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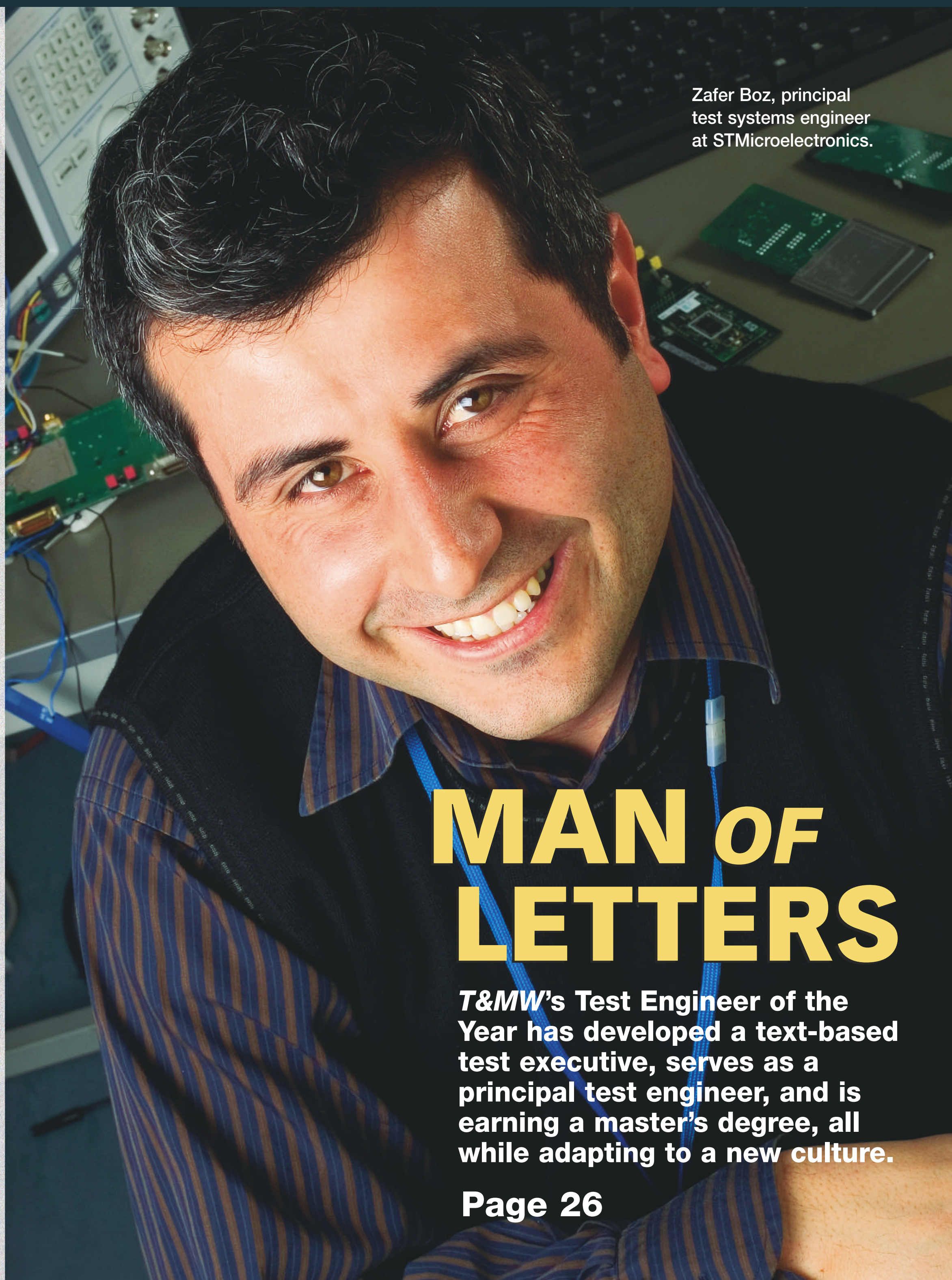

Zafer Boz, principal test systems engineer at STMicroelectronics.

MAN OF LETTERS

***T&MW*'s Test Engineer of the Year has developed a text-based test executive, serves as a principal test engineer, and is earning a master's degree, all while adapting to a new culture.**

Page 26

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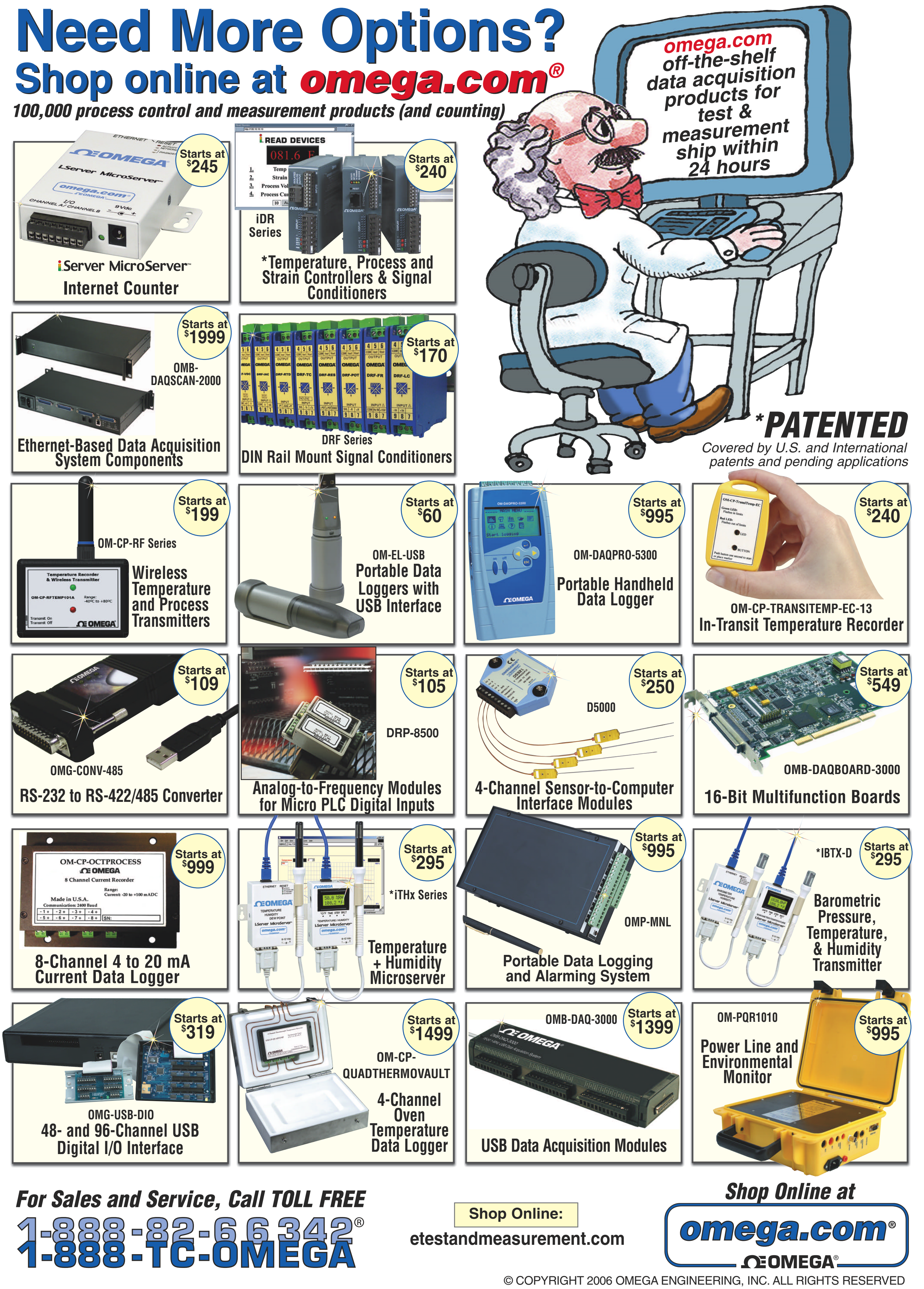
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Test & MEASUREMENT WORLD®

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VOL. 26 • NO. 2

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TECH TRENDS

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▶ **I love my scope, and you can't use it**
Martin Rowe comments on why locking your oscilloscope could lead to unintended consequences. www.tmworld.com/scope.

▶ **Taking the measure**
Read Rick Nelson's commentary on Thevenin's theorem, the science threat, binary stars, and VARs, VADs, and SIs, and then add some comments of your own. www.tmworld.com/blog.

Is the science threat real?

The supposed threat to US science, which I continue to believe is real (see my November 2005 "Editor's Note"), garnered some comment at a recent DesignCon panel. As reported in sibling publication *Electronic News* (February 10), Carl Guardino, president and CEO of the Silicon Valley Leadership Group (SVLG), cited statistics that show two of three middle school math and science teachers in the US do not even hold a degree in the subject they teach, and Dr. Belle W.Y. Wei, dean of San Jose State University's College of Engineering, noted that "young people are not inspired. This is the problem."

RICK NELSON, CHIEF EDITOR

Solutions range from individual mentoring efforts to multibillion-dollar government investments. But questions remain as to how big the problem really is. In "The Fake Science Threat" (*Washington Post*, February 6, p. A15), columnist Sebastian Mallaby describes the efforts of Gavriel Salvendy, an American scientist from Purdue University, to set up an engineering department at Tsinghua University in Beijing. As part of the program, graduate students earning $60 per month receive a $125 bonus for each paper they publish in an international journal. That certainly provides them with the inspiration that Dr. Wei says is lacking in the US.

US technologists should engage in global cooperative efforts while building their own prowess.

But Mallaby questions what this really means for the US. He comments that "while generous math and science funding should be a government priority, the invocation of the threat from China is mostly spurious." He contends that competition between countries is different from competition between companies. He suggests that cooperative efforts such as Salvendy's aren't helping China catch up with us but rather are helping us keep ahead of China. Because China sells to Americans, he says, whatever makes China more productive has some upside for the US as well.

At the DesignCon panel, Timothy G. Saponas, worldwide higher education manager at Intel, seemed to agree at least in part with Mallaby, saying that US science vs. China science is not an apples to apples comparison and that US-educated engineers still have a leg up.

Mallaby's position is an intriguing notion. I concur that it's beneficial for the US to help promote science education in other countries. I also agree with private investor Jim Hogan's comments to the DesignCon panel that we should send our students overseas to expose them to global competition.

But we would be foolish to overlook the deep problems here. Increased financial support for science education and further efforts to inspire scientific pursuits remain critical to the US. T&MW

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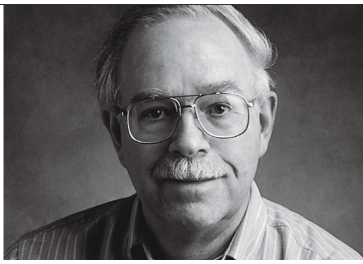
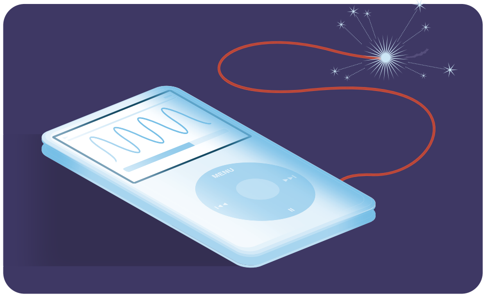


Mission: Improbable

"Good morning, Mr. Phelps. The displayed image shows a Haplygonics model J2000 RF sweep generator that has a defective impulse-modulator transformer, T301, manufactured by OneGoodTurn Transformers and marked 'TF-XZ5.' Your mission, should you decide to accept it, is to locate service information and a replacement for T301. This iPlod will self-destruct in five seconds... four...."

So where do you start? Chances are, you'll fire up your favorite Internet search engine and enter "TF-XZ5," only to view pages of listings sponsored by surplus-component dealers, some of whom apparently used character-permutation programs to create part numbers for every conceivable component since the invention of the wheel. If you're fortunate, one of the dealers will actually stock the component. If not, you're headed for....



Level 2: Your search engine reveals that OneGoodTurn Transformers is still in business. Its Web page lists an e-mail address and telephone number. You dash off a message requesting specifications, pricing, and availability for the TF-XZ5. If you're lucky, someone at OGTT promptly replies with all of the information you requested. If you receive an uninformative reply, you're on your way to Level 3. If you receive no reply whatsoever, you skip Level 3 and go to Level 4.

Level 3: The answer to your e-mail or phone call includes phrases such as "That's a proprietary component," or "That's an obsolete component," or "We no longer manufacture that component," or "That's not one of our part numbers." You repeat Levels 1 through 3, but this time you insert "Haplygonics model J2000" in the search window. No dice.

Upon reaching Level 4, you remove your shoe phone, dial your contact at the Office of the Secretary of TheFence and speak the code words: "I think we'll pass on this one."

Mission improbable? No. Far-fetched? Not at all. Inane satire? Possibly. Lost customer good will? Definitely.

To find out for yourself, pretend that you're a previous—or potential—customer of your company who is looking for replacement parts and service information for an older product. If you encounter the runaround, a stonewall, or the blank-stare treatment, I hope that you, the reader, are in a position to fix the problem. T&MW

FOR MORE MISSIONS

If you're a fan of the original "Mission: Impossible" series, you can review the shows at:
www.museum.tv/archives/etv/M/htmlM/missionimpo/missionimpo.htm

Cell phones, schmell phones...see a shoe phone at:
www.wouldyoubelieve.com/azarian.html

But seriously, folks, for basic information about fixing just about anything that's electronic or electrical in nature go to:
repairfaq.ece.drexel.edu

Test & Measurement World's Web site includes a directory of test-industry associations and professional societies:
www.tmworld.com/society

For an extensive collection of resources that can help you locate component data and more, go to:
www.epanorama.net/links/searchlinks.html

Google has accumulated a 20-year collection of USENET newsgroup threads. If other search efforts fail to yield information about a test instrument or a component, you may find it worthwhile to rummage around in the archives:
groups.google.com/support

A FOLLOW-UP

Reader Brian Wood responded to my December 2005/January 2006 column, "Here, kit, kit...:"

"...We created a plan that we are hard at work implementing that will create "DZKit" products under the company name of The DZ Co., patterned after Heathkits made by The Heath Co. The "DZ" comes from my ham call—W0DZ. [Our] goal is to recreate the Heathkit experience in its entirety, right down to the yellow-covered manuals."

For more information, go to
www.dzkit.com

93000 platform takes aim at DRAM final test

Agilent Technologies has entered the DRAM final-test market with the 93000 High-Speed Memory (HSM) Series, which targets devices used in memory-hungry computers and consumer-electronics products. With the HSM, Agilent is offering a DRAM-test complement to its Versatest V5500 single-insertion flash-memory final-test system, introduced in July 2005.

Debbora Ahlgren, an Agilent Automated Test Group VP & GM, said she believes the time is opportune for adapting the 93000 architecture for DRAM test. "I believe we are at a juncture in memory test not unlike the juncture that we saw when Agilent introduced the first tester-per-pin architecture," she said. The original 93000 targeted single-insertion test of SOCs. In the memory space, Ahlgren said, the 93000 HSM enables similar single-insertion approaches to testing high-speed memory cores as well as I/O.

The 93000 HSM is available as part of an Agilent-engineered, integrated test cell; it supports 16-site test for XDR (extreme data rate) or 32-site test for GDDR (graphics double data rate) DRAMs in a single test head. It also supports at-speed capture of failure data on all sites in parallel and includes an at-speed, per-pin algorithmic pattern generator. It comes with the vendor's new memory-test language (MTL), based on C++. The 93000 HSM Series is available in 2.2-Gbps and 3.6-Gbps speed classes. www.agilent.com.

