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Test & MEASUREMENT WORLD

THE MAGAZINE FOR QUALITY IN ELECTRONICS

Todd Marcucci, global lab manager at Littelfuse.

PROTECTION at FULL POWER

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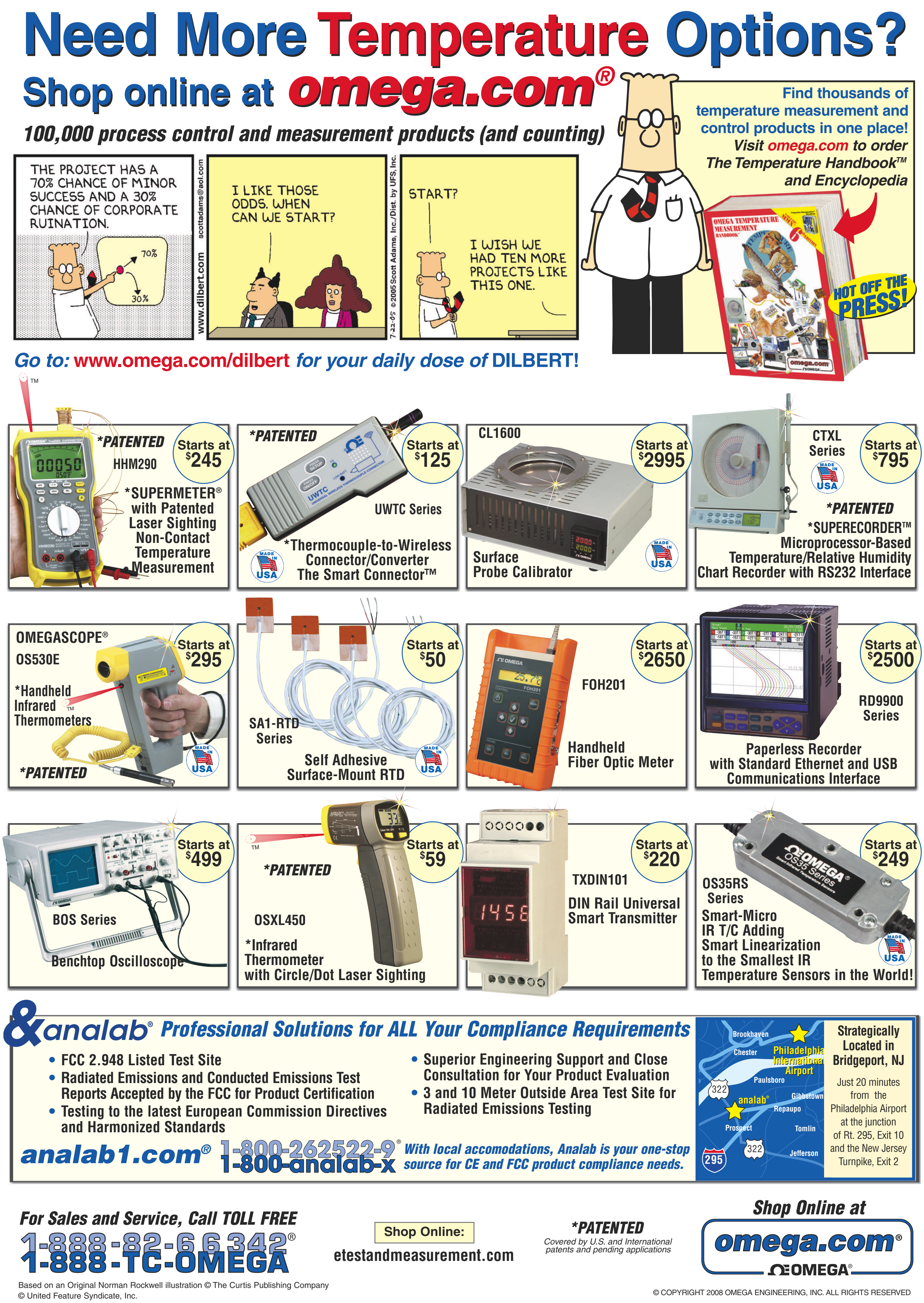

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Test and measurement giants

Senior technical editor Martin Rowe says that *Bill & Dave: How Hewlett and Packard Built the World's Greatest Company* is "a must read for anyone associated with Hewlett-Packard or Agilent Technologies—employees, alumni, customers, and competitors." Read the complete review and then share your Bill and Dave stories.

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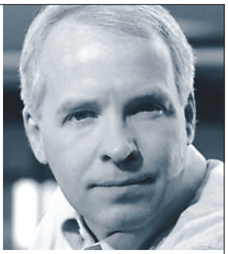
RICK NELSON
CHIEF EDITOR



Fractal engineering vs. synergy

Engineering is a segmented profession. It divides into high-level disciplines—mechanical, electrical, civil, chemical, structural, automotive, aerospace, and so on. When you look closely at these high-level disciplines and begin to break them down, you find—fractal like—that you don't make much headway in cutting down on the number of areas of engineering specialization available to you. Just as a fractal divides and repeatedly subdivides into components that appear to be as complex as the original, engineering disciplines divide and repeatedly subdivide into specialties of increasingly fine yet no less complex granularity.

It's quite appropriate that this be the case. Engineering is much too complex for any practitioner to become proficient in more than a very narrow number of specialization areas, and it's necessary to rely on teams made up of various specialists to cover all the facets necessary to get a product to market. Despite the emergence of electronic-system-level (ESL) design, it's difficult for register-transfer-level (RTL) designers, for example, to grasp all the complexities of the aerospace, medical, or automotive products that the integrated circuits they are designing might ultimately populate.

"The bottom line: Holistic is good."

Unfortunately, specialization often results in the formation of walls. The classic wall separates design and test, but even within test, walls arise that are counterproductive to cost-effective production of quality products. In this issue, I report on a wall that arises between two test disciplines (p. 16). Here's Glenn Woppman, president and CEO of Asset InterTech, when commenting on his firm's acquisition of International Test Technologies: "One thing we've found is another wall—hopefully not as high a wall—between structural test and functional test."

What's needed is a holistic approach toward our subject matter that can break down the walls between design and test and the various test subsets. And holistic approaches toward electrical engineering do exist. Here is Steve Wigley of the Semiconductor Test Consortium and LTX, writing at www.tmworld.com/guests: "the STIX initiative…dramatically increases the potential positive impact of the consortium on the semiconductor industry, by extending its influence beyond simply the tester architecture. It represents a more holistic approach to addressing the technical and economic issues that affect the entire global semiconductor test supply chain."

The bottom line: Holistic is good, but even the best efforts of today bring together only the most closely related fractal components of the electrical-engineering profession. And that brings up why I'm writing this. I've been writing and reporting for *Test & Measurement World* for nearly 10 years, most recently serving as Chief Editor. I'll be retaining that position while also taking on the responsibilities of *EDN* Editor in Chief. In that role, I'm rejoining the magazine at which I first got my start in technical journalism after leaving the engineering profession.

Going forward, the respective *EDN* and *T&MW* staffs will continue to focus on their specialties, but will also be concentrating on the synergetic intersections of their respective areas of expertise in an effort to bring you the information you need to succeed in this multifaceted world. As we move forward, I welcome your comments. Contact me at rnelson@reedbusiness.com. T&MW

> > > *POST YOUR COMMENTS AT WWW.TMWORLD.COM/BLOG.*

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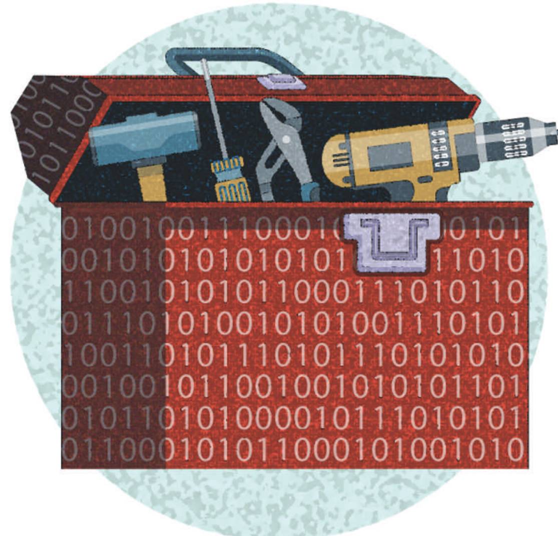
TESTVOICES

[An exclusive interview with a test engineer]

The software is most of the work

Todd Grey is a senior test engineer at Maxim Integrated Products in Dallas, TX. Though relatively new to Maxim, Grey has been a test engineer for more than 25 years. He supports production test in initial product runs on digital devices that contain simple microprocessors and EEPROM. The devices contain a one-wire communications interface and are used in printer cartridges and in ID devices. Senior technical editor Martin Rowe spoke to Grey by telephone.



DANIEL GUIDERA

Q: What are your major responsibilities?
A: I'm responsible for production test, which consists of helping designers understand how production test differs from simulation. I'm also responsible for reducing test costs and for supporting the production floor when problems arise.

Q: What do you teach designers about production test?
A: Our production ATE [automatic test equipment] forces us to operate devices using different clock speeds than the devices see in actual use. For example, suppose a device uses three clock domains. Each domain runs separately. But we test the devices with all clock domains generated from a single source. All domain clocks are multiples of the single clock source.

Our digital IC testers operate based on time slices. Simulations generate test vectors that tell you when to strobe a device or pin, and those times don't always align with the tester's clock. We often ask designers to run a simulation under the conditions the device will encounter while undergoing a test.

Q: How do you support production?
A: I develop the software for our ATE. I also design test fixtures that let us test devices both on the wafer and assembled into packages. I spend 95% of my test-development time writing code. The test code contains the test procedures and the tester's user interface that walks a technician through each test. My job also requires that I minimize the cost of test. Our devices typically have between two and eight pins and cost between $1 and $2 each. To minimize test costs, we use 64-pin digital IC testers rather than 512-pin or 1024-pin testers. We also perform reduced pin-count testing on devices while they're still on the wafer. We get about 60% to 80% test coverage while devices are still on the wafer. Then, we run a final test on packaged devices.

Q: How many devices are in a production run?
A: A typical initial production run in Dallas is about 5000 pieces. Full-scale production takes place in the Philippines. I spend about half of my time on the Dallas test floor. If a production test issue arises, I typically review the test procedure.

Q: What do you consider the most significant test challenges facing test engineers today?
A: Cultural differences in people around the world are a big challenge. At my previous employer, we had designers and test development in several countries. In other countries, Americans may be perceived as "pushy," particularly when it comes to schedules. Sometimes, people will tell you that they can deliver according to your schedule because they don't want to offend you by giving an honest answer. Americans need to explain to others that we appreciate an honest answer so that we can plan accordingly and be ready on schedule. Maxim keeps all test development in the US, so we don't see these cultural differences during development. But production is in the Philippines, so we run into it there. T&MW

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

NFL awards Anritsu spectrum analyzer contract

Anritsu announced it has been awarded a contract in excess of $500,000 by the National Football League (NFL) to supply the league with 36 MS2721B Spectrum Master handheld spectrum analyzers. The MS2721B spectrum analyzers will be used by the NFL's game day frequency coordinators (GDC) to research, troubleshoot, and analyze the RF spectrum at the league's 32 stadiums before, during, and after games.

The MS2721B units delivered to the NFL are configured with interference analysis and channel-scanner options to ensure that the GDCs efficiently coordinate the approximately 400 or more frequencies used at each stadium during a regular season NFL game. RF is used by team coaches to communicate with players on the field; by broadcast TV and radio entities; by medical teams; and by security and public-safety personnel.

"Wireless communications usage has increased greatly since the league first implemented GDCs at Super Bowl XXX," explained Jay Gerber, manager, NFL Frequency Organization Group. "We also had to consider the ever-shrinking RF spectrum as a result of digital TV and re-allocation of frequencies. Recognizing these factors, we wanted to provide our GDCs with the instruments they need to do the job effectively. The Anritsu MS2721B analyzer has proven to be a great tool to ensure they locate and resolve any RF conflict." www.us.anritsu.com.

NASA develops integrated signal and image-processing software

Engineers at NASA Glenn Research (Cleveland, OH) have developed the NDE Wave and Image Processor software and have made it available to US citizens. The software lets you perform analysis and processing operations on digitized waveforms, images, and series of images. It can extract specific information from signals and also help you predict or find defects in physical items.

As a signal processor, the software lets you analyze data in both the time and frequency domains. You can apply digital filters, calculate power, find timing delays, and remove noise from signals. As an image processor, the software lets you colorize, crop, and reorient images; denoise; enhance details; find edges of objects; and make measurements.

The NDE Wave and Image Processor also lets you perform wavelet analysis on signals and images. "The software brings wavelet processing into an interactive environment with its commercial-grade user interfaces," said developer Donald Roth. It comes with 40 standard wavelets that you can apply to signals and images. Help files show you how to apply wavelets.

While the software is in the public domain, it requires the National Instruments IMAQ Vision Run-Time 8.5 engine. When you download the software, you get the run-time engine, which you can use for 30 days. After that, you must purchase a license for $299 from NI. US citizens can obtain NDE Wave and Image Processor at technology.grc.nasa.gov/software.

Editors' CHOICE

Condition serial data signals

Transmission channels can easily distort 10-Gbps signals, making them unrecognizable to receivers, and transmitters often add pre-emphasis to the signals to overcome the transmission losses. The BertScope digital pre-emphasis processor (DPP) boosts or attenuates test signals at speeds from 1 Gbps to 12.5 Gbps. It attaches between a BertScope bit-error rate (BER) tester/oscilloscope and a transmission channel. You can use the DPP to test receivers on serial buses such as 10-Gbit Ethernet, Serial Attached SCSI (SAS), PCI Express, and DisplayPort. The DPP's input consists of a data stream from the BertScope and a clock. It combines the two and forms a data stream with an embedded clock.

