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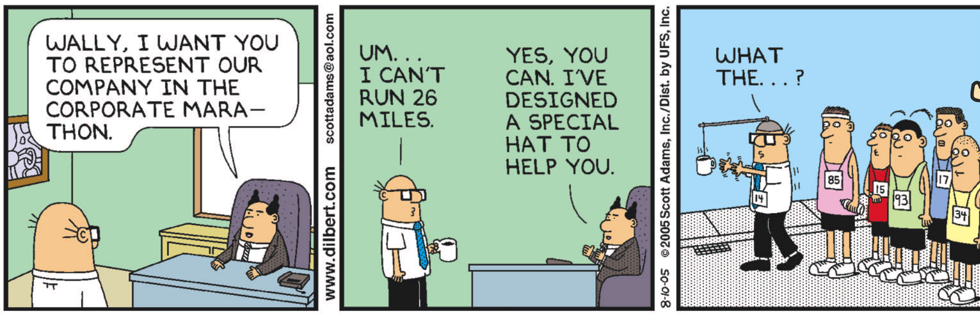

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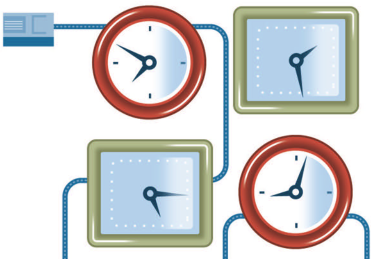

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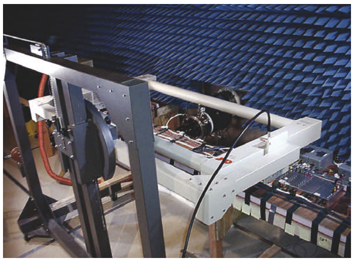

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Compliance Test Report

- **Early testing avoids EMC woes**
  Finding the sources of electromagnetic interference (EMI) at the prototype stage can be nearly impossible. You'd be better off catching the problems at the design stage, as advocated by renowned EMC consultant Doug Smith in this exclusive interview.

- **Stretching immunity test to 6 GHz**
  In February, the International Electrotechnical Commission issued Edition 3.0 of the 61000-4-3 radiated immunity test standard, which extends the range for testing from 2 GHz to 6 GHz. This article explains how you can prepare for the impact of the extended range on your test facilities.

www.tmworld.com/compliance

Longtime engineer reflects on changes

Werner Haussmann worked for HP/Agilent for 39 years, and his long career let him see development and support of test-and-measurement products from many perspectives. He recently gave us an insider's take on how test instruments have changed over time. One observation: Price can be more important than performance.

www.tmworld.com/haussmann

Happy Anniversary

Test & Measurement World is celebrating its 25th anniversary this year. But we're not alone. Many other firms also reached a significant milestone in 2006. Find out who.

www.tmworld.com/25th

Work/life balance

This month's cover story looks at the factors that might discourage people from considering engineering as a profession. One factor is the perception that engineers are work-obsessed drones with no social life. The Workshop for Women in Design Automation, held at the July DAC conference, addressed that issue head-on. Read our online pre-conference interview with WWINDA participants and our post-conference coverage.

www.tmworld.com/dac_2006

2006 Salary Survey

- **How does your salary compare?**
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Test & MEASUREMENT WORLD

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Reed Electronics Group

Competing with basketball

This issue's cover story describes the current state of engineering education in the US. The shortcomings are clear, as laid out by several speakers who discussed the challenges at last month's NIWeek trade show.

Ben Streetman, dean of the College of Engineering at the University of Texas, Austin, summed up the key problem: "We graduate 70,000 engineers per year in the US and import an equal number. Other people have been paying to educate half our engineers." In the short term, he said, it's a "sweet deal." But he added, "Ultimately, it's a strategy for failure. As technology advances elsewhere, we can't expect the best and brightest [from other countries] to keep coming."

RICK NELSON, CHIEF EDITOR

Solutions range from the establishment of mentoring programs to the infusion of substantial R&D and technical-educational investments from the government or private organizations.

Investment could indeed increase the supply of technical-education resources, but lack of supply may not be the problem. In fact, DEKA Research president Dean Kamen is adamant that it isn't. Delivering a keynote address at NIWeek from one of his Segway scooters, Kamen attributed the state of engineering education to a lack of demand for it.

"You get what you celebrate," said Dean Kamen, who works to give engineering the cachet of sports.

Twelve-year-olds, Kamen said, see a bright future for themselves in professional basketball—not engineering. And collegiate athletes who don't make a pro team can fall back on their sports-management degrees, which they earn at a rate of 84,000 per year. "If the world is going to compete in anything that involves handing out hot towels, [the US] is going to win," Kamen lamented.

"You get what you celebrate," Kamen said, which in the US is sports and entertainment. He said pro athletes and entertainers have full-time jobs being in front of children. Engineers tend to have jobs that keep them out of public view. Kamen is working to change what we celebrate through the FIRST (For Inspiration and Recognition of Science and Technology) program, a multinational competition for engineers and students—with plenty of recognition for the participants at venues like Disneyland and the Georgia Dome.

Others, too, are working to celebrate engineering. Leah Jamieson, dean of the Purdue College of Engineering, said that the Engineering Projects in Community Service (EPICS) program, which she co-founded, emphasizes engineers' roles as citizens and demonstrates that engineering is a helping profession. But while EPICS draws on resources from the academic community, FIRST needs volunteers like you to serve as team mentors for young participants. Visit www.usfirst.org to see how you might help. T&MW

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

BRAD THOMPSON
CONTRIBUTING TECHNICAL EDITOR
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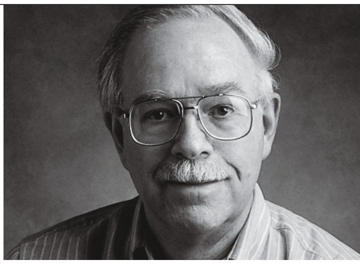


Amusing ourselves to deaf

A new phrase recently entered our collective vocabulary: ear spray. That's the audio leakage that you hear when standing next to an MP3 user who has the volume setting cranked to the max. Audio leakage from the perpetrator's earphones (or possibly sinus cavities) gets into your ears, too. You experience tinny, scratchy highs and dull thumps that might have once been music, while the earphone wearer experiences another step toward permanent hearing loss.

And let's not overlook boom cars. Equipped with stereo systems capable of delivering 140-dB-plus sound levels to their drivers, passengers, and casual bystanders, these vehicles aren't intended for casual listening. For example, a Ford Bronco equipped with a 48-kW sound system can deliver 175 dB from its loudspeakers. That's considerably above the 85-dB threshold of hearing damage.

Other sources of entertainment-related acoustic punishment include rock concerts, motion-picture theaters, and The Land of Honk, Buzz, and Boom (reached by visiting the electronics department of any "big-box" retailer). Unlike drive-by or walk-past audio assaults, attendance at these events is voluntary.

And yet, one listener's buzz and boom can impress another listener as crystal-clear highs and awesome bass. You can buy hardware for recording and reproducing sound at your neighborhood drug store, and even a personal computer's sound card and spectrum-analysis software can ferret out a signal's harmonics. But as Martin Rowe reported in his "Tech Trends" column in *Test & Measurement World*'s July 2006 issue, audio instrumentation manufacturers note that a sound card's performance as an instrument often falls short in several important aspects.

If we can't agree on objective or subjective measurements of music quality, surely a simple loudness measurement could be within our reach. I envision a cell phone of the future that will measure sound-pressure levels, dial into a central database to ascertain the average level for the immediate surroundings, locate and photograph the offending noise source, and shoot the whole works to the local noise-abatement board.

I *want* one. T&MW

FOR FURTHER READING

For an overview of the influence exerted by audio equipment on test instrumentation: "Audio: Not what it used to be," by Martin Rowe, *T&MW*, July 2006: www.reed-electronics.com/tmworld/article/CA6347077.html.

How many dBa does it take to fluff a bystander's ponytail? www.mtv2.com/sitewide/apps/mediaplayer/asxmaker.jhtml?vid=42748.

For a discussion of loud car stereos' social and legal aspects, a list of remedies, and suggestions for action: www.popcenter.org/Problems/problem-car-stereos.htm.

Explore ear spray and a remedy you can try: Technology.guardian.co.uk/weekly/story/0,,1761703,00.html.

...and listen to the "Ear Spray" story: www.npr.org/templates/story/story.php?storyId=5545142&ft=1&f=1049.

This column's title is derived from the late social critic Neil Postman's book, *Amusing Ourselves to Death: Public Discourse in the Age of Show Business.* Although he didn't anticipate the Internet, cell phones, or audio players, his commentary definitely applies to our current entertainment-intensive culture. For a review of his book: www.intellectualconservative.com/article3933.html.

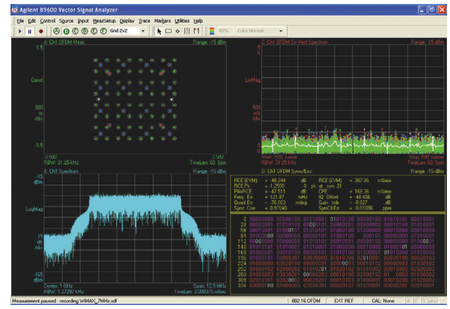
You can't buy one at your local Ford dealer, thank goodness, but here's a Ford Bronco that's equipped with a 48-kW sound system: www.wired.com/wired/archive/8.10/stereocar.html.

Heart of herring? This comparative list of sound levels may explain how you got that way: www.makeitlouder.com/Decibel%20Level%20Chart.txt.

To protect your hearing while wearing headphones, review these suggestions: www.headwize.com/articles/hearing_art.htm.

For an article that describes microphones for acoustic measurements: www.pcb.com/Linked_Documents/Vibration/Microphone_Handbook.pdf.

Analyzer, generator, and test set tackle RF



Agilent Technologies has introduced a series of instruments aimed at tackling RF measurement chores for R&D and manufacturing applications. Targeting high-volume cell-phone manufacturing applications is the E6601A communications test set, which integrates GSM, GPRS/EGPRS, WCDMA, and HSDPA test capability. It features a built-in open Windows XP PC, so users can develop, download, and execute test programs without the need for an external PC. Product manager Dan Aubertin reports that the E6601A operates up to 30% faster than alternative cell-phone test setups. Base price is $27,100.

The new MXG signal generators are mid-range instruments targeting component test, according to product marketing manager Frank Palmer, but he added that they don't scrimp on specs like adjacent channel power, achieving adjacent channel leakage ratios of better than –65 dBc for a four-carrier 3GPP WCDMA signal and –71 dBc for a single-carrier signal. Analog versions operate from 250 kHz to 1 GHz, 3 GHz, and 6 GHz and cost from $6200 to $15,000; vector-signal versions operate from 250 kHz to 3 GHz ($16,000) or 6 GHz ($25,000).

Finally, the MXA signal-analysis platform works with Agilent's 89601A vector signal-analysis software to make WiMAX (**pictured**) and other standards-based measurements. Product manager Ivan Clinton expects the instrument to find equal use in the lab and factory. Optional software provides preconfigured test routines for WiMAX, WCDMA, HSDPA/HSUPA, and phase-noise applications. Four models provide 20 Hz to 3.6 GHz, 8.4 GHz, 13.6 GHz, and 26.5 GHz, with base prices from $25,900 to $42,900. www.agilent.com.

Draft 802.11n products emerge

Although the much-heralded IEEE 802.11n WLAN standard is probably a good year away from formal ratification, end products based on draft 1.0 of the standard were released by a handful of vendors in 2006. Approximately 300,000 total draft n routers, clients, and access points shipped out from Linksys, D-Link, Netgear, Buffalo, and Belkin, according to market research firm In-Stat.

"Buyers of these draft n products are early adopters willing to pay two to three times the price of standard 802.11g products," commented In-Stat analyst Victoria Fodale. "In-Stat expects the transition to 802.11n will be bumpier than that from 802.11b to 802.11g; comparatively, during the first quarter that In-Stat started tracking shipments of 802.11g products, in 1Q03, shipments totaled 900,000 802.11g units. Additionally, 2Q is typically a slow quarter, and it will be interesting to see how vendors position draft n products within their traditional 3Q back-to-school and holiday promotions."

On the 802.11n chipset side, draft n chipsets from Atheros, Broadcom, and Marvell are powering draft n end-products. In addition, Intel is set to release its Kedron 802.11n wireless module within its Santa Rosa mobile platform in early 2007, even though the standard will not be ratified by then. Consequently, there is much pressure on Task Group N within the IEEE 802.11 working group to come up with a more solid standard to put PC OEMs more at ease with the thought of embedding draft n solutions into mobile PCs.

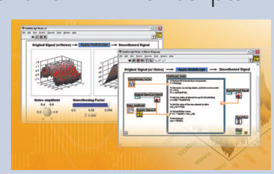
In-Stat is owned by *Test & Measurement World*'s parent company. www.instat.com.

Editors' CHOICE

LabView reaches 20th anniversary, adds new features

Celebrating the 20th anniversary of its LabView software, National Instruments has released version 8.20 of the popular programming environment. The new version adds features such as math scripts, a driver export wizard, and technical data management.

The MathScript feature lets you write and run "m-file" scripts designed for programs such as Matlab and Comsol. You can call math scripts from LabView programs to manipulate data, or you can write scripts that call LabView code to add data-collecting instruments to your scripts. You can also add user panels to your scripts and enter parameters and initiate scripts interactively or programmatically. MathScript gives you access to more than 600 math functions.



The driver export wizard helps you convert instrument drivers written in LabView into Windows DLLs, so you can develop custom drivers for use with any Windows-based language. The new technical data management schema lets you save data in XML format, and you can also document test results by embedding descriptions within test data.

Base price: $1195. *National Instruments, www.ni.com/labview.*

Spirent chosen for 10-Gbps testing

Spirent Communications reports that the China Academy of Telecommunication Research (CATR) of the Ministry of Information Industry (MII) has selected Spirent for large-scale testing of 10-Gbps core routers. Spirent testers will enable CATR to test the performance of core routers under high-capacity configurations and extreme network conditions. The CATR test environment consists of 16 ultra-high-capacity 10-Gbps packet-over-SONET (PoS) interfaces. www.spirentcom.com.

IEEE.tv is on the air

In August, the IEEE unveiled its Internet-based TV network. The initial release was accessible by members only, but by September, programming that promotes engineering careers and demonstrates new technologies was expected to be available to the public. Programs will be added monthly, and membership will still be required to view some content. www.ieee.org/ieeetv.

CALENDAR

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

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

Electronica, November 14–17, Munich, Germany. Sponsored by Global-Electronics.net. *www.global-electronics.net.*

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

Correction

Because of a copyediting error, Brian Doody's title was incorrectly stated in the August Viewpoint column (p. 64). He is chief operating officer of Dalsa. We apologize for the error.—*Eds.*

Editors' CHOICE

Spectrum analyzers reach 14 GHz

The RSA6100A Series of spectrum analyzers combine real-time performance, capture bandwidth, and dynamic range to meet the needs of digital RF applications. They employ Tektronix DPX waveform-image-processor technology to produce a live RF spectrum presentation that reveals difficult-to-detect RF signals and signal anomalies. The first offerings in the new series—the 6.2-GHz RSA6106A and 14-GHz RSA6114A—provide 110-MHz real-time acquisition bandwidth with a 73-dB spurious-free dynamic range.

The DPX technology displays the live spectrum by processing more than 48,000 spectrum measurements per second, compared to 50 per second for other analyzers. DPX achieves this rate (assuring a 100% probability of intercept for signals as narrow as 24 μs) by using dedicated, real-time hardware to process the incoming signal.

In addition to live RF, the waveform image processor provides an intensity-graded display to show the history of the occurrence for dynamic signals and immediate feedback on signal variations over time. The Windows XP-based instruments provide a user interface that includes default settings for particular measurements, but the engineer can override the settings for added control. Each RSA6100A also provides a 10.4-in. XGA touch-screen display, a mouse, a keyboard, and conventional front-panel controls.

Base price: 6.2-GHz RSA6106A—$69,900; 14-GHz RSA6114A—$75,000. *Tektronix, www.tektronix.com.*

DAC innovations span digital DFM to RF test

> > > Design Automation Conference, July 24–28, San Francisco, CA, IEEE, EDA Consortium, and SIGDA, www.dac.com.

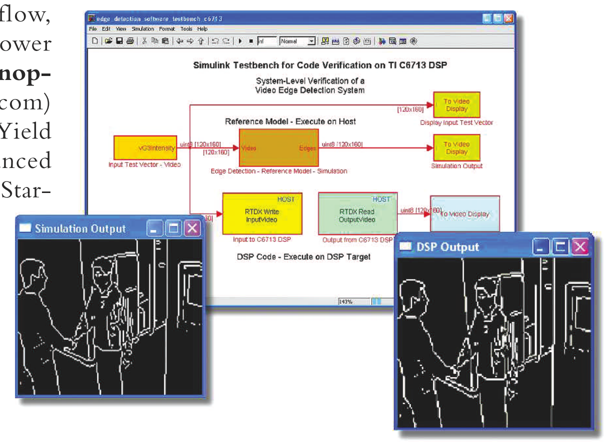
Agilent Technologies (www.agilent.com) announced the Connected Solutions Workbench, a test platform that enables system-level testing for wireless networking and cellular communications systems. **Advantest** (www.advantest.com) demonstrated its 80-lb Certimax semiconductor design-verification system, which employs PXI cards to provide 128-pin, 125-MHz event-based test capability. **EMA Design Automation** (www.emaeda.com) announced its Compliance Assurance System to support companies striving to comply with environmental legislation.

Mentor Graphics (www.mentor.com) announced that its YieldAssist and TestKompress design-for-test tools have been adopted within TSMC and UMC flows and that its Calibre nmDRC tool has been qualified on AMD and Intel processors. **The MathWorks** (www.mathworks.com) introduced model-based-design links to Mentor Graphics' ModelSim and **Texas Instruments**' (www.ti.com) Code Composer Studio. Link for ModelSim enables users to verify RTL-level models from within Matlab and Simulink. Link for Code Composer Studio Development Tools enables developers deploying embedded software on TI's digital signal processors and microcontrollers to perform continuous verification of code.

Cadence Design Systems (www.cadence.com) announced that it has added compression and yield diagnostics capabilities, is qualified in TSMC's reference flow, and is joining the Power Forward initiative. **Synopsys** (www.synopsys.com) presented the PrimeYield tool suite and announced enhancements to its Star-RCXT extraction tool and PrimeTime static timing-analysis tool.

Magma Design Automation (www.magma-da.com) emphasized the integration of its software into TSMC's Reference Flow 7.0, and it highlighted its DFM methodology for nanometer designs. **Virage Logic** (www.viragelogic.com) announced that its Area, Speed and Power (ASAP) technologies have been adopted by **CEVA** (www.ceva-dsp.com), **SOCLE** (www.socle-tech.com), and **MIPS Technologies** (www.mips.com).

Atrenta (www.atrenta.com) highlighted the fact that **STMicroelectronics** (www.st.com) has standardized on Atrenta's Spyglass design closure tools. **LogicVision** announced that it is teaming with GDA Technologies on Serdes test IP. Using LogicVision's ETSerdes, a full set of high-speed I/O parametric tests can be performed at production test speeds. T&MW



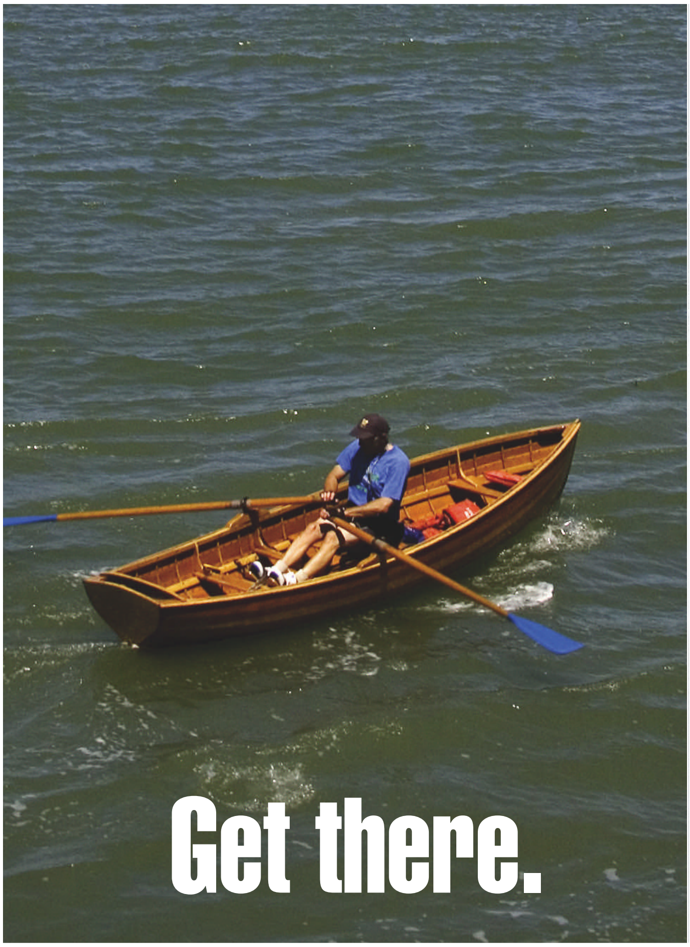
A link to TI's Code Composer Studio enables developers to perform continuous verification of code.
Courtesy of The MathWorks.

