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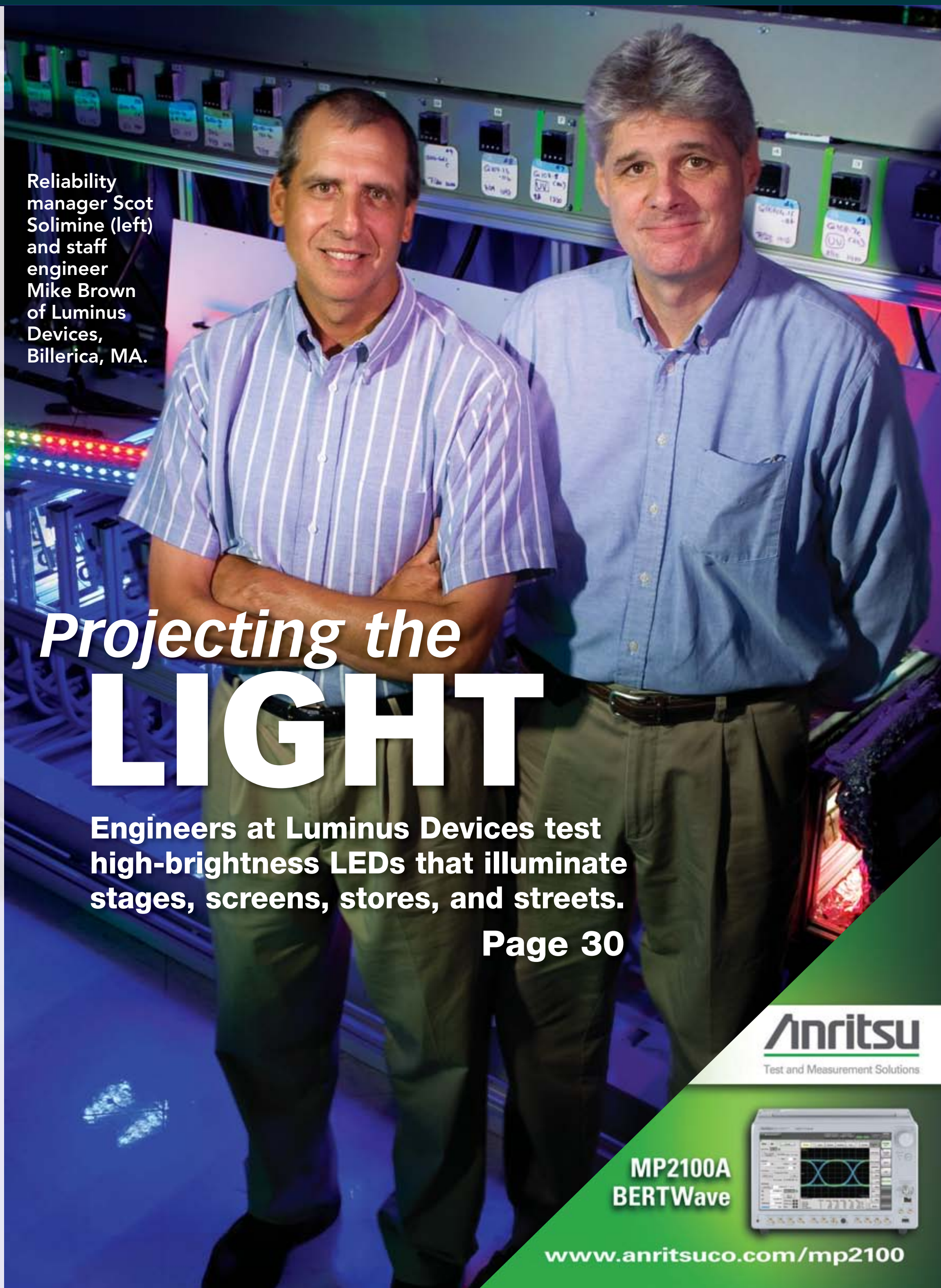
Test & Measurement World

THE MAGAZINE FOR QUALITY IN ELECTRONICS



Reliability manager Scot Solimine (left) and staff engineer Mike Brown of Luminus Devices, Billerica, MA.

Projecting the LIGHT

Engineers at Luminus Devices test high-brightness LEDs that illuminate stages, screens, stores, and streets.

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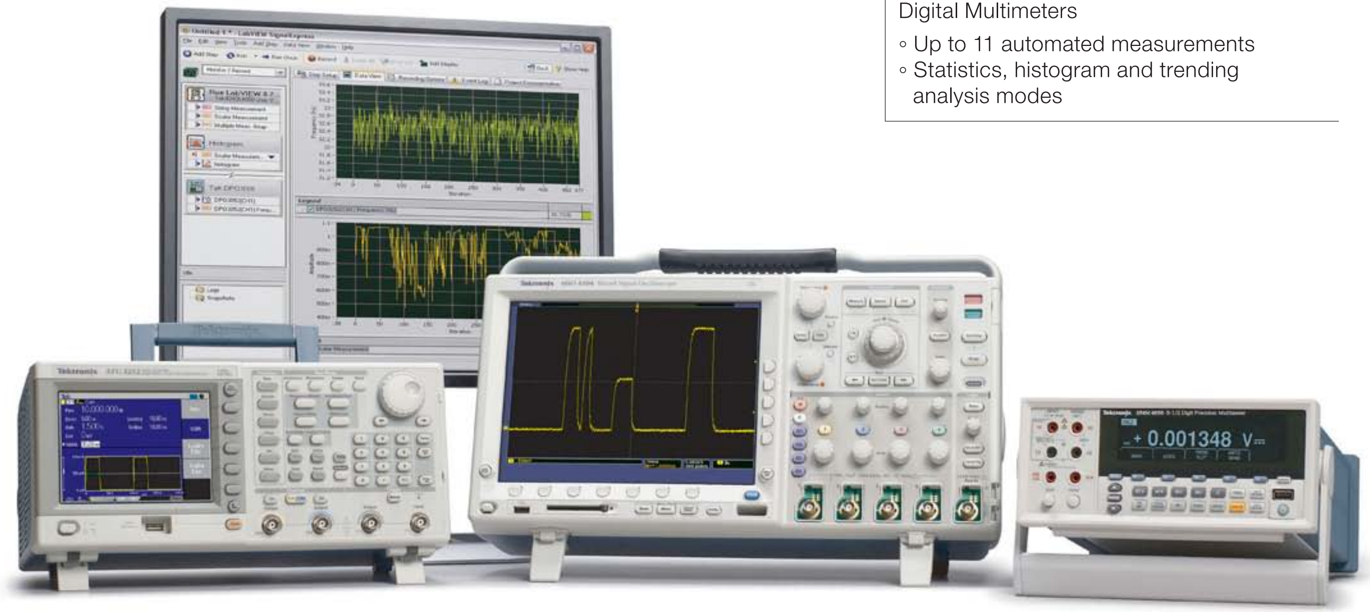

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COVER BY: ADRIEN BISSON

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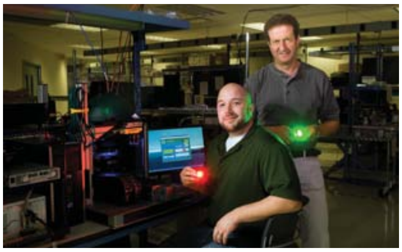

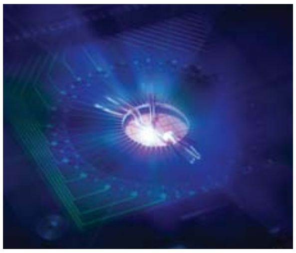

TECH TRENDS

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Taking MIMO RF test to the Nth degree

In the first installment of a four-part series on technologies that drive test innovation, Richard McDonell of National Instruments says that testing MIMO-based devices introduces several challenges for engineers, including the need to generate and analyze multiple RF streams in parallel and the need to understand spatial multiplexing, beamforming, and diversity coding techniques.

www.tmworld.com/guest_ni_mimo

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Answer one of our four Test & Measurement Challenges correctly, and you could win a $100 American Express gift check, courtesy of *Test & Measurement World*. The topics for this month's challenges are Eye Diagrams, X-Y Mode, Triggering, and RF Signal Analyzers.

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RICK NELSON
EDITOR IN CHIEF

Enhance your LED skills

New HB (high-brightness) LED devices are poised to revolutionize lighting. Although they may not be fully competitive with compact fluorescent bulbs for green home lighting, that could change, and they are already finding use in medical-device, automotive, architectural, and signage applications, for which they save power and space while offering the ability to shape light into unlimited colors. This last ability lifts them from the realm of the practical into the world of fine art, as evidenced by the work of Leo Villareal, an artist who works with LEDs to create computer-driven imagery, light sculptures, and site-specific architectural work. You can see his work at the San Jose Museum of Art through January 9, 2011.

To effectively apply LEDs, you must understand packaging, control-electronics, thermal-management, and test-and-measurement issues.

From an engineering perspective, to effectively apply LEDs you must understand packaging, control-electronics, and thermal-management issues. You can learn more about these issues at a full-day workshop titled "Designing with LEDs," scheduled for September 29, 2010, in Chicago and sponsored by sibling publications *Design News* and *EDN*. In four technical paper tracks, you can learn about power management, thermal management, LEDs and solar power, and optics and light measurement. Panel presentations by major LED manufacturers will discuss LED life, reliability, and future products. You can also see exhibits of the latest in HB LEDs, connectors, packaging technologies, and power-management and thermal-management components. The workshop is co-located with Assembly & Automation Technology Expo (AATExpo.com) and five other events at the Donald E. Stephens Center in Rosemont, IL; see the *T&MW* events calendar for more information: www.tmworld.com/events.

When it comes to testing and measuring LEDs, you needn't wait for the workshop. This issue brings you two feature articles on the topic. In our cover story, senior technical editor Martin Rowe recounts his visit to Luminus Devices, a company that manufactures LEDs that appear in stage lighting, portable projectors, retail stores, homes, street lights, and projection TVs. As Rowe writes, lighting designer Kevin Adams chose stage lights that contain Luminus Devices' LEDs when he designed the lighting for Green Day's "American Idiot" musical on Broadway. Rowe explains how Luminus employs wafer probers, source-measure units, and spectrometers to measure parameters such as forward operating voltage, reverse leakage current, dominant wavelength, and brightness.

In our second feature this month, Bryan C. Bolt, technology development manager for test systems at Cascade Microtech, describes the issues facing test equipment makers as the HB LED market experiences a compound annual growth rate projected to exceed 30% over the next several years. He notes that despite a lack of industry standards and a technology roadmap, vendors of test equipment must accommodate the range of test configurations found across the spectrum of manufacturers while controlling the cost of test.

It's certain that both design and test engineers have work to do as the applications and markets for HB LEDs expand. T&MW

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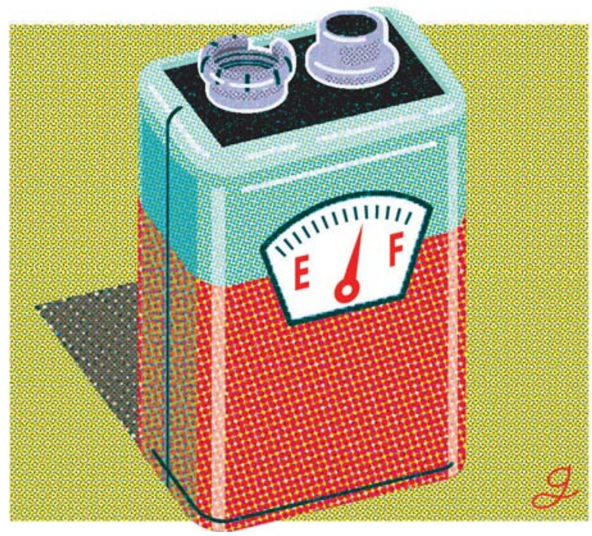
[An exclusive interview with a test engineer]

Automated power

Sambit Panigrahi is system integration and tools lead in the battery-management solutions group at Texas Instruments (Dallas, TX). He's responsible for integrating systems used to test ICs such as battery fuel gauges that manage power for rechargeable batteries. The gauges can support batteries that are available in more than 600 different packages and chemistries and may have up to four cells. Senior technical editor Martin Rowe spoke with Panigrahi by telephone.



DANIEL GUIDERA

Q: How do you test battery fuel gauges?
A: The power-management devices are really microcontrollers with analog front ends, so a test system tests the firmware for how the device responds to known physical conditions. Our battery fuel gauge ICs are SBS (Smart Battery System) compliant and thus must meet SBS specs so end users can easily swap devices from multiple manufacturers.

We create test conditions by applying voltages and currents with source-measure units from Keithley Instruments. We simulate temperature with a digital potentiometer that acts like an external sensor. We have practically no test components inside the firmware in our devices to aid our testing, so we don't "trick" the devices to think that they are experiencing anything. We do, though, send commands to change the device modes, threshold values, and so forth. Our devices have RISC processors and limited memory. By changing the flash-memory contents in the devices, we can place a device in different modes. We then change physical conditions to test that mode.

Q: What responses do you look for?
A: We typically run as many as 200 tests on each device. We test conditions such as overvoltage or battery temperature. By setting the battery voltage too high, we check that the controller responds correctly. That is, it must trigger an error flag that the tester can then interrogate and verify that the correct trigger occurred.

Q: How have you structured the test software?
A: The software is based on National Instruments' LabView and TestStand. TestStand lets operators set test parameters and conditions. We've developed automated scripts that execute the tests. LabView executes the scripts by communications through drivers encapsulated in DLLs (dynamic link libraries) and OCX (object linking and embedding control extension) files.

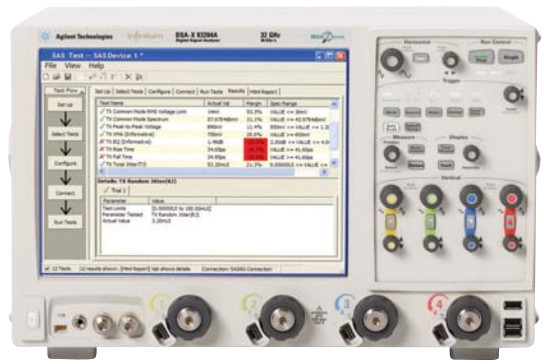
The DLLs are sometimes packaged in executable files that we distribute to customers so they can test their battery assemblies. LabView calls the drivers and runs the tests, reporting the results to TestStand.

Q: Which other departments do you work with when developing the testers?
A: We work with firmware engineers within the company, but we also work with field-applications engineers who have direct contact with the customers. We do most of the data gathering in Dallas as well as some of the software development. Some of the software development also takes place in India.