The DPP conditions the amplitude of bits by as much as 1.8 V based on bit transitions. For example, the first bit in a stream may need a 1.6-V amplitude, where following bits need 800 mV. Then, when a bit changes from 0 to 1, the DPP will amplify the signal. A 1-to-0 bit change causes the DPP to decrease signal amplitude. The DPP uses three tapped FIR filters to amplify or attenuate signals. You can control the instrument through its USB interface.

Price: $39,000. *Synthesys Research, www.bertscope.com.*

New version of VHDL underway

Accellera has announced that its members and Board of Directors have approved the VHDL 4.0 standard specification, which refines VHDL 3.0 based on feedback from trial implementations. The organization plans to release the latest version of VHDL (Very High Speed Integrated Circuit [VHSIC] Hardware Description Language) to the IEEE for balloting in 2008.

Accellera reports that VHDL 4.0 addresses more than 90 issues that were discovered during the trial implementation period for version 3.0 of VHDL (which was approved in October 2006), including enhancements to generic types, Intellectual Property (IP) protection, property specification language (PSL) integration, VHPI (VHDL application programming interface) integration, and the introduction of fixed- and floating-point types.

Jim Lewis, chair of the VHDL Analysis and Standards Group (VASG) at the IEEE, commented, "The VASG has plans in place to bring Accellera's VHDL 4.0 to IEEE for balloting as IEEE 1076-2008. We are pleased that these VHDL language extensions and productivity enhancements are being standardized for industry adoption with Accellera's support." www.accellera.org.

CALENDAR

APEX and IPC Printed Circuits Expo, March 29–April 3, Las Vegas, NV. Sponsored by IPC, www.goipcshows.org.

SAE World Congress, April 14–17, Detroit, MI. Sponsored by the SAE, www.sae.org.

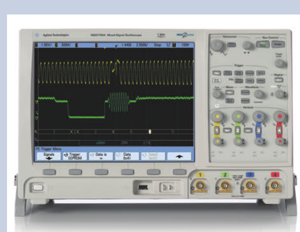
The Vision Show, June 10–12, Boston, MA. Sponsored by the Automated Imaging Association, www.machinevisiononline.org.

See our complete calendar at www.tmworld.com/events.

Editors' CHOICE

Mixed signals with fast updates

Agilent's MSO/DSO 7000 series moves the company into the tall and shallow oscilloscope field. The 10 models, five with 16 logic inputs, feature 12.1-in. displays in cases less than 7-in. deep. Dubbed "InfiniiVision," the oscilloscopes can update their screens at up to 100,000 times a second. The high update rate is possible because of a single field-programmable gate array (FPGA) that performs signal acquisition and processing.



The MSO/DSO 7000 oscilloscopes feature optional decode and triggers for popular communications buses such as RS-232, I²C, SPI, and CAN. Other optional applications include vector signal analysis, FPGA dynamic probing, power analysis, and segmented memory, which optimizes use of the instrument's acquisition memory.

Each model has 8 Msamples of acquisition memory for two channels. Four-channel models have 4 Msamples available for each pair of channels. Sample rates run up to 4 Gsamples/s depending on the model. Bandwidth ranges from 350 MHz to 1 GHz. You can upgrade any of the digital-signal oscilloscope (DSO) models to mixed-signal oscilloscopes (MSOs) by adding the 16 logic channels. Your total cost will be the same as a new MSO.

Base prices: two-channel, 350-MHz DSO—$6950; four-channel MSO—$17,900. *Agilent Technologies, www.agilent.com.*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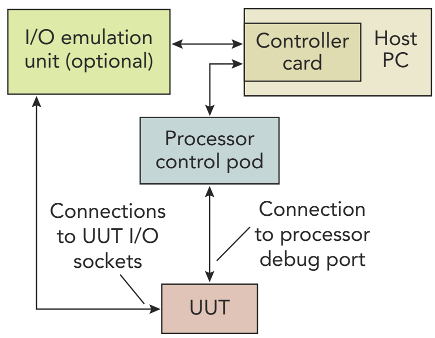
The wall between structural and functional test

Enlightened, multidisciplinary engineers may be dismantling the oft-decried wall between design and test, but some of the bricks that made up that wall may have been reassembled into a wall between two test disciplines: structural and functional test. Glenn Woppman, president and CEO of Asset InterTech, encountered that wall when Asset teamed up with International Test Technologies (ITT) in an effort to combine JTAG and CPU emulation test technologies. Efforts to dismantle that wall ultimately helped lead to Asset's December acquisition of ITT.

In a phone interview I conducted with Woppman and Billy Fenton, Asset's chief technologist for CPU emulation and former ITT CEO, Woppman commented that boundary scan has been widely adopted in the communications, networking, and telecom space and in the defense and avionics space. He said Asset originally pursued a partnership with ITT to take advantage of ITT's strength in the computer segment. "When we got our partnership together a few years back, we saw that Billy and ITT were real strong on the Intel architectures, and his tools had and still do have automated test-program generation."

Fenton concurred that 15-year-old ITT has had its main emphasis over the last decade on Intel x86 architectures. "In the earlier years, we were very much focused on the standard PC-type space. But in the last number of years, we've been involved, although still with the Intel x86 architecture, more in the embedded space. We also did support other processor types, which would be more prevalent in the mil-aero-telecoms-type space, and we had some success in those spaces, but certainly the computation space was where we were most successful."

Woppman noted that Asset and ITT share a common background in taking a non-intrusive approach in which test takes place through a JTAG port. The difference, he said, is that while Asset has



An integrated product platform employing a converged controller card supports JTAG structural and CPU-emulation-based functional test.

taken a more structural approach, ITT comes at it from a board functional level. It was their combined efforts to address customer needs that led them to discover the structural/functional test wall.

Fortunately, the wall turned out not to be very high for high-mix, low-volume manufacturers. When the Asset-ITT partnership proposed to engineers at those companies a combination of boundary-scan structural test and emulation functional test, Woppman said, "They tended to get it."

The wall, however, proved to be much higher for high-volume manufacturing. Woppman said that high-volume manufacturers tend to have teams dedicated to structural test only or functional test only, and, he said, if you try to introduce one test discipline to practitioners of the other, "They don't tend to get it."

He said that he expects, however, that the groups will learn to cooperate, and that ultimately Asset, ITT, their customers, and other test vendors can cooperate to develop single test stations. He said that fortunately, "The two groups who say 'I only do structural' and 'I only do functional' are beginning to talk." T&MW

Rising Micro Electronics selects LTX system

LTX has announced that Rising Micro Electronics (RME) has selected LTX's X-Series test system for testing of its 3G cellphone TD-SCDMA (time-division synchronous-code-division multiple access) transceivers and WCDMA transmitters and receivers. The Guangzhou, China, maker of RFICs used LTX's local applications-support resources to develop test programs and to facilitate test-program transfer to RME's subcontract test providers for production testing. www.ltx.com; www.rising-ic.com.

Plexus adopts Agilent 3-D x-ray system

Agilent Technologies and Plexus have announced that Plexus, a global electronic manufacturing services provider, has selected the Agilent Medalist x6000 automated 3-D x-ray inspection system as part of its test-and-inspection strategy for new products. "The addition of 3-D x-ray completes our portfolio of production test and inspection equipment," said Gary Simpson, engineering and manufacturing manager at Plexus. "This enhancement to our existing 2-D x-ray capability provides the automated solution we need to serve our customers," he added. www.agilent.com; www.plexus.com.

Pulse-Link chooses V93000 for UWB test

Verigy has announced that Pulse-Link has selected the Verigy V93000 as the preferred test platform for its CWave UWB devices. Verigy worked with DA-Test, a semiconductor test service provider, to propose and implement the solution for Pulse-Link's CWave UWB chipset. www.da-test.com; www.pulselink.net; www.verigy.com.

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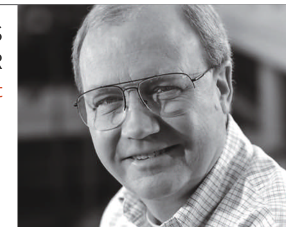
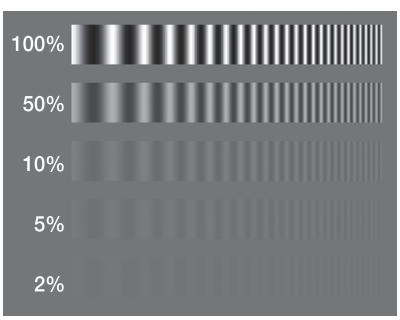


Take lens MTF into account

Many vision-system designers understand basic image-distortion effects and how to correct them, but they may need to account for the modulation transfer function (MTF) of a lens, too. The MTF describes how a lens affects contrast information and thus how "sharp" an image appears. So, if you plan to measure edge locations, part placements, or dimensions, pay attention to the MTF of the lens.

Tests that measure MTF use targets of alternating black and white lines at progressively smaller widths. Line "frequencies" may vary from a few lines per millimeter to hundreds of lines per millimeter. A perfect lens would pass this spatial-frequency information to an image sensor without distorting the contrast information. Thus, you would always measure an MTF of 100%, or a full-scale contrast difference between black and white lines.



These bands show how five MTF values affect images of the same black-to-white (b/w) pattern. Many tests use alternating b/w bars, but this test used b/w patterns created by a swept-sine function. Courtesy of Norman Koren.

Unfortunately, no one manufactures perfect lenses, so all images show some gray at a black-white transition. But wide lines still provide an MTF of 100% because the centers of the alternating lines appear pure black or pure white. As the lines get narrower, images lose contrast, and the black and white lines blur and appear grayer. Still-narrower black and white lines appear all gray, and you can no longer distinguish between them. Because no contrast information gets to the image sensor, the MTF now equals 0%. As an analogy, think of a swept square wave that passes through a low-pass filter. At low frequencies, the signal looks pretty good, but at high frequencies, the signal disappears.

Some lens suppliers provide plots of MTF values. A typical plot shows the MTF vs. spatial frequency at the center of an image (on axis). Some plots may show the relationship between the MTF and the distance from the lens' central axis. The MTF decreases as the off-axis distance increases. The lens aperture setting—its f stop—can affect the MTF, so you need to learn the test conditions that were used to create the MTF charts. When you look at MTF plots, make sure you know the units for the lines, or spatial-frequency, axis. Vendors will specify lines per millimeter or line-pairs per millimeter. Ten line pairs equals 20 lines. If you cannot obtain an MTF plot, run a program such as Imatest (www.imatest.com) that will perform MTF and many other lens and image tests.

According to the Luminous Landscape photography Web site (see "For Further Reading"), the larger the MTF value at 20 lines/mm, the better the contrast-reproduction capability of a lens. The larger the MTF value at 60 lines/mm, the better the lens' resolving power and subjective sharpness. Generally, a lens with an MTF above 80% at 20 lines/mm will produce an excellent image. Consider a lens with an MTF between 79% and 60% as just satisfactory. T&MW

FOR FURTHER READING

Koren, Norman, "Introduction to resolution and MTF curves." www.normankoren.com/Tutorials/MTF.html.

"Understanding MTF." luminous-landscape.com/tutorials/understanding-series/understanding-mtf.shtml.

IR light source covers broad spectrum

The MHAB-100 incandescent infrared light source from Moritex offers a broad light spectrum unachievable with LED light sources. The 100-W halogen light source delivers illuminance of up to 30,000 lux across the spectral region of 1000 nm to 1800 nm. The infrared light emitted by the MHAB-100 penetrates into or through materials, facilitating applications such as wafer alignment, MEMS inspection, solar panel inspection, and semiconductor device coaxial transmission observation. www.moritex.com.

Vision software available in trial version

Cognex is offering a free trial version of its VisionPro 5.0 machine-vision software, which the company says can be used to acquire data from any camera, including GigE Vision, FireWire, Camera Link, and high-speed analog models. The software's tools gauge, guide, identify, and inspect parts with repeatable results, despite variations in part appearance due to the manufacturing process. www.cognex.com/software.

Cyros named AIA president

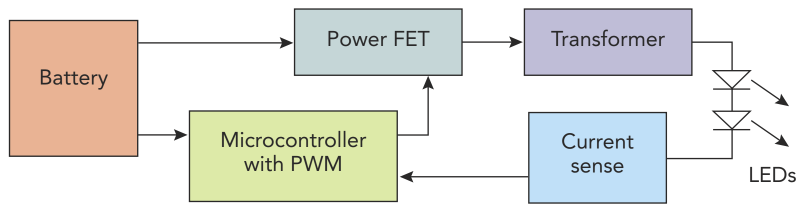
The Automated Imaging Association board of directors has elected Michael Cyros as its president. He succeeds John Merva, who served three years as president. Cyros, president of the North American subsidiary of Allied Vision Technologies, has served two terms on the AIA board. www.machinevisiononline.org.

WEBCAST

Oscilloscopes aid embedded designs

"Small adjustments in microcontroller firmware can produce significant improvements in embedded-system performance," says David Saar, president of Saar Associates, in the Webcast "Embedded design techniques for optimizing control parameters." In the Webcast, sponsored by Tektronix in conjunction with *Test & Measurement World* and *EDN* and presented live January 23, Saar describes how to use a mixed-signal oscilloscope to select the right values for parameters such as gains, offsets, delays, hysteresis values, and pulse-width-modulation (PWM) parameters in embedded systems. In particular, Saar notes that a mixed-signal scope with deep memory can often gather necessary measurement data in a single acquisition.