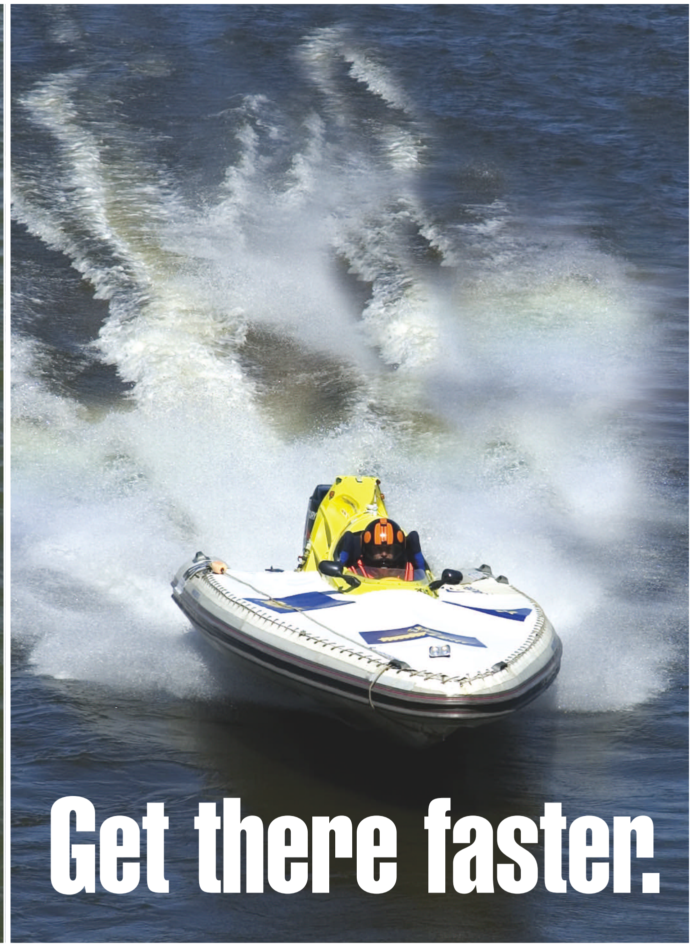
PXI Express, LabView 8.20 highlight NIWeek

> > > NIWeek 2006, August 8–10, Austin, TX, National Instruments, www.ni.com/niweek.

Conduant (www.conduant.com) highlighted its StreamStor PXIe-416, a real-time data-recording system that supports the PXI Express environment. **PLDApplications** (www.plda.com) launched its PXIe XpressLite CY2 development kit for CompactPCI Express. The kit includes a x1 add-in board, based on Altera's Cyclone II FPGA. **Goepel electronic** (www.goepel.com) exhibited its prototype 3060 communications module for ECUs; initial versions support PXI Express and PCI platforms. **PLX Technology** (www.plxtech.com) showcased its PCIe bridging technology in Compact PCIe/PXI Express (PXIe) applications.

For its part, **National Instruments** introduced LabView 8.20 (p. 11) as well as the NI PXI-5152 general-purpose digitizer/oscilloscope, which extends the company's digitizer offering to 2 Gsamples/s by providing a 1-Gsample/s real-time sampling rate on two simultaneous channels or 2 Gsamples/s on one channel at 8-bit resolution. The company also introduced two PXI Express data-acquisition modules—the NI PXIe-6259 and NI PXIe-6251 M Series, which deliver analog and digital I/O with up to 250-Mbytes/s dedicated per-slot bandwidth. In addition, NI announced four PXI Express remote, embedded, and rack-mount controllers, which provide up to 1-Gbyte/s system and slot bandwidth. Finally, the company debuted the PXI-1033 chassis with PCI Express support in the form of an integrated MXI-Express remote controller. T&MW





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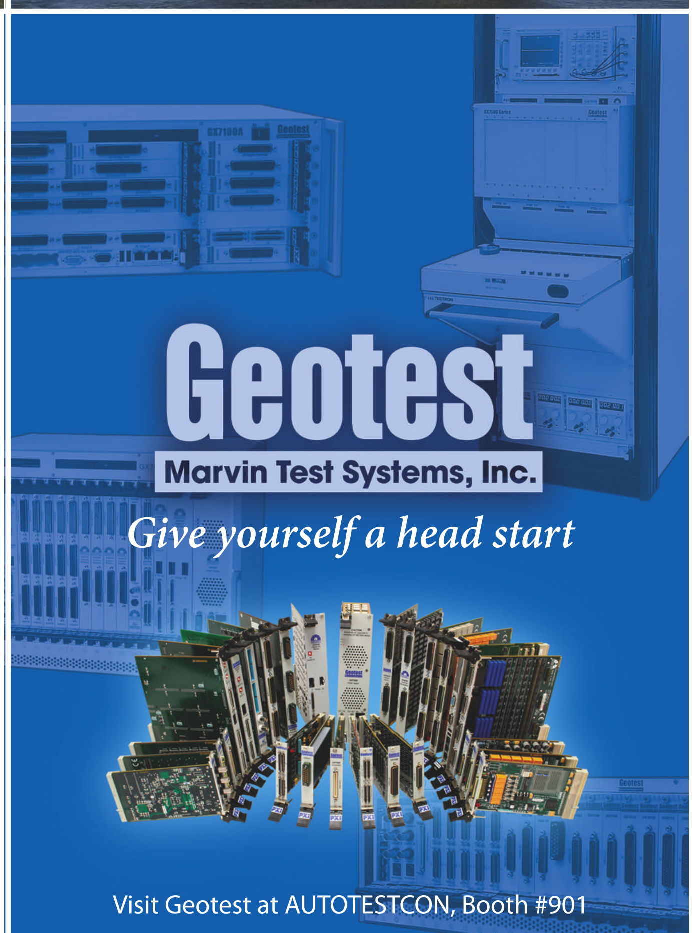

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50 Ohm Dbl Shield Coax RG223/U				
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50 Ohm Coax RG213/U				
1 Ft. to 10 Ft.	P01D13B02B02	$25	$23	$22
50 Ohm Dbl Shield Coax RG214/U				
1 Ft. to 10 Ft.	P01D14B07B07	$29	$27	$26
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50 Ohm Coax RG188A/U				
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50 Ohm Coax RG316/U				
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SMA Right Angle to SMA Right Angle				
50 Ohm Coax RG58C/U				
1 Ft. to 10 Ft.	P01D58S17S17	$27	$25	$23
50 Ohm Dbl Shield Coax RG142B/U				
1 Ft. to 10 Ft.	P01D42S18S18	$29	$27	$25
50 Ohm Dbl Shield Coax RG223/U				
1 Ft. to 10 Ft.	P01D23S18S18	$28	$26	$24

CLICK & USE CODE "HD0910" FOR THESE PRICES!

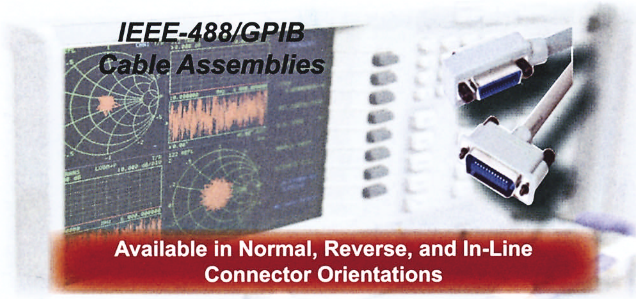
Standard 1 Ft. Increments		1-24	25-49	50-99
50 Ohm Coax RG58C/U				
1 Ft. to 10 Ft.	P01D58N02N02	$18	$17	$16
50 Ohm Dbl Shield Coax RG223/U				
1 Ft. to 10 Ft.	P01D23N03N03	$20	$19	$18
50 Ohm Dbl Shielded Coax RG214/U				
1 Ft. to 10 Ft.	P01D14N04N04	$23	$22	$21
50 Ohm Dbl Shield Coax RG142B/U				
1 Ft. to 10 Ft.	P01D42N03N03	$22	$20	$19
50 Ohm Coax RG213/U				
1 Ft. to 10 Ft.	P01D13N01N01	$21	$20	$19
50 Ohm Dbl Shielded Coax RG400/U				
1 Ft. to 10 Ft.	P01D40N03N03	$22	$21	$20

CLICK & USE CODE "HD0910" FOR THESE PRICES!

Standard 1 Ft. Increments		1-24	25-49	50-99
50 Ohm Coax RG58C/U				
1 Ft. to 10 Ft.	P01D58T03T03	$15	$14	$13
50 Ohm Dbl Shield Coax RG142B/U				
1 Ft. to 10 Ft.	P01D42T05T05	$17	$16	$15
50 Ohm Dbl Shield Coax RG223/U				
1 Ft. to 10 Ft.	P01D23T05T05	$16	$15	$14

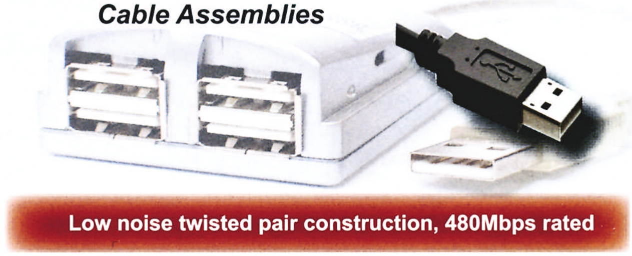
Length	Model	1-9
Type: ST - ST Duplex		**Multi-Mode**
1 Meter	X031	$11.49
2 Meter	X032	$15.49
3 Meter	X033	$16.49
4 Meter	X034	$17.99
5 Meter	X035	$18.99
Type: SC - SC Duplex		**Multi-Mode**
1 Meter	X071	$16.49
2 Meter	X072	$20.49
3 Meter	X073	$21.99
4 Meter	X074	$22.49
5 Meter	X075	$24.49
Type: FC - FC Duplex		**Multi-Mode**
1 Meter	X151	$35.99
2 Meter	X152	$37.99
3 Meter	X153	$39.90
5 Meter	X155	$40.99
Type: LC - LC Duplex		**Multi-Mode**
1 Meter	X191	$37.49
2 Meter	X192	$39.99
3 Meter	X193	$40.99
4 Meter	X194	$41.49
5 Meter	X195	$41.99
Type: MTRJ - MTRJ Duplex		**Multi-Mode**
1 Meter	X321	$18.99
2 Meter	X322	$19.49
3 Meter	X323	$20.49
5 Meter	X325	$21.49

IEEE-488/GPIB Cable Assemblies



Model #	Length	1-9
Connector Orientation: Normal / Normal		
IENN-0	0.5 Meter	$53
IENN-1	1 Meter	$56
IENN-2	2 Meter	$62
IENN-3	3 Meter	$67
IENN-4	4 Meter	$73
IENN-5	5 Meter	$78
IENN-6	6 Meter	$84
IENN-8	8 Meter	$95
Connector Orientation: Reverse / Reverse		
IERR-0	0.5 Meter	$52
IERR-1	1 Meter	$55
IERR-2	2 Meter	$60
IERR-3	3 Meter	$65
IERR-4	4 Meter	$70
IERR-5	5 Meter	$75
IERR-6	6 Meter	$80
IERR-8	8 Meter	$91
Connector Orientation: Inline / Inline		
IEII-0	0.5 Meter	$38
IEII-1	1 Meter	$40
IEII-2	2 Meter	$45
IEII-3	3 Meter	$50
IEII-4	4 Meter	$56
IEII-5	5 Meter	$61
IEII-10	10 Meter	$86
Connector Orientation: Normal / Inline		
IENI-0	0.5 Meter	$47
IENI-1	1 Meter	$50
IENI-2	2 Meter	$55
IENI-3	3 Meter	$61
IENI-4	4 Meter	$67
IENI-5	5 Meter	$72
IENI-10	10 Meter	$99
Connector Orientation: Reverse / Inline		
IERI-02	0.2 Meter	$49
IERI-05	0.5 Meter	$50
IERI-1	1 Meter	$53
Connector Orientation: Normal / Reverse		
IENR-03	0.3 Meter	$52
IENR-05	0.5 Meter	$53
IENR-1	1 Meter	$56

USB-2.0 Cable Assemblies



Model #	Length	1-9
Type-A Male to Type-A Male		
UBN-3003	3 Ft	$8
UBN-3006	6 Ft	$9
UBN-3010	10 Ft	$10
UBN-3015	15 Ft	$12
Type-A Male to Type-B Male		
UBN-3103	3 Ft	$7
UBN-3106	6 Ft	$8
UBN-3110	10 Ft	$9
UBN-3115	15 Ft	$11
Type-A Male to Type-A Female		
UBN-3203	3 Ft	$8
UBN-3206	6 Ft	$9
UBN-3210	10 Ft	$10
UBN-3215	15 Ft	$11

CAT 5E and CAT 6 Patch Cables

Model #	Length	1-9
Category 5e Type		
C5S-0101	1 Ft	$1.59
C5S-0103	3 Ft	$1.99
C5S-0105	5 Ft	$2.39
C5S-0107	7 Ft	$2.79
C5S-0110	10 Ft	$3.39
C5S-0115	15 Ft	$4.29
C5S-0125	25 Ft	$6.59
C5S-0150	50 Ft	$11.79
Category 6 Type		
C6S-0101	1 Ft	$5.99
C6S-0103	3 Ft	$6.99
C6S-0105	5 Ft	$7.99
C6S-0107	7 Ft	$8.99
C6S-0110	10 Ft	$10.99
C6S-0115	15 Ft	$12.99
C6S-0125	25 Ft	$17.99
C6S-0150	50 Ft	$29.99

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Features screw threads for mating and serves as a threaded version of the BNC connector. The TNC is a 50 O connector available in both standard and reverse polarity.

Listings and descriptions of cable type and connectors

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Step 3:	Connector B	TNC FEMALE
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Step 5:	Quantity	1

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BNC "T" F/F/F
AB09
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10+ $9.99

BNC/F to N/M
AB10
1-9 $7.49
10+ $6.99

BNC/M to SMA/F
AB13
1-9 $18.99
10+ $17.49

BNC/M to RCA/F
AB26
1-9 $6.49
10+ $5.99

SMA Adapters

SMA/F to SMA/F
AS05
1-9 $15.49
10+ $14.49

SMA Bulkhead F/F
AS06
1-9 $10.99
10+ $9.99

SMA Right Angle M/F
AS08
1-9 $21.99
10+ $20.49

SMA/F to TNC/M
AS12
1-9 $21.99
10+ $20.49

SMA "T" F/M/F
AS15
1-9 $18.99
10+ $17.99

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10+ $10.49

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AN08
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10+ $11.49

N "T" F/M/F
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1-9 $25.49
10+ $23.99

N/M to SMA/F
AN13
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10+ $23.99

N/F to SMA/F
AN15
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MARTIN ROWE
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EMC Directive faces changes in 2007

THE EUROPEAN UNION'S new EMC Directive (2004/108/EC) will replace its predecessor (89/336/EC) on July 20, 2007, with compliance mandatory on July 20, 2009. The EU hopes to simplify the compliance process with the new directive. No longer will you need a Competent Body to verify compliance. Instead, the directive lets manufacturers more easily self-certify and place the CE Mark on their products. The second major change comes in the distinction between "apparatus" and "fixed installations," where apparatus are products sold on the open market. Fixed installations are systems such as computer networks and industrial controls that are built for a single location and can't be moved.

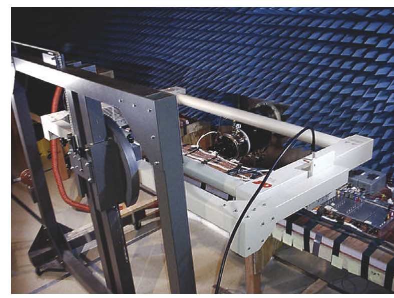
To find out how the new directive will *really* change things, I asked three prominent EMC engineers. "The new directive will put a lot of Competent Bodies and Notified Bodies out of business," said Roland Gubisch, engineering manager for EMC and telecom at Intertek's lab in Boxborough, MA. "Technical construction files [TCFs] are no longer required to be reviewed by these bodies."

Thus, manufacturers can claim compliance without a third-party review of test results and other technical documents, but customers may still require test and design documentation showing compliance. The new directive merges Competent Bodies and Notified Bodies, then it makes the use of these bodies optional.

"The burden is on the manufacturer to comply," said David Bare, CTO at Elliott Labs in Sunnyvale, CA. "Large manufacturers may write their own TCFs, but smaller ones will probably still use third parties such as test labs to write TCFs."

"There may be less testing," added EMC consultant Brian Jones. "Manufacturers may instead choose the more detailed technical documentation option, but customers could require third-party assessment. It's difficult to predict."

The new directive allows for fixed installations to use equipment that is exempt from EMC compliance. So, custom equipment such as control panels or embedded systems, often designed and built by small companies and not sold on the open market, is exempt. "In the UK, the enforcement authorities would take the view that if there was an EMC problem with a fixed installation, they would ask the responsible person what good engineering practices have been employed," said Jones.



The new EMC Directive gives manufacturers more freedom to self-certify products. Courtesy of DLS Electronic Systems.

"Good engineering practices" include shielding, grounding, and PCB layout to minimize interference. "You have to do these things anyway," said Bare, "because without good signal integrity, your product probably won't work."

You can still use harmonized standards that contain test procedures and limits when testing your products, but the new directive does not require this. You can, for example, claim that if you test to FCC Part 15, you don't need to test to harmonized EMI emissions standards if your test results show enough margin to give you confidence of compliance.

Furthermore, you need not repeat compliance tests for small design changes. Many manufacturers will choose to perform a comparison between a known-compliant product and a modified one. If the results let you conclude conformance in the modified product, you may place the CE Mark on your product with confidence. The reasoning for compliance should be included in the technical documentation. T&MW

Military frequency standard

Systems requiring a stable 10-MHz frequency source can use the 9250 module from Symmetricom. It's designed for applications that need a stable frequency source such as military and aerospace communications, navigation, and targeting systems. It has a stability of less than 10^{-8} over one year. www.symmsda.com.

Vibration applications book

IOtech's *Vibration Analysis Catalog* contains information on the ZonicBook/618E eZ-Analyst software for real-time and acoustic analysis, eZ-TOMAS for rotating machine monitoring and analysis, eZ-NDT for resonant inspection, and eZ-Balance for machine balancing. It also describes options such as a signal-conditioning module with TEDS support and a 16-slot signal-conditioning module. www.iotech.com.

Beyond 10-Gbit Ethernet

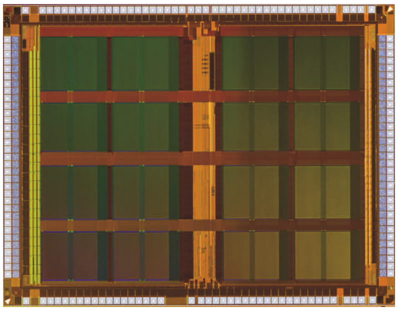
After approving the IEEE 802.3an standard governing 10 Gigabit Ethernet, the IEEE 802.3 Working Group began studying the next generation of Ethernet technology. The new Higher Speed Study Group (HSSG) will evaluate the definition of a greater than 10-Gbps MAC data rate and the related PHY capability. www.ethernetalliance.org.

STEVE SCHEIBER
CONTRIBUTING TECHNICAL EDITOR
sscheiber@aol.com

Thanks for the (MRAM) memories

CHOOSING ONBOARD memory technologies involves tradeoffs. SRAMs and DRAMs are fast and permit a virtually unlimited number of read/write cycles, but the stored information evaporates when you shut off the power. Permanent(ish) storage means enduring the slow data transfer rates and limited life of Flash memory on a card or stick or the moving parts and high power consumption of a conventional hard drive.

Now, a development in memory technology promises to change the rules. Freescale Semiconductor has begun volume production of magneto-resistive RAM (MRAM). MRAMs store data as magnetic states rather than charges. With this approach, the state doesn't "leak" away. There is no discernible degradation with time, and retaining stored information requires no power. The speed of MRAMs compares favorably with that of SRAMs and other fast devices.



The MRAM uses magnetic polarization rather than electric charges to store information. Courtesy of Freescale Semiconductor.

Freescale's initial offering is a 4-Mbit device on a 44-pin 400-mil thin small-outline package (TSOP). Companies are already looking at the devices to provide instantaneous start-up as well as fast, nonvolatile, but easily updated power-on self-tests (POSTs). MRAMs will also allow more extensive stored test procedures on boards and systems that can be triggered by more conventional test equipment during production or field repair.

The company claims that MRAM technology will usher in an era of electronic products offering advantages in size, cost, power consumption, and product performance. Although their current modest capacity prevents MRAMs from supplanting bulk-storage alternatives for the moment, their nonvolatility and minimum heat dissipation will encourage incorporation into high-volume products, such as new kinds of smart cards, that require high data integrity and permit little tolerance for manufacturing defects. The high volume of such products will tend to favor inspection over more traditional manufacturing test.