Q: What were the major challenges you faced when developing the testers?
A: People were used to performing these tests manually, without automated scripts. Thus, they had to get used to an automated system. With the old system, sending a command to a controller that set a voltage and waiting for a response could take between 8 s and 10 s, and the test operator could see when the controller under test responded to the stimulus command. The operator could then check the appropriate alarms. With automated systems, we had to program the systems with greater accuracy to wait, say about 10.25 s, before checking the device under test. T&MW

Every other month, we interview an electronics engineer who has test, measurement, or inspection responsibilities. To participate in a future column, contact Martin Rowe at martin.rowe@cancom.com. To read past "Test voices" columns, go to www.tmworld.com/testvoices.

SAS software supports 6-Gbps and 12-Gbps scope measurements



Agilent Technologies recently introduced two automated test software programs for SAS (Serial Attached SCSI) physical-layer transmitter compliance testing. One program (N5412B SAS-2) supports SAS 6-Gbps, while the other (SAS12G) supports 12-Gbps interfaces.

The N5412B SAS-2 software runs on the Agilent Infiniium 90000 Series or 90000 X-Series oscilloscopes and helps engineers verify physical-layer transmitter compliance for SAS 1.5-Gbps, 3-Gbps, and 6-Gbps silicon, expanders, port multipliers, and high-density and solid-state disk drives. The test methods are based on the UNH-IOL (University of New Hampshire InterOperability Lab) Consortium's SAS-2 physical-layer test suite.

The N5412B software performs tests for spread-spectrum clocking specifications, transmitted signal requirements, and out-of-band specifications. It also provides automated compliance test support for intra-enclosure and internal-enclosure interface points, displays the results in a flexible report format, and provides a margin analysis that shows how closely a device passes or fails each test.

The SAS12G UDA (user-defined application) software for Infiniium 90000 X-Series scopes provides 12-Gbps physical-layer transmitter measurements for engineers designing to the requirements of the upcoming SAS-3 specification. The software determines if designs meet the specification and predicts system interoperability. The UDA test methodologies are leveraged from the N5412B software. www.agilent.com.

Semiconductor market continues to grow

The SIA (Semiconductor Industry Association) has reported that global sales of semiconductors grew to $25.2 billion in July, an increase of 1.2% from June when sales were $24.9 billion and an increase of 37.0% from July 2009 when sales were $18.4 billion. Year-to-date sales totaled $169.2 billion, according to the association, an increase of 46.7% from the $115.3 billion reported for the first seven months of 2009.

"Worldwide sales of semiconductors were strong in July despite growing indications of slower growth in the overall economy," said Brian Toohey, president of the SIA, in a prepared statement. "The continued proliferation of semiconductors into a broad range of products provides opportunities for industry expansion even in a period of slower overall economic growth. Although recent public statements from a number of major manufacturers have emphasized limited visibility for the near term, we continue to expect that industry growth for 2010 will be in line with our midyear forecast of 28.4%." www.sia-online.org.

Editors' CHOICE

NI debuts 6-GHz PXI VNA

At NIWeek 2010, National Instruments complemented its release of LabView 2010 (see *Test & Measurement World*, August 2010, p. 12) with the introduction of the NI PXIe-5630 6-GHz two-port VNA (vector network analyzer) that targets automated design validation and production test. The instrument's two-slot PXI footprint enables test engineers to incorporate vector network analysis into their test systems without the added cost and large footprint of traditional bench VNAs.

Optimized for automated test, the NI PXIe-5630 VNA offers automatic precision calibration, full vector analysis on both ports, reference-plane extensions, and a flexible LabView API (application programming interface) that supports parallel test. The instrument features a frequency range of 10 MHz to 6 GHz, a dynamic range of greater than 110 dB, and sweep speeds of less than 400 µs/point over 3201 points.

Engineers can combine up to eight NI PXIe-5630 modules in a single PXI chassis and perform multisite RF test. They can control the NI PXIe-5630 interactively by using its soft front panel, or they can control it programmatically by using APIs for NI LabView software and the NI LabWindows/CVI ANSI C development environment.

Base price: $25,999. *National Instruments, www.ni.com.*

CALENDAR

EOS/ESD Symposium, October 3–8, Reno, NV. *Electrostatic Discharge Association, www.esda.org.*

International Test Conference, November 2–4, Austin, TX. *IEEE, www.itctestweek.org.*

Vision 2010, November 9–11, Stuttgart, Germany. *Messe Stuttgart, www.messe-stuttgart.de/vision.*

Electronica, November 9–12, Munich, Germany. *Messe München, www.electronica.de.*

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

Editors' CHOICE

USB DAQ system works in isolation

The DEWE-50-USB2-8 data-acquisition system from Dewetron supports up to eight signal-conditioning modules for measuring temperature, strain, vibration, sound, voltage, and current. The chassis-based system has a dedicated 24-bit, 200-ksamples/s ADC for each channel. The system features 1800 V of isolation, which can eliminate ground loops and provide safety.

Besides accepting eight analog inputs, the system has two counter-timer channels in the chassis and two CAN bus ports for communications with vehicles. High-voltage modules are available for ±10 V to ±1400 V, and low-voltage modules range from ±10 mV to ±50 V. Current-input modules cover ±0.1 A to ±5 A. Temperature modules are available for thermocouples and RTDs. Analog-output modules can generate signals up to ±10 V. In addition, the chassis has one 5-V analog output per input channel.

The instrument chassis connects to a PC through a USB port. At the chassis end, the USB connector can lock in place to prevent accidental removal. The DEWE-50 includes Windows drivers and application software for logging and plotting data.

Base price: chassis—$7500. *Dewetron, www.dewamerica.com.*

EMC products clear the noise level

> > > IEEE International Symposium on Electromagnetic Compatibility, July 25–30, Ft. Lauderdale, FL; IEEE EMC Society, www.emc2010.org.

ETS-Lindgren introduced its 3119 double-ridged waveguide horn antenna used for wireless testing and EMI immunity testing. The antenna can handle up to 1500 W with a bandwidth of 400 MHz to 6 GHz.

ETS-Lindgren also announced that it will be conducting a series of three-day courses in EMC testing at its facility in Cedar Park, TX. The course will include lab time in the company's 3-m semianechoic chamber. Topics will include EMC standards, test preparation, radiated emissions and immunity testing, reporting of results, measurement uncertainty, and lab accreditation.

Aeroflex demonstrated its new Model 3250 spectrum analyzer series for EMI emissions testing. The series consists of four models with a maximum bandwidth of 3 GHz to 26.5 GHz (all bandwidths start at 1 GHz). The Model 3250 uses a 30-MHz ADC to digitize signals, after which the instrument converts signals to the frequency domain. From there, the Model 3250 lets you measure spurious emissions channel power, total power, and average power. It also uses spectral masks for comparing signals against emissions standards.

Teseq upgraded its ITS 6006 immunity test system by increasing the instrument's internal RF power meter's bandwidth to 6 GHz. Its linear measurement range has expanded to cover –45 dBm to +20 dBm. Besides the power meter, the system includes RF switches and connectors that let you route signals from an RF generator to equipment under test. The company also upgraded the NSG 3060 EMC test system by adding the TSM 3751 telecom surge module.

AR introduced the Model FL7060 electric field probe used to characterize EMC chambers. The probe has a sensitivity range of 2 V/m to 1000 V/m, and it can make 2-V/m measurements without the need for a zero adjustment. Because it's laser powered, the probe can operate continuously, without batteries. AR also demonstrated a PC-based digital emissions receiver that measures emissions from 20 Hz to 18 GHz in 140-MHz bands. It can capture a range of frequencies from 30 MHz to 1000 MHz in 7 s and can make peak, quasi-peak, average, and RMS-average measurements.

Tektronix exhibited its 20-GHz RSA 6120 spectrum analyzer. The instrument makes a series of frequency scans that are 110 MHz wide, and it converts digitized signals into the frequency domain. The RSA 6120 has 80-db dynamic range.

Teseq's ITS 6006 immunity test system includes RF switches and connectors so you can route signals from an RF generator to the equipment under test. Courtesy of Teseq.

Agilent Technologies introduced EMI measurement software for its X-series signal analyzers that lets you make real-time precompliance measurements based on commercial standards such as CISPR 16-1-1 or military EMI standards. The application lets you view signal lists that include peak, quasi-peak, and RMS values of signal emissions. You can also create lists of failed frequencies. The software lets you find and remove ambient signals from a frequency scan.

Rohde & Schwarz demonstrated its RTO and RTM line of oscilloscopes. The company also showed its modular BBA100 broadband amplifier, which includes RF switch modules and amplifier modules for several frequency ranges. In addition, the company exhibited its ESPI precompliance test receiver. The R&S ESPI3 covers 9 kHz to 3 GHz, and the ESPI7 covers 9 kHz to 7 GHz. Measurement uncertainty is less than 1.5 dB.

TECHNICAL PROGRAM

During the technical program, Professor Frank Leferink of the University of Twente in the Netherlands used several PCBs (printed circuit boards) to demonstrate EMI at the board level. Leferink showed how vias in boards may form current loops that can radiate energy, and he explained how placing bypass capacitors on the underside of a board can defeat the purpose of the bypass capacitor. The loop inductance from an IC to its bypass capacitor can radiate emissions that the capacitor should squelch.

Leferink also showed how the layout of PCB traces can result in crosstalk. A coupling path can cause signals in a trace to appear on an adjacent trace. Differences in line terminations can create coupling paths. T&MW

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ATE workshop weighs functional test

The evolutionary path of semiconductor ATE (automated test equipment) seemed clear at Semicon West, held July 13–15 in San Francisco. Gone are the expensive, big-iron functional testers of yesterday, to be replaced by low-cost systems like the V101 (**figure**), which Verigy displayed at its booth. In addition, Advantest at the show touted the delivery of its milestone 1000th T2000 SOC test system, which went to Xilinx at the FPGA maker's San Jose, CA, facility. The T2000 was developed to help Intel and other IC vendors control test costs though the support of structural test techniques and multisite capability.

Yet, despite the evidence on the show floor, the book isn't closed on functional test. Functional test will remain necessary for analog test, which is not extensively supported by DFT (design for test) efforts, and the V101 and T2000 both offer mixed-signal options. But participants at the IEEE ATE Vision 2020 workshop, held July 15 in conjunction with Semicon West, also suggested other situations in which functional test has a future.

Han Ta of Cisco Systems, for example, cited unmodeled defects, noise, crosstalk, and lack of margin as issues that might require a functional-test approach rather than a DFT-based approach. He suggested a "functional built-in self-test" approach that can support tests across asynchronous domains.

Presenter Ken Lanier of Teradyne conceded that DFT has done a lot—improving fault coverage, reducing test times, and speeding time to market, for instance. But, he said, scan test is a divide-and-conquer approach that might not ensure that all parts of an increasingly complex SOC (comprising CPU, MPEG decoder, graphics engine, memory, and media interfaces, for example) work well together. That, he said, might require protocol-aware functional test.

The V101 low-cost SOC test system includes new mixed-signal testing capabilities.
Courtesy of Verigy.

Complicating the coming test challenges will be the emergence of 3-D devices with through-silicon vias (Ref. 1), which will present challenges of physical access, regardless of whether the test signals applied are structural or functional. Marc Loranger of FormFactor discussed the challenges and advantages of direct-on-TSV microbump probing, which can detect bad TSVs and TSV formation defects. Stojan Kanev of Cascade Microtech described both contact and non-contact test methods, noting that design for testability will be key for 3-D probing success.

Test is likely to see rapid evolution as ATE makers and their customers contend with 3-D and other complex devices. The Vision 2020 workshop can help you keep up. Visit www.atevision.com for news of future events. T&MW

REFERENCE

1. Nelson, Rick, "The time is now for 3-D stacked die," *EDN*, July 15, 2010. p. 9. www.edn.com.

To read past "Tech Trends" columns, go to www.tmworld.com/techtrends.

Contactors suit ICs with differential signals

Multitest now offers differential contactors that are custom-tailored for semiconductor test applications. Using 3-D electromagnetic simulation software and lab-correlated data, the company optimizes contactor materials and probes for specific impedances, matching the characteristic impedance of the board and contactor as closely as possible to that of the tester electronics and the DUT (device under test). www.multitest.com.

JTAG controller for PCI Express

Part of the ScanBooster line of JTAG/boundary-scan controllers from Goepel Electronic, the ScanBooster/PCIe-DT is compliant with the PCI Express bus specification. It can be used to perform JTAG/boundary-scan tests, emulation tests, and in-system programming of PLDs, FPGAs, and flash serial EEPROMs. The PCIe-DT comprises a PCI Express plug-in card coupled with an external TAP (Test Access Port) transceiver. www.goepel.com.

Pickering debuts PXI supply

Pickering Interfaces has introduced the 41-743, a single-channel power supply able to provide 2 A up to 20 V and 0.8 A up to 48 V. The supply includes remote-sense connections as well as a voltage monitor and programmable current limit. The module supports both PXI triggering and external triggering. www.pickeringtest.com.

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Near infrared techniques find MEMS defects

Detecting defects within MEMS (microelectromechanical systems) is not an easy task. The components inside these structures are a varied mix of electrical circuits, mechanical devices, and sensors. The most common defects in MEMS—subsurface cracks, particle contamination, and voids—often occur in the substrate or in the bond between the wafer and the device, so it is difficult to detect them with inspection methods that use transmitted light. Nondestructive methods for inspecting MEMS include ultrasound-based acoustic inspection, x-ray, SWIR (short-wave infrared), and NIR (near infrared), said Tom Persico, director of technology for McBain Systems.

Acoustic-based inspection using ultrasonic fluid immersion is good at finding macro defects but only down to around 100 microns, said Persico. "Although x-ray easily penetrates many materials, the wavelengths are very long, and the longer the wavelength, the worse the resolution," he said. NIR inspection systems, according to Persico, are best for detecting defects down to a micron in size. NIR systems not only find subsurface defects, but also measure critical alignment marks between two die layers, between two wafer layers, or between a die layer and a wafer layer, he said. "Another use we're seeing is detecting process damage, such as from 3-D wafer-stacking processes that are still being fine-tuned."

NIR wavelengths are usually defined as starting above the visible spectrum, around 650 nm, and continuing up to wavelengths of about 1000 nm, said Persico. "Just because you can create a NIR image, however, that doesn't mean it shows you what you need to see," he said. "With highly doped parts, extra-thick materials, or rough or unpolished surfaces, you'll need to reach higher wavelengths to see through the material well enough."