Saar provides specific application examples, including that of a high-brightness LED power system (**figure**) that controls brightness by means of a microcontroller-based PWM controller. He describes how to use a mixed-signal scope to monitor the gate of the controller's power transistor as well as analog levels such as power-transistor drain voltage, LED voltage, and LED current. Saar also describes how to correlate microcontroller program execution with measured results by inserting a temporary marker in the microcontroller's software. He further describes how to use the observed data to choose an optimum hysteresis level that minimizes ripple.



An embedded controller in an LED power system yields its operational secrets to a mixed-signal oscilloscope.

Other examples presented in the Webcast include a battery-powered stepper-motor controller, for which Saar explains how to determine optimum step delays for normal operation and for operation near the end of battery life. He also presents an ultrasonic range detector, for which he shows how to determine optimum gain settings and optimum transmitter voltage and frequency.

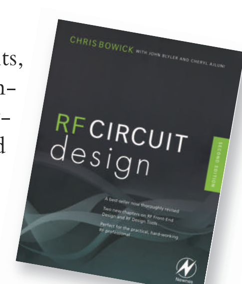
To see detailed information on these three examples, you can view the archived Webcast at www.tmworld.com/webcasts.

Rick Nelson, Chief Editor

BOOK REVIEW

RF book's new edition adds EDA tools, skips test

RF Circuit Design, 2nd ed., by Chris Bowick with John Blyler and Cheryl Ajluni, Newnes (www.newnespress.com), 2008. 256 pages. $44.95.



In *RF Circuit Design, 2nd ed.*, John Blyler and Cheryl Ajluni have updated Chris Bowick's 1982 edition to accommodate changes that have occurred over the last 26 years. Part handbook and part textbook, the book introduces basic concepts but quickly relates them to real-world components like thin-film resistors, chip and ceramic capacitors, chip inductors, and toroidal core inductors. Sample data sheets throughout the book keep the theory grounded in real-world engineering concerns. Topics covered include resonant circuits, filters, impedance matching, small-signal and power-amplifier design, and RF front-end design.

A significant addition to the second edition is a chapter on RF design tools that covers schematic capture, place and route, simulation, and verification. The chapter describes various flavors of hardware description languages, including VHDL-RF/MW—the HDL extension that supports RF and microwave designs with extensions that support finite-element modeling (FEM), frequency-domain modeling, nonlumped circuit elements, and parasitics.

The RF design tools chapter provides design examples using tools like the Mathworks' Matlab/RF Toolbox, Agilent Technologies' Advanced Design System (ADS), Mentor Graphics' Board Station RE placement-and-routing tool and Eldo RF simulator, Cadence Design Systems' RF Design Methodology kit, FTL Systems' Auriga modeling and verification tool, and Applied Wave Research's Visual System Simulator (VSS). In addition, the chapter describes the RF design flow at foundry UMC, presents RFIC simulation examples involving a WLAN receiver and a downconverter, and presents a case study of a system-level transceiver design.

One thing this new edition doesn't cover is the last 26 years' worth of innovations in the RF and microwave instrumentation that you'll need to take advantage of to make sure your RF designs work. For that, you'll need to maintain your subscription to *Test & Measurement World*. (Disclosure: The book's publisher is owned by *T&MW*'s parent company.)

Rick Nelson, Chief Editor

COMPLIANCE

IPC prefers devil it doesn't know

IPC in January urged the European Commission not to expand the scope of its RoHS directive. In fact, the organization went so far as say that "substance restrictions beyond RoHS would more appropriately be addressed under the current REACH [see "The devil in the acronyms"] directive to avoid unnecessary confusion and regulatory overlaps," as Fern Abrams, director of government relations and environmental policy for the IPC, put it in a January 10 letter to the Commission.

In a February 5 posting at EDN.com, Abrams elaborates on IPC's position, but first wonders, "Is advocating REACH over RoHS akin to dealing with the devil....Or has IPC, in advocating regulation under REACH over RoHS, failed to heed the old adage, 'better the devil you know than the devil you don't?'"

Abrams acknowledges that REACH is big, complex, and potentially costly to implement, addressing as it does SVHCs as well as CMR, PBT, and vPvB substances. But, she writes, "perhaps there is something to be said for complexity. After all, the RoHS regulation was brief and to the point. So brief that it left many wondering what it required and how to implement it.... REACH, on the other hand, spells everything out. We may not like the process, but at least there is a process."

She concludes, "Clearly, REACH is not a model regulation that IPC would like to see replicated. But,...substances in the REACH process will not be banned without careful consideration of the full societal impact, which is more than can be said of RoHS."

See the online version of this article at www.tmworld.com/2008_03 for links to Abram's EDN.com post as well as to her January 10 letter to the European Commission.

Rick Nelson, Chief Editor

The devil in the acronyms

CMR: carcinogenic, mutagenic, or reprotoxic (toxic to reproduction)

PBT: persistent, bioaccumulative, and toxic

REACH: registration, evaluation, and authorization of chemicals

RoHS: restriction on hazardous substances

SVHC: substance of very high concern

vPvB: very persistent and very bioaccumulative

RF TEST

Calibrated radio

DEVICE UNDER TEST
Radio transmitter and receiver cards used in wireless communications. The cards, which are placed in an antenna module that mounts on towers, operate at frequencies from 6 GHz to 11 GHz.

THE CHALLENGE
Calibrate transmitters and receivers over three frequency bands to ensure the cards have the correct output power with minimal spurious noise and receive level. Conduct exhaustive performance tests.

THE TOOLS
- Agilent Technologies: digital multimeter, DC power supply, RF spectrum analyzer, RF signal generator. www.tm.agilent.com.
- Averna: test-management software. www.proligent.com.
- Marconi (now Aeroflex): RF signal generator. www.aeroflex.com.
- National Instruments: graphical programming language, test executive. www.ni.com.
- Rohde & Schwarz: RF power meter. www.rohde-schwarz.com.
- Xantrex Technology: DC power supply. www.xantrex.com.

PROJECT DESCRIPTION

A manufacturer of transmitters and receivers of digitally modulated signals needed to reduce test time because the cards require calibration during production test. Test-system integrator Averna (www.averna.com) built eight production test systems for the cards.

RF transmitters require calibration for them to produce specified output power across their frequency range. Prior to implementation of the new test systems, a technician would need 4 to 5 hr to calibrate a transmitter/receiver pair. Now, the calibration and test time is about 20 min.

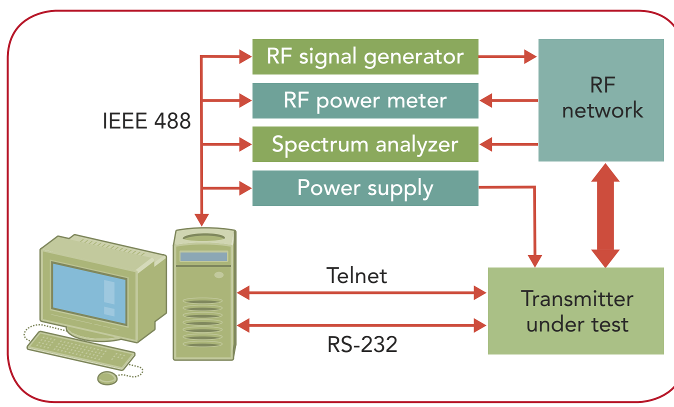
The test stations calibrate transmitter cards for gain, output power, modulation, offset, and balance over the 6–7 GHz, 7–8 GHz, and 10–11 GHz bands. Transmitter frequency and power level is set in software and sent to the transmitter through a Telnet interface.

To calibrate the transmitter's RF power, the software sets the card's signal attenuator to nominal. An RF power meter (**figure**) measures the output power. Based on the measurement, the software adjusts the transmitter's power by changing the output of a digital-to-analog converter (DAC) that drives the transmitter's power amplifier until the power is within tolerance. The DAC's output value must change with frequency to compensate for frequency-dependent losses. The test repeats across the specified frequency band until the output power is within tolerance across the band. (An RF signal generator provides a 19.44-MHz reference frequency.)

The system adjusts the transmitter's gain by adjusting the attenuator—this adjustment prevents overloading of the power amplifier. The final calibration adjusts the transmitter's phase imbalance to minimize spurious noise. Gain and phase-imbalance calibrations minimize signal output errors. The test system stores all settings in the transmitter's flash memory.

The card's receiver needs attenuator calibration, RF and IF filter calibration, and received signal strength indication (RSSI) testing. An RF synthesizer and I/Q modulator provide the input signals to the receiver. Filter calibration ensures that the maximum signal strength reaches the receiver's detector circuits. The software polls each unit under test (UUT) to get RSSI data on received signal power. (The online version of this article contains a diagram of the receiver test station and the software architecture: www.tmworld.com/2008_03.)

A graphical programming language handles all communication among the host PC, the instruments, and the UUT. A test executive lets technicians select tests, and it provides a user interface. A test-management platform works with the test executive to retrieve test results and make them available to engineers and to management.



An automated test system calibrates RF transmitters used in wireless communications.

LESSONS LEARNED

Averna software engineer Alex Pelland likes the Telnet interface because it provides standardized handshaking with the UUT that's built into the protocol. He also prefers a structured approach to software development. "The architecture accelerates and simplifies the introduction of new models or options," he said. "We have implemented generic drivers and we can set each driver to configure the test equipment for a specific UUT. We tried to avoid hardcoded parameters wherever possible."

Martin Rowe, Senior Technical Editor

PROTECTION at FULL POWER

To ensure their components protect your circuits, Littelfuse engineers may damage or destroy their parts, sometimes in spectacular fashion.

BY MARTIN ROWE, SENIOR TECHNICAL EDITOR

LANE CAMERON

DES PLAINES, IL—Protecting circuits may not be at the forefront of every design engineer's mind, but it is paramount in the minds of Littelfuse engineers. The 80-year-old company manufactures fuses, gas-plasma arresters (also called gas-plasma tubes or GDTs), varistors, thyristors, electrostatic discharge (ESD) suppressors, positive temperature coefficient (PTC) devices, and diodes that protect sensitive electronic circuits, building wiring, and everything in between. While Littelfuse has some 27 facilities worldwide, product evaluations take place at technical centers in Des Plaines; Irving, TX; and Wuxi, China. At these facilities, engineers subject components to excessive current, lightning, ESD, overvoltage, and extreme temperatures. The electrical stresses range from a few volts and amperes to the thousands of both, depending on a product's specifications.

Global lab manager Todd Marcucci, based in the Irving facility, was on hand for my Des Plaines visit. "Our labs support product development and customers in the company's three main business units: electronic, automotive, and industrial-power applications," he explained. "In addition, we help customers achieve standards certifications and other design requirements of their products." Marcucci oversees the operations at all three technical centers.

In Irving, engineers who test the company's semiconductor products perform environmental tests, semiconductor parametric tests, ESD tests, and lightning tests. They also measure high-frequency characteristics such as S-parameters, bit-error rate, capacitance, and impedance, and they perform time-domain reflectometry. In China, engineers perform semi-

< Todd Marcucci oversees test labs in Illinois, Texas, and China.

conductor parametric testing, environmental testing, ESD testing, and failure analysis.


LANE CAMERON

Roberto Marquez supervises engineers and technicians in the high-power lab.

Heavy duty

The Des Plaines facility houses a high-power lab, a medium-power lab, and a product-evaluation lab in an area covering 6000 ft^2. The high-power lab boasts its own electrical generator that can deliver more than 11,500 V and 50,000 A to large fuses and other devices. Because the devices may explode when subjected to that much energy, they reside in a separate room during the tests to keep engineers and technicians safe.

Figure 1 shows a simplified diagram of the high-power lab, which was built in 1984. The electric utility company supplies 12,000 V that drive a motor, which turns a generator that electrically isolates the system from the power grid for safety. Another room houses the secondary transformer and a resistor/inductor bank that lets engineers create the desired voltage, current, and power factor. The bank can deliver more than 1000 kVA to the fuse under test. A rectifier converts the AC power to DC when needed.

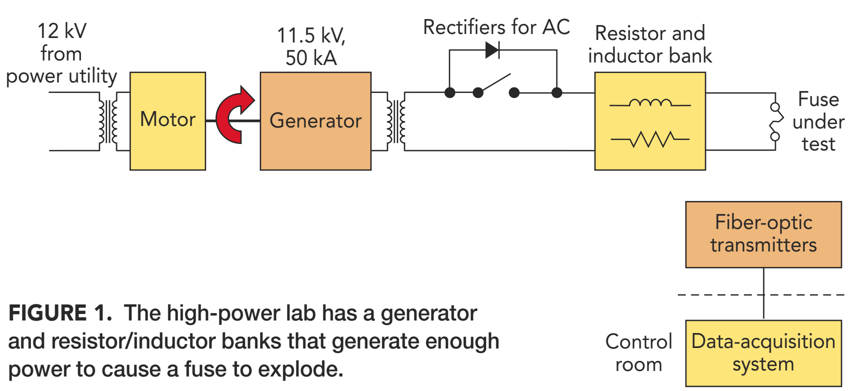


FIGURE 1. The high-power lab has a generator and resistor/inductor banks that generate enough power to cause a fuse to explode.

Engineers, including power lab supervisor Roberto Marquez, perform overload tests and short-circuit tests on fuses. After selecting the desired resistors and inductors for a test circuit, Marquez and his team of engineers and technicians will perform an open-circuit test to verify that the device under test (DUT) will receive the correct voltage. Fiber-optic transmitters from LeCroy produce light with an intensity that is proportional to voltage, and they deliver that signal to a Nicolet data-acquisition system in the control room. From there, digitized signals go to computers for waveform analysis and storage.