The devices' decreased power consumption will reduce heat dissipation at the board level. Ironically, the resulting reduced need for elaborate cooling mechanisms such as heat sinks and fans could actually increase access to portions of the circuit, facilitating some conventional test steps.

As MRAM capacity increases, test equipment manufacturers will incorporate them into the test equipment itself. Their reduced power consumption will permit systems to include more memory, permitting more complex test patterns at both in-circuit and functional test levels. Battery-powered test equipment will become more practical for applications such as field testing, testing on the manufacturing floor, and depot deployment. T&MW

FOR MORE INFORMATION

"Magnetoresistive Random Access Memory," Freescale Semiconductor white paper, www.freescale.com/files/memory/doc/white_paper/MRAMWP.pdf.

Goepel supports Altera USB-Blaster

Goepel electronic has developed an option in its System Cascon software suite to support Altera's USB-Blaster download cable. The option enables the USB-Blaster to be used as a native JTAG/boundary-scan controller throughout the product life cycle. The USB-Blaster can also be used to program flash devices in-system and to configure Altera FPGAs via the Jam Standard Test and Programming Language (STAPL), the JEDEC standard JESD-71, the Simple Vector Format (SVF) specification, or the IEEE 1532 standard. www.altera.com, www.goepel.com.

Multiplexer switches up to 750-V peak

The 40-320 PXI multiplexer from Pickering Interfaces has switching capability to 750-V pk and 10 W. Configured as a 12-channel or 24-channel multiplexer, the module includes high-voltage suppressors to reduce transients when connected to long input cables and to minimize RF radiation when switching live circuits. www.pickeringtest.com

Firms bundle software with camera

Basler's eXcite intelligent camera series now supports release 7.1.1 of Halcon software from MVTec Software. Halcon is a software library for industrial image processing that contains more than 1150 operations. The eXcite camera merges digital camera technology and a 1.0-GHz Linux PC in a compact housing. It can capture and process images based on C++ application software, and it lets you feed calculated results directly into a production process and trigger removal of defective parts from an assembly line. www.basler-vc.com, www.mvtec.com.

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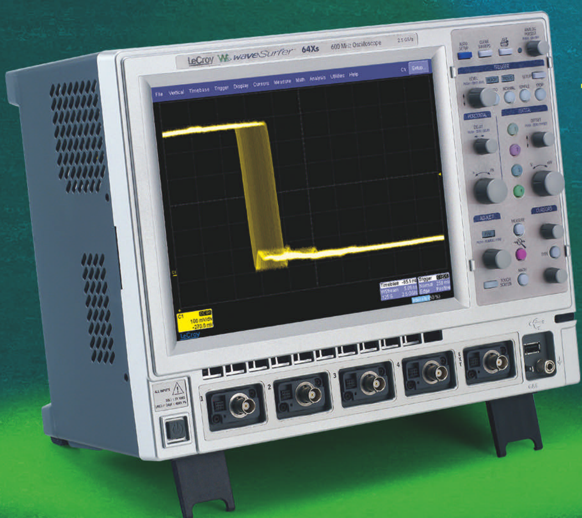

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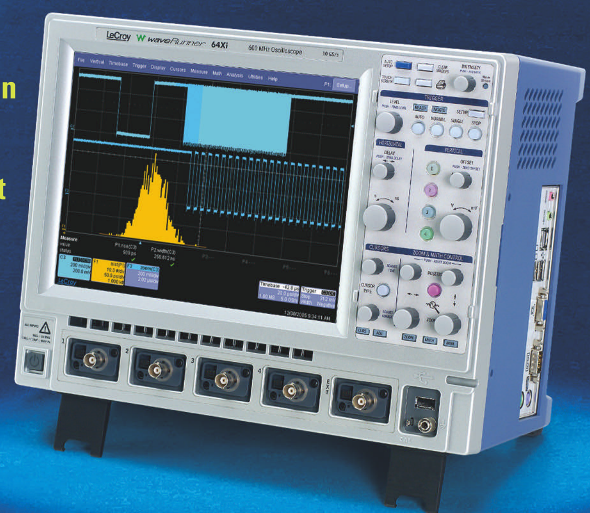

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APPLICATION NOTE

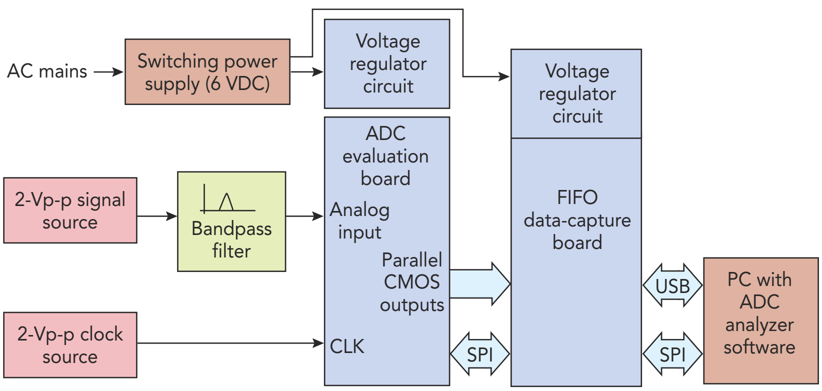
Learn the basics of ADC testing

In our June 2006 cover story, "The world is still analog," I described how engineers at Analog Devices use evaluation boards to characterize high-speed analog-to-digital converters (ADCs) (Ref. 1). To learn more about the 17 AC tests and eight DC tests that the engineers perform on ADCs, you can turn to a recently published application note, "Understanding High Speed ADC Testing and Evaluation" (Ref. 2).

The figure shows a typical test setup for many of those measurements. If you use digitizing measurement equipment such as oscilloscopes or data-acquisition systems, this note will help you understand ADC specifications. If you design ADCs into embedded systems, you'll benefit from the explanations of how to evaluate an ADC.

The authors discuss how to set up tests and how to use characterization software that you can download. The software performs FFTs and measures signal-to-noise ratio, signal-to-noise and distortion, spurious-free dynamic range, and other parameters. From the app note, you'll learn which signal sources to use and when to apply low-pass filters and bandpass filters to your test setup.

Martin Rowe, Senior Technical Editor



A typical characterization setup consists of signal and clock sources, a filter, a power supply, an evaluation board, and a data-capture board. Courtesy of Analog Devices.

REFERENCES

1. Rowe, Martin, "The world is still analog," *Test & Measurement World*, June 2006. p. 26. www.tmworld.com/2006_06.
2. Brannon, Brad, and Rob Reeder, "Understanding High Speed ADC Testing and Evaluation," Analog Devices, Norwood, MA, 2006. www.analog.com (search for "AN-835").

BOOK REVIEW

Switching augments instrument systems

Switching Handbook: A Guide to Signal Switching in Automated Test Systems, 5th ed., Keithley Instruments (www.keithley.com), 2006. 190 pages. Free.

Do you need a switching system? Maybe not if your DUT has only a few I/O pins or you have the budget and lab space necessary to assign an individual instrument to each of the possibly hundreds of signal lines you need to drive or measure. In general, though, you'll find it desirable to employ switching systems to effectively deploy your test equipment in automated measurement applications.

But knowing that you need a switching system is far different from knowing which system to use. Switches can only approximate the ideal: infinite open resistance, zero closed resistance, zero switching time, and zero crosstalk with neighboring devices. Keithley Instruments' *Switching Handbook* is a concise compendium of the information you need for choosing wisely.

If you are new to switching, you'll find Chapter 1's overview of switch topologies (scanning and multiplex switching, for instance) and its discussion of special RF signal-switching requirements to be helpful. So, too, will you find useful Chapter 2's description of electromechanical, dry-reed, mercury-wetted-reed, and solid-state relays. Chapter 3 goes into detail on how to specify switching systems, covering topics ranging from insulation resistance to voltage standing-wave ratio. Chapter 4 explains how real-world uncertainties related to factors like contact potential, switching speed, and cold vs. hot switching can affect your measurement accuracy or switching-system performance.

An extensive section (Chapter 5) is devoted to describing switching system requirements based on the type of signal you want to switch (voltage or current, low frequency or RF, for instance) and the type of load (resistive or reactive) you intend to connect to your switch output. The subsequent chapter provides details on the wires and cables you'll use to connect your switch, instruments, and DUT.

The final chapter describes several specific applications: battery charge and

Switching augments instrument systems *(continued)*

discharge measurements, capacitor leakage tests, continuity tests, temperature scanning using thermocouples, and diode testing. It goes into detail about measurements specific to printed-circuit boards, accelerated cell-phone life tests, and VCSEL testing. The book also provides a handy glossary.

Like other free Keithley handbooks (www.reed-electronics.com/tmworld/article/CA6277901.html), this book includes vendor-specific examples, such as using the Keithley System 40 Microwave/RF switch system in the cell-phone life-test example. The book also provides an appendix describing the company's switch cards and modules, but it provides more than enough generic information to make it worthwhile regardless of where you get your switching systems.

Rick Nelson, Chief Editor

SIGNAL INTEGRITY

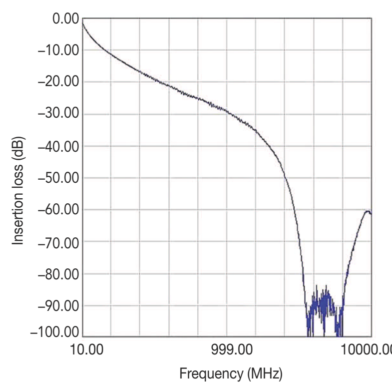
External PCI Express reaches 30 m

PCI Express (PCIe), a serial version of the parallel PCI bus, has replaced its older cousin as the expansion bus in new PCs. Now, PCIe is coming out of the box.

External PCI Express puts from one to eight 2.5-Gbps lanes on a cable for computing-intensive applications. The cabling standard isn't finalized (it's currently at version 0.7), but it calls for a cable length of 7 m. Even so, engineers at Molex have run the bus as far as 30 m, as they demonstrated during GlobalComm 2006 (June 5-7, Chicago, IL).

To find out how they did it, I spoke with Gourgen Oganessyan, senior signal-integrity engineer, and Galen Fromm, electrical project engineer, by phone. "When you extend a cable," said Oganessyan, "you run into problems at high data rates. Attenuation in the cable reduces differential amplitude, and reflections occur. Both cause bit errors." To reduce bit errors, Molex partnered with Quellan, a company that makes a cable-extender module that equalizes the signal before it reaches the receivers and thus improves reception, which opens the signal eye.

For their demo, the Molex engineers used Stratix GX multigigabit transceiver blocks from Altera (standard SerDes devices) as transmitters and receivers. The devices contain programmable equalizers that can be tuned to a specific application. At the transmitters, the engineers applied pre-emphasis, amplifying higher frequencies to compensate for the low-pass-filter effect of a long cable. The SerDes devices also perform equalization at the receiver. The Quellan module has allowed Molex to optimize the features of both devices to drive the extended cable in a power-efficient way.



Insertion-loss measurements provided data used to equalize the transmission line. Courtesy of Molex.

"We wanted to best utilize the equalization in the Altera device and the Quellan module," explained Fromm. "We needed a custom module, so we provided Quellan with differential insertion-loss measurements." From the measurements (**figure**), Fromm set the taps of digital filters in the Altera device's DSP core. Quellan created a module for PCIe by integrating a Molex PCIe connector into its design.

At the final stage, Oganessyan and Fromm experimented with longer and longer lengths of cable starting at 20 m. They stopped at 30 m. At the GlobalComm demo, they ran a PRBS pattern through the cable assembly for nine hours on each day of the show, achieving a bit-error rate of less than 10^{-14}.

Martin Rowe, Senior Technical Editor

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Software tests network software

DEVICE UNDER TEST

Software that telecom carriers use to manage access networks and configure and provision services such as DSL for subscribers. It includes a GUI that provides an alternative to the Telnet interface when users need to access the DSLAMs. Using a client-server architecture, the software runs on a server that communicates to DSLAMs using Simple Network Management Protocol (SNMP).

THE CHALLENGE

Test the software by simulating both operator actions and a network of DSLAMs. Develop and run test scripts for automated interoperability testing. Provide pass/fail results in less than 24 hr.

THE TOOLS

- ADTRAN: DSL access multiplexers. www.adtran.com.
- Gambit Communications: Agent simulation software. www.gambitcomm.com.
- Mercury Interactive: TestDirector test-management software; QuickTest Professional (QTP) test-automation software. www.mercury.com.
- Shunra: LAN/WAN network-emulation software. www.shunra.com.

PROJECT DESCRIPTION

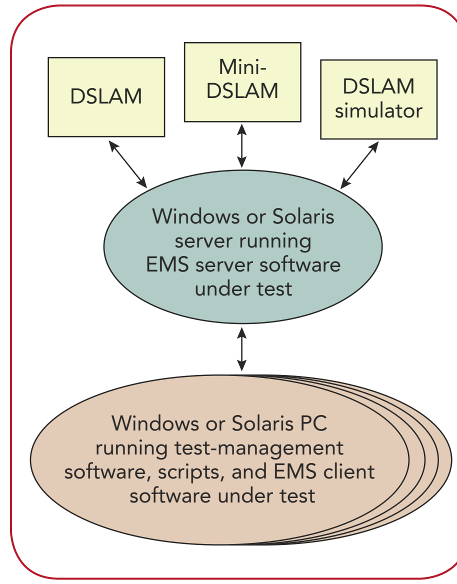
Adtran (Huntsville, AL, www.adtran.com) manufactures network-access equipment such as digital subscriber loop access multiplexers (DSLAMs) used by both carrier and enterprise business customers. The company also provides Element Management Software (EMS) that telecom carriers use to manage, activate, upgrade, and troubleshoot DSL services for subscribers.

The software runs on a Solaris or Windows server. It manages the DSLAMs using simple network-management protocol, and it provides a user interface to set and retrieve DSLAM configuration parameters. Telecom carriers use EMS to manage DSLAMs over geographic areas that can cover several states. Users at the carriers' offices communicate to the EMS server using client Windows or Solaris-based software through a wide area network (WAN).

Product qualification engineer Mike Barfield performs interoperability tests on the EMS. When the company adds new features, Barfield verifies interoperability between Adtran's access products and EMS. Each new EMS release adds features that Barfield tests manually. He also verifies that existing features still work. Rather than test previously existing features manually, Barfield develops automated tests using QTP, called "regression tests."

Regression tests check previously released functionality on a simulated carrier's access network. "A customer may have as many as 6000 network elements or more," he said. "A high-density DSLAM can service as many as 1344 subscribers, while a mini-DSLAM, used in remote areas, may serve up to 48 subscribers."

Barfield simulates user interactions by applying parameters and checking input boxes to previously existing features. To automate the user actions and to send commands to the DSLAMs, Barfield creates scripts for the EMS clients. He tests an EMS server with several thousand simulated DSLAMs before running new feature and regression tests. The software generates the EMS load by creating a large database on the server, sending alarm traps, and allowing device discoveries (**figure**). The functional and agent simulation software identify issues that occur on a stressed server.



Test-management software organizes and executes automated and manual tests.

Barfield uses TestDirector, which functions as a test executive, to select and run the tests. For example, one test case might check DSLAM parameters in the EMS by sending commands and checking the actual responses against expected responses. Checkpoints in the test script provide pass/fail results. If a failure occurs, the test software will capture a screen showing the failure, report the actual versus the expected results, and log the results.

LESSONS LEARNED

"Automation pays off," said Barfield. "It saves considerable time in testing and retesting your product." He can run several hundred test cases over a 24-hr period. He recommends that you plan sufficient time for updating your tests at the beginning of a test cycle: Identify manual tests that you can automate, remember that not all tests are suitable for automation, focus on the test objective and add checkpoints so you can verify the actual and expected results, and organize your test plan so it is easy to manage.

Martin Rowe, Senior Technical Editor

THE FUTURE *of* ENGINEERING

MARTIN ROWE, SENIOR TECHNICAL EDITOR, AND AMY LASKOWSKI, CONTRIBUTING EDITOR

As *Test & Measurement World* reaches its 25th anniversary, we editors are looking to the future.

And that future resides in the young men and women considering technical careers, their teachers and mentors, and the industry leaders who work with the academic community.

Electrical engineering can be a rewarding career. You learn how things work, you solve problems, and you use your knowledge to create products that enhance—and even save—lives. The field changes rapidly, providing new opportunities for engineers to grow professionally, be creative, and make a difference in the world. For these and other reasons, many engineers wouldn't dream of doing anything else.

The engineering profession in the US, however, is at a crossroads. New technologies offer the promise of rewarding careers, and there are infinite products yet to invent. But despite these limitless opportunities, enrollment in engineering programs at American universities is flat at best.

The numbers speak for themselves. **Figure 1** shows the number of US electrical and computer engineering (ECE) degrees earned from 1971 through 2003. From the late 1970s though the 1980s, ECE degrees rose steadily, and salaries went right along with them as employers snatched every ECE graduate in sight. By the 1990s, ECE degrees dropped steadily.

To find out why people choose—or do not choose—engineering as a career, what employers look for, and industry's role in engineering education, we spoke with professors, students, and professionals.

From our interviews, we found numerous reasons why young people enter engineering, the most prominent being that they already know an engineer, usually a parent or relative. Knowing someone in the field gives young people the introduction they need to pursue engineering as a career. Furthermore, teachers and shop courses may pique someone's interest in engineering. Conversely, many bright students never study engineering because they don't know anything about what engineers do.

Math and science: just the beginning

Many students consider engineering careers because they're good at math and science and receive encouragement to enter the field from their parents, teachers, and guidance counselors. "I think that's a reasonable thing to do," said Professor Gary S. May, ECE department chair at Georgia Institute of Technology (Georgia Tech). "It doesn't mean that it's the only career that's available to you, or you'd be a perfect engineer because of that. But I think it's a reasonable thing to tell students that engineering is an option for you because you have this aptitude."

An aptitude for math and science is certainly a requirement for an engineering career, but is it enough? Not according to Professor Richard Vaz of Worcester Polytechnic Institute (WPI). Vaz, who is associate dean of the Interdisciplinary and Global Studies Division at WPI, said that the best engineers also have a passion for solving problems.

UCSB Professor Steve Long also cited "the willingness to do critical thinking" that makes good engineers. He argued that engineers are naturally curious and they want to know about something that's not necessarily in a textbook.

Not everyone, though, has a clear reason for studying engineering. "When I ask students why they want to study engineering, very rarely can they articulate a reason," said Vaz. "If they can, it usually doesn't line up well with what en-

ELECTRICAL ENGINEERING FACULTY AND STUDENTS COMMENT ON ENGINEERING CAREERS, INDUSTRY INVOLVEMENT, AND HOW THE WORLD PERCEIVES ENGINEERS.

gineers really do, which is solve problems and make the world a better place." Some people, we learned, go into engineering because of the prospect of earning a decent living with just a bachelor's degree. (See "Is engineering a profession?" p. 36.) "That [belief] won't get you very far," added Long. He also cited "pushy parents" as another wrong reason that some young people study engineering.

While some people study engineering who might have been better at something else, many people who could make good engineers miss the opportunity because they don't know what engineers do. "We don't see enough of the brightest people coming into engineering because early in their educational paths, they get advice that essentially blocks their way," said Moshe Kam, professor of ECE at Drexel University and VP of the IEEE Educational Activities Board (EAB). "There is a feeling that we won't have enough people, we won't have the right people, and because of that, we won't have enough innovation," he added.

Kam based his conclusions on meetings with representatives from 53 companies that hire electrical engineers. He also found that high school guidance counselors may unconsciously steer women with the ability and prerequisites for studying engineering into other fields because, "It's not something that women do, and that's a myth that we need to shatter." (See "Where are the women?" below.)

Georgia Tech's May noted that some of the issues that divert women away

Where are the women?

Twenty-five years ago, female engineers were uncommon. The number of women in the field is rising, but don't be fooled into thinking that the profession is becoming more equally split between the sexes. According to the American Society for Engineering Education, 12,500 bachelor's degrees were awarded to electrical engineering students in the US in the 2004 academic year. Only 15% (or 1875) were awarded to women (Ref. 1). This number is especially astonishing, since a recent article in the *Washington Post* reported that more women enroll in college than men (Ref. 2).

Professors and school administrators acknowledge that too few women in engineering poses a problem, and the students notice it as well. We interviewed many professors, students, and professionals who cited the issue of girls losing interest in the sciences around sixth grade. Professor Richard Vaz from WPI explained, "A lot of people believe it has to do with social pressures, and social messages about gender-specific roles." Engineering remains a male-dominated field, which might be intimidating to young women considering it for a career choice.

Ben Hutt, an engineering student at Northeastern, offered his take on female engineering students: "I think they have to break through the 'do you really think you can do it?' stage first, but after they show that they are, in fact, able and willing to do the work, they get a lot of help, and maybe more than others, because women engineers are seen as a rarity."

Tamra Kerns gives great advice to women entering engineering: The important lesson is to walk in and know you are going to contribute and be a meaningful part of the team.