Different materials may also require different wavelengths. NIR may be high enough for penetrating most silicon substrates but not for some proprietary semiconductor materials. In these cases, you need wavelengths above 1000 nm in the SWIR spectrum. "Our DDR300 NIR system actually uses both, operating between 900 nm and 1700 nm," Persico said.

Automated production-floor tools that use NIR technology can detect defects and measure small features inside multilayer MEMS and other chips.
Courtesy of McBain Systems.

NIR inspection and metrology systems range from manual benchtop systems used mostly in the lab to fully automated tools used on the fab production floor, said Persico. Automated NIR tools are somewhat new. "Some fabs add an IR camera to production equipment, but don't really optimize the tool for NIR," he said. "There are also benchtop microscopes with IR, but they still need to work in conjunction with the software, camera, motion control, and a light source for the particular application."

In the future, McBain expects to improve its NIR inspection and metrology systems with new optics for better resolution, typically on the macro side, said Persico. That means smaller pixels, higher pixel density, higher sensitivity, and lower noise. "Customers want to see the same small features in the same field of view but in a larger area, so they don't need to buy two different tools. That's because throughput is everything for semiconductor manufacturers." T&MW

To read past "Tech Trends" columns, go to www.tmworld.com/techtrends.

AOI system targets modules, sensors

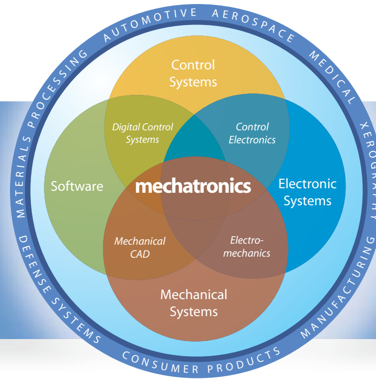
The Reveal Imager Series is designed for inspection and metrology of camera modules and image sensors in back-end-of-line environments. The Reveal accurately detects particles that are 1 micron or larger, checks for process defects, and can measure and forward-feed exact sensor and pixel-array positioning. www.vitechnology.com.

GigE camera adds software features

Basler Vision Technologies has enhanced the software for its Runner family of GigE linescan cameras. Shading correction compensates for nonhomogeneous lighting conditions so vision application software can detect defects more easily. To create the camera's correct line-acquisition rate, the multiplier increases the frequency of an incoming trigger signal, while the divider reduces that frequency. www.baslerweb.com.

HD frame grabber streams video

The new HDV62 PCI Express frame grabber offers video streaming and uncompressed image acquisition in 1080p high-definition. It also provides up to 1920x1080p resolution at 60 fps, progressive scan, noise reduction, and a wide aspect ratio. An onboard FPGA and 512-Mbyte buffer are included for streaming uncompressed video and performing real-time color-space conversion. www.adlinktech.com.



Isn't there enough real inertia around?

Electronic inertia through acceleration feedback improves performance.

Kevin C. Craig, PhD, is the Robert C. Greenheck chair in engineering design and a professor of mechanical engineering, College of Engineering, Marquette University.

For more mechatronics news, visit: mechatronicszone.com.

In a motion-system context, the idea of adding inertia to a system, (that is, adding mechanical mass) is not usually desirable as it slows down system response. One familiar exception is adding a flywheel to an engine or machine to smooth out speed fluctuations. Two of the most important benefits of feedback control are "command following" and "disturbance rejection." Usually, the focus of attention in a control system is on command following, but in many situations, the ability of a system to reject disturbances (that is, have a high dynamic stiffness) is paramount.

For a motor-velocity feedback-control system, increasing inertia J reduces the high-frequency disturbance response, meaning it makes the system dynamically stiffer at high frequencies. But the closed-loop command-following is degraded. How can you add inertia without degrading command-following performance?

A common industry motion-control system has three cascaded feedback loops: motor current, velocity, and position. Newton's Second Law says that torque is proportional to angular acceleration, so if you can measure or estimate acceleration, you can scale the acceleration by inertia J to give units of torque, and then by $1/K_T$, the inverse of the motor torque constant, to give current. This is then multiplied by a gain K_{AFB}, and subtracted from the current command to the current-control loop. K_{AFB} has a similar effect to increasing inertia J; hence the alternate name "electronic inertia." To ensure that the command-following performance remains the same, the PI velocity control gains must be scaled by the same factor $(1 + K_{AFB})$, as shown in **Figure 1**:

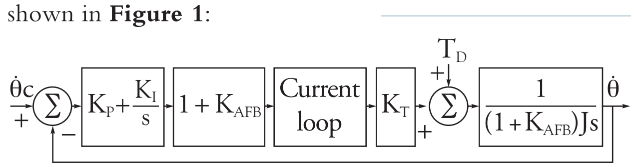


Figure 1.

The velocity command response is unaffected by the value of K_{AFB} because the loop gain increases in proportion to the inertia, producing no net effect. So, why should you add electronic inertia? The real benefit of acceleration feedback is that the disturbance response is improved by acceleration feedback through the entire frequency range in proportion to the term $(1 + K_{AFB})$, as shown by the transfer function and frequency-response plot (**Figure 2**).

This improvement cannot be realized significantly above the bandwidth of the current loop, as the acceleration feedback signal cannot improve the system at frequencies where the current loop cannot inject current. Of course, a robust acceleration feedback signal is required. This can be accomplished through differentiation of a position sensor signal and filtering or through the use of an observer.

For mechatronics engineers, here is one situation where adding inertia is highly desirable. T&MW

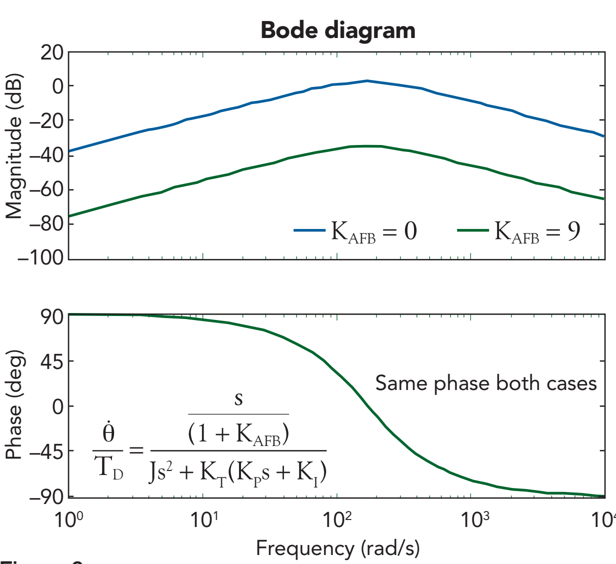


Figure 2.

PRODUCT TRYOUT

Clever device logs temperature

NI USB-TC01 Thermocouple Measurement Device, National Instruments, www.ni.com/daq. Price $129.

The NI USB-TC01 lets you measure temperature with a thermocouple and log data through a USB port.

Courtesy of National Instruments.

National Instruments has released a thermocouple measurement device that almost runs by itself. Yes, you can develop your own application for the NI USB-TC01 if you wish, but you don't even need to install a driver or application software in order to use it.

The USB-TC01 will run on any PC with Windows XP or later. You don't need administrator rights, because there is nothing to install, but you do need Microsoft .NET 2.0 SP1 or later. I found that out when I tried to use the logger on an old laptop. See my blog post "Cable box raises the temperature" for an explanation of how I used the logger (Ref. 1).

The NI USB-TC01 lets you log temperature with most any thermocouple; a type J thermocouple comes in the box. To use the device, you connect a thermocouple to the logger and then connect the logger to a USB port on the PC. The PC will think the device is a CD-ROM drive, because the measurement software runs directly from within the logger. The USB-TC01 also comes with the LabView source code, so LabView programmers can modify the software to suit their needs.

When you connect the device, you get an immediate temperature reading on the PC screen. The display also provides three options: Temperature logger, LabView code, and Download additional applications. Selecting the logger option opens another window where you can plot, log, and save data.

The USB-TC01 is a useful device, but its 1-sample/s fixed sample rate can result in more data than an application requires. I found myself wishing I could change the interval between samples; a menu with interval options of 0.1 s, 0.2 s, 0.5 s, 1 s, 2 s, 5 s, 10 s, and 60 s would be very helpful.

I contacted National Instruments about this and learned that the company is currently developing firmware that will add variable sample rates; the firmware will be available for download.

National Instruments also has several free applications that you can use with the USB-TC01. They run on your PC, not from the USB module. Clicking on "Do more with your NI USB-TC01" in the logger application lets you download applications such as an alarm generator or limit logger.

Martin Rowe, Senior Technical Editor

REFERENCE

1. Rowe, Martin, "Cable box raises the temperature," Rowe's and Columns blog, www.tmworld.com/blog/Rowe_s_and_Columns.

DESIGN FOR TEST

DFT remains EDA bright spot

DFT (design for test) is one area of the EDA (electronic design automation) industry that remained strong and kept growing right through the recession, according to Walden C. Rhines, chairman and CEO of Mentor Graphics. In an interview conducted July 14 at Semicon West in San Francisco, he said, "I think the thing that's been most exciting for us is the success of our LogicVision acquisition," which has enabled Mentor to integrate scan-based test with built-in self-test. Rhines said the future holds considerable promise for increased scan compression, adding, "With the capability to integrate built-in self-test with compressed scan, I see a very fruitful roadmap ahead for growth of products and for continuing to help our customers in keeping their test costs at manageable levels while increasing their quality and their ability to quickly analyze and correct problems in their designs."

As for testing forthcoming 3-D chips with through-silicon vias, Rhines said, "There will be large growth in known-good-die testing. In fact, the tester people I talked to today said that's already happening," with die testing occurring preliminary to the die-stacking

Walden C. Rhines, chairman and CEO of Mentor Graphics, says the future holds promise for scan compression.

Courtesy of Mentor Graphics.

DFT remains EDA bright spot *(continued)*

process. "That's generating revenue for tester companies," he said, concluding, "The tests involve test programs, test vectors, test analysis—and that's all very good for the electronic design-automation industry, and particularly Mentor because we have such a very large share of the design-for-test EDA market today."

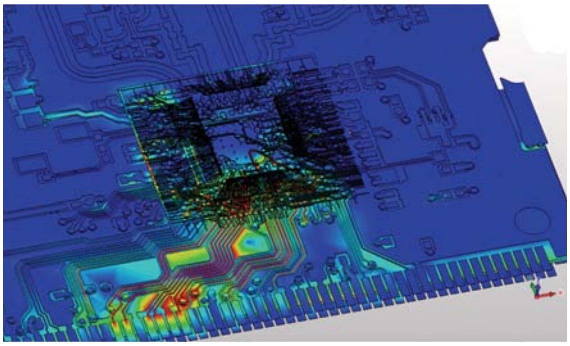
In the wide-ranging interview, Rhines also addressed the challenges the EDA and semiconductor industries face as geometries shrink and EUV (extreme ultraviolet) lithography arrives. He also commented on the challenges that embedded-system designers face and on tools available to solve system-level power-optimization and other problems. You can read the complete interview on the Web at www.tmworld.com/rhines_0710.

Rick Nelson, Editor in Chief

EMC

EM simulation helps meet EMC specs

Simulating your product's EM (electromagnetic) radiation will help ensure that you pass FCC and CE Mark tests and will help keep your project on schedule. The FCC requires manufacturers to perform EMC (electromagnetic compatibility) tests on electrical and electronic products to ensure that EM radiation will not cause interference with radios, phones, and TVs. In addition to passing tests for EM radiation, a product must also exhibit electromagnetic immunity, meaning that a strike from a defined EM pulse will not significantly disturb the product's performance.



Crosstalk from the signals on the bottom traces of a PCB create surface currents on the upper left. Courtesy of CST.

Because a design might have hundreds of circuit-board traces that interact, you need sophisticated software tools to perform EM simulations. These simulations must take into account both small and large features over a broad frequency range. You must also select an appropriate simulation method, which can be either a time-domain technique, such as FEM (finite-element method), or a frequency-based one, such as MOM (method of moments). For the largest problems, you need to break the simulations into subdomains or use asymptotic-solutions techniques.

It's unlikely that a single piece of software can provide all the EMC analysis you need, so you should assemble a suite of software tools—from companies such as Agilent Technologies, Altium, Ansys, AWR, Cadence, CST, and Mentor Graphics—to help battle your EMC, signal-integrity, and power-integrity demons. Sibling publication *EDN*'s July 15 cover story (Ref. 1) discusses the various capabilities of these tools and describes the computing power you'll need to run them.

Paul Rako, Technical Editor, EDN

REFERENCE

1. Rako, Paul, "EM simulation for EMC: keeping a lid on interference," July 15, 2010, p. 26. www.edn.com/article/509651-EM_simulation_for_EMC_keeping_a_lid_on_interference.php

Synchronize sensors and cameras

Trigger circuits provide measurements and images at the right time.

By Shih-Jie Chou, Rui-Cian Weng, and Tai-Shan Liao, National Applied Research Laboratories, Instrument Technology Research Center, HsinChu, Taiwan

Measurement systems often use cameras and other sensors that must be synchronized. We developed an aerial-photography system that uses a camera built from CCD image sensors, an IMU (inertial measurement unit), and a GPS unit. We then built circuits to provide trigger signals to synchronize the measurements at the optimal rate. The GPS provides information on spatial location, while the IMU provides information on spatial azimuth; the IMU combines a gyroscope, a magnetometer, and an accelerometer to produce angular and acceleration measurements of a three-axis vector.

Figure 1 shows the system we developed for making aerial photographs. It consists of four Atmel area-scan CCD image modules, one linear image-sensor module, two Dalsa PCI frame-grabber cards, the IMU, a clock-adjustment circuit, and a microcontroller. We used a Tektronix digital oscilloscope to view the trigger signals during development.

The trigger signals that synchronize the sensors are the key to this measurement system. The clock-adjustment circuit sends an external trigger pulse to the frame-grabber cards, which generate trigger signals for the system. Video modules consisting of the image sensors receive trigger signals from the frame grabbers. Each frame grabber captures an image and stores it in onboard memory before capturing the next image.

The external trigger pulses also control the sensors, GPS, and IMU. **Figure 2** shows a photo taken at 7000 ft in Mailiao Township, Yunlin County, Taiwan, using the external trigger circuit to drive and combine with the linear sensor and the IMU

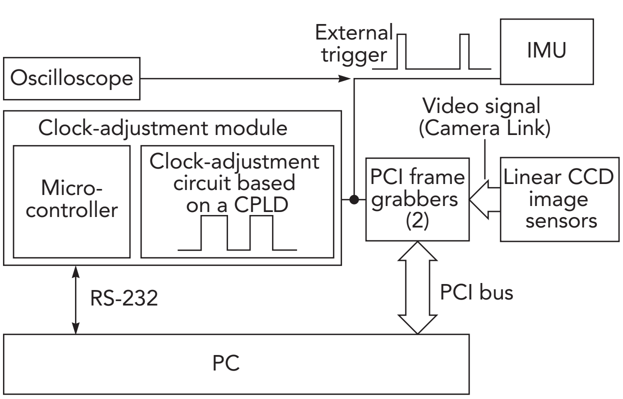


Figure 1 The clock-adjustment circuit generates a series of pulses that trigger the frame grabbers and the IMU.

