog and PXI generators contained noise spikes and elevated noise floors proportional to the IF signal power. Bloomy president Peter Blume added a 12-MHz low-pass filter (LPF) to reduce the noise level, but doing that required both the new and old test setups to produce more IF signal power to get an audio response from the stereo. Blume discovered that, all along, the stereo responded to noise instead of to the IF signal.

The filter produced a measurement about 20 dB higher than the customer expected, and the actual IF rejection ratio wasn't measurable using the traditional test procedure. Specifically, when the FM band noise was reduced, the stereo's audio output was unresponsive to IF signals above 100 dBμV, the maximum power for both signal generators. The new test system uses a power limit to evaluate the pass/fail test result instead of automatically performing a test procedure that would provide an invalid measurement.

Martin Rowe, Senior Technical Editor

Staff and students combine to form a unique test lab that's widely respected in the data-communications industry.

TODAY'S TESTING, TOMORROW'S ENGINEERS

Student Matt Hersh (left) gets assistance with a Gigabit Ethernet test board from staff engineer Andy Baldman.

MARTIN ROWE, SENIOR TECHNICAL EDITOR

DURHAM, NH—You may not think of New Hampshire as a hotbed for data-communications testing, but you should. In this town a few miles from the seacoast resides the University of New Hampshire InterOperability Laboratory (UNH-IOL, www.iol.unh.edu), part of the UNH Research Computing Center. The UNH-IOL is a testing lab that has the respect of just about every maker of data-communications equipment. Since its founding in 1988, the UNH-IOL has become known for its technology expertise and for a spirit of cooperation that helps member companies solve conformance and interoperability problems.

The UNH-IOL currently tests products in 20 technology categories, including Ethernet, DSL, IPv6, Serial Attached SCSI (SAS), Serial ATA (SATA), Fibre Channel, and Wi-Fi. Companies join the UNH-IOL to take advantage of its heavily equipped test beds and extensive technical resources. Test beds contain hardware and software tools developed at the lab for performing compliance tests, and they also contain networking equipment from member companies that the lab uses for interoperability testing. For an annual membership fee ranging from $14,000 to $20,000, a member company may bring its products to the lab for a week of individual testing on a test bed or for a week of group testing, called a "plugfest." Some companies belong to more than one technology group; the lab refers to each group as a "consortium."

Students perform most of the tests, which cover components such as communications ICs, subsystems such as network-interface cards, and network elements such as switches and routers (see "Let the students do the testing," p. 32). Member companies often send an engineer to the lab for a week to work with students on standards compliance testing or interoperability testing. "Catch the Rabbit," p. 30, highlights how

Student Aarti Patel performs a test using the IPv4 Interoperability test bed.

Rabbit Semiconductor used the UNH-IOL when the company added Ethernet to its microprocessors.

The test beds are richly equipped, because companies that join a lab consortium must agree to contribute their products. "We have networking and communications equipment that companies won't give to each other," said Gerard Nadeau, manager of the UNH-IOL's Fast Ethernet Consortium. "We act as a buffer between companies, and we can work out problems without giving away proprietary technology."

"Some companies leave every product they bring to the lab," added Bob Noseworthy, manager of the lab's 10 Gigabit Ethernet Consortium. "But 10-Gbps products are expensive, so we may share products with the IPv6 Consortium."

Because companies provide products for the test beds, their products are continually tested against new products. "We've found interoperability problems with equipment that's been on the market for years" said staff engineer Andy Baldman. "When that occurs, we contact the manufacturer and explain how their product interacts with a new device."

UNH-IOL clients appreciate the lab's role as a technology intermediary. "The UNH-IOL gives us a neutral ground," said George Dobrowski, director of technology and product planning at Conexant, a member of the lab's DSL Consortium. "We can bring our DSL chips there for a week of intense testing." Conexant uses the DSL test bed to run interoperability tests on new designs because "the UNH-IOL has equipment combinations that we can't replicate in our own lab."

Beds and tools

Test beds contain networking equipment, test equipment, and test tools. Often, staff and graduate students develop hardware and software test tools before such tools are commercially available. "We have, on occasion, used a company's prototype or evaluation board as the basis for developing a test tool," said Nadeau. "If member companies give us the hooks into their products, we can design a somewhat automated tool for more in-depth analysis than we could achieve with standard test equipment."

The lab has several Ethernet test tools that graduate students and staff have designed in collaboration with member companies. But because the lab lacks the facilities to fabricate test boards, member companies often pitch in to design and build them.

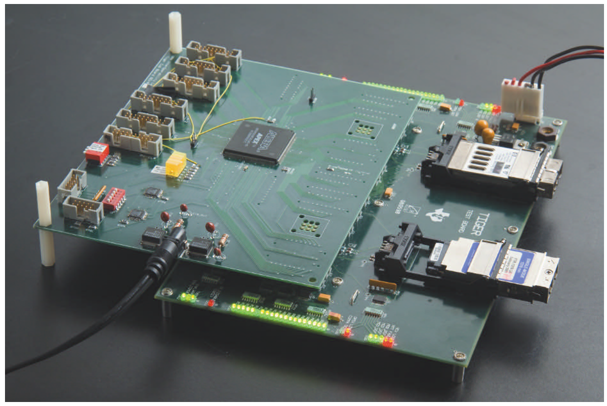


FIGURE 1. The "Tiger" board provides access to Ethernet ICs and lets students view serial data in a parallel format.

One such test tool is the "Tiger," designed by UNH-IOL and Texas Instruments (**Figure 1**), for testing Gigabit Ethernet (GigE) and Fibre Channel devices. The Tiger provides students with access to an Ethernet IC's signals. It provides 20 digital outputs that connect to an Agilent Technologies logic analyzer. With the tool, students testing GigE ICs can see a parallel representation of a GigE data stream—while the data is in a 10-bit format. They can view two 10-bit sequences at once on the logic analyzer. (GigE uses 8b/10b encoding that converts 8-bit data into 10-bit data. The extra bits add bit transitions to provide for clock recovery.)

Another test tool used for Ethernet testing lets students view a Fast Ethernet Auto-Negotiation sequence, which is a significant part of conformance testing. This tool consists of a custom interface board (**Figure 2**) that connects to a digital I/O card from Viewpoint Systems that then connects to a PC. The Auto-Negotiation sequence consists of a series of 100-ns pulses that occur at 100-ms intervals. The interface board contains one-shot flip-flops that elongate the pulses to lengths long enough for the digital I/O board to capture them. A custom software application written in LabView provides a graphical display of the sequence.

When performing tests, the students follow carefully written test procedures that describe how to set up and run tests based on clauses in communications standards. The procedures, available for downloading from the UNH-IOL Web site, clarify ambiguities in standards that require measurements without specifying how to make them.

UNH-IOL engineers play an important role not only in interpreting industry standards but also in helping to develop them. For example, consortium managers Eric Lynskey (Ethernet in the First Mile) and Bob Noseworthy (10 Gbit Ethernet) and others regularly attend committee meetings of IEEE 802.3 Ethernet subcommittees, and they often edit IEEE standards documents.

Catch the Rabbit

During my visit to the UNH-IOL, I met Lynn Wood, an engineer with Rabbit Semiconductor. Rabbit is adding Ethernet to its processor ICs, and Wood spent a week at the lab running compliance tests. Wood tested receivers, transmitters, complete Ethernet subsystems, and software drivers.

This was Wood's second visit to the UNH-IOL for this project. After performing basic function tests in his lab, Wood came to the lab because, "If you look at the Ethernet spec, you can't figure out what to test. UNH-IOL has worked all of that out." On his first visit, Wood worked with his device in FPGA form because he could quickly make design changes based on test results. This time, he was there to test the final FPGA design before the company commits to building it in ASIC form.

Wood performed 10BaseT Ethernet transmitter and receiver PHY-layer tests under worst-case conditions. He tested his devices using long cables and used a UNH-IOL tool to create simulated signals with varying jitter, crosstalk, skin effects, return loss, and rise time. The test tool uses Matlab scripts to generate Ethernet worst-case signal conditions. Wood performed bit-error-rate measurements to verify that the receivers could maintain 10^{-12} BER or less under worst-case conditions.

Martin Rowe, Senior Technical Editor

Physical-layer measurements

The Tiger and Auto-Negotiation test tools let students test Ethernet products at the Ethernet physical (PHY) and data-link layers, but much of the lab's conformance testing for Ethernet and other technologies focuses on the analog signaling in the PHY layer. Jitter is perhaps the most critical PHY-layer measurement, and the UNH-IOL has been a pioneer in the area. Andy Baldman measures jitter in serial data streams by capturing them with high-bandwidth oscilloscopes from Agilent, LeCroy, and Tektronix. Although today's oscilloscopes can perform jitter analysis, the UNH-IOL staff created its own tool using Matlab when the lab started offering jitter conformance testing for Token Ring networks.

"Once upon a time, scope companies just made scope hardware, so we had to develop our own software tool for separating total jitter from deterministic jitter," said Baldman. Because he knows exactly how his algorithm works, he can answer questions about how the measurements were made when a product fails.

Baldman will use a scope maker's internal conformance software if he knows its algorithm. He spent the summer of 2005 working for Agilent Technologies on the company's Ethernet compliance software. He started using it because he knows how it works, but he also knows that engineers in the industry use scopes from other makers. Thus, he compares results obtained from Agilent, LeCroy, and Tektronix scopes. He's working with test-equipment makers to harmonize the

methods of jitter measurement to provide more consistent results.

Baldman's relationship with test-equipment makers is typical of other UNH-IOL staff members. Much of the test equipment in the lab is donated, and staff and graduate students often develop their test procedures that use the donated equipment.