How can society encourage women to become engineers? There are several ways. For instance, a strong role model, especially a female role model, is an important factor to many women choosing to enter engineering. People are more likely to become engineers when they see a family member or close friend working in the field. Didi Smith, an engineering student at University of California at Santa Barbara, explained that she became interested in engineering when her dad helped her build her first circuit in fourth grade. Her father is an engineer and encouraged Didi to become interested in science and math.

Shelley Gretlein stresses the importance of making the engineering career one that is sought after by women.

Girls who attend elementary schools with a strong science curricula are more likely to enter a scientific field because they recognize all the exciting opportunities that science can offer. Because students must declare the engineering major by their first year of college to allow enough time to complete all the required classes, middle schools and high schools must put extra energy into the sciences to demonstrate to students, especially female students, all the career opportunities available.

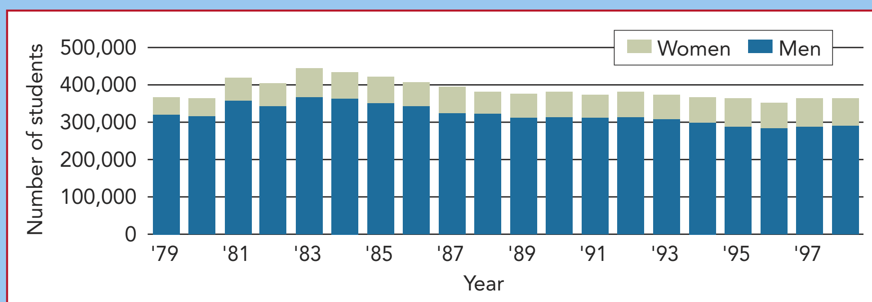
Women tend to be interested in fields dealing directly with people, such as teaching or healthcare. Therefore, teachers and mentors must emphasize the humane side of engineering and point out that it can certainly help people—bioengineers create artificial limbs, while civil engineers build water lines for areas hit by natural disaster. Professor Vaz elaborated: "There's a lot of research that suggests very strongly that women choose career paths that they can see leading to meaningful careers. Women are far more interested than men in careers where they can make a difference, make the world a better place, and help people. They are statistically more likely to be searching for a helping profession. Engineering is a helping profession, but it does not present itself as such."

from engineering also apply to minorities. "We have to show that engineers are normal people with normal lives with the same sorts of concerns as everyone," he said. "This also affects our ability to recruit minority students. I say that from experience."

Educate the public

Kam and others within IEEE's EAB are working to educate the public about the rewards of an engineering career. The most visible effort is the Web site TryEngineering.org. Launched on June 5, 2006, the site goes beyond electrical and computer engineering, with interviews of chemical engineers, civil engineers, and mechanical engineers. The site provides information for students, parents, guidance counselors, and teachers. It also provides a search engine for finding engineering schools. Kam explained that the site shows engineering in a positive light, showing the "can do" attitude of engineers. Using the site, prospective engineering students can ask questions of, and get replies from, working engineers and undergraduates.

Kam also acknowledged that engineering schools can do a better job of attracting and keeping good students. For one thing, he said that some engineering schools still operate with a "boot camp" mentality. "It's not that students can't cope with the curriculum," he explained. "They transfer out of engineering because of a 'weed out the weak' atmosphere. It not only chases away women and minorities, it also chases away a



The percentage of women engineering students grew between 1979 and 1998.

Source: Society of Women Engineers, www.swe.org/SWE/ProgDev/stat/statundergrad_table.html.

Perhaps the final way to draw more women into engineering is to recruit girls while in high school, by holding camps and workshops run by current professionals. At Georgia Tech, engineering student Kathryn Taylor is involved with a summer camp that works with local children, getting them excited about science. She explained, "We're putting up displays, doing music synthesis, learning how to do a hot air balloon, just small experiments and expositions that show what engineering is and what engineers do."

Outside support

Engineering is not an easy major, and consider the added stress if you are trying to prove yourself because you are one of the only women in your department. That is where support groups such as the Society for Women Engineers, Women in Science and Engineering (WISE), and Women in Computer and Electrical Engineering come in. These groups provide women with mentors and networking connections when they search for jobs.

Tamra Kerns, director of software product strategy at National Instruments, always gives two pieces of advice to young women entering the field: First, as long as you are an expert at what you do, when you open your mouth, you have the opportunity to eradicate and get rid of the perception that because you are a woman, you won't make a good engineer. Second, when you walk in a room, you have to know that you belong there. If you were to walk in with a chip on your shoulder because you know you are the only woman, everyone senses it and will treat you differently. The important lesson is to walk in and know you are going to contribute and be a meaningful part of the team, because that is how you will be treated.

For the most part, women entering the engineering profession won't find themselves alone. Telle Whitney, trained as a computer scientist and now president of the nonprofit Anita Borg Institute for Women and Technology, commented, "I think there is a great community of women in engineering who support each other." Events like the Workshop for Women in Design Automation, for which Whitney serves as a steering committee member, provide venues for such support.

On a positive note, women's enrollment in college and engineering has been rising, but it can go even higher. The more encouragement given to young girls to be passionate about science and consider it for a career, the more engineers will be born.

Shelley Gretlein, LabView Real-Time and Embedded group manager at National Instruments, summed it up: "We, as engineering leaders, need to ensure that engineering is considered 'cool' and 'fun.' It needs to be a career that is sought after. It's a challenge and a privilege to be an engineer. We're the ones solving the tough problems that make the world a better place—from getting to Mars to curing cancer. [It is] a field designed and optimized for the best and the brightest. . . women!"

Amy Laskowski

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2. Mathews, Jay, "Are Boys Really in Trouble?" *Washington Post* online, June 27, 2006. www.washingtonpost.com.

good chunk of the male population."

The media plays a role, too. Talk of outsourcing may lead young people to believe that there's no future in engineering, particularly ECE, because of today's worldwide communications. Many companies have moved manufacturing and some engineering offshore. Software engineering is the most obvious, but some hardware-engineering functions have moved, too. Still, everyone we interviewed said that there are, and will always be, many engineering opportunities in the US. Engineers innovate, which creates new products as well as the jobs needed to design and produce them.

Gary S. May, ECE professor and chair, Georgia Tech: "We have to show that engineers are normal people with normal lives with the same sorts of concerns as everyone."

Although a great deal of semiconductor manufacturing has moved offshore, by no means has all of it gone. "I don't think the bleak views are justified," added Professor Fred Looft, ECE department head at WPI. "A lot of manufacturing is coming back because of quality issues. I've talked to people who have done it." One such company is Cypress Semiconductor, which recently moved some testing operations back to Minnesota from Asia (Ref. 1).

UCSB's Long and Professor Doug Williams, ECE associate chair at Georgia Tech, differ on the area of microelectronics. Long tends to steer students away from IC fabrication, arguing that these jobs are moving to places like Taiwan and Korea. "You can probably count on the fingers of one hand the companies in the US that are doing much fabrication work."

Williams, however, stated that the microelectronics program at Georgia Tech is "booming." He sees an increase in companies looking for graduates with microelectronic experience. With that, he sees a corresponding increase in research dollars that companies are putting into semiconductors.

One person who sees a bright future in ECE is Andrew DuPont, a graduate student at WPI. "Just because you get an electrical engineering degree doesn't mean that you have to be an electrical engineer," he said enthusiastically. "The degree can lead to many opportunities."

Broad field

Indeed, a degree in electrical engineering can open many doors, in part because electrical engineering is so broad. Electrical engineers have taken on many tasks that you might expect people with other technical degrees to do. Semiconductor processing, for example, is highly populated by electrical engineers, but its basis is in physics and chemistry. Other areas include optics (as applied to communications), aerospace engineering, and even life sciences. "A lot of people don't realize that a lot of biomedical devices are actually electrical devices," noted Georgia Tech's May.

Doug Williams, professor and ECE associate chair, Georgia Tech, sees engineering enrollment increasing, but ECE enrollment is holding steady.

Engineering jobs also cut across technical disciplines. More and more, mechanical, chemical, and biomedical engineers use electronics to measure a product's performance. "Who says you're not going to do test and measurement on a chemical process for drug manufacturing?" asked Looft. "That's a huge area. And you better know a little bit about chemical processing when you go into that job."

Some people with engineering degrees move out of engineering jobs but stay in their respective industries by moving into sales, marketing, and management (a few even become editors covering the industries from which they came). Others move into fields such as law and medicine. Law firms, looking for patent lawyers with technical backgrounds, may hire engineers or engineering graduates and pay for law school.

Those who choose to enter the engineering work force may find that they need skills beyond math, science, engineering basics, and

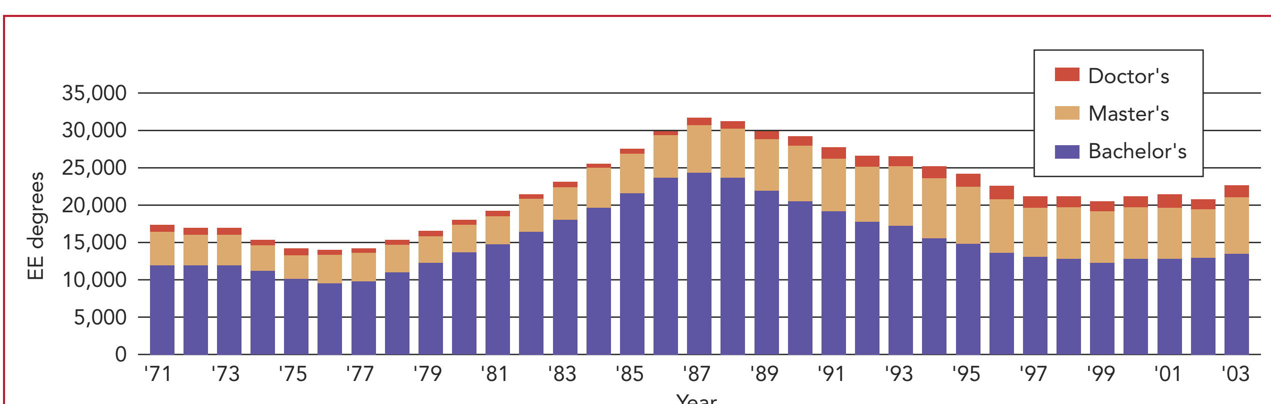

FIGURE 1. Electrical and computer engineering degrees rose in the 1980s and dropped through the 1990s, with master's degrees becoming a larger portion of the total. Source: National Center for Education Statistics, nces.ed.gov/programs/digest/d04/tables/dt04_283.asp.

problem solving. We asked the participants what additional skills employers now look for in engineering graduates. While we received some differing answers, everyone agreed that communications skills sit atop the list.

No longer is it enough to design circuits and get test results. You must communicate those results through written reports and presentations. Georgia Tech's Williams noted that the university has integrated writing of technical documents into several courses, which UCSB's Long echoed. WPI has even created an interdisciplinary major or double major in technical writing.


Moshe Kam, ECE professor at Drexel, is working with the IEEE to educate the public about the advantages of an engineering career.

While schools have responded to employers looking for better communications skills, some in academia remain skeptical. One such person is Professor John Orr of WPI. "The standard example is if you hear an after dinner speech from the VP of company xyz, [he or she] will describe that employers need graduates with good communications skills, good teamwork skills, and some global experience. But when hiring managers come to campus, they look for skills such as experience with the latest Cadence software release. They're looking for engineers who can be productive from day one."

Regardless of whether communication courses are included, it's becoming virtually impossible for schools to provide all of the required engineering skills at the undergraduate level. In fact, some people have begun to question if you should be able to enter the engineering work force with just a bachelor's degree. Employers are looking more and more for graduates with master's degrees, and the number of master's degrees relative to bachelor's degrees has risen in the past 30 years (Figure 1). *(continued)*

Is engineering a profession?

Engineering is one of the few fields where a bachelor's degree curriculum provides much of the background needed to enter the work force. You don't always need a master's degree, although people find that employment opportunities increase if you have it. "I'm finding that a lot of the companies that contact me are looking for master's degree level people," said Professor Steve Long of UCSB. All others we interviewed concur, saying that you can't fit enough into the bachelor's degree anymore.

Even if an employer requires an ECE master's degree, you still don't need a license to be an engineer. Thus, some people argue that engineering isn't a true "profession" compared to law, medicine, or social work.

"I think we've reduced the status and stature of engineers compared to lawyers and physicians," said Moshe Kam, a professor at Drexel. "It has to do with gross deficiency in registration and in the definition of the first professional degree."

WPI professor Fred Looft questioned that philosophy, saying, "You don't need a master's degree to work in sales." He may be right, but plenty of sales and marketing people in electronics have advanced degrees. They may have entered the work force with a bachelor's degree, and then gone on to get a master's degree in engineering or business while working.

"We can control entry like the AMA does, and become a higher level, but narrower profession," said Professor John Orr of WPI. "Barriers to entry have their own distasteful aspects. Personally, I'd like to see the master's degree as the entry level to the profession, but I recognize that we're just not there yet."—*Martin Rowe and Amy Laskowski*

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At the same time, the number of PhDs has remained relatively flat. During the last business downturn, companies may have scaled back their research budgets, relying on universities to do the work. "There's a lot less research going on in industry than there used to be," said UCSB's Long. "Most companies have decimated their research labs." Long argued that companies are looking for fewer PhDs than they did 10 or 15 years ago because they don't have the facilities and don't want to pay the higher salaries.

In recent years, industry has become more involved with academia. That's good for the most part, as long as industry lets the teachers teach. Often, companies sponsor student projects or contribute to the funding of research labs. Students benefit from having worked on real-world projects and by making industry contacts, which can lead to employment upon graduation. Employers benefit because they can hire graduates with practical experience.

Overall, industry involvement in projects is welcome, because the companies provide equipment, materials, and sometimes funds for student projects. "If they're paying for a project, then they should have the say over the project," said WPI's Looft. "But it can get too involved. I have companies that want to tell us what we're going to do, educationally."

Drexel's Kam doesn't agree. "I'm sure that there are horror stories here and there of companies who donated the

Industry and academia form symbiotic relationship

Universities may be providing industry with the engineers of tomorrow as well as the basic R&D that will ultimately evolve into marketable products. But the industry/academia relationship isn't a one-way street.

Daniel Mak, education program manager at Agilent Technologies, said his company works to "prepare today's students to be ready to face the real world by providing the opportunity for hands-on experience."

The test industry works at two levels. According to product manager Mark Cejer at Keithley, the company will furnish basic instruments for undergraduate courses. But at the graduate level, universities have fabs and other advanced facilities and may need more sophisticated instrumentation, such as semiconductor characterization equipment.

To support nanotechnology research, said Keithley's Mark Cejer, "We developed a whole new user interface we call a nanotech toolkit."

Mak sees a similar division of the education market but adds that graduate-level labs look for software as well, particularly EDA tools.

Universities can provide test vendors with a look at emerging technologies so the vendors can adapt. Cejer cited nanotechnology as an example. "A lot of the work gets done by the students who aren't EEs. They don't necessarily want to be instrumentation experts."

To help universities apply Keithley's semiconductor characterization system to emerging nanotechnology research, Cejer explained, "We developed a whole new user interface we call a nanotech toolkit."

Concluded Mak, "We look beyond selling instruments and toward a total education solution. We work interactively with a professor to develop a curriculum, providing application notes and creating lab exercises. We let the professor focus on teaching, not developing lab programs."

Rick Nelson, Chief Editor

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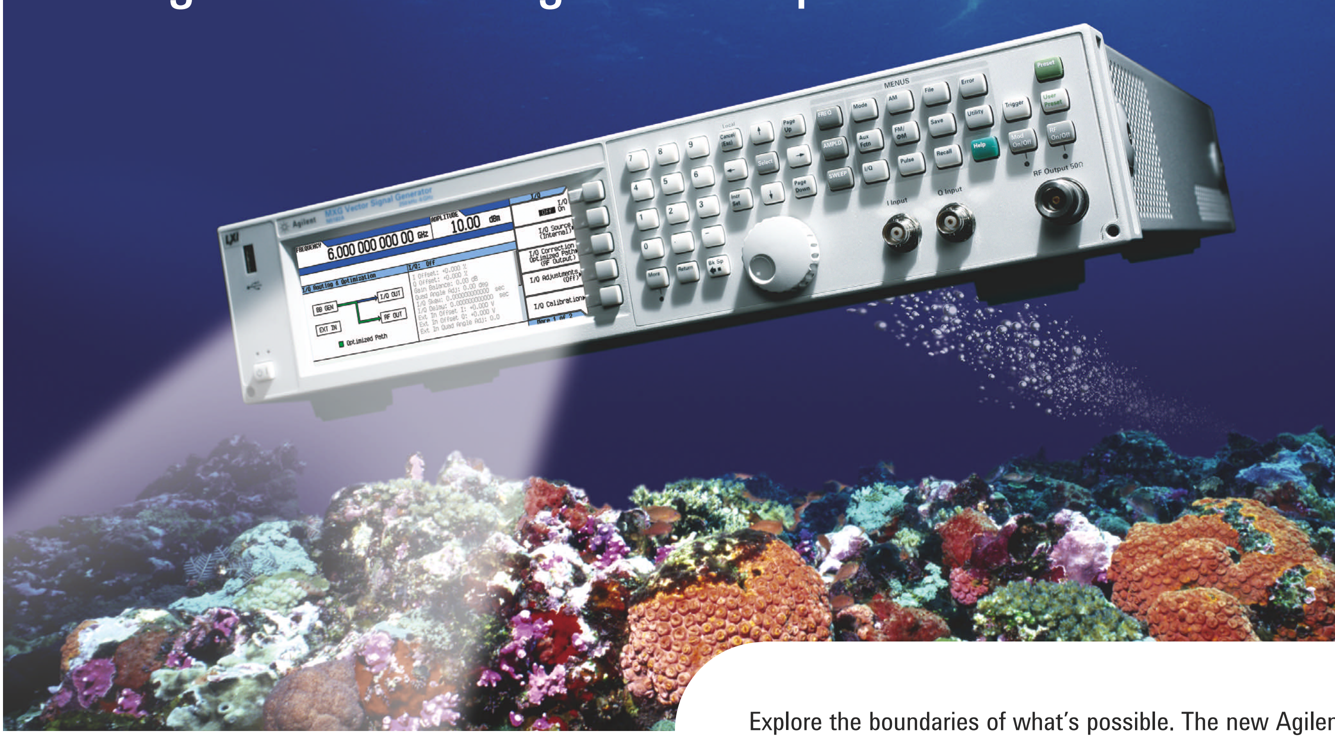

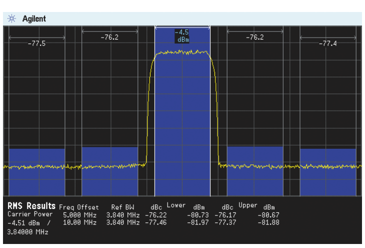

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equipment and wanted to control the curriculum," he said. "But I wouldn't call it a trend nor would I say this is widespread." Georgia Tech's May agreed that a few companies want too much involvement, but he doesn't think it's excessive. Companies are, after all, stakeholders in the graduates that these universities produce.

Looft said that companies go over the line when they say "you didn't get it done" meaning that a student project didn't produce a marketable product. When that occurs, he reminds companies that a student project is an educational endeavor that may not produce a working product.

Kam takes a different approach. He argued that companies need to get more involved in the educational process. "Industry is absent from the accreditation process," he said. He wants to see greater participation from industry so universities can produce the engineers best qualified to keep companies competitive.

Whether you think the world has too many or too few electrical engineers, you'll probably agree that engineers make an impact on people's lives every day. Engineering has proven to be a satisfying career for many. Your work makes a difference in the world. Now, go out and tell someone how engineers contribute to society. T&MW

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The engineers of K–12


COURTESY OF LEGO.

College students represent the immediate future of engineering, but the longer term talent now attends K–12. In a panel discussion held at last month's NIWeek trade show, Mary Wells, senior program officer for the Texas STEM (science, technology, engineering, and mathematics) project, described efforts to improve STEM education in 35 pilot programs in Texas high schools. For younger children, Jens Maibom, Lego education VP, said his company has worked with National Instruments to develop the LabView-programmable Lego Mindstorms NXT. In the First Lego League—the "little league" of the high-school-level First Robotics Competition (www.usfirst.org)—children aged 9 through 14 employ Mindstorms to gain experience in technology.

Panelist Leah Jamieson, dean of the Purdue College of Engineering, described ways to improve engineering's attractiveness as a career path through the Engineering Projects in Community Service (EPICS) program, which she co-founded. EPICS, she said, emphasizes engineers' roles as citizens and demonstrates that engineering is a helping profession. Jamieson also suggested that training teachers in K–12 technical education would help. "We are systematic about how we teach electrical engineering and mechanical engineering," she said, adding that there is an opportunity to be systematic in teaching engineering educators as well.

Rick Nelson, Chief Editor

See the online version of this article for more on First, STEM, Legos, and other educational initiatives and tools, www.tmworld.com/2006_09.