Next, technicians install a bus bar across the test circuit's terminals and measure the current by measuring the voltage across a calibrated shunt. Fiber-optic transmitters also send a signal proportional to current to the control room. After removing the bus bar, technicians install the fuse under test onto the circuit. Switches controlled by operator buttons on a panel in the control room deliver current to the fuse.

The engineers perform an overload test by first running current through the fuse under test for up to several minutes. This current is supplied from another source, because using the generator will cause the resistors and inductors in the bank to overheat and become damaged.

For this test, engineers apply 200% of rated current through the fuse, but at a low voltage. "We monitor for voltage across the fuse, and when the voltage starts to increase, indicating that the fuse is starting to open, we apply the fuse's rated voltage across it," said Marquez. "A switch disconnects the current from the low-voltage current source and connects the high voltage, high current from the generator to the fuse under test." The amount of current through the fuse is the same both before and after the switchover, but the voltage greatly increases.

To give me an idea of how much energy is involved, a technician connected a 10-gauge solid wire across the test terminals and applied 32,000 A at 600 V through the wire. The result: The wire vaporized with an explosion followed by a puff of smoke. (You can watch a 5-s video of this event in the online version of this article at www.tmworld.com/2008_03.)

The high-power lab houses a surge generator that emulates lightning surges on AC mains lines and telephone lines. A Hipotronics high-voltage power supply generates 100 kV at 50 mA DC. It also generates pulses of 100 kA at 75 kV. The 100-kA, 75-kV pulse has a rise time of 8 µs and a fall time of 20 µs (from 10% to 90% of peak current). The power supply contains a bank of twenty-eight 1-µF charging capacitors, each the size of a cinder block, that discharge through a switch. A grounded silver ball sits atop each capacitor to prevent arcing among the capacitors at the high voltages. A 1-Ω resistor, 18 in. long, completes the circuit and produces the desired wave shape.

"We calibrate the surge tester by measuring the open-circuit voltage and

short-circuit current for each discharge," said Marcucci. For the short-circuit current measurements, engineers measure current with a current probe from Pearson Electronics that connects to a Tektronix oscilloscope.

In the medium-power lab, engineers test devices such as automotive fuses, GDTs, varistors, PTCs, and electronic fuses. "Medium power" at Littelfuse is high power at most companies. Engineers can test devices with up to 500 A at voltages from 10 V to 480 V. At 60 A, engineers can apply up to 600 V to a device. To test the devices, engineers mount them on printed-circuit boards (PCBs) that connect the devices in series. A power supply then provides power to the devices. Parts that don't mount on PCBs may be connected with wires.

FIGURE 2. Automotive fuses, such as these in blade packages, undergo life tests that last 100 hr.

Because of the power levels generated in the high-power and medium-power labs, Littelfuse engineers have designed the facilities for safe operation. Relays isolate the power until engineers and technicians can safely operate the equipment. "We have interlocks on everything," said Marcucci. For example, DUTs are tested in chambers, and interlocks prevent power from being applied to a part while a chamber door is open.

High-power and medium-power tests let engineers evaluate products for their circuit-protection abilities, which relates to product safety. Many Littelfuse customers require this testing to obtain safety certifications from Underwriters Laboratories (UL). UL engineers often come to Littelfuse to witness tests. "We have a very good relationship with UL," said product-evaluation lab manager Dave Shuemaker. "UL is here at least once a week," added Marquez.

UL engineers may also witness tests in the product-evaluation lab, where engineers perform numerous electrical and environmental tests. Constant-current DC power supplies (built in-house) provide current ranging from 2 A at 150 V to 1000 A at 20 V. Engineers use these supplies to run overload (opening time) tests, current-carrying capacity (life) tests, temperature-rise tests, and voltage-drop tests. "Typically, half of the products in an evaluation lot receive destructive testing, while the other half receive evaluation testing," said Shuemaker. "Design engineers come to the lab after they've completed initial testing."

LANE CAMERON

Dave Shuemaker manages engineers and technicians in the product-evaluation lab, where parts undergo a wide range of functional and environmental tests.

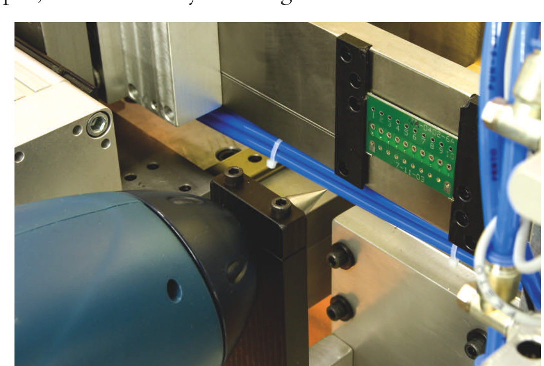
Product evaluations

To run a life test on an automotive fuse (**Figure 2**), a technician will connect 12 or 24 parts in series, then pump 110% of the fuse's rated current through the device. (The customer specifies if the test should use 12 or 24 fuses.) This test will run for 100 hr, after which engineers will evaluate the fuses for resistance. On some electronic fuses, engineers will run long-term reliability tests at 75% of rated current for one year.

In a temperature-rise test, engineers test fuses by running them at 100% of their rated current. Thermocouples mounted to each device connect to an Agilent Technologies data-acquisition system, which records the temperatures.

Environmental chambers from Thermotron, Blue M, Webber, and Espec let engineers run elevated ambient-life tests at temperatures ranging from –73°C to 343°C and let them perform humidity, moisture-resistance, accelerated aging, and whisker tests (for lead-free components) on devices from 10% RH to 98% RH at temperatures up to 180°C. The engineers also use the chambers to perform thermal-shock tests (per MIL-STD-202) from –70°C to 200°C.

"A typical thermal-shock test is –65°C to 125°C," said Shuemaker. "We typically run that test for 15- or 30-minute cycles, while changing the devices temperature in just a few seconds. Dampers in the chamber alternately blow hot and cold air on the devices."



LANE CAMERON

FIGURE 3. An ESD simulator tests ESD suppressors in an automated tester that moves the parts into place.

Littelfuse also has thermal chambers that move devices among room-temperature, hot, and cold zones. For semiconductor devices, the company's engineers may simply alternate parts between baths of ice water and boiling water.

(continued)

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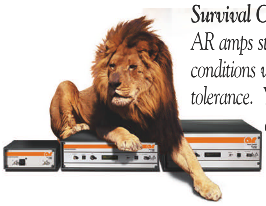

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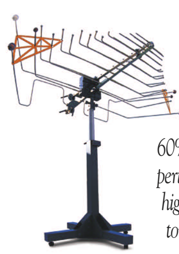

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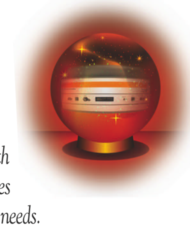

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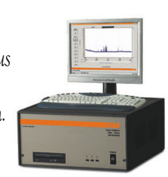

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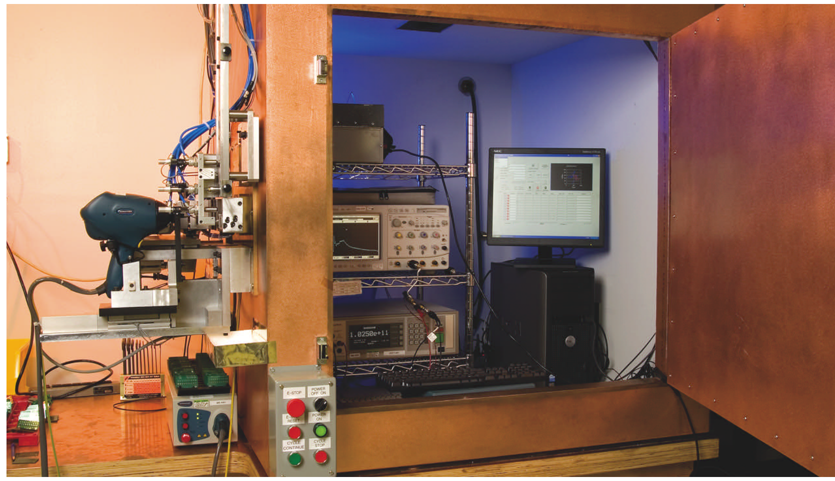


LANE CAMERON

FIGURE 4. A shielded RF enclosure prevents electromagnetic (EM) fields generated by the ESD simulator from affecting test equipment.

Shuemaker mentioned that a military customer recently requested that devices be monitored for continuity during a thermal-shock test. For this test, the chamber that uses dampers to blow in hot or cold air works best because the parts don't move. "If continuity breaks," he said, "we stop the test. It's purpose is to prove that our parts don't have cold solder joints." An Agilent data-acquisition system measures resistance of the DUTs while they are in the chamber.

A technician connects all of the 144 fuses in a series using fixtures that hold up to 10 parts. A digital multimeter (DMM) measures the continuity of each fixture. "At first, the customer wanted us to monitor every part," said Shuemaker, "but that takes a technician a long time to connect wire to the parts."

After Littelfuse gained the confidence of the customer, engineers changed to monitoring each fixture as a whole rather than wiring every part. Shuemaker noted that after six months of testing the parts, only one loss of continuity was detected, and it was because of a wire break in the test fixture. No parts have failed.

Because so many electronic components are now made with lead-free solder, Littelfuse engineers must evaluate the effects of lead-free solder reflow techniques on their components. Reflow ovens in Des Plaines subject PCBs containing Littelfuse components to air temperatures up to 310°C (board temperature to 265°C).

Littelfuse components must also withstand shock and vibration tests. The company's engineers subject components to half-sine and sawtooth vibration waveforms and 100-Hz sinusoidal vibration per MIL-STD-202. Shock tests can inflict up to 1500 g of force on a part.

Electrical stress

The Littelfuse engineers also test components for electrical surge and ESD. Components designed to protect AC mains lines and telecom products must pass surge tests. A lightning test system from Thermo Keytek subjects devices to waveforms required by standards such as FCC 47 Part 68 and Telcordia GR 1089 (for telecom circuit protection) and IEC 61000-4-5 (surge immunity for everything else).

Littelfuse also manufactures ESD suppressors in surface-mount packages with sizes as small as 0.04x0.02 in. (called "0402" packages). The product-evaluation lab contains a room where engineers such as Pete Pytlik evaluate ESD suppressors to see how well they withstand repeated pulses.

Pytlik developed an automated ESD tester that consists of a Schaffner ESD simulator. Using air discharges, the automated tester tests devices mounted on PCBs, up to 10 parts per board. The system can hold as many as 24 loaded boards. A motorized handler aligns each device to the tip of the ESD simulator where pneumatics move the ESD simulator tip to the device (**Figure 3**). The online version of this article contains a link to a video of the ESD tester in operation: www.tmworld.com/2008_03.

Each device may be subjected to up to 1000 pulses before the ESD simulator retracts and the handler positions the next device for a test. At 1000 pulses per

device, the system takes 5 hr to test 10 devices. Testing 24 boards worth of parts can take a week.

The ESD test system also consists of a 4-GHz Agilent oscilloscope and a QuadTech megohmmeter/insulation-resistance tester. The oscilloscope monitors the ESD waveform while the megohmmeter measures the DUT's resistance after the ESD simulator subjects the DUT to pulses. Resistance data on each part is stored in a SQL database. RF switches connect the 100X oscilloscope probes to the DUT.

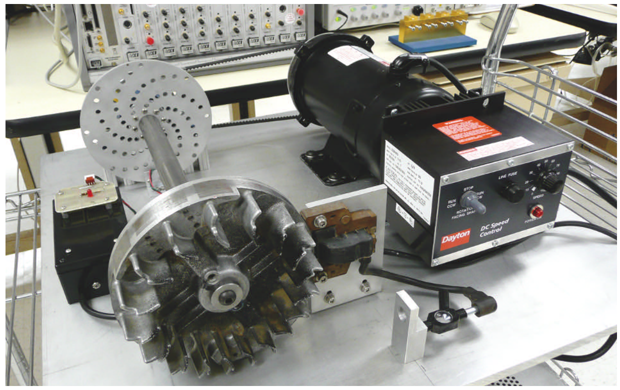


FIGURE 5. A custom tester simulates the rotations of a small engine for testing SCRs and thyristors.

Both the oscilloscope and megohmmeter reside in a Lindgren RF enclosure that acts as a Faraday cage (**Figure 4**), shielding test equipment from the broadband electromagnetic waves produced by the ESD pulses. "I don't understand how anyone can do ESD testing without a Faraday cage," commented Pytlik. "The pulses create EM fields that can affect the instruments. You can see the signal when you open the chamber door."

Marcucci also noted that Littelfuse engineers sometimes build custom testers. One such system tests silicon-controlled rectifiers (SCRs) and thyristors for a customer that supplies electronics to a company that makes small engines (**Figure 5**). A DC motor with a variable-speed control lets technicians dial in the required speed of the attached standard flywheel assembly. A Hall-effect sensor produces a pulse for each revolution to verify the exact speed on a scope. A modified ignition coil facilitates the monitoring of the coil's trigger and ignition pulses, and a fixture lets technicians insert devices to test.

The Des Plaines testing labs, and those in Texas and China, let engineers and technicians subject Littelfuse devices to a wide range of electrical and environmental stresses. Because Littelfuse devices protect circuits of all sizes, engineers must evaluate the parts using a wide range of electrical conditions that range from just a few volts and amps to thousands. All that testing produces parts that safeguard your circuits. T&MW

NONSIGNALING TECHNIQUE IMPROVES RF TEST

A new approach eliminates the need for real-time emulation of base-station or network functions during wireless-device production testing to speed the alignment process.

BY HENRY GROPP,
ROHDE & SCHWARZ

Many wireless devices now combine GSM, WCDMA, Bluetooth, WLAN, GPS, and FM technologies while also operating at the high data rates required for mobile Internet. And because customers demand that mobile radio service be available on any continent, many devices also operate in multifrequency bands and support multimode operation.