"We can't get out of the starting gate without test-equipment makers," noted Noseworthy. "The difficulty is that we try to play evenly with all the manufacturers." Test-equipment makers also rely on the UNH-IOL for their own product testing, often bringing new equipment to the lab for evaluation. (The online version of this article contains testimonials from test-equipment makers about their relationships with the UNH-IOL: www.tmworld.com/2006_04.)

Students and staff use test equipment for more than just measurements. The lab's DSL Consortium, managed by Matthew Langlois, uses data generators from Spirent Communications and wire-line simulators from Spirent, Telebyte, and Sparnex to test DSL modems and DSL access multiplexers (DSLAMs), which are used by service providers. Data generators create data streams and wire-line simulators simulate worst-case line conditions for each of the DSL modulations that the lab supports (ADSL1, ADSL2, ADSL2+, and VDSL2).

During a compliance test, a digitizer captures the DSL signals on a phone line and transfers them to a PC through a National Instruments digital I/O card. The PC measures longitudinal balance, transmit power, noise margin, and bit-error rate. The digitizer acts as a digital storage oscilloscope with flexible sampling clocks and an arbitrarily deep capture buffer greater than 512 Mbytes, which far exceeds that of commercially available scopes. With the digitizer card, students running a test can store as many samples as they need in the PC's hard drive and perform signal analysis offline.

The DSL test bed (**Figure 3**) consists of five DSLAMs and hundreds of DSL modems. DSL modem makers and chipset makers such as Conexant come to the lab because the test bed has DSLAMs from all suppliers. Modem makers can typically use the lab's standard test suite, although some will run customized tests.

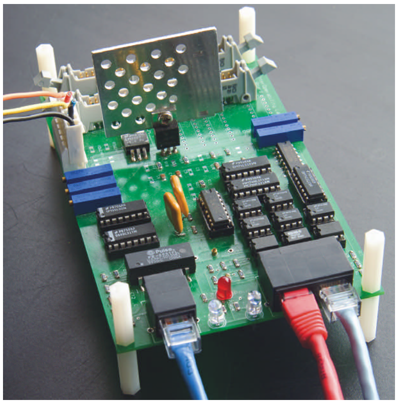


FIGURE 2. An Ethernet Auto-Negotiation test tool provides a parallel representation of bits between two Ethernet devices.

"The standard test suite takes about 18 hours to run," said Langlois. "It takes a week to run through all five DSLAMS."

Testing the next Internet

While the UNH-IOL focuses heavily on deployed technologies such as Ethernet and DSL, the lab is also involved in the next Internet technology, IPv6. "IPv6 is the next Internet protocol," said technical manager Erica Williamson. "With IPv6, we should never run out of IP addresses."

The UNH-IOL is a leading IPv6 test lab, with a test bed that consists of routers, firewalls, servers, cameras, a network time server from Symmetricom, and router and network testers from Agilent and Ixia. Makers of voice, video, and data-communications products come to the UNH-IOL to test their IPv6 protocol stacks. Test tools include software that lets students and staff manipulate data traffic. "We look at every 'must' and 'should' in the protocol specification to see how an equipment maker implements it," said Williamson. Testing of an IPv6 product takes from one to two weeks.

The lab's IPv6 Consortium's test bed includes a connection to the world's largest IPv6 network. Dubbed the MoonV6 project (www.moonv6.org), the IPv6 network is a joint effort led by the North American IPv6 Task Force that includes the UNH-IOL, the Department of Defense, and network service providers. Its aim is to promote the use of the IPv6 protocol. At a MoonV6 plugfest, makers of video and voice equipment, routers, and firewalls test their products for interoperability.

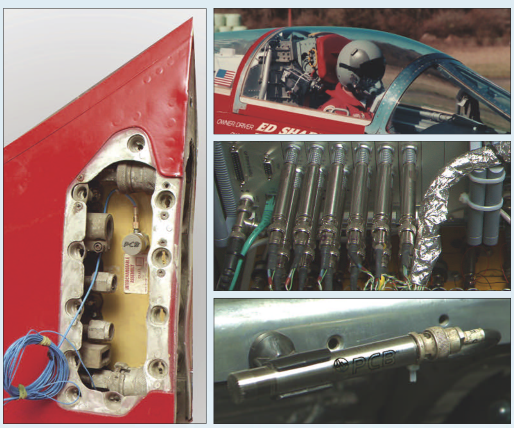
While IPv6 is an up-and-coming technology, 10BaseT Ethernet is mature and stable. Thus, the UNH-IOL has dropped its 10BaseT Ethernet Consortium, but the lab still tests new 10BaseT products on an individual basis for backward compatibility and conformance.

Let the students do the testing

Students play a major role at the UNH-IOL. In fact, about 100 of the 120 UNH-IOL employees are students, most of whom are undergraduates majoring in electrical engineering or computer science, although some have nonengineering majors. Students do the lab's testing under guidance from a graduate student or staff member.

Students learn about the UNH-IOL from open houses, through friends, or through faculty members. A professor may recommend a student to the UNH-IOL for a position. Students typically work about 15 hours per week. "We assume no knowledge of computer networks, and we assume that everything a student knows about networks is wrong," said EFM Consortium manager Eric Lynskey. The UNH-IOL usually hires first- or second-year students. After being hired, students must spend 13 weeks at "boot camp" during the summer, where they learn the basics of computer networks and become familiar with the lab's test tools.

Students do most of the testing, using hardware and software test tools developed by staff engineers and graduate students. "Students will learn LabView and Matlab, and once they gain enough experience, they can tweak test code," noted Lynskey. Sometimes, a student will develop a test tool for academic credit such as a senior project or a master's thesis. In addition to gaining practical experience from their UNH-IOL jobs, the students also make industry contacts that often lead to employment after graduation.—*Martin Rowe, Senior Technical Editor*



Serial-bus technologies that are gaining in popularity include SAS and SATA. The UNH-IOL has formed the SAS Consortium, which currently has five full members, but it supports SATA as a testing service only. "We're trying to convince companies to help us start an SATA consortium," said Baldman. He's currently developing test beds for both serial buses. Part of the difficulty stems from these products being so new that manufacturers often don't have many samples to contribute.

Makers of SAS and SATA disk drives and host-bus-adapter cards can use the UNH-IOL to perform interoperability tests under specified worst-case conditions. The test beds that Baldman is developing use a "golden worst case" set of cables built by Molex specifically for the lab. The cables come in three different lengths and gauges although they produce identical amounts of signal loss.

"Some companies want different lengths so they can say their products were tested with different length cables," said Baldman. "While the cables may be equivalent from a signal-loss perspective, the ability to demonstrate that you work across different length cables is still very valuable to our members from a marketing perspective."

Although the UNH-IOL is best known for testing wireline technologies, its staff and students can test IEEE 802.11 wireless devices, too. Jeremy Kent manages the lab's Wireless LAN Consortium, which contains a precompliance test bed (the UNH-IOL is a certified Wi-Fi precompliance lab). The lab has dozens of wireless devices that let students perform interoperability tests. The test bed includes wireless test systems from Azimuth Systems and VeriWave as well as a vector network analyzer and signal generator from Rohde & Schwarz. The test bed can perform measurements such as transmit power and protocol analysis. A graduate student is developing a receiver test tool as part of a master's thesis.

The UNH-IOL has gained the respect of many people in the data-communications industry. Its test tools and procedures are the envy of many engineers. IC manufacturers, card manufacturers, network-equipment manufacturers, and test-equipment makers rely on the UNH-IOL's spirit of cooperation and technical expertise to verify that their products will work in the field. T&MW

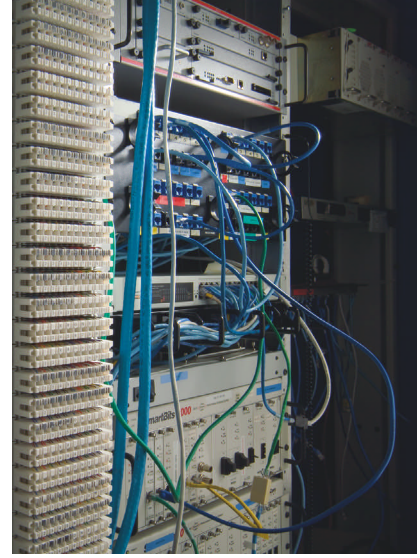


FIGURE 3. Students use the DSL test bed to perform compliance and interoperability tests.

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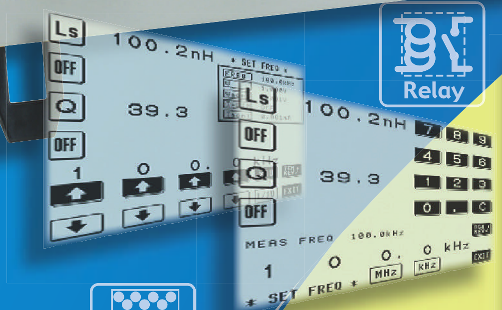