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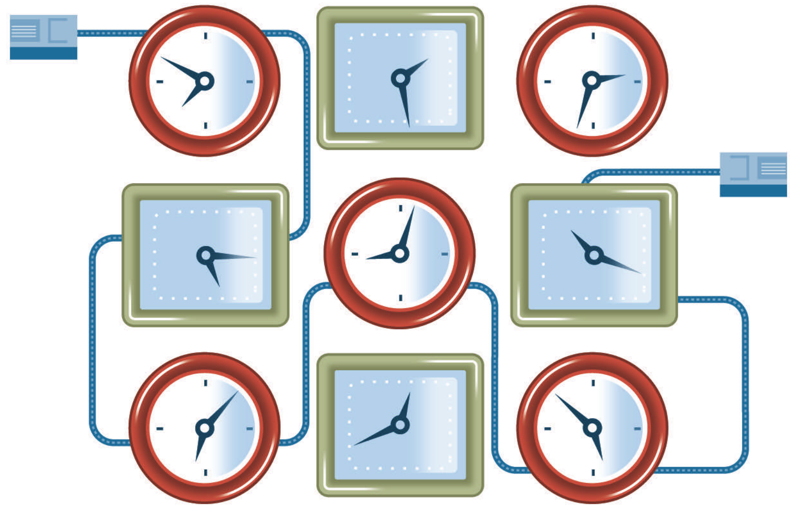

You can choose the LXI instrument class that provides the triggering speed and synchronization capability your application demands.

LXI TRIGGERING

BOB RENNARD, LXI CONSORTIUM

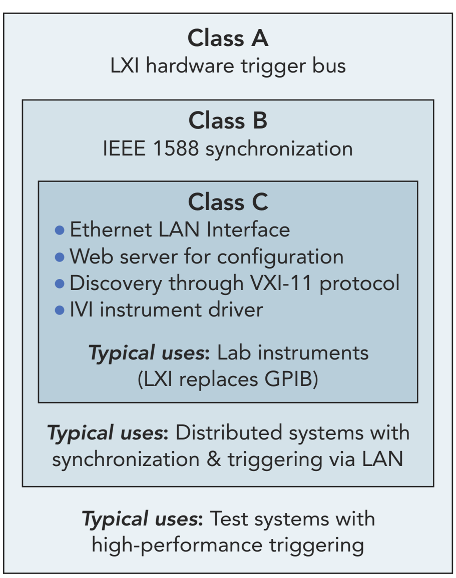

FIGURE 1. LXI instrument classes correlate with use models.

Ethernet, the world's most widely adopted communication standard, transformed the way we work. Now, you can apply the benefits of Ethernet to transform the way you build test systems. Spurred by the belief that Ethernet is the natural successor to GPIB (IEEE 488), test and measurement companies, software companies, and system integrators created the LXI Specification, an Ethernet-based interface that combines the simplicity of GPIB with additional features that will enhance test system speed and capabilities.

LXI devices are defined by three functional classes, which differ primarily in their triggering capabilities (**Figure 1**):

- Class C, the base class, requires Ethernet connectivity, a Web interface, an Interchangeable Virtual Instrument (IVI) application programming interface (API), discovery, and some basic physical and mechanical features.
- Class B adds IEEE 1588 Precision Time Protocol and peer-to-peer communication to the base class. (See the 1588 Web site, ieee1588.nist.gov, or the LXI Consortium Website, www.lxistandard.org, for more information.)
- Class A requires both the IEEE 1588 Precision Time Protocol and an eight-channel low-voltage differential signalling (LVDS) high-speed trigger bus.

Uniform triggers

A key feature of the LXI Specification is a uniform triggering model and an API that treats all trigger sources equally. By defining identical procedural calls between a LAN trigger and a hardware trigger, programmers use a single set of API calls and can switch easily between hardware, software, and time-induced triggers.

For example, if you use a driver named 'Arb' to program an arbitrary waveform generator and want to use the LXI trigger bus line number 2 as the source of a trigger signal, you would write this line of code:

```
Arb.Trigger.Source = "LXI2"
```

If you then wish to switch to a LAN trigger with the same ID, you would simply change the command to:

```
Arb.Trigger.Source = "LAN2"
```

The LXI Specification recommends that LXI devices be capable of triggering any available action by any available means, although this will not be practical in all cases.

If a measurement can be triggered by a traditional hardware trigger line, then you should also be able to trigger it with a LAN trigger, the LXI trigger bus, or any other trigger input supported by the device. You simply configure the device to accept the appropriate trigger source and route it to the desired action.

The IEEE 1588-based time trigger software layer allows programmers to specify an action and set an "alarm clock" to "go off" at any specified time. This enables programmers and system integrators to execute complex test sequences in near-perfect unison and eliminate wait statements from test code.

For instance, an arb can be programmed to begin at a specified time and sequence through a series of timed steps. A receiver in the same test system could track the digitizer's operation with near-perfect timing and with no connections between the instruments or controller other than LAN. This is particularly useful in distributed systems, where time-based triggers can eliminate cable-length latencies.

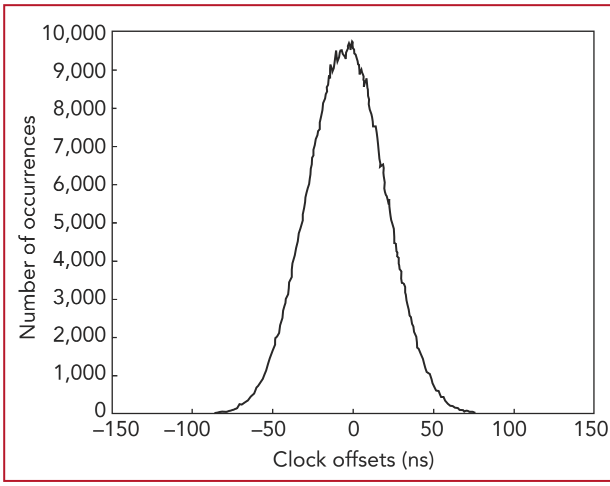

FIGURE 2. The histogram from an IEEE 1588 boundary clock shows the typical clock accuracy available with IEEE 1588.

In the real world, however, clock synchronization is not perfect. Clocks are typically accurate to 50 to 100 ns. As the IEEE 1588 clock synchronization algorithm adjusts the system clock, some uncertainty—or jitter—will be introduced, and this will mask the precision of a time-based trigger. It is worth noting that while the 50- to 100-ns figure is typical today (**Figure 2**), 1-ns implementations have been documented, and the second release of IEEE 1588 promises to improve clock accuracy below 1 ns.

Some applications are not sensitive to jitter or will find jitter less problematic than latency. For example, many physical data-acquisition applications do not have tight timing requirements. Also, consider a radar test range where the distance between instruments may be considerable. With cable latencies of roughly 1-ns/ft, significant delays can result with widely separated instruments or test stations. Since IEEE 1588 is a UDP-based system, it works best on subnets built behind a single router. Where very long distances, measured in kilometers or more, are involved, GPS offers a convenient synchronization mechanism to tie subsystems together.

IEEE 1588 derived time-based triggers are not a panacea for all test applications, providing the motivation for alternative trigger mechanisms. For example, time-based triggers are not ideal for very fast asynchronous events and some UUT-induced trigger events, so LXI supports a high-speed eight-channel LXI trigger bus and LAN triggers. LAN-based triggers operate by sending electrical signals over a wire, much like traditional hardware triggers, but LAN-based triggering eliminates trigger cabling in many applications, simplifying system integration and streamlining device upgrades.

LAN-based triggers with IEEE 1588 also go beyond traditional hardware triggers because they can carry time-stamp information that hardware triggers cannot. Time stamps provide a time record of when an event happened, or they coordinate when multiple events occurred, simplifying post-acquisition analysis. Similarly, an LXI device can use a circular buffer, as with a logic analyzer, to "look back" in time to capture an event that happened before the trigger signal was received.

(continued)

What is LXI?

LXI (LAN eXtensions for Instrumentation) is the LAN-based successor to GPIB. It goes beyond GPIB to provide additional capabilities that make it easier for system designers and integrators to create faster, more efficient systems.

LXI is an instrumentation platform based on industry-standard Ethernet technology that improves the modularity, flexibility, and performance of small- and medium-sized systems. LXI's compact package, high-speed I/O, and reliable measurements meet the needs of R&D and manufacturing engineers supplying electronics to the aerospace/defense, automotive, industrial, medical, and consumer electronics markets.

The LXI Specification defines small, modular instruments using the low-cost, open-standard Ethernet LAN as the system backbone. LXI was developed to offer the size and integration advantages of modular instruments without the cost and constraints of card-cage architectures.

Many LXI instruments have no front panels, displays, or expansion cards, which shrinks the physical size of deployed systems. LXI offers a significantly smaller form factor, simple low-cost PC-standard I/O, and easy rack mounting with no card cage, yet maintains linkages with full-featured instruments for development and troubleshooting.

LXI modules use the host PC and Ethernet connections to display setup and results. LXI modules feature self-contained power supplies to improve reliability and enable widely distributed system architectures.

LXI provides many advantages over conventional GPIB systems. For example, it reduces setup and integration time by connecting directly to the standard ports on a PC. It does not require special cards or cables or expensive controllers. Also, LXI software and drivers simplify test system setup.—*Bob Rennard, LXI Consortium*

Peer-to-peer communication

In addition to IEEE 1588 Precision Timing Protocol, the LXI Specification requires Class A and B devices to support peer-to-peer communication. Prior to LXI, most test-and-measurement system architectures relied on a master-slave configuration using a central controller. With the exception of some basic trigger lines, which carry little more than a trigger edge, there is no instrument-to-instrument communication in these setups. Each instrument communicates directly with the controller, which then sends commands to other instruments. Master-slave systems with high channel counts or controller-based measurement applications can quickly overtax central controllers, creating a processing bottleneck that stalls high bandwidth I/O and degrades performance well below expectations.

With LXI, instruments can communicate with one another independent of the controller, simplifying common applications such as stimulus-response measurements. Also, LXI allows system designers to download executable code or scripts that are triggered by a message from other instruments in the system, further freeing the controller to deal with data rather than control. With less system management, the system is more responsive.

Applying LAN and IEEE 1588

The IEEE 1588 Precision Time Protocol provides system integrators with several advantages. Some are easy to envision, such as the ability to synchronize over great distances or to time-stamp large quantities of data. An antenna test range comes to mind as does a high-channel-count data-acquisition system.

Others advantages are more subtle, such as eliminating physical trigger cables in many applications or eliminating the need to calibrate and correct for multiple trigger cable delays. Such advantages simplify the programmer's task and make software maintenance easier because hardware can be changed without disrupting the test program.

IEEE 1588 and LAN triggering can replace some trigger cables, but not all. The ability to replace cables depends on test-system speed requirements, which are often driven by the device under test. Some test systems, such as data-acquisition applications measuring temperature, pressure, or mechanical stimuli, require millisecond or microsecond resolution. Both resolutions are well within the capabilities of IEEE 1588. Time-critical applications, often seen in RF applications such as high-speed radar or scope and logic-analyzer triggering, require nanosecond and subnanosecond resolution that IEEE 1588 cannot provide. Other applications with fast asynchronous or device-induced triggers are a poor fit for IEEE 1588-based triggers.

Using IEEE 1588 time stamps allows instrument suppliers and system integrators to "go back in time," using circular buffer techniques to investigate events leading up to a trigger. This technique has been used for years in logic analyzers and oscilloscopes, and IEEE 1588 makes it practical for many other instruments and systems.

Automatic time stamping means controllers and application software no longer have to keep track of when data was taken, simplifying one of the most tedious and fragile aspects of developing large test systems. Many aerospace systems have hundreds or thousands of control and data lines, many of which can be eliminated by distributing a sense of time out to the edges of the tester. The result is simpler cabling and instrument-to-

What is the LXI Consortium?

The LXI Consortium is a not-for-profit (501c3) corporation founded in 2004 consisting of companies in the test-and-measurement industry. The group's goal is to ensure interoperability and a consistent user experience by developing, supporting, and promoting the LXI Specification.

The consortium was formed because several companies recognized they were following parallel development paths for LAN-based modules. It made sense to combine these efforts into an industry standard to ensure interoperability and a positive customer experience.

For more information, visit www.lxistandard.org.

UUT interfaces, shorter reconfiguration times, and elimination of some fragility in the test program set, or TPS.

Imagine instrumenting a jet engine with thousands of sensors to monitor complex stimulus and response channels. Or consider a modal-analysis system with thousands of strain gages on an airframe, where tight timing interrelationships are critical to maintain phase relationships between adjacent points. With time stamping and parallel execution, data interpretation and fault trees become simpler, tests can execute faster, and many difficult channel-synchronization tasks become trivially simple.

The LXI Web interface and Ethernet connectivity enables widely distributed applications. For example, an engineer in Finland can work with a contract manufacturer in China, looking at the same instrument screen to troubleshoot a problem or monitor a process without either leaving home. This has profound implications on a company's need to replicate specialized expertise in multiple locations.

By leveraging the efforts of thousands of engineers in the Ethernet industry, LXI gives system designers the familiarity of GPIB with the power of new capabilities. The IEEE 1588 Precision Time Protocol is a core enabler for LXI, providing a low-cost network-centric time base. LXI builds on IEEE 1588 by defining how to apply it to a variety of test and measurement situations. It offers significant value to test system design. While today's IEEE 1588 speed and resolution are insufficient to meet the most demanding test applications, they are sufficient for many applications and offer numerous possibilities for the future. T&MW

Bob Rennard *is president of the LXI Consortium and program manager at Agilent Technologies in Santa Rosa, CA.*

ON THE WEB

Visit the LXI blog on the *T&MW* Web site to keep up-to-date on the technology, ask questions, or share your expertise. Moderated by chief editor Rick Nelson, the LXI blog is open to the entire industry.
www.tmworld.com/blogs

Vote for the 2007 TEST ENGINEER of the Year

Our editors have selected six finalists for this annual award. Now, it's your turn to choose the winner.

Testing is the cornerstone of successful development and manufacturing for any electronic component, system, or end product. Without testing, quality is just a dream. The test engineer builds in quality—from design to production—and often plays a critical role in identifying in-service issues or introducing product improvements.

To recognize the vital role that the test engineer plays and to salute the creativity and hard work that goes into making products safer, more reliable, and more economically viable, *Test & Measurement World* announces its fourth annual Test Engineer of the Year competition. Thanks to the generosity of the award sponsors—Agilent Technologies, Keithley Instruments, and National Instruments—the winning candidate will designate a $30,000 donation to an engineering school.

From the many engineers who have been nominated for this award over the past few months, our editors have selected six individuals as the finalists. When reviewing the summaries of their accomplishments, please consider both their on-the-job skills as well as their overall contributions to the test field and the industries they serve. Then, cast your vote using our online ballot.

Test & Measurement World will present the 2007 Test Engineer of the Year award at our "Best in Test" gala during the 2007 APEX Show (February 20–22, 2007, Los Angeles Convention Center). In addition, the cover story of our March 2007 issue will profile the winning engineer.

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AEROSPACE

Pavan Bathla

Moog

As test equipment lead for the remote electronic units (REUs) at Moog, a manufacturer of control products for the aerospace industry, Pavan Bathla is responsible for estimating the time, cost, level of automation, resources, and skill sets required for testing. He chooses the tools and platform, architects the hardware and software, and breaks down the tasks for his team to perform.

Due to the production volumes on the REU, Bathla chose what he calls an asynchronous concurrent and reject test strategy, which tests the different REU types in parallel and halts tests on initial failure detection. This strategy provides the highest possible throughput and device utilization, thereby saving his company time and money. He demonstrated expertise in the architecture of the ATE by getting the Simulink actuator model, more than 400 switch permutations, and data-acquisition hardware on both the Windows and PXI-real-time operating systems to all work together in harmony. By using a PXI platform rather than the proprietary DSpace system the company traditionally used, Bathla significantly reduced the cost of hardware-in-the-loop simulation.

In addition, he has led the test software philosophy team for his division and has spearheaded user group meetings. Bathla maintains a blog called Synergy Energy, which is his channel for sharing knowledge and collaborating with counterparts in the industry.

METROLOGY

Jay L. Bucher

Promega

Currently manager, metrology services, at Promega, a maker of products that help researchers in the life sciences, Jay Bucher boasts a lengthy career in testing—including 24 years working in US Air Force calibration laboratories. Many of Bucher's efforts have benefited the worldwide metrological community. For example, he helped create the American Society for Quality (ASQ) Certified Calibration Technician (CCT) Program and is a subject matter expert for exam questions.

Bucher is editor and co-author of *The Metrology Handbook* and *A Quality Calibration System: Developing and Managing a Calibration Program*; both issued by ASQ Quality Press. He is also the managing editor and publisher for the ASQ metrology-focused quarterly publication, *The Standard*, and he has published several papers and made a number of presentations to professional groups.

Over the years, Bucher has served as a division officer for ASQ Measurement Quality Division (MQD) in several capacities and currently is MQD treasurer. He has organized and coordinated a new section in Wisconsin for the National Conference of Standards Laboratories International (NCSLI) and currently is the North Central Regional Coordinator for NCSLI. Bucher is a recipient of the Max J. Unis award, which honors outstanding contributions to the metrological community and is the highest recognition available from ASQ MQD, and he also received the NCSLI 2005 Region/Section Coordinator of the Year Award.

RF TEST

Stephen J. Cousineau

Skyworks Solutions

Stephen Cousineau is RF production test development manager at Skyworks Solutions, a maker of radio solutions and precision analog semiconductors. He works exclusively in the production test environment, where even a few milliseconds of test time savings is important.

While the ATE systems at the company were able to perform parallel RF testing and the test handlers could perform multisite testing, these capabilities were not being used because of two technical road blocks. First, the tester did not have sufficient RF resources to address all of the I/O ports on a cellular phone transmitter (TX) front-end module in a multisite mode. Second, because the load board was of hard-dock design, it was impossible for engineers to create a load-board layout that did not compromise one of the sites for RF measurements.

Cousineau found the key was expanding the capability of the RF test head through the use of an internally designed RF multiplexer containing switching, filtering, coupling, and amplification. The new RF multiplexer is housed in a fixture that mounts to the test head and soft docks (with flexible RF cables) to the test handler. Custom test code calibrates and controls the RF multiplexer. With this new system, test time has been cut in half and throughput has been doubled.

ENVIRONMENTAL TEST

Clayton Forbes

National Technical Systems

Clayton Forbes is the senior dynamics engineer for NTS, an engineering and testing services provider. As the program manager on a qualification and acceptance test program for engine hose assemblies manufactured by Smiths Aerospace for the Space Shuttle, Forbes worked closely with Smiths Aerospace, Boeing, and the United Space Alliance to enable a tight deadline to be met on leak, flow, pressure, and burst testing. When the USS Nimitz aircraft carrier required vibration testing on an onboard file server for the storage of aircraft technical data, Forbes answered the challenge, designing a test fixture to accommodate the 7.5x6x3.5-ft, 3770-lb file server.

In addition to his lab work, Forbes supports customers in aerospace, defense, transportation, electronics, and telecommunications, in both the US and Europe, providing training and consulting services on product design for compliance and reliability. He takes an active role in the development of standards as a participant in the GR-63-CORE Issue 3 and MIL-STD-810G working groups and in the ANSI T1.E1 committee developing compliance standards for telecommunications equipment. Internally, Forbes provides training in dynamics theory and test troubleshooting, enabling best practices to be deployed across the NTS network.

COMMUNICATIONS TEST

John Gmitter

Harris

John Gmitter is a lead test engineer in Harris Corp.'s RF Communications Division, which designs and manufactures secure radio systems. Gmitter and his team needed to create a "next generation" test platform that would consume less floor space, reduce test times, cost less, and be expandable for increasing throughput.

In particular, the engineers needed to move away from a set of test instruments that was no longer going to be supported by the manufacturer. Gmitter and his team evaluated multiple platforms and hundreds of instruments and ended up developing a modular hardware platform and software architecture that allowed instruments to be interchanged. The architecture supports parallel testing and high instrument utilization. The system, which is built from off-the-shelf hardware and software, can incorporate additional instruments when required. The project accomplished all of the stated goals and is expected to give Harris a competitive advantage.

SEMICONDUCTOR TEST

Eric R. Ramelli

Philips Semiconductors

A senior test engineer at Philips Semiconductors, Eric Ramelli has a strong knowledge of the Credence Vista series and the Agilent 93K testers, and he has become a valued mentor for other engineers. He has also helped solve problems when the company has encountered tester limitations. In one case, Ramelli created binning on the ATE to help the production facility pinpoint tester issues. One product being tested required a resistive measurement of 10 Ω. Such small values are difficult to measure due to factors such as tester driver resistance, socket resistance, and contact resistance.

