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May 2007
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Test & Measurement World

THE MAGAZINE FOR QUALITY IN ELECTRONICS

Alex Laparidis, director of video systems testing at Verizon Labs.

Testing brings home TELCO TV

At Verizon Labs, engineers test every aspect of video delivery, from the headend to the home.

Page 26

Have you ever seen 18 GHz in a better shape?

Spectrum analysis that goes anywhere – up to 18 GHz. The R&S®FSH18

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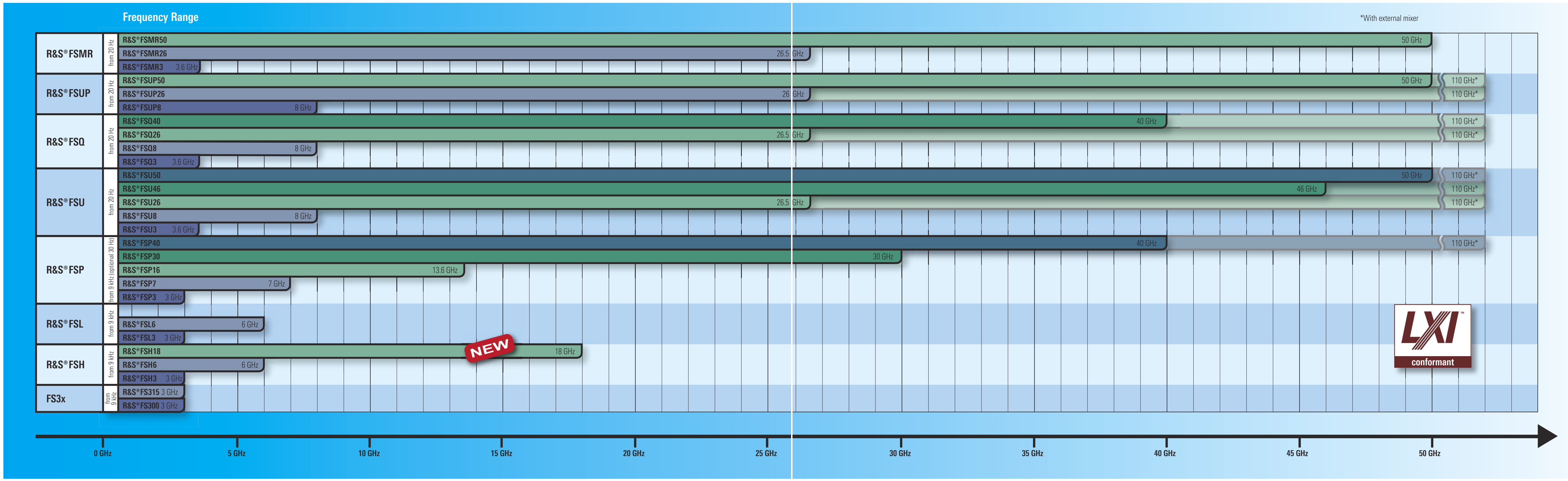
The Rohde & Schwarz World of Spectrum Analysis



R&S®FS300 Cost-efficient 3 GHz spectrum analyzer for applications in service, production and education

R&S®FSH Versatile handheld spectrum analyzer up to 18 GHz for mobile applications in the field and in service

R&S®FSL Compact lightweight analyzer for applications in development, service and installation with 20 MHz I/Q demodulation bandwidth

R&S®FSP Medium-class spectrum analyzer up to 40 GHz for most lab applications, service and measurements in production

R&S®FSU High-end spectrum analyzer up to 50 GHz for applications in R&D and production with high demands on dynamic range

R&S®FMU Baseband analyzer with balanced and unbalanced analog inputs (I/Q)

R&S®FSQ Signal analyzer with integrated spectrum analyzer up to 40 GHz (similar to the R&S®FSU) and up to 120 MHz I/Q demodulation bandwidth

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R&S®FSUP Phase-noise test set and signal source analyzer with integrated high-end spectrum analyzer

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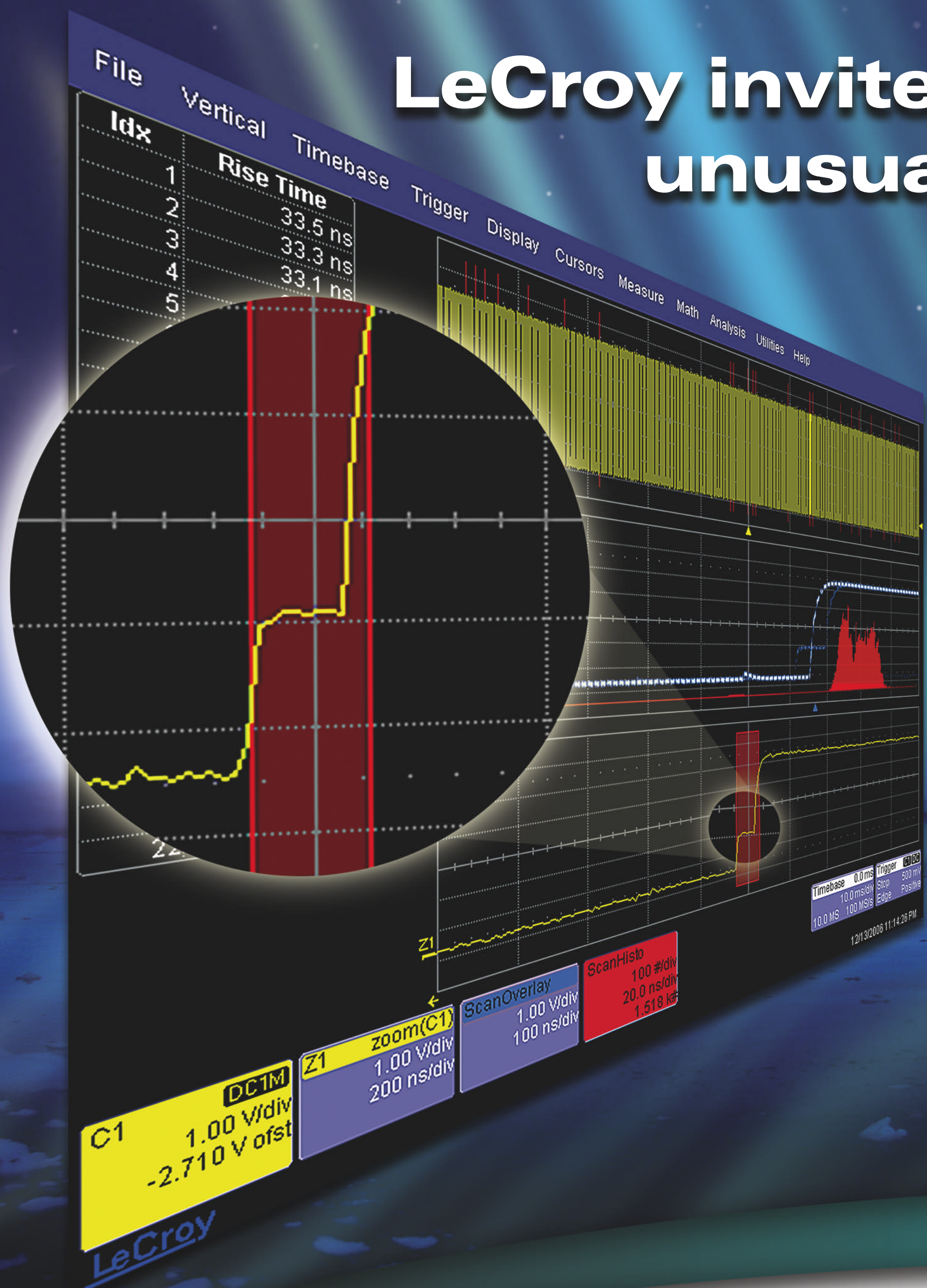
LeCroy invites you to unusual events.



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EDN Innovation 2007 FINALIST

EDN HOT products 100 WINNER

EDN Magazine has included LeCroy's WaveRunner® Xi and WaveSurfer® Xs with WaveScan in it's 'Hot 100 Products' list. WaveScan is also an EDN 2007 Innovation Award Finalist.

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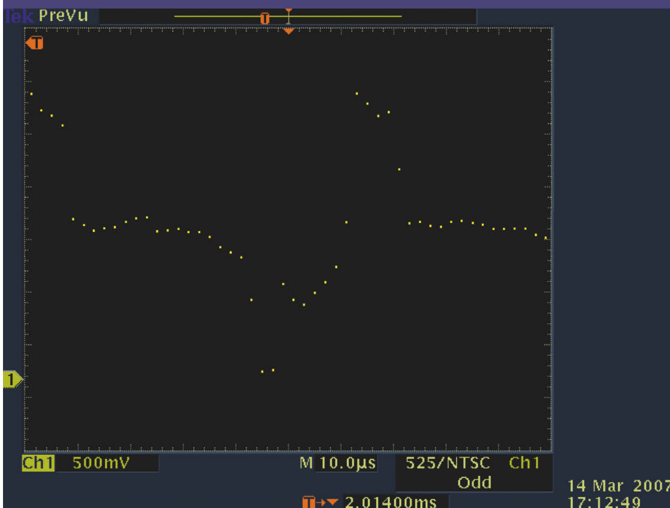
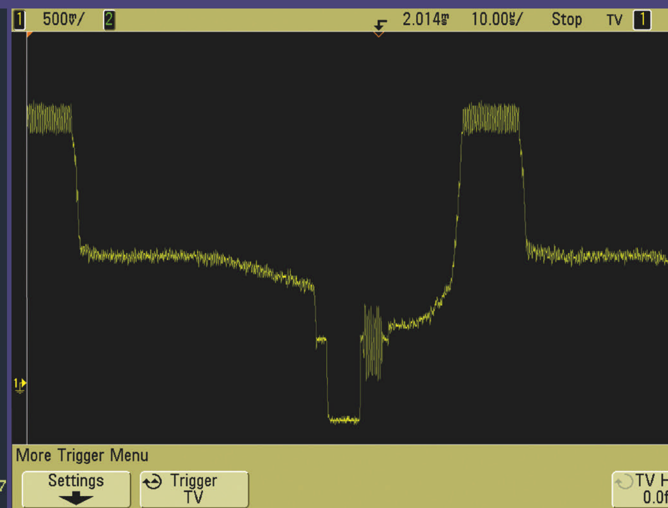


Tektronix TDS3054B display



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Agilent 5000 Series portable oscilloscopes

Specification	Tektronix TDS3000B Series*	Agilent 5000 Series**
Bandwidth	100 MHz – 600 MHz	**100 MHz – 500 MHz**
Sample Rate	100 MHz: 1.25 Gsa/s 200 MHz/300 MHz: 2.5 Gsa/s 400 MHz/500 MHz: 5 Gsa/s	**100 MHz: 2 Gsa/s** **300 MHz: 2 Gsa/s** **500 MHz: 4 Gsa/s**
Memory Depth	10 kpts, max	**1 Mpts, max**
Channels	2, 4	**2, 4**
Waveform Update Rate	3,600 wfms/s, max	**100,000 wfms/s, max**
Connectivity	Centronics, LAN (GPIB, VGA-out optional)	**USB, LAN, GPIB, XGA-out (all standard)**
Display	VGA resolution, <16 intensity levels	**XGA resolution,** **256 intensity levels**

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**Tektronix TDS3000B Series User Manual 071-0957-04, October 4, 2004.*
***Agilent 5000 Series Oscilloscope data sheet, Pub No 5989-6385EN, April 18, 2007.*
Agilent and Tektronix oscilloscope acquisitions taken at identical settings: horizontal timebase = 2ms/div, vertical volts/div = 500 mV/div, connect the dots = on. 10:1 passive probes used for both measurements. Final screen images show both acquisitions zoomed in to 10 µs/div.

Agilent Technologies

Test & MEASUREMENT WORLD®

MAY 2007
VOL. 27 NO. 4

COVER BY: MARK WILSON

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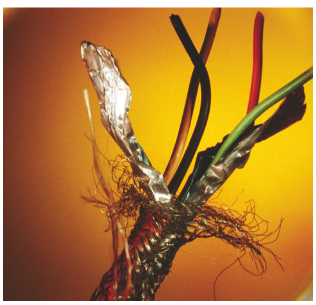

Failure analysis / Page 45

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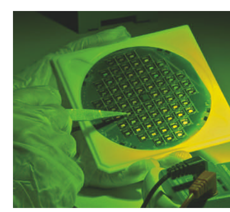

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> Check out these exclusive features on the *Test & Measurement World* Web site:

Should you migrate test applications to Windows Vista?

Michael Neal of National Instruments explains that a new security structure, virtualization, and a 64-bit version will raise compatibility issues should you migrate your test application.

www.tmworld.com/vista_neal

PXI, LXI cover automotive and aerospace landscape

In this *T&MW* interview, David Owen, business development manager for Pickering Interfaces, discussed the challenges of performing tests for the automotive, aerospace, and defense industries and explained the roles that PXI and LXI play.

www.tmworld.com/aa_owen

Blog commentaries and links

Taking the Measure

Rick Nelson, Chief Editor

- Mysteries in temperature measurement
- Test your FPGA interconnects

Rowe's and Columns

Martin Rowe, Senior Technical Editor

- How hard do you push test equipment?
- The year of the mixed signal

Education and Careers

Amy Laskowski, Contributing Editor

- Storybooks teach engineering to students
- Engineers have the power to fix global warming

www.tmworld.com/blogs

Take a Test & Measurement Challenge

If you answer one of our T&M Challenge questions correctly, you'll be entered into a drawing for a prize, courtesy of the contest sponsor. Current challenges cover oscilloscopes and data acquisition, and the prizes are an Apple iPod and Bose Noise-Cancelling headphones. New challenge questions every month!

www.tmworld.com/challenge

From the archives

- **The big picture: large-format lenses**

Knowledge of mechanical, optical, and illumination issues can help you successfully implement large-format imaging systems, which offer advantages in resolution, sensitivity, and ease of integration over their smaller-format predecessors for online inspection, factory-floor automation, and high-end scientific applications. For more, read this article from our April 2006 issue.

www.tmworld.com/archives

Test & MEASUREMENT WORLD

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Reed Electronics Group

[EDITOR'S NOTE]

Five exabytes of distraction

E-mail's role as the pre-eminent Internet application may be ending. Evidence mounts that e-mail is becoming an unreliable communications method—choked with spam and irrelevant messages—that faces competition from instant messaging, VoIP, and social networking.

With regard to spam, the research firm IDC predicts that 2007 will be the first year in which spam e-mail volumes exceed person-to-person e-mail volumes worldwide. "Spam volumes are growing faster than expected due to the success of image-based spam in bypassing anti-spam filters and of e-mail sender identity spoofing in getting higher response rates," says Mark Levitt, a VP at IDC, who adds, "Instant messaging, joined by free and low-cost VoIP calling, will result in slower e-mail growth, especially among teens and young adults."

RICK NELSON, CHIEF EDITOR

As for young adults, I commented on March 5 on the difficulty college administrators have contacting students, in part because students lose or ignore e-mail messages. E-mail's deficiency in this regard was made horribly clear at Virginia Tech. By some accounts, social-networking sites like Facebook have been more effective than standard e-mail at informing students of the events of April 16.

Senders must begin to bear e-mail's cost.

Text messaging, too, is proving its value as an alternative. Text messages to 67,000 students at the University of Texas at Austin in January notified them of an impending ice storm and kept them safe indoors.

In the business world, sheer e-mail volume—which IDC expects to approach 5 exabytes worldwide in 2007—suggests that e-mail has staying power. But even for corporate users, e-mail is losing its luster, a fact that *Wall Street Journal* columnist Jason Fry attributes to "…the rising tide of unnecessary e-mail that threatens to drown us in apathy and distraction."

The problem is that the cost of messages is born almost entirely by the recipient. Various schemes have been proposed to alter this fact—one is Get Back Software's PostWare, which imposes noncash postage on messages. The drawback is that it only works within an organization's internal e-mail system, but it seems to be a step in the right direction of being able to imbue truly important e-mail messages with the significance of an overnight FedEx package.

Of course, any communications channel can be no better than the message crafted to go over it. Anticipating the January ice storm, UT-Austin administrators had a crystal-clear message: "Stay home." It's far less clear what message Virginia Tech administrators could have transmitted that would have significantly changed the tragic outcome. T&MW

See the online version of this article (www.tmworld.com/2007_05) for links to source material. Post your comments at www.tmworld.com/blog.

TESTVOICES

[An exclusive interview with a test engineer]

Diodes and x-rays

Rob Stadelman is a project engineer with Central Semiconductor (Hauppauge, NY, www.centralsemi.com), a manufacturer of discrete semiconductors. The company's products include transistors, diodes, bridge rectifiers, MOSFETs, and thyristors. Senior technical editor Martin Rowe recently asked Stadelman about the challenges he faces.

Q: What is your role in test?

A: Whenever we need a new test capability or need to improve a test capability for electrical or mechanical test (including inspection), that job falls to me. I recommend new test methods and research new equipment for purchase. I often develop bench testers from scratch, such as a zener-diode tester.

Q: How does the zener-diode tester work?

A: It's quite simple, just a power supply to provide current and a digital mulitimeter (DMM) to measure voltage across the device. It lets us test using a continuous DC current as opposed to a pulsed current that most automated testers use.

We adjust the heating time so that the device is tested at its operating temperature. We get a more accurate V_z measurement because the device is at thermal equilibrium. Software lets operators enter min and max voltages, and the tester gives a pass/fail indication.

Q: What sort of mechanical inspection projects have you done?

A: We just completed investigating a new x-ray system for looking inside components to check for proper assembly. X-ray inspection systems have come a long way, especially in terms of automation and level of detail.

Q: How long did you spend investigating x-ray systems?

A: Six months to a year. The process involved our sending samples to manufacturers. We got photos back to see if the quality was what we expected. When we narrowed it down to three our four, we visited them. We've made our selection and are waiting for the budget allocation to purchase this system.

Q: How different are new systems from the system you currently have?