Figure 2 This aerial photograph was taken from a height of 7000 ft during a flight over Mailiao Township, Yunlin County, Taiwan.

We needed to design a circuit to change the external trigger clock's frequency to obtain the best frame rate. The CCD sensors that go into the linear-image-sensor module have 12,288 pixels, where each pixel is 5 µm x 5 µm in size. That produces images of about 500 lines per frame. The CCD image sensors have a maximum output rate of 320 Mpixels/s. They use a Camera Link interface to send image data to the frame grabbers, which transfer the images to a PC over the PCI bus.

The clock-adjustment circuit generates the external trigger clock pulses. We implemented it on an Altera CPLD using Altera's development software to simulate the trigger signals and design the circuit. The clock-adjustment circuit provides up to 15 trigger-signal frequencies to the system.

The system's Atmel microcontroller contains 256 bytes of RAM plus 8 kbyte of programmable flash memory for program storage. The microcontroller communicates to a PC over RS-232 so it can also receive commands and report its current state. This handshake process includes the decoding and encoding parameters for generating the trigger signal. The mi-

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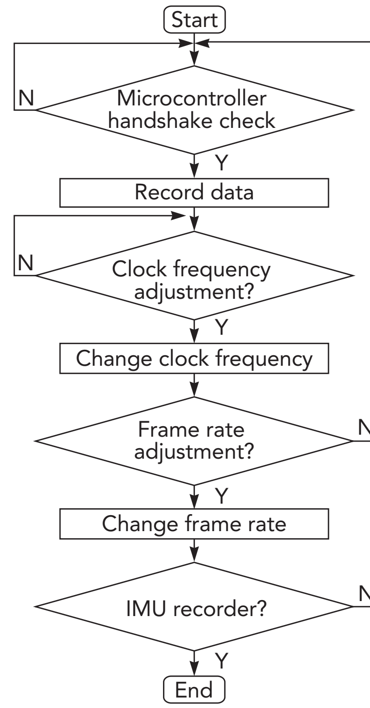

Figure 3 Microcontroller software adjusts the trigger pulse frequency that drives the measurements.

crocontroller also sends commands to the digital-timing-adjustment circuit that change the pulse frequency of the external trigger.

We optimized the frame rate of the CCD image module using the 15 trigger frequencies. The external trigger signal also triggers the IMU to record and store spatial parameters. **Figure 3** shows the algorithm for finding the optimal trigger frequency. The frame rate and the trigger frequency are linearly proportional.

The IMU is a key sensor in the system, and there must be a direct correlation between the IMU and the frame grabbers. If the external trigger frequency is 1 kHz, then each of the two frame grabbers will capture 1000 frames/s and the IMU will sample at 1 ksamples/s.

Through experimental results using aerial photography, we found that the system successfully synchronized all of the sensors. T&MW

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Projecting the LIGHT

ENGINEERS AT LUMINUS DEVICES TEST HIGH-BRIGHTNESS LEDS THAT ILLUMINATE STAGES, SCREENS, STORES, AND STREETS.

BY MARTIN ROWE, SENIOR TECHNICAL EDITOR

BILLERICA, MA—When lighting designer Kevin Adams designed the lighting for Green Day's "American Idiot" musical on Broadway, he wanted to illuminate the stage with white light. He found the light he wanted in stage lights that contain LEDs manufactured by Luminus Devices (Ref. 1).

Luminus Devices manufactures LEDs that appear not only in stage lighting, but also in portable projectors, retail stores, homes, and even street lights. They've also appeared in projection TVs.

Started in 2002, the Billerica-based Luminus produces LEDs as large as 12 mm^2 that produce blue, red, green, and, of course, white light at its foundry in nearby Woburn, MA. Such a large size presents test issues not present in typical 1-mm^2 LEDs. Assembly, packaging, test, and engineering take place in Billerica, where engineers design and test the LEDs under conditions that exceed specifications. Those tests assure users of consistent brightness, color, and reliability.

Luminus delivers LEDs packaged on either ceramic substrates or on metal-core PCBs (printed-circuit boards). When an LED is assembled onto metal-core PCBs (**Figure 1**), Luminus places either a glass window (shown) or a dome-shaped lens (not shown) over the device. The assembly includes a power connector that looks similar to those used in automotive fuses. The devices need heat sinks and large pins because they can operate at up to 30 A of forward current. The devices dissipate as much as 150 W, which produces temperatures as high as 150°C at the device junctions.

All that power produces light that's too bright for a person to look at directly. In fact, the LEDs are so bright that you can easily see them in sunlight. Indeed, engineers were running a life test with LEDs shining through a window on the day of my visit. The online version of this article contains a short video of pulsing light that I took while standing outside the building (www.tmworld.com/2010_09).

Injecting high current

Testing begins when wafers arrive from the fab. A wafer-probing system injects up to 10 A of current for 0.2 ms to 2 ms from a Keithley Instruments SMU (source-measure unit) into

In the reliability lab at Luminus Devices, reliability manager Scot Solimine (left) runs accelerated life tests on the company's LEDs. Staff engineer Mike Brown analyzes any failure modes and suggests corrective actions.

each device. The SMU also measures forward-operating voltage and reverse-leakage current. "We would like to synchronize two SMUs to produce 20-A current pulses," said test-engineering manager Michael Joffe. "Pumping 20 A through an LED will provide better prediction of a wafer's quality."

During a test, a spectrometer detects an LED's shade of color, including the dominant wavelength—the one that most influences how the human eye perceives color. "We do full spectral analysis on the LED," said Joffe. VP of engineering Arvind Baliga added, "We screen RGB [red-green-blue] LEDs at the wafer level based on forward voltage, reverse current, dominant wavelength, and brightness. White LED die are binned by color point after screening for forward voltage, reverse current, and brightness."

Baliga explained that the screened LEDs are then tested for uniformity, which lets engineers detect possible defects; a big LED can have occasional processing variations across its surface. When engineers detect defects, they look back through the fabrication process and locate the root cause.

After dice are sorted, they are assembled onto substrates or boards. Products for sale go to production test, but new designs first go through engineering evaluation. A team of six test engineers and technicians develop and maintain test stations for both engineering and for production. They also evaluate new designs.

The test engineers measure LED packages for forward voltage, reverse current, brightness, and color. They also measure a device's temperature. They can't, however, measure an LED's junction temperature directly. They measure temperature at the most accessible point and calculate junction temperature based on the thermal properties of PCBs, heat sinks, and the devices

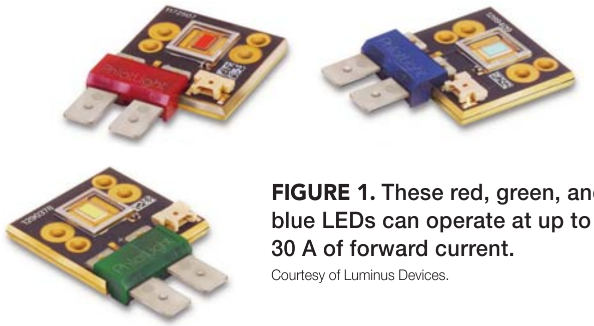


FIGURE 1. These red, green, and blue LEDs can operate at up to 30 A of forward current.
Courtesy of Luminus Devices.

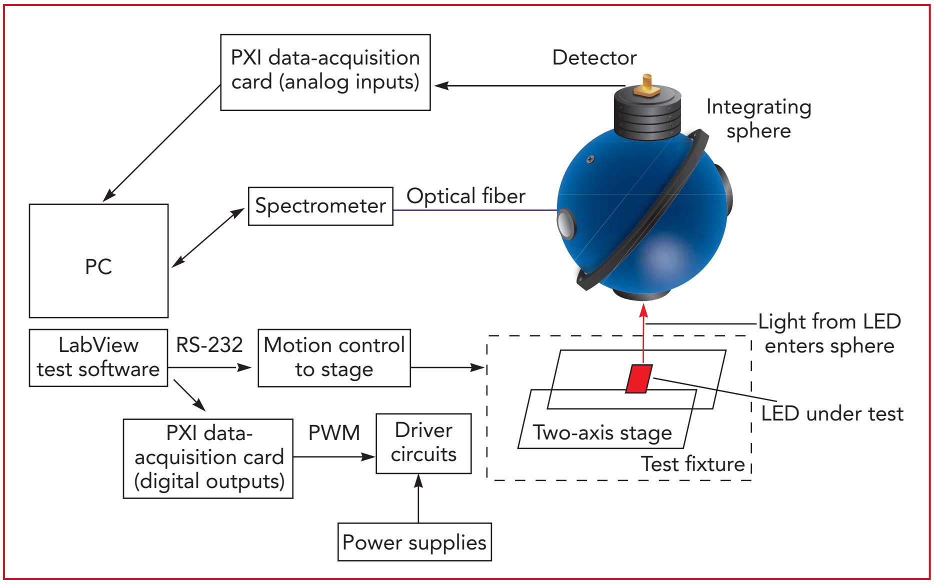


FIGURE 2. A test system consists of an integrating sphere that captures light from an LED under test. A custom driver circuit provides pulsed current up to 30 A.

themselves. Temperature and forward current affect an LED's light intensity and color.

The engineers test LEDs using both pulsed and direct current. Testing LEDs at 30 A is more difficult than testing at, say, 1 A, particularly with pulsed current, because the shape of the current waveform affects LED performance. For example, overshoot will change the average intensity of the LED in the period when the LED is on.

Testing large LEDs

Dedicated test equipment isn't always available to engineers developing new technologies such as the 12-mm^2 LEDs. "You can't buy COTS [commercial off-the-shelf] test equipment for our high-current devices," said Baliga. Thus, the test engineers at Luminus have to design, assemble, program, debug, and calibrate testers in house. **Figure 2** diagrams a test system used in production and in engineering.

An integrating sphere is the heart of the tester. Its detector converts light from the LED into a voltage that a National Instruments data-acquisition card can digitize. That lets the tester measure light intensity. An optical fiber attached to the sphere transfers light to a spectrometer that measures the LED's optical spectrum and dominant wavelength.

The size of the sphere affects the resolution and accuracy of the light measurements. Test stations for production and engineering use 12-in. diameter integrating spheres. An R&D test station uses a 20-in. sphere, while stations that sort devices use 4-in. spheres.

Test stations also need fixtures, and Luminus engineers must design fixtures that cool the LEDs' 150 W of heat. "That's as much heat as in a professional-grade soldering iron," said Joffe. Furthermore, the LEDs must be tested under consistent current and temperature conditions. The test fixtures are water cooled, and the engineers have designed mechanical fixtures that provide consistent contact with heat sinks.

Engineering test stations must be flexible enough to test an LED regardless of its mechanical configuration. Engineers need to test devices mounted on boards with heat sinks or on devices in die form. The Luminus engineers designed an engineering test station that lets an experienced test operator run automated tests of 100 LEDs. A two-axis stage moves the LED under test into position under the integrating sphere. The test operator controls the stage to correctly position each LED under the sphere.

Test engineer Aaron Plaisted is one of three test engineers who build test stations. In the engineering lab, test stations need flexibility to accommodate new device packages. A custom PCB holds the LEDs and routes current to LEDs under test. A TDK-Lambda DC power supply provides current to an LED under test. The test engineers designed drive circuits controlled by pulses from a National Instruments multifunction data-acquisition card that route the current to an LED. "We test LEDs at current up to 36 A," said Plaisted. Precision 0.3-Ω, 10-W power resistors (**Figure 3**) in series with the driver circuits let engineers measure the current flowing into the LED under test with a data-acquisition card.

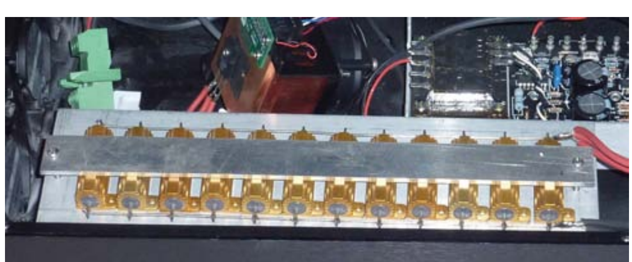


FIGURE 3. Power resistors in series with LEDs produce a voltage used to measure LED current.

Because HB (high-brightness) LEDs are relatively new, their fabrication processes are not as mature as those of most semiconductors. Process engineers are still learning how to optimize production processes, and they rely on data from test engineers, reliability engineers, and failure-analysis engineers.

Finding where it fails

You probably expect incandescent bulbs to fail, but not LEDs. While LEDs can last for years, they still need reliability testing. LEDs can lose brightness over time, so even if an LED is still producing light, a user may perceive it as having failed if the light output diminishes. That's where reliability manager Scot Solimine and staff engineer Mike Brown come in.

Solimine spends much of his time in the reliability lab, which houses banks of LEDs under test (**Figure 4**). (Covers over the LED banks diffuse the bright light so it won't hurt anyone's eyes.) Solimine runs reliability tests on lots of about 100 devices assembled from at least three wafers. He typically tests about 20 devices for a particular condition such as accelerated aging, temperature, vibration, shock, or humidity.

"Customers think LEDs should last for 25,000 hr and retain 30% of their brightness," he said. But 25,000 hr would make for a long test, so Solimine tests LEDs for 6000 hr, after which time an LED should retain at least 92% of its brightness. **Figure 5** shows a typical plot of brightness over time.

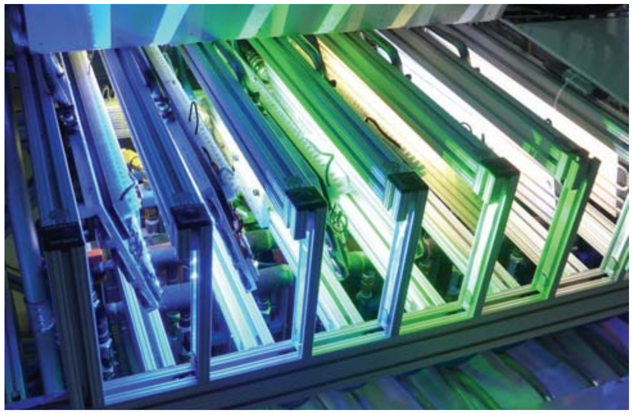


FIGURE 4. Banks of LEDs in the relaibility lab may run for 6000 hr or longer.