Once an accurate measurement procedure was developed, Ramelli needed to help the production facility determine when the tester hardware was generating incorrect measurements that were causing good parts to fail, such as when a dirty socket added contact resistance. These complications needed to be caught quickly to prevent the rejection and disposal of good parts. Ramelli helped devise many methods—such as a delta resistance calculation between pins—that enabled the test floor to pinpoint troubles. He also developed a test program to allow a microcontroller to trim out its internal RC oscillator circuit. Older methods had extreme test time, which consumed resources. The new test method allows a square wave to be used for comparison purposes to generate the value to be used in the program. T&MW

Vision sensor adds color

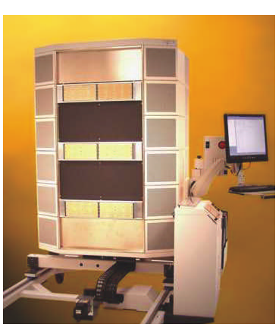
The new color version of the Omron Smart Sensor, the ZFV-C, offers sensing capabilities close to human vision, including the ability to distinguish shapes and colors. Color sensing enables the ZFV-C to "see" images invisible to monochromatic sensors. Integrated color filters enable sensing of only selected colors when it is necessary to get a better image. The ZFV-C also features a "teach and go" function using a color LCD screen and simple menu to reduce setup to a few simple steps. The screen shows a live image for instant feedback during both setup and inspection operations.

There are eight sensor functions available, depending on the controller used: counting, pattern recognition, size verification, position, brightness, width, text verification, and hue (comparing sensed color to a reference color). As many as five sensors can be connected to one controller bus through a snap-on system, allowing five different inspections in one pass to greatly increase productivity.

Price: $2300. *Omron Electronics, www.omron.com/oei.*

Magnum Grande tests 720 devices at once

Nextest Systems' Magnum Grande provides up to 7680 I/O pins deployed over 960 sites. The 12-chassis system, which targets flash memory test, brings with it a 25% test cost reduction over last year's 320-site configuration, the company reports. The system uses the same floor space, operating software, test programs, and spare parts as its predecessor.



Each Magnum system is built from a set of "site assemblies," each of which contains all of the data-generation, error-processing, timing, and DC resources required to test a variety of devices, including both NAND and NOR flash memories. Each site assembly also includes an embedded 1.2-GHz PC for local control of the test process.

Base price: less than $400 per pin. *Nextest Systems, www.nextest.com.*

Mixed-signal module for OpenStar system

The BBWGD (for Base Band Waveform Generator Digitizer) module for Advantest's T2000 test system accommodates DC, audio, and video as well as baseband signals to address the increasing number of mixed-signal I/O channels appearing on system-on-chip devices. The 16-channel mixed-signal module, which the company says will address multisite test applications, includes 300-MHz arbitrary-waveform-generator/digitizer capability with total harmonic distortion below –80 dBc. A high-density 2-GHz pathway to the test-system load board optimizes gain/phase linearity and I/Q pair matching. The module's eight differential 400-Msamples/s AWGs and eight differential 128-Msamples/s digitizers enable x4 DUT baseband testing per module.

A DSP-based architecture simplifies calibration and enhances I and Q channel amplitude and phase matching. The local DSP capability minimizes data transfers to central processing resources. The module permits multiple-DUT triggering to support asynchronous designs; it also supports multiple clock domains and pattern burst modes.

Base price: less than $50,000. *Advantest, www.advantest.com.*

Portable scope has four isolated channels

The OX 7104-CK from AEMC is a multipurpose instrument that functions as an oscilloscope, fast Fourier transform (FFT) analyzer, harmonic analyzer, and multimeter. Each of the four channels is isolated, with a 600-V CAT III rating.

As a scope, the instrument has 12-bit resolution. It samples at up to 1 Gsample/s in real-time mode or 25 Gsamples/s in equivalent-time-sampling mode. It has 100-MHz signal bandwidth and can store up to 20 ksamples per channel of data.

As a true rms multimeter, the OX 7104-CK has 8000-count resolution and can measure at rates up to 50 ksamples/s. As a recorder, it can accept a variety of sensor inputs with 0–10 V or 4–20 mA outputs.

The OX 7104-CK has a 5x7-in. stylus LCD touch screen, and it can display up to eight traces at once. It has RS-232, parallel, and Ethernet communications ports. When used with Ethernet, the instrument can use its internal Web server to send data and receive commands.

Base price: $3595. *AEMC, www.aemc.com.*

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Protocol tester

Aimed at mobile equipment manufacturers and mobile operators, Tektronix' K1297-G35 protocol test platform lets you test new technologies at data rates of up to four times 14.4 Mbps. The protocol tester enables rapid deployment of 3G and 3.5G technologies with test features that provide scalability to support multi-interface, high-capacity test applications. The K1297-G35 allows functional testing of a wide range of interfaces in mobile networks. Software packages are available that support more than 3000 protocols covering technologies such as HSDPA and HSUPA, UMTS, TD-SCDMA, GPRS, and GSM.

Tektronix, www.tektronix.com.

Low-g accelerometer

Measurement Specialties' new Model 4000 signal-conditioned accelerometer with temperature compensation can handle low-frequency monitoring in test, instrumentation, and vibration-sensing applications. The lightweight device features a VDC output with a ±2.5-V reference that provides a differential or single-ended output. Operating from a 10- to 24-VDC power supply, the Model 4000 draws a minimal 5 mA of current while operating over a –20°C to +85°C temperature range. The Model 4000 has a frequency response from 0–250 to 0–1500 Hz and has sensitivities of 1000 to 10 mV/g.

Measurement Specialties, www.meas-spec.com.

Op amp

Texas Instruments has introduced a precision op amp that uses a zero-crossover, single-input-stage architecture to achieve glitchless rail-to-rail performance. Featuring distortion of 0.0006% THD+N, low noise of 4.5 nV/√Hz, and gain bandwidth of 50 MHz, the OPA365 serves a variety of single-supply portable-instrumentation, data-acquisition, test-and-measurement, and audio applications.

The single-stage input topology reduces distortion and delivers common-mode rejection ratio of 100 dB minimum and 120 dB typical over the entire input range (100 mV beyond the supply rails), making it suitable for driving analog-to-digital converters without degradation of differential linearity. Other features include fast settling time of 300 ns to 0.01%, offset voltage of 200 µV maximum, and single-supply operation from 2.2 V to 5.5 V.

Texas Instruments, www.ti.com/analog.

PCI Express analyzer

The PETracer Gen2 Summit x16 protocol analyzer from LeCroy captures and analyzes PCI Express 2.0 serial data at speeds of 5 Gbps per lane. It can capture and analyze data from bidirectional lane widths of x1, x2, x4, x8, and x16, and it provides 8 Gbytes of trace memory. A new raw recording mode allows bytes to be recorded as they come across the link, allowing debugging of PHY layer problems.

Working with the manufacturer's CATC Trace analysis software, the PETracer decodes bus data and presents the PCI Express protocol layers. The software provides real-time statistics, protocol traffic summaries, detailed error reports, and scripting, and it creates user-defined test reports. You can initiate a data capture triggering on PCI Express Events such as Link Conditions, transaction layer packet (TLP) headers, data-link layer packet (DLLP) messages, and data payload. Ethernet and USB ports provide connection from the analyzer to a host PC.

The analyzer supports spread-spectrum clocked (SSC) traffic, and "lane swizzling" which lets a board developer lay out a mid-bus probe pad with lanes in non-standard order, thus simplifying PCB design.

LeCroy, www.lecroy.com.

X-ray system

Comet has enhanced its FeinFocus µCT-FOX series of x-ray inspection systems with the introduction of the FeinFocus HDCT-FOX. The system combines high-resolution 2-D x-ray technology with 3-D computed tomography (CT) techniques for inspecting and analyzing complex electronic devices.

According to the manufacturer, the HDCT-FOX is ideal for applications requiring high magnification, such as inspection of MEMS/MOEMS, semiconductor packages, high-density interconnects, and hybrids. The system captures high-resolution 2-D images and reconstructs 3-D volume models, providing insight into design and manufacturing processes. A modular hardware- and software-based CT interface accommodates a variety of imaging chains, with automatic configuration of the detector for optimal CT resolution.

The FeinFocus HDCT-FOX is designed for integration with the iView technology developed by TeraRecon, allowing instantaneous uploading of sets of 3-D images to a secure Web site. This feature allows failure-analysis labs to transmit 2-D and CT imagery using a high-speed Internet connection, so the x-ray scanning process can be centralized while the image analysis is decentralized.

Comet, www.comet.ch.

Test kit

Pomona Electronics' SMD Multi-Use Test Kit provides the tools needed to test small components and circuit boards. Each of the 16 tools can attach to surface-mount chips with pitches down to 0.008 in. (0.2 mm). The kit includes two Micro SMD Grabber test clips; two Mini SMD Grabber test clips; two clip leads for Micro SMD Grabbers; benchtop DMM modular test leads; multi-stacking 2-mm safety-sheathed patch cords; two SMD test probes with sharp, spring-loaded tips; two 4-mm banana plug to 2-mm sheathed banana jack adapters; two mini alligator clips with 2-mm jacks; and a large folding pouch for trouble-free storage and access.

Price: $127. *Pomona Electronics, www.pomonaelectronics.com.*

Software for vision sensors

Cognex has unveiled Version 3.3 of its In-Sight Explorer software for its In-Sight vision sensors. The software includes new calibration, communication, and other tools that, according to the company, shorten integration time when engineers are deploying vision sensors in robotic guidance and inspection applications. The new software offers nonlinear calibration for improving repeatability by correcting for lens and perspective distortion, and it also includes robot drivers and sample code to facilitate integration.

Cognex, www.cognex.com.

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Agilent Technologies

Spectrum analyzers

The 9100 spectrum analyzer series from Boonton Electronics provides a frequency range of 100 kHz to 4 GHz, as well as a resolution band-

width range of 100 Hz to 1 MHz and a video bandwidth range of 10 Hz to 1 MHz. The instrument also features a displayed average noise level of –135 dBm with a 1-kHz resolution bandwidth filter.

The 9100 is offered with a complete set of accessories, including standard and touchless inductive probes. Additional power measurement capabilities include channel power, adjacent channel power ratio, and occupied bandwidth. A standard TCP/IP interface permits remote control over a domain network.

Boonton Electronics, www.boonton.com.

E-field probe

AR Worldwide RF/Microwave Instrumentation has introduced what it claims is the world's first 18-GHz laser-powered e-field probe. Model FL7018 operates from 3 MHz to 18 GHz over the range of 1 V/m to 1000 V/m. Part of the company's Starprobe family of laser-powered e-field probes, the FL7018 achieves the 1-V/m measurement capability by using noise reduction and temperature compensation techniques. When rotated about its angle mount, the probe provides isotropic response of ±1.0 dB at frequencies up to 8 GHz.

AR Worldwide, www.ar-worldwide.com.

Protocol tester

The new CDMA2000 1X option for Anritsu's MD8470A protocol signaling tester enables the desktop instrument to verify CDMA2000 1X and PPP signaling and application performance.

Based on a cdma2000 network simulator, the CDMA2000 1X option uses a Perl-based scripting API as its primary interface for performing system configuration, physical channel, and condition setup. The simulator controls the air interface and PPP message transmission and reception and supports the PPP signaling protocols LCP, IPCP, PAP, and CHAP.

Base price: MD8470A with CDMA2000 1X—$130,000. *Anritsu, www.us.anritsu.com.*

Differential probe

Yokogawa has introduced the PBD2000 2-GHz differential probe for low-voltage differential signaling applications with its DL9240 digital oscilloscope. Providing 1.5-MHz system bandwidth, the small head enables contact with fine-pitch circuits. Key features include a

common-mode rejection ratio of less than –12 dB from 100 MHz to 1 GHz and 1.1-pF input capacitance. Other parameters include a 10:1 input attenuation, a differential input voltage of ±5 V max, and a 50-kΩ input resistance.

Yokogawa, www.yokogawa.com.

CCD camera

Touting 3 CCD color technology, Toshiba's IK-TF9C high-speed camera produces an output resolution of 2048x1536 pixels with full-frame rates of 20 frames/s and partial-scan rates of 40 frames/s. The three-chip IK-TF9C also incorporates Toshiba's progressive-scan technology, which eliminates image jitter, making the camera useful for high-speed industrial machine-vision applications. The IK-TF9C is both lightweight (165 g) and compact, with dimensions of just 44 mm x 44 mm x 78.3 mm. It also features a C-mount for lenses, an 8-bit RGB digital output, and a Camera Link interface.

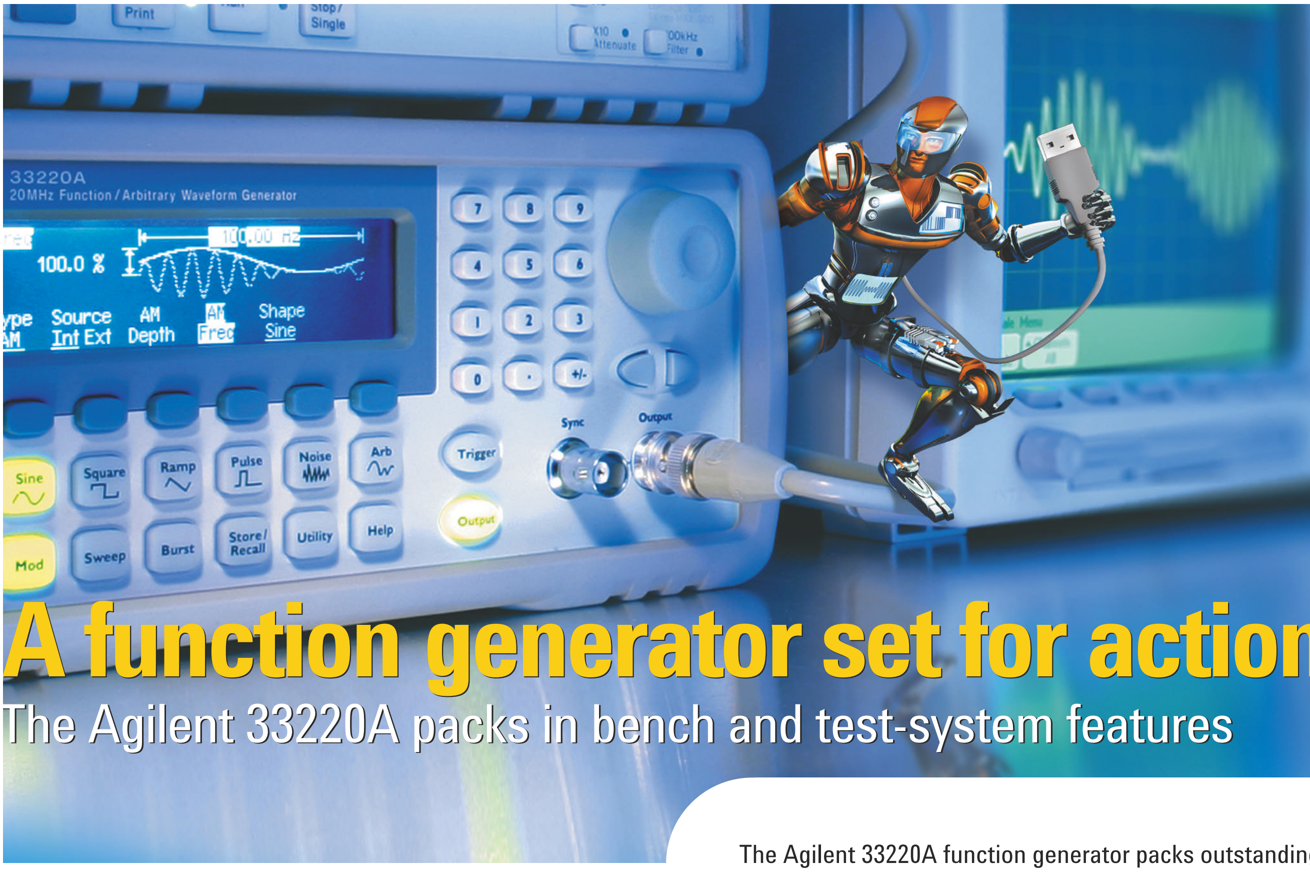
Toshiba, www.cameras.toshiba.com.

High-shock accelerometers

The 71 series of subminiature surface-mount piezoresistive accelerometers from Endevco has resonant frequencies from 180 kHz to 700 kHz and zero damping for shock measurements ranging from 6000 g to 60,000 g. The devices respond accurately to the fast rise time and short-duration shock events typical of kinetic impact testing and high-shock component test applications. Sensitivities range from 3 µV/g to 30 µV/g. With a frequency response extending down to DC, these transducers can be used to measure long-duration transients.
Endevco, www.endevco.com.

Electrostatic voltmeter

The Model 325 electrostatic voltmeter from Trek covers a measurement range from millivolts to ±40 V over probe-to-surface distances of 0.2 mm to 2 mm. The instrument also offers a sensitivity of 1 mV, a response time of less than 3 ms, and accuracy that is better than ±0.05% of full scale. The Model 325 can monitor devices sensitive to ESD, test the reliability and characteristics of dielectric materials and films, and measure the surface potential of bare or processed wafers to analyze doping and thin-film characteristics.
Trek, www.trekinc.com.



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CATALOGS & PRODUCTS

The following write-ups were supplied by advertisers in this issue.

USB test and measurement

Data Translation's 2006 USB product guide offers details on the company's broad range of USB data-acquisition products. You can choose from low-cost, simultaneous, high-performance, and DSP products. Free copies are available at www.datx.com/productguide. *Data Translation, www.datatranslation.com.*

Free RF measurements CD

Keithley Instruments' CD, *Making Quality RF Measurements*, is packed with information that can save you time, money, and effort when configuring an RF measurement system. It includes an archived seminar, white papers, articles, application notes, data sheets, and technical notes. *Keithley Instruments, www.keithley.com/at/389.*

Modular oscilloscope

The ZT450 family from ZTEC Instruments includes high-speed and analog-bandwidth modular digital storage oscilloscopes (DSOs) for PCI, compact PCI/PXI, and VXI. The ZT450 family is a complete DSO in modular instrumentation form. *ZTEC Instruments, www.ztecinstruments.com.*

Industrial PC

The UNO-3062L is an industrial fanless PC with a Celeron processor, two PCI extensions, and one internal CF slot. Base price: $1089. *Advantech, www.eautomationpro.com/us.*

Clock recovery unit

The new Centellax "AnyRate" clock recovery unit is compact and low cost, starting at $5000. The CRU automatically recovers the clock from any 622-Mbps to 13.5-Gbps bit stream. *Centellax, www.centellax.com/?TR1C1-A.*

Power distribution and control

Pulizzi's AC power-distribution and control systems are rack- or strip-mounted with circuit-breaker protection, EMI/RFI filtering, spike/surge protection, system-remote power on/off, remote reboot, emergency shutdown, redundant (dual) power, sequential power up/down and power regulation. *Pulizzi Engineering, www.pulizzi.com.*

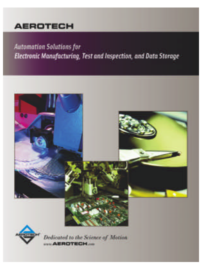
PCB customer service

Sunstone Circuits offers quick-turn pricing for two- to six-layer prototype boards and production volumes to eight layers. With more than 30 years experience in PCB manufacturing, Sunstone offers free circuit board design software downloads and expert design checks on demand. *Sunstone, www.sunstone.com.*

Imaging optics

Navitar's electronic imaging and machine-vision optics are now available through the company's patent-pending automated online Optical Wizard. The tool dynamically suggests appropriate lens solutions in response to user input. *Navitar, www.opticalwizard.com.*

Motion-control and positioning



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

Test and debug solutions

Intellitech lowers your costs with patented approaches to prototype test, silicon debug, production PCB test, multi-PCB system test, environmental stress screening, and in-the-field test. *Intellitech, www.intellitech.com/tmwcp.*

Audio analyzer

The dScope series III is a high-performance PC-based audio analyzer and test system for both analog and digital audio. Features include multitone tests, automation scripts, and USB connection to a PC. *Prism Sound, www.prismsound.com.*

GigE camera

The Genie-M640 is a Gigabit Ethernet digital camera specifically engineered for industrial applications. The Genie is based on CCD and CMOS sensors and available in both color and monochrome. *DALSA, www.imaging.com*

Low-cost ICT

CheckSum provides low-cost ICT systems that identify faults and functional failures. The company also provides ICT programs and fixtures with in-system programming (ISP), TestJet, and boundary-scan test to enhance high-density SMT tests. *CheckSum, www.checksum.com.*

Automated switching systems

Providing a large number of off-the-shelf switching systems, Universal Switching offers automated solutions spanning DC to 40 GHz in sizes from 1x2 to 1024x1024 and packaged in either rack-mounted or VXI formats. Standard interfaces include Ethernet, GPIB, and serial. *Universal Switching, www.uswi.com.*

(continued)

CATALOGS & PRODUCTS

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HV harness tester

Cirris' new easy-wire CH2 wire harness and backplane tester offers high-voltage testing of up to 20,000 points at voltages to 1500 VDC and 1000 VAC. *Cirris Systems, www.cirris.com.*

Oscilloscopes

Yokogawa's signalXplorer DL9000 series 500-MHz to 1.5-GHz digital oscilloscopes provide high performance (fast acquisitions, long memory, four math channels, and I²C, CAN, and SPI analysis) at an affordable price. *Yokogawa Corporation of America, www.yokogawa.com/tm.*

Serial and digital I/O

A new product catalog details Sealevel Systems' diverse selection of serial and digital I/O products including Ethernet, USB, low-profile PCI, PCI, PC/104, PCMCIA, and CompactFlash interfaces. *Sealevel Systems, www.sealevel.com.*

Flying probe testers

Mechanical accuracy, productivity, and test capability are combined in one piece of equipment, which is intended for a wide range of applications. The 4040 Hi-Line system is the state-of-the-art of flying probes test systems. *SPEA, www.spea.net.*

RF/microwave products

A new CD provides a tour of all AR Worldwide products, including RF and microwave amplifiers, transient

EVM Solved!