A: The existing system is analog. It uses a video-processing card, and it displays the image on the screen. New systems are digital and PC based. Our operators can run a system with a keyboard and a mouse as opposed to running an embedded system. That's much easier to use, plus new systems deliver pictures with much better resolution. Our new system will also provide us with automation we don't currently have.

Q: What automation features will you get with a new inspection system?

A: We sell many of our parts as individual die on trays. The new system will be able to identify missing die on a tray. We do that manually now. We'll also be able to store digital images and share them over a network. We'll be able to perform automatic die-voiding calculations, which is a huge advantage over our current system.

Q: What other automated test systems do you have?

A: We have an automated system that measures AC parameters such as T_{on}/T_{off}, switching time, diode reverse-voltage recovery, and gain-bandwidth product. Over the years, we've made some software changes. For example, we were able to program the system to better adjust an oscilloscope's time base, thus providing a more accurate measurement.

Q: What other functions do you perform?

A: I spend about half of my time developing and specifying test systems and the rest evaluating new designs. I run environmental and stress testing on new devices. Sometimes, customers request specific tests for voltage, current, or temperature. I often handle those requests. 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.

The latest crop of multimeters

grown from the best-selling Agilent 34401A

Specification	34405A	34401A	34410A/11A
Display	5½ digits, dual display	6½ digits	6½ digits, dual display
Basic DC Accuracy	250 ppm	35 ppm	30 ppm
Max Readings/s (continuous to PC)	19	1,000	10,000 (34410A) 50,000 (34411A)
Connectivity	USB	GPIB, RS-232	GPIB, USB, & LAN LXI Class C Compliant
Price	$745	$1,172	$1,595 (34410A) $1,995 (34411A)

U.S. list price. Prices subject to change

It's true. The Agilent 34401A is the industry's best-selling bench digital multimeter. Now there's a new line of DMMs—built upon the same trusted technology, but with expanded capabilities and features.

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Agilent Technologies

Keithley ACS enhances semiconductor characterization

Keithley Instruments aims to fill a gap in on-wafer semiconductor test between benchtop analyzers and production parametric test systems with its new Automated Characterization Suite, or ACS. The ACS works with the company's Model 4200 semiconductor characterization system as well as with its source/measurement instruments and pulse/pattern generators.

The Model 4200 itself (pictured) is now available with the new Model 4205-PG2 pulse-generator card, which offers a patent-pending "Segment ARB" mode that lets users generate complex waveforms using simple line segments. New Model 4200-based applications support RF, power-FET, and flash test.

The ACS is designed to address the challenges introduced by emerging technologies such as scaled CMOS and LDMOS. The suite helps engineers perform extended test and data collection without having to rely on custom in-house or third-party software. ACS supports automation at the wafer or cassette level to enable unattended testing and collection of large statistical data samples.

For wafer-level test, Keithley ACS systems feature a utility that lets users build wafer-description files with integrated test plans. Color-coded wafer maps are updated in real-time during test execution to show pass/fail metrics. An interactive prober controller allows users to control wafer movement using the ACS software during test development to validate test setups on actual structures and during lot disposition to navigate to a problem area of the wafer and execute testing manually. A range of drivers offers integration with a range of semiautomatic and fully automatic probers. www.keithley.com.

CodeSymphony software works with PowerPC evaluation kits

Corelis has announced that its CodeSymphony software development and JTAG debug environment will now be included as part of AMCC PowerPC 405EZ evaluation kits. CodeSymphony is based on Eclipse, an open platform that provides a suite for building, compiling, and debugging embedded applications for PowerPC 4xx systems.

When used with the Eclipse Integrated Development Environment (IDE), CodeSymphony provides a simple GUI for managing a project. Developers can set up one or more build environments by specifying the compiler and build options, allowing for revisions of an embedded system. CodeSymphony also provides a prebuilt GNU C/C++ cross tool-chain for Linux and Windows that includes a compiler, linker, and debugger, along with other tools configured for PowerPC targets.

"The use of Eclipse for the CodeSymphony software environment provides the best in terms of embedded technology, support, and flexibility for our customers in the embedded market," said Terence Nakada, embedded tools product manager at Corelis. "And by adding JTAG emulation, users can readily migrate their application code from the development board to the actual target board." www.amcc.com; www.corelis.com.

Universal Switching acquires Matrix Systems

Universal Switching reports that it has acquired all product lines and assets of switch-module and system-manufac-

Editors' CHOICE

Expand your oscilloscope's bandwidth

With serial data streams constantly increasing in speed, an oscilloscope can quickly need replacing. The ScopemaX from Wavecrest can extend the life of a 1-GHz to 6-GHz oscilloscope by making measurements at up to 12.5 GHz and at data rates up to 6 Gbps.

The ScopemaX converts an incoming signal into one that the oscilloscope can accurately display, and it currently works with specific models of scopes from Agilent, LeCroy, and Tektronix. It provides one single-ended or differential input from a cable or probe. SMA cables connect the ScopemaX to the oscilloscope.

Windows-based oscilloscopes that let you install software will control the ScopemaX through the oscilloscope's USB port. Even if your oscilloscope does not let you install software, you can still take advantage of ScopemaX. Just install the software on a PC and connect the PC to an oscilloscope through a GPIB port and to the ScopemaX through a USB port.

You can use the ScopemaX software to perform jitter analysis, measure rise and fall times, look at eye diagrams, and perform time-interval analysis. Using the ScopemaX software, you can compare the performance of oscilloscopes from different manufacturers through a common interface.

Price: $35,950. *Wavecrest, www.wavecrest.com.*

turer Matrix Systems, located in Calabasas, CA. Founded in 1969 by Jack Singleton, Matrix pioneered advances in modular switching products. Norton Alderson, VP of marketing at Universal Switching, said that his company will maintain a portion of the Matrix line, although some products will be discontinued, or "available only to reorder clients." Universal Switching will support "in-warranty" products shipped by Matrix since April 16, 2006, and will support most out-of-warranty issues on an individual basis. www.uswi.com

Standard covers CAN transceivers

The International Electrotechnical Commission (IEC) has issued "Integrated Circuits—EMC evaluation of CAN transceivers," a standard that specifies test methods, setups, signals, and procedures as well as failure criteria for evaluating the electromagnetic compliance (EMC) of transceivers used in controller area networks (CANs). Topics include immunity against RF common-mode disturbances on the signal lines, emissions caused by nonsymmetrical signals regarding the time and frequency domain, immunity against transients, and immunity against electrostatic discharges (ESD). www.iec.ch.

CALENDAR

International Microwave Symposium, June 3–8, Honolulu, HI. Sponsored by IEEE Microwave Theory and Techniques Society (MTT-S). *www.ims2007.org.*

Design Automation Conference (DAC), June 4–8, San Diego, CA. Sponsored by IEEE, SIGDA, and EDA Consortium. *www.dac.com.*

International Robots & Vision Show, June 12–15, Chicago, IL. Sponsored by Automated Imaging Association and Robotic Industries Association. *www.machinevisiononline.org.*

Learn about other conferences, courses, and calls for papers at www.tmworld.com/events.

Editors' CHOICE

Spectrum analyzer covers 20 GHz for $20k

Anritsu's MS271xB family of microwave spectrum analyzers cover from 9 kHz to 7.1 GHz, 13 GHz, and 20 GHz. Prices start at $12,950, $16,950, and $19,950, respectively. Features include 1-Hz to 3-MHz resolution bandwidth, amplitude accuracy better than ±1.3 dB, phase noise of –114 dBc/Hz at 10-kHz offset, and 100-dB (typical) dynamic range.

The instruments can perform RMS detection and channel power ratio measurements as well as AM/FM demodulation and limit testing. For EMC precompliance testing, the analyzers have a quasi-peak detector and CISPR bandwidths. They also offer a 65-dB range input step attenuator and 20-W input protection. Optional power-meter functionality supports Anritsu's 6-GHz PSN50 sensor with ±0.16-dB power-measurement accuracy.

All three models offer optional WCDMA/HSDPA RF measurements and IQ demodulation hardware to support WCDMA demodulation. The 7.1-GHz MS2717B has an optional tracking generator to support filter and amplifier measurements and optional WiMAX measurements. Each analyzer has a 256-Mbyte compact flash drive and a 256-Mbyte USB flash drive as well as Ethernet and USB 2.0 connections. Power consumption is 35 W.

Anritsu, www.us.anritsu.com.

Network or spectrum analyzer – you choose the mode

The new R&S®ZVL – the instrument with two faces

Many users need both a network analyzer and a spectrum analyzer. But budgets are often tight and space is limited. And sometimes a portable solution may be required. Rohde & Schwarz has the answer: the new R&S®ZVL. Not only is it the most compact and lightweight network analyzer in its class, it also is a full-fledged spectrum analyzer.

The R&S®ZVL features exceptional characteristics in each operating mode:

- Bidirectional two-port network analyzer with spectrum analyzer functionality
- Two models from 9 kHz to 3 GHz or 6 GHz
- Only 16 lbs in weight and extremely compact
- Battery operation or DC power

ROHDE&SCHWARZ

www.rohde-schwarz.com/ad/zvl

OFC technical sessions feature test and measurement

> > > OFC/NFOEC, Anaheim Convention Center, Anaheim, CA, Optical Society of America. www.ofcnfoec.org.

During an OFC/NFOEC technical session on optical test and measurement, Wolfgang Moench of JDSU described a measurement technique that he says will change the way engineers measure OSNR in optical receivers. His presentation, "Measuring the Optical Signal-to-Noise Ratio in Agile Optical Networks," resulted in a lively discussion about measurement techniques.

The next presentation, "Fault Location for Branched Optical Fiber Networks Based on OFDR Technique Using FSF Laser as Light Source," Nianyu Zou described a technique for finding faults in fiber-optic cables using the frequency domain, or OFDR, using a frequency-shifted feedback laser. Norman Swensen of ClariPhy Communications followed with details of testing components of IEEE 802.3aq (10GBASE-LRM) in "Standards Compliance Testing of Optical Transmitters Using a Software-Based Equalizing Reference Receiver."

ON THE EXHIBIT FLOOR

Anritsu introduced a Universal Transport Analysis (UTA) module for its CMA 5000 multilayer test instrument. The UTA module lets you test 10-Gbps optical networks. Anritsu also introduced the MT9820A optical-component tester that lets you perform optical-loss measurements by controlling up to four tunable laser sources. **EXFO** introduced its FastReporter software that gathers measurements from the company's portable optical-network testers for engineers to analyze and report. The company also introduced the AXS-110 optical time-domain reflectometer (OTDR) for testing access networks and enterprise networks.

LeCroy introduced Eye Doctor software for its digital oscilloscopes that performs simulation of signals. You can use Eye Doctor to simulate how a signal will look at the end of a transmission channel based on signal measurements at the transmitter and on the channel's design specifications. **Apex Technologies** displayed the AP2440A series of optical spectrum analyzers. The AP2440A measures both optical power and phase, which you can use to measure chirps and pulses in the frequency domain.

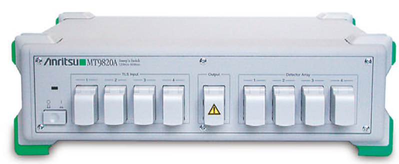
SyntheSys Research announced two additions to its BertScope line of bit-error rate testers (BERTs) and eye-diagram analyzers. The BertScope CRJ 12500A adds clock recovery and jitter analysis to the BertScope. The unit lets you measure the spectral components of jitter from 200 Hz to 90 MHz. The company also announced the BertScope LRM optical test system. The add-on lets you test transmitters and receivers for use in long-reach multimode applications, or IEEE 802.3aq networks.

The Agilent N4376B tests optical components at 850 nm.

Courtesy of Agilent Technologies.

Centellax demonstrated its 40-Gbps BERT system. It consists of a 40-Gbps PRBS pattern generator, a demultiplexer, a 40-GHz divider, a 50-GHz amplifier, a 40-Gbps amplifier, and at least one 10-Gbps BERT. **Luna Technologies** announced the OBR 4400 Optical Backscatter Reflectometer, a high resolution OTDR. The instrument lets you diagnose fiber-optic components and assemblies such as splices, breaks, connectors, and bends.

Agilent Technologies introduced two instruments designed to streamline optical measurements. The N4917A optical receiver stress test set tests optical receivers at data rates up to 12.5 Gbps. The instrument produces calibrated transmission streams with known, adjustable eye openings. The N4376B lightwave component analyzer eases the setup involved in characterizing components at 850-nm wavelengths. It can produce and capture optical or electrical signals. The instrument cuts test setup time and provides repeatable measurements.



The Anritsu MT9820A characterizes optical components from 1250 nm to 1650 nm.

Courtesy of Anritsu.

JDSU introduced the OTU-8000, a rack-mounted instrument for remote testing of fiber networks from FTTx to long haul. The unit holds two OTDR modules that let network operators find faults in deployed cables. The company also introduced the Optical Component Environmental Test System (OCETS) that can test FTTx components such as splitters. **Yokogawa** introduced a firmware upgrade and remote-control software for the AQ7270 OTDR and a 40-Gbps differential quadrature phase-shift-keying optical transmission module. T&MW

For more coverage of OFC/NFOEC, including links to vendors' Web sites, see www.tmworld.com/ofcnfoec_2007.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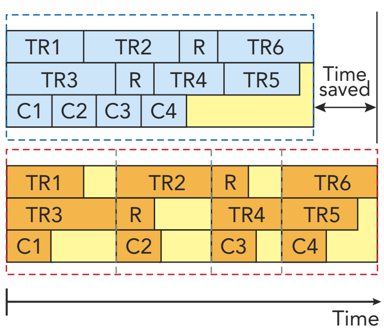
Parallel parametric test goes asynchronous

Parallel test is a surefire method for speeding up production, and asynchronous parallel test has long been known as an effective way of significantly improving throughput while making the most of your existing test hardware (Ref. 1). What's new is the application of parallel techniques to semiconductor parametric test applications.

Keithley Instruments pioneered the concept in the form of a synchronous parallel test capability and has published a book—reviewed on p. 22 of this issue—that discusses the benefits of parallel parametric test, provides hints on how to apply the technique to legacy devices, and describes how to design new test structures to take full advantage of the parallel-test capability.



In this three-threaded application, Agilent's SPECS asynchronous test scheduler (top) aims to squeeze out some of the measurement dead time (highlighted in yellow) left by synchronous tests (bottom) of transistors TR1 to TR6, resistor R, and capacitors C1 to C4.

In December, Keithley released version 5.2 of the KTE Interactive Test Environment software for the company's Series S600 Parametric Test System. KTE V5.2 includes a routine called PT_Execute, which allows quick evaluation of parallel versus serial test. The company also added a feature called FMI (for force-measurement interlock), which employs firmware and software to reduce crosstalk, noise, and measurement variability in parallel test applications.

Now, Agilent Technologies has upped the ante by introducing asynchronous parallel parametric test capability with the April launch of its 4080 Series parametric test platform. The new system employs what Agilent calls the SPECS (Semiconductor Process Evaluation Core Software) test shell to support both synchronous and asynchronous parallel test.

According to Alan Wadsworth, marketing manager for Agilent's Hachioji Semiconductor Test Division, the 4080 parametric test platform is designed to serve wafer fabs running advanced processes, including those extending down beyond 45 nm, for which engineers need extensive data to contend with issues such as linewidth variation. Apart from the system's parallel test capability, Wadsworth noted that the 4080 Series has a more powerful CPU than does its 4070 Series predecessor; the new CPU alone, he said, boosts throughput of legacy serial test programs transferred from 4070 systems by 10 to 20%.

But the real gains come from developing programs that take full advantage of the 4080's asynchronous parallel test capability: Parallel asynchronous test can decrease test times by up to 50% over conventional sequential test methods, Wadsworth said. Asynchronous mode, he added, aims to squeeze out some of the measurement dead time left by synchronous-parallel-test approaches (**figure**).

The 4080 comes in three models: the 4082A performs general-purpose parametric test, the 4082F targets flash-memory-cell parametric test for NAND/NOR devices, and the 4083A includes a 20-GHz 8x10 RF matrix to measure up to five RF structures in a single touchdown. T&MW

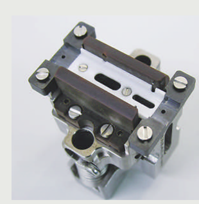
REFERENCE

Mazza, Ed, "Asynchronous Testing Increases Throughput," *Test & Measurement World,* December 2000. www.tmworld.com/archives.

SIA-3100 integrated with ASL 1000

Wavecrest has announced the integration of its SIA-3100 signal-integrity-analysis system into the Credence ASL 1000 linear and mixed-signal IC tester. The integration enables tests of reference clocks and PLLs up to 6 GHz and of Serial ATA and Gigabit Ethernet interfaces to 1.5 Gbps. The SIA-3100's Gigaview software supports compliance measurements and provides diagnostic information for characterizing and predicting long-term IC performance. www.wavecrest.com, www.credence.com.