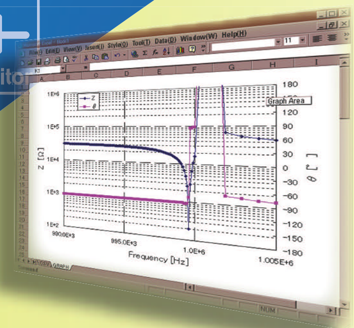

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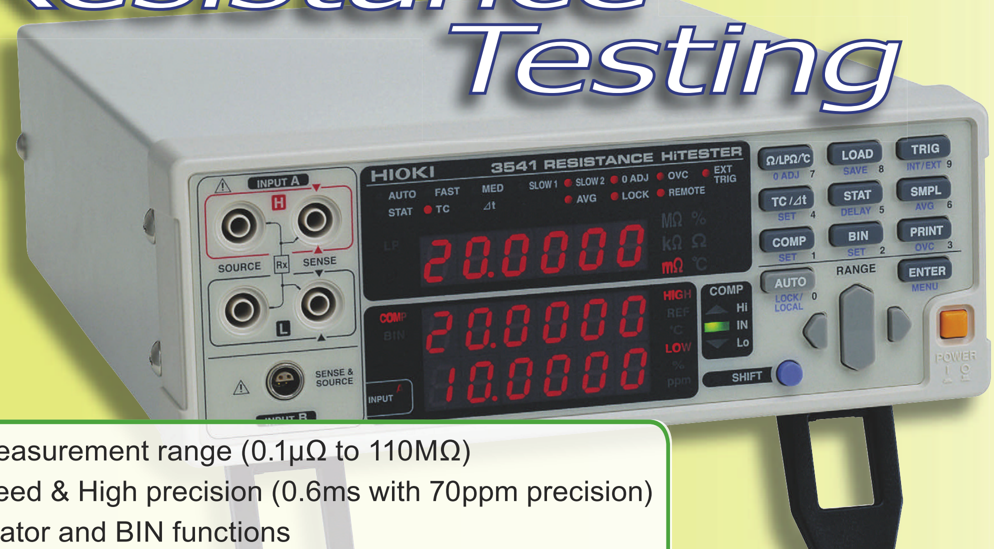

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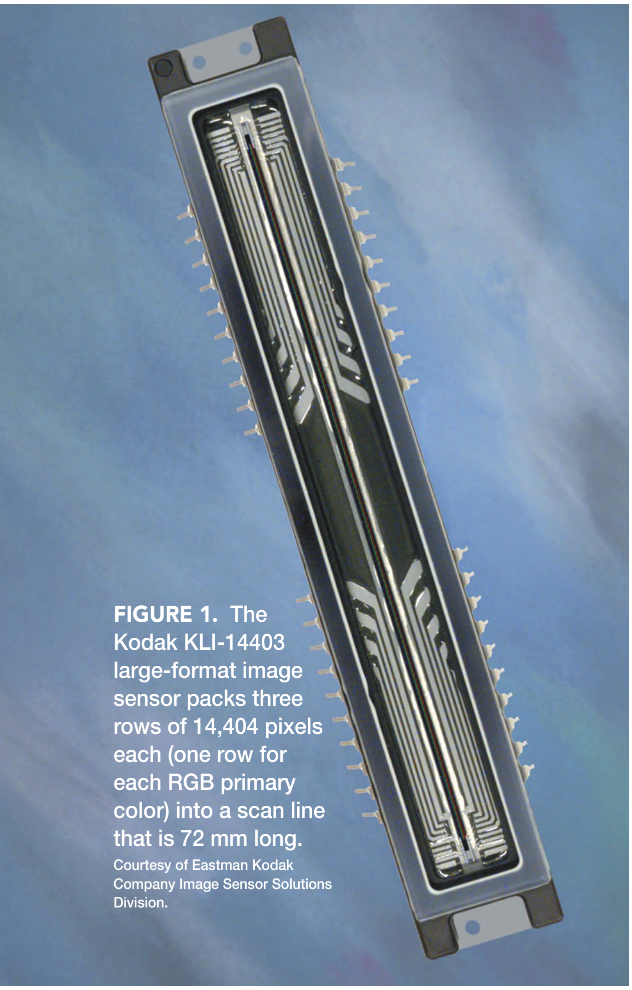

FIGURE 1. The Kodak KLI-14403 large-format image sensor packs three rows of 14,404 pixels each (one row for each RGB primary color) into a scan line that is 72 mm long.
Courtesy of Eastman Kodak Company Image Sensor Solutions Division.

THE BIG PICTURE

KNOWLEDGE OF MECHANICAL, OPTICAL, AND ILLUMINATION ISSUES CAN HELP YOU TAKE ADVANTAGE OF LARGE-FORMAT IMAGING SYSTEMS.

ANDREA TOLLISON,
EDMUND OPTICS

Large-format imaging systems offer advantages in resolution, sensitivity, and ease of integration over their smaller format predecessors for online inspection, factory-floor automation, and high-end scientific applications. One key to successfully implementing a large-format system is to select the right large-format lens—a task that first requires an understanding of the complete setup, including sensors, illumination, and mounting options.

Availability of large-format area- and line-scan sensors (**Figure 1**) has increased over the past few years. Area-scan sensors have grown from a 1-in. format (12.8x9.6 mm) to 36x24 mm. Line-scan image sensors used to be limited to 10 mm, but now have a maximum size of 90 mm.

The consumer digital-imaging industry has largely driven these developments, with consumers demanding the convenience of digital photography combined with the image quality of film photography. This drive toward better image quality is driving advances in CCD-chip manufacturing and testing.

Although chip manufacturers have long been able to reduce CCD pixel sizes, they do so at the cost of decreased signal-to-noise ratio (SNR). All else being equal, the signal from a CCD pixel varies in proportion to its area. The electronic noise sources, however, do not. So, decreasing the pixel area reduces the signal level for the (more or less) same noise level, and SNR drops precipitously. Small changes in the unit under test (UUT) that cause small signal changes become more difficult to detect.

The question becomes: "How do you increase sensor resolution without sacrificing sensitivity (measured by SNR)?" One answer is to increase the number of pixels without reducing individual pixel size, which increases overall sensor size. Large-format area- and line-scan sensors both take advantage of this philosophy.

One camera vs. many

Rather than using a large-format camera, you could assemble a high-resolution image from multiple lower-resolution images acquired with multiple small-format CCD cameras. But this strategy, which engineers have been forced to use in the past, raises issues of image registration and mechanical alignment.

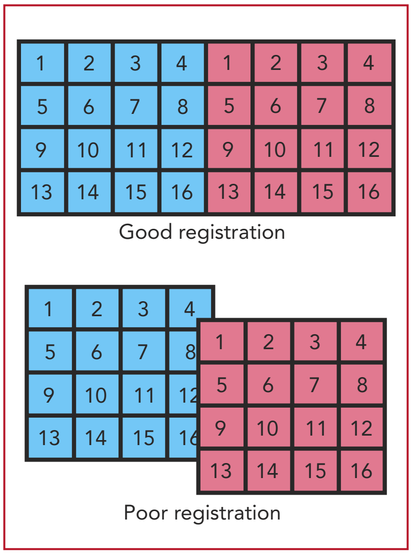

FIGURE 2. Registration can be a serious issue for multiple-camera systems.

Registration relates pixels in an image acquired with one camera to adjacent pixels acquired with another (**Figure 2**). Image registration needs to be completed before other analysis can occur. The goal is to create a coordinate system that spans the images so image-processing algorithms can seamlessly operate on the combined data set as if it were one image. There are many image-registration methods offering tradeoffs between speed and accuracy.

Mechanical alignment makes registration possible. Before image-processing software can stitch together images acquired with multiple cameras, the cameras must be rigidly mounted so the pixels of one line up with the pixels of the next one and then stay aligned to better than 1-pixel resolution from frame to frame.

Consider a setup in which three cameras are directed toward the same part from slightly different positions. Each camera would need to be mounted rigidly and have up to six mechanical degrees of freedom to allow initial alignment. In addition, each camera would need a separate lens with its own focus adjustment and iris control. The image-processing software for such a setup would have to account for both angular differences between the cameras as well as small variations in the lens settings—neither of which is easy for software to do.

You can eliminate these image-registration concerns and simplify system setup by replacing three cameras with just one large-format camera. The test-software developer can then focus on fundamental image-processing issues, saving development time as well as test time on a per-piece basis. An added benefit is that processing becomes simplified, with only one video signal to process rather than three.

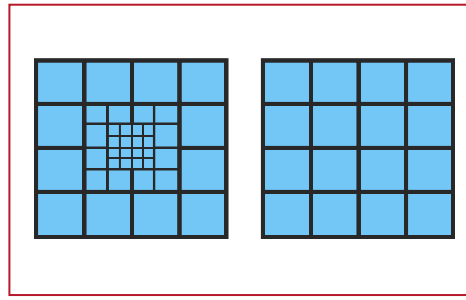

FIGURE 3. Human eyes emphasize optical performance near the field center (left), whereas machine-vision systems demand consistent resolution across the entire field of view.

Large-format challenges

Of course, as many economists have pointed out, "there is no such thing as a free lunch." Engineers wanting to partake of large-format cameras' advantages have to pay for them by heeding considerations that users of small-format systems may take for granted.

For example, the ability of a large-format camera to capture large amounts of data can create a bottleneck when the information is transferred to a computer. The rate at which the camera transfers image information depends on the number of pixels and the operating frame rate.

The buses used to transfer data from analog cameras can accommodate 640x480 pixels at 30 frames/s. Digital buses move data more quickly, but as sensors acquire more pixels, the information content of each image can overwhelm even these digital data-transfer techniques. When image transfer becomes a bottleneck, the frame rate must go down. The result can be less than what one would perceive as a "live feed." One way to alleviate the bottleneck is to employ line-scan cameras, if your application permits (see "Frame and scan rates," p. 40).

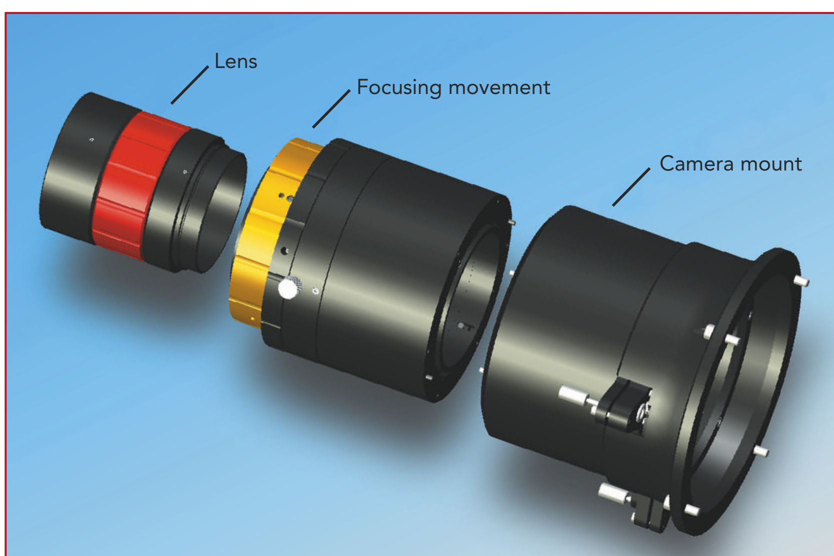

FIGURE 4. A modular lens-mounting scheme separates the lens system into three subassemblies: the lens optics, the mechanical focusing system, and an interface for the camera mount.