The Department of Energy and the Environmental Protection Agency have developed a new test standard called LM-80, which specifies the methodology to be used in determining LED lifetime and reliability. Lighting manufacturers must show evidence of conformance to the LM-80 standard in order to receive Energy Star approval (Ref. 2).

Solimine assesses reliability using accelerated life testing. That lets him achieve 10 years' worth of life-testing data in a few months. He may have to sign off on a design after just 2000 hr of testing, but the customer may expect 60,000 to 70,000 hr of life from a device.

Accelerated testing on HB LEDs involves driving them harder than most customers do. For example, a customer may drive a 30-A LED with a 25% or 50% duty cycle at 360 Hz, so Solimine will test parts with continuous DC current. He also raises the ambient temperature to see how it affects brightness and LED life.

Combinations of junction temperature and current let him develop reliability models. In some tests, Solimine will raise device junction temperatures to 220°C just to see how an LED responds. Most tests use junction temperatures between 150°C and 180°C.

"If you run at temperatures that are too high, you could uncover failure modes that customers will never see," said Solimine. "We usually try to test at junction temperatures about 20% over published specifications." The same applies to current, which is why he tests LEDs rated for 30 A at 36 A. He may test smaller LEDs (3 A to 9 A) at twice their rated forward current.

Although Luminus engineers test their LEDs under conditions that exceed published specifications, some customers exceed even those conditions. One customer pumped 40 A through the LEDs. They failed.

When Solimine tests LEDs under continuous current, he can use a single TDK-Lambda power supply to test as many as 40 devices connected in series because it has enough voltage to keep the LEDs forward biased (each LED drops about 4 V). In total, the lab has about 100 kW of electrical power for driving devices.

Solimine runs reliability tests under conditions that stress an LED more than most customers. But customers keep finding new LED applications. Solimine has added tests as new applications arise. For example, he runs one test using 30 A pulsed current for 0.2 s on and 1.2 s off, which is more like a thermal cycle compared to running them at 360 Hz, because at that frequency, the LED is on for much shorter periods. Other tests run at low current with high ambient temperatures, while others run at high current.

Not all of the current pumped through an LED produces light. An LED's circuit model is a resistor in parallel with a diode. Thus, a shunt current passes through the resistance, not through the diode. When running at low current, say 2 A, a shunt current of 500 mA can make a difference in reliability because 25% of the current doesn't illuminate the LED. Another customer, however, may run the same device at 30 A. There, a loss of 500 mA is less significant. An LED's shunt resistance increases over time, which fixes the leakage problem.

Failure modes for large devices are different from those for small devices. For example, a defective area that causes failure of a 1-mm^2 LED may have little impact on the performance or reliability of a large Luminus LED, but larger defect areas increase the likelihood of failures. **Figure 6** shows the difference between an acceptable device and a failed one.

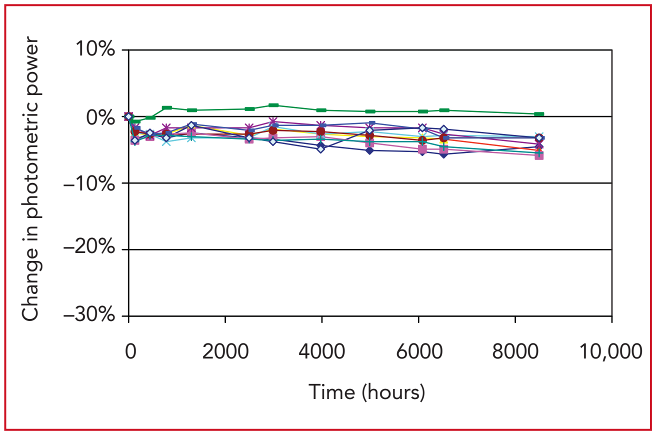


FIGURE 5. An LED's brightness degrades slightly over time. A device is deemed acceptable if it retains 92% of its brightness after 6000 hr of use. Courtesy of Luminus Devices.

Learning from failures

When failures occur, Solimine relies on staff engineer Mike Brown to analyze them. Brown analyzes failure modes both from internal tests and from field returns. He looks for repeat failure modes and makes suggestions on corrective actions.

Brown, who has worked at Luminus since 2003, explained, "When we started, we didn't understand the failure modes of the devices. Our wafers may have 70 different layers of doping in the layers, any one of which can go out of control. We've discovered and fixed numerous failure modes over the years and spent much time analyzing failures to learn about them."

As Brown learned more about failure modes, he could recommend better ways to test production parts. At one time, Luminus would burn-in 100% of its production products until engineers learned to better control the manufacturing process. That improved wafer yield, but still left failure modes caused by packaging. Thus, Brown and other Luminus engineers had to learn how packaging caused failures and how to fix them.

"As we've increased production, we've learned how to minimize failures in less time. We used to burn-in for 4 hr. Today, we can get reliable products with a 5-min stress test." Brown has uncovered packaging-related failure modes such as those caused by epoxy.

Baliga, the VP of engineering, emphasized that with each new product, Luminus engineers encounter fewer failures because they've learned how to minimize them. Still, new failure modes occur as customers try new applications. Brown noted that Luminus engineers learn a great deal from customers and how to fix new failure modes. "Each new application is an opportunity to learn about failure modes," he said. Some customers use the LEDs with low current for best efficiency while others want the highest power.

What is a failure? Customers have different expectations. To some customers, a loss in brightness constitutes a failure. The amount of acceptable brightness loss also differs among customers. One user has an end-of-life specification of a 50% drop in brightness. Another might consider an LED to have failed if it loses

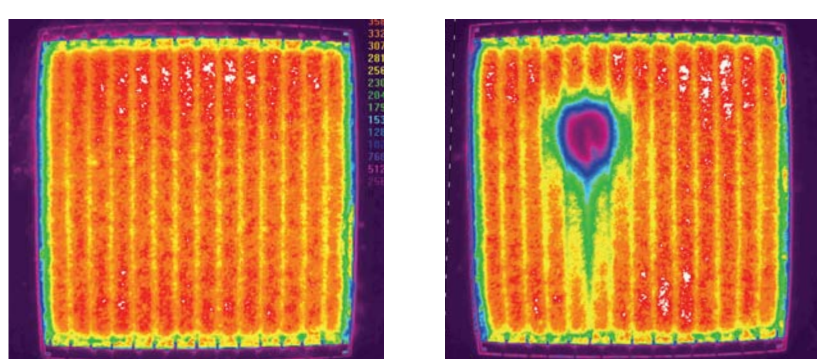
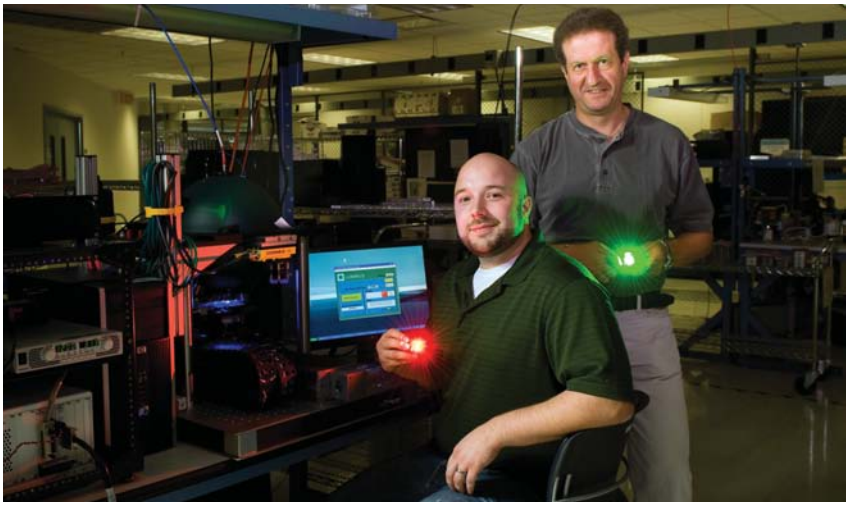


FIGURE 6. Uniformity tests reveal the light intensity across a device's surface. These images show (left) acceptable uniformity and (right) a failed device.



LEDs can generate as much heat as a professional-grade soldering iron, according to test-engineering manager Michael Joffe (right). Test engineer Aaron Plaisted commented that Luminus tests LEDs at current up to 36 A.

ADRIEN BISSON

10% of its brightness in the first year, which is why Luminus engineers specify an 8% dropoff in one year to be a failure mode. To others, only a complete loss of light is a failure.

Over time, Brown has developed a library of failure modes by intentionally overstressing the company's LEDs. Because of that experience, he can often tell the failure mode just by looking at the device, such as when that customer pumped 40 A through an LED. He also found one customer who was pumping too much current through a device without realizing it. The customer eliminated the problem by changing driver circuits.

Luminus engineers also try to emulate customer applications. The video of the pulsing light in the online version of this article shows one example. The pulsing pattern is unique to a particular customer, so engineers ran that pattern on an LED 24 hr a day to find where it might fail. Given the brightness of the LED, its light illuminates the parking lot at night during such tests. Fortunately, there are no homes across the street, so it doesn't bother anyone. T&MW

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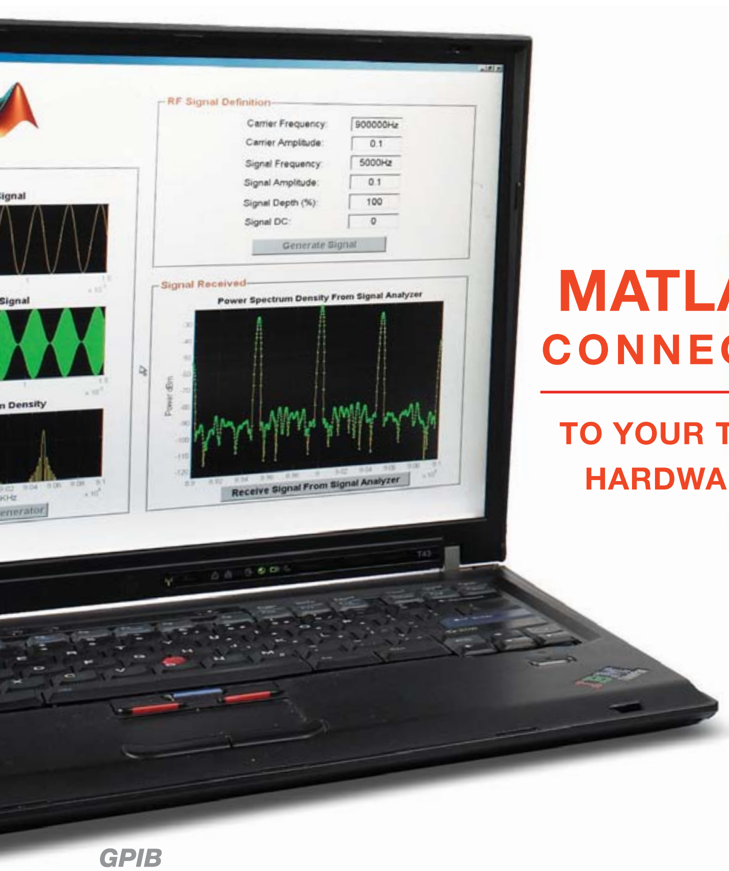
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Carrier Amplitude: 0.1
Signal Frequency: 5000Hz
Signal Amplitude: 0.1
Signal Depth (%): 100
Signal DC: 0
Generate Signal
Signal Received
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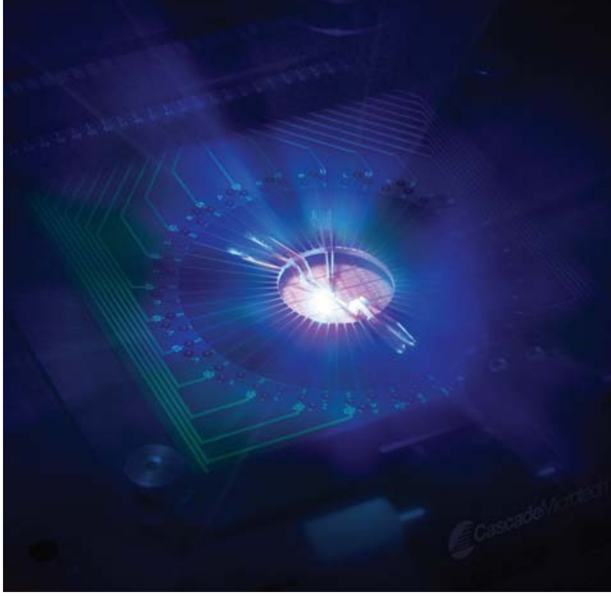

As markets for display backlighting and solid-state lighting grow, equipment vendors adapt to meet the needs of a rapidly changing industry.

LED test

BY BRYAN BOLT, CASCADE MICROTECH

Rapid market growth for HB (high-brightness) LEDs is driving what was once a niche industry into full-fledged high-volume production. With the emergence of applications such as display backlighting, and with the brass ring of SSL (solid-state lighting) almost within reach, some analysts are projecting a CAGR (compound annual growth rate) of greater than 30% over the next several years (Ref. 1).

New players are scrambling to enter the market, and established manufacturers are retooling to compete for their share of the new business. The rapid growth is adding complexity to an already complicated IP (intellectual-property) landscape. New device architectures, materials, and processes are being introduced—in some cases to get around existing IP and in others to attain a cost or performance advantage over the competition (see "A growth industry" in the online version of this article at www.tmworld.com/2010_09).

These factors combined with a shortage of industry standards and the lack of a common technology roadmap present major challenges for manufacturers of equipment used in LED production. This is certainly true for the providers of wafer-level test systems, which are used for in-process testing of optical and electrical properties for each die on every HB LED wafer produced. New equipment must accommodate the range of test configurations found across the spectrum of manufacturers. At the same time, the equipment must keep the cost of test low to help reduce the overall cost of LEDs and contribute to the successful adoption of LED technology in consumer applications.

LED manufacturers need equipment that is designed especially for LED test, because general-purpose test equipment that requires significant customization results in unacceptable levels of R&D spending. Likewise, repurposing semiconductor test equipment for LEDs imposes a similar overhead—the effort needed to modify the equipment would distract LED manufacturers from their actual objective.

LED test equipment should have a modular and flexible design so it can support the broad and changing needs of LED manufacturing. Purpose-built tools, integrated with all necessary instrumentation and automation, will provide improved cost of ownership and will allow LED manufacturers to focus on the production of LEDs (see "Manufacturing in transition," in the online version of this article).