Multitest tackles 2-kV automotive IC



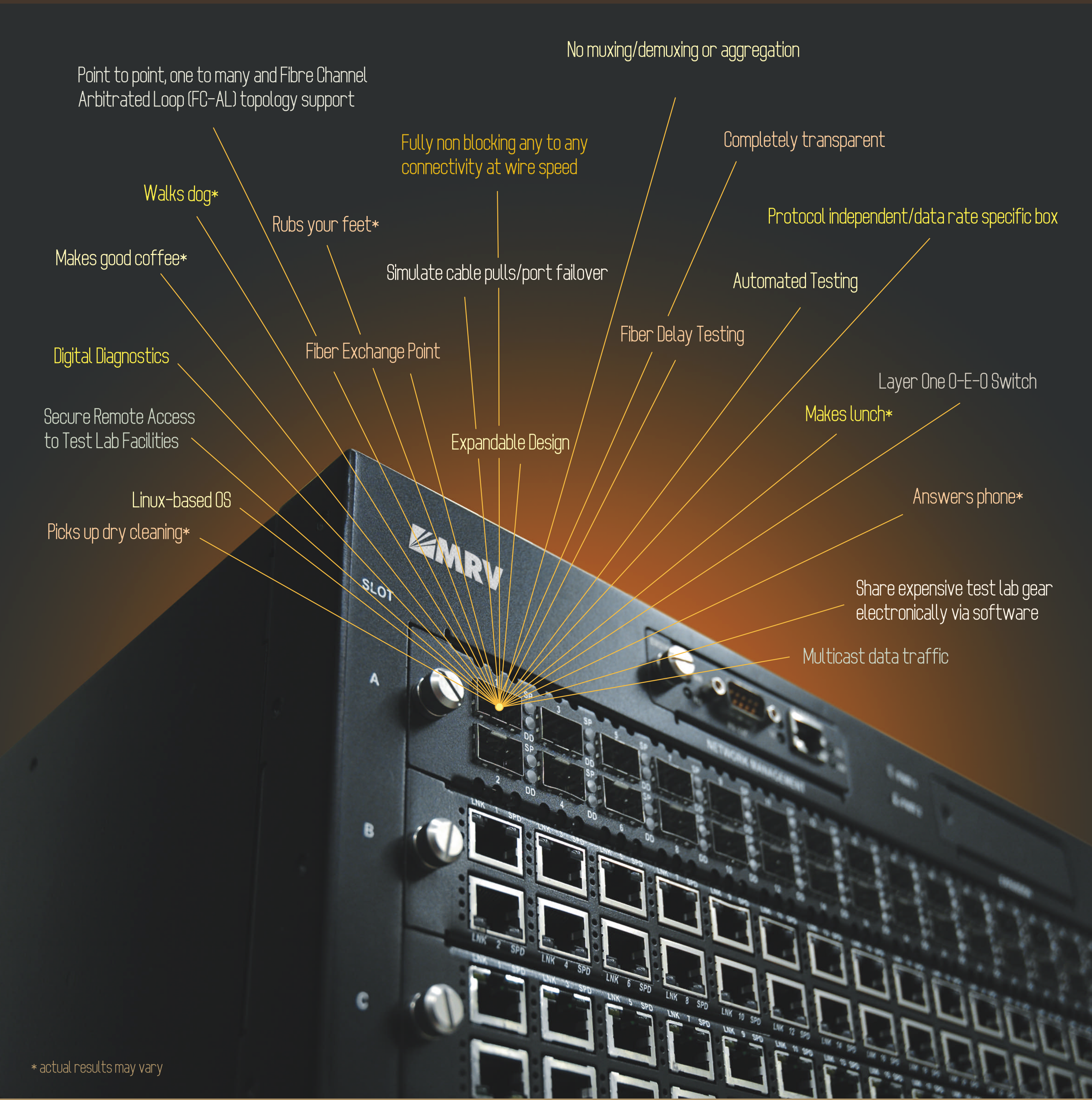
Multitest reports that an international IDM has used its equipment to test an automotive IC at up to 2.0 kV. To meet the high-voltage test requirement while eliminating arc-over, Multitest developed a test-handler "conversion kit contact cassette" to complement a dedicated contact-socket design. www.multitest.com.

Teradyne unveils J750Ex

Teradyne says that its new J750Ex highly parallel test configuration delivers 50% higher throughput than other J750s. It features 200-MHz/400-Mbps digital performance and dedicated instrument resources for digital, mixed-signal, memory, and converter test. All J750 systems are device-interface-board (DIB) compatible. Existing J750 test programs can be run on the J750Ex, and customers can upgrade installed J750 systems to the J750Ex. J750 prices start at $99,000. www.teradyne.com.

At times, nothing could be better than a free port

(Especially when that port can do so much)



Test Automation with a Physical Layer Switch

Media Cross Connect switches are ideal for the Lab Manager and Test Engineer who are trying to create a “light’s out” and “wire once” environment. The Media Cross Connect can automate cable reconfigurations in storage systems, servers, peripherals and operating systems. In test labs, the Media Cross Connect offers superior test efficiency and productivity as well as cost performance by allowing test engineers to centralize, share and truly distribute redundant pieces of expensive test gear such as protocol analyzers, traffic/data generators, devices under test (DUT’s), servers and storage systems.

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Filters improve images

Designers may not immediately think of an optical filter as a way to enhance images. But a basic $30 polarizing filter can attenuate specular reflections from nonmetallic surfaces and eliminate the need to tweak lighting.

Colored filters also enhance monochrome images. "A red filter narrows the spectrum and reduces chromatic aberration," noted Greg Hollows, vision integration partners coordinator at Edmund Optics. "All lenses exhibit some chromatic dispersion, which means colors across a wide range of wavelengths do not simultaneously focus on the surface of an image sensor. As a result, an image may show some blurring, which decreases a camera's spatial resolution."

Color filters such as these screw onto lenses and pass or block light within narrow wavelength bands.
Courtesy of Edmund Optics.

A color filter also can increase the contrast between objects. Think of blue components on a PCB. When observed through a red filter, these objects appear dark, and the high contrast between them and the PCB lets a vision system locate and measure well-defined edges.

Using red light has another advantage: Silicon image sensors have high responsivity at red wavelengths, so removing light toward the blue end of the spectrum reduces the sensor's sensitivity only slightly. This red-light sensitivity extends into near-infrared (NIR) wavelengths (750–1100 nm), which the human eye cannot detect.

As a result, NIR light can produce some unexpected results, because it can reflect from surfaces that would appear dark in visible light. So, if your camera produces images that show things you cannot see in visible light, your lens may need a filter that blocks NIR wavelengths. (Manufacturers offer cameras with built-in NIR filters, although you can specify a camera without this type of filter.)

In some cases, though, NIR light can work to your advantage and reveal defects you cannot see under visible light. Metal parts, for example, challenge vision systems when finished and unfinished parts look alike. But if NIR radiation reflects differently from bare metal and finished metal, a camera with good NIR response and equipped with an NIR bandpass filter can distinguish between good and bad parts. The filter blocks non-NIR ambient light.

At the other end of the spectrum, ultraviolet light also inspects things not visible to the eye. "Consider a pharmaceutical package," said Steve Kinney, product manager at JAI. "Under white light, a portion of the package might appear unmarked, but special inks printed in this area could reflect UV light. So, an inspection station outfitted with a UV light, a UV-sensitive camera, and a UV bandpass filter could read the 'invisible' information." Even if someone examined the package with a UV light, they could not read the label. T&MW

FOR FURTHER READING

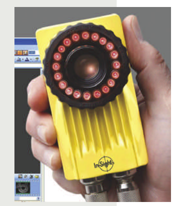
"Interference Filters: The Key to It All," C&L Instruments. www.fluorescence.com/tutorial/int-filt.htm.

Wagner, Julianne, "Successful Polarization Techniques," Edmund Optics. www.edmundoptics.com/techSupport/DisplayArticle.cfm?articleid=257.

The online version of this article contains additional information about optical filters. www.tmworld.com/2007_05.

Cognex debuts fast vision sensors

Cognex says its In-Sight 5600 vision sensor offers twice the processing speed and memory of the In-Sight 5400 series. The In-Sight 5600 line-up includes 640x480-pixel and 1600x1200-pixel models. Cognex also announced its In-Sight Explorer 3.4 software, which includes enhanced optical character reading and verification tools as well as onboard image storage for reviewing results without a PC. www.cognex.com.



CMOS camera delivers CCD-like image

Adimec's 4150m machine-vision camera employs a rolling-shutter CMOS sensor to generate 4-Mpixel blemish-free images that enhance the capabilities of machine-vision systems for applications such as AOI and semiconductor inspection. The camera produces a resolution of 2352x1728 pixels with a pixel size of 7 μm. It operates at speeds to 140 full-resolution frames/s in continuous-readout mode. www.adimec.com.

Microscope has UV, NIR, and visible applications

Craic Technologies has introduced its UVM-2 broadband microscope for UV, NIR, and visible microscopy. This instrument can image from 250 to 2000 nm over narrow bands or large spectral regions. It acquires transmission and reflectance microscopic images with submicron resolutions. Absorbance, transmission, and reflectance illumination in all three regions can be done with the same microscope. www.microspectra.com.

FIBER OPTICS

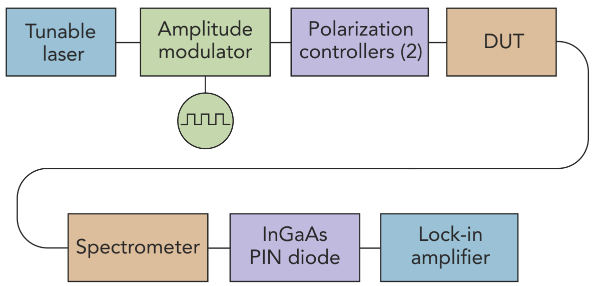
Optics on silicon lose polarization dependence

MIT researchers recently announced that they may have found a solution to polarization-dependence problems in ICs. Light traveling in fiber-optic cables experiences randomized polarization, which makes steering light in silicon difficult. By eliminating this dependence, an IC can process optical signals without needing to convert them to electrical signals.

The MIT researchers overcame the problem by manipulating the light polarization, thus making the light's polarization parallel to the substrate's surface. The device best manipulates light that has a polarization state that is parallel to the substrate's surface.

The process involves separating the signal's vertical transverse-magnetic (TM) and horizontal transverse-electric (TE) polarization components, rotating one polarization by 90º, sending both through identical structures, rotating the other component by 90º, and combining the polarization components. The process makes the IC immune to polarization errors.

To find out how the researchers measured the technique's effectiveness, I met with researcher Peter Rakich at his office on the MIT campus. Rakich explained that amplified spontaneous emission from the tunable laser limits the purity of the polarization state, making some extra steps necessary to obtain high-fidelity measurements.



Researchers at MIT used this setup to measure the optical output power of a polarization-independent IC.

The signal is first modulated at 5 kHz before going to the polarization controller. A Glan-Thompson polarizer in the first polarization controller cleans the polarization of the light. It also acts as a course polarization tuner, enabling the synthesis of any polarization state through computer control. The second controller maps the polarization into TM and TE states relative to the IC's surface.

To verify that the device under test (DUT) is polarization independent, Rakich used a computerized polarization controller that generates 100 known polarization states. A spectrometer and InGaAs PIN diode follow the device, which lets researchers filter the laser light and convert it to an electrical signal.

The researchers proved that the DUT was polarization independent because its outgoing optical power was virtually the same for all 100 known polarization states. If the device had not been polarization independent, power measurements would have shown a wide variation. The online version of this article (www.tmworld.com/2007_05) contains a link to an article that describes the technique in detail.

Martin Rowe, Senior Technical Editor

INSTRUMENTATION

Test instrument revenue to approach $4.5b in 2010

General-purpose test-equipment revenues will reach nearly $4.5 billion worldwide in 2010, up from $3.6 billion in 2006, according to Doug Raymond, VP for measurement and instrumentation at Frost & Sullivan (www.frost.com). Raymond presented his forecast at *Test & Measurement World*'s annual awards breakfast, which was held February 21 during the APEX show in Los Angeles, CA.

Raymond attributed the growth in part to the defense sector's demand for general-purpose test equipment and to market growth in the Asia Pacific region. He noted that technology advancement in the communications and information industry (with the emergence of WiFi, PCI 2.0 Express, WiMax, 3G/4G, high-rate digital, and wireless video applications) is also fueling demand for general-purpose test equipment.

But Raymond did cite some restraints on growth: sales of used test equipment slow sales of new equipment; price pressure experienced in Asia Pacific markets restrains revenues; the plethora of communications standards is challenging test-equipment suppliers to efficiently address the market; and synthetic instrumentation is changing the nature of the general-purpose-test market.

He said that at 33.7% of the market, oscilloscopes are the largest category within the general-purpose instrument market. In second place is the spectrum-analyzer segment at 17.3%. Other categories include signal generators, multimeters, network analyzers, logic analyzers, power meters, and arbitrary waveform generators. Raymond noted that 10 companies—Agilent Technologies, Tektronix, Fluke, Rohde & Schwarz, LeCroy, Anritsu, Yokogawa, Advantest, Aeroflex, and Keithley Instruments—make up 81% of the worldwide general-purpose test market.

See the online version of this article (www.tmworld.com/2007_05) for a link to Raymond's presentation, which covers future market evolution, breaks out revenue figures for Asia, and provides insights into printed-circuit-board test and inspection.

Rick Nelson, Chief Editor

BOOK REVIEW

Time-to-market pressure drives parallel parametric test

Parallel Test Technology: The New Paradigm for Parametric Testing, 1st ed., Keithley Instruments (ggcomm.com/Keithley/PPTHandbook.html), 2006. 60 pages. Free.

No part of a product life cycle is immune to time-to-market pressures, and that includes wafer-level parametric tests on scribe-line test structures. Parallel parametric test is emerging as a technique that can not only cut test times but also optimize the use of instruments within a parametric test system.

As the handbook *Parallel Test Technology* points out, parametric test systems are typically equipped with multiple source-measure units. Assuming a full complement of eight such units, seven will sit idle during sequential test of a simple resistor. With parallel parametric test, the remaining seven can be deployed to simultaneously test a couple of transistors and a diode, for example.

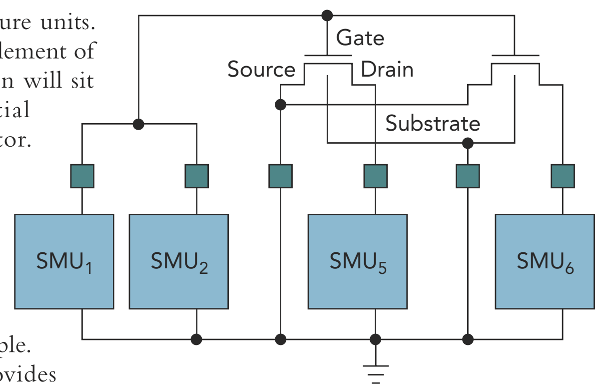
The handbook provides clear guidelines on implementing parallel test. For example, it advises that, at least initially, parallel parametric test should be applied to structures located within a single test element group (a group of capacitors, inductors, transistors, and vias, for example, that together help evaluate specific failure modes).

The book also recommends that you establish a measurement baseline using sequential test before performing parallel test, that you use caution when introducing parallel test on legacy test structures that have shared terminals, and that you take note that prober overhead can adversely affect parallel-test time savings.

For existing designs, a full chapter discusses effective ways to harvest the "low-hanging fruit"—for instance, it identifies electrically isolated devices as good candidates for parallel test. The chapter describes the shared-terminal legacy structures (**figure**) that can pose problems for parallel test.

A subsequent chapter discusses ways to optimize the design of test structures to facilitate parallel test (for instance, employ layouts that minimize parasitic resistance) and estimates the time savings that can result.

The book helps relate parallel test to other test considerations. For example, a sidebar in chapter 1 contrasts parallel test with adaptive test (a results-based approach that determines the number of sites to be tested and the number of tests to be performed based on previous measurements) and advises against ramping up parallel and adaptive test at the same time.



The shared-gate configuration in this legacy test structure prevents source-measurement units SMU_1 and SMU_2 from independently driving the two transistors' gates.

The book cites Keithley's S680 DC/RF parametric test system from time to time, and an appendix focuses on parallel test implementations using the company's pt_execute program, but the bulk of the information presented is generic.

Rick Nelson, Chief Editor

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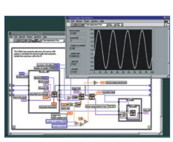

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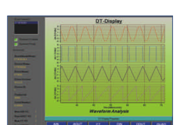

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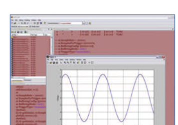

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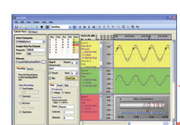

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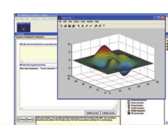

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PROJECTPROFILE

INSTRUMENTS

Check the clock oscillators

DEVICE UNDER TEST
Crystal oscillators, voltage-controlled oscillators, and quartz resonators. Frequencies range from 32 kHz to 6 GHz. Most devices are assembled in surface-mount packages, with 7x5 mm being the most common size. The devices come with several output options, including low-voltage differential signaling (LVDS), CMOS, positive emitter-coupled logic (PECL), and clipped sine wave.

THE CHALLENGE
Evaluate new oscillators in the engineering lab prior to production. Measurements include frequency, jitter, phase noise, rise time, fall time, input current, output power, and stability. Perform temperature-stability tests at temperatures ranging from –40°C to 85°C.

THE TOOLS
- Agilent Technologies: digital multimeter, frequency counter, phase-noise tester, triple-output power supply. www.tm.agilent.com.
- Tektronix: oscilloscope. www.tektronix.com.

PROJECT DESCRIPTION

Crystek (www.crystek.com) manufactures crystal oscillators, voltage-controlled oscillators, and quartz resonators in Ft. Myers, FL. The devices provide timing signals for microprocessors used in embedded systems, for telecom routers, and for other applications. Prior to each new product release, director of engineering Ramon Cerda and a team of engineers evaluate parts.

The most critical measurements that the engineers make are output frequency, jitter, and phase noise. They use evaluation boards that contain SMA connectors that provide test points and connections to test equipment. The evaluation boards also contain a plastic fixture that holds the oscillator in place.

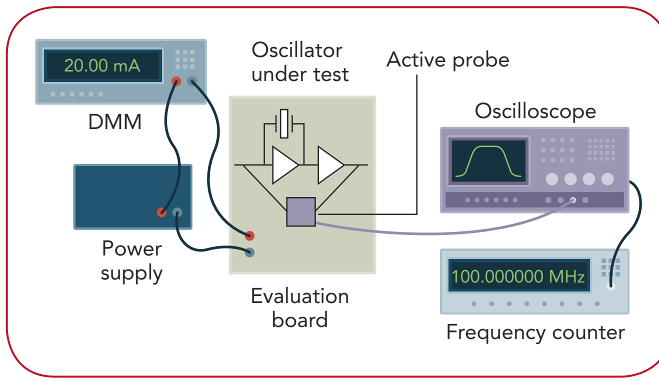
The engineers measure frequency with a 10-digit RF frequency counter, and they use a 1-GHz, 10-Msamples/s oscilloscope to measure jitter, rise time, and fall time. The frequency counter uses an in-house, GPS-based reference clock. They also measure phase noise with a phase-noise tester.