Another challenge facing engineers who want to use large-format cameras is obtaining compatible lenses that meet machine-vision performance specifications. Companies that manufacture large-format, high-speed cameras generally do not make the compatible lenses, so you need to turn to third-party suppliers.

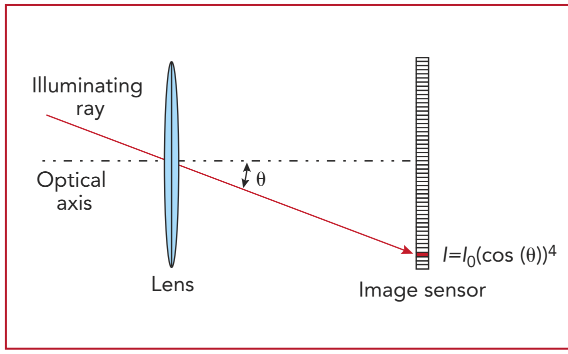

FIGURE 5. Image brightness naturally falls off toward a frame's edge.

Many photographic lenses can cover large film frames, but they are not the ideal choice for machine-vision applications. The resolution of a photographic lens, even one intended for use with large-format CCD cameras used by professional photographers, is optimized for the center of the image. The resolution at the edges may differ significantly. Human eyes emphasize the center of a scene and accept considerably poorer performance toward the edges (**Figure 3**). Imaging applications are not as forgiving.

Unlike human eyes, which have an area of enhanced visual acuity (the fovea) at their centers, the pixel size of a machine-vision camera is constant over the entire chip. Engineers studying the resulting images want to reliably detect the smallest features they can, independent of where they fall in the field of view (FOV). Meeting this demand for good optical performance over the entire field requires a lens whose resolution is uniform over the entire sensor area.

Engineers looking to integrate large-format cameras into their production-control systems have had only a few off-the-shelf machine-vision lenses to choose from as components. If none of them met the system requirements, the engineers were forced into paying for the

Frame and scan rates

In some large-format imaging applications, the use of a monochrome or color line-scan camera, in which the sensor consists of just a single row of pixels, can break data-transfer bottlenecks. The camera views parts moving by, such as on a conveyor belt. The sensor captures one row of pixels at a time at a scan rate adjusted to match the production-line speed. The display then shows an accurate view of each UUT without the need to stop the line to take images.

The amount of data a single line of pixels generates is significantly less than what an area-scan sensor would generate in the same time. Engineers who use large-format line-scan cameras can keep production rates high without compromising inspection resolution.

Not all inspection applications can use line-scan cameras, however. When parts don't move past the inspection station at a constant speed, you may need to image each part individually with an area-scan camera, whose frame rate depends on the signal format. Engineers should expect to trade processing speed for higher resolution. The maximum frame rate will depend on the signal format chosen and on the resolution of the camera being used. If the field of view (FOV) is flexible, it may be possible to control the resolution by lens selection. Tightening the FOV by increasing magnification permits the use of a lower-resolution camera and increases the system frame rate.—*Andrea Tollison*

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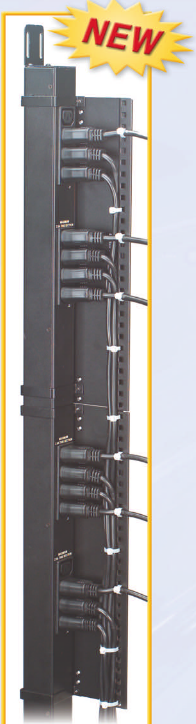

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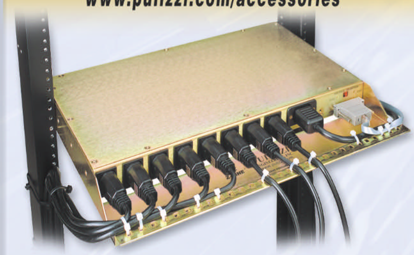

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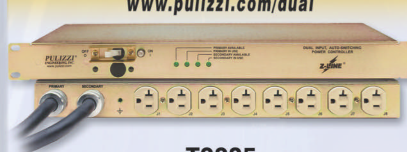

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costly (and time-consuming) design of a custom lens. Fortunately, machine-vision lens developers are starting to develop off-the-shelf large-format lenses.

Once you have an appropriate lens, the next challenge is mounting the lens to the camera. There are perhaps as many different mounting standards for large-format area- and line-scan cameras as there are manufacturers. One way to address this problem is to have a modular mounting system (**Figure 4**), which separates the lens system into three subassemblies: the lens optics, the mechanical focusing system, and an interface for the camera mount. This system accommodates different mounting standards with the simple change of the relatively inexpensive camera-mount module.

Lens selection starts after you've selected a large-format camera for your inspection system.

A final challenge to the system developer is to provide even illumination. Photographic lenses, again, fail to meet the machine-vision performance criterion. The human eyes that view photographic images (being logarithmic detectors) suppress illumination variations as well as concentrating on image centers, so they readily forgive illumination variations between the center and the edge.

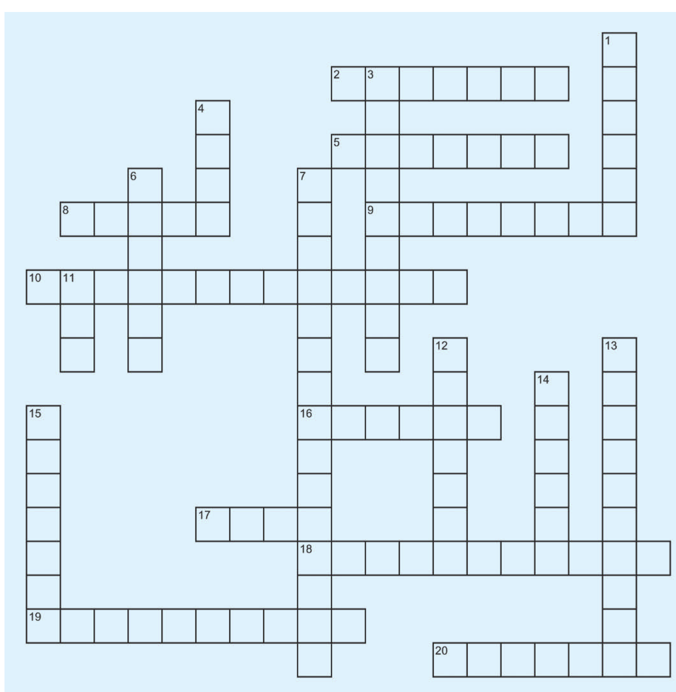
For machine-vision systems, good lighting can make the difference between success and failure. Unfortunately, the laws of radiometry work against lens designers trying to obtain even illumination across the field. Even a perfect lens design will have some fall off of illumination levels at the edges of the FOV. Image brightness varies with $\cos^4\theta$, where θ is the angle between the optical axis and a ray passing through the lens center to reach the off-axis image point (**Figure 5**). A 120-mm focal-length lens used with a line-scan camera having a 90-mm sensor will suffer an image-brightness falloff by 20% between the center and ends of the pixel line.

Photographic lenses do even worse, however. Their designers generally trade brightness variations for improved resolution near the edges via a technique called vignetting. By adding baffles in the light path, the lens designers selectively block off-axis rays that enter through the lens' edge, which contribute the most to spherical aberration. Vignetting, however, can reduce the light level by another 50% to 60% below the center brightness.

Finding the right lens

Lens selection starts after you've selected a large-format camera for your inspection system, because the camera's physical

DAQ Attack



ACROSS

2 The name of the high-performance, multithreaded, NI data acquisition driver

5 He helped to derive mathematical operations that transforms a signal from the time domain to the frequency domain, and vice versa

8 Unwanted signals

9 A measure of the capability of a DAQ system to faithfully indicate the value of the measured signal

10 Containing one or more type of I/O operation on a single device

16 Annual conference of virtual instrumentation held in Austin, TX

17 A semiconductor device containing programmable logic components that can be reprogrammed based on varying functionality requirements

18 Devices that convert a physical phenomenon into a measurable electrical signal

19 18 bits of this provides 262,144 discrete levels

20 He helped discover that a signal must be sampled at least twice as fast as the bandwidth of the signal to accurately reconstruct a signal

DOWN

1 Number of years since National Instruments was founded

3 Circuitry and components to protect from high-voltage transients, ground loops, and common mode voltages

4 Ask questions, watch demonstrations, read white papers, and learn about the latest technologies at the NI Developer __________.

6 Butterworth, Chebyshev, Elliptic, Bessel, etc.

7 Acquiring two or more different signals at the same time

11 PC-bus with external connection for hot-swappable, plug-and-play operation

12 Industry leading data acquisition series of devices from NI

13 New high-speed PC-bus with serial, point-to-point topology

14 Fundamental components used to digitize and generate analog signals

15 An event that occurs in order to begin an acquisition or generation

Go to www.tmworld.com/crossword to complete the crossword online and to view the puzzle's solution.