Simple strength tests pale in comparison to Agilent's new tools that can analyze signal quality in a wide range of wireless applications

Error vector magnitude (EVM) is one of the most useful means of describing the quality of RF signals, such as the digitally modulated signals widely used in modern wireless signals.

EVM measurements can provide a great deal of insight into the performance of digital communications transmitters and receivers. For example, EVM can pinpoint exactly the type of degradations present in a signal and can even help identify their sources.

Now, engineers performing these important EVM measurements will find the task a lot easier with tools such as The PSA Series, Agilent Technologies' highest performing spectrum analyzer family. Whether their field is cellular, emerging wireless communications, aerospace or defense, R&D and manufacturing engineers can easily, quickly and accurately perform analysis on signals using Agilent's flexible digital modulation analysis measurement personality.

While it can sometimes be quicker and easier to rely on simple signal strength tests for communications signals, these "quick and dirty" methods may do a poor job of alerting you to problems that could lead to quality-of-service breakdowns. Getting to know EVM can help.

Key benefits of EVM

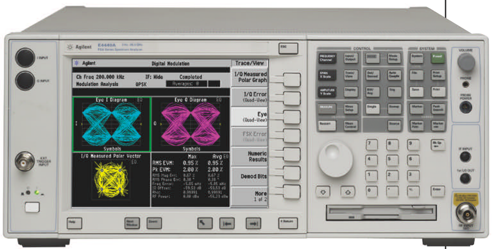
By definition, EVM is the difference between the complex voltage value of a demodulated signal and the value of the signal actually received. The reason EVM is so useful is that it provides you with considerable detail on signal quality, including both amplitude and phase errors in the signal. This can provide a more complete picture of the signal and its environment.

EVM is, in a sense, both tactical and strategic. It helps provide a quantitative figure-of-merit for a digitally modulated signal, as well as a broader methodology for diagnosing and repairing causes of signal impairments and distortion.

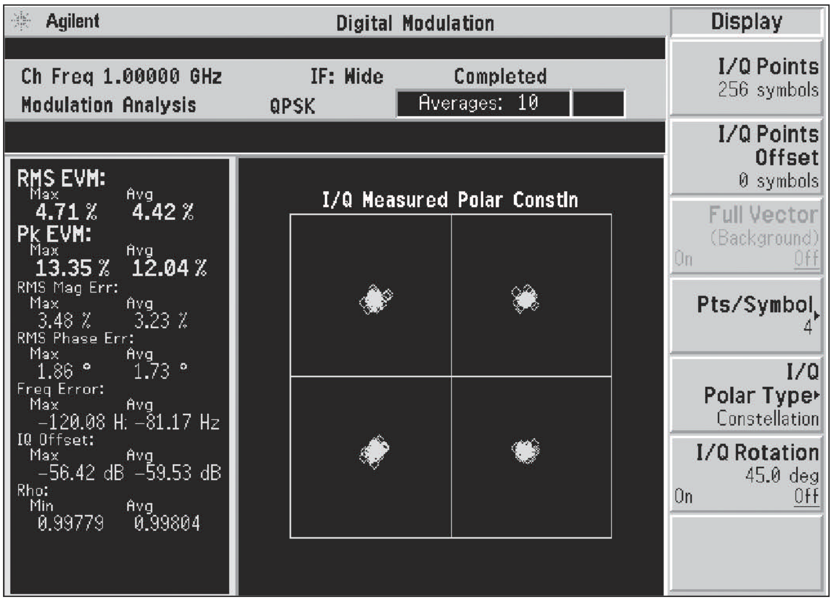
One further measure of EVM's growing importance is the fact that it is now the required modulation quality measurement in digital modulation standards, such as those based on QPSK, QAM, spread-spectrum, or OFDM.

Making EVM measurements

When you perform an EVM measurement, the analyzer samples the transmitter output to capture the actual signal trajectory. Then, the signal is demodulated and, based on information regarding such functions as symbol clock timing and baseband



Engineers who need to perform key EVM measurements will find the task a lot easier using Agilent's PSA family of spectrum analyzers.



Polar constellation view of QPSK signal with a symbol rate error. EVM is now the required modulation quality measurement in digital modulation standards

filtering parameters, you can derive mathematically a corresponding ideal or reference signal.

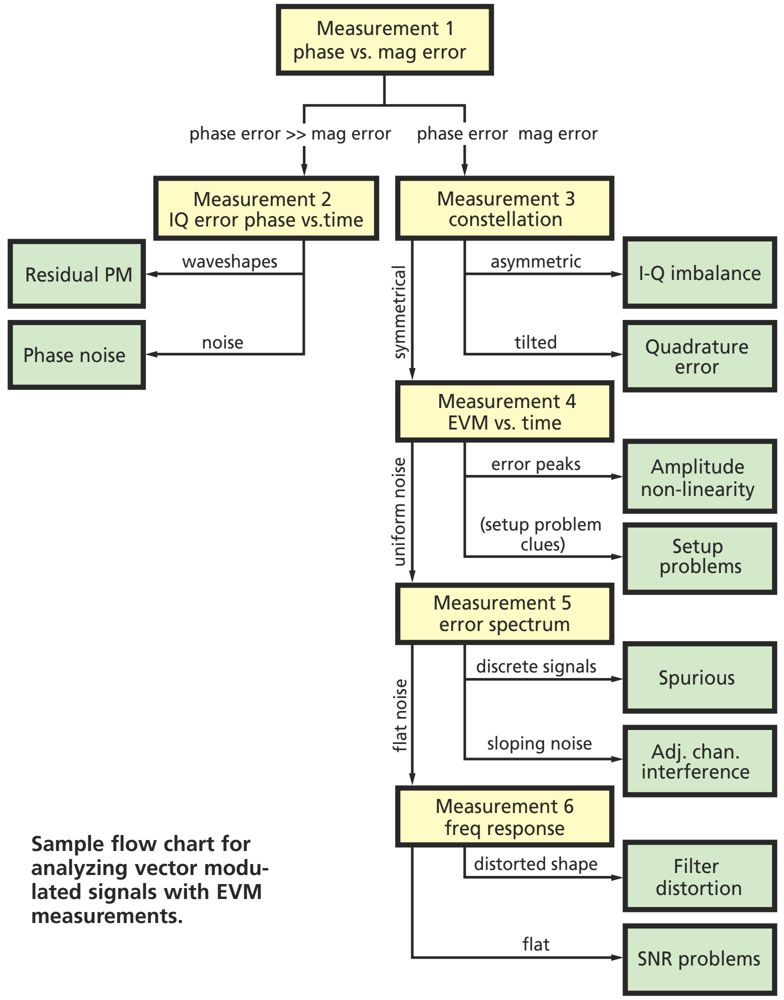
The error vector, then, is the vector difference at a given time between your ideal reference signal and the actual measured signal. This is a complex quantity that contains a magnitude and phase component. The reported EVM is the root-mean-square (RMS) value of the error vector overtime at the instants of the symbol clock transitions. Most importantly, it is an acutely sensitive measure of quality.

The EVM value can also be reported in units of dB. Some standards even use the term "relative constellation error" (RCE) -- referring to the constellation of values from which the measure derives, instead of EVM.

While the error vector has a phase value associated with it, this angle generally turns out to be random, because it is a function of both the error itself (which may or may not be random) and the position of the data symbol on the constellation (which, for all practical purposes, is random).

A more useful angle is measured between the actual and ideal phasors (I-Q error phase or phase error), which contains information useful in troubleshooting signal problems. Likewise, I-Q error magnitude, or magnitude error, shows the magnitude difference between the actual and ideal signals.

EVM troubleshooting tree



Sample flow chart for analyzing vector modulated signals with EVM measurements.

Hints for EVM success

If you are new to EVM or simply want to get better results, here are eight key "hints" that can help you achieve success. These tips include:

1. EVM is sensitive to any signal flaw that affects the magnitude and phase trajectory of a signal for any digital modulation format.

2. Measurements of EVM to quantify the errors in digital demodulation can provide powerful insight into the performance of a digital radio receiver.

3. Enhance the value of EVM as an indicator of modulation quality by using equalization in the measuring instrument.

4. Quickly confirm or rule out phase noise, incidental phase modulation and residual AM problems by resolving EVM into its magnitude and phase error components and comparing their relative sizes.

5. Verify most I/Q impairments by magnifying the scale of the constellation and looking at the EVM metrics.

6. Small errors in the symbol rate can be characterized by a 'V' shape seen on the magnitude of the error vector versus time display.

7. The main indicator of a wrong alpha coefficient and incorrect windowing is large EVM between the symbols and small EVM at the symbol points on the display of magnitude of the error vector versus time.

8. The best way to determine if an in-channel spur is present is by looking at the error vector spectrum display

These hints are described in detail in an Agilent Technologies booklet downloadable online.

FOR MORE INFORMATION

For more information about EVM, contact Agilent Technologies at 1-800-829-4444 or visit www.agilent.com/find/PSA_EVM to download the following application notes:
1. "8 Hints for Making and Interpreting EVM Measurements".
2. PSA Series Spectrum Analyzers Flexible Digital Modulation Analysis Measurement Personality, Technical Overview.

The following write-ups were supplied by advertisers in this issue.

generators, and RF test accessories. It also includes application notes and brochures from AR's RF/Microwave Instrumentation, Modular RF, and Receiver Systems divisions. *AR Worldwide, www.ar-worldwide.com.*

Mass interconnect

The new *Mass InterConnect Solutions* product catalog from VPC will simplify the configuration of a Mass InterConnect Solution. Exploded views, drawings, and other information are available for each product family. *Virginia Panel Corp., www.vpc.com.*

Ultra LED testing

Ultra FINN, the latest innovation in LED color and intensity verification from Test Coach, features improved accuracy, increased speed, and even greater reliability, all in a miniaturized package. *Test Coach, www.testcoach.com.*

Portable USB interface

DDC has introduced a multi-protocol USB 2.0 interface for MIL-STD-1553 and ARINC-429 data bus applications. The rugged construction and small size of the interface make it appropriate for avionics labs, field service, flight-line test equipment, and flight instrumentation applications. *Data Device Corp. (DDC), www.ddc-web.com.*

RF connectors

Gore 100 Series connectors are ultra-high-density blind-mate, high-performance microwave interconnects. The connectors are robust

CATALOGS & PRODUCTS

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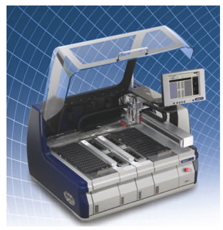
and durable, provide performance through 100 GHz, and maintain superior electrical performance. *W. L. Gore & Associates, www.gore.com.*

Automated programmer

The FLX500 is an automated programmer in a desktop footprint. It is easy to install with a universal power supply and self-contained pneumatic system. The FLX500 provides high yields, excellent throughput, and an automated learn functionality. *Data I/O, www.dataio.com.*



Frame grabber

The $795 PIXCI ELI PCI Express x1 Camera Link frame grabber captures up to 204 Mbytes/s from more than 100 cameras. Windows/Linux software with camera controls is included. Video-to-disk and measurement are optional. *EPIX, www.epixinc.com.*

15X finite objectives

Edmund Optics 15X finite conjugate objectives feature a standard 160-mm back tube length. The all-reflective design makes them ideal for applications requiring broadband collection and focusing. The new objectives feature high numerical apertures, a long working distance, and no chromatic aberration. *Edmund Optics, www.edmundoptics.com.*

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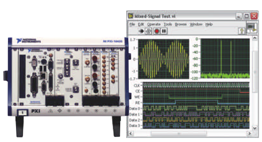

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PXI powers event-based testing

Richard A. Quinnell, Contributing Technical Editor

At a PXI Technology and Applications Conference (PXI TAC) held May 11 in San Jose, CA, a representative of equipment maker Advantest spoke of event-based "reality testing" for chip design verification. To learn more about this test approach and the role of PXI in its implementation, I spoke with Jerry Katz, Advantest R&D's manager of test technology.

Q: How does "reality testing" differ from conventional approaches for design verification?

A: If you look at the EDA tools that designers use to evaluate the chips they are developing, their test files produce a sequence of time differences, or events, along with the value changes for signals in the chip at those events. These event files mimic real-world signals. A traditional validation tester does not do that. Because it is cycle-based, it is unable to accurately recreate signal events as they occur but must lock its output levels to a set of clocks. This requires making compromises in the signal timing because of clocking limitations in the tester.

Q: What do these differences mean for test engineers?

A: Cycle-based testing requires different test vector streams than the ones used in EDA. This leaves us with two domains: design and test. Each domain has its knowledge base, tools, and languages, and they have little in common. That puts a wall between the two that makes it hard to transfer the test requirements and results between the two.

Q: Why has event-based testing not been done before?

A: Everyone in the industry has toyed with the idea of event-based testing, but memory technology has been a limitation. Event-based testing consumes as much as two times more memory than cycle-based. Making the shift also required us to rethink the way validation test is to be done. We had to continually ask ourselves, "What is the test supposed to accomplish?" rather than, "How do we do that?" to make sure that we could make a successful transition.

Q: What is the role of PXI in this new approach?

A: We developed a prototype on a proprietary backplane, but we wanted our design to be based on an open architecture. PXI is a well-established architecture that is laboratory oriented. In addition, it has seen a lot of innovation in the last few years. Many of the top-of-class instruments now available are in the PXI, not benchtop, format. The open architecture allowed us to concentrate our design on the digital portion of the tester and purchase other boards as needed to create the test capability the customer wanted. In addition, the open architecture allows customers to expand their test system with new boards or to design their own. (*Editor's note:* Advantest's Certimax system is the resulting PXI-based validation tester; see p. 78.)

Q: Any other advantages to PXI?

A: The compact form factor and low power requirements of PXI allowed us to create a system with a small footprint that only required 110-V power. Also, PXI is at the lower end of the cost spectrum. It let us produce a test instrument that companies could afford to own without requiring a test volume high enough to support dedicated equipment and staff. And because it is event-based, it can use the test vectors that the EDA tools generate, bringing test back closer to the design domain. □

Jerry Katz
Manager of Test Technology
Advantest R&D

INSIDE THIS REPORT

EDITOR'S NOTE

The price of freedom

Richard A. Quinnell, Technical Editor

PXI provides test engineers with a tremendous asset—the freedom of flexibility in test design. By combining a handful of modules in different ways, engineers can create the equivalent of an entire storeroom of benchtop instruments. There is a price to freedom, however. It must be carefully managed.

Freedom without any restrictions is chaos, so restrictions have their value. Some of the most valuable design restrictions are called standards. The standards governing PXI ensure that modules will work together in the same chassis. Yet, this can still lead to chaos when design teams work in a vacuum and re-invent solutions or develop incompatible approaches.

Managing the freedom that PXI provides, then, becomes an exercise in finding the right restrictions, such as design rules. With the proper design rules channeling the test-development effort, teams can maximize the opportunities for later re-use of their work. It is not easy to develop appropriate rules—too many restrictions can turn development into a chore and be counterproductive—but the payback in terms of saved time can be significant. The use of a mass-interconnect system, covered in this issue, is one example of a restriction that provides benefits while maintaining significant design freedom.

Freedom is necessary for innovation. Wisely managing that freedom is the way to achieve the greatest benefit. □

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

HIGHLIGHTS

Advantest brings PXI instruments to event-based IC tester

Representatives of Advantest Technology Solutions (ATES) were on hand at the Design Automation Conference (July 24–28, San Francisco, CA) to demonstrate the company's Certimax semiconductor design verification system. In its initial configuration, the 80-lb system employs PXI cards to provide 128-pin, 125-MHz test capability. Four systems can operate in parallel to provide 512-pin capability.

Jerry Katz, manager of test technology at the Advantest America R&D Center, demonstrated the system's waveform viewer and editor, which helps to bridge the design-to-test gap by presenting data from the design environment "as is" at the validation stage of the process. Users can edit waveforms without having to deal with the complexity imposed at the design-to-test interface by cycle-based big-iron test systems. Katz demonstrated the tester's digital-test capabilities in conjunction with Mentor Graphics ModelSim. He showed how the system can compile a test bench from ModelSim and generate a VCD file with no need for cyclization.

Users wishing to augment digital test with analog measurement capability can add analog PXI instruments and invoke analog source or measurement functions from within National Instruments' LabView, Katz said. He said that a key goal for the Certimax system is to provide the benefits of an instrument without the complexities of big-iron ATE. Base price is about $1000 per pin. www.advantest.co.jp.

PXI scope offers 2-Gsamples/s performance

During NIWeek 2006 (August 8–10, Austin, TX), National Instruments announced that the new NI PXI-5152 general-purpose digitizer/oscilloscope extends the company's digitizer offering to 2 Gsamples/s by providing 1-Gsample/s real-time sampling on two simultaneous channels or 2 Gsamples/s on one channel at 8-bit resolution. For repetitive signals, engineers can use the module's equivalent-time sampling (ETS) mode to sample at up to 20 Gsample/s.

Engineers can configure the PXI-5152 digitizer through software to perform custom measurements in areas such as semiconductor chip characterization and ultrasonic nondestructive test. The module features 300-MHz bandwidth and ranges from 100 mV to 10 V with 50-Ω and 1-MΩ software-selectable input impedance. Onboard memory extends to 512 Mbytes. Base price: $4999. www.ni.com.

PXISA site hosts Webcast

The PXI Systems Alliance (PXISA) and alliance member Goepel electronic have developed a Webcast that covers issues facing test engineers in the automotive industry. The Webcast, "Intelligent PXI Devices for Automotive Communication," is available on the PXISA Web site.

The presentation focuses on the testing of electronic control units, a key component in automotive electronics. Topics include the complexity of electronic components in automobiles, the role of communication buses, the functionality of various buses, ways to develop and test communication buses, and PXI tools for testing automotive communication systems.

The Webcast is narrated by Sven Bohn, US technical support manager for Goepel electronic's Automotive Test Division. www.pxisa.org.