The difficulty in making these measurements comes from the oscillator's high output impedance—up to 10 kΩ for devices with clipped-sine-wave and CMOS outputs. Connecting two instruments to an oscillator's output places too heavy a load on the device. "You can't just use a T connector to route signals to two instruments," warned Cerda. Rather than build a buffer circuit, Crystek engineers use the oscilloscope's buffered analog output, which is a replica of the scope's input signal.

Crystek's engineers use an active probe to minimize loading on the circuit. The active probe loads the oscillator with less than 1 pF. A 15-pF capacitor on the board provides a known, stable load. A power supply connects to the evaluation board through a digital multimeter (DMM), which measures the oscillator's input current.

For devices with sine-wave outputs, the engineers calculate the amplitude in dBm based on the peak-to-peak amplitude. For these devices, with outputs to 6 GHz, engineers use a spectrum analyzer and can characterize the device in the frequency domain. For square-wave outputs (output frequencies to 200 MHz), engineers measure rise time, fall time, and duty cycle (45% to 55%). The oscilloscope's jitter-measurement software measures cycle-to-cycle and periodic jitter.

Engineers perform these and other tests at temperatures beyond the device's specified range. Temperature cycling ranges from –40°C to 85°C. The engineers measure frequency, amplitude, and phase noise over temperature. In addition, they perform measurements for varying input voltages, which range from nominal voltage (5 V, 3.3 V, or 2.5 V) to ±10%.



Engineers connect an oscillator to an oscilloscope, which connects to a frequency counter.

LESSONS LEARNED

"When testing crystal oscillators and other devices with high output impedances," said Cerda, "test equipment can load the device under test. A buffered output from an oscilloscope is a must." Cerda warned against using a "T" connector, because both the scope and the counter will load the oscillator's output, thus changing the output signal. "It's also important that your oscilloscope has enough bandwidth to let you accurately measure a square-wave oscillator's third harmonic," he added.

Martin Rowe, Senior Technical Editor

Testing brings home TELCO TV

AT VERIZON LABS, ENGINEERS TEST EVERY ASPECT OF VIDEO DELIVERY, FROM THE HEADEND TO THE HOME.

MARTIN ROWE, SENIOR TECHNICAL EDITOR

WALTHAM, MA—In 2005, Verizon began offering voice, video, and data services over its new fiber-to-the-home (FTTH) network. The move into broadcast and on-demand video thrust engineers at Verizon Labs into video-network integration and testing.

Verizon Labs has locations in Massachusetts, Virginia, New York, and Texas, all of which play some role in video testing. The Waltham, MA, facility, once GTE Labs, now houses test facilities that replicate a complete video-distribution network, from gathering content to delivering it to your home. Alex Laparidis, director of video systems testing, oversees a team of about 40 engineers in the video-test labs. Manager of video systems testing Andrew Marquis manages video lab infrastructure and

Alex Laparidis directs more than 40 engineers in Verizon Labs' video-test labs. Engineers test all aspects of voice, data, broadcast video, and video on demand.

MARK WILSON

ensures that test engineers have the equipment they need.

The division's engineers use several interconnected test beds to verify that video headends, core and edge-network routers, line terminators, home routers, and set-top boxes (STBs) will deliver a video experience worth paying for. For example, engineer Stan Lee operates an end-to-end long-haul core network and metro network to test routers and content distribution. Bill Downey, who manages the test beds' day-to-day operations, uses the long-haul network to test equipment at the ends of the video-distribution network.

In the Customer Premises Equipment (CPE) lab, Rick Halstead manages engineers who test the network components installed in homes. Although CPE is at the end of the network, the CPE lab is fully

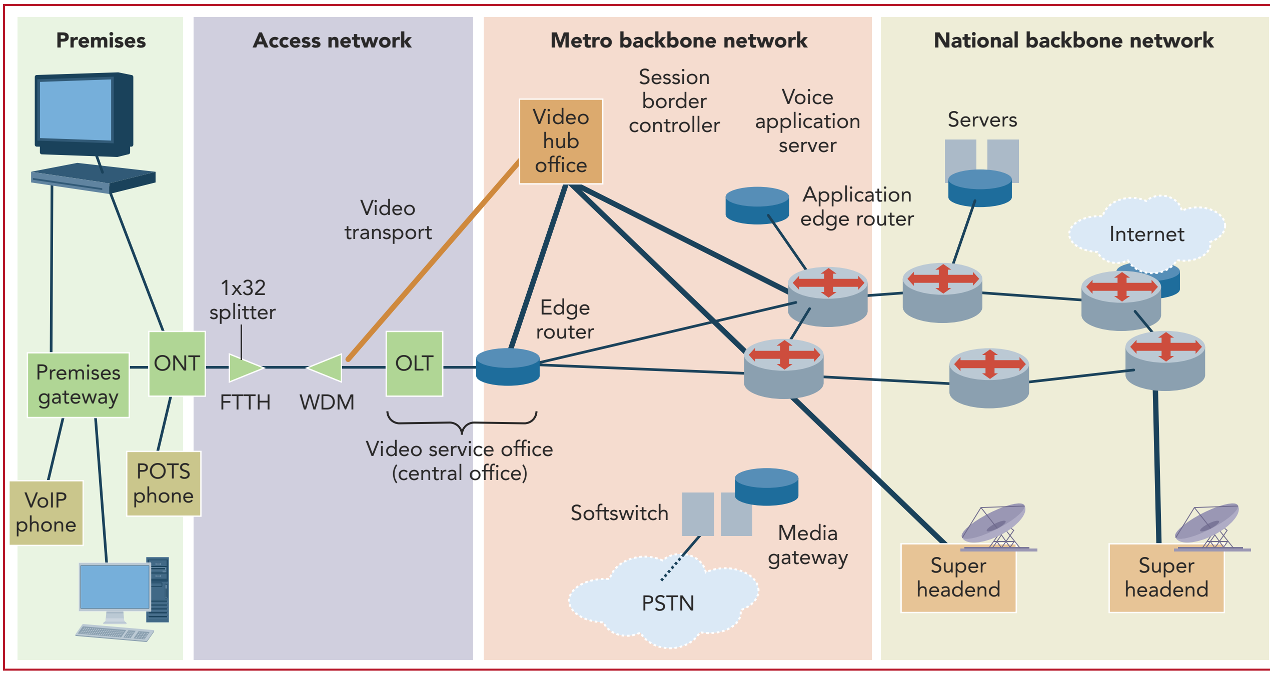


FIGURE 1. Verizon Labs simulates a complete service network in one building.

integrated into the rest of the test network. Earl Vanderhoff uses the Video Distribution Lab to run automated tests on set-top boxes.

Not all test beds are interconnected. Engineers in the RF lab, for example, test network components separately from the rest of the network.

The complete network (**Figure 1**) consists of interconnected equipment located on two floors and on the building's roof. Satellite antennas receive analog and digital content from providers such as CNN and ESPN. Aggregators in the super headend (SHE) combine the programs into Ethernet streams for long-haul transport over a SONET network.

Video hub offices (VHOs) combine the national TV content with local content such as broadcasts from local stations and local commercials. The combined video feed travels over a "super trunk" to a video service office (VSO) located in a Verizon central office (CO). Depending on the distance to a VSO, the TV signals may travel as 6-MHz analog and digital channels or remain in IP form. Longer distances require that the video streams remain in IP form.

At the CO, an optical-line terminal (OLT) distributes voice, data, and video-on-demand (VoD) content to home and small businesses through optical splitters. The network optically combines broadcast video signals with the output of the OLT using a wavelength-division multiplexer (WDM). Each splitter can support up to 32 subscribers. (See "Verizon's last mile," p. 34, for a description of the FTTH optical network.)

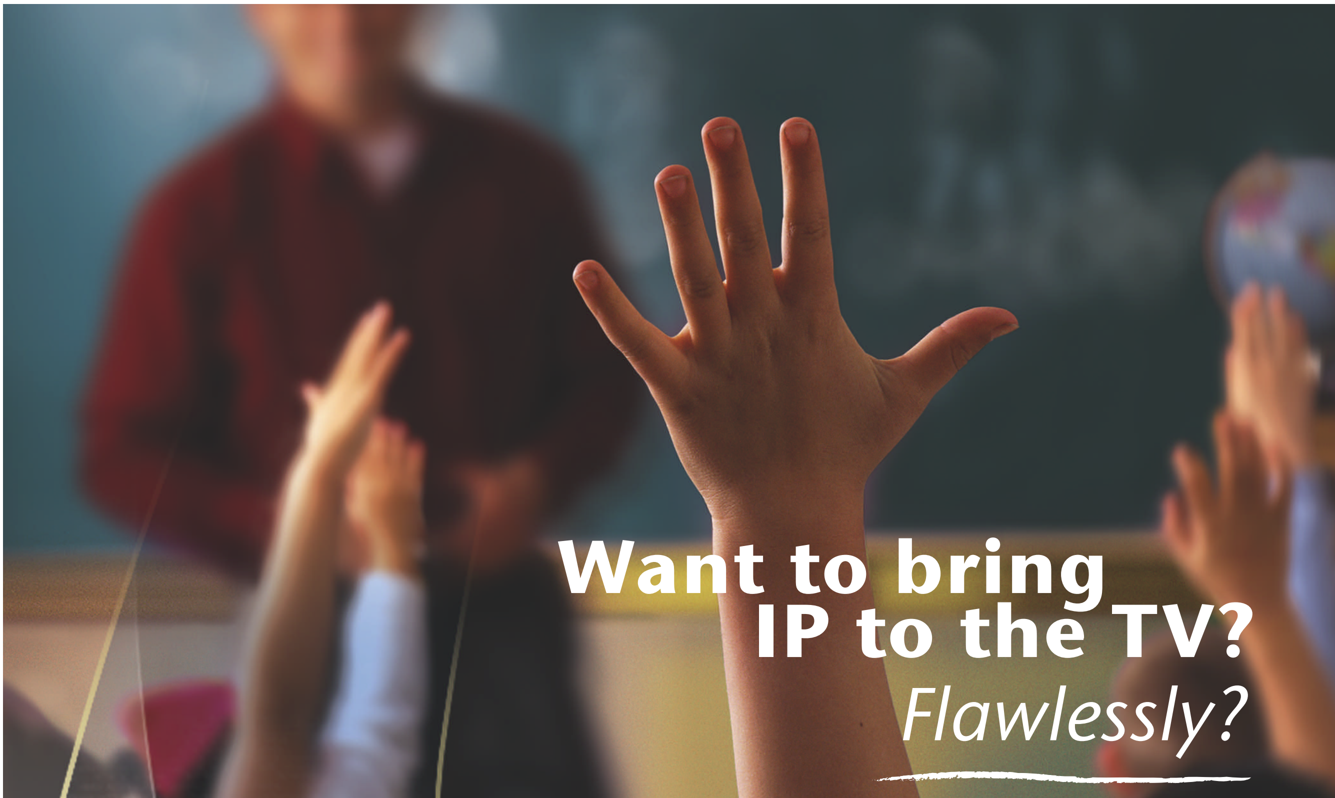
The network terminates at a subscriber's home where an optical-network terminal (ONT)—usually located on an outer wall—converts the optical signals into electrical signals. Coax and twisted pair cables carry signals throughout the home. A broadband premises gateway distributes services to VoIP phones, computers, and STBs. In the Waltham facility, a small theatre contains a complete home network, starting with the ONT, that's connected to an OLT and to the video infrastructure in the other labs.

Glossary of terms

BER	bit-error rate
BPON	broadband passive optical network
CNR	carrier-noise ratio
CO	central office
CPE	customer premises equipment
CSO	carrier second-order
CTB	carrier triple-beat
DWDM	dense-wavelength-division multiplexing
FEC	forward-error correction
FTTH	fiber to the home
GPON	gigabit passive optical network
MoCA	Multimedia over Coax Alliance
MPEG	Motion Picture Experts Group
NTSC	National Television System Committee
OLT	optical-line terminal
ONT	optical-network terminal
POTS	plain old telephone service
PSTN	public switched telephone network
QAM	quadrature amplitude modulation
SHE	super headend
SNR	signal-to-noise ratio
SPDI	Sony/Philips Digital Interface
STB	set-top box
VHO	video hub office
VoD	video on demand
VSO	video service office
WDM	wavelength-division multiplexer

Video lab

In the video lab, two SHEs capture video analog and digital video broadcasts from five satellite dishes on the roof. (In the actual network, the SHEs are located in Illinois and Florida to prevent a single natural disaster from taking down the



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MARK WILSON

Rick Halstead tests Verizon's FiOS network with TVs from numerous manufacturers.

network feed.) Encoders convert all incoming analog video content to MPEG-2 format. The MPEG stream is then formatted into IP packets for transport over the SONET OC-192 (10-Gbps) long-haul network. All content travels over the long-haul network encapsulated in IP packets.

Before sending IP video to the long-haul network, the SHEs add program information and content rules in XML format. XML data identifies each program within the MPEG stream so customers can get the program they want.

"The XML data must comply with CableLabs specifications for content routing," said test engineer Scot Arena. He runs functional tests on the network, its components, and on vendor software releases by forcing errors into the XML data. "We need to see how the network responds to errors," he said. (The CableLabs consortium represents the cable telecom industry and pursues new cable telecom technologies, www.cablelabs.com.)

Arena also verifies the quality of the VoD MPEG video before it enters the transport network. He uses video testers from IneoQuest, Pixelmetrix, and Triveni Digital to measure video quality. He compares video quality before and after the IP streams containing the MPEG streams travel through the network.

The video lab also contains an RF test system (**Figure 2**) that engineers use to test the optical transmitters and ONTs over the 55.25-MHz to 870-MHz broadcast TV band. Downey explained that this tester simulates the analog and digital video signals from which engineers can measure frequency response, distortion, and channel crosstalk.

The test system, built by Matrix Test Equipment, contains several RF signal generators that re-create different combinations of analog and digital signals. Typically, the system produces thirty to forty 6-MHz analog channels. The remainder of the broadcast channels are in digital form. Amplifiers convert the electrical RF signals into optical signals for testing.

The Verizon engineers use a Rohde & Schwarz quadrature amplitude modulation (QAM) tester and an Agilent Technologies spectrum analyzer to characterize the signals. For the QAM (digital) channels, they measure modulation-error ratio. They measure bit-error rate (BER) both before and after forward-error correction (FEC). The engineers make measurements on the RF signals before they enter the amplifiers and then repeat the measurements as the signals exit the ONT, comparing the results to see how the network degrades the signals.

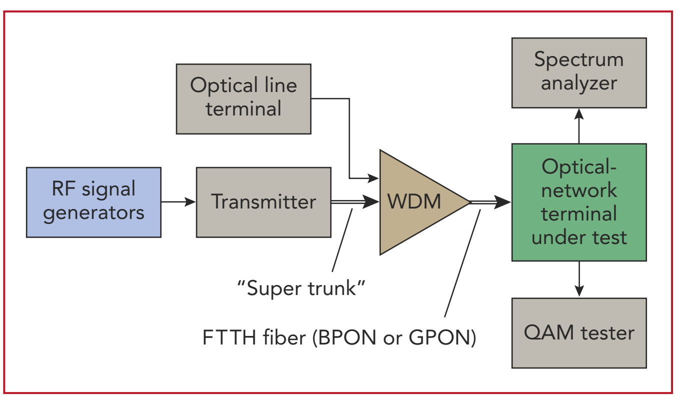

FIGURE 2. Engineers in the RF lab test optical network terminators for their RF characteristics.

On the analog channels, engineers measure signal-to-noise ratio (SNR) as well as carrier second-order (CSO), carrier triple-beat (CTB), and carrier-noise ratio (CNR) distortion as the system turns adjacent channels on and off. "ONTs have automatic gain control," Downey noted, "and we test at incoming optical power that simulates an end-of-life laser." The engineers perform this test with several ONTs to check for interoperability problems. A typical ONT test takes several weeks to complete. *(continued)*

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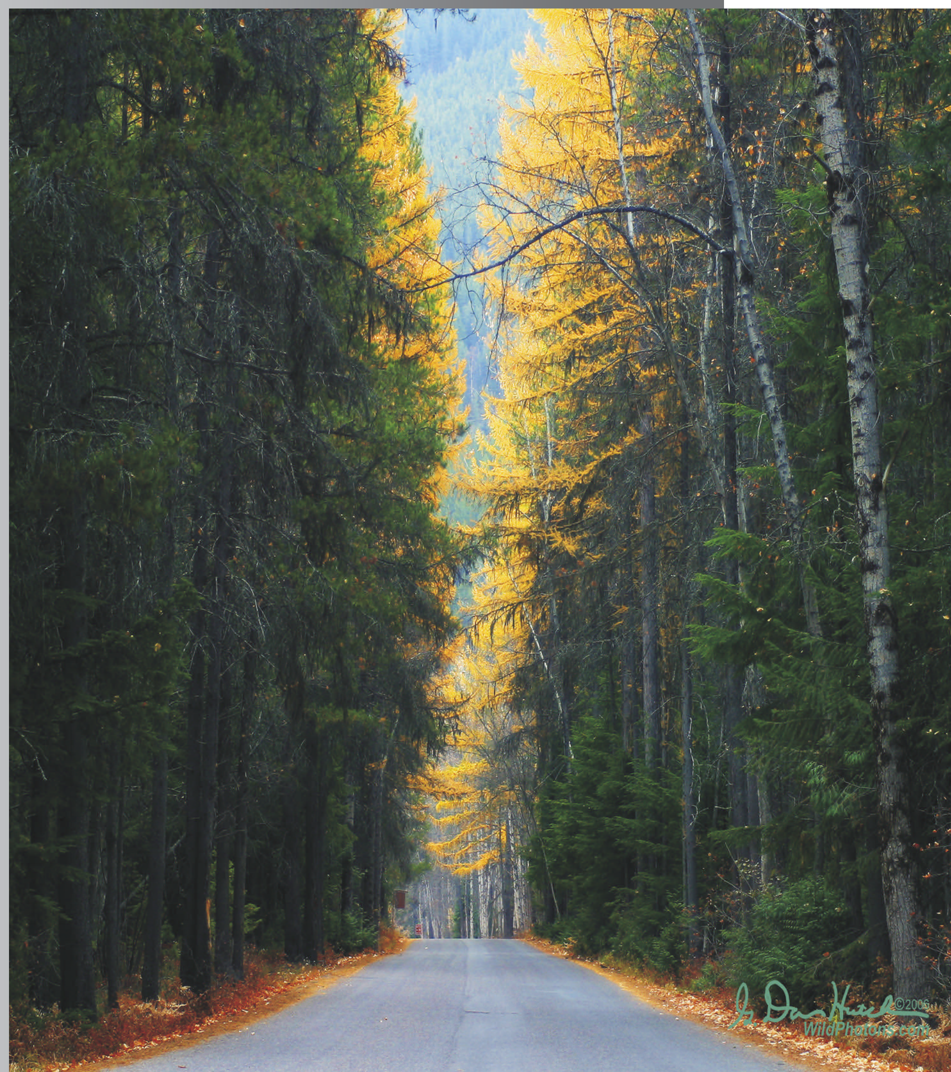

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The long haul

Downstairs from the video lab, Verizon Labs keeps its long-haul and medium-haul portion of the video network—the dense-wavelength-division multiplexing (DWDM) lab. Here, Stan Lee tests how all of Verizon's services travel between cities on long-haul networks (up to 4000 km) and around cities on metro networks (up to 75 km). Rolls of fiber connect the optical transport equipment. He runs tests whenever a supplier makes a software change or when Verizon adds a new service.