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parameters determine the lens specifications. When choosing a lens, here are some questions you should ask:

- **What are the sensor's physical dimensions?** For a line-scan camera, the important value is the sensor length. For an area-scan camera, the horizontal and vertical dimensions are important. Camera vendors will often quote these as the "sensing area" HxV (horizontal size x vertical size). If the vendor does not specify the sensing area, you can calculate it by multiplying the number of pixels by the pixel size. Note that the number of pixels as well as the pixel dimension may differ between horizontal and vertical directions.
- **What is the pixel size?** Usually specified in microns (µm), the pixel size will determine the best image-space resolution (that is, the resolution at the image plane) that the lens-and-sensor combination can achieve. Make sure the lens can at least achieve pixel-level resolution.
- **What type of mount does the camera have?** Typical camera-to-lens interfaces are C-mount (cine-mount) or CS-mount (cine-short-mount) lenses, although others are also available. In addition to knowing what type of lens mount a camera has, you also need to know the camera's flange distance (the distance from the camera's mounting-flange surface to the CCD's active surface). This information allows you to specify a camera-mount adapter module to make connecting the lens to the camera much easier and to save adjustment and alignment time.

You will also want to know the requirements and limitations of the imaging system:

- **What is the allowed working distance range?** Working distance for a machine-vision camera is the distance between the front of the lens to the camera-mounting flange. Any constraints on working distance are important because mounting adapters for large-format lenses can be quite long.
- **What is the desired FOV?** Or, what is the desired resolution? For a given camera, the system's FOV and resolution depend upon one another. Determine whether the size of the image on a display screen or the smallest distinguishable feature size is more important, then use that value to choose the correct system magnification.

The benefits available to engineers who integrate large-format cameras into their inspection systems outweigh potential concerns. It is important, though, to understand the effects that frame rate and illumination falloff can have on a system. As new electronic signal formats are developed and as new large-format lenses are released, these considerations will become more familiar, and the advantages to making the switch to large-format systems will become even more convincing then they are today. T&MW

Andrea Tollison *is the applications engineering manager at Edmund Optics, Barrington, NJ.*

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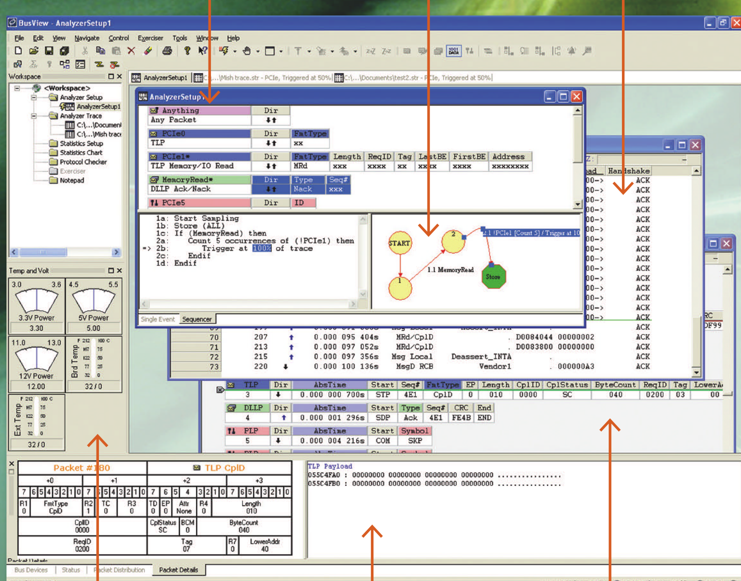

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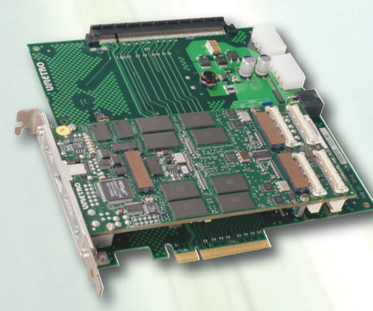

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IMPROVING STRAIN MEASUREMENTS

BOB MAGEE, HBM

Most electronics engineers don't give much thought to strain measurements—EEs are usually more concerned with electrical reliability than with structural integrity. But for engineers who develop products such as aerospace components and semiconductor-processing equipment, strain is a crucial measurement. If a design doesn't hold together structurally, it doesn't matter how well the electronics work.

An increase in the number of composites and the rising sophistication of structural and mechanical components keep expanding the need for more accurate strain measurements. While traditional stress-strain equations may work fine on cylinders, beams, and other structures made of homogeneous materials, they fall short for irregular shapes and nonhomogeneous composites.

Moreover, as manufacturers look for ways to shrink the size and weight of their products, parts are being stressed closer to their strength limits. This reduces the margin of error below that which calculations or computer modeling can achieve alone, and it raises the need for a very precise physical measurement.

Demand for strain-measurement resolution to the fraction of a microstrain range (millionths of an inch per inch) is on the rise in design and prototyping of autos, medical devices, semiconductor-processing equipment, and sports equipment. Airframes or truck chassis that were once strain-tested at 50 measurement points and to 10 or 100 microstrain are now monitored at 150 points to the single-digit microstrain level or below.

Consider two examples in which we at HBM have been involved. In the first, a semiconductor crystal furnace uses strain gages on a load cell to measure weight change of the crystal as it grows. It requires strain measurement resolution of 1.06 microstrain. In the second, the rim of an aircraft landing gear needs strain-measurement resolution in that same range to verify a new lightweight design. With varying wall thicknesses to optimize the strength-to-weight ratio coupled with a very irregular geometry, the shape of the rim defied any type of modeling or calculations to quantify stress at critical points. Using high-precision strain measurement, the designers were able to shave several extra pounds out of the part.

Designing the test setup

How can you be confident of getting good results in high-precision strain measurements? First, decide what you want to learn from your test. This may seem self-evident, but often, it isn't.

For instance, a designer of ceramic hip implants recently called us to order a strain gage and amplifier to measure strains in a prototype socket. I asked which direction of strain he was most interested in, and he simply didn't know. We finally settled on a rosette, which measures strain in three directions at once.

Once you know what you want to learn, you need to follow three basic steps to set up your strain-measurement system: Select the right strain gage, select the right amplifier, and install everything properly. If, as in the hip-joint case, you have a complex project, be sure to ask for help early on. You'll save a lot of time, money, and false starts.

Choosing strain gages

For single-microstrain-level measurements, the only real choice is the foil-type resistive strain gage. Although semiconductor strain gages work fine under stable conditions, they are subject to reading errors from many sources, especially changing temperatures and even variations in light and darkness.

Foil-type strain gages work on the principle that a change in length changes the resistance proportionately. In an energized Wheatstone bridge, that change in resistance generates a highly precise, very stable, proportional signal. The resistance material is usually constantan, but it may also be CrNi. Strain gages are also available in a variety of resistances, lengths, and geometries.

These eight guidelines cover the most frequent problems we see in the field:

- For composites and other nonhomogeneous materials, select the longest practicable strain gage. The greater length increases the odds of capturing a true average strain for the material as a whole.

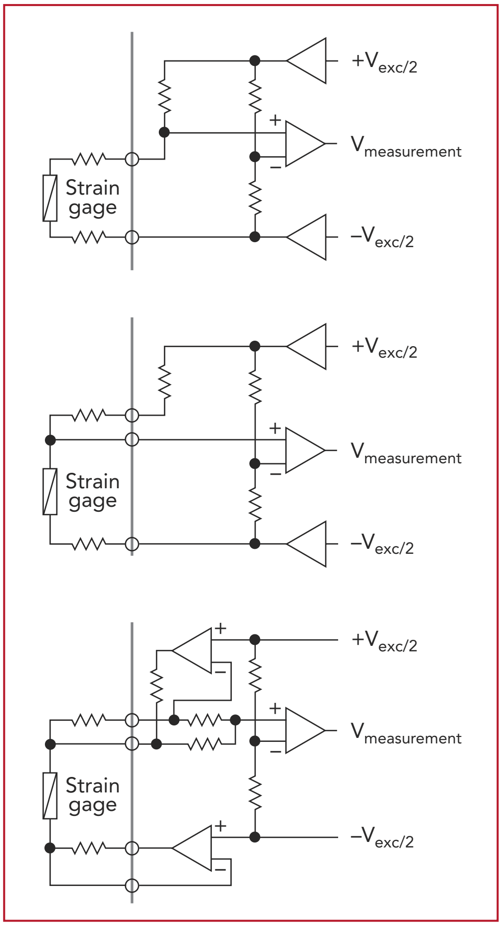


FIGURE 1. You should choose an amplifier that accommodates two-wire (top), three-wire (middle), and four-wire (bottom) hookups.

- For high-humidity applications, specify the lowest practicable resistance. The lower resistance offsets errors caused by the swelling of the insulation in response to humidity.
- For strain measurements around irregularities and stress-concentration areas, use the smallest practicable strain gage. You'll get a truer strain reading at the worst-case point.
- For ambient-temperature applications, constantan-based strain gages work fine. For temperatures above 200°C, specify CrNi gages. And be sure to consider the temperature of the surface where the gage is mounted, not ambient air. Even on a 72°F day, metal gets hot in sunlight.
- Use CrNi strain gages for long-term cyclic strain tests. CrNi delivers a longer fatigue life than constantan.
- Use encapsulated gages. Encapsulation protects the gage against handling damage.
- Use gages with built-in leads. This saves a lot of soldering and installation time, and it reduces the risk of damaging the gages during installation.
- If you know the direction of principal strain, use uniaxial gages. If you're not sure, go to a rosette or side-by-side gage. Both measure axial, biaxial, and shear strain at a point.

Look at amplifier specs

As important as it is to choose the right strain gage, the choice of an amplifier is even more critical for achieving high precision. Strain measurements can be no more accurate than the amplifier that processes the signal from the strain gages (although even the best amplifier can't undo mistakes in strain-gage selection and installation).