T&MW announces 2006 award winners

At a breakfast ceremony held on February 9 in conjunction with the APEX show (February 8–10, Anaheim, CA), *Test & Measurement World* announced the winners of our annual awards.

Publisher Russ Pratt began the presentations by announcing the winner of the 2006 Test Engineer of the Year award: Zafer Boz of STMicroelectronics. Boz was nominated because of a C-language-based test executive he developed for evaluating wireless LAN chips.

Boz was one of six nominees chosen by our editors. We profiled the six in our September 2005 issue and invited our readers to vote for the Test Engineer of the Year. As part of his award, Boz has designated an engineering program to receive a $20,000 grant, courtesy of National Instruments, the award sponsor.

Upon receiving the award, Boz said that he was "very surprised and very pleased," and he added, "I feel very lucky to have been selected as one of the six finalists and be alongside five other very experienced and respected engineers." (For a profile of Boz, see p. 26.)

Next up were the annual product awards. Chief editor Rick Nelson recognized the 12 products that won 2006

Zafer Boz (with plaque) accepted the Test Engineer of the Year award from Russ Pratt (*T&MW*'s publisher, left), Eric Starkloff (marketing director of National Instruments), and Rick Nelson (*T&MW*'s chief editor).

Editors' CHOICE

2.5-GHz vector signal generator

The Model 2910 vector signal generator employs a software-defined radio architecture to accomplish digitally what used to be done in analog, resulting in a low-cost instrument that provides speed and flexibility while maintaining signal quality. The instrument employs off-the-shelf FPGAs and DSPs to avoid the costs associated with custom ASICs.

The 2910 can generate nearly any type of signal in the 400-MHz-to-2.5-GHz range having a modulation bandwidth up to 40 MHz. The synthesizer design provides for frequency-tuning times of less than 3 ms, and the instrument's leveling approach uses all-electronic attenuation to provide better than 3-ms amplitude level settling. (Sweep and list modes provide frequency and level settling within 1.5 ms.)

Other features include a 64-Msample (256-Mbyte) arbitrary-waveform-generator memory to provide for rapid switching between waveforms. Amplitude level accuracy, linearity, and repeatability all spec out at ±0.5 dB. GSM phase error of less than 0.3° and EDGE error vector magnitude (EVM) of better than 0.4% illustrate the instrument's modulation quality. A hierarchical interface approach puts functions most often used near the top of the hierarchy. Graphical and tabular signal views are available. The LXI Class C-compliant instrument includes built-in digital cellular signal-generation capability.

Base price: $14,500. *Keithley Instruments, www.keithley.com.*

Best in Test awards. Our editors present these awards to recognize innovative products in the electronics test and measurement industry.

We announced this year's winners in our December 2005/January 2006 issue, and readers used an online ballot to vote for the one that would be named the Test Product of the Year. The winner is the PXI-5922 digitizer from National Instruments, a single-slot PXI card that can change its resolution with the sampling rate (see p. 23). Eric Starkloff, marketing director of NI, accepted the award plaque for his company.

John Newcomer (center) of Keithley accepted the Test of Time award from Russ Pratt and Rick Nelson.

Finally, Nelson announced the recipient of the 2006 Test of Time award, an award that recognizes a product that continues to provide state-of-the-art performance at least five years after its introduction. The 2006 recipient is the Keithley Instruments 2400 SourceMeter. Introduced in 1995, the 2400 source measure unit solved measurement problems for engineers testing passive and active components (see p. 25). John Newcomer, the company's western manager, accepted the award for Keithley.

T&MW inaugurated the Best in Test awards program in 1991. You can learn more about the awards and previous winners at www.tmworld.com/awards.

CALENDAR

SAE, April 3–6, Detroit, MI. Sponsored by Society of Engineers. *www.sae.org.*

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

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

Editors' CHOICE

BERT gets compliance software

Agilent Technologies' jitter-compliance software for its N4903A J-BERT lets the tester automatically perform jitter compliance tests on serial-bus receivers. The J-BERT can generate serial data streams with calibrated, controlled jitter and then detect errors from the receiver's output. It can also sweep through frequency and amplitude ranges of jitter and produce a jitter-performance curve.

You can compare your measurements against jitter-tolerance compliance curves for PCI Express, SerialATA II, Fibre Channel, Fully-Buffered DIMM (FB DIMM), Common Electrical I/O (CEI) 6/11, 10 Gigabit Attachment Unit Interface (XAUI), 10 Gigabit Serial Electrical Interface (XFI), and 10 Gigabit Small Form Factor Pluggable (XFP) serial buses. You can control periodic jitter, random jitter, bonded uncorrelated jitter, intersymbol interference, and sinusoidal interference. You can also create your own tolerance curves.

Agilent has also announced that N4903A customers can get additional free downloads of measurement utilities. The first is a quick eye and pattern-capture utility.

Price: N4903 compliance software for J-BERT—$9995. Base prices for the J-BERT: 7 Gbps—$120,000; 12 Gbps—$160,000. *Agilent Technologies, www.agilent.com.*

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Tabor's unique design combines two technologies, making use of the best qualities from each of the types of generators. While being a true arbitrary waveform generator (AWG), memory-based with all the memory management capabilities to create complex waveforms, it implements a DDS to create all the standard modulation formats and frequency agility capabilities. Ranging from 50MS/s to 1.2GS/s, Tabor's Wonder Wave Series is designed to solve a myriad of applications from the simplest need to the most demanding requirement and challenging waveforms - all this at an affordable price tag.

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MODEL	TABOR WW2571/ 2	Agilent 33250a	Tektronix AWG420
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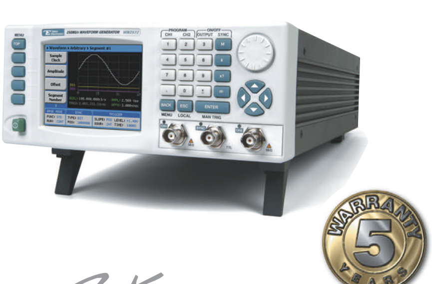
Type	True Arb Implementing DDS	DDS Based AFG	True Arb
WaveformType	All Standard, Arbitrary and Real- life waveform	Standard and only limited Arbitrary	Arbitrary Only
Sample Clock Rate	1.5S/ s to 250MS/ s	200MS/ s	10kS/ s to 200MS/ s
Memory Size	1 Meg (2 Meg optional)	64k	4 Meg
Memory Management (Sequences/ Steps)	10 / 16,000	N/ A	1 / 8,000
Vertical Resolution	16 bits	12 bits	16 bits
Modulation	AM, FM, FSK,ASK, (n)PSK, Frequency Hops, sweep and more	AM, FM, PM, PWM, FSK and sweep	AM, (n)PSK
Max Frequency (Sine/Square/others)	100MHz/ 100MHz/ 32MHz	80MHz/ 80MHz/ 1MHz	80MHz/ 80MHz/ 1MHz
Max Amplitude	16Vp- p	10Vp- p	10Vp- p
Digital Outputs	16 Bit LVDS parallel	N/ A	16 Bit LVDS parallel
Connectivity	LAN, USB and GPIB	GPIB, RS232	LAN and GPIB
Warranty	5	3	1
Price Starts at	$4,495 *	$4,553	$18,500

Specification compiled from Tabor 2571/2 data sheet, Agilent 33250a data sheet 5968-8807EN, March 14, 2005 and Tektronix AWG420 data sheet 76W_14841, March 3, 2002.
Prices are taken from the vendors websites.



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MARTIN ROWE
SENIOR TECHNICAL EDITOR
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Tall and shallow or short and deep?

IN JANUARY AND FEBRUARY, LeCroy and Tektronix introduced oscilloscopes that feature large displays and shallow footprints (Ref. 1). Design engineers like this tall form factor because the instruments use little bench space. But what about test-system builders? Taller scopes consume scarce rack space while leaving the space behind them potentially unused. To find out what oscilloscope form factors work best in test systems, I spoke with several test-system integrators.

"My rack has no space for the tall form factor," claimed Curt Schlenker, systems engineer at Instrumentation Engineering. He has a customer with 10 installed systems that use a Tektronix TDS724D scope, which is no longer produced. When he had to duplicate the system, he had to find a used instrument.

Jay Nemeth-Johannes, CTO of CompleteTest, was more open to tall scopes. "The Tektronix DPO7000 is 17.75 in. wide, so it should fit nicely into a rack. If the system needs another tall instrument," he noted, "it may fit nicely side by side with the new large-screen scope. Instruments that don't fit in the traditional 19-in. rack are nothing new." He expressed some concern about vertical space consumed by the tall form factor. "If a physical display is important, then get a scope that's easy to use. If not, then use a modular scope and a virtual display."

The traditional short and deep oscilloscope form factor saves rack space over tall scopes designed for the bench. Courtesy of Instrumentation Engineering.

For Tim Brooks, president of B&B Technologies, the form factor of box scopes is irrelevant. "We use PXI almost exclusively," he said. "We can find about 95% of what we need in this format."

Brooks isn't alone in his sentiment. "PXI digitizers and scopes are available from several suppliers," added N.D. "Buck" Smith, principal at Cal-Bay Systems. "They typically have 14-bit or 16-bit resolution and sample at up to 200 Msamples/s. Other PXI scope cards with 8-bit resolution sample much faster."

While modular scopes offer an alternative to box scopes, IE's Schlenker likes boxes because he can operate a scope offline to troubleshoot the system. "The best solution is to eliminate the display but provide a VGA output," he said. His colleague, senior software engineer Asish Shah, offered an alternative. He'd like to see a no-display scope that contains an Ethernet port and a Web server so he can operate the scope with a browser.

As I see it, the biggest problem with using a tall scope in a system isn't the form factor but the computer interface. IEEE 488 is still the I/O bus of choice for test-system builders because of its large installed base. An IEEE 488 port is standard on the DPO7000, optional on the LeCroy WaveRunner Xi, and not available on the DPO4000. I expect IEEE 488 ports to slowly disappear as designers switch to USB or Ethernet. T&MW

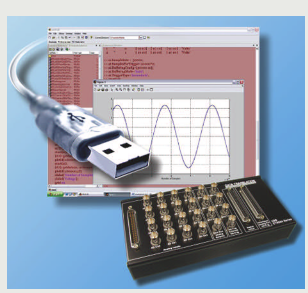
REFERENCE

1. LeCroy announced the WaveRunner Xi series on January 11. Tektronix announced the DPO7000 series on January 4 and the DPO4000 series on February 14. The online version of this article contains links to *T&MW's* coverage of these announcements. www.tmworld.com/2006_03.

Synchronize your PC's clock

SymmTime 2006 uses your Internet connection to retrieve a time signal from a public time server and update your PC's clock. You can view the time in 42 time zones with digital or analog clock displays. The software is available as a free download. www.ntp-systems.com/lp_SymmTime2006.asp.

Data-acquisition modules support Matlab



Data Translation's free DAQ Adaptor for Matlab software provides direct access to analog and digital I/O data through Matlab's Data Acquisition Toolbox. You can use the DAQ Adaptor to configure your hardware through Matlab and acquire data directly into the software. www.datatranslation.com.

NI SignalExpress for Tektronix instruments

National Instruments has released SignalExpress software, Tektronix Edition, which comes on a CD with Tektronix DPO4000 oscilloscopes and AFG3000 waveform generators. The software will find and connect to either instrument through a USB port so you can configure the instruments, store data, and analyze test data. You can purchase an upgrade to the full edition of SignalExpress for $995. www.ni.com/tek.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Material changes

In its biannual International Technology Roadmap for Semiconductors (ITRS), the Semiconductor Industry Association offers some bold predictions (Ref. 1). Although the document aims primarily at device-level manufacturing and test, its conclusions suggest considerable challenges at the board and system levels as well.

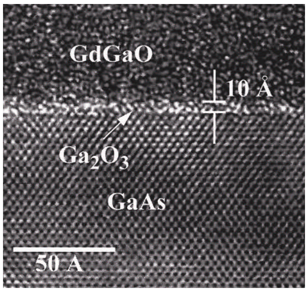
The ITRS predicts more aggressive scaling than it has in the past. Feature dimensions reached 90 nm in 2004, less than the 100 nm predicted for 2005 in 2001. Current expectations are for 25-nm transistor gates to arrive in 2007—six years earlier than forecasted in 1999. According to the Roadmap, by the end of the decade, memory will cost an eighth of what it does today, and microprocessor speeds will have tripled.

As features continue to shrink and devices combine numerous functions and technologies on a single piece of silicon, devices will feature either huge numbers of I/O pins or else fewer pins with the chip generating large amounts of logic and processing before sending signals out. The increasing circuit complexity will complicate test and inspection tasks at board and system levels as well. Developing comprehensive functional tests at the board level, for example, will require taking advantage of test capabilities that designers must include on the devices themselves to make them manufacturable.

Many of these technological innovations will appear first in consumer products, where enormous demand and severe price pressures will challenge manufacturers to tightly control production processes and create efficient, cost-effective test and inspection strategies at least as well as they do today. According to the Roadmap, "some of the most important test challenges are actually centered on some of the more subtle historical missions of manufacturing test—reliability and yield learning."

One of the most radical of the Roadmap's predictions—migration from silicon-based designs to molecular switches and organic packaging—will not begin to appear until after 2010. Yet, some hints of what is coming have already occurred, and the movement away from silicon-based logic recently took a giant step forward.

On January 30, Freescale Semiconductor announced the first commercially viable device that combines the high performance of GaAs semiconductor compounds with the advantages of traditional MOSFETs. Freescale says the new approach could make such operations as analog-to-digital conversions virtually instantaneous, because GaAs generates less noise and conducts electrons up to 20 times faster than traditional silicon can. Previous efforts to incorporate SiO_2 dielectrics in GaAs technology proved unsuccessful. Freescale has identified other GaAs-compatible materials (**photo**) that provide scaling capabilities similar to those of their silicon predecessors.



The GaAs MOSFET breakthrough was enabled by unpinning the Fermi level at the oxide-GaAs interface using a Ga_2O_3 template layer and a GdGaO dielectric layer.

Courtesy Freescale Semiconductor.

The SIA Roadmap's stated purpose is to "guide shared research by industry, universities, and national labs," particularly calling attention to areas that no known manufacturing solution can support. "It is in these areas that breakthroughs in research are needed." T&MW

REFERENCES

1. *The International Technology Roadmap for Semiconductors,* 2005 edition, Semiconductor Industry Association, Sematech, Austin, TX, 2005. www.itrs.net/Common/2005ITRS/Home2005.htm.

Test, inspection at APEX

Test and inspection took center stage at APEX (February 8–10, Anaheim, CA; IPC, www.ipc.org). Landrex Technologies introduced two second-generation Optima 7300 Series AOI systems (**pictured**). ViTechnology introduced its Vision 2006 software and debuted the Vi-1K benchtop AOI system. Machine Vision Products premiered its Ultra 850G AOI system. FocalSpot announced its Concept FX BGA/SMT inspection and rework system.

Several inspection products were new to the North American market: Phoenix|x-ray's Nanotom 160-kV computed-tomography system and Nanome|x inspection systems, Viscom's S6056 AOI system for PCBs, and X-Tek Systems' Nanotech x-ray source.

For testing, Seica debuted the Aerial L4 vertical-board-clamping addition to its Pilot flying probers. Goepel Electronic introduced a FireWire-compliant member of its ScanFlex boundary-scan platform. Data I/O previewed a production programming system for high-volume duplication of multimedia cards and Secure Digital cards.

Digitaltest announced that Primus Technologies has selected a Condor system for board programming and test. W.L. Gore announced that it has added connector-assembly configuration capability to its online cable-configurator tool. Finally, Elektrobit introduced to the North American market its J401-11 "Tiny" test handler and display-tester software for LCDs and keyboards.