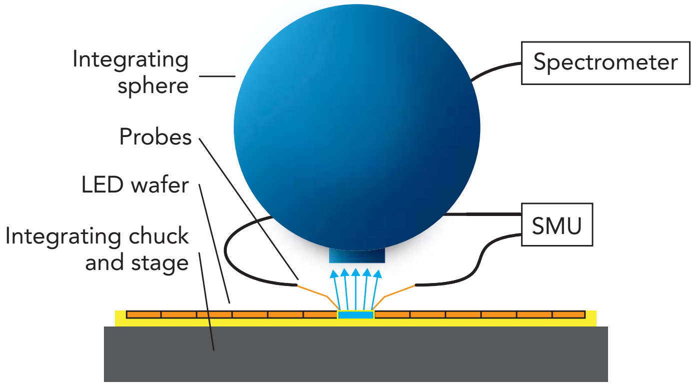

FIGURE 1. Typical wafer-level LED test components include a wafer prober, an SMU (source measure unit), and probes to apply an electrical current to the DUT (device under test) and to measure its electrical parameters. An LED test system also includes light-collection optics, such as an integrating sphere or optical fiber, and a spectrometer to measure the spectral output and optical power of the DUT.

In-process test

Testing of in-process LED devices to determine their characteristics is an essential element of the manufacturing process. In-process testing is conducted for a number of purposes at both the wafer level and the die level. The full test suite varies from manufacturer to manufacturer, but all manufacturers include tests to identify defective dice and to determine electrical properties, optical power output, and spectral output for each die (see "White-light LEDs," p. 40).

The typical setup used for LED measurements (**Figure 1**) consists of a wafer prober, an SMU (source-measure unit), and probes that apply an electrical current to the DUT (device under test) and measure its electrical parameters. An LED test system also includes light-collection optics, such as an integrating sphere or optical fiber, and a spectrometer to measure the spectral output and optical power of the DUT.

Testing takes place throughout the value chain, including at the epi-houses that produce and sell undiced LED wafers (epi-wafers), packaging houses that dice and package chips from procured epi-wafers, and vertically integrated LED manufacturers that carry out all process steps from bare wafer through packaged device. Each die may be tested up to four times before the packaged device is qualified and ready for sale.

After epitaxial film growth, lithography, and metallization, the wafer is populated with thousands or tens of thousands of operational LED chips, depending on device and wafer dimensions. At this point, each die is tested for functionality, and results are recorded to a wafer map to ensure that no avoidable downstream process costs, such as packaging, are wasted on bad dice. Initial functionality may be determined by a simple light/no-light test, or it may be determined on the basis of electrical and optical performance criteria.

Because subsequent wafer-processing steps could affect a device's characteristics, a manufacturer may choose to test device performance at several additional points. For example, after wafer dicing, stress relief of the device and changes in geometry can alter flux output, spectral output, and the light-extraction efficiency of individual dice. Therefore, testing is sometimes performed on the diced wafer mounted to a film-frame carrier to ensure the best possible measurement accuracy. Similarly, processes such as laser lift-off, which involves transferring of the LED's active film layers from one substrate to another, can alter device performance and may necessitate another round of test. Testing of white-light LEDs may be performed before and after application of the phosphor that is used to produce a broad (white) spectral output from blue or ultraviolet LEDs. Finally, packaged devices must undergo a last round of testing to account for performance changes encountered during the packaging process.

The requirement for this substantial test burden is driven by the demanding applications that will ultimately make use of the LEDs. The human eye is remarkably sensitive to variations in color and

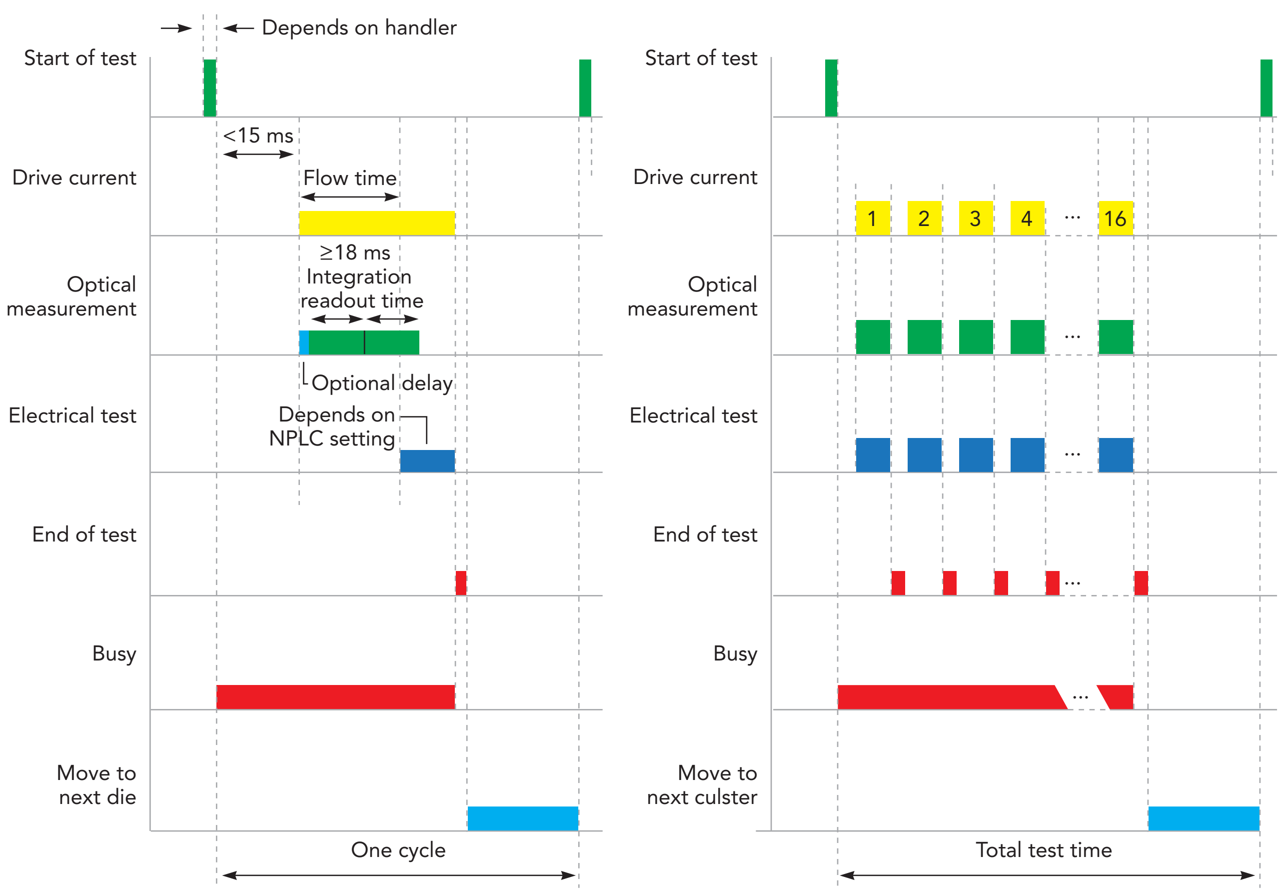

FIGURE 2. These timing diagrams for (left) single-die test and (right) multidie test show that a time-consuming move to the next test region is performed after every die for single-die testing, but only once for every 16 dice tested using multidie test.

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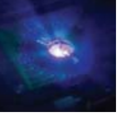

White-light LEDs

Two principal methods exist for producing white light using LEDs (Ref. A). In the first method, red, blue, and green chips are combined to achieve a broad color gamut. LEDs made using this method can achieve excellent results for color rendering, but it may be difficult to maintain proper color mixing over the life of the lamp due to differing degradation rates between the three components.

The second method, which is more commonly used for solid-state lighting applications, is based on a single LED and a phosphor (**Figure A**). Most often, a blue GaN or InGaN LED is coated with a phosphor such as Ce:YAG (cerium doped yttrium-aluminum-garnet).

Blue light emitted by the LED undergoes Stokes scattering in the phosphor to create a broad output spectrum like that shown in **Figure B**. Note the large blue peak from the light which makes it through the phosphor without being Stokes shifted.—*Bryan Bolt*

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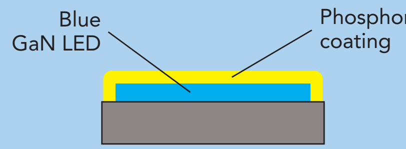
FIGURE A. (right) This white LED includes a single blue GaN chip with a phosphor coating instead of red, blue, and green chips.



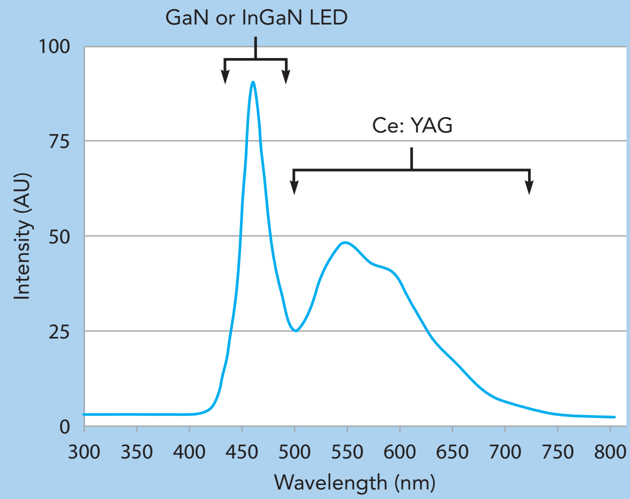


FIGURE B. (above) Stokes scattering of blue light results in this output spectrum, with intensity shown in AUs (arbitrary units).

intensity. For colors near the peak of the visual wavelength-discrimination function, variations of 1 or 2 nm can be detected by the eye. The eye can also see intensity variations as small as 1% or 2% under ideal viewing conditions (Ref. 2).

According to Sudhakar Raman, VP of business development for Veeco's LED/Solar MOCVD business, "The epitaxial process defines wavelength and initial brightness." Raman added, "Variations in the epitaxial growth conditions during processing can show differences within each wafer, wafer to wafer, run to run, and tool to tool. These contributors can result in significant variations in color and intensity for older processes, while state-of-the-art processes and equipment can achieve yield variation of <10 nm for color and <10% for intensity."

When LEDs are used in arrays such as those used to illuminate a room or the taillight of an automobile, die-to-die variations in color and intensity can be visible to the observer and lend a non-uniform appearance to the illumination. Although process improvements have been significant in recent years, die-to-die variations in color and intensity are still at levels that are easily detected by the human eye. Testing and sorting is therefore required to make use of the maximum number of dice produced. This sorting process, called binning, ensures that all LEDs in a given lot will meet customer requirements for color, output power (flux), and electrical properties. Tightly binned LEDs command higher prices due to the added value they offer consumers. The need for tight binning, among other factors, is pushing demand for higher and higher test accuracy.

Challenges for equipment suppliers

A range of new device technologies, along with increasing demands for performance, contributes to the challenges faced by manufacturers of LED production and test equipment. In addition, the lack of a clear LED technology roadmap that is consistent from manufacturer to manufacturer translates into uncertainty regarding the features that will be needed to serve the majority of the customer base. Innovations spurred by the many competing companies in this space have led to wide variability even in areas where some level of standardization might be expected.

One example is the wide range of substrates used across LED manufacturing, which places considerable demands on the wafer-handling subsystems of manufacturing equipment. Most of the current LED production is carried out on 2-, 3-, and 4-in. wafers. Some manufacturers will introduce 6-in. processes this year, while others are discussing 8-in. and beyond for the near future.

Sapphire is the leading substrate material, SiC is in production with some manufacturers, and processes based on bulk GaN, silicon, and other materials are also in the works. Devices may need to be tested on noncircular submounts, thinned wafers, or diced wafers as well.

Unlike with most silicon-semiconductor equipment, new offerings for LED must often serve legacy technologies (for example, 2-in. wafers) yet also meet the latest requirements for performance, such as higher throughput or increased accuracy. Wafer-level test systems must accommodate a number of other configuration variations. For example, some devices require electrical contact on the top surface, while others require top and bottom side contact. Optical test for devices built on transparent substrates may require light collection to be made from beneath the wafer, while opaque substrates force light collection to be performed above the wafer surface. Device dimensions ranging from around 250 μm up to 10 mm wide require significantly different collection optics to effectively sample light from across the spatial and angular ranges of their outputs. HB LED drive currents range from hundreds of milliamps to several amps with accompanying output fluxes varying similarly (Ref. 3).

Many areas of uncertainty and inconsistency can be found throughout LED manufacturing (see "A lack of standards," in the online version of this article). For LED test, the top priorities are to continue to improve test accuracy while significantly driving down the cost of test.

Reduction in equipment COO (cost of ownership) will be a critical step in bringing down the cost of LED technology. According to the US DOE SSL Manufacturing Roadmap, a 2X improvement in COO every five years is the recommended target (Ref. 4).

Improving throughput is a key factor in improving COO for wafer-level test systems. One way to do this is by performing multidie test rather than traditional single-die test. In multidie test, a probe card contacts a number of dice simultaneously. Electrical test may be performed sequentially or in parallel by the use of multiple SMUs. Optical test is performed sequentially to avoid optical crosstalk between adjacent dice under test.

ON THE WEB

The online version of this article includes sidebars that discuss the reasons the market for LEDs is burgeoning ("A growth industry"), the need for new tools for LED production ("Manufacturing in transition"), and a proposed new standard for evaluating LED quality ("A lack of standards").
www.tmworld.com/2010_09

Because only a single wafer-stage move is required for each group of LEDs contacted by the probe card, multidie test reduces test time while still providing sufficient integration time for optical measurements (**Figure 2**). Depending on cluster size and test parameters, throughputs as high as 70,000 dice per hour may be achieved on multidie test systems such as the Cascade Microtech BlueRay.

Additional reductions in COO can be realized by increasing the level of test-system automation. Even in low-cost regions, the labor cost associated with manual loading and alignment of each wafer is too high for high-volume production. Test systems must take over some of the repetitive tasks that are commonly performed manually today.