If you compare amplifier specifications carefully, you'll find big differences—differences that can affect performance substantially. Here are some tips for finding the best amplifier for your application:

- The key specifications are bus frequency and resolution. A high bus frequency enables you to capture transient events better. The resolution determines how precisely a data-acquisition system captures the analog strain data from the strain-gage signals. It is the amplifier's resolution characteristic that most influences the precision of strain measurements.
- For highest measurement accuracy, look for 24-bit resolution and high bus frequency. For example, a 19.2-kHz amplifier can fully describe a 1-ms transient in an airframe that a slower amplifier would miss completely. And most transients in transportation structures happen that quickly.
- For versatility, look for an amplifier with both carrier-frequency and DC operating modes. Whenever possible, try to run your strain tests in the carrier-frequency mode. This mode spontaneously eliminates a lot

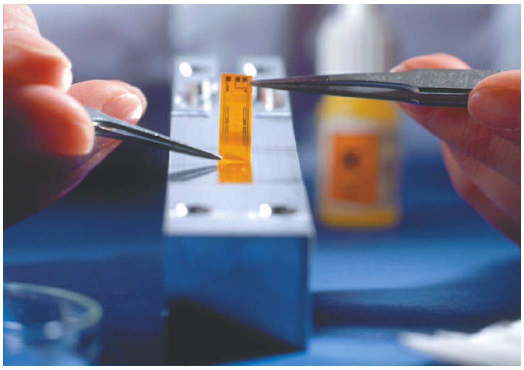


FIGURE 2. You can apply strain gages to a clean, smooth surface using a room-temperature adhesive for short-term tests at room temperatures. For long-term tests or tests at high temperatures, you can use heat-cured adhesives.

of measurement error sources, such as electrical and thermal noise and losses over long lines, and it creates a purer signal for data storage and analysis.

- Be sure the amplifier can handle two-, three-, and four-wire hookups (**Figure 1**). These circuit arrangements with the strain gages can improve accuracy where long cables between gage and amplifier cannot be avoided. (See more about cables under "Installing a system," below.)
- Compare robustness. Available amplifiers vary widely in this regard. If possible, pick up the amplifier and see how solid it feels. Look at the frame construction. Slide cards in and out of their slots. You want an amplifier that will stand up physically to the testing environment for many years.
- To simplify setup, look for an amplifier with built-in displays and controls. You'll be able to check things out as you go right at the amplifier and won't need a PC at that stage.

Installing a system

Though reasonably rugged, strain gages do need to be handled with care. In particular, keep them flat, and don't put anything on top of them. Here are four other things to keep in mind during installation:

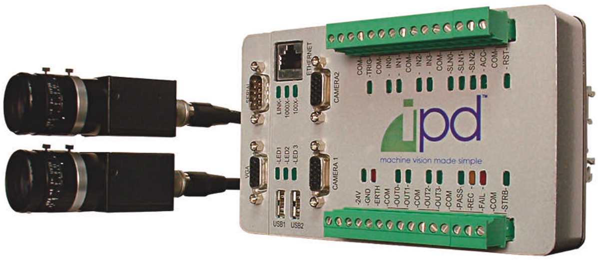
- Be aware that long analog cables between the strain gage and the amplifier are susceptible to electrical noise and line losses, and this can introduce errors. Keep cable lengths as short as possible. Consider using three- or four-wire hookups as well as intermediate analog-to-digital converters.
- Surface preparation is essential for obtaining a meaningful strain measurement (**Figure 2**). Be sure the surface is absolutely clean and smooth (we recommend a 16-microinch finish), so the gage can directly contact the material of interest. Otherwise, you may not be measuring what you think you are. Any tool marks or similar irregularities can deform the gage enough to destroy it or introduce errors. We recommend getting down to bare material, then roughing it slightly with sanding or grit blasting.
- Room-temperature curing adhesives are convenient and are adequate for shorter term testing at normal temperatures. But if you are planning extended tests lasting multiple months or if there's any chance of heating at the point where the gage is installed, use heat-cured adhesives.
- When connecting leads, be careful not to overheat or damage the strain gage. Also, examine joints to ensure they have been properly soldered; poorly soldered joints can introduce resistive errors.

Detecting dewdrops

Even with the proper equipment in place, you need to be watchful for any factors that could affect your measurements. Recently, we helped one of our customers prepare an airplane wing outdoors for load and strain testing that was to start the next day. All strain gages were in place, properly wired to reduce analog cable lengths, and all connected to a precision measurement amplifier. The next morning, the system registered a change in strain, even though no loads had been applied. It turned out that we had measured strain in the wing due to the weight of the dew that had settled on the wing overnight. T&MW

Bob Magee *is a sensor applications engineer with more than 15 years experience working with strain gages. He has served five years with Hottinger Baldwin Measurements, based in HBM's Marlborough, MA, facility, supporting strain-gage applications and all HBM products. He received his BSME degree from the University of Massachusetts, Lowell, and prior to working in the sensor industry was a nuclear engineer overhauling aircraft carriers. He is a member of SEM and ASME.*

For more product information, visit the *T&MW* Web site: www.tmworld.com/webproducts



Appliance supports single or dual cameras

Housed in a compact, DIN-mountable enclosure, the VA20 vision appliance incorporates its intelligence inside its camera controller, as opposed to the camera head. This configuration allows users to position the controller alongside other automation controllers to simplify interfacing; it also permits the use of small camera heads that can facilitate mounting.

The VA20 comes with the vendor's iNspect software preinstalled to eliminate version-control problems. The VA21 version includes the vendor's Sherlock software as well as iNspect. Each device is equipped with a Gigabit Ethernet-compliant network connection that allows a real-time image feed to the Web browser. On both versions, the iNspect application interface is exposed through a standard Web browser on a connected network computer. Alternatively, for users who prefer in-place setup, the VA21 offers the ability to connect keyboard, mouse, and monitor directly to the unit.

The VA20 is equipped with external connections located on its front. The device includes status lights for every input and output connection to help application debugging. On the sensor side, the VA20 provides users with a choice of standard sensor resolutions of 640x480 and 1024x768 pixels; resolutions to 1600x1200 are also available.

Base price: $3495. *ipd, a Dalsa Coreco Group, www.goipd.com.*

Modules mate RS-232 or RS-422/485 to WLAN

The Industrial Automation Group of Advantech has introduced its EDG-4100W and EDG-4110W serial-to-wireless IEEE 802.11b boards for enabling wireless networking. The 54-x59-mm modules can fit into most legacy OEM serial devices, and both modules provide virtual COM-port mapping for communications with a host PC through an IEEE 802.11b wireless network. The modules offer transmission rates to 230 kbps and support the TCP/IP protocol. They come with Microsoft Windows 98/NT/2000/XP/2003 drivers, RS-232 or RS-433/485 interfaces, and eight universal digital inputs/outputs.

Base price: $250. *Advantech, www.eautomation-pro.com/us.*

Power meter gets upgrade

Agilent's new N1911/12A P-series power meter adds several features to existing P-series meters, including complementary-cumulative-distribution-function (CCDF) statistical analysis in tabular format; sensor backward compatibility (with the Agilent 8480, E441xA, and E9300 series); user-configurable rise-time, fall-time, and pulse-period measurements; and automatic pulse-period, pulse-repetition-interval (PRI), and pulse-repetition-frequency (PRF) measurements. The instruments target accurate and repeatable wide-bandwidth (to 40 MHz) peak-power measurements for the aerospace, defense, wireless, and communications markets.

Base prices: single-channel power meter—$7075; dual-channel power meter—$9975; 18-GHz wideband power sensor—$3675; 40-GHz wideband power sensor—$4300. *Agilent Technologies, www.agilent.com.*

Shielded chambers augment RF test

Rohde & Schwarz has announced the R&S TS712x shielded RF test chambers for RF tests on devices with a radio interface. The R&S TS7121 model is designed for tests on small modules and devices. Its RF test chamber can be expanded to house additional test equipment, such as audio test sets for use with mobile phones. The R&S TS7123 model is designed for larger devices, such as automotive radios.

Both the TS7121 and TS7123 can be fitted with either an automatic or manual door. The interior of the RF test chambers may optionally be lined with absorbent material to attenuate high-frequency electromagnetic waves; the absorbent material also works in the audio frequency range, where it reduces reflections and ambient sound.

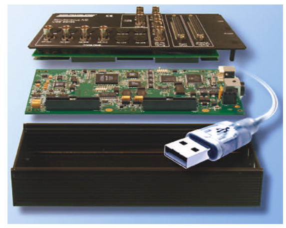
The operating range of the chambers is 400 MHz to 6 GHz, and typical isolation values of 65 to 70 dB can be achieved. RF, analog, and digital interfaces are fitted for input and output signaling to the device under test.

Base price: $6510. *Rohde & Schwarz, www.rohde-schwarz.com.*

> > > > > > >

USB module increases sampling rate

Data Translation continues to expand its line of USB data-acquisition modules, this time reaching a new high for sampling rate: 2 Msamples/s on each channel. The DT9832A has two 16-bit analog inputs, each with its own analog-to-digital converter. It also contains two 500-ksample/s analog outputs (optional), 32 digital I/O lines (16 in/16 out), two timer/counters, and three quadrature decoders. A companion model, the DT9832, has four analog inputs that can sample at 1.25 Msamples/s on each channel.



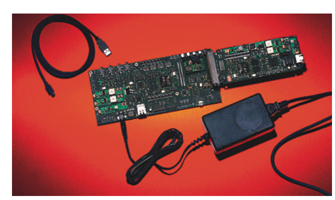
If you don't need all analog-input channels but need high-speed digital I/O, you can set up the digital inputs so they all clock at the 2- or 1.25-MHz sample rate when you set up a channel-scan list.