For details and supplier links, see www.tmworld.com/apex06.

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BOARD TEST

Integrating boundary scan into ATE channel cards

The success of IEEE 1149.1 boundary scan might suggest that you could toss your ATE and fixtures and replace them with a PC, a boundary-scan control card, and the four-wire Test Access Port (TAP). Indeed, boundary scan offers a simple, low-cost tool for quickly testing the structural integrity of a board prototype, for debugging hardware, and for verifying embedded software.

But this lab-oriented approach becomes insufficient for production test. Boards often include non-JTAG components, and it's wise to use ATE to test for shorts before you power up your board under test. Finally, JTAG remains a serial test technique, and even at speeds of 30 MHz and more, JTAG-based programming operations can be excessively long.

Approaches that move beyond JTAG-only production tests include a "dual test strategy," which employs a conventional in-circuit test stage followed by a JTAG benchtop stage, but this two-stage, divide-and-conquer approach imposes high costs.

ATE systems whose channel cards have embedded JTAG circuitry can seamlessly apply serial boundary-scan and conventional parallel tests.

Another approach is to encapsulate JTAG test capability within a conventional ATE system. That approach, however, suffers from limitations with respect to operations such as checking continuity between JTAG and non-JTAG components. Stand-alone JTAG controllers in a lab can do such checks, but they loose that ability when encapsulated in the ATE.

An alternative approach is to employ ATE channel cards with embedded JTAG circuitry so that either the base ATE controller or a JTAG controller can control each channel. With this approach, the JTAG controller sees the channel cards as a chain of interconnected JTAG components, which it would commandeer seamlessly to perform boundary-scan tests.

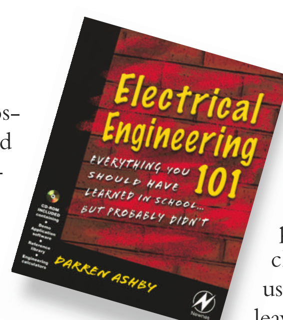
For details on boundary scan's evolution to this point and on the application of JTAG access to ATE channel cards, see the online version of this article at www.tmworld.com/2006_03.

David Sigillo, US General Manager, Seica

BOOK REVIEW

An EE course without the all-nighters

Electrical Engineering 101, Darren Ashby, Newnes (www.newnespress.com), 2006. 352 pages. $39.95.



Darren Ashby, who describes himself as a "techno geek with pointy hair," takes a common-sense approach to his subject in *Electrical Engineering 101*, where he imparts the basics that "have been either left out of your education or forgotten over time." His coverage extends from Ohm's law through logic and programming and on to management.

I never took an introductory course in the EE department where I earned my undergraduate degree. To my best recollection, my 100-level classes included introductions to electricity, logic, programming, and differential equations in the physics, philosophy, computer science, and math departments, respectively. My first EE classes involved loop and node equations, phasor descriptions of complex impedances, and deMorgan's theorem.

I see a lot of value in Ashby's treating these introductory topics from a consistent perspective—except for the differential equations, which he omits. I also welcome his intuitive approach to the subject. Intuition was frowned upon in my education, but I believe common-sense analogies are invaluable in learning a complex topic.

Ashby takes a very practical approach, including a chapter on using tools, and he doesn't leave off on how to use soldering irons. He encourages the strenuous use of people as well—especially of field-applications engineers, which I didn't know existed until I became one upon graduation.

He is weakest with theoretical concepts. For example, his description of

An EE course without the all-nighters *(continued)*

Thevenin's theorem (any two-port network can be represented by a voltage source in series with an impedance) is at once overly complicated and incomplete. He goes on about shorting voltage sources to zero (a necessary but not sufficient step in developing Thevenin equivalency) and presents a two-port circuit that he claims can be converted to a Thevenin equivalent. Of course it can, but he never bothers to show the result. (The details are left to the student!) To his benefit, he does describe how to use his Thevenin approach to rapidly evaluate a time constant.

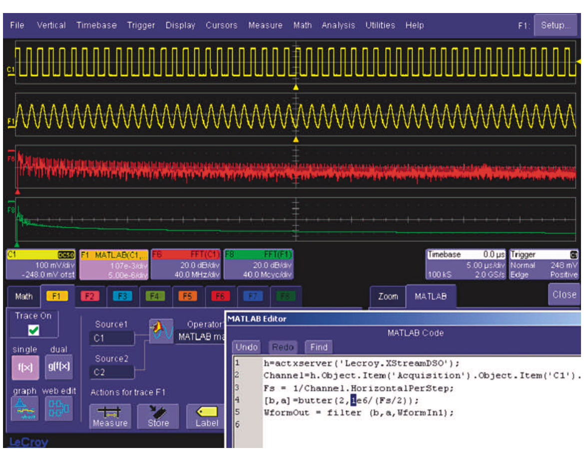
So, don't look for strong theoretical underpinnings in this book. Ashby would have been well advised to leave the theory completely out and concentrate on the intuitive, commonsensical techniques that he presents quite well. (Disclosure: The book's publisher is owned by *Test & Measurement World*'s parent company.)

Rick Nelson, Chief Editor

INSTRUMENTS

Use Matlab in a scope's data stream

Many oscilloscopes contain embedded PCs that run Windows, enabling you to install PC software, including programs that can perform data analysis right in the scope. To use such programs, you can operate the scope manually, store data in a file, and analyze your measurements. But you won't get the benefits of automation that way.



Matlab can apply a digital filter to a waveform in real time.
Courtesy of LeCroy.

You can also "connect" data-analysis programs to a scope through the scope's instrument drivers. That lets you automate the signal acquisition, but you're just operating the scope as though it's connected to a separate PC. Thus, you're still analyzing data offline. You can, though, get real-time signal processing with Matlab.

Matlab contains an ActiveX server that opens a communications path between the math software and a scope application. You can use the server to perform instrument control through drivers, but you can also use it to embed Matlab into a scope's data stream. By doing this, you can move data into Matlab, apply a signal-processing algorithm, and display the results as part of the scope's normal waveform display. With Matlab in the scope's data stream, you can filter signals (**figure**), calculate the decay time in a damped sinusoid, extract a signal's fundamental frequency and convert the resultant signal back to the time domain, and automatically reposition an eye diagram to center it in a compliance mask.

To learn more about these applications and how to implement Matlab into a scope's data stream, download "Run Matlab inside an oscilloscope's data flow," a paper by Mike Hertz, field applications engineer at LeCroy, from the online version of this article at www.tmworld.com/2006_03.

Martin Rowe, Senior Technical Editor

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Because the N6700 is part of Agilent Open, integration couldn't be easier. You'll find LAN, USB, and GPIB ports built in. The product is system ready and it can be integrated into your test-software environment. New LXI compliance adds even more flexibility by enabling local and remote measurements, monitoring, and testing. More power, indeed.

**All prices listed are US dollars at time of printing.*

Agilent Technologies

PROJECTPROFILE

FIBER-OPTICS TEST

Quick custom optical networks

DEVICE UNDER TEST
Fibre Channel and Gigabit Ethernet host-bus adapters that connect servers to storage systems. The adapters use 32-bit and 64-bit drivers for the Windows, Mac, Linux, and Solaris operating systems.

THE CHALLENGE
Develop a configurable network that lets a team of more than 40 test engineers run performance tests and verify adapter features such as data rate. Check that performance doesn't degrade with each new hardware or driver release. Test the hardware and software to ensure that they will handle packet faults and physical faults.

THE TOOLS
- Apcon: optical switches. www.apcon.com.
- EdenTree Technologies: network-configuration software. www.edentree.com.
- Finisar: Fibre Channel and Gigabit Ethernet analyzers and error generators. www.finisar.com.

PROJECT DESCRIPTION

Qlogic (Aliso Viejo, CA, www.qlogic.com) manufactures host-bus adapter cards that connect servers to storage devices and storage-area networks (SANs). Each time the company makes a design change, its test engineers must check performance, features, and error handling.

Host adapters connect to storage devices and SANs over Fibre Channel links at data rates up to 4 Gbps or over Ethernet at 1 Gbps. To configure a test SAN, test engineers had to manually connect fiber-optic cables from the device under test to networks and test equipment. Whenever an engineer needed to test for a lost optical link, he or she had to manually disconnect and reconnect the optical cables. To increase productivity, staff engineer Matt Holley designed a configurable network using software-controlled physical-layer switches.

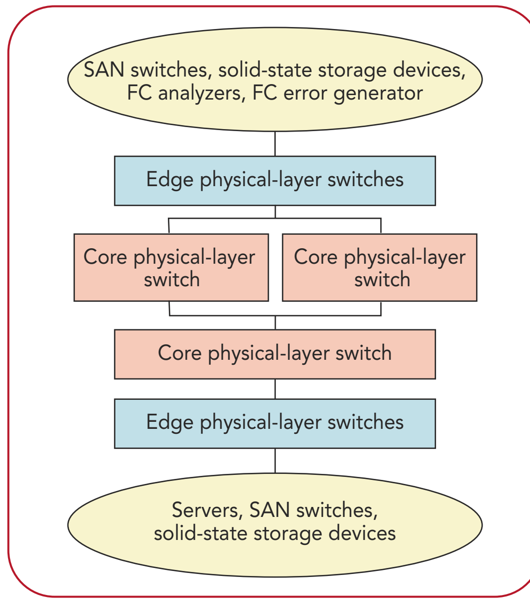
Holley designed a two-tiered switched optical network using a core switch/edge switch topology. The **figure** shows a simplified diagram of the network, which consists of twelve 144-port optical switches, 130 hosts, 42 Fibre Channel switches, 58 storage devices, six tape devices, three Fibre Channel analyzers, and two Fibre Channel error generators in two labs. By the end of 2006, Holley plans to double the number of ports in the network from its current 1728 to more than 3400.

Ethernet connects the optical switches to a server running the configuration software. Engineers operate the configuration software over the company network, and the software schedules each use of the test system to avoid conflicts. Engineers can also invoke scripts that connect to the server to automate the test network's configuration.

During a test, the engineers introduce faults to verify that a host adapter recovers from errors. The error generators let engineers intercept and modify bits within frames or packets. They also break connections through the optical switches.

"If a connection is reestablished within 30 s, then the host adapter should continue to work normally," said Holley. "We also test for broken connections that go longer than 30 s. The connection should fail, but the host adapter should fail gracefully, without causing problems such as system crashes." Engineers verify that the host adapter can correct recoverable errors and provide error-free transmission.

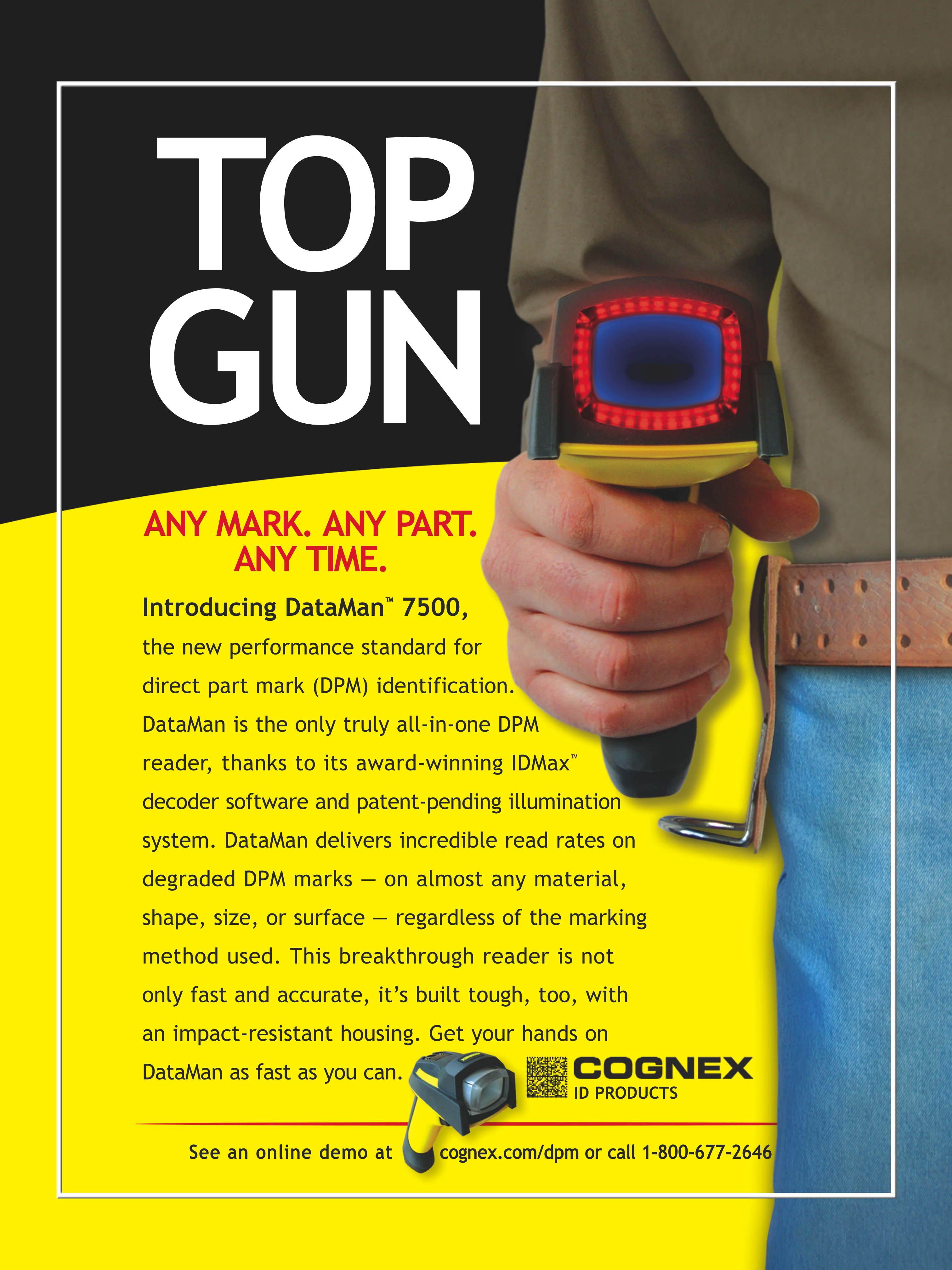
After test engineers verify that a new product or updated product passes its tests, QLogic sends test results to Microsoft for device-driver certification. The company also sends test results to other software companies such as Red Hat and Novell for certification.



Physical-layer switches and software let test engineers configure an optical network from their desks.

LESSONS LEARNED

Although the optical switches can connect network devices in seconds as opposed to 15 minutes per test, Holley found the test engineers were somewhat reluctant to move to an automated network. The optical switches more than doubled the number of cables and transceivers interconnecting devices, which confused some test engineers because they didn't know the exact cables they were using. If a manually connected cable failed, they knew which one to replace. "We needed to train the test engineers on how the optical switches connect devices in the background," noted Holley.—*Martin Rowe, Senior Technical Editor*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BEST IN TEST

The PXI-5922 single-slot PXI card employs a custom multibit delta-sigma ADC to support high acquisition speeds at high resolution.
Courtesy of National Instruments.