Equipment makers will play an important role in contributing to the overall cost reductions that are needed to enable mass adoption of LED lighting. As processes, technologies, and standards continue to mature, test manufacturers must remain agile and continue to cooperate with customers and other industry suppliers in order to provide lasting solutions. T&MW

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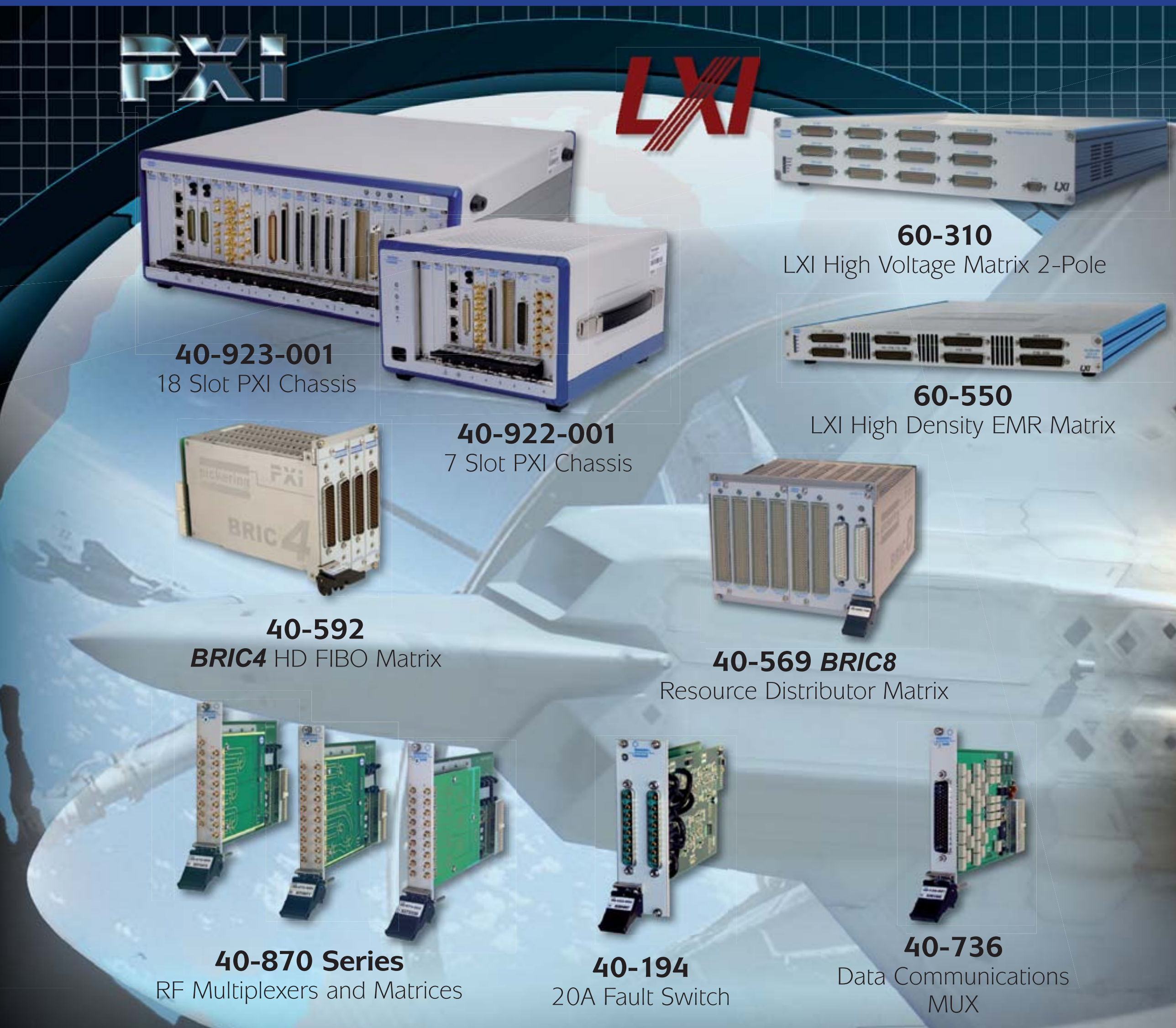

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TEST REPORT

PXI snags savings with HIL test

By Richard A. Quinnell, Contributing Technical Editor

Arrestor systems on aircraft carriers can help planes that are damaged or have mechanical issues come to a safe landing. Testing such systems without endangering plane and pilot, however, requires a specialized facility. The design team at Process Automation used PXI to create an HIL (hardware-in-the-loop) tester to minimize the time needed to test an arrestor control system. I spoke with automation systems consultant Greg Sussman to learn more about the application.

Q: What is an aircraft arrestor?
A: The arrestor is used on military land-based runways to provide braking assistance for a safe and controlled stop during landings. A hook on the aircraft catches a cable that crosses the runway. On both ends of the cable are about 1200 ft of heavy nylon mesh tape wound onto reels that have disc brakes under the control of an embedded control system. The system measures the aircraft's speed and determines its response to the applied braking so it can compensate for the differences in mass of various aircraft and apply an appropriate braking algorithm for a controlled deceleration.

INSIDE THIS REPORT

Q: What was Process Automation's role in the development of this system?
A: The system's vendor, Zodiac Aerospace, called us to design a replacement for the system's electronic controls, which were based on components that had gone out of production. The new system design used the National Instruments CompactRIO hardware platform.

Q: What was the role of PXI?
A: We used PXI as the platform for an HIL test system during debug of the control system and software. The tester provided a real-time simulation that emulated the physical plant's response to the controller. The tester looked like the real hardware to the controller and contained a model of both the system and the aircraft physics during a landing. If, for instance, the controller sent a command to change the disc brake control valve setting, the tester would read the signal from the controller and then return signals from the virtual physical plant showing how it and the aircraft responded. We could simulate normal operation for various aircraft and landing scenarios and also simulate a defined set of failure conditions to make sure the controller design was right before committing to field test.

Q: What was the advantage of using this approach?
A: Obviously, it is too risky to debug a system on real aircraft landings, but there is a test facility that uses jet sleds to accelerate a dead load sized to simulate various aircraft and landing speeds. Scheduling time at the facility, however, requires long lead times, and test time is expensive—$50,000 a day—so it made sense to minimize the facility test time by wringing out the design as much as possible ahead of time. With the tester, we reduced our facility use to five days for the new design from the 20 days that were needed for the prior design.

Greg Sussman
Automation Systems Consultant
Process Automation

Q: Why use PXI?
A: Other platforms would have needed custom hardware, external PCs for the user interface, and external racks of equipment. With PXI, we were able to put everything into a single, four-slot chassis for less than half the cost and with less risk than VME or VXI. A multicore controller with NI's Hypervisor let us run Windows on one core for the user interface and VxWorks on the other three cores for the real-time simulation. An FPGA board provided custom signals as well as analog I/O for the control interface.

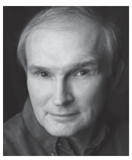
Q: Any recommendations for other HIL test developers using PXI?
A: A good system model is the cornerstone of HIL testing. If the model is not accurate, then your testing is flawed from the outset. Tools like NI's System Identification Toolkit can help you develop that model for a PXI system. □

GUEST COMMENTARY

PXI moves to the forefront for mil/aero applications

By Mike Dewey, Geotest—Marvin Test Systems

The US and other military services across the globe are large users of ATE (automatic test equipment). With the electronics content for communications, avionics, weapons, and many other military systems constantly expanding and becoming more complex, military depots and



other maintenance and repair organizations are expanding their test needs. In the past, mil/aero test systems have relied upon a variety of platforms and standards including GPIB and VXI, but new technologies and platforms are emerging as preferred replacements for GPIB and VXI. In particular, the continued growth of PXI for commercial and mil/aero test applications has been impressive. In a December 2008 report, Frost & Sullivan forecast an annual growth rate in excess of 17% per year for PXI and estimated that 100,000 PXI systems would be deployed by the end of 2009.

The continued growth and acceptance of PXI bodes well for the mil/aero ATE market. With this growth comes the increased selection and diversity of vendors and products, further benefiting the market and offering users a range of options and technologies. Today, PXI instrument vendors offer a broad range of capabilities, ranging from high-precision 7.5-digit DMMs (digital multimeters) to microwave instrumentation that is capable of addressing both legacy and future electronic warfare applications. And in the performance digital space, there are now products that support the full range of capabilities needed for LRU (line-replaceable unit) and SRU (shop-replacement unit) test applications.

PXI has also found its way into the world of operational-level and flight-line test applications. Today, you will find PXI-based test systems on the front lines in Afghanistan and Iraq, supporting the war fighter with field testing of weapons systems and aircraft as well as supporting next-generation aircraft such as the F-35.

PXI's compact footprint, coupled with its performance and instrumentation offerings, makes it the platform of choice for next-generation mil/aero test systems. And with the continued growth of the PXI market, the adoption of the PXI architecture for future mil/aero ATE offers users the opportunity to deliver cost-effective and robust next-generation test solutions. □

Mike Dewey *is senior marketing product manager for Geotest—Marvin Test Systems and has been active in the test and measurement industry for more than 25 years, holding positions in design engineering, engineering management, marketing, and product management with Geotest, GenRad/Teradyne, ADR Ultrasound, and Motorola Government Electronics Group. He is a senior member of the IEEE and has served as a board member for the PXI System Alliance, the VXI Consortium, and the LXI consortium. miked@geotestinc.com.*

EDITOR'S NOTE

In praise of backward thinking

By Richard A. Quinnell, Contributing Editor

Brain tickles can be fun. They happen when your thinking was going along one path and you suddenly recognize that your thinking could go along an entirely new path

that you didn't see before. It's the "aha" moment when new possibilities suddenly present themselves that can make engineering very satisfying.

The conventional view of PXI technology is as an information-gathering platform. PXI systems may generate stimulus signals, but their main purpose is the acquisition of data. But thinking backward about PXI can be a brain tickle that opens up new possibilities in test.

You could use a PXI-based system to receive stimulus signals and to generate, not acquire, data. Instead of an information-gathering unit, the PXI chassis becomes a simulator.

Such use of PXI appears twice in this issue of the PXI Test Report. In "PXI snags savings with HIL test" (p. 45), Greg Sussman of Process Automation explains that a PXI system serves as the key simulator in hardware-in-the-loop testing of an aircraft arrestor system.

The discussion of medical applications on p. 47 reports that Active Diagnostics used PXI hardware and software in a neurosimulator the company developed for physician training.

These two examples represent an entirely new application area for PXI that arose from thinking backward about PXI in test. PXI in simulation and for HIL testing may just be the beginning. There may be other ways of looking at PXI that are not obvious until you first see them, perhaps by starting to look at PXI sideways. □

Contact Richard A. Quinnell at richquinnell@att.net.

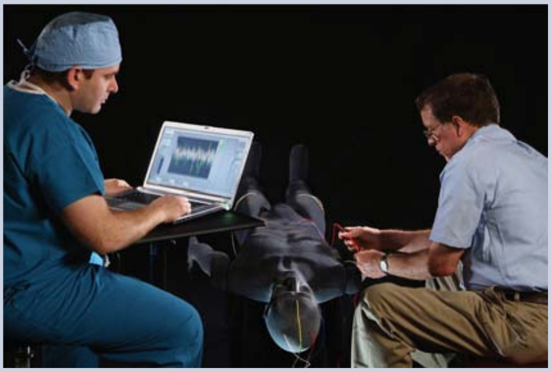
Care required when PXI serves medicine

By Richard A. Quinnell, Contributing Technical Editor

Instrumentation development and manufacturing test for medical equipment are growing application areas for PXI technology. Engineers working in these fields face unique challenges, though, because of regulations that require the design and manufacture of medical devices to follow tightly controlled processes. Design techniques that use off-the-shelf modules, such as PXI, require extra care from the design team and extra support from their vendors.

There are many reasons why PXI is appealing to the medical industry, according to John Hottenroth, market development manager for scientific and biotechnology instrumentation at National Instruments. One key appeal is the ability that PXI gives medical developers to quickly create prototypes. "Many of these customers are experts in their medical field looking for design help," says Hottenroth. "With PXI, they are able to take their ideas and form prototypes to prove the ideas out, then quickly bring the product to market."

One recent example is a neurosimulator that Active Diagnostics developed for surgical training of neurophysiologists. In an application note on the NI Website (Ref. 1), David Miller and Michael Russell of Active Diagnostics explained that PXI "hardware and software tools provided an easy-to-use solution that allowed us to quickly prototype and reuse much of the code in our final deployment."



PXI helped speed the prototyping and software development of this Active Diagnostics neurosimulator for training physicians on the human nervous system's response to surgery. Courtesy of National Instruments.

This ability to quickly develop prototypes can also be valuable in obtaining funding, especially when a company is just starting out. "There's no shortage of venture capital for medical companies," Hottenroth explained, "but having a working demo helps them win backing."

Once the prototype is ready, the role of PXI in production can vary based on anticipated volume, noted Hottenroth. Low-volume production, such as for high-cost systems that sell in the tens per year, may well employ off-the-shelf PXI as an embedded system. For higher volumes, customers are more likely to want the custom form factors and reduced pricing available by using OEM components such as backplanes rather than assembled systems.

However PXI enters production in the medical industry, though, developers face the same regulatory challenge: required controls on the design and manufacture of their products. In the US, the FDA's (Food and Drug Administration's) regulations on this control appear in the Code of Federal Regulations, Title 21 (21 CFR), part 820. Further, once the design is complete, it must receive certification from the FDA and cannot change without notification to—and in some cases recertification by—the FDA.

This requirement for control and certification creates challenges for medical-device designers using off-the-shelf modules and software such as PXI products. The solution involves help from the PXI vendor. Certification is the medical device developer's responsibility, but the vendor can help by supplying complete information on the design and manufacture of its products to streamline the certification process. By designing, building, and testing its products in conformance to industry standards, a vendor also helps ease the subsequent certification efforts of its medical customers.

Because the manufacture of medical products requires tight controls, PXI vendors should provide medical instrumentation customers with advance notice of changes to their hardware. This notification allows those customers to inform the FDA and to anticipate that a product might require recertification. Another option is for the vendor to set aside parts to continue building the original version for the medical customer when a design changes, such as for an upgrade in processor. Vendors could also offer customers lifetime buys of products that will undergo substantial change or will be removed from the market.