Programs from the SHEs in the video lab travel through Ethernet-over-SONET rings, then through the DWDM network, then back to SONET rings (**Figure 3**). All traffic, including video, travels through this portion of the network as IP streams. Broadcast video will later return to its original form before reaching the access (FTTH) network.


MARK WILSON

Bill Downey tests equipment at the ends of a video-distribution network.

Each SONET ring has its own protection. In case of failure, subscribers will see at most a momentary lapse in TV service. Eight copies of video streams (four from each SHE) travel though the test bed so Lee can test the network by breaking the streams. The network should recover from a failure within 50 ms.

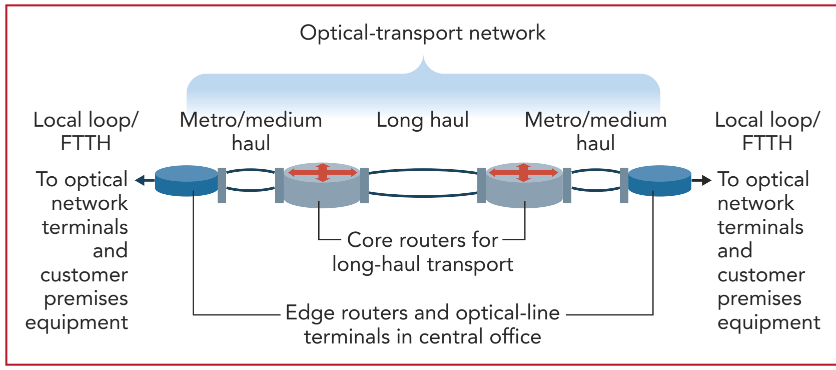

FIGURE 3. An optical-transport network in the lab contains core routers, edge routers, and OLTs.

Lee used four optical cables from one SHE to demonstrate the network's ability to recover from a fiber cut. A TV, connected to the FTTH access network, which is connected to the long-haul network, let me see the effects of line breaks, one at a time. With each break, I saw a momentary freeze in the TV picture, but it was hardly an annoyance. When Lee broke the fourth optical connection, the TV picture remained frozen.

Lee does more quantifiable testing than simply looking at a TV screen. He monitors the network's transport layer with protocol testers from Agilent Technologies, Anritsu, and Exfo. He measures BER with a tester from Digital Lightwave, and he performs field-level tests with optical-network testers from Sunrise Telecom.

To perform a test, Lee uses real and in-house generated network traffic. In-house voice traffic comes from Spirent generators, and data comes from Spirent and Ixia data generators. The network also has several T1 links to Class 5 switches in Silver Spring, MD, where Lee gets voice traffic to add to the network. He uses the voice traffic to load the network with voice calls to check interference with data and video.

Lee also decodes and analyzes MPEG streams and measures video quality with testers from IneoQuest, Pixelmetrix, and Triveni Digital. "We look at the SONET level, the MPEG level, and the Ethernet level," he said.

Voice, VoD video, and data traffic from the metro network routers connect to OLTs located in Verizon COs. In the lab, the OLTs reside near the metro routers and connect to ONTs located upstairs. The FTTH network, which uses broadband passive optical network (BPON) and gigabit passive optical network (GPON) technology, connects homes to Verizon's network. Upstairs, engineers in the video lab can monitor the video after it travels over the FTTH network.

Into the home

Verizon's network ends inside subscribers' homes where it must work with TVs or STBs, computers, POTS phones, and VoIP phones. That's where Rick Halstead and his staff in the CPE lab test CPE products for a quality experience.

In the CPE lab, engineers use six test benches, each of which simulates in-home networks. (Verizon has 20 CPE test benches in Reston, VA.) One engineer works at each bench.

A typical test bench consists of a rack with an ONT, six or seven STBs and TV screens, a stereo receiver, and a VCR. A home router connects the STBs to several laptop PCs and to the network. The lab has about 25 TVs that engineers use to test for compatibility with the STBs.

Test cases—scripts that run on an automated tester by TestQuest—include home network integration, an interactive program guide, VoD, and emergency alerting. A PC in the tester runs Mer-

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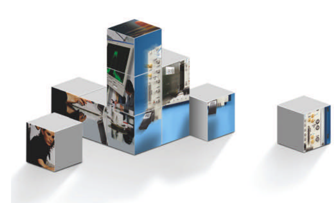

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Verizon's last mile

Verizon's fiber-optic service, known as "FiOS," consists of an FTTH network. Voice, video, and data travel over three wavelengths—1550 nm, 1310 nm, and 1490 nm. The "last mile" FTTH access network connects an ONT outside a customer's house to an OLT at a CO. Verizon uses broadband passive optical network (BPON) and in some places gigabit PON (GPON) technology between OLTs and ONTs at subscribers' homes (**Figure A**).

Broadcast video in both analog and digital forms travel over the 1550-nm wavelength in a 55.25-MHz to 870-MHz band where each channel uses 6 MHz. Broadcast TV isn't, as many believe, sent using IPTV. The network converts all broadcast TV channels from MPEG over IP to their original analog or digital forms at the video hub office. Verizon uses QAM to transmit digital TV channels and standard NTSC video for the analog channels. About thirty to forty 6-MHz analog channels travel over the fiber. Analog channels let subscribers connect TVs to the network without an STB. Verizon does use IP for voice, data, and VoD services.

Each BPON or GPON link from an OLT passes through a splitter to the subscriber's home. Thus, the 32 subscribers share the BPON or GPON link's bandwidth (GPON can handle 2.4 Gbps, so each home gets at least 80 Mbps). At first, Verizon installed BPON OLTs and ONTs, but the company soon realized that subscribers would demand more bandwidth as they watched more VoD, which requires about 15 to 20 Mbps per video stream.

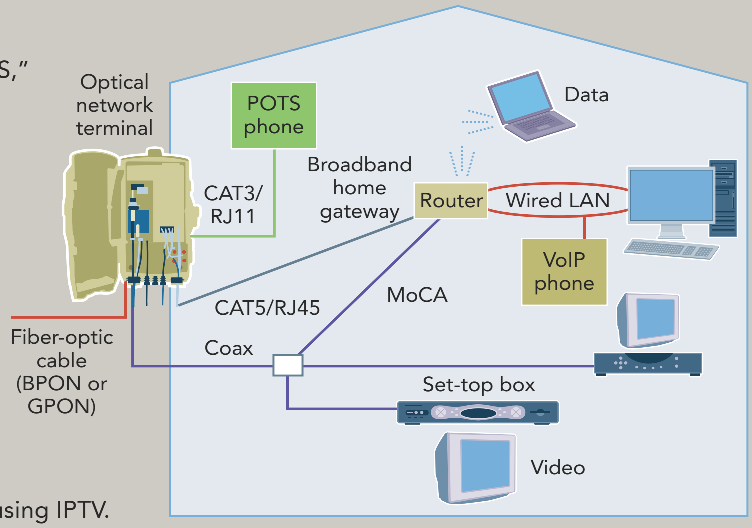


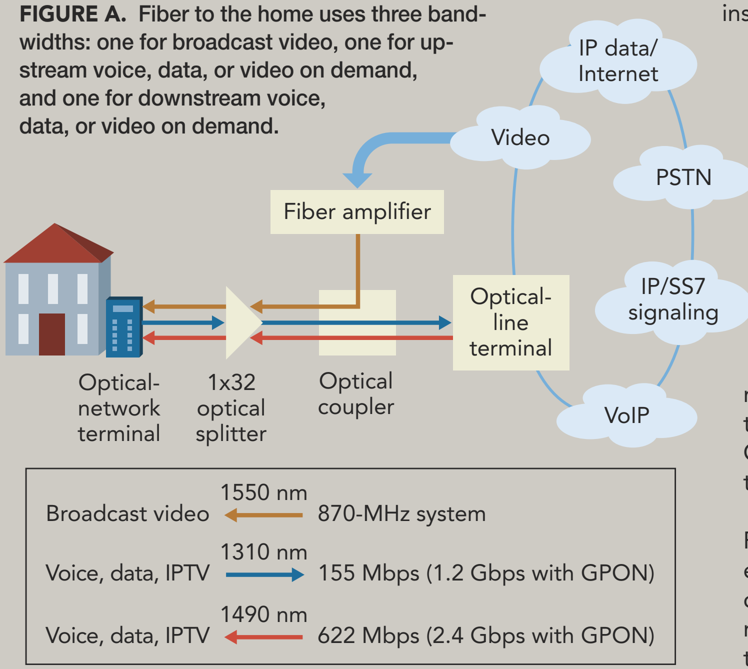
FIGURE B. An optical network terminal connects the fiber-optic line to customer premises equipment (TVs, phones, and computers).

For homes without FiOS, Verizon's line of demarcation between its network and the customer's premises ends at a network-interface box. The customer is responsible for wiring. With FiOS, Verizon's responsibility extends to STBs, phones, and computers inside the home.

The ONT converts optical to electrical signals for in-home distribution (**Figure B**). Here, the ONT splits the services into voice, data, and video. POTS voice lines connect to phones through standard RJ-11 connectors. An Ethernet/RJ-45 connector routes data to a 100-Mbps home gateway, which connects to computers through a wired or wireless LAN. A coax cable from the ONT distributes video to TVs and STBs based on Multimedia over Coax Alliance (MoCA, www.mocalliance.org) standards, and this enables transmission of IP traffic over coax on a 1.1-GHz channel. Broadcast video travels over the 55–870-MHz band.

When a person subscribes to Verizon FiOS, technicians will come to the customer's home and install the ONT, router, STBs, coax, and Ethernet cables. Network components remain the property of Verizon. Customers just rent them.—*Martin Rowe*

FIGURE A. Fiber to the home uses three bandwidths: one for broadcast video, one for upstream voice, data, or video on demand, and one for downstream voice, data, or video on demand.



cury Quality Center software that tests the STBs under stressful conditions. For example, a test might consist of two STBs running VoD programs while a PC downloads a large file and several VoIP calls come over the line. "We check the quality of service for each TV, PC, and phone," said Halstead.

The TestQuest system plays STB commands sent from a remote control. "It receives infrared signals from a remote, stores them, and plays them to an STB through an infrared transmitter," Halstead explained. Engineers run a sequence of remote buttons and the system records them, thus producing consistent commands for the STBs.

A server PC in the system contains a video-capture card, which lets the system check that the correct menu screens appear at the proper time. Audio and video switches let engineers test programs on each TV screen.

Engineers also check the system for virus vulnerabilities and for denial-of-service attacks. In a denial-of-service attack test, a PC sends large amounts of data traffic to the STB and engineers look for operating-system abnormalities.

Multiple users

While Halstead and others test all of the CPE products that Verizon provides to homes, test engineer Earl Vanderhoff specializes in stressing STBs from a user perspective. He has developed an automated system that exercises the boxes under the load of 120 simulated users. The automated system checks VoD orders for the correct program by maintaining a database of movie clips.

When a simulated user orders a movie through a remote control, the system captures a segment of the delivered movie and compares it to the reference clip. If the wrong movie plays, the system captures 25 s of the program in DVD quality, and it records the failure in a log. "We can run as many as 3000 VoD sessions over a weekend," said Vanderhoff. "We can also use the video capture to compare video quality if there's a change at the SHE."

Vanderhoff also performs real-time picture-quality analysis on STBs, which have several audio and video outputs. They include a combination of left and right audio outputs, a composite video output, a component video output, a digital video output, an S-video output, a Sony/Philips Digital Interface (SPDI) audio port, and an RF video output.

Video changed everything

When expanding into the video-transmission business, Verizon required its engineers to create test plans, execute test cases, and create test reports. Rigorous procedures ensure that engineers test all network elements to uncover potential problems. The testing at Verizon Labs lets the company make informed decisions about products before deploying them.

"The skills required to test video are different from those needed to test traditional telephone equipment," said Laparidis, the director of video systems testing. "To support video testing, we brought in engineers with video expertise that complement the skills of other engineers. We constructed or redesigned the architecture to support end-to-end system integration. This gave us the ability to test a network system's integration through the customer experience." T&MW

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PROBE-MARK INSPECTION

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The semiconductor manufacturing industry is seeing a dramatic increase in the demand for probe-mark inspection, driven primarily by the introduction of multiple die packages, the adoption of new materials, and the prevalence of new designs implemented in advanced wafer processes.

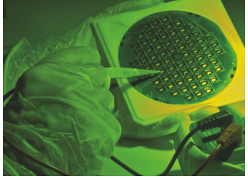
Probe marks result from the physical contact between the probe tip and the bond pad during electrical testing, usually after the wafer-fabrication process is complete. Although some marking is unavoidable, manufacturers have discovered that excessive marking can have an impact on yield and device reliability and, therefore, must be closely controlled. In fact, large, deep, or misplaced probe marks can result in poor adhesion with the wire bonds used for connections between die in multichip packages, and this poor adhesion is one of the primary causes of yield loss in multichip devices.

Multichip packages have become popular because of the need to increase memory density in a range of applications and because manufacturers of handheld devices (such as cell phones) often want to combine logic and several kinds of memory in the smallest possible physical package.

The automotive industry is also finding that probe marks can have an impact on reliability, and with the industry's emphasis on "zero-defect programs," many auto manufacturers now require 100% probe-mark inspection.

Other trends also contribute to the growing demand for probe-mark inspection. Advanced fabrication processes use low-k dielectrics that, depending on the particular material used, are either softer or more brittle than conventional dielectrics and are, therefore, more easily damaged or deformed by the probe. In the continuing drive to put more circuitry in a smaller area, designers have opted to position bond pads over active circuitry, so excessive marking or punch-through can damage

FIGURE 1. Probe-pad problems, and in particular damage caused by contact between the pad and the electrical test probe, are a primary cause of failure in wire-bond interconnects. In this example, the probe marks cover more than 25% of bond pad area and have exposed underlying passivation. Courtesy of Rudolph Technologies.



the circuit directly. Advanced bond-pad designs often incorporate a copper layer or post, which can shed material during the probing process, resulting in copper particulate contamination elsewhere.

The cost of probe cards has escalated tremendously—in some cases to more than $200,000. Correlating probe marks with probes allows engineers to monitor the condition of individual probes and repair or rework them before damage is irreversible. Some manufacturers are implementing pre-probing bond-pad inspection in order to protect expensive probes from the damage that contaminated or improperly formed pads might cause.

Economic drivers for multichip packaging

The increase in demand for multichip packages is driven by increased consumer demand in several different sectors. Some things you can never get enough of—for computers and electronics, one of those things is memory. A number of new product introductions illustrate the surge in demand for memory, among them the powerful Xbox 360 and PlayStation3 gaming systems, and Windows Vista, with its requirement for gigabytes of DRAM and sizeable flash memory to support the quick boot capability.

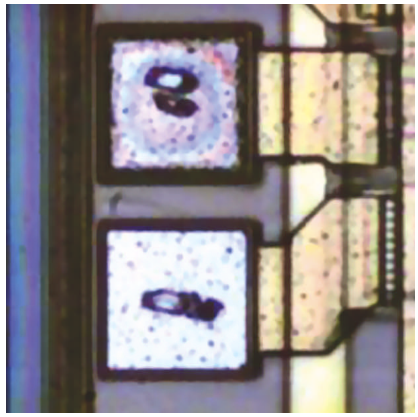


FIGURE 2. Probe marks are only one of several mechanisms that can cause wire-bond failures, and an inspection system must be sensitive to the broadest possible range of defects. In this case, the pad shows evidence of corrosion. Courtesy of Rudolph Technologies.

A second trend driving demand for multichip packaging is the evolution of the cell phone from a simple communication device to a multifunctional handheld personal entertainment system incorporating such disparate capabilities as still photography, video and audio recording and playback, gaming, text messaging, e-mail, Web browsing, and per-

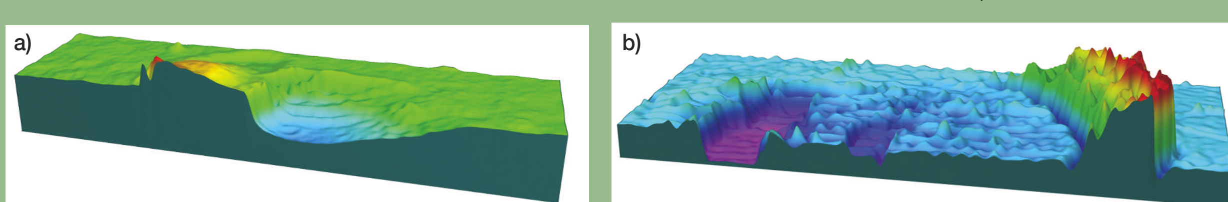
Confocal microscopy for probe-mark characterization

Process inspection equipment used to inspect probe marks is designed to handle high throughput while capturing process excursions with high probability. Once excursions are detected, the first questions are: What do probe marks in the anomalous areas look like? And how do they compare with the normal process?