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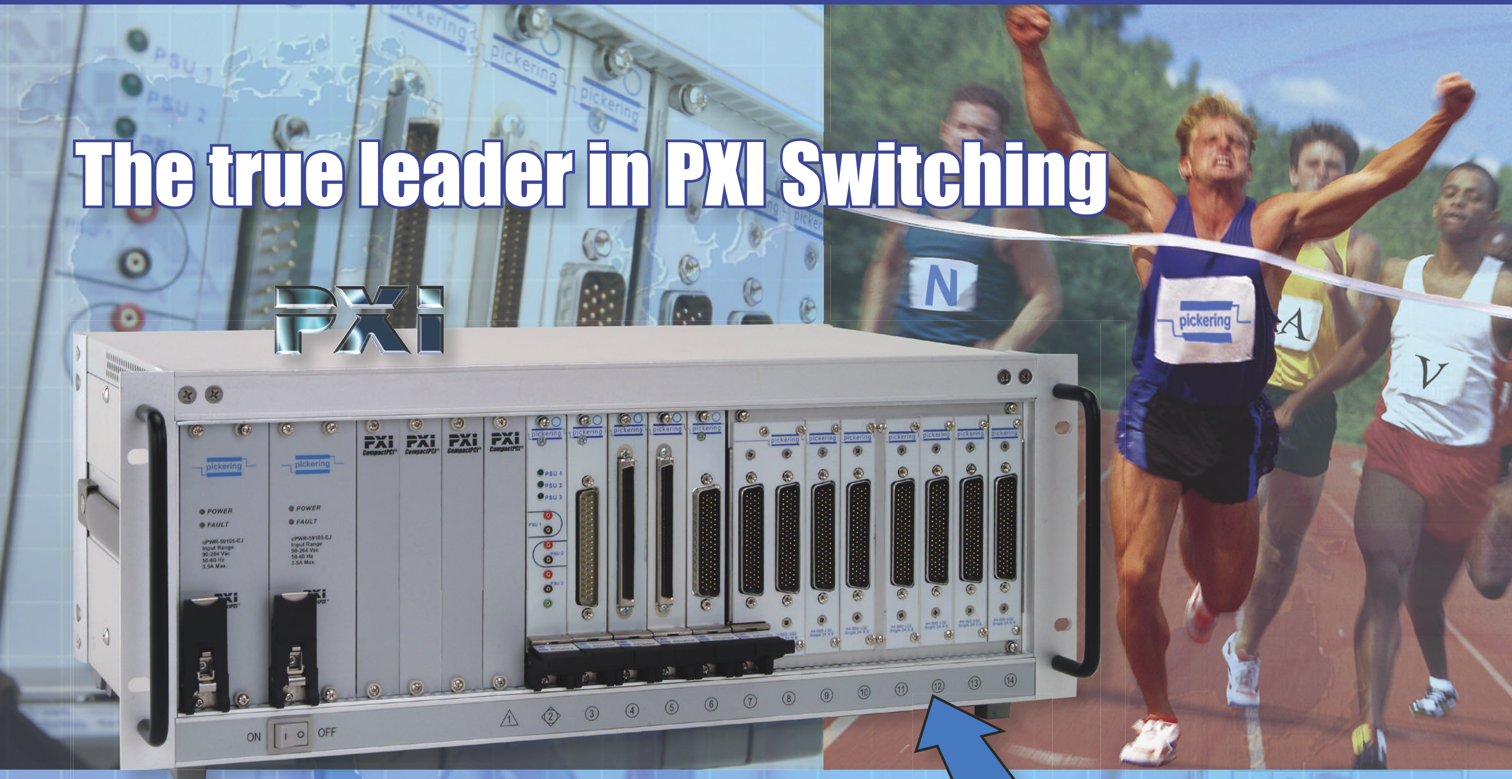

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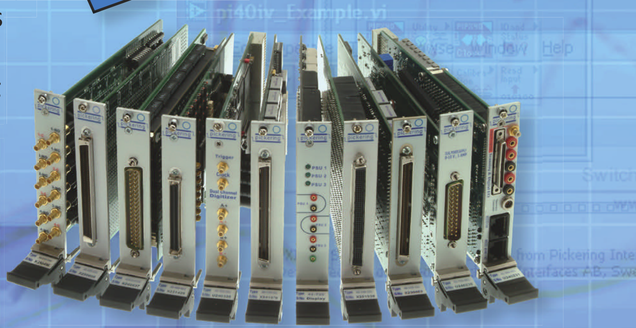

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Mass interconnect for PXI

Richard A. Quinnell, Contributing Technical Editor

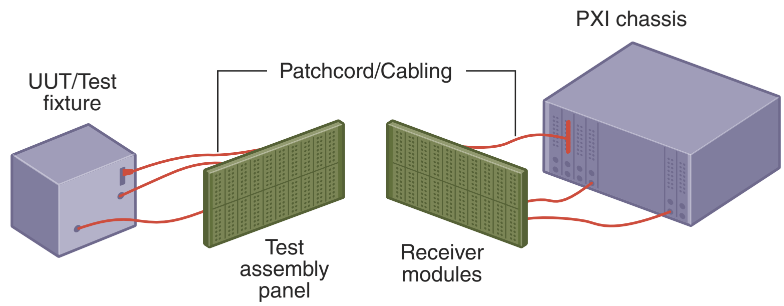
Sometimes, flexibility comes at the price of complexity. When you need to test many similar, but not identical, configurations, the cabling of PXI test equipment can become a chore. By using a mass-interconnect system, you can simplify reconfiguration while maintaining the advantages of PXI's modularity.

In a mass-interconnect system, patch cables bring the PXI test equipment's front-panel signals to a series of receiver modules, which mount onto a panel. The receiver modules mate to a corresponding set of panel-mounted test assembly plugs, which connect to the unit under test (UUT).

The UUT may be hard-wired to the test-assembly plugs, connected with patch cables, or plugged into a test fixture. Often, the receiver-module panel and the test-assembly panel use a levering mechanism to overcome the insertion forces for the modules.

Mass interconnect thus reduces the hook-up between the UUT and the test equipment to a single, multi-pin connector. All of the cabling complexity resides in the links between the receiver panel and the test equipment and in the links between the test assembly plugs and the UUT. Once the links are established, connection to all of the signal lines becomes a single, plug-in operation. Mass-interconnect systems can handle as many as 14,000 connections.

A number of companies offer the building blocks for a mass-interconnect system, including MAC Panel, MEI Technologies, TTI Testron, and Virginia Panel. These companies also offer receiver modules with preconfigured patch cabling for many PXI modules. Test-chassis vendors are also beginning to support mass interconnect. The Geotest GX7102 chassis, for instance, has a hinged front cover that can accommodate a receiver module panel and associated patch cabling.



A mass-interconnect system has several parts and turns complex wiring setups into a single connection.

Simplify repeated tests

Bill Berger, applications engineer at Virginia Panel, explained that a mass-interconnect system can be used to support a series of related tests, such as production tests of devices or boards in a family of similar products. He said that a PXI test chassis equipped with a mass-interconnect receiver panel can handle a number of product variations. The test assembly provides all of the wiring changes necessary for accommodating the differences among the UUTs. The test equipment and its receiver module wiring remain the same.

Berger further explained that with a mass-interconnect system, you can easily replace a PXI module with a new or upgraded model. You simply remove the patch cables that run to the module and attach them to the replacement unit.

If the cables are designed with some slack to them, Berger said that you can reconfigure the placement of PXI modules in the chassis without changing the cabling. If the new module has reorganized, different, or additional I/O ports, only the patch cables and receiver modules associated with that one module require changes.

Berger advised that, when designing the receiver panel, you should leave room for extra receiver modules to enable the system to handle the additional I/O of an upgraded PXI module as well as the I/O of any additional modules you want to add.

Consider for unique tests

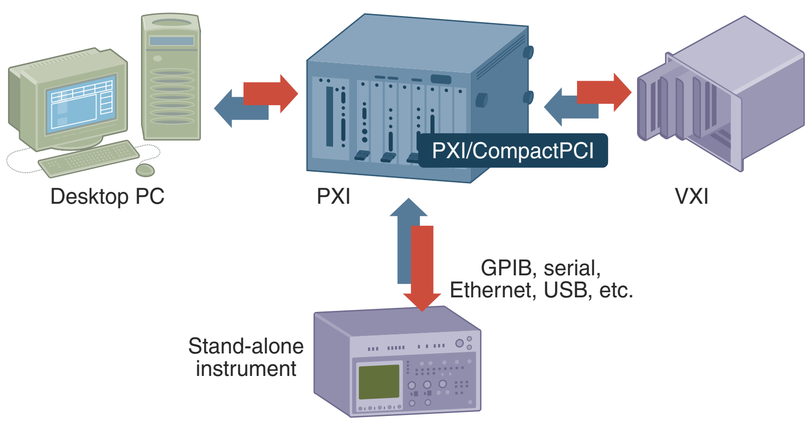
The major drawbacks to using a mass-interconnect system are the initial cost and the need to develop a different test assembly for each product. These factors may seem to preclude the use of mass interconnect for unique tests or exploratory lab testing, but even in these situations, Berger said that mass interconnect offers advantages. One is the reduction of wear-and-tear on the PXI modules. The receiver panel takes all the abuse. The module connectors only see a small number of insertions and removals and are protected from damage caused by bumps and spills.

Another advantage is that mass interconnect can simplify the use of a PXI test chassis as a series of virtual instruments. By developing mass-interconnect assemblies with labeled connectors corresponding to the front panel of a bench instrument, you can quickly reconfigure the PXI test chassis from, say, a spectrum analyzer to an oscilloscope. You would simply attach the mass-interconnect assembly and load the software on the test chassis to configure the inter-module connections and turn the test chassis into an instrument that offers a labeled I/O panel. □

Tips for building PXI systems

Richard A. Quinnell, Contributing Technical Editor

Developing a PXI-based measurement system can be as simple as plugging PXI modules into a chassis and writing a basic application program to control the instruments. You can build a more advanced system by adding test-management software and by adding stand-alone instruments to form a hybrid system. To help engineers understand the potential of PXI, N. D. "Buck" Smith, principal engineer at Cal-Bay Systems, presented these system-integration guidelines during the PXI Technology and Application Conference (PXI TAC) that toured North America this past spring.



A hybrid system design allows developers to reuse equipment to keep costs low. Keeping a modular system approach in mind will maximize the return on the efforts at system development. Courtesy of National Instruments.

Create a hybrid system

The PXI system controller often includes integrated peripheral interfaces for buses such as Gigabit Ethernet, USB 2.0, GPIB, and RS-232. The PXI system can also connect to VXI, LXI, and other PXI systems. Because of this capability, you can use PXI to create hybrid systems that keep system costs down by reusing instruments you already have. Many Tektronix digital oscilloscopes, for instance, offer remote connectivity through PCI, GPIB, or Ethernet ports and the company's OpenChoice software. These instruments can serve as the data-acquisition portion of a hybrid PXI test system, eliminating the need to acquire a separate module. Such re-use thus helps keep system costs down.

Plan for the future

While it is tempting to focus solely on the current project when designing a test system, such an approach is not the best use of the PXI environment. If you build a system that can perform only a single set of measurements, you will have difficulty adapting the system for future applications. A flexible design will be easier to modify and expand, saving time and money in the long run.

You can start by defining the I/O you need and may already have in PXI or stand-alone instruments. When evaluating existing instruments or considering purchases, however, be sure to calculate the number of bus transactions that will be needed for control and data transfer. Then, verify that the bandwidth and latency of the bus that will link the instrument to the test system will meet the system's performance needs. GPIB may be good enough for DMM measurements, while Ethernet may be needed for data acquisition. Keep in mind that the PCI bus underlying PXI is one of the highest-performing bus options available, so the highest performance requirements may be best met by using a PXI module.

Unless the performance of a dedicated instrument is essential, consider implementing the functions of that instrument by combining PXI cards. A PXI cable tester module, for instance, embodies the functions of a continuity checker and a switch in an integrated instrument that performs its dedicated function with high efficiency. Populating the PXI system with a DMM module and a switch module allows recreation of that same functionality with somewhat less efficiency but with greater flexibility. If needs change, for instance, the DMM can make voltage measurements rather than simply check continuity, and the switch can be used to route signals other places within the instrument rather than just to the continuity checker.

Next, provide the bus interfaces (such as GPIB, VXI, or USB) and the device drivers that the equipment requires. To keep software development costs down, look for one of the many free device drivers that are available. Both instrument and module manufacturers often supply drivers for their products. In addition, National Instruments provides a large library of drivers on its Web site (www.ni.com).

Define the user interface and measurement functions you want in your system, and use a modular structure for the applications software. One way to achieve a modular structure is to make each basic measurement function a callable operation and then create a framework that combines the basic measurements into the function that you need. You may also want to consider using test-management software to manage and execute test procedures automatically and data-management software to store the measurement data.

Plan your module placement

Placing PXI modules in slots arbitrarily will result in suboptimal system performance. Slot 2, for instance, offers a tuned and matched set of trigger connections to the next 12 system slots. These matched triggers have less than 1 ps of skew between them. Therefore, to achieve top performance when creating a multichannel, synchronized data-acquisition system, you must place the triggering source in slot 2.

Keep in mind, too, which instruments will need to be located next to one another. An RF downconverter and its associated digitizer will work best when located next to one another. Bus segmentation should also be considered. To keep loading and skew from compromising bus performance, PCI and PXI systems limit direct backplane connections to four slots. Larger backplanes break the bus into segments that connect together through PCI bridges.

Functions such as direct-to-disk data recorders, which require a high-bandwidth data path among only a few modules, achieve their top performance when those modules inhabit a single system bus segment dedicated to that function. Similarly, modules needing precision timing (<6 ns) between them should be located on the same segment. Check the needs and interactions of system modules and assign them to backplane segments appropriately.

Allow for expansion and upgrades

Test system requirements inevitably change over time, and in general become more demanding. To avoid having to develop a new system as needs grow, build in some expansion options. If the system needs a data-acquisition card, for instance, choose a multifunction card that meets the present system needs with one of its functions. Such cards typically have additional I/O capabilities that may come in handy as new system requirements develop.

Another, relatively simple, way to ensure expansion capability is to use a PXI chassis that has at least two more slots than you need for your initial system. Alternatively, leave the rightmost slot open. This provides you with the option of using a PXI remote controller to expand your instrument to a second chassis should your system needs grow significantly. □

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PRODUCTS

DMM with function generator

Signametrics has updated its 7½-digit SMX2064 digital multimeter by adding a function generator that outputs sine or pulse waveforms. The PCI, PXI, or VXI plug-in DMM now outputs sine waves from 1 Hz to 200 kHz with 2-mHz resolution. The pulse source can generate bursts up to 60,000 pulses or a continuous signal with 1-µs resolution. Two auxiliary inputs enable the DMM to measure three DC voltage sources simultaneously. Support software is included. *Signametrics, www.signametrics.com.*

CompactPCI Express kit

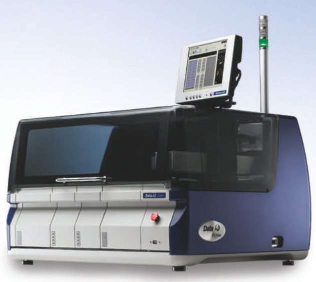
PLDApplications has unveiled the PXIe XpressLite CY2 development kit for CompactPCI Express. The kit includes a x1 add-in board, based on Altera's Cyclone II FPGA, as well as a free PCI-SIG compliant PCIe IP controller, a free test bench, and a Philips PX1012A-EL1 PHY implementation. The board includes an x1 PXIe male connector, a Mictor (matched-impedance connector) for probing, and a prototyping matrix for daughter-card extensions. It also has LEDs and switches to simplify development and is programmable via a JTAG connector or the EPCS16 (AS configuration). *PLDApplications, www.plda.com.*

PXI chassis

NI's new PXI-1033 chassis offers PCI Express support in the form of an integrated MXI-Express remote controller. The chassis offers five peripheral slots and includes a host card to control the system via a cable from either a PCI Express-equipped desktop computer or an ExpressCard-equipped laptop computer. With the MXI-Express controller, you can achieve up to 110 Mbytes/s sustained throughput to the host PC. The chassis integrates with NI's LabView, LabWindows/CVI, SignalExpress, and NI TestStand software. *National Instruments, www.ni.com.*

Data recorder

The StreamStor PXIe-416 from Conduant is a real-time data-recording system that supports the PXI Express environment. This 3U PXI-Express card offers four-lane endpoint connectivity to the host PXI-Express fabric. It can record at 600-Mbytes/s for more than 3.5 hr. The instrument supports more than 8 Tbytes of storage when it is attached to four separate StreamStor DM4 data modules with a total of sixteen 500-Gbyte disk drives. *Conduant, www.conduant.com.*



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KEVIN MADDY
President
RVSI Inspection
Hauppauge, NY

Kevin Maddy has 27 years manufacturing experience, the past 14 years as an executive specializing in turn-around management, organizational reengineering, and the implementation of lean manufacturing practices. Approximately 50% of his experience is in the area of plant management, 30% in business development, and 20% in finance. He has held positions with corporations such as Ford Motor, Unisys, and United Technologies and was a contributor in the turn-around and restructuring of Pratt & Whitney. He holds a BS degree in business. Shingijutsu Company in Japan trained him in the implementation of lean manufacturing practices.

Chief editor Rick Nelson spoke with Maddy at Semicon West and followed up with e-mail questions.

Lean techniques drive inspection firm's rebound

Q: Could you briefly describe RVSI's product offerings?
A: RVSI offers two lines. The LS8800 is a fully automated in-tray inspection system for final inspection of semiconductor packages such as BGA, TSOP, and QFP. The second line is our wafer-inspection system. The latest model, the WS3800, provides macro defect inspection for both flip-chip and wire-bond wafers.

Q: RVSI has been through turbulent times. What is its current status?
A: RVSI has made incredible progress since Ancora purchased it in March 2005. We are on track with our business plan. Sales will more than double this year and again in 2007.

Q: When did you join RVSI, and what do you hope to contribute to the company's efforts going forward?
A: I joined RVSI in September 2005. Since I have more than 27 years of manufacturing experience on the shop floor in the automotive and aerospace industries, I do offer a different perspective. I am very customer-focused and strive to be easy to deal with. I also have the in-depth knowledge of integrated product-development processes and lean manufacturing techniques that brings a new mind-set to managing the business and working in partnership with its customers.

Q: How is evolving semiconductor technology changing inspection requirements, and how is RVSI meeting these requirements?
A: Package shrink is the main challenge. Devices present more I/O contacts and tighter pitches in smaller areas. The I/O contacts themselves are smaller; therefore, the metrology requirements are tighter.

Because RVSI's technology is based on electronic laser triangulation, we can adapt by obtaining our 3-D measurements at tighter sampling rates. Ironically, the advancements being measured in semiconductor technology translate into higher capabilities for our systems. More complicated, faster devices let us fire our laser at faster rates, obtain tighter data samples, and process millions of points at higher speeds and higher accuracies.

Q: How have you brought about RVSI's recent progress?
A: We have focused on operational improvements, on improving our products, and on changing our strategy with respect to the aftermarket and cost of ownership. We first focused on operational improvements to improve quality, on-time delivery, and lead times through the implementation of lean manufacturing principles.

Q: What about improving your products—could you provide an example?
A: I will provide two: First, the recently introduced LS8800 lead scanner overtakes the competition in speed across roughly 80% of the market segment. We have also improved our package visual inspection (PVI) system through a speed upgrade, making it six times faster than previous models.

With respect to our wafer scanner, we just announced another speed increase, which makes it the fastest 3-D scanner in the industry—twice as fast as the competition. Most significantly, we have enhanced the 2-D inspection capability of the machine, an area where RVSI has not seriously played. Case in point: We recently won several surface-defect application orders in China, Taiwan, and Korea. T&MW

Kevin Maddy comments on aftermarket issues and provides more details on RVSI products in the online continuation of this interview: www.tmworld.com/2006_09.

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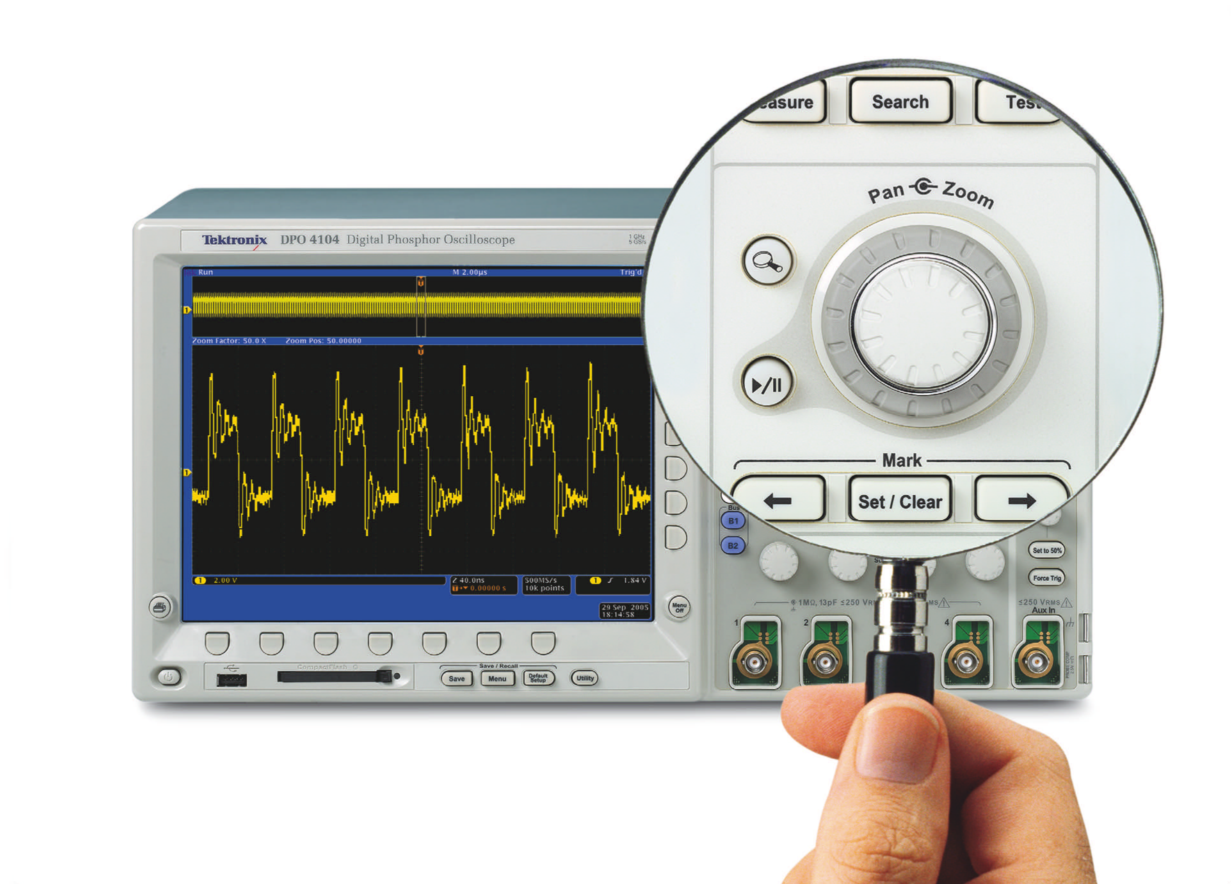

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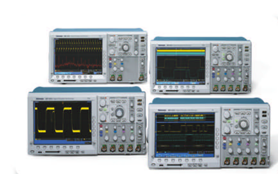

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