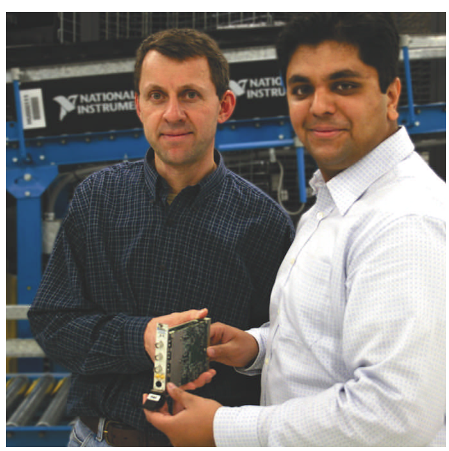
OPTIMIZING
resolution and sampling rate

RICK NELSON, CHIEF EDITOR

Engineers now can use a single digitizer to make measurements over flexible ranges of sampling rate and resolution. The National Instruments PXI-5922 single-slot PXI card can, for example, provide 16 bits of resolution at 15 Msamples/s, 18 bits at 10 Msamples/s, or 24 bits at 500 ksamples/s. Combined with software such as NI's LabView, the card can serve as the heart of numerous types of instruments, including audio analyzers, frequency counters, spectrum analyzers, ultrasound nondestructive inspection systems, and I/Q modulation analyzers.

Given the PXI-5922's flexible performance and suitability for use in such a wide range of applications, it's not surprising that *Test & Measurement World* readers have chosen it as the 2006 Test Product of the Year (www.tmworld.com/awards).

Kaustubh Wagle, National Instruments' product marketing manager for digitizers, said the card represents the latest innovation in a more than five-year effort to move digitizer frequency vs. resolution curves "up and to the right, gaining higher speed as well as higher resolution."



Niels Knudsen, principle hardware architect (left), and Kaustubh Wagle, product marketing manager for digitizers, with a PXI-5922.
Courtesy of National Instruments.

But achieving the 5922's high resolution for a wide range of frequencies proved to be challenging. Typically, Wagle said, NI leverages off-the-shelf components. To that end, he said, "We took a survey of all available ADC technologies out there—flash, SAR, delta-sigma. All these ADCs have different pros and cons, but none gave the sampling rate and resolution that we needed." For example, single-bit delta-sigma converters provide the necessary resolution but not sufficient speed. The solution? "We designed our own ASIC, called the Flex II ADC."

The Flex II ADC, he explained, employs a multibit delta-sigma conversion approach that provides the resolution of single-bit delta-sigma devices while offering higher conversion speeds. The multibit approach, however, exhibits nonlinearities that generate unwanted harmonics. To deal with that problem, Wagle said, the designers implemented a patented linearization technique. The result is an instrument offering –120-dBc (typical) spurious free dynamic range to 100 kHz.

Wagle cited the audio field as one area where the 5922 will find use. "If you look at audio, you might be surprised that a card like the 5922 would be required. After all, the audible frequency range is only 20 kHz." But, he said, "there is this notion out there among audio chip and equipment manufacturers that people not only hear but also feel the music by means of ultrasonic waves."

To ensure that they can measure any anomalies that a listener might in any way detect, Wagle said, "These companies want to test high-order harmonics way beyond 20 kHz," and they need to do it at 24-bit resolution. Existing 24-bit products, Wagle said, top out at 200 ksamples/s, while the 5922 continues working to 500 ksamples/s.

There's more to the NI PXI-5922 than the Flex II ADC. For example, it incorporates an analog front end that complements the Flex II ADC, eliminating input bottlenecks that could degrade dynamic performance. The input amplifier has software-selectable input impedances of 50 Ω and 1 MΩ. T&MW

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It sources, it measures, it automates

MARTIN ROWE, SENIOR TECHNICAL EDITOR

Since the dawn of electrical devices, engineers have had to perform basic voltage, current, and resistance measurements. One instrument that helps with these tasks is the 2400 SourceMeter from Keithley Instruments. In recognition of the 2400's longevity, *Test & Measurement World*'s editors have presented it with the 2006 Test of Time award, an award that recognizes product lines that continue to provide state-of-the-art performance for at least five years after their introduction.

The Keithley Instruments Model 2400 SourceMeter is the 2006 Test of Time award recipient.

Introduced in 1995, the 2400 was the first of what is now a full line of SourceMeters. It solved measurement problems for engineers testing passive and active components including resistors, capacitors, discrete semiconductors, laser diodes, circuit-protection devices, disk-drive heads, battery chargers, relays, and DC/DC power supplies. Some customers even use the 2400 to calibrate handheld DMMs.

Product manager Mark Cejer discovered customers using Keithley's source-measure units (SMUs), particularly the Model 236, for testing components. "The 236 was designed for materials and semiconductor research, but we found customers using it in many other applications," he noted. Cejer began interviewing customers to see what they wanted in an SMU. "They wanted more measurements, more speed, more I/O, and better computer communications, so we set out to design an instrument optimized for engineering and production measurements."

Chuck Cimino, lead engineer of the 2400 design team, found engineers using the Model 236 to make resistance measurements even though the instrument had no resistance function. "They were measuring voltage and current, then calculating resistance in a PC, so we decided to design in a resistance-measurement function," Cimino told me. "Customers wanted six-wire resistance measurements, something we had never designed into our products before." With the six-wire-ohms feature, engineers can use the 2400 to evaluate in-circuit components.

Prior to using the 2400, engineers used the Model 236 or other instruments to test components. The most popular set was a power supply and DMM. Others used curve tracers to evaluate discrete semiconductors. The 2400 eliminated the need for separate instruments. Because it has digital I/O, engineers use it to control component handlers, which automates production testing.

The 2400 presented Keithley with several design challenges. "Accuracy wasn't an issue because we already had a good analog front end," said Cimino, "but we had to design an instrument with twice the power of the 236 with added features and make it fit into a case half the size."

Another first for Keithley was the 2400's microcontroller, which was originally designed for automotive applications. It has a coprocessor that's dedicated to measurements, freeing the main processor to handle the display, analog outputs, digital I/O, and computer communications (IEEE 488 and RS-232). The instrument was also the first Keithley product to use flash memory technology for storing firmware. Thus, Keithley engineers can provide custom firmware to customers by e-mail.

Cimino led a team of eight electrical and software engineers who developed the Model 2400. They worked for 16 months to complete the project. Their efforts have paid off, not only for Keithley, but for engineers in many industries. T&MW


Chuck Cimino led a team of eight engineers in the 2400's development.


Mark Cejer is the product marketing manager for Keithley's SourceMeter line.

MAN *of* LETTERS

DAVID LEVENSON/REDUXPLUS

TEST ENGINEER OF THE YEAR Zafer Boz has developed a text-based test executive, serves as a principal test systems engineer, and is earning a master's degree, all while adapting to a new culture.

RICK NELSON, CHIEF EDITOR

READING, UK. Is a picture worth a thousand words? Not to Zafer Boz, who prefers text-based to graphical programming for the large-scale test programs he helps develop at STMicroelectronics. As a consequence of his preference, he developed a C-language-based test executive—called STE, for ST Test Executive—to help evaluate the wireless LAN chips his division designs. Boz developed STE and deployed it at other company facilities while pursuing a master's degree and also while continuing to perform his full-time test-engineering duties at STMicroelectronics.

The STE software is getting rave reviews from ST engineers in the UK and France, as well as from contractors in the US who are doing work for ST's UK wireless LAN business unit. "I wanted our engineers to be able to focus on their test work, rather than compiling code," said Boz. Although STE remains an internal tool, Boz would like to patent it for wider use. The software can be easily reconfigured to handle a number of different applications—functional tests, debugging, soak testing, calibration, and production test.

Boz's journey to his present position has spanned geography as well as technology. Now the principal test systems engineer in ST's Wireless LAN Business Unit, he was born in Turkey and became interested in technology while attending professional high school—roughly equivalent to a cross between high school and junior college in the US. He scored well in a university qualifying exam, enabling him to enter a four-year electrical engineering program at Ankara University.

Principal test systems engineer Zafer Boz develops automated tests for STMicroelectronics' wireless-LAN business unit.

In our September 2005 issue, we profiled the accomplishments of six outstanding test engineers from various industries, and we asked our readers to vote for the Test Engineer of the Year. Your choice? Zafer Boz of STMicroelectronics.

As part of his award, Boz has designated Ankara University to receive a $20,000 engineering grant, courtesy of National Instruments, the award sponsor.

From factory automation to RF

Boz's initial interests were in electronic cardiographic sensors for medical-imaging applications, but on completing his EE degree, he took a job in the factory-automation field, where he worked on a project involving process temperature control. That project, he said, provided a vantage point from which he could develop both hardware and software and appreciate the links between them.

A requirement for military service ended his factory-automation career, and on completing his military service, Boz joined the Turkish firm Mikes, which, in cooperation with Lockheed Martin in the US, manufactured electronic warfare systems for Turkey's F-16 fighter planes. Mikes, Boz said, needed someone with both hardware and software skills that could be applied to test-system development, and Mikes hired him as a test system engineer. "I quite liked the concept of test system engineering. I liked being involved from the initial system-level design stage and developing test-requirements documents. I liked working with systems engineers, digital engineers, and RF engineers."

Furthermore, he liked working with expensive instrumentation, which wasn't widely available to him in college. His university program, he said, was very strong on math and physics. At Mikes, he said, he augmented his background in theory with practical hands-on experience, and he discovered an affinity for working with instrumentation: "I felt quite comfortable getting any equipment to do what is required," after a brief review of the relevant manual.

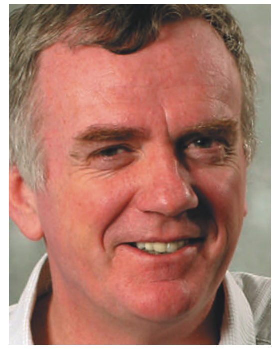
Moving to England

During his tenure at Mikes, Boz met his England-born wife-to-be, who was teaching in Turkey and with whom he now has two young daughters (see the photo accompanying the online version of this article, www.tmworld.com/2006_03). A Christmas holiday in England visiting his wife's family prompted Boz to consider seeking a job there. "I said to my wife, 'I'd like to practice interviews in a foreign land.'"

He did more than practice. He posted his resume on a Web site, went to three interviews, and landed three offers. The one he accepted put him at Synad Technologies in 2000, and he has remained there through the 2003 acquisition of Synad by ST-Microelectronics.

According to engineering manager Terry O'Sullivan, Boz's boss at ST, Boz signed on with Synad in April 2000, soon after the company's founding. O'Sullivan himself joined the company a few months later. The original goal of the company, O'Sullivan said, was to develop intellectual property that would speed the development of RF integrated circuits, but the founders believed they needed to focus on an applications area to which Synad itself could apply the IP it had developed. The company decided on wireless LAN chips.

O'Sullivan said, "Over the years, the synthesis tool has continued to evolve. When we are redesigning or designing new chipsets for WLAN applications, that tool is the first port of call. It does reduce the cycle time significantly, which ultimately saves money, so it is quite a benefit to the company at large. In fact, it enabled us to be one of the first to implement a dual-band chipset, at the time when ST acquired us in 2003. Some other companies were trying and failing [to implement dual-band chips capable of 2.5- and 5-GHz operation], and we believe the synthesis tool was a reason for our success. We felt we were on the cusp of some major wins."



JOHN CLARK

Engineering manager Terry O'Sullivan encouraged Boz to develop a test strategy that would allow rapid and accurate characterization and verification of reference designs.

The path to success required not only chip design but also the development and characterization of reference designs to demonstrate the capabilities of the chips themselves. O'Sullivan said, "I was taken on as the engineering manager to run the program to take the company's fabless ICs into reference designs, and to get into reference designs we had to do evaluation/characterization of the devices. And then after completing the reference designs, we had to support customers in production test."

He continued, "Zafer's role in that regard was to effectively implement the environments—and that's plural—to allow us to do evaluation/characterization work and then ultimately to allow customers to very easily run through a set of production tests to ensure that their solutions were actually performing as re-

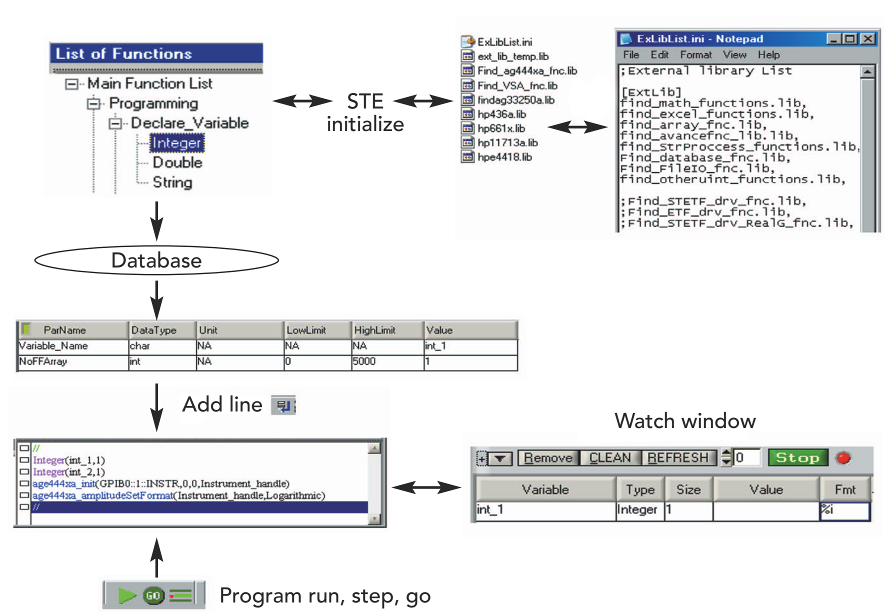


FIGURE 1. Within STE, a tree structure provides access to databases and external libraries. A watch window provides for changing parameter values on the fly.

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quired. So, it's quite an involved program technically. Wireless LAN was new to everybody back in those days—it was only five years ago, but it seems like a lot more. So, we had to pick up a lot of new techniques in terms of how to check out modulation schemes, how to check out transmitters' spectrum masks and receivers' sensitivity, how to deal with regulatory issues, and ultimately how to ensure those cards not only worked in a very structured environment from a test point of view but would go on into operation in a system-wide sense."

Boz and Professor Ahmet Kondoz discuss prospects for cooperation between Surrey and Ankara universities.

JOHN CLARK

Beyond the lab

That's when Boz and other members of O'Sulllivan's team got to put into practice their conception of the real world vs. the idealized world of a laboratory equipped with high-performance test equipment. "In the laboratory environment," said O'Sullivan, "everything is controlled. With the test equipment, everything is '50 Ω in, 50 Ω out'—everything is very controlled, and it all works reasonably well. But you take your device out of a test system, and it doesn't work so well, because you've got multipath transmissions, you've got noise, and you've got interference."

Boz's job, he said, was to initially examine the very deep technical requirements for evaluation and characterization as well as for production test in a structured test-equipment environment. Ultimately, he said, Boz had to develop "a structure whereby we could get a view of how a card would perform in a real system. It was not just 'set up some test equipment and play with it manually in a lab environment'—it was very structured, and it required a lot of innovation to come up with the techniques we ultimately used and depended on to get these cards through the process."

O'Sullivan continued, "WLAN at that point was very heavily focused on the laptop PC market, and we were developing chips you would load into a laptop PC and also into access points. Data rates involved there were anywhere from 1 Mbps to 54 Mbps over the air, and that was really stretching the technology."

Designing to IEEE 802.11b was the first challenge, according to O'Sullivan. "B operates to 11 Mbps in the 2.5-GHz ISM band, so we faced all the problems that plague unlicensed bands. One of the biggest issues we had actually was microwave ovens—we used to have times where we had to tell everybody at lunchtime, 'You can't use the microwave oven because we are testing.'"

He further explained that moving to the 802.11a standard brought its own challenges: "The emerging standard brought with it different issues and problems because it pushed the data rate up to 54 Mbps and operated in 5-GHz band, so you had the attendant issues of RF problems. A layman might think, 'Well, so what, you are only doubling the frequency.' But when you actually get down into the details of circuit design and analysis it's actually quite tricky. There are a lot of things to consider about how you route signals, how you avoid interference, how you screen yourself from your environment, how you calculate losses in your test setup—these are all actually quite important issues. If you don't take them into account in your test setup, all hell would break loose, and whatever you hand over would not be fit for the purpose."