Software support includes drivers for Windows 2000/XP and for LabView, Matlab, and Visual Basic. Both modules are available packaged with BNC and D-sub connectors or as unpackaged OEM versions.

Base price: $1970. *Data Translation, www.datatranslation.com.*

Move DSP signals with RapidIO

Texas Instruments has introduced an evaluation board and software development kit for its 1-GHz C6455 digital signal processor (DSP). The C6455 packs plenty of processing power, but moving those processed digital signals can slow system performance. The C6455 boosts data-transfer rates by moving bits through a 10-Gbps Serial RapidIO (sRIO) interface. The serial interface eliminates the need for an FPGA to handle communications. By losing the FPGA, DSP designs use less power.



The TMS320C6455 evaluation kit ($1795) consists of two boards, a motherboard and a daughterboard, each containing a C6455. They communicate over the sRIO bus through an AMC connector. The included software-development kit lets you develop applications such as a video transport system where one DSP encodes video and transfers it to the other over the sRIO bus for decoding. A decoded video stream can then connect to a PC for display through the board's Ethernet, USB, or PCI/HBI interfaces.

Texas Instruments, www.ti.com/dsp.

DAQ software adds charting functions

DaqView 8.0—IOtech's setup, data-acquisition, and display software—offers new real-time scope and charting modes, including multiple and overlapping traces per chart, auto-scaling, and zooming. DaqView allows you to verify signal connections, acquire and save data to disk, and view real-time data. Two upgrades are available. DaqViewXL/Plus provides real-time export to Microsoft

Excel from DaqView, as well as increased chart and scope capabilities and time-domain analysis. DaqView/Pro includes all the features of XL/Plus and adds frequency-domain analysis, digital filtering, and spectrum analysis. DaqView 8.0 is included with all DaqBoard and Personal Daq/3000 purchases. The 8.0 update is free for downloading.

Prices: DaqViewXL/Plus—$299; DaqView/Pro—$599. *IOtech, www.iotech.com.*

Portable scopes boast long capture time

LeCroy's WaveJet line of digital oscilloscopes includes two-channel and four-channel models with bandwidths of 100 MHz, 200 MHz, 350 MHz, and 500 MHz. WaveJet's 500-kpoint memory on each channel enables capture times that are 50X to 200X that of other products in its class. At a maximum sampling rate of 2 Gsamples/s, WaveJet provides a long capture time of 250 µs.

LeCroy, www.lecroy.com.

AOI system performs tabletop PCB inspection

Using a standard package library to simplify training and ensure program portability across manufacturing lines, YESTech's B2 benchtop automated optical inspection system for post-reflow PCBs inspects solder joints and verifies correct part assembly. A new image-processing technology integrates several techniques, including color, normalized correlation, and rule-based algorithms, to provide complete inspection coverage.

Price: $42,000. *YESTech, www.yestechinc.com.*

Software helps generate bug-free applications

Integrated Software Metrics (ISM) has released Version 2.0 of its Predictive Suite, extending the code-checking software's testing and quality assurance functionality to include support for Java and C#. By combining NASA metrics and thresholds with artificial intelligence, the Predictive Suite is able to identify and fix defects, errors, and bugs in software code. The tool suite, which includes Predictive Lite, Predictive Pro, and Predictive Server editions, achieves an accuracy rate of 98% when identifying errors in code. In addition to supporting Java and C#, Version 2.0 adds line-level detection, highlighting of keywords, unique user-generated metrics, and an updated engine that delivers increased speed, intelligence, and accuracy.

Integrated Software Metrics, www.ismwv.com.

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Sensor short-form catalog

The PCB Piezotronics short-form catalog contains a general overview of the various types of sensor instrumentation for measurement of acoustics, vibration, pressure, force, torque, load, shock, and strain. *PCB Piezotronics, www.pcb.com.*

Genie-M640 camera

DALSA Coreco's Genie-M640 (Gigabit Ethernet) digital camera is affordable, easy-to-use, and designed for industrial imaging applications. It offers a CCD, a monochrome sensor, 640x480 resolution, and a maximum of 60 frames/s. *DALSA Coreco, www.dalsa-coreco.com.*

DIN temperature/process autotune controllers

The CN9300, CN9500, and CN9600 series controllers display engineering units in °C, °F, BAR, PSI, pH, rH, and set (Universal Unit). The CN9-SW software permits remote supervision of up to 32 instruments using the Modbus protocol. *Omega Engineering, www.omega.com.*

USB data acquisition

Advantech's USB-4700 series consists of true plug-and-play data-acquisition modules. No more opening up your computer chassis to install boards. It's easy and efficient. *Advantech, Industrial Automation Group, www.eautomationpro.com/us/product.*

Switching handbook

Keithley's Fifth Edition *Switching Handbook* discusses the fundamentals of the switching function, basics of switching setup, and common switching mistakes. You can request a free copy by calling 800-588-9238 or by visiting the company's Web site. *Keithley, www.keithley.com/at/306.*

Optical components catalog

Edmund Optics' January 2006 optics and optical components catalog contains more than 7000 products for demanding applications. Over 200 new products in this catalog include EO-designed high-resolution MVO line-scan lenses, ReflX reflective microscope objectives, and Tech Spec precision aspheric lenses. *Edmund Optics, www.edmundoptics.com.*

1-MHz USB DAQ

IOtech's DaqBoard/3000USB multifunction data-acquisition boards are ideal for OEM and embedded applications. Features include analog inputs, waveform-capable analog outputs, 24 high-speed digital I/O, four counter inputs (quadrature encoder capable), and two timer outputs. *IOtech, www.iotech.com.*

Motion solutions brochure

Automation Solutions for Electronic Manufacturing, Test and Inspection, and Data Storage presents motion-control/positioning solutions for electronic assembly, automated optical inspection, pick-and-place, PCB laser drilling/stencil cutting, wafer singulation, and more. *Aerotech, www.aerotech.com.*

Vortex data recorders

The Vortex family of real-time data-recorder, playback, and analysis systems for analog and digital applications offer sustained recording at rates up to 385 Mbytes/s. *VMETRO, recorder.vmetro.com.*

PCI Express imaging

The PIXCI E1 frame grabber provides support for full-, medium-, and base-configuration Camera Link cameras on the PCI Express bus. The PIXCI E1 handles data at rates up to 204 Mbytes/s. Price: $995 with XCAP-Lite software. *EPIX, www.epixinc.com.*

Certification lab

TUV America is a global testing and product certification organization offering product safety testing, CE Marking assistance, NRTL and SCC services, EMC and environmental testing, medical services, and more. *TUV America, www.tuvamerica.com.*

USB test and measurement

Data Translation's free 2006 USB Product Guide offers details on the company's broad range of USB data-acquisition products. You can choose from low-cost, simultaneous, high-performance, and DSP products. Product charts simplify hardware and software selections. *Data Translation, www.datatranslation.com.*

Huntron product catalog

The *Huntron Diagnostic Systems* catalog includes information covering power-off test solutions for circuit board troubleshooting. The catalog features flexible, automated solutions including software-controlled robotic platforms. *Huntron, www.huntron.com.*

Infrared camera

FLIR's new SC6000 infrared camera features high-speed, high-resolution thermal imagery for advanced scientific and R&D applications. Designed for maximum flexibility and performance, the SC6000 is available in multiple wavebands, detector resolutions, and lens configurations. *FLIR, www.flirthermography.com.*

Test and measurement training

A knowledge and understanding of measurement science is central to quality standards such as ISO 9000 and QS 9001; ISO 16949, ISO 17025, and Guide 25; and ANSI Z540-1. WorkPlace Training helps engineers build the knowledge necessary to comply with these standards. *WorkPlace Training, www.wptraining.com.*

RF & microwave catalog

Agilent's free *RF & Microwave Test Accessories Catalog* lists test accessories such as switches, attenuators, and adapters. The catalog provides comparison tables to help you find the information you need for your specific design and test requirements. *Agilent Technologies, www.agilent.com/find/catalogmta.*

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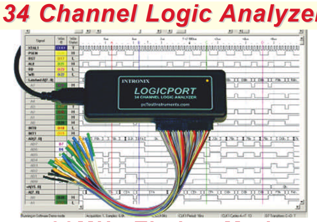

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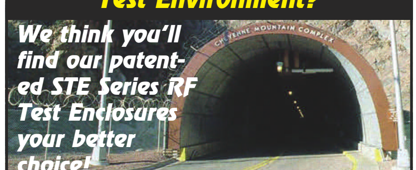

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VIEWPOINT

[An exclusive interview with a technical leader]

FRANCESCO LUPINETTI
Chief Technology Officer
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Plainview, NY

Francesco Lupinetti is the CTO and VP of engineering for Aeroflex Test Solutions. Joining Aeroflex in 2000, Dr. Lupinetti's background includes more than 25 years of experience in research, product development, engineering, general management, and business development. He has served with such companies as Ericsson, Italtel S.p.A., The Mitre Corp., and Sandia National Laboratories. Dr. Lupinetti received BSEE, MSEE, and PhDEE degrees from Mississippi State University.

In a recent telephone conversation, contributing editor Larry Maloney asked Lupinetti about Aeroflex, its product lines, and the communications test industry.

Instruments that stretch with the customer

Q: How does Aeroflex go about developing innovative technology?

A: Rather than catalogue products, Aeroflex develops specialized test instruments. We try to build in the best common functions—then add other features based on customer needs. We're better prepared to take this approach, because most of our instruments are what we call "synthetic," based on modular hardware and software.

We also follow a very well-defined technology development process, involving R&D, engineering, marketing, sales, and management. It takes into account market trends, as well as short and midterm sales opportunities. Then, we look at the roadmaps for technology development at customer companies, as well as product advances at our competitors.

Q: What role do acquisitions play in this effort?