Developers interested in applying PXI to the medical field can gain insight into the impact of this choice by reading the FDA's guidance on the use of off-the-shelf software (Ref. 2). The developer's best help, however, will come from working with a vendor experienced in applying PXI to medical care. □

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AXIe stakes claim as PXI's "big brother"

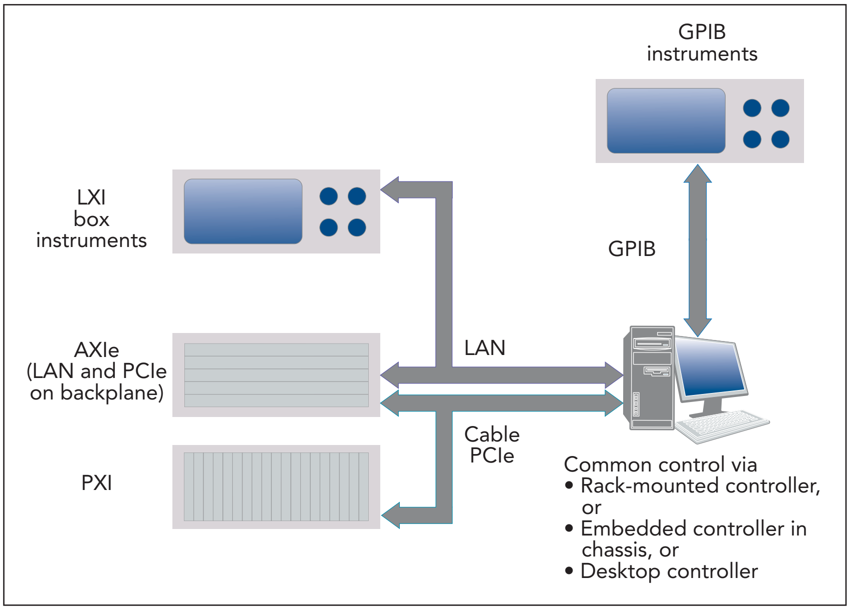
By Richard A. Quinnell, Contributing Technical Editor

Early July marked the release of specifications for a new modular test instrument standard—AXIe (AdvancedTCA Extensions for Instrumentation and Test). The specifications add clock, triggering, and other signals to a high-performance architecture that initially targeted telecom computing. Rather than seeing the new standard as a competitor to PXI, however, AXIe's developers see it as an extension of the PXI test-development model.

In November 2009, the newly formed AXIe Consortium—founded by Aeroflex, Agilent Technologies, and Test Evolution—announced it was developing a modular test-instrument standard based on the ATCA (Advanced Telecommunications Computing Architecture). Now, with the debut of the actual specifications, the AXIe developers expect the first AXIe modules to arrive before year's end. According to Larry DesJardin, GM for modular products at Agilent and chairman of the AXIe Consortium board, "Test engineers should have enough AXIe boards and system components to develop complete applications during 2011."

The ATCA specifications that AXIe leverages were developed to meet the high data rates and processing performance of the telecom industry. ATCA backplanes provide protocol-agnostic, multilane, switched-serial links among boards, and the backplanes support transfer speeds as great as 10 Gbps per lane. Blades that plug into the backplane are large (8U) and can draw as much as 200 W from system power—attributes that support the creation of complex, high-performance modules.

To make ATCA useful for test-system design, the AXIe specifications call for some subtle changes to the ATCA signal-line assignments. Eliminating two of ATCA's 16 blade slots, for instance, allows the AXIe 1.0 base specification to free backplane signal lines for use as timing, triggering, and local bus implementations. Twelve matched-length, MLVDS (multipoint low-voltage differential signaling) pairs provide a trigger bus that runs across all slots of the backplane. In addition, a signal set consisting of CLK100 (star clock), STRIG (star trigger), SYNC (star synchronization), and FCLK (fabric clock) signals runs from the system controller to each instrument slot to provide precision system timing (the online version of this article includes an illustration of the protocols, www.tmworld.com/2010_09).



The protocol-agnostic ATCA backplane allows AXIe systems to use PCI Express and Ethernet as backplane protocols, giving the systems native support for simple integration with both PXI and LXI systems. Courtesy of the AXIe Consortium.

Another change AXIe makes to ATCA backplane signaling is the elimination of RTMs (rear transition modules) that would normally occupy what the ATCA specification calls "Zone 3" backplane connections and would be used for module-specific I/O. According to David Poole, the CTO at Aeroflex and director of the AXIe Consortium, AXIe modules use front-panel connections for their unique I/O, and they use Zone 3 for supplemental AXIe standard signals. One supplemental specification, AXIe 3.1, defines such signals as additional triggers, a calibration bus, an analog bus, and DUT (device under test) I/O lines for use in semiconductor test applications. Poole noted that the AXIe Consortium plans to release several such 3.N supplemental specifications for specific applications.

Complementary capabilities

Based on a modular industrial computing architecture supplemented with timing and triggering buses, the AXIe naturally invites comparisons with PXI. But the two are not competitive, according to AXIe Consortium members, and Aeroflex, in fact, also makes PXI modules. "AXIe doesn't displace PXI," said Poole, "it simply gives access to the higher-end performance that will be required in the future."

"They are extremely complementary," added DesJardin, "with the main differences [being] the size of the boards, the amount of cooling and power available, and the bus capacity. AXIe is, in effect, a 'big brother' to PXI that extends the PXI programming metaphor." He pointed to compatibilities

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The Marvin Group ▸ Geotest - Marvin Test Systems, Inc. ▸ Toll Free: 888.837.8297 ▸ Tel: 949.263.2222 ▸ www.geotestinc.com between PXI and AXIe as evidence of this noncompetitive nature. "PCI Express is one of the signaling protocols used on the AXIe backplane and forms a fabric that is software-compatible with a PXIe system," he said. "An external system controller cannot tell the difference between an AXIe and a PXIe system, and the same drivers and development tools work for both systems."

Poole said that Ethernet is another of AXIe's supported backplane protocols, giving the system native compatibility with both PXI and LXI (**figure**).

An additional indication of compatibility is the definition of an AXIe carrier that can hold two PXI or PXIe modules for insertion and use in an AXIe system. "The carrier is like a mini, two-slot PXI card cage," said DesJardin. "Using PXI cards is not an efficient way of building an entire AXIe system, but [it is] a good way of adding niche functionality if you are missing only one or two modules to complete your design."

Instead of replacing PXI, then, AXIe aims to take up where PXI approaches its limits. "AXIe is for instruments that are tough to do in PXI," said DesJardin, "where the power and space restrictions of PXI are a barrier."

Poole added that AXIe also extends the computing performance available for test. "If you look around the industry, you see bus bottlenecks becoming a problem. With AXIe, however, you can use up to 32 10-Gbit lanes to handle data. Another great attraction of AXIe is that it allows a full fabric for multiprocessing. In PXI, the only high-speed bus available for multiprocessing is PCIe, and even then there is only one root complex."

And multiprocessing is only one performance-multiplying attribute that AXIe brings to test. ATCA has built-in power and system management that makes it easy to expand a system to multiple cages. "So essentially, we have unlimited expansion potential," noted Poole. "Now there is nothing that cannot be done in a modular instrument," added DesJardin.

The vision that the AXIe Consortium holds for modular test, then, calls for AXIe and PXI to form a continuum that stretches from small, portable test instruments to large, powerful systems. While many of the physical structures are different, the two share some types of data links as well as the control and programming model.

For many test-system developers, the deciding factors of which to use may ultimately depend on the size and speed requirements of the final system. "If you can do it in PXI, go ahead," said DesJardin. "If not, you now have a pretty compatible architecture that can get the job done." □

NI debuts Ethernet, USB DAQ systems

During NIWeek 2010, National Instruments announced new Ethernet and USB data-acquisition systems. The Ethernet-based NI CompactDAQ modular system (**pictured**) includes the NI cDAQ-9188 chassis, which is designed to hold eight I/O modules for measuring up to 256 channels of electrical, physical, mechanical, or acoustic signals. With more than 50 I/O modules to choose from, engineers can build remote or distributed, high-speed measurement systems using standard Gigabit Ethernet infrastructure.

The NI CompactDAQ uses NI Signal Streaming technology, which provides the ability to maintain bidirectional analog and digital waveforms continuously over a TCP/IP connection. Each chassis also can manage up to seven separate hardware-timed I/O tasks at different sample rates, including analog I/O, digital I/O, and counter/timer operations. Each chassis operates in a temperature range of –20°C to 55°C and can withstand up to 30 g of shock and 3 g of vibration.

The company's NI X Series USB data-acquisition devices integrate analog measurement and control channels, digital I/O, and counter/timers onto a single device that engineers can use for portable applications. The USB X Series devices include up to 32 analog inputs, four analog outputs, 48 digital I/O lines, and four counters. The eight new devices range from 500-ksamples/s multiplexed analog inputs to 2-Msamples/s/channel simultaneous-sampling analog inputs.

Base prices: CompactDAQ—$1399; X Series—$1149. *National Instruments, www.ni.com.*

Anritsu introduces Bluetooth/WLAN module testing software

Anritsu's CombiTest software is a PC-based application that provides remote control of the company's MT8860x WLAN and MT8852B Bluetooth test sets. Developed to meet the needs of Bluetooth and 802.11 WLAN silicon developers and volume manufacturers, CombiTest controls the MT8860x and MT8852B via a Windows user interface. Engineers can use CombiTest to create test plans by simply dragging-and-dropping Bluetooth and WLAN test cases from a preloaded list based on the most recent standards.

When using CombiTest software, development engineers can create comprehensive DVT (design verification and test) plans to fully characterize new designs. Results can be printed directly as well as automatically saved. In high-volume production lines, a subset of the DVT plan can be run to ensure quality of output. Anritsu said it developed CombiTest in response to feedback from volume manufacturers who are finding that reduced product lifecycles require continual update of test-system software.

Price: free to users of Anritsu Bluetooth and WLAN test sets. *Anritsu, www.us.anritsu.com.*

Field generator holds its own shield

Instrumentation in an anechoic chamber requires shielding to prevent the fields it generates from interfering with its operation. Shielding also prevents test equipment from adding unwanted interference in the chamber. The AS18013 field-generation test system from AR RF/Microwave Instrumentation consists of two shielded racks of equipment connected to antennas on a mast. The shielded, air-conditioned cabinets prevent unwanted signals from entering or exiting the rack.

The system includes traveling-tube and solid-state amplifiers, field probes, an RF power meter, field couplers, horn antennas, a signal generator, and an antenna mast. It forms a complete system for generating E-fields of known power and frequency. The AS18013 can generate fields at frequencies from 800 MHz to 18 GHz at 200 V/m. With upgraded amplifiers, antennas, and cables, the system can generate fields up to 40 GHz. The racks have extra space available for user-installed equipment.

Prices vary depending on system configuration. *AR RF/Microwave Instrumentation, www.ar-worldwide.com.*

DAQ module achieves 800-kHz sampling

Joining the DT9836 series of USB-based data-acquisition modules from Data Translation, the DT9836S is a completely isolated module with six 16-bit analog inputs that can be simultaneously sampled at up to 800 kHz/channel or 4.8 MHz total. Each analog input has its own ADC, eliminating phase shift between channels. As a result, the DT9836S can correlate measurements instantly, according to the company.

The DT9836S provides three quadrature decoders for measuring absolute and relative position and for detecting rotational speed. In addition, the module furnishes 32 digital I/O lines for time stamping, pattern recognition, and synchronizing external events. Two 32-bit counter/timers are available for testing applications, while 16-bit de-glitched DACs run at 500 kHz/channel for waveform generation. What's more, independent clocks and triggers offer maximum timing flexibility.

The DT9836S comes in two packaging configurations: a BNC connection box and an OEM version.

Base price: $2025. *Data Translation, www.datatranslation.com.*

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VIEWPOINT

[An exclusive interview with a technical leader]

MARK JAGIELA
President
Semiconductor Test Division
Teradyne
North Reading, MA

Mark Jagiela joined Teradyne in 1982 as a design engineer, developing image-sensor test systems. In 1989, he moved to Tokyo and served as GM of Teradyne's Japan Division. He returned to the US in 1999 as engineering manager for the VLSI Test Division in Agoura Hills, CA. In 2001, he became worldwide marketing manager of Teradyne's semiconductor test products, and in July 2003, he was promoted to president of the Semiconductor Test Division. Jagiela graduated from the University of Michigan with a BSEE.

Contributing editor Larry Maloney interviewed Mark Jagiela on new semiconductor test technologies at the Teradyne headquarters in North Reading, MA.

Strong rebound for semiconductor test

Q: How would you describe the business recovery in semiconductors?

A: Unlike in some sectors of the economy where recovery is somewhat muted, the rebound in electronics and semiconductors has been breathtaking. From the first quarter of 2009 to the first quarter 2010, Teradyne's product orders have grown by over tenfold. Our semiconductor customers need a lot of capacity, and their unit volumes are breaking records. It's a real sprint now for test equipment suppliers and our customers to get shipments to the point where they can meet this strong demand.

Q: What sectors of the semiconductor market show greatest demand?

A: Anything related to wireless communications is very robust. Another very healthy sector is automotive, where electronics content continues to grow with every model year. Anything related to analog, such as analog semiconductors for power management, also is surging. Sectors that are improving more slowly include solid-state image sensors for cameras, as well as semiconductors for PCs, which really did not fall off much during the recession. Business purchases of PCs, however, are starting to ramp up.

Q: What kinds of features do customers want in semiconductor testers?

A: Back in the '90s, equipment builders were chasing frequency. That's what our customers needed to test their new digital devices. That plateaued toward the end of the last decade, when customers began focusing more on the economics of test. We responded with equipment that enabled parallel test for SOCs [systems on a chip]. Today, parallel test for 8, 16, or 32 SOC devices has become the norm. We even see systems that can provide parallel test for 128 devices, in the case of microcontrollers. Customers also want enhanced software capability in test equipment to reduce the time and talent required to create and debug test programs. Today, software engineers make up a bigger portion of Teradyne's product development team than do hardware engineers.

Q: How are these features evident in Teradyne's new UltraFLEX-M tester for high-speed DRAM?

A: Its technology leverages our UltraFLEX platform for testing SOCs. Teradyne had been a high-speed DRAM test supplier in the '80s and '90s but got out of the business. When we decided to reenter the market, we had to bring something different to the party. DRAM test was one sector that was still chasing megahertz because of bandwidth concerns. The frequency needs for graphics and PC-based DRAM keep marching up. You go from DDR2 to DDR3 to DDR4, as well as similar classes of GDDR devices.

Our goal for the UltraFLEX-M was to deliver all the parallelism needed to economically test DRAM. But that was just for starters. We also needed the tester to perform at a frequency level that would allow it to be used not just for the current generation of DRAM—DDR3—but for DDR4 and for advanced graphics devices as well. These capabilities effectively doubled the asset life of the UltraFLEX-M introduced last fall, versus traditional DRAM testers.

Q: How have the acquisitions of Nextest and Eagle Test expanded the Teradyne product line?

A: If you drew a map of all the types of semiconductor devices, we have test equipment that covers the entire range—memories, SOC, digital, analog, and more. With Eagle Test's analog test capabilities and the high-volume, low-cost memory-test expertise we added from Nextest, we don't see a need for any major additions to our portfolio. Our goal now is to apply technology leverage within our own company to do a better job of serving customers. T&MW

Mark Jagiela answers more questions about new test systems and the recovery in semiconductors in the online version of this interview: www.tmworld.com/2010_09.

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