Focus on mobility

In addition to technical challenges, the ST team was also facing marketing issues, which began to surface before the ST acquisition. O'Sullivan said, "It became apparent that in the PC market, the prices of WLAN chipsets were being pushed down so hard and so fast that it was becoming quite a bloody marketplace. Despite our best efforts working with ODMs [original design manufacturers] in Taiwan to control costs, we questioned whether this market made sense. So, we decided to focus elsewhere, and we chose the mobile market."

The ST acquisition made this choice particularly fortuitous, according to O'Sullivan. "One of ST's main strengths is to take a collection of die and other bits and pieces, like maybe some passive components, and to implement [them] as a multi," or multiple-die package. Those packages provide the small footprint and low power consumption necessary for use in PDAs

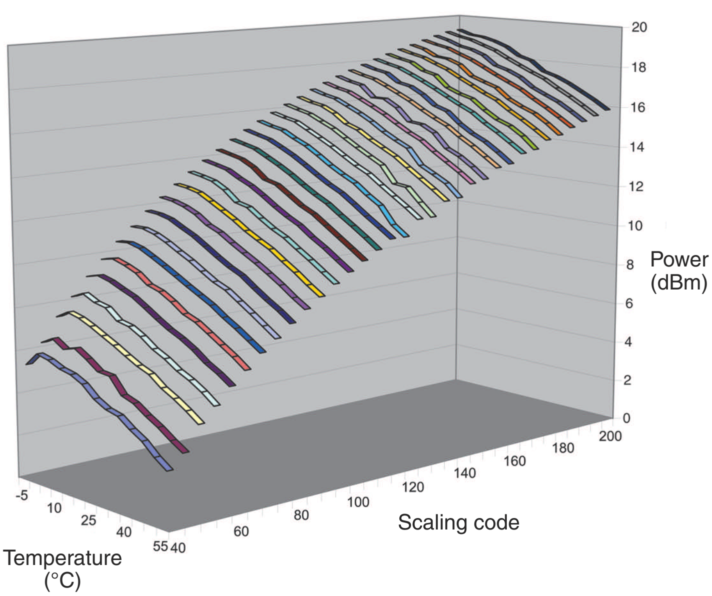

FIGURE 2. Device characterization requires consistent, repetitive testing under control of STE to determine, in this instance, transmission power relative to temperature and scaling code.

or high-end enterprise phones, and as costs and power consumption fall further, they could increasingly find use in midrange and even low-end phones.

Of course, the technology wasn't standing still, and further complicating the picture was the emergence of 802.11g, which moves A's 54-Mbps data rates into B's 2.5-GHz ISM band. Emerging chipsets need to embody G capability while continuing to minimize cost, footprint, and power consumption.

"I can't go to a customer and say, 'I'll give you a much smaller and less power-hungry device, but it only meets half the 802.11 specifications,'" said O'Sullivan. "We refer to the standards as the table stakes. You can't come to the table until you meet them. Then, you have to demonstrate your superiority with respect to cost, footprint, and power consumption."

To leverage ST's multichip-package capabilities while meeting the technical issues, the division needed a test strategy that would allow rapid and accurate characterization and verification of reference designs. "Zafer has helped me push that," O'Sullivan said.

"At Synad it was amazing," Boz commented. "I was employed as a test development engineer, and I started working with evaluation cards and got involved in software designs as well as hardware designs, with the help of RF engineers. I was doing initial chip characterization, so I managed to do multiple disciplinary things. At Synad, I've worked quite hard because I always get good motivation from the people around me, who are working hard as well. I was very happy to get lots of experience with chip characterization, which I didn't have experience with in Turkey, where we were working with huge boxes for the military."

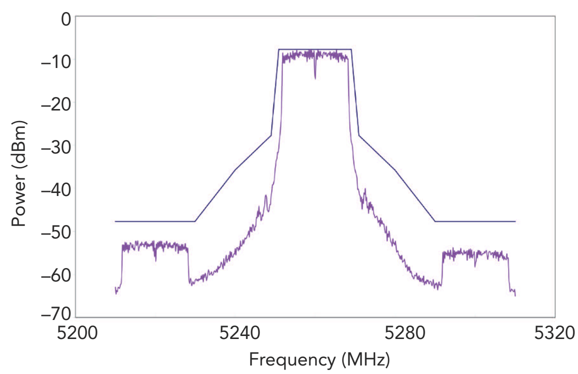

FIGURE 3. Spectral mask testing is one of many functions that STE and test-scripts developed with STE can control.

Developing STE

But test software development was an area where Boz proved to be particularly skilled. "I was always developing software applications for different purposes, like controlling RF synthesizers. One day, Terry mentioned that we needed software that we could reconfigure to change inputs and outputs and other parameters without the need to recompile code." Thus was born STE, which manages test racks containing instruments such as Rohde & Schwarz SMIQ vector signal generators and FSQ signal analyzers, controlling signal-generator parameters, acquiring signal-analyzer measurements, and supporting the export of measurement data to spreadsheets for further analysis and documentation.

Boz had acquired a familiarity with National Instrument's LabWindows/CVI while working at Mikes in Turkey, and this proved invaluable in the development of STE. He said that LabWindows' built-in libraries of math and instrumentation functions, its ability to communicate within the Windows environment, and its C language environment formed the basis of STE (**Figure 1**). Said Boz, "LabWindows/CVI is an excellent tool for engineers. I like the idea of LabView as well, but if you are an electronic engineer, you should, in my personal view, go and type your code yourself."

Boz said STE offers the benefits of both visual and text coding, and it also provides for external library support and includes a database to store function parameters. Within STE, a Windows-like tree structure provides access to the functions, and STE can link to external libraries. It operates on the functions stored in the database and allows on-the-fly parameter changes via a "watch window." With new parameter values, test programs can be run or stepped through without the need for recompilation.

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The key benefit, O'Sullivan said, is that STE provides a test environment that's fully automated—"you press a button and every time you run that test, you consistently get the same results. It makes the overall test setup easier and ensures consistency, and consistency is one of the big issues, especially when you are talking about the frequencies we are working at. We need to be sure that part after part after part after part is doing the right thing." STE has proven its usefulness in a variety of areas, including transmitter temperature characterization (**Figure 2**) and spectrum mask tests (**Figure 3**).

Boz does caution that STE is for engineers: "You have to know what you are doing. It is very powerful but very dangerous, too, if you don't know what to do."

The university connection

Not content with resting on his laurels, Boz is completing a master's degree program at Surrey University, where he is impressed with the practical hands-on experience students get. "I was amazed to see students actually involved in launching data-communications satellites." Boz himself is working on wireless subsystem design at Surrey, specializing, on the recommendation of O'Sullivan, in power-amplifier linearization.

Boz noted that Surrey is well funded when it comes to lab facilities. And in addition to having access to Surrey's RF measurement hardware, he also arranged with Agilent Technologies to obtain a license to Agilent's ADS electronic-design-automation software for RF and microwave applications. ADS, he said, will help him design the power amplifiers that embody the linearization techniques he is developing.

Boz's experiences at Surrey have motivated him to want to help develop more funding for Ankara University. As Test Engineer of the Year, Boz is entitled to assign a $20,000 grant to an engineering school, and he has designated Ankara University to receive the donation.

To help utilize and build on that initial grant, Boz solicited assistance from Professor Ahmet Kondoz, who teaches at the Centre for Communication Systems Research and directs the I-Lab Multimedia and DSP research group within the School of Electronics and Physical Sciences at Surrey. "Professor Kondoz has kindly accepted my request to help utilize the award," Boz said.

With the grant, said Kondoz, "We hope to start a relationship between Surrey and Ankara University, which I hope to continue with other funding from EU framework programs."

He added, "We hope to have key people from Surrey go to Turkey and give seminars, and we are exploring the possibility of some of their people coming to Surrey. We also want to set up students' prizes in Ankara University and pursue other ideas." Details, he said, are still under discussion. T&MW

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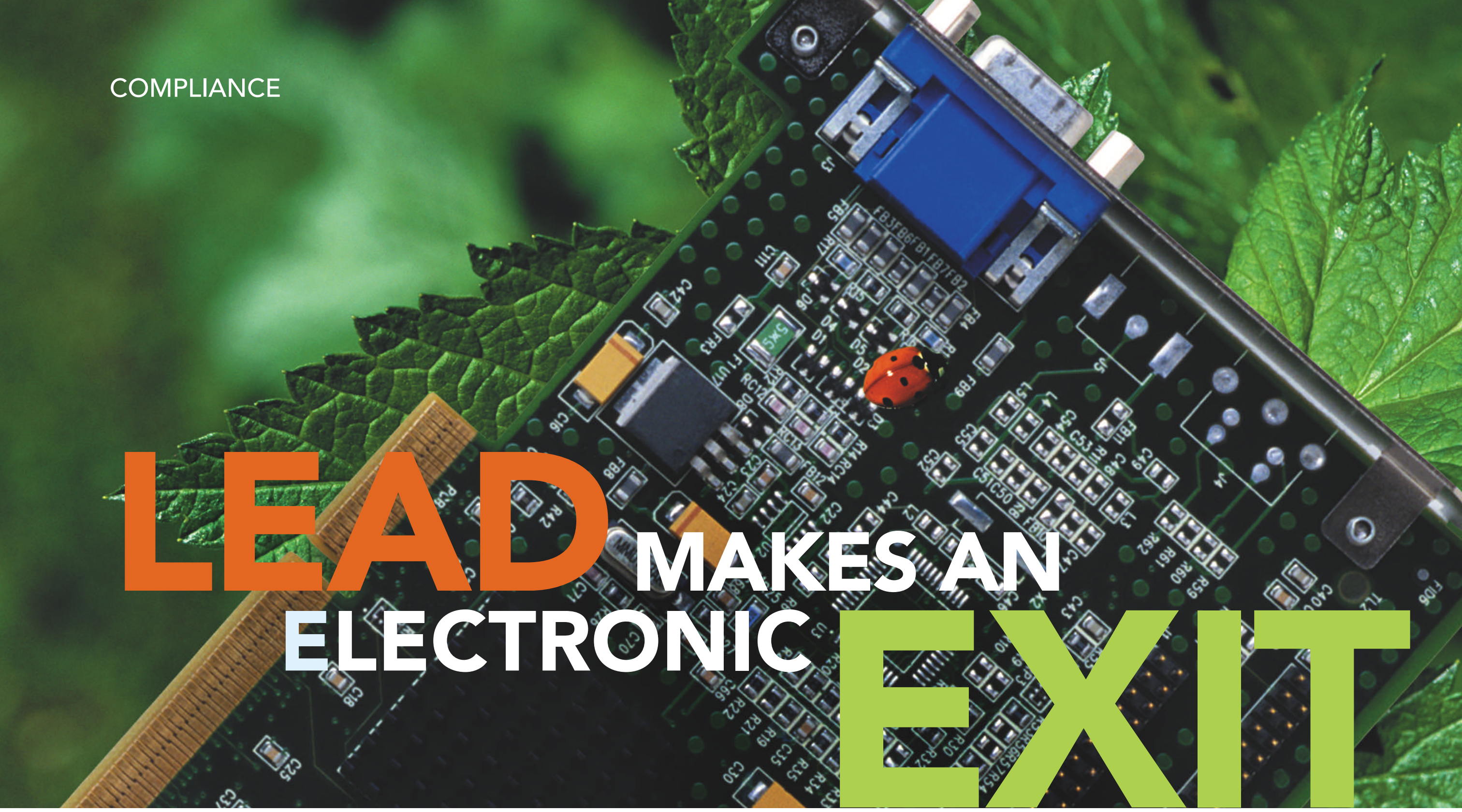

LEAD MAKES AN ELECTRONIC EXIT

Lead and other hazardous materials are coming out of electronic products. Test equipment has an exemption, but it still must be recycled.

MARTIN ROWE, SENIOR TECHNICAL EDITOR

First unleaded gasoline debuted, then it was unleaded paint, and now electronics is losing its lead. As new European Union (EU) regulations governing the use of lead in electronics and the disposal of electronic products go into effect, many manufacturers are scrambling to redesign their products and devise new recycling policies. Complying with the EU requirements can be difficult, but similar regulations are also being devised in countries such as China and Japan, so it's becoming mandatory for manufacturers to "get the lead out."

As of August 13, 2005, electronic products sold into the EU had to comply with Directive 2002/96/EC on waste electrical and electronic equipment (WEEE), which requires manufacturers to provide a means for recycling the materials in their products (Ref. 1). In addition, by July 1, 2006, many electronic products sold into the EU must be free of hazardous substances, as dictated by Directive 2002/95/EC (Ref. 2), which covers the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS). Of the six substances restricted by the RoHS directive, lead is the most prominent in electronic products (Ref. 3). Because of its "mission-critical" nature, test-and-measurement equipment is currently exempt from RoHS but not from WEEE (see "Why exempt?" p. 40).

To learn about the difficulties manufacturers face in complying with the directives, I spoke with representatives of two North American companies that have taken the first steps toward compliance. On November 18, 2005, Sealevel Systems (Liberty, SC) announced an RoHS-compliant PCI board that adds serial ports to computers. On December 7, Exfo (Vanier, QC, Canada) announced that its telecom-test products were in compliance with the WEEE directive when it went into effect in August.

Compliance achieved

Sealevel's COO, Ben O'Hanlan, said that the company decided in 2004 to research how to produce an RoHS-compliant product. O'Hanlan put manufacturing manager Mike Demos in charge of the project.

"The road to RoHS compliance is exhausting," claimed Demos. "We worked with 17 component manufacturers and three distribu-

tors to get the RoHS-compliant parts we needed. We changed 46% of the board's components, and we changed our PCB plating and reflow processes to remove the banned materials."

Because Sealevel was such an early adopter of RoHS, the company had difficulty procuring lead-free ICs, connectors, and passive components. Demos had to contend with long lead times—as much as 16 weeks for many parts. "I feel sorry for companies that are just starting out," said Demos. "If you don't have your parts orders in by now, you won't meet the deadline."

Electronics manufacturers must change their reflow processes to comply with the RoHS directive, but lead-free solders introduce manufacturing problems. The tin/silver/copper (SnAgCu, also called SAC) solder alloy seems the most promising, but it melts at 217°C, as opposed to 183°C for traditional tin/lead (63% Sn, 37% Pb) solder. **Figure 1** shows the reflow profile that Sealevel uses for its RoHS-compliant boards. Maximum temperature is 234°C.

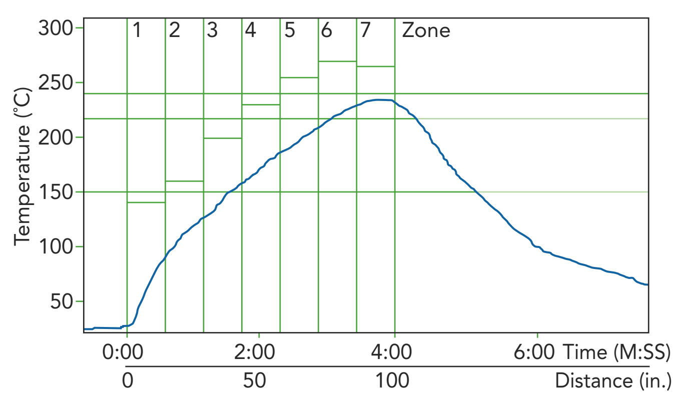

FIGURE 1. The reflow temperature reaches 234°C, but the time a board spends at that temperature is short enough to prevent permanent deforming of the PCB laminate. Courtesy of Sealevel Systems.