A: We've been fortunate to gain valuable intellectual property through acquisitions. UbiNetics is a good example. The people in that company possess an entrepreneurial attitude that enables them to go very far, very fast, and that spirit is spreading throughout our engineering departments.

UbiNetics has done a great job not only in being the first to market but also in forecasting customer requirements. We see that in a product like the TM500, a real-time tester for infrastructure developers of 3G communications networks. At a time when there is a proliferation of standards, UbiNetics has also strengthened our ability to provide instruments such as the SystemAT, which provides a strong basis for quality of service (QoS) type measurements.

Q: What are some other promising areas in communications test?

A: Increasingly, we are asked to provide test solutions for monitoring and optimizing wireless devices and base stations while the network is operating. Another big opportunity is test solutions that help customers meet compliance and characterization challenges for devices that must operate in an environment populated by different generations of systems. New cell phones have up to four bands, as well as Wi-Fi.

Then there are the emerging WiMobile and WiMAX technologies. Our testers ensure that all these devices work together.

Q: How about testers for the military market?

A: We've been very proactive in providing innovative solutions without jeopardizing the installed base. Our new compact 6000 series for avionics can test transponders, distance-measuring equipment, collision-avoidance systems, and so on. Engineers can also use this product as a development tool in the laboratory, as well as for maintenance and flight-line tests.

In military radios, we're developing more features for our broadband waveform generators and analyzers. We can now attain 500 MHz of instantaneous bandwidth, which is very valuable in capturing and analyzing emitters in complex battlefields. The PN9500 phase noise tester, mostly targeted for military uses, now includes jitter-test and spectrum-analysis capabilities.

Q: Where does Aeroflex stand on open systems?

A: We're strong supporters. Aeroflex is a member of the PXI System Alliance, the LXI Consortium, the SDR Forum for software-defined radios, and the WiMAX Forum for broadband wireless. Still, we understand that customers, when testing their devices, don't want to be limited to the minimal operating parameters that appear in the standards. They need to stretch their equipment to get an edge on competition. That's why we must offer additional flexibility in our tester products. T&MW

The online version of this article includes more Q&A with Francesco Lupinetti on such topics as synthetic instruments, test equipment costs, and new testers for radio and homeland security. www.tmworld.com/2006_4.

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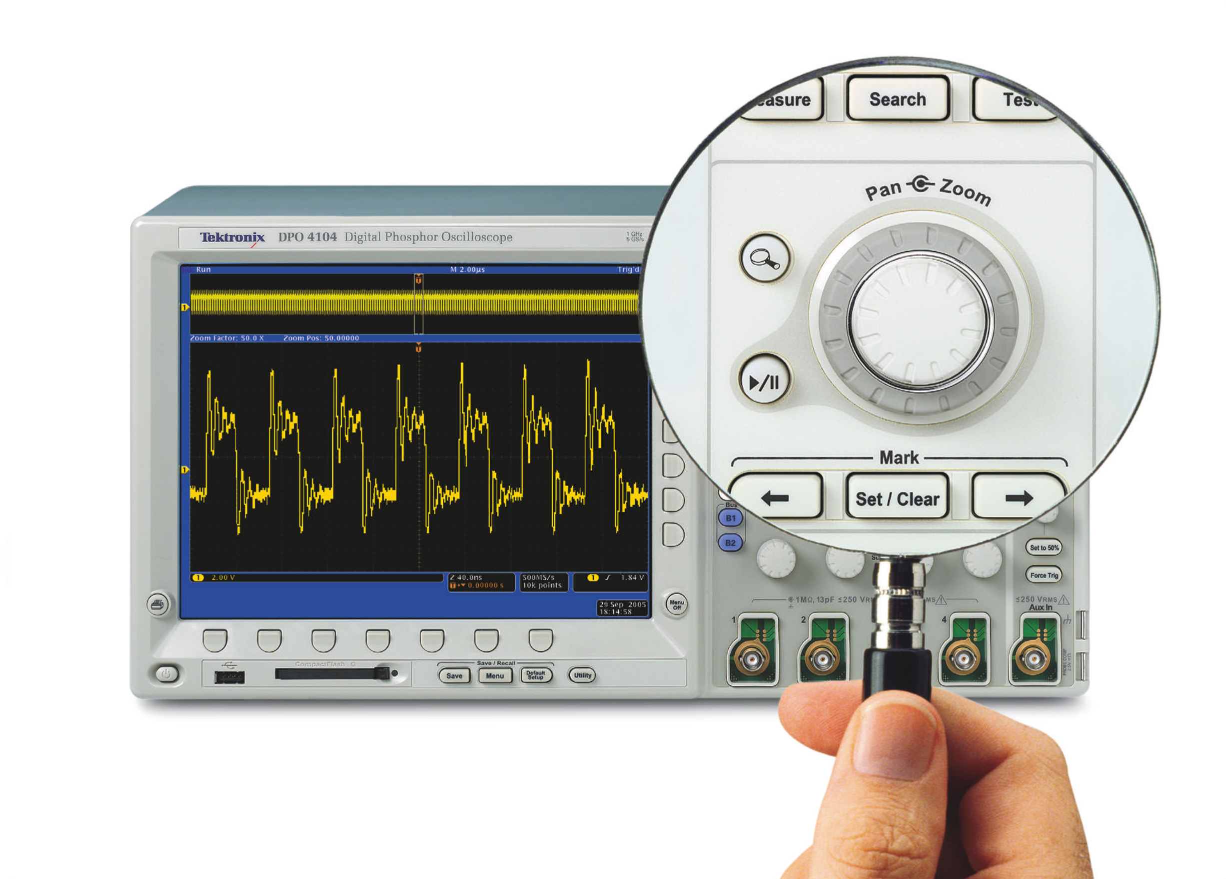

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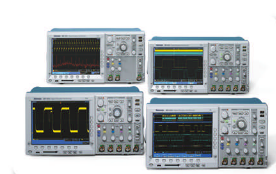

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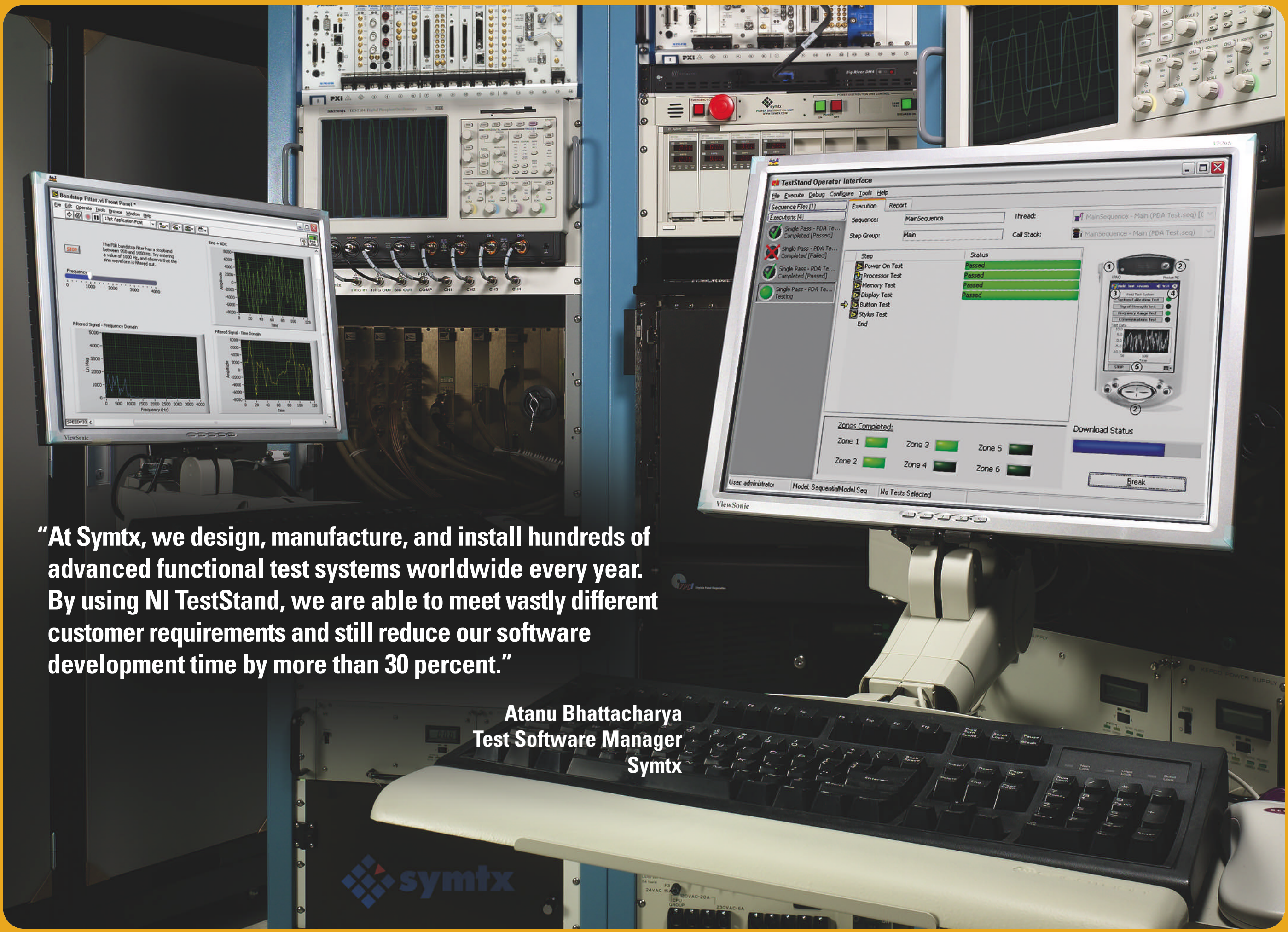

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