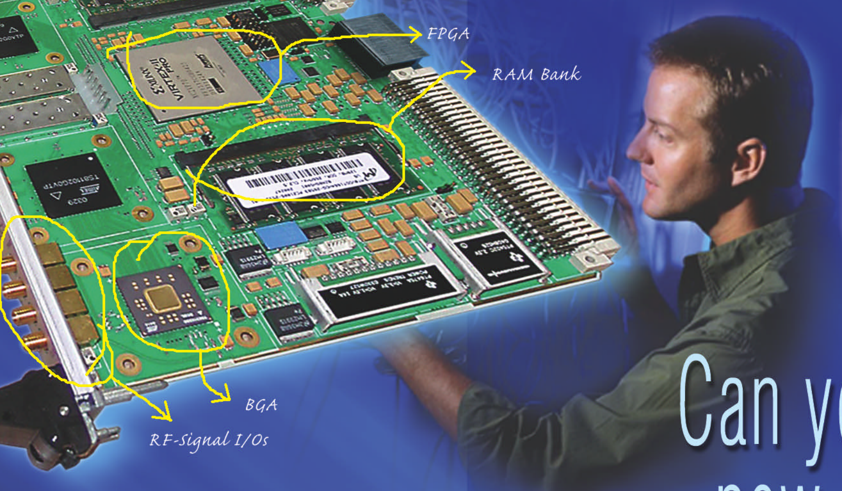
Efficient defect review, characterization, and root-cause analysis require a flexible and interactive tool that can provide both lateral and height measurements, that can revisit and fully describe features in the areas of interest, and that can provide engineers with timely data so they can correct the problems. The tool should supply the data required for production meetings as well as images that represent the data to management and remote customers. The tool should allow automated review and give engineers the option of full manual control to drill down to a solution.

To date, conventional optical review stations and scanning-electron microscopy have served this purpose, giving engineers good lateral measurements and pictures of the features but providing only a rough impression of their volumetric extent. Good depth measurement by these methods requires skillful cross sectioning to hit the deepest part of the features, a process that generally delays results for days, with the work in progress sitting in limbo, begging questions at every production meeting.

In a matter of seconds, advanced confocal profiling systems provide the same height information that is available from the most careful scanning electron microscope (SEM) cross-section measurement (**figure**). Cross sectioning is carried out on the data rather than on the sample, so that the untouched wafer can be returned to the process unharmed and lot disposition promptly determined. Analysis may be performed under automated recipe control, interactively under recipe guidance, or manually, allowing the engineer to quickly drill down to the root cause.—*A. Edward Robinson, PhD., VP applications and product development, Hyphenated Systems, Burlingame, CA. eddy@hyphenated-systems.com.*



These images generated by Hyphenated Systems' advanced confocal profiling systems provide the same height information available from scanning-electron microscope (SEM) cross-section measurements. a) This probe mark is relatively shallow, with the deepest portion less than 500 nm below the pad level. b) This mark is deeper and clearly shows a breakthrough to a barrier layer and the underlying dielectric around 1 µm beneath the pad surface. Courtesy of Hyphenated Systems.



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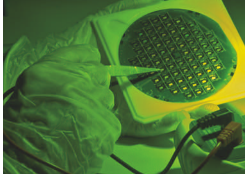

sonal digital assistance. These features require system-in-package (SiP) devices that combine multiple chips of different types—SRAM, DRAM, flash, logic, analog, and radio frequency—in a single package of minimal size. For example, the FreeScale PCM29415 SiP includes a FreeScale baseband processor, two Intel NOR flash chips, and a Samsung DRAM chip.

A third contributor to increasing demand for electronic devices, some of which are in multichip packaging, is the automotive industry. Latest generation vehicles contain tens and sometimes hundreds of integrated circuits. The growth trend is expected to continue, with the demand for additional safety and performance enhancements such as side-impact airbags, antilock braking systems, and traction control; increases in cabin and cockpit electronics for entertainment and navigation; and additional communication capabilities including satellite and wireless.

Driving inspection requirements

Wire bonding is by far the predominant interconnect technology for current multichip packages. As manufacturers have gained experience with multichip packages, they have realized the importance of probe-pad integrity.

In particular, damage caused by contact between the pad and the electrical test probe (**Figure 1**) is a primary cause of failure in wire-bond interconnects. Failure modes include excessive marking, which interferes with the bond reliability; punch-through, which reduces bond reliability and exposes underlying circuitry to the bonding process; and etch defects, in which overlying passivation is not completely cleared from the bond pad.

Another issue of growing importance is vendor accountability. Many SiP devices incorporate chips from different vendors. SiP integrators do not want to be held responsible for defects that occurred upstream in the supply chain, and many are implementing incoming probe-mark inspection or imposing requirements for outgoing inspection on their suppliers, or both.

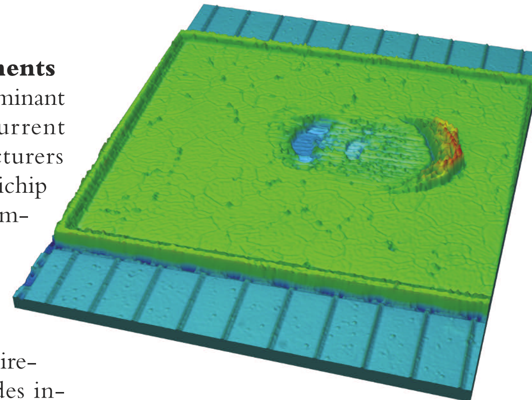

FIGURE 3. Confocal microscopy can provide for the detailed review and characterization of probe marks. In this example, the mark is well resolved in three dimensions, and a breakthrough to underlying layers is clearly shown. Courtesy of Hyphenated Systems.

New processes and materials—such as low-k dielectrics—being implemented at advanced technology nodes (65 nm and below) are also increasing the need for probe-mark inspection. This vulnerability is exacerbated by the relentless drive to put more circuitry on smaller die and the resulting trend to locate active circuitry beneath bond pads.

Another offender in the category of new materials is the use of copper on bond pads. Copper is a highly corrosive material (**Figure 2**), and copper particulates created during probing can easily damage the circuit.

Recent developments in testing technology are also contributing to the demand for probe-mark inspection. There is significant incentive to reduce any risk of damage to probe cards, such as might be caused by particulate contaminants on the probe pad. A number of manufacturers have implemented pre-probe inspections to minimize this risk. Probes wear during normal use but may be reconditioned or repaired up to a certain point. Careful analysis of probe marks can provide information that signals the need for reconditioning of a probe.

Another trend in test technology is the movement of electrical testing upstream, into the fabrication process, to allow faster detection, diagnosis, and correction of defective processes. Though

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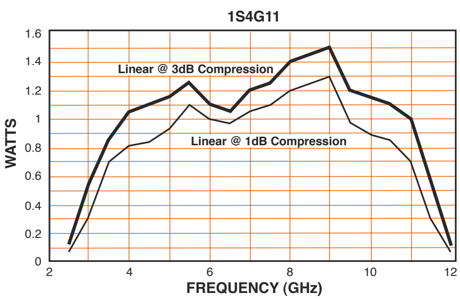

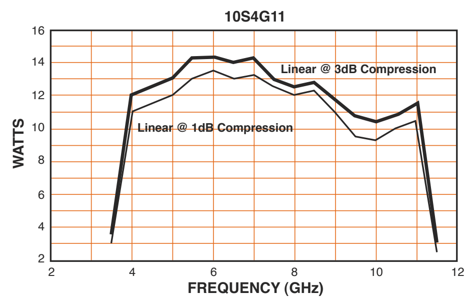

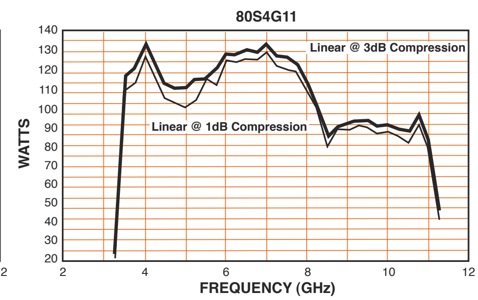

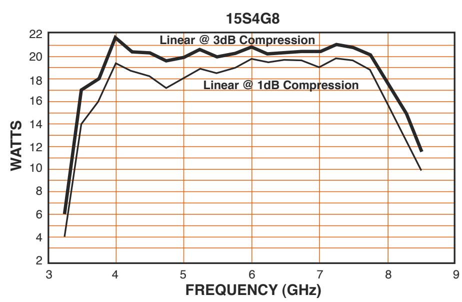

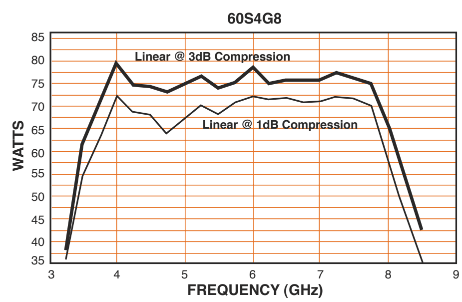

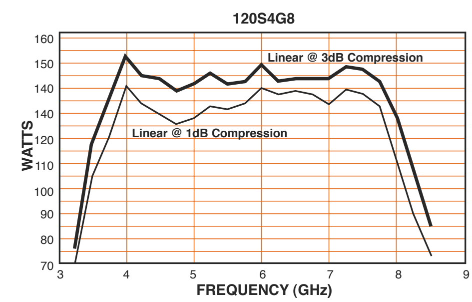

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The 4G11 amplifiers cover the 4 – 10.6 GHz frequency spectrum with available power ranging from 1 – 80 watts. They offer 100% mismatch capability, excellent linearity, low noise level, and outstanding harmonic content. But that's not all. Our new 4G8 family is specially designed to deliver excellent performance across the 4 - 8 GHz frequency range, with 15, 35, 60 and 120 watt amplifiers.

With wireless devices multiplying so rapidly, it's no wonder that the microwave spectrum is getting more and more crowded. That's why an increasing number of new and proposed EMC standards are pushing test limits higher in frequency and field strength.

Even these new standards don't take all potential threats into account. Nor do EMC standards allow for the possibility of transmitters operating in close proximity, which can produce RF fields far greater than those mandated in the standards.

So it's becoming more critical to test beyond the specs. Better to prevent equipment problems now then to try and fix them later.

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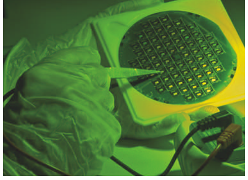

faster feedback is always desirable for process control, the need has become more urgent as the fraction of defects that cannot be detected with conventional in-line inspection techniques has grown at each successive technology node. Limiting, or at least detecting, probe-induced damage in the earlier stages of wafer processing will play an important role in the successful integration of electrical test into the fabrication process.

Probe-mark characterization, as distinct from probe-mark inspection, can help engineers determine appropriate probing parameters during the characterization phase of process development. Probe-mark characterization (**Figure 3**) relies on detailed three-dimensional inspection (see "Confocal microscopy for probe-mark characterization," p. 38). Three-dimensional inspection techniques tend to be too slow and expensive for production applications, but engineers can use them to carefully quantify the effects of variables such as probe force to determine the best operational window for their process.

Probe-mark inspection requirements

The probe-mark inspection process must be capable of evaluating a number of quantitative and qualitative characteristics. Quantitative measures include size, location within the pad, proximity to the edge of the pad, orientation relative to the center of the pad, and orientation trends across the wafer. Qualitative indicators include over-etch and under-etch, pitting, corrosion, abrasion, roughness, and punch-through. Advanced automatic defect classification (ADC) that makes efficient use of all available input to provide fast accurate classification is a practical requirement for probe-mark inspection in a production environment.

The use of multichip packages is increasing, driven primarily by consumer demand for larger memory, multifunction handheld devices, and increased electronic capabilities in automobiles. The primary first level interconnect technology in multichip packages is wire bonding. Probe marks created by electrical testing are a primary cause of failure in wire bonds. Probe-mark inspection is playing an increasingly important role in maintaining the yield and reliability of wire-bonding processes. T&MW

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A variety of factors can cause "magnet" wires to break, causing devices such as transformers and inductors to suffer catastrophic failures.

WIRE ENDS *yield failure clues*

STAN SILVUS, SOUTHWEST RESEARCH INSTITUTE

Say "failure analysis," and most engineers will think of damaged semiconductors or circuit boards. But even basic devices such as transformers, inductors, relays, solenoids, and motors can experience catastrophic electrical failures. These devices rely on current that passes through small-diameter solid "magnet" wire wound on a form or bobbin.

When a wire breaks, the device fails, and engineers and failure analysts must determine what went wrong so they can correct manufacturing problems and prevent future failures. Careful inspection of the failed wire ends can provide clues about environmental factors and failure mechanisms that caused a break. In some cases, the broken-wire ends can show signs of multiple failure mechanisms.

To start an analysis, you may have to remove coil-impregnation material—perhaps charred—that adheres to a wire and often obscures the cause of failure. You can chemically remove the coil-impregnating material and the wire insulation to reveal the appearance of the wire end.

Of course, before you apply any chemicals to a failed wire, you must determine the compositions of materials, particularly the products of corrosive chemical reactions, in the vicinity of the break. To detect the presence of specific chemical elements and compounds, you can use energy-dispersive x-ray spectroscopy (EDS), the preferred method, as well as wet-chemistry analysis, atomic-emission spectroscopy, and other analytical tools and techniques.

After you have a clear view of the wire ends, you can refer to the 13 scanning-electron micrographs in this article to home in on a failure mechanism. Most of the micrographs illustrate failures that were produced under lab conditions, so they show almost ideal failure characteristics. The micrographs can help you identify the following problems:

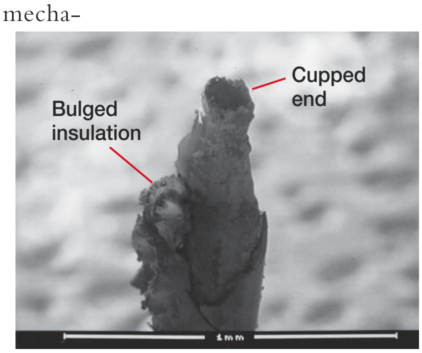

FIGURE 1. The end of typical corroded wire shows a cupped end and bulging insulation.

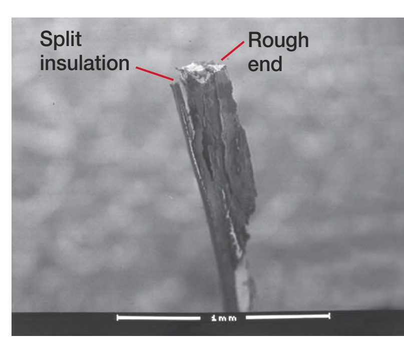

FIGURE 2. A build up of corrosion products split insulation in the area of a corrosion-induced failure.

Corrosion

Corrosion probably causes the most failures of wires in coils (Refs. 1 and 2). Ends of corroded wires vary widely in appearance, but they usually have odd shapes and appear rough and dirty. Insulation may be split or cracked by the build up of corrosion products between the wire and its insulation.

Close inspection may reveal some green-colored materials—the products of corrosion—on or near the wire end. (You cannot see the green material in the monochrome micrographs in this article.) EDS analysis of the corrosion products often reveals high chlorine content and may disclose other potentially corrosive elements, such as bromine or organic-acid residues. Usually, these corrosive materials come from solder flux improperly or incompletely removed from the coils. But corrosive materials also may exist in the operating environment of a device. Corrosive salt fog, for example, is common near a seashore.

Figures 1 and **2** illustrate the characteristics typical of corroded wire ends: bulging or split insulation (caused by build up of corrosion products), cupped or pitted end, and a rough, dirty appearance.

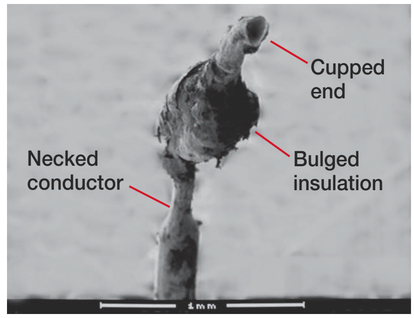

FIGURE 3. Although oddly shaped, this wire end shows signs of corrosion damage.

The oddly shaped end of the wire shown in **Figure 3** has the characteristics of a corrosion failure and includes evidence of a second corrosion site (the "necked" region) that had not corroded deeply enough to cause failure.

Fusing

Excessive current can cause copper magnet wire to fuse or melt, and the ends of the failed wire can reveal what happened. Typically, the rate of increase, or rise time, of the current can affect the shape of the wire end. If current increases slowly to the conductor's fusing limit, wire ends

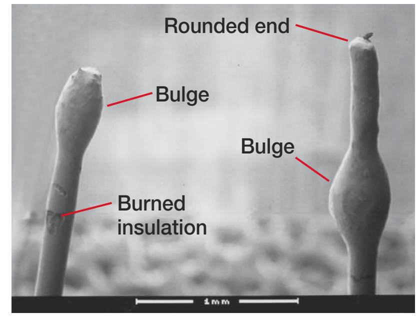

FIGURE 4. A slowly increasing current caused the copper to bulge and burned the insulation near the ends of a failed wire.

generally appear rounded and show signs of burned insulation and slightly melted or bulged copper (**Figure 4**). Aside from localized signs of burning, the insulation on the wire usually looks clean.

In contrast, if current increases suddenly, perhaps due to a short circuit, you often see a small ball of copper on one of the fused wire ends (**Figure 5**). In general, surface-tension forces in the liquid copper—melted by the high current—can form a ball or can round the end of a wire.

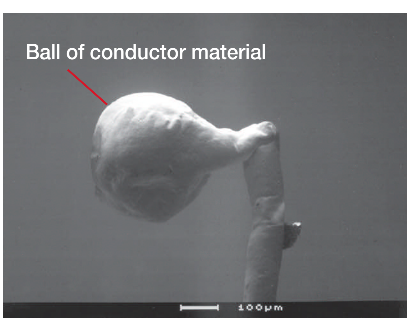

FIGURE 5. A short-duration current pulse melted this copper wire and caused a failure.