Standard FR4 PCB laminate material softens at such temperatures because of its low glass transition temperature (Tg) of about 140°C. Tg is the temperature where a polymer substance such as PCB laminate begins to lose its glass-like properties and take on rubber-like properties. Working with a contract manufacturer, Demos chose FR408 PCB laminate because of its Tg of 180°C.

Although the reflow temperature exceeds a laminate's Tg, the time that the laminate spends in its "rubbery" state is short enough to avoid permanent deformation. Tg, however, shouldn't be your only concern. "Many manufacturers are concentrating solely on the Tg as the primary metric," said Demos, "but the coefficient of thermal expansion (CTE) in the z-axis is equally important. The CTE of FR408 is 65 ppm/°C while that of standard FR4 is 165 ppm/°C. Too much thermal expansion can cause a laminate to crack."

In addition to changing its PCB laminate, Sealevel needed a way to identify RoHS-compliant serial-interface boards because the company is building both compliant and noncompliant versions of its product. Sealevel can't discontinue the noncompliant version because some customers still insist on it.

Although Sealevel's RoHS-compliant board uses the same circuit layout as the noncompliant version, the contract manufacturer needed a new solder-paste screen because of residual lead used in the noncompliant screen. That provided an opportunity for marking the boards.

Sealevel added a pair of identifier pads with gold plating (**Figure 2**) to both versions of the PCB. During solder pasting,

Why exempt?

While the vast majority of electronic products must comply with the RoHS directive by July 1, there are exceptions—most notably, military and medical electronics (category 8) and test, measurement, and monitoring equipment (category 9). These products require a higher level of reliability than, for example, consumer products.

"Don't expect this exemption to last forever," warned Jeffrey Bock, RoHS lead program director at TUV Rheinland. "The exemption on measurement equipment will probably end between 2008 and 2010." Many test equipment manufacturers recognize this and have begun to transition their product lines to lead free. "Even if you claim an exemption today," added Bock, "if your competitor's products comply with RoHS, then the market will force you to comply."

Test products such as ATE systems, data-acquisition and control systems and their components, and most bench test equipment are sold only to businesses. But some test products such as handheld DMMs are sold to consumers, and Bock argues that they could fall outside category 9. Jim Cavoretto, CTO at Fluke, argued to the contrary. "The RoHS directive doesn't apply to DMMs," he said, "because they're defined in category 9 as monitoring and control instrumentation. A small percentage of test equipment does find its way to consumers, but it's still out of the scope of the directive."

At Sealevel Systems, management had to decide if the serial-interface board was RoHS exempt because it is mainly used as part of a measurement system. "We chose to comply," said COO Ben O'Hanlan, "because the product can be used in other applications."

Despite the exemption for test and measurement equipment, numerous test equipment manufacturers are converting to lead-free products. For example, AEMC Instruments intends to comply by the July 1 deadline, and National Instruments and Agilent Technologies have statements on their Web sites that say they plan to comply. In fact, NI has already produced RoHS-compliant versions of the ICs used in its IEEE 488 controllers.

Martin Rowe

the solder screen for the compliant board lets solder paste pass through to the pad marked "RoHS," while the screen for the noncompliant board passes solder to the "Non-RoHS" pad. Thus, the boards are clearly labeled based on which pad is covered with solder.

RoHS and test

Sealevel engineers had to test the compliant cards to ensure that they would function properly despite being subjected to higher reflow temperatures. Prototype boards went through numerous thermal cycles before testing. Demos put the boards through a 0°C to 70°C cycle for three weeks, a –20°C to 80°C cycle for one week, and a –40°C to 100°C cycle for another week.

Sealevel's management chose to go for compliance on the interface card even though it could have argued that the product is exempt from RoHS based on its primary use in measurement systems. "Sooner or later, all of our products will have to comply with RoHS," said O'Hanlan, "so we decided to start the transition early."

Jeffrey Bock, RoHS lead program director at TUV Rheinland, sees the move toward compliance as inevitable. "As soon as one company complies with RoHS," he said, "its competitors will feel pressure to do the same or be seen as behind. Some telecom rack-mount equipment that's professionally installed is RoHS exempt, but some manufacturers have already begun to comply," he added. "That's forcing competitors to comply."

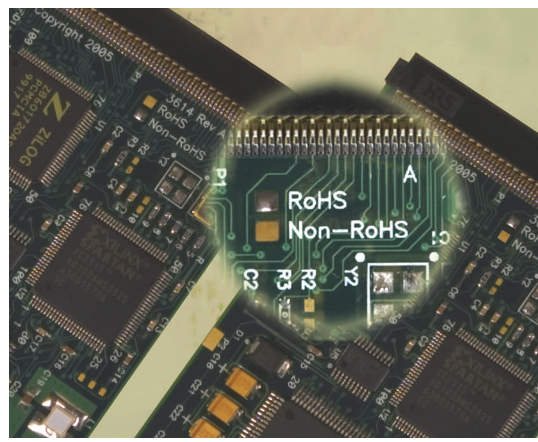

FIGURE 2. Solder on a pad indicates whether a board is RoHS compliant. Courtesy of Sealevel Systems.

WEEE requirements

Communications test-equipment maker Exfo is also moving toward RoHS compliance. The company has started receiving compliant parts, which it can use with its noncompliant reflow process. Once Exfo can get all the compliant parts it needs, it will switch to the compliant reflow process.

In the meantime, Exfo has announced that its products comply with the WEEE directive, which requires that manufacturers provide a means of reclaiming and recycling the content of their products sold into EU countries. "The WEEE directive is the minimum that countries must translate into legislation, while RoHS must be translated as is," said Stephen Bull, VP of R&D at Exfo. "The WEEE directive can vary from country to country within the EU. The paths to recycling are still confusing and differ."

In general, manufacturers or distributors who introduce an electronic product for sale in EU countries must take responsibility for its recycling. They must work with an EU recycler partner—one or more for each country—who will properly dispose of the products. Manufacturers must provide end-of-life instructions, making them available through a phone number or online. The instructions tell customers to send a product to the manufacturer's recycling partner, and depending on the country,

GET MORE INFORMATION

The online version of this article contains links to sites where you can learn more about the RoHS and WEEE directives and their impact on electronics manufacturers. **www.tmworld.com/2006_03**

either the original manufacturer or the distributor must pay for the shipping. Each manufacturer or distributor must also establish a secure Web site for providing dismantling instructions to the recycling partners.

To comply with the WEEE directive, Exfo places a symbol (**Figure 3**) on its telecom products that indicates that the product must be recycled in the EU. "Fifty percent of our telecom products' weight must be recyclable and 70% must be recoverable," noted project manager Marc Turgeon. According to Turgeon, "recyclable" means that a part can be reused to make another product, while "recoverable" means that a part can have value once disassembled. For example, it contains usable energy and can be burned.

To meet the weight requirements (called the "recycling rate"), a manufacturer must provide disassembly instructions. In addition, it must provide information on materials used in the product. TUV Rheinland's Bock noted that recyclers have machines that can separate recyclable materials from assembled circuit boards. The recycler then processes the materials into a form that makes them reusable.

FIGURE 3. Exfo affixes this logo to its products to indicate that they must be recycled in the EU.

Manufacturers and distributors have several options to provide funds for recycling. Exfo's Bull noted that the customer pays a recycling fee to the producer (manufacturer, distributor, or importer) at the time of purchase. In some countries, the producer passes on the recycling fee to a government association that pays for the recycling. In other countries, each producer must contribute to its own recycling fund.

The RoHS and WEEE directives force manufacturers to make their products more environmentally friendly and more easily recycled. The EU is leading the way, and US manufacturers will need to comply with regulations in order to remain competitive in worldwide markets. T&MW

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2. Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS). europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_037/l_03720030213en00190023.pdf.

3. The five substances other than lead are cadmium, hexavalent chromium, mercury, polybrominated biphenyls, and polybrominated diphenyl ethers. According to Molex, the five others have little use in electronic products. www.molex.com/leadfree.

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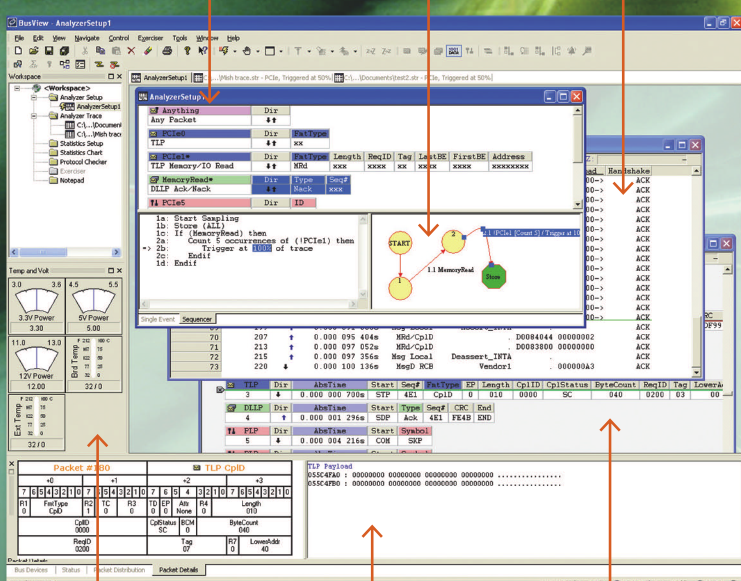

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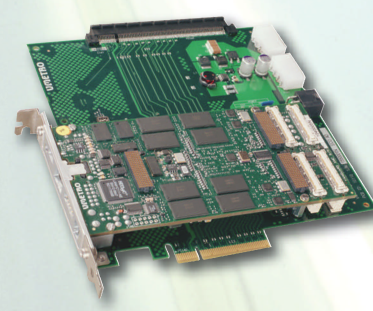

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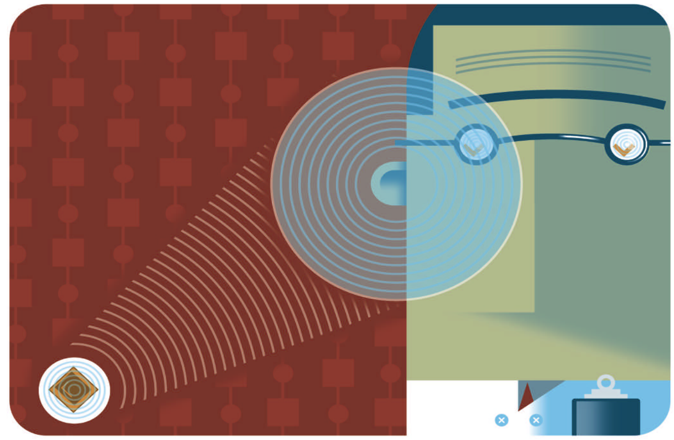


Acoustic microscopes let you see inside a chip, even when it's not there.

PROBING flip-chip interfaces

DR. LAWRENCE W. KESSLER, SONOSCAN

Failure analysts often use scanning acoustic microscopes to image flip-chip features such as underfill voids, delaminations, and disbonded solder bumps. As designers have decreased the size of IC features, microscope vendors have introduced higher-frequency and higher-resolution instruments that let analysts examine the ever-smaller features, such as the inner-layer dielectric (ILD) materials in advanced flip-chip devices.

At Sonoscan, we have found a way to process acoustic-microscopy signals and store them to create what we call a "virtual sample." Our software can then use this raw information to produce images at any depth within a flip-chip device or other sample, even in the absence of the physical part. Thus, if a chip fails, or if tests destroy it, failure analysts can use the virtual-sample data to construct an acoustic image of any part of a previously scanned device.

This capability lets failure analysts image the extremely thin and structurally weak ILD materials that help advanced chips achieve high speeds. In the past, individual layer features within the active portion of a die have not been targets for acoustic microscopy simply because previous microscopy techniques could not differentiate their small features.

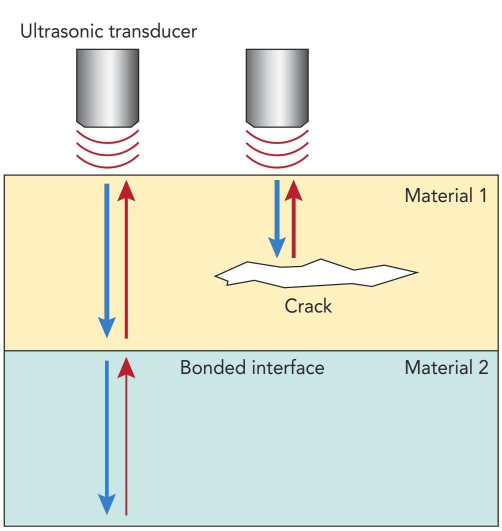
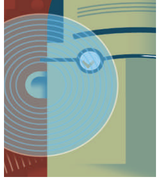


FIGURE 1. When ultrasonic pulses from an acoustic microscope encounter an interface, some energy reflects and some energy continues through the material. A crack or gap reflects almost all ultrasonic energy back to a transducer.

How scanning acoustic microscopes work

A scanning acoustic microscope focuses VHF or UHF ultrasound pulses from a transducer into a sample several thousand times a second. The reflected, or echo, signals provide information about interfaces between materials within the device. As the transducer moves from point to point in an x-y pattern across a sample, software converts the echo signals into a pixel that corresponds to each scanned point.

An interface between dissimilar materials reflects a portion of the ultrasonic signal back to the transducer, while the remainder of the signal crosses the interface and travels farther into the sample (**Figure 1**). Interfaces deeper within the flip-chip device also reflect and pass the ultrasonic signal. Cracks, delaminations, and other gaps, however, reflect virtually all of the pulse, so little acoustic energy travels through these features.



To restrict imaging to a desired depth, or to a thin horizontal layer, analysts set a time "window" that centers on the time it takes the signal to reach the depth of interest plus the time it takes the echo to return to the transducer. The microscope processes the echoes received during the window period to create an acoustic image of the "slice" through a chip that the analysts want to examine.

Most acoustic images are displayed as planar (2-D) monochrome or pseudo-color images that show the characteristics of interfaces. These images let analysts verify a device characteristic, such as a solder bump properly bonded to its bond pad, or detect the presence of a defect, such as a solder bump disbonded from its bond pad.

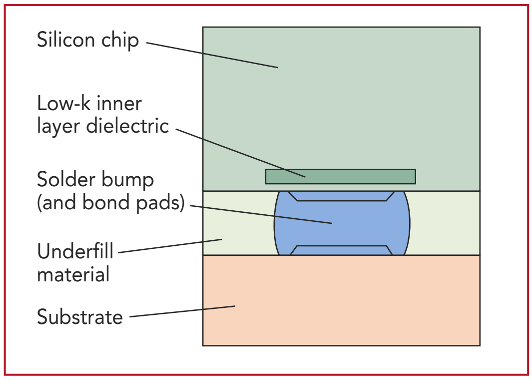


FIGURE 2. A cut-away diagram of a flip-chip device shows the relative sizes and shapes of features that interest failure analysts. The vertical scale is exaggerated to make the inner-layer dielectric (ILD) visible.

A new method

Instead of storing and processing echoes received from a sample only within a defined window, we have found a way to save every ultrasonic echo signal obtained during scans of a flip-chip device. This means that analysts aren't limited to viewing only a single layer immediately after performing a scan; instead, they can can access raw echo data from an entire volume of the scanned sample and examine any layer at any time.

When analysts have the raw echo data, they can go beyond planar images and apply other acoustic-microscopy techniques. These techniques include acoustic cross-sectioning, which provides the equivalent of a physically sectioned view *through* the part, and 3-D acoustic imaging, which scans multiple layers and adjusts the visibility of various features to provide transparency and perspective. (These techniques go beyond the scope of this article.)