While all these features are great for the customer, they create challenges for the test engineer. Each additional technology and frequency band that is added increases the test effort, leading to longer alignment times in production—clearly an impediment for meeting demands for low-priced products. Cost containment requires that manufacturers adopt completely new test approaches. Fortunately, nonsignaling test concepts and predefined test sequences can reduce test time by up to a factor of 10.

Two-step approach aligns RF devices

RF chips and components that are manufactured under cost-saving measures exhibit variations in their frequency and level characteristics. To ensure that the devices will function properly in a real network, manufacturers use complex alignment procedures during production to eliminate the variations. Most manufacturers prefer a two-step approach for this purpose (**Figure 1**):

- The first step involves measuring how much the actual transmit and receive parameters of a wireless device deviate from their ideal values. The correction values are then determined and stored in the device. In most cases, this requires the manufacturer to calibrate the transmit power stages and the receive signal strength indication (RSSI) for various mobile radio bands and technologies.
- The second step involves verifying that the fully calibrated device works as intended. The manufacturer measures transmit parameters such as modulation quality, spectrum, and power and compares them with the parameters for the technology for

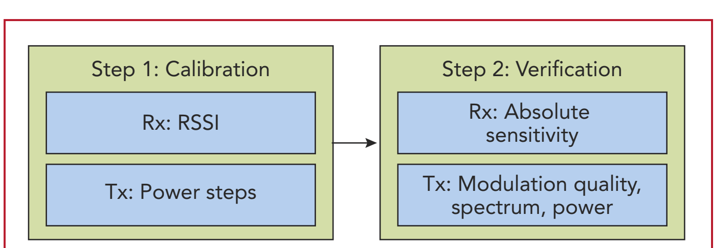


FIGURE 1. Typical steps in the production of wireless devices involve, first, measuring the deviations of the actual transmit and receive parameters from their ideal values, and second, checking the fully calibrated device.

which the device is designed (GSM, Bluetooth, WLAN, etc.). In most cases, the absolute sensitivity of the receiver is determined by means of a bit-error-ratio (BER) test.

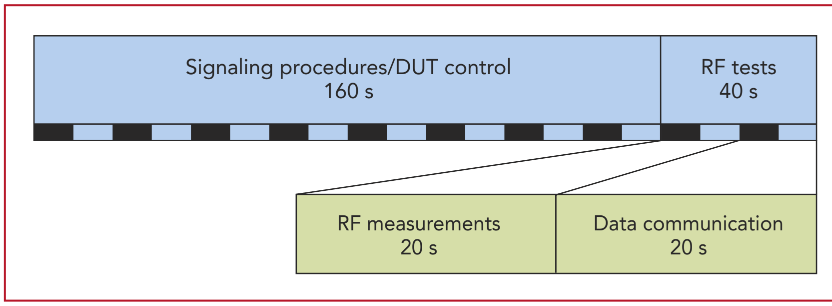


FIGURE 2. The signaling sequences for driving a GSM/GPRS/WCDMA mobile phone typically require 160 s; RF tests add another 40 s.

Using the nonsignaling concept

Because each additional technology and each additionally supported frequency band prolongs the two-step test alignment process, some manufacturers are turning to approaches that involve nonsignaling techniques for aligning wireless devices. In such an approach, the first step—the calibration step—is carried out in a nonsignaling mode in which the device under test (DUT) is operated in a special test mode. The measuring equipment includes RF analyzer and generator functions but does not perform real-time emulation of base-station or network functions. The wireless device is not yet aligned and therefore does not yet perform as it will in later network operation.

In the second test step, verification is carried out by means of the signaling mode. In this mode, the tester simulates various functions of the base station and of the network in real time. Signaling procedures are used in the wireless device to switch through all the technologies, bands, levels, and so on, to be tested.

It is the second step—the verification step—that offers the potential for sizeable savings, since the signaling, as compared to the RF measurements alone, takes up to four times longer. The main reason for this difference is that signaling procedures were actually developed for real network operation, not for extremely fast production test. In contrast, the nonsignaling mode is the test mode that is especially speed-optimized for production. As a result, the DUT can quickly activate the required test signals (level, frequencies, technologies).

The signaling sequences for driving a GSM/GPRS/WCDMA mobile phone typically require 160 s (**Figure 2**). When you also add in the RF tests, the time is typically increased by a further 40 s. In the classic signaling method, the alignment can thus typically be expected to take 200 s. If you use the nonsignaling approach, the DUT could be aligned in 40 s—a time savings as high as 80%. Communications testers like our R&S CMW500 employ a nonsignaling technique for both steps.

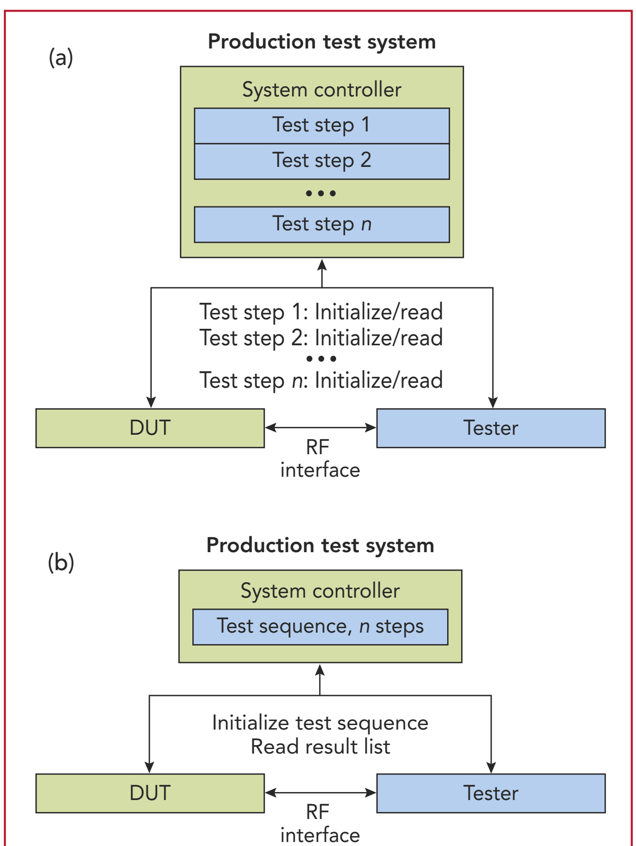


FIGURE 3. (a) Test has typically been carried out one measurement at a time, with reinitialization of the DUT and tester required after each step. (b) Predefined test sequences allow test results to be accumulated and transferred to a system controller all at once.

Predefined test sequences reduce data communications

At Rohde & Schwarz, our analyses of test times in the nonsignaling mode have shown that a further increase in the speed of the individual RF measurements does not necessarily lead to a drastic reduction in alignment time. Many radio communication testers already attain a high measurement speed at which they measure GSM signals in real time, for example, so they can carry out a modulation analysis on one time slot for each GSM frame without any problem. Thus, the largest potential for improvement in data transmission is found within the production test system itself.

At present, the most commonly applied test concept is to carry out individual measurements one at a time. The system controller requests each measurement separately—that is, both the DUT and the tester are reinitialized at each test step (**Figure 3**). At the end of each single measurement, the result obtained is returned to the system controller from the tester.

Because production systems must be able to handle not only the measurements themselves but also diverse tasks such as driving the test fixture, their control software consists of many layers that must be

traversed from top to bottom and back again for each test step. This is a time-consuming process that creates a bottleneck.

To shorten the cycle, mobile communications testers with a nonsignaling mode make use of predefined test sequences instead of single measurements. First, the complete sequence of all tests to be carried out is transferred from the system controller to the DUT and tester in one operation. After receiving a start trigger, the DUT and the tester process the sequence simultaneously. The DUT activates the signals to be measured, and the tester starts the appropriate measurements in sync. The results are stored in transient memory. At the end of the sequence, the list of all results is transferred to the system controller.

Therefore, the software layer structure must only be traversed a total of two times: once from top to bottom for initialization and then back again in order to transmit the list of results. This approach allows a further 50% reduction in test time in the nonsignaling mode.

In the past, chipset and wireless device manufacturers focused on customizing their solutions to meet the end customer's requirements. New features such as higher data rates, better ease of operation, and smaller dimensions should offer a more attractive solution.

To implement the test modes that must be used for nonsignaling production concepts, chip designers must include special test modes on their devices. For established technologies such as GSM and WCDMA, fulfilling this task should not be any problem. The extra development effort will quickly pay for itself.

New technologies such as LTE, however, represent a notable challenge. To ensure they present a stable and functioning solution to the customer on schedule at rollout, manufacturers use a production test setup that matches how the device will operate in a real network as precisely as possible. As a result, signaling concepts are employed for new product designs. Measuring equipment that employs nonsignaling techniques must, therefore, be able to accommodate signaling tests as necessary.

It is possible for the test time in wireless device production to be reduced by a factor of up to 10. For this to happen, chipset manufacturers must integrate the required test modes, and the production line must incorporate a tester with a nonsignaling mode and predefined test sequences. T&MW

Henry Gropp *has been product manager for mobile radio testers at Rohde & Schwarz in Munich since 1997. His main tasks are product definition and marketing of mobile radio test assemblies. After earning a degree in avionics with emphasis on communications/navigation from Riga Aviation University in 1989, he worked in test equipment development at the Dresden Aircraft Factory. From 1993 to 1997, he served mobile radio customers as a sales engineer at Rohde & Schwarz.*

NOMADIC PRODUCTS PUT POWER SOURCES TO THE TEST

Power sources substituting for batteries must respond unlike conventional supplies.

BY ALEX MENDELSOHN, CONTRIBUTING TECHNICAL EDITOR

Cellphones and other wireless communications devices can be difficult to test because of the dynamic requirements they place on their batteries. To conserve power, these devices rapidly switch into high-power operation and then drop back into lower-power idle, power-down, or hibernation sleep modes. As a result, the power sources that substitute for batteries during test and evaluation need features that often aren't available in general-purpose supplies.

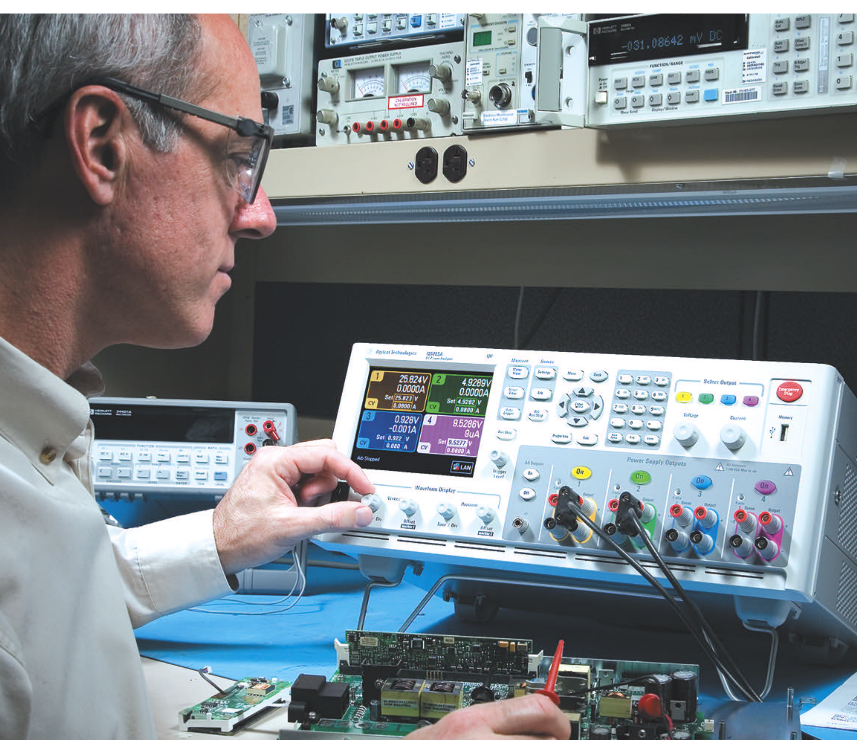
Laboratory power supplies can act as substitutes for electrochemical power sources during tests, but because battery-charger circuits also need to be evaluated, programmable sources are a must. In addition, specialty power supplies offer features such as intelligent control of output voltage ramp-up and ramp-down, datalogging, and waveform generation, as well as the features of instruments such as precision ammeters and voltmeters. You may also need a programmable electronic load in order to evaluate battery discharge characteristics.

Circuits respond to a fully charged battery differently from the way they respond to one that has a low level of charge or is completely discharged. "The trend is toward lower-voltage circuitry and longer operation between recharge," said Bob Green, senior market development manager at Keithley Instruments. "It's driving designers to decrease the minimum voltage at which devices will operate before they automatically turn off to prevent damage."

"You can no longer simply select any convenient bench supply that provides the right mix of voltage and current," said Green. "You need supplies optimized to operate with resistive loads. General-purpose power supplies, even if they're designed to operate across a range of loads, aren't suitable."

Dynamic loads

Capturing waveforms, such as a cellphone's voltage levels during a start-up sequence, also requires instrumentation that can record and display rapidly changing voltages and currents as well as transients. Determining the type of current pulses a battery-powered device under test (DUT) draws is essential. In most cases, pulse magnitude, rise times, fall times, and frequency need to be measured. "A sup-



Requiring no programming, the N6705A combined analyzer and power source from Agilent Technologies measures DC voltage and current draw of battery-powered products. The instrument houses multiple power-supply modules, a DMM, a recording oscilloscope, an arbitrary waveform generator, and a datalogger. Courtesy of Agilent Technologies.

ply's voltage droop and recovery must be ascertained, based on the amount that will cause a DUT to fail the test or shut off," noted Green.