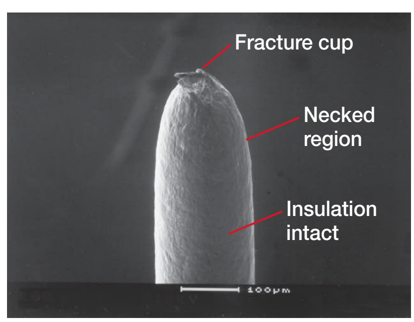

FIGURE 6. Excessive tension stretched this copper wire until it separated.

Tensile failure

The "necked" region and small cupped fracture zone shown in **Figure 6** characterize a break caused by excessive tension on the wire. Generally, the insulation appears clean and free of corrosion products. A tensile break in fine-gauge magnet wire usually occurs because of an improperly secured lead wire or terminal connected to the magnet wire. The loose lead wire or terminal can transmit excessive tension to the wire. This type of failure usually occurs close to a terminal or lead-wire attachment point.

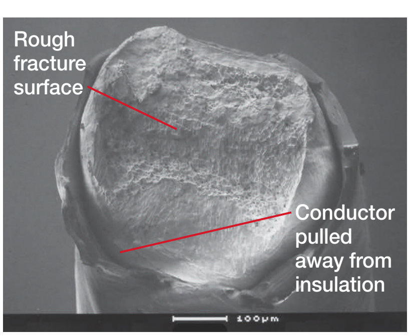

FIGURE 7. Bending a wire many times at one point caused this fatigued-wire failure.

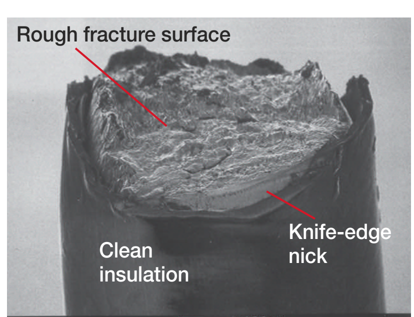

FIGURE 8. A nick in this wire concentrated stress at one point and led to this fracture.

Metal fatigue

Metal fatigue, caused by cyclic bending of a magnet wire, produces a rough but relatively flat end (**Figure 7**) when the wire fails. Insulation that surrounds the broken end may have pulled away from the metal conductor as shown in Figure 7. Despite its roughness, the wire end does not have the dirty look and green deposits associated with a corrosion failure.

A nick, scratch, or abrasion in the wire surface concentrates stress at this point and increases the susceptibility of the wire to tensile or bending stress. Intentionally nicking the wire surface with a

sharp knife and then cyclically bending the wire until fatigue failure occurred produced the wire end shown in **Figure 8**. This wire end shows evidence of the nick, but the remainder of the surface is characteristic of a fatigue failure.

In properly manufactured and protected coils, mechanical damage to fine magnet wire occurs rarely. But something or someone may stretch coil wires until they break, wires may suffer from fatigue caused by vibration, or someone may cut wires either accidentally or intentionally.

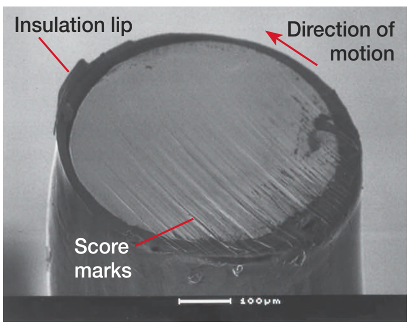

FIGURE 9. A transverse knife cut through a wire leaves score marks and a small insulation lip where the knife exited the cut.

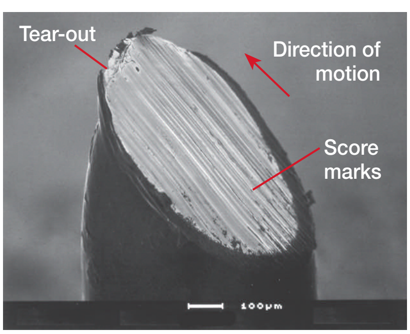

FIGURE 10. Wire severed with a knife at an angle shows score marks and tear-out of copper and insulation at the exit point of the knife.

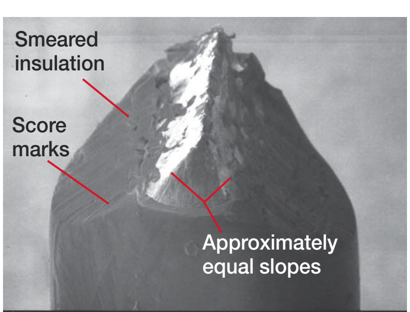

FIGURE 11. Well-sharpened diagonal wire cutters leave a characteristic ridge in the center of a wire.

Tool cuts

When investigating a wire failure, engineers and analysts should keep in mind that an unintentional cut with a tool could have severed the wire. Careful analysis of the wire-end marks can indicate the type of tool used and even the "angle of attack" on the wire.

The appearance of a cut end varies with the type of cutter that severed the wire. **Figure 9** shows a wire cut transversely with a sharp knife, and **Figure 10** shows the effect of a similar knife cut made at an angle. Score marks that run parallel to the direction of the knife blade's travel characterize these types of cuts.

A conventional pair of diagonal wire cutters leaves a ridge on the end of the wire as shown in **Figure 11**. Properly sharpened cutter blades produce equal slopes on each side of the central ridge. Because the cutter's blade pushes insulation into a cut, you often observe insulation "smearing" on the cut end.

Figure 12 shows a wire cut with a shear cutter. Score marks and a lip appear in this cut, as does some insulation smearing. The many parallel score marks show the direction of tool motion. When you see insulation smearing in this type of cut, the insulation is clean and neither burned nor pulled away from the wire.

Multiple causes

At times, more than one mechanism may cause a wire to fail. Generally, you can see evidence or characteristics of each mechanism, but they may not appear as clearly as those shown in the accompanying micrographs of single-cause failures.

The wire end shown in **Figure 13,** for example, resulted from a combination of corrosion and fusing. Attack by a corrosive substance reduced the cross section of the wire and increased its local resistance. The normal operating current caused this region of the conductor to fuse, so the wire end has the rough, dirty appearance and green, chlorine-containing deposits commonly associated with a corrosion failure. Additionally, it has a small copper ball, which indicates that current-induced fusing caused the final failure.

Although many mechanisms can cause a wire to fail, each one leaves a signature that helps engineers and failure analysts diagnose the cause or causes. T&MW

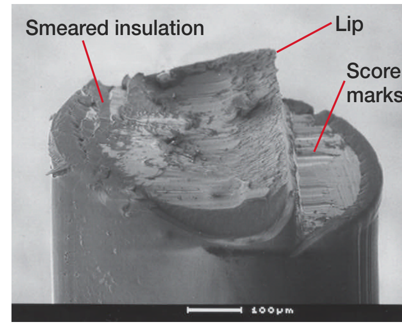

FIGURE 12. Shear cutters leave a characteristic mark such as the one that is visible on this cut-wire end.

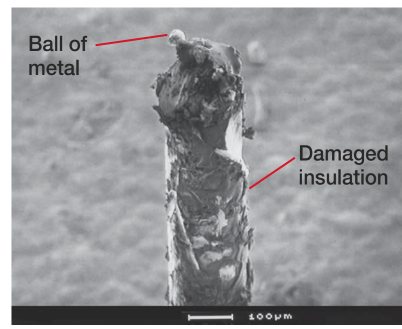

FIGURE 13. This wire failed when normal operating current passed through a section narrowed by corrosion.

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Agilent launches 3-D in-line AXI system

Agilent Technologies has announced what it calls the world's fastest in-line automated 3-D x-ray inspection system that can detect printed-circuit-board assembly (PCBA) solder and manufacturing-assembly defects.

Called the Agilent Medalist x6000 AXI, the new system more than doubles the throughput of other systems, such as Agilent's 5DX, while making use of full 3-D capability to find defects, according to the company.

It targets the growing number of boards using array packages (which grew 30% in 2006) as well as increasing joint counts, which are becoming as high as 60,000 per board. The company reports that the new system can inspect 3 in.^{2}/s, vs. 1.5 in.^{2}/s for the 5DX.

The increased throughput reduces the number of systems required to meet manufacturing volumes, and it enables complete 3-D inspection of an entire PCBA at in-line speeds. In the past, high-throughput 2-D systems have been used in limited applications where the PCBAs under test are predominately single-sided. Double-sided PCBAs, however, require 3-D inspection so users can discriminate between the top and bottom sides of boards.

Typical communication and computation products can have 35% overlap or more between the solder joints, Agilent reports, which compromises the test-coverage effectiveness of in-line 2-D approaches. In addition, the Medalist x6000 provides a new development environment that incorporates several automatic test-development features that help new users develop high-quality, high-coverage programs in half the time previously required, according to Agilent.

The company has not released price information but says prices will be comparable to 5DX prices. *Agilent Technologies, www.agilent.com.*

Vicor debuts high-density bus converter

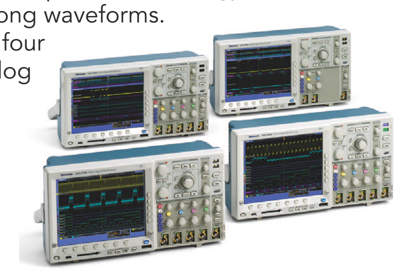
Vicor has announced the availability of a high-voltage V•I Chip BCM bus-converter module with a power density of greater than 1000 W/in^3. Designated B384F120T30, the high-efficiency (>95%) module employs the company's Sine Amplitude Converter (SAC) technology and operates from a 360- to 400-VDC primary bus to deliver an isolated low-voltage secondary.

The 12-V (nominal) output can be paralleled for high current or connected in series to create a 48-V bus. The V•I Chip package measures 1.28x0.87x0.26 in. and is compatible with standard pick-and-place surface-mount machinery and assembly processes. It provides flexible thermal management through its low junction-to-case and junction-to-board thermal resistance. The low impedance of the BCM converter enables point-of-load capacitance minimization or elimination, while the positive temperature coefficient of the output means that converters can provide load-current sharing with no interconnect circuitry.

Base price: $37.50 in OEM quantities. A 300-W BCM evaluation board costs $99; a 1.2-kW demo board costs $399. *Vicor, www.vicr.com.*

Oscilloscopes add logic channels

Intended for engineers who design mixed-signal and FPGA-based systems, the new MSO4000 series of small-footprint oscilloscopes from Tektronix function much like the company's DPO4000 models but with an additional 16 logic channels. The MSO4000 line also features the company's Wave Inspector technology that lets you scroll through long waveforms.



The MSO4000 consists of four models with two or four analog channels and bandwidths of 350 MHz, 500 MHz, and 1 GHz. All models have 10 Msamples of waveform memory on all analog and digital channels. The digital channels have a time resolution of 60.6 ps, which corresponds to 16.5 Gsamples/s. You can attain that resolution when you turn on the MagniVu high-resolution signal-acquisition technology, which acquires 10,000 samples centered on the trigger point. Otherwise, you get 500 Msamples/s across the entire 10-Msample memory.

The logic probes consist of two eight-channel pods that plug into the oscilloscope's front panel through one connector. You enable digital channels with a button just above the logic-probe connector. With two groups of eight digital channels, the DSO4000 lets you split channels to opposite sides of a board under test.

Prices: $8700 to $17,200. All prices include analog and digital probes. *Tektronix, www.tektronix.com.*

USB frame grabber handles 60 fps

The Sensoray Model 2255 frame grabber is a multichannel, low-latency, USB video-capture device that features a total capture rate of 60 fps. It allows for simultaneous video capture of up to four composite NTSC or PAL video sources at 15 fps, and it can cap-

> > > > > > >

ture two channels at a full 30 fps. The frame grabber supports full-frame-rate capture across all channels simultaneously using monochrome or scaled-down modes.

The 2255's support for a variety of output formats eliminates the need for format conversions in many applications. Supported formats include RGB packed (24 bits/pixel, bitmap compatible), YCrCb packed (16 bits/pixel, YUY2 compatible), YCrCb planar (16 bits/pixel), and Y8 (8 bits/pixel, monochrome). The YCrCb planar configuration is optimal for image-processing applications.

The 2255 is powered through the USB 2.0 connection on a PC, eliminating the need for an external power supply. The supplied software development kit contains drivers for Linux and Windows, an API, and a demo program that illustrates the use of the API. The driver supports multiple units, allowing for system expansion and integration.

Base price: $515. *Sensoray, www.sensoray.com.*

Cycle and analyze DC power

Automatically sequencing power to a board or device generally requires you to write code for a programmable power supply and then measure voltage and current with a different instrument. Not so with the N6705A DC power analyzer from Agilent Technologies, which combines up to four DC power supplies with digital multimeter (DMM), oscilloscope, arbitrary waveform generator, and datalogger functions. Thus, the instrument provides DC power for your UUT and also makes the voltage and current measurements. It can display all channels in oscilloscope or digital multimeter (DMM) displays on the screen at once.

The N6705A accepts up to four modular DC power supplies from the family of 21 that also work with the company's N6700 ATE power supply. You can then configure a power-up sequence using the N6705A's front panel, and you can save sequences in the instrument for later use.

Should a problem occur, you can remove power by pressing the emergency stop button. Even then, the N6705A will continue to record voltage and current. The datalogger mode looks like a strip-chart recorder; it has 64 Mbytes of memory. You can save screens as images, and you can save data for export.

Prices: N6705A mainframe—$6500. Power-supply modules range in price from $450 to $2500. *Agilent Technologies, www.agilent.com.*

PXI turns 10

Richard A. Quinnell, Contributing Technical Editor

In recognition of the PXI standard's 10th anniversary, I spoke with some of the industry's pioneers. Included in the conference call were Loofie Gutterman, president of Geotest and current president of the PXI Systems Alliance (PXISA); Mike Dewey, senior marketing product manager at Geotest; Mark Wetzel, a National Instruments' engineer and the PXISA Technical Chair; Spencer Stock, PXI product manager at NI; and Fred Bode, former executive director of PXISA.

Q: What prompted creation of the PXI specification?

Bode: It started out at National Instruments. NI basically had the idea to improve on what was being done with VXI—but based on CompactPCI—and then enlisted support from the test and measurement community.

Wetzel: Existing modular standards of the time were not meeting the cost and performance needs of customers. The PCI infrastructure offered lower cost and easier driver development, while the PCI bus itself offered four to eight times the performance of what was implemented earlier. The industry also needed a compact form factor.

INSIDE THIS REPORT

Dewey: We had a substantial effort going into VXI at the time, but that spec was 10 years old and lagging in performance. PC-based instrumentation was not the way to go, partly because of I/O limitations. A modular approach offers 20 or 21 slots in a 19-in. rack. That's a lot of I/O in a small space.

Gutterman: We had been looking for years for a PC-based platform for test, but while the PC had a good bus, its form factor was not right. In fact, what we needed were multiple form factors. VXI had multiple forms but they were not interoperable. PXI has both 3U and 6U sizes, and the boards are interoperable, so when we first saw PXI at Autotestcon in 1997, we said "Wow, this is what we are looking for."

Q: Has the resulting specification met all of your expectations?

Bode: Early on, we had to overcome a reputation of PXI being less capable than other test approaches. There was some truth to that in the beginning, but fairly quickly, high-performance products came out and that went away.

Then, PXI began to penetrate a bunch of applications that didn't have products to address their needs. Since then, there have been modifications such as the low-power mainframe that opened up additional applications, and now there is PXI Express. PXI has had a history of adopting forward-looking changes while staying backward compatible, allowing it to embrace newer applications.

Fred Bode, then director of the PXI Systems Alliance, and cohorts sign the papers giving birth to the PXI specification. Courtesy of the PXI Systems Alliance.

Gutterman: The flexibility of the standard was something that no one really expected, but this ability to create major improvements while maintaining backward compatibility has been an important factor in PXI's success. This success is demonstrated by the industry's commitment to the platform. There are now 60 to 65 companies making products, with more than 1400 products out there and dozens of new products each month.

Stock: When you look at all the data, PXI has been a huge success. According to Frost & Sullivan, PXI sales worldwide are seeing a compound annual growth rate of 23%, dwarfing the rest of test and measurement, which is growing at about 5%.

Q: And the future for PXI?

Stock: PXI Express is going to allow developers to solve applications that no other technology can. They used to say that PXI didn't have a history. Now, it is 10 years old and a proven solution. With PXI Express, the technology is on the forefront of test technology, and for some applications, it is the only off-the-shelf platform available. □

EDITOR'S NOTE

Compatibility is key to customer loyalty

Richard A. Quinnell, Technical Editor

PXI is celebrating its 10th anniversary this year. During that decade, perception of the standard went from it being considered a single company's vision to being seen as a main contender in the design of next-generation test systems. One of the keys to this remarkable growth in market acceptance is the PXI Systems Alliance policy of retaining compatibility.

All standards evolve over time, and technology also changes, opening opportunities that did not originally exist or creating complications that were not anticipated. How the governing body handles this evolution is one key to a standard's continued market acceptance.

A guiding principle in the evolution of PXI has been compatibility. This includes backward compatibility as well as cross compatibility among modules, cages, connectors, and software. The PXISA has worked to ensure that whatever changes it introduces to the specification do not make new products incompatible with older ones

Unlike consumer designs, which have market lifetimes sometimes measured in months, test systems can have operational lifetimes measured in decades. By keeping an eye on compatibility, the PXI community has successfully kept the specification in line with technology while preserving the users' investment in PXI equipment. This has been key to building customer loyalty to the standard and promises an even greater second decade for PXI. □

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

HIGHLIGHTS

Tegam joins PXI Systems Alliance

Tegam has announced its membership in the PXI Systems Alliance (PXISA). Tegam specializes in waveform generators, precision amplifiers, RF power calibration, and low-level measurements.