To collect virtual-sample data, the ultrasonic transducer scans across the chip several times as it "probes" progressively deeper regions. Software combines the echoes—if any—from the various depths beneath each transducer position to create a single waveform that contains information about all material interfaces. This collection of waveforms—one waveform per scanned position—becomes a virtual-sample file. Although a scanning acoustic microscope could collect data from all depths in a single scan, the process would yield distorted results because the technology lacks a depth of field sufficient to obtain information for all depths with one measurement. Thus, the microscope must focus the transducer for each depth.

In a flip-chip device, the die-to-underfill interface reflects a portion of the ultrasonic energy. The remaining ultrasonic energy travels deeper into the chip where defects (if any) within the underfill as well as the underfill-to-substrate interface also pass and reflect ultrasonic energy.

Scanning the ILD

A flip-chip includes several closely spaced interfaces such as the union of a solder bump and its bond pad, the mating of the bond pad to the IC die, and the attachment of the passivation layer and the die underfill (**Figure 2**). In a layer slightly above this, you can observe the porous ILD material used in the high-frequency flip-chip devices. The low-dielectric constant of this material permits the high-speed operation of the electronic circuits on the chip. The porosity of the ILD makes it relatively easy to discern in a scan.

Although the ILD material provides electrical advantages, it presents a manufacturing challenge because of its porous structure, which makes it prone to crack during processing. Cracks and other gaps in most materials efficiently reflect ultrasound, but cracks in ILD materials tend to be extremely thin, which can make them difficult to detect in a sonic microscopy image. Recent tests at

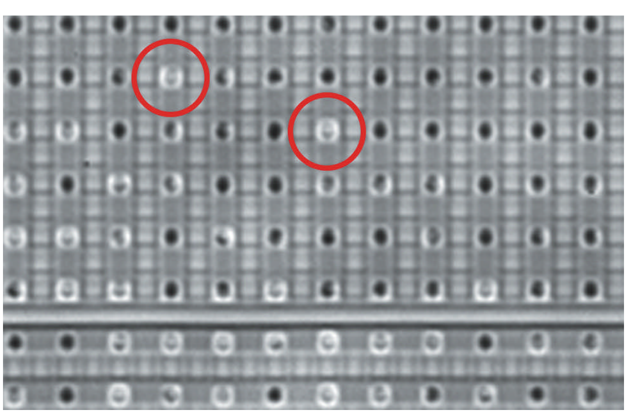


FIGURE 3. This acoustic image of a small portion of a flip chip shows the features that exist within a thin layer near the interface between the chip and its underfill. The circled areas show defects; probably cracks in the ILD material.

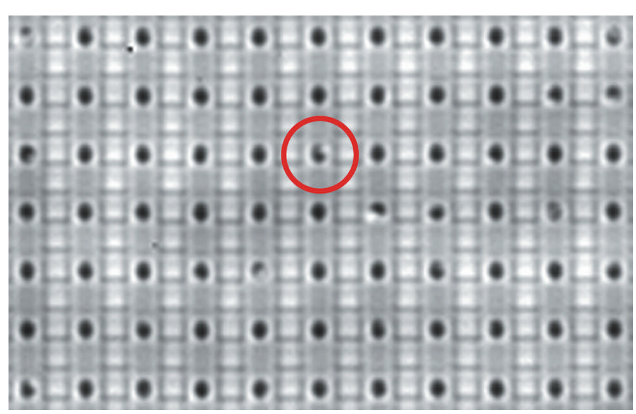
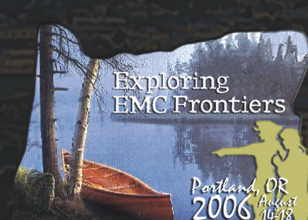


FIGURE 4. This circled area in this flip-chip image shows a small defect—probably an ILD crack—that only partly obscures the dark solder bump beneath it.


Ready to Hipot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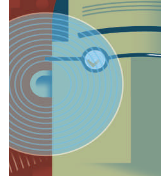


Sonoscan have shown we can detect cracks that range in width from 1000 Å down to 100 Å.

The location of these ILD cracks presents another imaging challenge: They often occur only several microns above the interface between the chip surface (generally the surface of the passivation layer) and the top surface of the underfill material. Because delaminations can occur at this latter interface, we didn't know whether an acoustic microscope could distinguish between nearby underfill delaminations and ILD cracks. As it turns out, it can.

Figure 3 shows the acoustic image of a small portion of the chip-underfill interface on an advanced flip-chip device. This image results from data obtained from a high-resolution 300-MHz transducer. The window applied to the echo signals lets the microscope scan vertical features from just above the top of the ILD layer to just below the tops of the solder bumps that attach the flip chip to a substrate. We had scanned the device and saved a virtual-image file that let us produce this image even though we no longer had the device.

In this type of acoustic image, a solid bond between each solder bump and its associated bond pad appears as a medium-gray to dark-gray dot. (In this case, the darker areas indicate a "good" interface—one that passes most of the ultrasonic energy.) Most of the bonds shown in Figure 3 look good, but larger, more reflective (white) features obscure those bonds beneath them. As a result, you cannot determine whether those hidden bonds are good or bad. (The light areas indicate high reflectance of ultrasonic energy at an interface due to a gap or crack.) Circles highlight two such locations, which may contain cracks in the ILD material over the active portion of the chip. This type of high-resolution acoustic image lets analysts determine the relative depth of the various features in this device, even when only a few microns separate them.

Detailed analysis of the acoustic images may yield more information about potential defects. The image in **Figure 4** results from processing virtual-image data from a flip-chip device similar to the one shown in Figure 3.

The superimposed circle identifies one bump bond partially obscured by a small white "notch" that appears to be a small crack in the ILD material. Given the fragility of the material, this crack could "grow" and cause a failure later in the chip's life.

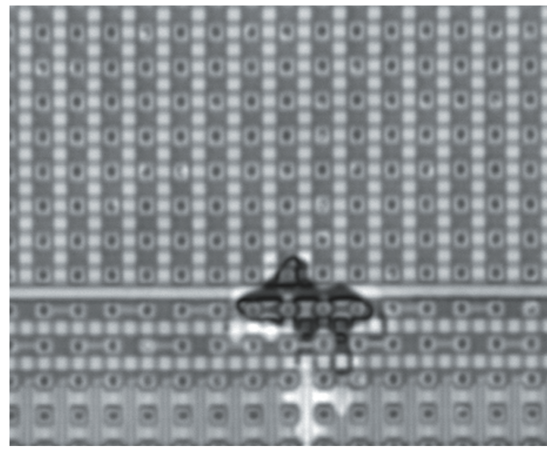


FIGURE 5. Two underfill voids, one void above the underfill (white area) and the other void below the underfill (black area), appear in this 300-MHz image. The image shows several questionable ILD features—the lighter solder bumps in the upper matrix of dots.

Figure 5 shows a similar flip-chip device imaged at 300 MHz, but to obtain the raw data, we used a transducer that provided higher contrast and lower resolution. The two large features—one black and the other white—represent voids in the cured underfill material. The void that appears white is located at the top of the underfill—the interface with the chip. The black void occurs at the bottom of the underfill, where the latter interfaces with the substrate. This void appears black in the image due to constructive and destructive interference of the ultrasonic signal. T&MW

Lawrence W. Kessler *is president and CTO at Sonoscan, a supplier of scanning acoustic microscopes that specializes in acoustic-microscopy development and applications research. Dr. Kessler has written more than 150 technical papers and holds nine patents that cover ultrasonic imaging-system technologies and applications.*

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

Bluetooth tester handles EDR and AFH

Anritsu's MT8852B Bluetooth test set combines both Bluetooth Enhanced Data Rate (EDR) and Adaptive Frequency Hopping (AFH) testing capability. The ability to conduct EDR and AFH tests turns the test set into a verification tool for chipset developers, module manufacturers, and developers of a range of consumer products that have Bluetooth interfaces.

The MT8852B performs the new radio layer measurements defined in the Bluetooth Revision 2.0 EDR standard, along with basic rate measurements, from a single "run" button key-press. To verify reliable connections with other Bluetooth products, the MT8852B performs transmitter error vector magnitude (EVM) and receiver-sensitivity tests at the higher data rates associated with EDR. It has a typical test time of less than 10 s for new EDR products, meeting the demands of high-volume manufacturing lines. In addition, the MT8852B can perform AFH tests to determine device performance in the presence of interfering signals, such as those from WLAN, Digital Enhanced Cordless Telecommunications (DECT) phones, and microwave ovens. All measurements are performed in the instrument, eliminating the need for an external PC.

In addition to delivering accurate measurements, the MT8852B tests are performed in full compliance with the Bluetooth 2.0 EDR test specification and can be customized for either extended testing or high-speed testing. Anritsu's free BlueTest production test software automates the creation and running of test scripts, storing results in a built-in database for fast production line setup. A "quick test" measurement script runs in 10 s for high-speed product testing.

Base price: $24,000. *Anritsu, www.us.anritsu.com.*

Analog generator delivers 3 GHz

The R&S SMA100A analog signal generator offers a compact footprint that requires only two 19-in. rack units, delivering pure output signals over its operating frequency range of 9 kHz to 3 GHz. Single sideband (SSB) phase noise is –135 dBc (and optionally –140 dBc) at a 20-kHz carrier offset at 1 GHz and a 1-Hz measurement bandwidth, wideband noise of –157 dBc at a carrier offset greater than 10 MHz, and nonharmonic noise suppression of –90 dBc at a 10-kHz carrier offset. An optional low-jitter 1.5-GHz clock synthesizer is available as well.

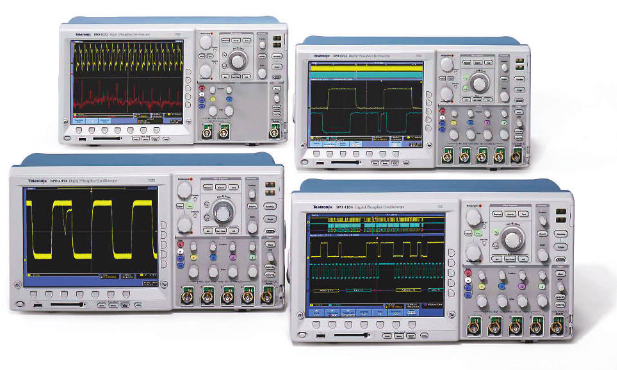
With level and frequency-setting times under 3 ms, the R&S SMA100A is suited for production and ATE applications. Frequency and level changes can be saved in a list, allowing setting times to be reduced to less than 450 µs. The output level of the R&S SMA100A ranges from –145 dBm to +25 dBm and can be set quickly via the electronic attenuator.

The R&S SMA100A can generate amplitude modulation and pulse modulation signals, and frequency and phase modulation are optional. For military and aerospace applications, the instrument can be upgraded with a precision pulse generator. The signal generator can be remote-controlled via IEEE 488, USB, and Ethernet, and its graphical user interface makes benchtop operation simple.

Base price: $18,720. *Rohde & Schwarz, www.rohde-schwarz.com.*

Scroll through waveform samples

Tektronix has produced what can only be described as the high end of the low-end range with the DPO4000 series of oscilloscopes. These scopes differ from other Tektronix models, because of their 10 Msamples of waveform memory per channel and because of a feature called Wave Inspector, which helps you search through



the scope's long memory to find the event of interest.

Wave Inspector adds a knob and eight buttons to the scope's front panel. The knob has two parts: pan and zoom. You can mark distinct points on a waveform, and you can use a particular characteristic of a waveform as a trigger.

The DSP4000 series has a 10.4-in. LCD display and is just 5.4-in. deep. Three four-channel models cover 350 MHz, 500 MHz, and 1 GHz, and a two-channel model covers 350 MHz. The scopes also include a USB peripheral port on the front panel and a slot for a CompactFlash drive.

Price: $7000 to $14,000. *Tektronix, www.tektronix.com.*

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Sensor makes laser measurements

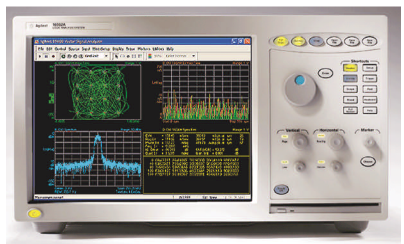
The Omron ZS smart measurement sensor combines two-dimensional CMOS imaging with precise laser measurement. The high-speed, high-sensitivity inspection system provides 110-µs response time and 0.25-µm resolution for inspecting moving work pieces and capturing data on the fly. The sensor's gain setting can be customized for specific environmental conditions.

The ZS features separate sensing heads and amplifiers. Five sensor heads are available for distances ranging from 20 to 200 mm and for measuring ranges from ±1 to ±50 mm. Two regular reflection heads handle transparent and mirror-surface work pieces; three diffuse reflection heads can measure black rubber and dark plastic work pieces. Data is transferred between the sensing head and amplifier via a high-speed interface with no signal degradation. All heads are rated IP67 to withstand washdown for measurements in harsh environments.

Price: amplifier—$1450; sensor heads—$2450 to $3450. *Omron, www.omron.com/oei.*

Logic analyzers do vector signal analysis

Agilent Technologies has integrated its logic analyzers with the company's 89600 Series VSA (vector signal analysis) software. The company describes the resulting combination as a digital vector-signal-analysis system that delivers precise, accurate modulation measurements on the digitized communication signals found in DSP-based radio transceivers used in cell phones, base stations, satellite and military communications systems, and radar applications.



Running on Agilent 1680, 1690, and 16900 series logic analyzers, the Digital VSA software provides analysis of digital base-band or digital IF signals in a variety of formats, including scalar base band, scalar IF, complex I/Q, magnitude and phase, and phase only. It also permits flexible demodulation that measures carrier offset, error vector magnitude (EVM), and frequency error for QPSK, QAM, GSM, EDGE, WiMAX, W-CDMA, and others. Finally, it supports multiple display formats, including phase vs. time, frequency vs. time, and spectrogram.

Base price for the addition of the Digital VSA software to a logic analyzer: $10,000. *Agilent Technologies, www.agilent.com.*

Thermal shock chamber needs little room

You can now add thermal shock testing to your quality assurance program without gobbling up lab space or power. Just 44 in. wide, Espec's TSD-100 thermal shock chamber meets MIL-STD-883 test method 1010.7 for samples of up to 22 lbs, and it reduces power consumption by 60% compared to the company's ETS4-2CW chamber. The chamber's 4-ft^3 interior volume permits testing of larger products and subassemblies, as well as large quantities of components such as ICs. To further reduce the size of the TSD-100, Espec mounted the touch-screen controller on the door. *Espec North America, www.espec.com.*

14-bit PCI digitizer

A deep-memory digitizer joins AlazarTech's family of 14-bit, 125-Msample/s PCI waveform digitizers. The dual-channel ATS460-128M packs 128 Msamples of acquisition memory per channel. An optional dual-port memory upgrade allows data to be transferred to host PC memory even if an acquisition is in progress. Each of the ATS460's two channels has 65 MHz of full-power analog-input bandwidth. With software-selectable attenuation, you can achieve an input voltage range of ±20 mV to ±20 V. Price: ATS460-128M—$3995; dual-port memory upgrade—$645. *AlazarTech, www.alazartech.com.*

I2C bus analyzer/tester

The CAS-1000-I2C is a combined bus analyzer, exerciser, debugger, tester, and programmer for monitoring and testing devices and systems incorporating one or more I2C buses. You can use the instrument to monitor in real-time and log I2C bus traffic, generate traffic to exercise the bus and communicate to its components, program in-system EEPROMs, validate bus specification compliance, confirm the protocol of bus traffic, and emulate I2C-compatible devices that are not yet connected to the bus. The CAS-1000-I2C also includes a JTAG controller that, when used with Corelis's optional ScanExpress software, performs boundary-scan interconnect testing and in-system programming of flash memories and CPLDs. *Corelis, www.corelis.com.*

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Test & MEASUREMENT WORLD

Communications
TEST REPORT

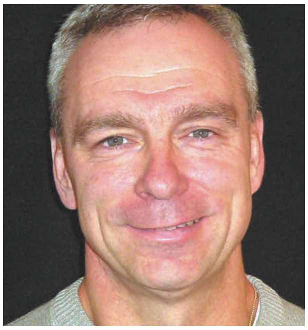
WIRELESS COMMUNICATIONS

Meeting the demands of Wi-Fi test

Richard A. Quinnell, Contributing Technical Editor

The wireless data communications market is surging, and test equipment vendors are riding that wave. One such vendor is Azimuth Systems (Acton, MA), a Wi-Fi test equipment maker that was formed in 2002 and introduced its W-Series test platform in August 2003.