Cellular telephones, in particular, impose burdens on a power source's dynamic response. The North American IS-54 cellular standard uses frequency-division multiple access (FDMA) and time-division multiple access (TDMA), with RF transmissions allocated in time slots of 6.67 ms. European GSM FDMA/TDMA cellphones transmit in slots as short as 576 µs.

Intended for testing battery-operated products, Keithley's dual-channel externally triggered Model 2306-VS battery/charger simulator has ultra-fast transient response to provide output characteristics identical to actual batteries delivering pulsed loads.

Courtesy of Keithley Instruments.

For both standards, when a cellphone switches from standby to full power, its current draw can increase by as much as 1000%. Unfortunately, conventional supplies are usually specified for about a 50% change in current. What's more, while a battery's voltage will decrease slightly by the value of the IR drop across the battery's internal resistance, a conventional bench supply can cause a greater internal voltage drop, sometimes more than 1 V.

For circuits that operate at full power for short intervals, such as a cellphone's power-amplifier stage, a full-power event can be over before a conventional power supply recovers. If the supply can't recover quickly, the performance of the DUT can be compromised.

"Many bench supplies can take milliseconds to recover to their original voltage level," said Green. "If the supply voltage drops below the threshold of a cellphone's low-battery detection circuitry for a sufficient amount of time, for example, the phone may turn off during testing. That would give a false indication of a failed device."

Control and power monitoring

To get around those kinds of problems, instrumentation companies offer specialized power sources. Keithley, for one, has a number of GPIB-equipped power supplies providing both voltage control and power monitoring. Keithley's dual-channel Model 2306-VS battery/charger simulator, for example, with external triggering, can be used for development as well as high-speed production testing of DC battery-operated products such as cellphones, RFIC power amplifiers, and other precision components that require a DC voltage supply. The 2306-VS is priced at about $3500.

Similarly, the company's multichannel Series 2600 System SourceMeter instruments are scalable, high-throughput power sources that deliver precision DC, pulses, and low-frequency AC. Keithley claims its Series 2600 instruments, which carry price tags of about $4000 to $5000 per channel, operate from two to four times the test speed of typical supplies used in I-V functional test applications.

These automated supplies can be used to test devices that undergo substantial load changes for short time intervals. They can simulate a battery's response during a large load change by minimizing drops in voltage and then recovering to within 100 mV of the original voltage in 40 µs or faster. They can also simultaneously measure short-pulse load currents.

Some of Keithley's programmable DC sources, with internal resistance values that can be set from a dead short to 1 Ω, can also simulate a battery's internal resistance. Onboard analog-to-digital converters, used to measure voltage across precision internal shunts, also do double duty as external digital multimeters (DMMs). Keithley's multi-quadrant instruments, able to source both positive and negative voltage and current, can also sink current, taking on the characteristics of a discharged rechargeable battery to support test of battery-charger circuits.

Running embedded test script processors (TSPs), the Keithley systems are designed to lower GPIB traffic. Test scripts are available for sweeping, pulsing, and generating waveforms, as well as for performing common component tests. These Basic-like sequences run in real time on microprocessors within the instruments, rather than on host computers, although users can customize the canned routines by using a PC-hosted Keithley tool called Test Script Builder.

Keithley's instruments include nonvolatile storage that can save up to 50,000 lines of TSP code and more than 100,000 readings. A single TSP, running on a master unit, can also control and acquire data on as many as 32 channels in larger test suites.

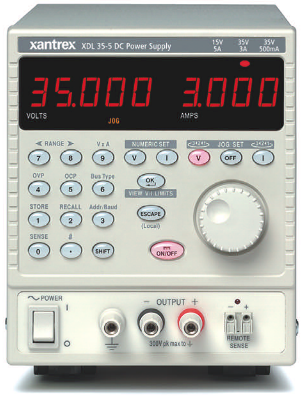
No user programming required

Some vendors eschew user-programming or manual setup entirely. Agilent Technologies, for example, has an extensible DC power analyzer that performs DC sourcing and measurement without the need for any coding. The $6500 N6705A analyzer is intended to streamline setup and shorten the time it takes to view critical sequences such as turn-on and turn-off timing and startup or inrush current.

The instrument, which can measure applied DC voltage and current draw of a DUT, combines up to four DC power-supply modules, a DMM, a recording oscilloscope, an arbitrary waveform generator, and a datalogger. The N6705A displays voltage or current over time, and its front panel gives the user access to sourcing and measuring functions. Outputs are selected with color-coded pushbuttons, and output terminals are color-coded, as is the display.

Built-in logging features can store a few seconds-worth of data, to as long as days or even weeks of data. The analyzer can throttle ramp-up and ramp-down rates, for example, or generate transients and disturbances to see how a device might respond under stressed or worst-case conditions.

Bob Zollo, manager for power products at Agilent's Basic, Emerging, and System Technologies Division, explained that because the N6705A includes so many instrument functions, it simplifies test-system setup: Users don't have to cobble together a test system based on a datalogger or DMM, and they don't need to gather shunts and transducers, cable the system, connect it to a PC, and then program it. He observed that if you built your own test system, "You could spend more time creating the software and debugging the equipment than you would running your tests."



As quiet linear sources, remote-sensing power supplies from Xantrex exhibit less than 0.35-mV RMS voltage noise and less than 0.2-mA RMS current noise. Courtesy of Xantrex Technology.

Agilent's analyzer is based on 1U-sized multiple-output programmable switch-mode supplies. These can change voltage in 160 µs and deliver DC with just 5-mVp-p noise. An N6705A can accept from one to four power modules ($450 to $2250 each), totaling up to 600 W. The auto-ranging analyzer also includes 50-kHz 4000-point digitizers for measurement purposes.

Agilent's power analyzer and source is also compliant with LXI Class C specs and can be driven across any 10/100BaseT Ethernet LAN through a Web browser. Agilent's product can also be connected directly to a PC using USB 2.0 or GPIB.

Built-in processing

Some vendors rely on built-in processing horsepower, rather than host computers, to handle battery analysis. Kepco's switcher-based BOP series of instruments, for example, are four-quadrant programmable voltage and current supplies.

Equipped with graphical LCDs, the BOP power supplies can handle as much as 1-kW of DC power bidirectionally. The six models in the series accommodate voltages from ±10 V to as high as ±100 V and are useful for testing higher-powered systems such as portable tools or automotive electrical systems.

The BOP architecture simultaneously clocks three microprocessors. One is dedicated to the instrument's user interface, another accommodates GPIB, RS-232/RS-485, and multi-instrument IEEE 1118 bus transactions, and the third oversees analog functions. All three communicate internally over a 56-kbps full-duplex optically isolated serial bus.

BOP sources, priced at about $2100, are equipped with 320x240-pixel monochrome displays that dynamically depict analog and digital representations of output voltage and current. As four-quadrant supplies, they can source and sink current, so they're suitable for exercising batteries as well as for characterizing devices such as photovoltaic arrays.

Azimuth Systems is another company offering hardware and software to measure power, specifically for battery-powered WiFi devices. The company's Azimuth Battery Life Performance Test, priced at about $6000, works with its W-Series hardware platform.

Azimuth's hardware and software lets you test the time it takes a battery to run to exhaustion. In operation, you can put a DUT into different operational modes during a test run of realistic scenarios. The software will help determine how a battery-powered product such as a cellphone will actually be used, delivering metrics revealing actual standby and talk times.

Electronic loads

In some cases, test executives and automated test systems can be overkill. For many tests, all that's needed to ascertain battery suitability is a controllable load. Xantrex Technology and B+K Precision count among companies making electronic loads.

B+K Precision's Model 8500 DC load, selling for about $1000, is programmable across an RS-232 or optional USB interface. Equipped with a vacuum-fluorescent display, the Model 8500 can be set anywhere between 0 and 120 V, sinking from 1 mA to as much as 30 A, under a 300-W maximum profile. The instrument is overcurrent, overvoltage, overpower, and overtemperature protected.

For higher power levels, Xantrex offers the SL Series Sorensen-brand loads in modular and rack-mount configurations that can dissipate as much as 1.8 kW. These loads lend themselves to battery and battery-charger testing as well as to characterization of high-power fuel cells, inverters, AC-to-DC and DC-to-DC converters, and voltage-regulator circuits.

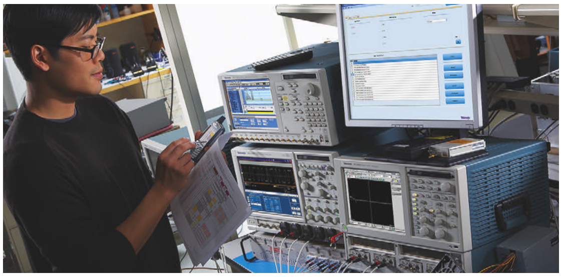
Like Kepco's BOP sources, the SL Series loads can be operated from the front panel, via GPIB or RS-232 links, or under analog control. Pricing for chassis housing multiple modules starts below $5000.

For applications that require low noise and programmability, Xantrex offers its XDL linear sources, which typically exhibit less than 0.35-mV RMS voltage noise and less than 0.2-mA RMS current noise. For production line testing, XDL boxes can store up to 10 setups in nonvolatile memory, with preset overvoltage and overcurrent trips. XDL Series supplies also offer remote sensing, which can be useful when measuring heavy currents.

Programmable DC loads can be used for power-supply, battery, and DC-to-DC converter testing and calibration. The Model 8500 from B+K Precision can load a circuit between 0 and 120 V DC, sinking from 1 mA to as much as 30 A.
Courtesy of B+K Precision.

Xantrex product marketing director Jason Lee said that for power levels ranging from 1.2 kW to 3 kW, customers typically choose switchers as alternatives to heavier and more costly linears. Some Xantrex switchers cost less than $1300. Based on so-called zero voltage switching (ZVS) technology, these moderately priced sources are claimed to exhibit ripple and noise comparable to linear supplies, and they respond rapidly to transient loads. Xantrex also offers the DLM line, which includes 600-W models that deliver outputs adjustable from 0 to as high as 300 VDC, at currents adjustable from 0 to as much as 75 A.

While ordinary lab supplies can sometimes substitute for batteries, today's programmable power sources, with intelligent features and built-in instruments, can simplify and speed up testing. Simulating a battery's performance accurately requires power supplies with bandwidth sufficient to minimize voltage drops during large current transients, as well as circuitry capable of emulating the impedance of a battery. Voltage and current stability, including freedom from oscillation, overshoot, and undershoot, are essential ingredients that the latest generation of power sources can deliver. T&MW



Software suite automates compliance testing

TekExpress Framework is a software suite that lets you set up and control equipment for physical-layer compliance tests. It finds the equipment, manages the measurements, provides a user interface, performs pass/fail tests, and produces test reports.

The software suite is a base for application-specific software add-ons, the first of which is for Serial ATA Generation 2 testing. TekExpress SerialATA performs 153 compliance tests. You get one-button operation of all transmitter, receiver, and data-channel tests.

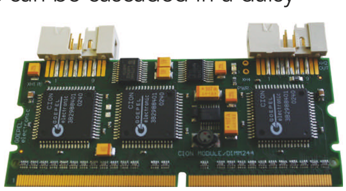
The TekExpress SerialATA add-on, called a method of implementation (MOI), supports Tektronix oscilloscopes and arbitrary waveform generators. It also supports third-party equipment such as a frame-error analyzer and an RF switch (all instruments are sold separately).

Prices: TekExpress Framework—$4900; MOI modules—$4900–$19,900. *Tektronix, www.tektronix.com.*

JTAG module tests DDR2 Mini DIMM 244 interfaces

Goepel electronic's Module/DIMM244so, a member of the company's CION product family, is serially controlled via a boundary-scan test-access port (TAP), and it enables the testing of all signal and voltage supply pins of JEDEC-standard-compliant (JESD79-2C) DDR2 Mini DIMM 244-pin sockets.

The CION Module/DIMM244so plugs directly into the sockets to be tested. Because the modules are equipped with a transparent TAP, several boards of the same or different types can be cascaded in a daisy-chain configuration.



The structural boundary-scan test of all DIMM 244 signal and voltage supply pins are executed by the onboard CION ASIC ICs. All channels can be independently switched as input/output/tristate. The Module/DIMM244so provides safety mechanisms to prevent damages in case of shorts or adverse voltage conditions.

The new hardware module is supported by Goepel's ScanBooster and ScanFlex boundary-scan controller families as well as by the System Cascon integrated boundary-scan software platform.

Base price: $1000. *Goepel electronic, www.goepel.com.*

CW generator delivers fast switching speeds

Agilent Technologies' N5183A MXG compact microwave analog signal generator delivers a low cost of ownership and is an extension to the company's MXG signal-generator platform, providing frequency coverage to 20, 32, or 40 GHz. Featuring fast frequency switching speeds and self-maintenance, this signal generator provides manufacturing and R&D engineers with the performance required to make a wide range of measurements on broadband components and systems. It is targeted at electronics warfare (EW), radar, military-communications, and broadband-wireless-access applications.

The N5183A MXG is a continuous wave (CW) signal generator designed to maximize uptime and reduce cost of ownership. Its ≤900-µs switching speed optimizes throughput. A simple design delivers easy self-maintenance that reduces downtime to one working day, making it possible for users to maintain or repair the instrument in-house.

Delivering +18-dBm output power to 20 GHz, the instrument also features a level accuracy, with optional step attenuator, of ±0.6 to ±0.8 dB. Other options include analog modulation and pulse modulation, all housed in a compact 2U (3-in. high) package. The N5183A MXG can serve as a replacement for legacy HP/Agilent signal generators. It is program-compatible with the 8340, 8360, 8370, ESG, PSG, and 8662A/8663A series of signal generators.