Tegam is currently preparing to launch the Model 4040A Fast PXI Instrumentation Amplifier, which is designed to work with PXI digitizers and oscilloscopes. The Model 4040A offers 100-V differential inputs with 70 dB of CMRR. The bandwidth ranges from DC to 50 MHz with programmable gain, attenuation, offset, and filters. www.tegam.com.

Geotest unveils chassis and controller

The GX7600 mainframe from Geotest—Marvin Test Systems is a compact nine-slot PXI Express Smart chassis that accommodates up to eight instruments as well as an embedded single-slot PXI Express controller, such as the new GX7940, or a PXI Express remote bus controller, like the x1 or x4 MXI-PXI Express interface. The GX7600 also incorporates built-in hard-disk and DVD-RW drives, a 400-W power supply, and chassis smart functions, providing onboard per-slot temperature and power-supply monitoring.

You can team the chassis with the GX7940 PCI Express single-slot controller. The GX7940 comes with a 1.4-GHz or 2.0-GHz Pentium M processor and up to 2 Gbytes of memory. The module supports Gigabit Ethernet and USB interfaces, as well as the GX7600's embedded storage peripherals. www.geotestinc.com.

Module streamlines distributed application development

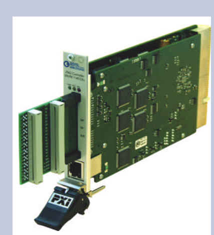
An add-on module for National Instruments' LabWindows/CVI 8.1 ANSI C development environment lets you create and deploy reliable and deterministic applications to dedicated real-time hardware, such as PXI-based systems and desktop PCs.

The LabWindows/CVI 8.1 Real-Time Module simplifies the process of transferring data between real-time and Windows applications, while its new high-resolution timing engine achieves more precise timing and determinism.

The network variable technology introduced in LabWindows/CVI 8.1 provides a simplified interface for communicating with applications written in LabWindows/CVI, LabView, Visual Basic .NET, and C#. Using network variables and the LabWindows/CVI Real-Time Module, you can publish and share live measurement data between test systems located on the factory floor and remote supervisory machines without the complexity of low-level TCP programming. www.ni.com.

Goepel introduces PXI JTAG controllers

Goepel electronic has introduced its SFX/PXI 1149/CX-x 1-slot/3U PXI boundary-scan controllers. Members of the company's ScanFlex family, two-TAP and four-TAP versions are available in 20-, 50-, and 80-MHz performance classes. Exchangeable Conpac connector paddle cards simplify the interfacing with interconnection hardware from firms including Mac Panel and Virginia Panel. www.goepel.com.



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Taming power in PXI

Richard A. Quinnell, Contributing Technical Editor

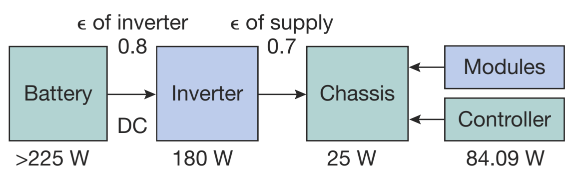
Today's communications systems are placing an increasing demand on test-system performance, requiring more extensive use of digital signal processing and faster logic-clock speeds. At the same time, a need for portability for wireless system test is increasing interest in battery-powered PXI. While one trend is pushing power demands higher and the other trend requires lowering power, they both spell an increased need for careful power management by PXI system designers.

Whether the goal is to maximize the power available or to minimize it, you should start by developing a power budget. The PXI specification states the minimum currents that a chassis must provide to a board location (**table**), and recommends a maximum total power of 60 W for a 6U board and 30 W for a 3U board. Within those ranges, developers are relatively free to allocate power as they wish.

One limitation does arise in the specification for a low-power PXI chassis. Developed to provide a lower-cost alternative that addresses smaller installations with limited power needs, the low-power PXI chassis establishes a maximum total current that the system must provide.

While a low-power chassis must still be able to supply at least 2 A to each slot at 5 V, for instance, it only needs to provide a total of 10 A to the system. A low-power chassis must bear special marking to identify it so developers do not try to over-draw power.

Even with the full-power chassis, there are limitations that must be considered. According to David Manor, VP of engineering at Geotest—Marvin Test Systems, the power pins used in the board design need consideration. The specification allows a maximum of 1 A per pin, so power to a board can be limited by the number of pins that are connected to the rails. Manor pointed out that the 5-V rail has 11 pins available, for a total of 11 A to a board that needs high power. He also noted that both the per-slot and total chassis power budgets need to be evaluated together.



Be sure to factor in the efficiency of the inverter and the power supply along with the chassis and board demands when determining battery needs for a portable PXI system. Source: National Instruments.

The supply must guarantee enough current to meet the needs of all boards in the system. As a conservative estimate, use 125% of maximum total board demand when determining the power supply requirements to allow for possible upgrades to the system and for degradation in the power supply over time.

Don't forget power-supply de-rating

Just as aging can affect the availability of current from a supply, so can temperature. Spencer Stock, PXI product manager at National Instruments, said that developers should look at how the chassis power supply is to be de-rated with temperature and compare that to their overall system needs. A power supply that meets requirements at 25°C may not provide adequate current at 50°C. Stock also cautioned that developers should look at both the de-rating and the maximum temperature at which power levels are guaranteed when evaluating the power supply for their chassis.

Another point for evaluation, said Stock, is access to the supply. Many early PXI chassis designs had the power supply directly wired to the backplane. This complicates removal and replacement of the supply in the event of failure. Now, Stock noted, chassis vendors are creating more modular designs, with a power supply that plugs into a docking station, making removal and replacement a simple operation.

When dealing with an alternative power application, such as battery operation of a PXI system, the need for power budgeting becomes critical. Some DC-powered chassis are commercially available, such as the NI PXI-1000B, but often developers will choose to use a conventional chassis and an inverter to supply AC power from a battery. Either way, the power budget will need to be expanded to include chassis elements such as fans and indicator lights along with the modules. The power draw of an empty chassis becomes a useful specification.

Using an inverter to power a conventional chassis from a battery source means that the efficiency of the power supply will also need to be a part of the power budget calculation. In its white paper, "Determining the Power Consumption of a PXI System" (Ref. 1), NI notes that the efficiency of the inverter and of the power supply both need to be evaluated (**figure**). Take the total power draw of the modules divided by the power supply's efficiency rating and add the empty chassis power draw to determine the power that the inverter must provide.

Dividing the inverter power demand by the inverter efficiency will give the power demand that the battery must meet. The system's required operating time between charges then determines the battery capacity required. Choosing a battery so that the demand is 80% of its specified capacity will provide margins for error and for battery degradation over time.

Avoid overheating in PXI chassis

Along with supplying the needed power for their systems, PXI developers need to address removal of the heat that components generate. In nearly every case, heat removal is accomplished by using fans to provide air cooling. While this may seem like a straightforward task, there are still some considerations to be addressed.

One of the first considerations is to ensure that the airflow in a PXI system is properly channeled. A commercial chassis design will typically provide the same cooling-air volume to each slot location, but only if the chassis is filled. To maintain uniform airflow, users should insert blank cards into their unused slots. Without the blank cards to help channel the airflow, most of the cooling air may end up flowing through the unused volume rather than the occupied slots.

Developers should also be on the lookout for airflow restrictions, such as cabling. Cables that cross the top or bottom of the card cage can cause hot spots within the cage. Similarly, cables at the back of the system have the potential of blocking the air exhaust from the cage, reducing cooling efficiency.

The use of cooling fans carries with it the generation of acoustic noise. That noise is becoming a problem in some system designs, according to Geotest's Manor, especially in desktop installations. To address this problem, PXI system developers and chassis vendors are using variable-speed fans rather than always running the fans at full speed. Typically, a temperature sensor at the air intake for a chassis automatically controls the fan speed. The warmer the intake air, the faster the fans blow. This helps ensure efficient cooling under a variety of ambient conditions while minimizing the fan noise.

MINIMUM CURRENT FOR PXI SLOTS

Voltage	Min. Per Slot Current	Max. Total for All Slots (Low-power systems)
+5 V	2 A	10 A
+ 3.3 V (I/O Voltage)	2 A	10 A
+12 V	0.5 A	1.5 A
–12 V	0.25 A	0.75 A

By addressing the challenges of cooling and powering PXI systems, developers will be able to create the systems they need even if they exceed specifications in some areas. Manor points to a customer that had a system populated with 16 high-performance digital boards in a chassis, each of which drew more than the 60-W slot limit.

By sizing the power supply appropriately and incorporating an additional back panel with variable-speed fans to provide adequate airflow, the customer was able to adequately power and cool the design. As Manor noted, power requires attention from developers but should not be considered a barrier. "Don't let power concerns or cooling limit your design," he said. "Pretty much any problem can be solved." □

REFERENCE

1. "Determining the Power Consumption of a PXI System," National Instruments, zone.ni.com/devzone/cda/tut/p/id/3243.

PRODUCTS

PXI solid-state multiplexers

Pickering Interfaces' 40-680 family of high-density solid-state multiplexers is aimed at low-current and low-voltage applications where speed of operation and low contact bounce are essential. The switch modules can be used to switch DMMs for four-terminal resistor measurements or as an input switch to data-acquisition systems.

The 40-680 is available in 160-channel single-bank, eight-channel 20-bank, and 40-channel four-pole versions. It can handle voltages to greater than ±15 V and has a low typical on resistance of 150 Ω. *Pickering Interfaces, www.pickeringtest.com.*

PXI DAQ cards

Adlink Technology America has introduced the DAQ-2016 and PXI-2016 cards, which feature a maximum transfer rate of 800 ksamples/s per channel. The four-channel cards offer 16-bit resolution and a variety of analog and digital trigger sources. To support channel count expansion using an external clock, the cards can synchronize multiple external devices using a system synchronization interface or a PXI trigger bus. The DAQ-2016 and PXI-2016 cards deliver two 12-bit, 1-Msample/s analog output, 24-channel programmable digital I/O lines, and two 16-bit timers/counters. *Adlink Technology America, www.adlinktech.com.*

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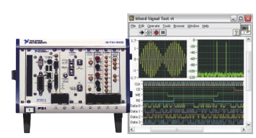
- Software-defined configuration and automation with National Instruments LabVIEW and LabWindows™/CVI, C/C++, NI TestStand, and Microsoft .NET



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Programmable Power Supplies	Up to 20 W, 16 bits
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To learn why each of these customers chose PXI, visit **ni.com/pxi**.

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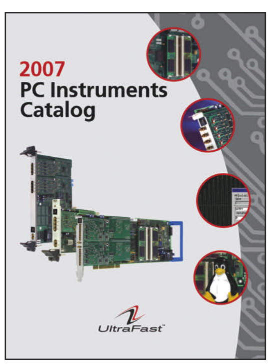

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VIEWPOINT

[An exclusive interview with a technical leader]

NORTON W. ALDERSON
CEO
Universal Switching Corp.
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Norton Alderson has more than 30 years of experience in the switching industry. Studying in southern California, he began his electronics career in the late 1970s as an electronics technician at Matrix Systems. He later rose to head the CAD department at Matrix Systems and later became senior staff engineer. In 1992, Alderson cofounded Universal Switching with Hans Johansson. Since then, the company has expanded to become a global ISO 9001:2000-certified supplier of switching products for the defense, communication, ATE, and broadcast industries.

Contributing editor Larry Maloney spoke with Alderson about industry trends in a recent telephone interview.

The hub between stimulus and test

Q: Where does your company fit in the test market?

A: Universal Switching focuses entirely on programmable switching products. We take the approach that it is better to provide innovative, best-in-class products in a single area of expertise than to offer a wide range of different technologies. Our product line includes DC to 40 GHz and everything in between, including AC/DC power switching, audio, and ATE instrumentation. We also support composite video, high-resolution RGB-HV video, high-speed ECL or LVDS digital data, microwave signals all the way to 40 GHz, and HF, RF, and IF signals.

Q: What are your dominant applications in test?

A: They range from development test, such as a survivability lab where products come under a battery of environmental tests, to automated test equipment (ATE) in production settings. Our products serve as the hub or glue that connects stimulus signals to various points on the device under test (DUT), while also connecting measuring equipment to test points on the DUT. We see a potentially vast market for switching systems in the expanding data-communications sector, as well as in ATE, cellular phones, and video imaging.

Q: How much of your overall business comes from the test field?

A: It now stands at about 30%, and it has been growing, primarily as a result of the increase in automated test solutions. Other key markets include broadcasting and communications. For example, we switch microwave signals in satellite communications centers. In defense, our switches are used in surveillance operations. Increasingly, our switches are used for routing high-speed digital data for the broadcasting industry.

Q: What kinds of features do engineers want to see in switches?

A: It's a continuation of the trends we've been seeing for some time: more capacity, smaller footprint, higher performance, superior quality, and lower cost. In addition to the traditional serial and GPIB interfaces, we now see more requests for Ethernet. To control these interfaces, you don't need to write software. We offer our own downloadable software, RouteWarePro. With this GUI, engineers can be up and running in just a few minutes with our systems.

Q: How has the Web changed the way you relate to your customers?

A: It's just an incredible way to provide information to your end users. At first, some companies were reluctant to fully use it, out of concern that competitors would also learn more about them. But it is an overwhelming benefit to customers all over the world to have this product and application information available 24/7.

Q: What percentage of your business is in switches for VXI applications?

A: We still see some interest in the military market, and we introduced an 11-slot VXI mainframe product in 2006. But overall, there has been a decline in VXI products over the last five years. It is interesting that some manufacturers of VXI and PXI are moving back to rack-mounted solutions with LXI.

Q: Why did your company join the LXI Consortium?

A: LXI could be an important new standard, but we are taking a wait-and-see attitude. To some extent, the emergence of LXI is an attempt by dedicated VXI and PXI manufacturers to revitalize their product lines. But we like LXI from the standpoint that it uses Ethernet control and can be configured within a rack-mount package. So, I expect to see a fair amount of growth in LXI. T&MW

Norton Alderson offers additional comments on trends in switch products and new growth opportunities in the online version of this interview: www.tmworld.com/2007_05.

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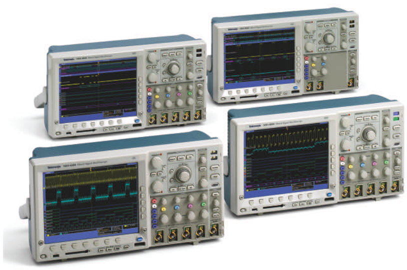

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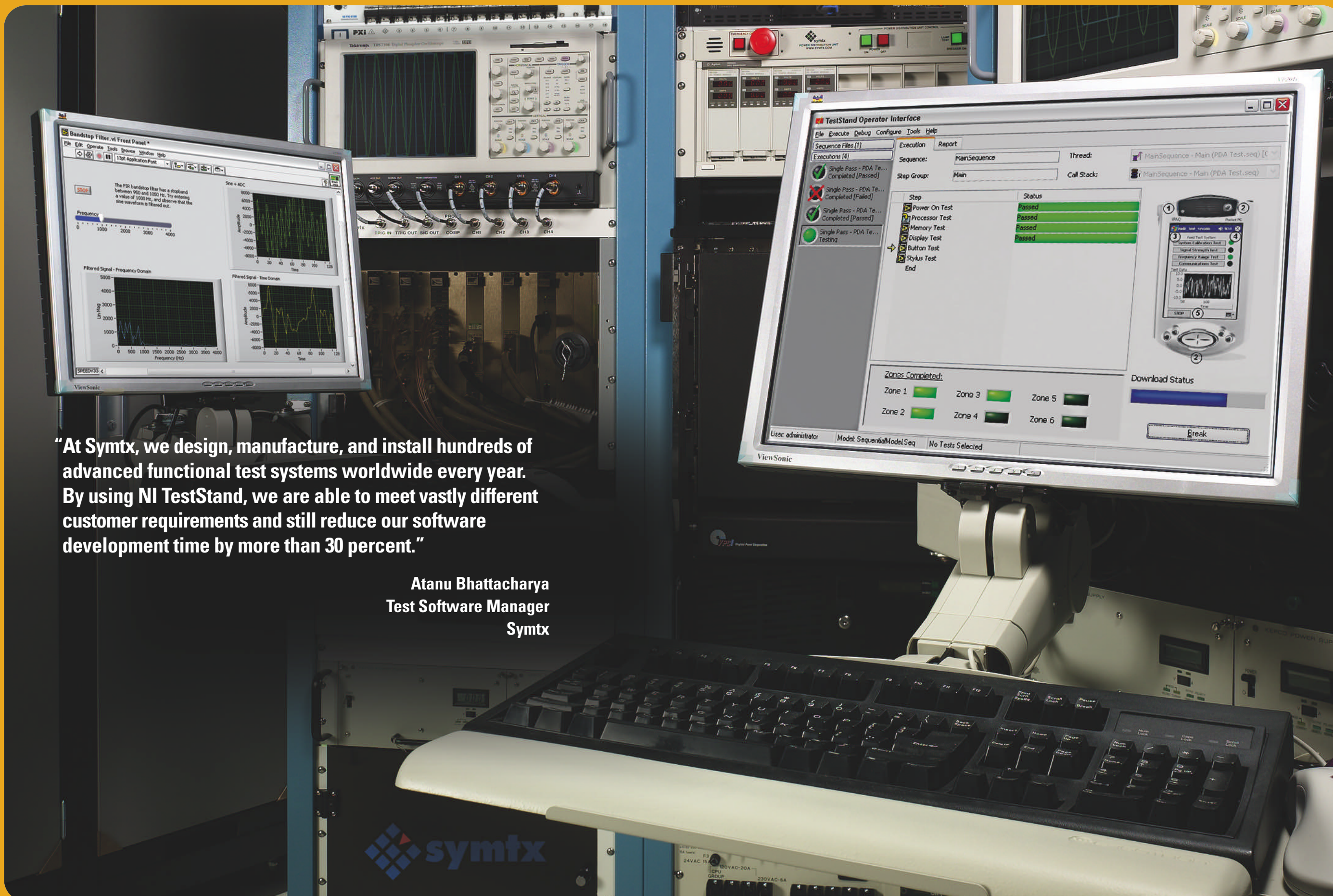

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