Price range: $18,000 to $30,000. *Agilent Technologies, www.agilent.com.*

WaveViewer software gets faster

SynaptiCAD has released a new version of its free WaveViewer waveform-viewing tool. The new version can now read both analog and digital data captured by Agilent Technologies mixed-signal oscilloscopes. It also provides support for importing timing-parameter data in several field-programmable gate array (FPGA) manufacturers' formats, including Altera Timing Analyzer Output (*.tao) and Xilinx Speed File format (*.txt).

The new version sports 5X to 20X faster waveform rendering for analog waveforms or for waveforms containing bus data. It also sports waveform-data compression enhancements, resulting in compressed files up to 50X smaller than in previous versions. The PLI shared library that simulators use to directly create the tool's native compressed btim format was also optimized to reduce simulation overhead. With the new shared library, simulations run using SynaptiCAD's VeriLogger Extreme Verilog simulator execute up to 3X faster than previously when waveform streaming was enabled.

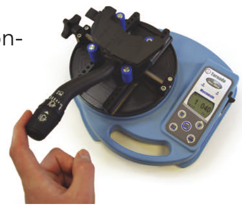
The upgrade includes a number of new features to improve browsing and annotation of waveform files. Users can sort visible signals by name, and a search tool helps find signals and signal values.

Price: free. *SynaptiCAD, www.syncad.com.*

Mecmesin debuts digital torque tester

Mecmesin, a manufacturer of force and torque testing equipment, has announced the launch of the Tornado digital torque tester. The Tornado is designed to assess the low-level torques associated with small rotating components in automotive and other applications. The Tornado provides for pass/fail alerting with five programmable memory settings. It includes a facility to characterize the two torque peaks associated with tamper-evident closures, it has an onboard memory that stores up to 500 readings, and it includes a bidirectional data interface for easy export of results.

Designed for laboratory or production use, the compact and portable Tornado features a water-resistant casing fabricated in non-painted polypropylene. Four capacity models are available: 13 lbf-in., 26 lbf-in., 50 lbf-in., and 90 lbf-in. An adjustable mounting plate grips the base of a sample, presenting it for application of clockwise or counter-clockwise torque by hand. Five dedicated function keys on the tester's membrane keypad provide quick access to the most commonly used functions.



Mecmesin, www.mecmesin.com.

Test & MEASUREMENT WORLD

PXI

TEST REPORT

Extending PXI

By Richard A. Quinnell, Contributing Technical Editor

Channel capacity can be a limiting factor in many test setups, but when your PXI card cage is filled to capacity, you are not out of options. A PXI Express extension system will let you add even more instruments to your system by linking an expansion chassis to the host system through a PCI Express (PCIe) cable. Chris Ni, product manager for Adlink Technology, a manufacturer of PXI chassis and modules, recently explained the benefits of using extension systems in test applications.

Q: What benefits can test engineers gain by using an extension system?

A: The first reason to use an extension system is to increase the number of slots available in a single computer system. Most PCs have only a few slots, and even a PXI system is limited to 20 slots. With the bus extension technology, a single PXI system can double the capacity by chaining in an extended PXI chassis. In theory, the capacity of a PXI system is unlimited. You can chain as many extended PXI chassis as needed if the allocation of system resources is not an issue.

The second reason is to separate the I/O cards from the host computer. This can help increase measurement accuracy by distancing the modules from the computer's electronic noise. It also makes the system more modular, which makes repair easier. Separating the I/O from the host also allows installations where the instruments operate in a hazardous environment while the host is in a safer location. [*Ed. note:* Adlink manufactures extension systems that operate over PCIe cables as long as 7 m.]

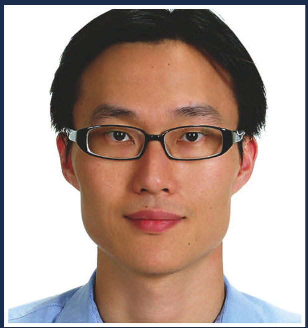
Q: Does using an expansion chassis create timing problems in a test system?

A: Timing and triggering are handled on the PXI backplane, not the host system, so this is not an issue with chassis extension. The extension system is just a transparent bridge to the host system.

The only problem we have ever encountered with timing in an extension system occurred when a customer used its own card designs in a PCI system. The design placed the board's PCI controller too far from the connector. It worked all right in a standard PCI system, but not in the expansion chassis. The poor placement added too much delay, and the host controller missed the card during power-up enumeration because it took too long to respond.

Q: What are the advantages to using PCIe for the extension system's link?

A: One reason to use PCIe is that the bandwidth to the host processor is not shared, so the data rate is guaranteed. In PCI and PXI systems, the bus must be shared with all cards in the slot, so bandwidth and access are not deterministic.



Chris Ni
Product manager
Adlink Technology
Courtesy of Adlink Technology

Test engineers might also choose PCIe extension technology because its data throughput is high. The sustained data transfer rate of PCIe-to-PCI/PXI expansion is over 100 Mbytes/s. This allows engineers to design test systems that use a server-class computer for data processing. PCIe provides the bandwidth that allows an expansion chassis to leverage the full power of such computers.

Compared to a PCI-based expansion, PCIe also decreases latency in the interaction between host and chassis. This is because PCIe uses newer technology, including a bridge chip and an equalizer, to link the host and chassis.

Q: What options does your company offer for PXI extension systems?

A: Adlink offers both PCI-to-PXI and PXI-to-PXI extension systems using StarFabric links as well as a PCIe-to-PXI extension system. We will also be coming out with an ExpressCard expansion option for laptop users. These extension systems can use any PXI-compliant chassis from any vendor as the expansion chassis. □

INSIDE THIS REPORT

GUEST COMMENTARY

With a decade behind us, it's full steam ahead!

By Nicole Faubert, GaGe/KineticSystems

In 2007, the PXI Systems Alliance (PXISA) proudly marked the 10th anniversary of the PXI specification and celebrated the success of the standard at events held throughout the year. The PXISA also boosted its marketing efforts to highlight PXI as the platform of choice for applications such as data acquisition, automated test, and process control.

The year began with the makeover of the PXISA's Web site, www.pxisa.org. Featuring a new design, the site is the "go-to" place for all that is PXI. It includes a list of companies that provide PXI products and services, application notes and application examples written by member companies, and information about the latest PXI products available on the market.

Autotestcon 2007 was the official site of the PXI specification's 10th anniversary party. The PXISA booth featured three multivendor demonstrations comprising various 3U and 6U PXI/cPCI modules from member companies. The demo systems highlighted the flexibility of the PXI standard, which enables engineers to build complete test systems using PXI modules from multiple vendors. The demos were so well received that the Alliance showcased them at Productronica 2007 as well.

Also in 2007, the PXISA gained two key members in Agilent Technologies and Keithley Instruments, and Aeroflex became a board member of the organization. In 2008, the PXISA plans to build upon the momentum of the past year by recruiting new members and by increasing industry awareness of PXI through more multivendor demonstrations at trade shows. With Frost & Sullivan projecting that sales will grow from $284 million in 2007 to more than $520 million in 2010 (Ref. 1), it is easy to see why PXI systems and components will continue to be a dominant test platform. □

REFERENCE

Vidyasankar, S., "The ATE industry's hybrid theory," *Test & Measurement World*, Dec. 2007/Jan. 2008, p. 23. www.tmworld.com/2007_12.

Nicole Faubert *is responsible for the marketing efforts at GaGe/KineticSystems and is a member of the PXI Systems Alliance marketing committee. nfaubert@gage-applied.com.*

Do you calibrate PXI?

By Martin Rowe, Senior Technical Editor

At the 2005 Measurement Science Conference, a consultant described instrument cards as "mindless beasts," because they are measurement instruments whose uncertainties can't be quantified. While that may be true to some extent, PXI measurement cards perform important production measurement functions every day. Manufacturers may calibrate PXI cards with NIST-traceable standards during production, but what happens to the calibration once the cards are placed in service?

PXI cards present the same calibration problems as their PC-plug-in and VXI bretheren: Cards calibrated in a cal lab may not be in the chassis where they are used every day, and are thus calibrated in an environment that does not represent reality. Differences in temperature, air flow, and EMI can affect measurement uncertainty.

Perhaps calibration wasn't so important when the only PXI measurement cards were 12-bit data-acquisition cards. But today, you can get PXI digital multimeter (DMM) cards with as much as 7.5 digits of resolution, rivaling many bench meters. As resolution improves, calibration becomes more important.

If you use PXI systems with analog measurement cards such as DMMs, data-acquisition cards, oscilloscopes, or signal sources, do you ever calibrate them? What do you do to calibrate PXI cards?

- We remove the cards from the chassis and send them to our cal lab.
- We send the whole chassis to our lab for calibration.
- We send just the cards to an outside cal lab.
- We send the whole chassis to an outside cal lab.
- We calibrate the cards in place by bringing the calibration equipment to the test station.
- We return the analog PXI cards to the manufacturer for calibration.
- We don't calibrate card-based instruments.

Which do you do? What calibration standards do you use to calibrate the instruments? How long is your system out of commission during calibration? How often do you calibrate PXI cards?

Tell us your story by sending an e-mail to mrowe@tmworld.com, and we'll consider including it in a future article about system calibration. □

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PXI and bench instruments evenly matched

By Richard A. Quinnell, Contributing Technical Editor

When two approaches to the same problem exist in a market, they are bound to compete at some level. For PXI and bench instruments, that competition began in the area of automated testing, where PXI's PC-based control and modular nature gave it compelling advantages. But improvements in modular instrument technology along with new software interfaces are blurring distinctions between PXI and desktop instruments, making the choice of which approach to use more complex.

The introduction by Aeroflex at Autotestcon 2007 of the 3000A PXI chassis for RF test highlighted this blurring of lines. The chassis includes a built-in touch-sensitive display panel that works with the system controller to turn a populated chassis into a self-contained instrument. Instead of having the separate keyboard and monitor that make most PXI systems seem like computers with an instrumentation peripheral, the Aeroflex chassis seems like a traditional bench instrument.

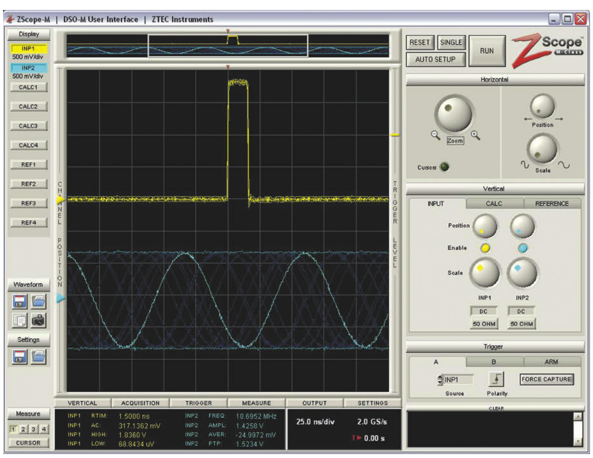


Fig. 1 User interface software is allowing PXI instruments to mimic the look and feel of bench instruments, blurring the distinctions between them. Courtesy of ZTEC.

This type of operation addresses the need for programming that many engineers see as a barrier to using PXI on the R&D engineering bench. Paul Knight, a test development manager for Radio Frame Networks in Redmond, WA, expressed this concern in an e-mail response to *T&MW* senior technical editor Martin Rowe's blog posting "Do you use PXI on the bench?" at www.tmworld.com/blogs.

"We use PXI in our production test equipment, but have not been able to replace traditional instruments on the engineer's desk," wrote Knight. "I believe the lack of front panel controls and/or software panel control limits the effectiveness of the [PXI] instruments. Engineers do not want to have to write code to make measurements."

But that barrier is collapsing. Software packages from companies like ZTEC and National Instruments are now offering graphical user interfaces that mimic the look and operation of bench instruments.

Instead of requiring users to select from menus or create a program to control operational parameters when setting up and making measurements, these interfaces provide users with the opportunity to press buttons and twiddle knobs—or at least perform the on-screen equivalent. The free ZTEC ZScope software package for the company's PXI oscilloscope modules, for instance, presents users with the image of an oscilloscope front panel to provide both instrument control and data display (**Figure 1**).

Increasing competition

By allowing users to operate a PXI system like a bench instrument, such interfaces bring the two test methodologies into more direct competition. This might lead a potential instrument purchaser into looking at the relative performance of each approach, but such an evaluation may well prove inconclusive. PXI and bench instruments are evenly matched in many applications and performance specifications (**Figure 2**).

"PXI has come a long way in the 10 years since its introduction," said Richard McDonell, senior group manager for PXI and instrument control at National Instruments. "Early units had lower resolution [than bench instruments] and worked at only 100 ksamples per second or so." Now, McDonell pointed out, PXI can push the state of the art. At last year's Autotestcon, NI, BAE Systems, and Phase Matrix demonstrated a jointly developed PXI platform that measures signals as high as 26.5 GHz.

This does not mean that both PXI and bench methodologies have achieved identical performance. "Benchtop instruments typically lead in high-end (28-bit) resolution or ultra-high frequency ranges," said McDonell, "but by and large, they are very comparable."

Further, resolution is only one aspect of performance in test systems. Chris van Woerkom, senior marketing engineer at Agilent Technologies, pointed out that metrics such as measurement throughput can also be important. He noted that many PXI instruments depend on the system's CPU to turn raw data into meaning-

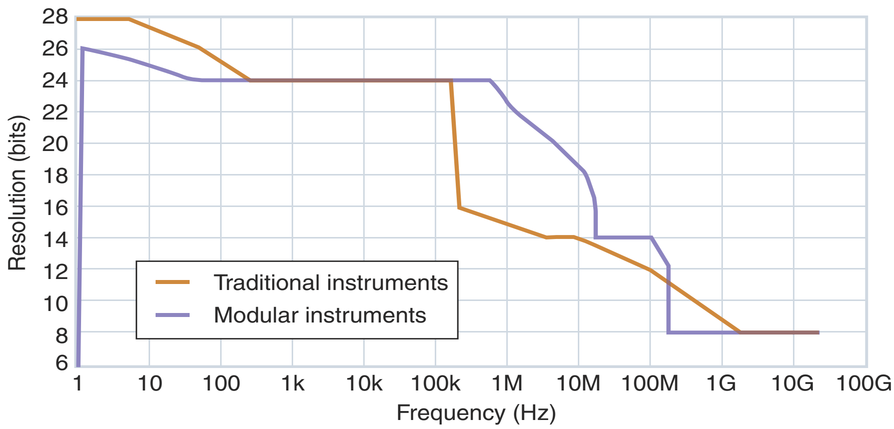


Fig. 2 In key performance parameters such as frequency and resolution, differences between PXI and bench instruments have virtually vanished.

Courtesy of National Instruments.

ful measurements. In a well-populated system, then, the need to share bus bandwidth may limit an instrument's achievable measurement throughput despite it having a high data rate. Bench instruments do not suffer from such limitations because they have built-in processing.

That kind of built-in processing is making its way into PXI instruments, though. "We're now seeing PXI modules with processing being performed in the module," said ZTEC's director of marketing and product strategy Boyd Shaw. "In the last five years, modular oscilloscopes have gone from being just digitizers to having all the performance in the module. We now have the same kinds of signal conditioning, waveform analysis, and parameter measurement algorithms as benchtop devices."

No clear superiority

The result is that—from a performance standpoint—neither bench nor PXI instruments have a compelling claim to superiority. Nor is that situation likely to change. Individual products of one type or another will temporarily win the top performance slot, but that honor typically is now trading back and forth.

Further, consolidation within the test instrument community is creating vendors that offer both PXI and bench products, ensuring that technical advances in one will inevitably make their way into the other.

Agilent, for example, has acquired PXI companies PXIT and Acqiris and is now offering some PXI and bench instruments made with identical boards, parts, software, and specifications. The only differences are the interface and the footprint. "We are differentiating ourselves with superior metrology," said van Woerkom, "and letting our customers decide which package to purchase."

This kind of commonality is also eroding another traditional difference between PXI and bench instruments: the ease of porting R&D test development to the production floor. With modular instrumentation becoming the foundation of production test equipment, using PXI in the lab gave an advantage over bench instruments when it came time to create production test routines. When both types of instruments use the same core elements, either choice yields the benefit.

Instead of performance, then, developers selecting between bench and PXI test instruments might consider how they are going to use the instrument. Each approach has advantages under different scenarios. PXI instruments, for instance, can typically fit more functionality into a smaller package than bench instruments. A PXI system can provide dozens of channels in the same size package as a typical two-channel bench oscilloscope, making PXI better suited for space-constrained installations. On the other hand, bench instruments do not have the bus, size, or power constraints of PXI systems, so they can offer more diverse functionality and built-in processing than individual PXI modules.

Further, most or all of the functionality in bench instruments is hardwired and does not need to wait for an operating system and software to configure the instrument before making a measurement. This makes bench instruments better suited for taking quick-look measurements. LeCroy points out that its WaveJet portable oscilloscope, for instance, is on and ready to use in less than 3 s. The operating systems used in PC-like PXI controllers take far longer just to boot.

In the end, a user's choice of platform may simply boil down to preference. Older engineers whose careers pre-date PXI and modular instrumentation may feel more comfortable using buttons and knobs than mouse clicks and keystrokes. Younger engineers, having spent nearly their entire lives using personal computers, may feel precisely the opposite.

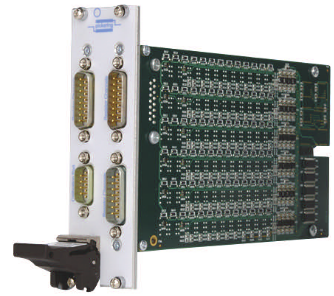
None of these factors is compelling enough to make one approach win out over the other across the board. Improvements in interfaces, ease of use, packaging, and function density may eventually allow PXI instruments to overtake bench devices in all uses, but not any time soon. Said ZTEC's Shaw, "People will need benchtop instruments for years to come." □

PRODUCTS

Module simulates RTDs

Pickering Interfaces has released the 40-262, an 18-channel variable-resistor module designed to simulate PT100 and PT1000 RTDs. The 3U PXI module can provide a resistance setting resolution of better than 10 mΩ over the entire resistance range and an accuracy of better than 0.1% for all resistance settings, according to Pickering. Each simulation channel is able to provide a short-circuit or open-circuit setting to simulate faulty wiring connections to a sensor. Calibration of each resistor channel can be verified by connecting the calibration port to a digital multimeter.

Pickering Interfaces, www.pickeringtest.com.



NI introduces SMU and switch modules

National Instruments has introduced its first PXI source-measure unit (SMU) as well as two high-density PXI switches, products that the company says can be used in semiconductor parametric tests and electronic device and component validation. Engineers can use these modules to characterize voltage and current parameters on high-pin-count devices.

The NI PXI-4130 is a programmable high-power 3U PXI module that features a single isolated SMU channel with a four-quadrant ±20-V output that incorporates remote four-wire sense. This channel can source up to 40 W in quadrants I and III and sink up to 10 W in quadrants II and IV. An additional power-supply channel handles voltage and current source and readback. The five available current ranges offer measurement resolution down to 1 nA.

The NI PXI-2535 and PXI-2536 switch modules offer 544 crosspoints, which NI claims is the largest matrix density available for a single 3U PXI slot. The PXI-2535 is configured as a 4x136 one-wire matrix; the NI PXI-2536 is configured as an 8x68 one-wire matrix. The modules provide switching speeds as high as 50,000 crosspoints/s.

Base prices: PXI-4130—$2499; PXI-2535 and PXI-2536—$2999.
National Instruments, www.ni.com.

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JOHN R. REGAZZI
CEO
Giga-tronics
San Ramon, CA

John Regazzi has served as CEO and a director of Giga-tronics since April 2006. Prior to joining the company in 2001 as VP of engineering, Regazzi spent 22 years with Hewlett-Packard and Agilent Technologies, holding a variety of leadership positions, including R&D project manager, R&D section manager, and solutions architect. Regazzi holds a BSEE degree from Rutgers University and an MSEE degree from Lehigh University.

Contributing editor Larry Maloney conducted a phone interview with John Regazzi on trends in microwave test and switching applications.

Where switching meets instrumentation

Q: What is Giga-tronics' prime area of technical leadership?

A: We are primarily an RF and microwave design company, with expertise in signal generation and routing. For example, we can offer engineers high-speed digital techniques for frequency synthesis. We are vertically integrated around signal-generation technology, building our own YIG oscillators, our own phase-lock loops (PLLs), and all the microwave modules for signal conditioning. As for leadership, I would point to our advanced synthesizers, which feature our Accumulative High-Frequency Feedback loop design. This allows very low divide numbers in our PLL, which translates into very low phase noise. We also can achieve microhertz tuning resolution in a single loop. The result is fast frequency switching in a compact, low-cost design.

Q: Who are the customers for these synthesizers?

A: There's the bench engineer who wants a cost-effective signal generator with good phase noise. But the fast-switching capability also puts us into applications that need a fast local oscillator to collect a lot of data, such as antenna test and RFIC test.

Q: To what extent are you combining your products into systems solutions?

A: A good example is our cable correction feature. Here, our synthesizers and power meters work together to achieve very fast correction of path loss within switching systems. At a recent trade show, we highlighted our Ascor switching solutions, and we had the synthesizer and power meter calibrating all the measurement paths automatically. This is a common task in ATE, and the combination of our products performs this function in seconds, compared to nearly 30 min for competitive products.

Q: Are you also able to design custom test solutions?

A: Yes, especially with our Ascor line. Switching solutions find themselves between standard test equipment and the device under test, which is almost always unique with various inputs and outputs, connectors, and so on. So, switching solutions need to be customized. On the Delta Launch Vehicle, for instance, Ascor reviewed what had become an obsolete suite of test assets and suggested design improvements that led to a new Giga-tronics contract with Boeing. Ascor designed a single-tier "Hypertac" receiver mechanism, which reduced high insertion forces. Among other examples, customized Ascor switches are found in a new testing system for the Space Shuttle's steering motor control unit. Currently, we are designing a switch upgrade on testers targeted for Boeing's new 787 Dreamliner.

Q: Does this expertise in instrumentation and switches give Giga-tronics an edge with customers?

A: In many ways, yes. Our switch designers are cognizant of the fact that instruments make measurements through the switch path. So, over the years, we have developed a set of best practices in design. For example, our switches offer about five times more bandwidth for the same switching arrangements than competitive products. We use transmission line techniques when we are developing the circuitry for the paths, so we are able to compensate for the discontinuities of the relays. We also isolate all the grounds. As a result, our products end up getting used in applications where others have failed, such as measuring very small signals in the presence of noise or where you must maintain the fidelity of a signal. In short, our instrumentation background has made our switch designers much more sensitive to how switches are used with test equipment, and they've modified their designs accordingly. T&MW

John Regazzi discusses changes in his company's operations as well as trends in new product development in the online version of this interview: www.tmworld.com/2008_03.

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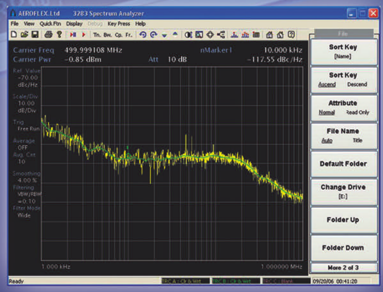

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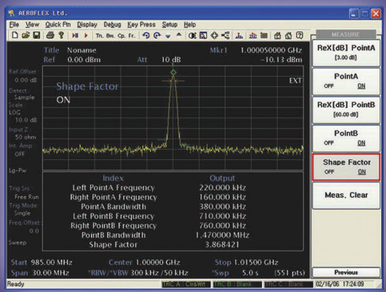

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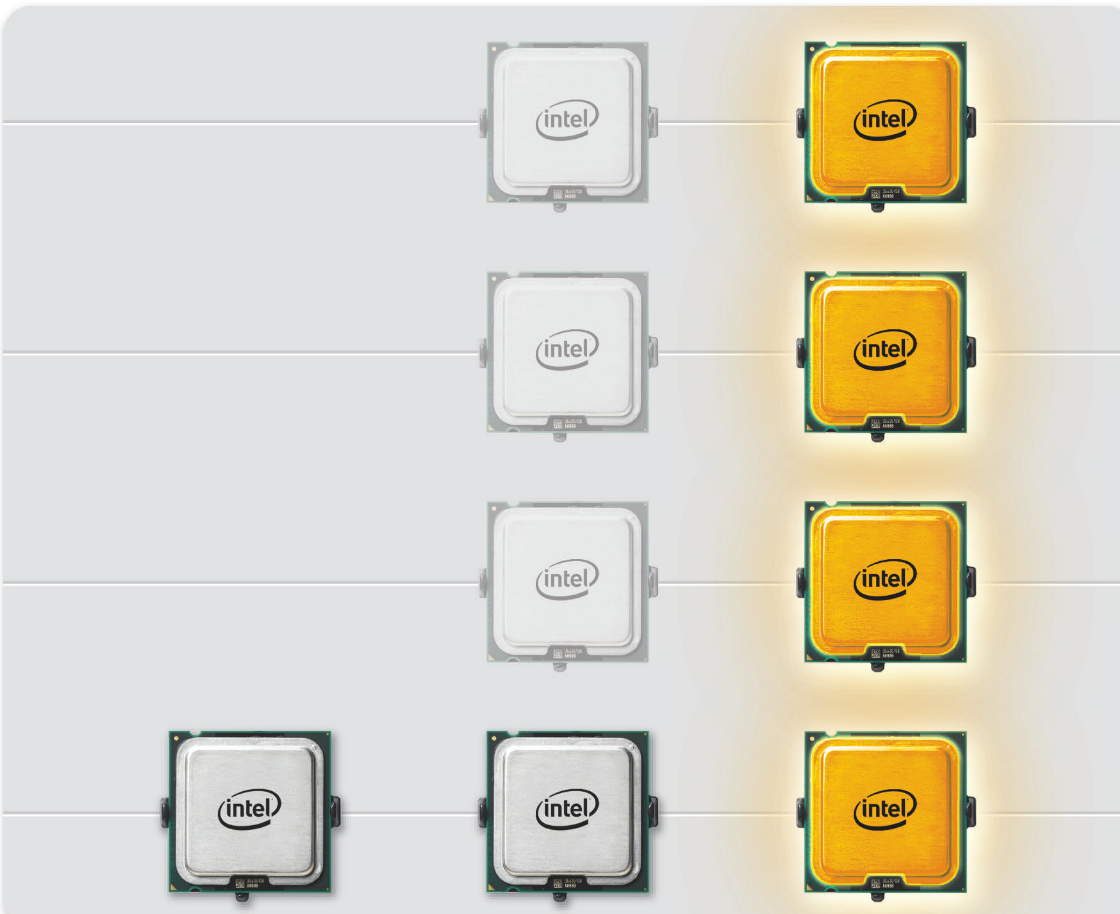

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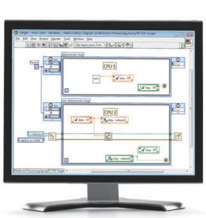

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