In January, Azimuth announced that it recently shipped its 1000th test module. I spoke with Azimuth CEO Ray Cronin to get his perspectives on the test needs of the Wi-Fi market.



Azimuth Systems CEO Ray Cronin sees the ability to emulate motion as a key element of wireless data communications test.

Q What has made your company so successful in the field of Wi-Fi test?

A Our people and our products. We saw that there was a need for a whole new class of test equipment for wireless data communications and consciously decided to fuse specific areas of expertise. We took the disciplines of wireless, Ethernet, and test equipment and put them together to build our team and fill that void in wireless test.

Q What do you mean by a "new class of test equipment?"

A Legacy test equipment has been based on testing the radio platform and the network separately. In fact, if you say "wireless," most engineers simply think "radio." We realized that there needed to be a shift. You need to test more than just the function of a device; you must also test the performance of the applications that the device runs, and test it as people are moving.

To do this, you have to control the physical layer to emulate motion and roaming. That introduces a whole new generation of problems, and we needed a new approach to test the motion-versus-performance issue as quickly and precisely as we can test the radio.

Q What is the role of standards in this new approach to testing?

A Having standardized tools and methods allows vendors and customers to get the same test results. With wireless, it can be hard to get a repeatable result, and it's almost impossible without standards.

Having repeatable results allows vendors and customers to communicate more effectively about problems when they arise. Standardized tools also help developers validate their applications robustly.

Q Where do you see Wi-Fi test going from here?

A Wireless communications is still in its infancy, and in the next few years, there is going to be a huge proliferation of applications that put the network into areas that haven't been expected. This includes the use of wireless for games and television, the use of phones as data ports, and establishing communications with automobiles. Over the next 10 years, we will move away from connecting computers through cable to connecting people over the airwaves. We will need to be able to test the effects of motion on video and voice as well as on data communications. The real question is: Will this stuff perform the way customers are used to when connected through cables?

Q Any final words of advice for Wi-Fi developers?

A Expect to move from testing the physical layer to higher layers in the stack. That is where the effects of motion, roaming, and rate adaptation will be felt. The silicon vendors will make sure their radio works. You need to test your design's functional performance. □

Stay up-to-date on communications test topics, and subscribe to *T&MW*'s monthly Communications Test newsletter, at www.tmworld.com/comm.

INSIDE *this issue*

EDITOR'S NOTE

Triple play or triple threat?

Richard A. Quinnell, Technical Editor

A lot of the buzz in the communications industry is the so-called "triple play," the combination of broadband data, IP telephony, and IP television on a single connection. Consumers have indicated that they will pay for broadband access if they can get more than fast Web surfing. As a result, IP service providers are starting to follow that money.

This poses a challenge for test engineers. The inclusion of telephony in the form of VoIP complicates test considerably by imposing a quality-of-service (QoS) factor that needs investigation. Test engineers have had to move beyond simple system functional and bandwidth testing to investigate the interaction of many factors and their impact on applications performance. The system may be functioning perfectly and still not provide the right QoS for a decent voice channel.

The situation becomes even more complicated with the addition of IP video. Now added to sound-quality issues are video quality and a host of other behaviors that affect the user's experience of the product offering. Test can no longer stop at checking function and adherence to specifications. It must account for the interactions of systems and software to help identify and pinpoint problems.

Test engineers will need to add application expertise to their system knowledge, or vendors will need to provide more automated and intelligent test tools. Most likely, a little of both will be needed to tackle the triple threat of data, VoIP, and IPTV. □

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

NEWS

Alliance forms to promote Ethernet

THE ETHERNET ALLIANCE is a newly formed group dedicated to the expansion of IEEE 802 Ethernet technologies. The Alliance aims to help member companies increase acceptance and reduce time-to-market of Ethernet products, and it will provide resources to demonstrate multivendor interoperability of IEEE 802 Ethernet products.

Activities for 2006 will focus on incubation of new technologies based on Ethernet standards, interoperability demonstrations, and education. Founding members of the Ethernet Alliance include firms such as Agere Systems, Intel, and Xilinx as well as the The University of New Hampshire InterOperability Laboratory (UNH-IOL). www.ethernetalliance.org. □

CETECOM Spain obtains PTCRB GERAN approval

Centro de Tecnología de las Comunicaciones (CETECOM) Test Laboratory, in Spain, has been approved by the Personal Communication Services (PCS) Type Certification Review Board for PTCRB GERAN testing. CETECOM can now offer conformance testing services for the two private certification schemes used in GSM and UMTS communications known as Global Certification Forum (GCF) and PCS Type Certification Review Board (PTCRB).

This approval complements CETECOM's portfolio of services, which cover standards such as 2G/3G, Bluetooth, Wi-Fi, and WiMAX. www.cetecom.es. □

Firms collaborate on HSDPA RF tester

AGILENT TECHNOLOGIES and Anite Telecoms have developed an HSDPA RF conformance tester that should be available in April, and the companies expect to shortly announce a complete W-CDMA RF conformance tester.

By adding Anite Baseband Processor and Anite System Software to the Agilent GS-8800 tester, the companies have created the GS-8800+ system for testing 3G wireless devices for conformance to 3GPP TS 34.121 specifications. This expands the capabilities of the GS-8800 system, which already supported GSM, GPRS, EGPRS, cdma2000, cdmaOne, 1xEV-DO, and AMPS technologies. Customers who own GS-8800 systems can upgrade to the GS-8800+. www.agilent.com; www.anite.com/telecoms. □

Report examines market for Gigabit Ethernet test equipment

IN A REPORT ENTITLED, "World Gigabit Ethernet (GbE) & 10 Gigabit Ethernet (10GbE) Test Equipment Markets," Frost & Sullivan reveals that the market earned revenue of $233.3 million in 2004 and projects to reach $626.9 million in 2011.

"However, research indicates that prices for both GbE and 10GbE test equipment will lower significantly over time, which may lower the business opportunity," said Frost & Sullivan program manager Jessy Cavazos Sujatha Chellathurai. "As network equipment manufacturers lower their prices, so do test equipment vendors."

The study discusses the prevailing market challenges, drivers, and restraints, and also provides detailed analysis by vertical market and application. www.testandmeasurement.frost.com. □

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www.agilent.com/see/memorytest

Agilent Technologies

NETWORK TEST

DSL tests focus on copper

Richard A. Quinnell, Contributing Technical Editor

Wireless communications seem to be getting all of the attention these days, but there still remains a huge market and installed base for copper-carried DSL services. The market's increasing interest in voice and video over broadband is changing the focus of field test for DSL, however. Instead of being satisfied with providing a "best-effort" DSL service, test is now focusing on maximizing the performance of the copper network.

The original test requirements on DSL installations were fairly basic. The two key questions were "Can the customer surf the net?" and "Is it fast enough?" Answering those questions involved looking at the cable's signal characteristics and verifying they were within set limits, then ensuring that the DSL modem could synchronize with the line card at the central office.

This "best-effort" approach held true as ADSL saw wider deployment, but it started to shift as installations migrated to ADSL2, ADSL2+, and VDSL2 to gain reach and bandwidth. The major discontinuity in test requirements came when service providers wanted to offer voice and multiple channels of video as part of a bundled service.

"One change was an increasing focus on service quality to support the more complex services of VoIP and IPTV," said Jon Beckman, product line manager at JDS Uniphase. "The other change was an ever-increasing focus on the physical plant—the cable network. The self-install model [for customer premise equipment] now demands a lot more of the copper plant."

The focus on service quality means that DSL field test equipment now requires more capability to measure and help diagnose problems. Tools have had to go from making simple good/bad decisions to helping correlate service quality with physical layer characteristics and to isolate the location of problems in the network.

Taking a close look at the network cabling is an integral part of that effort. "There is more focus on drilling down to the copper layer," said Beckman. "The evolution of DSL has driven an increase in the frequencies the cables must carry, from 2.2 MHz for ADSL to 30 MHz for VDSL. That means you need to look at the health of the copper plant to find problems such as corroded splices and the like."

Tools such as the HST3000 perform a variety of field tests.

Courtesy of JDS Uniphase.

New equipment to address all these needs must thus offer both greater automation and more capabilities in measuring physical characteristics. The HST3000 from JDS Uniphase, for example, can perform leakage, balance, and TDR testing on the cable; monitor datacom interfaces; test data layers such as PPP and FTP throughput; and serve as a Web browser to verify connections. It also offers VoIP phone emulation and a host of QoS measurement parameters, and it can emulate a set-top box to verify IP video services. Other similar products include the CoLT 450 from Exfo and the Tech-X field tester from Spirent Communications (see p. 60).

These products cannot do everything, of course, and to mitigate their limitations, many field units capture live data and store it for analysis in the lab. The units can also log data to help engineers analyze trends in the network and cable plant's behaviors.

Ultimately, however, these tools will continue to increase in both automation and in performance levels. As the xDSL installations get ever faster and more capable, so will the tools for field test. □

FIELD TEST

VoIP test moves to the field

Richard A. Quinnell, Contributing Technical Editor

After years of languishing in the laboratory, voice over Internet Protocol (VoIP) has started to achieve a respectable installed base, and this is prompting test equipment vendors to focus more energy on addressing the needs of VoIP field testing. Test equipment introductions are now offering more portability, preprogrammed test suites, and expanded capabilities.

Several factors have converged to promote the growing interest in field testing, according to Jason Steele, product manager for IP diagnostics at Tektronix. "VoIP test is starting to go beyond lab validation and development," said Steele. "The specs have calmed down, so requirements are more stable, and large-scale services are being deployed, so the need for field testing has increased. Customers are asking, 'Now that it is out of the lab, how do I get it to provide quality service?'"

The needs of the field test engineer are different from those of the laboratory test engineer in two significant ways, Steele noted. One is that field testing demands portability, typically implying battery power and compact form factors. The second is that field testing typically needs to be less exploratory in nature. Unlike the laboratory test, which seeks to probe the limits of a design, field test focuses on verifying proper operation and on troubleshooting problems. "You need a lighter feature set compared to laboratory equipment," Steele said. "You still need measurement tools, but features such as load generation might only need to handle five to ten calls versus thousands of calls in the laboratory."

Even handheld tools such as the Tech-X Plus are offering automated test configurations.

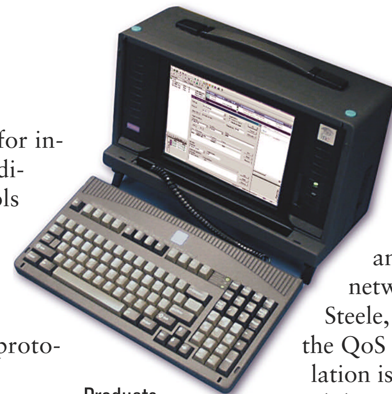
Courtesy of Spirent Communications.

A number of field-oriented tools have become available. The Performer series from RadCom, for instance, includes ruggedized, portable VoIP tools with internal storage to allow later lab analysis of field data. Tektronix makes the Spectra and Spectra2 protocol-analysis tools in portable form, as well. Agilent Technologies and Spirent Communications both offer handheld units. Agilent's FrameScope Pro includes traffic generation and quality of service (QoS) measurement capabilities. Spirent's Tech-X Plus offers built-in diagnostic tests for common installation problems.

Portability is essential

Because portability is a key issue for field use, some companies have elected to create software-only tools that work with a laptop computer, helping keep the field engineer's toolkit to a minimum. Tektronix, for instance, offers its Spectra2 tool in a software-only edition, Spectra2 SE. Similarly, Touchstone's WinEyeQ VoIP monitoring and analysis tool is software-based. Both depend on the laptop computer's LAN port for connection to the network under test.

Automation is also an issue for field use. "Ease of use is becoming a key point," said Steele, "and anything you can do to simplify the testing job is appreciated in the field." He added that by automating key test procedures, vendors are able to free test engineers from having to become experts in programming the tool.



Products such as the Spectra2 offer compact and ruggedized enclosures to meet portability requirements.

Courtesy of Tektronix.

The main questions that VoIP field test tools must help answer about the network, according to Steele, revolve around the QoS that a VoIP installation is offering and its ability to blend with traditional telephony. "Nearly 95% of calls still traverse the traditional TDM [time division multiplexed] network, so tools need to examine the bridge across the two types of network." The Spectra2, for instance, now supports protocols such as BICC (bearer independent call control) to address this need.

Field needs continue to evolve, however. New VoIP installations are aimed at offering more than phone service. IP video is one application that is gaining a lot of attention, and most of the VoIP tools now address the requirements of these additional media, as well. And the perfect mix of tool capabilities has not yet become clear. With large enterprise-wide VoIP systems beginning to be deployed, there has been an increasing demand for tools with the right level of complexity.

Steele noted that there is a need for a tool somewhere between one aimed only at installation testing and one with the full capability of a laboratory tool. "Installing in an enterprise is a big effort," he said, "and you need to be able to track down some large-scale effects."

To meet these evolving needs, test equipment vendors are paying attention to their customer's requests. "A lot of our tools are driven by customer demand," Steele explained. Vendors will continue to improve their VoIP field test tools as more installations arise and other technologies, such as wireless, converge with VoIP. □

PRODUCTS

Spectrum analyzer viewer application

You can view data captured with the BumbleBee handheld spectrum analyzer application on any Windows-based PC. This application displays RF data from the BumbleBee iPAQ PocketPC PDA through a USB port or from the iPAQ's removable SD or CF card slots. Price: $250. *Berkeley Varitronics Systems, www.bvsystems.com.*

Transceiver development platform

The RTS 2502 data-recording system allows dual-channel wideband A/D data recording and playback. The platform targets transceiver applications, such as military radios and commercial wireless base stations. Base price: $29,995 for hardware only. *Pentek, www.pentek.com.*

RF vector signal generator

The Model 2910 RF vector signal generator delivers switching speeds 2 to 10 times faster than comparable generators. The instrument offers optional built-in signal generation software personalities for key cellular formats targeted at mobile phone testing. Base price: $14,500. *Keithley Instruments, www.keithley.com.*

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BARBARA B. HULIT
President
Fluke
Everett, WA

On becoming president of Fluke in September 2005, Barbara B. Hulit assumed responsibility for the Fluke Industrial and Fluke Precision Measurement businesses. Hulit came to Fluke from The Boston Consulting Group (BCG), where she was a VP and director with responsibility for the firm's packaged-goods sector.

Over the past seven years, Hulit has worked extensively with Fluke and was instrumental in the identification of the company's new indoor-air-quality and thermography businesses. Her background also includes senior positions in sales and marketing for Noxell, Frito-Lay, and Marketing Corporation of America. She holds an MBA from the Kellogg School at Northwestern University and a BA in marketing from the University of Texas at Austin.

Chief editor Rick Nelson interviewed her by e-mail.

Identifying customers' unmet needs

Q. Could you describe the role of Fluke within Danaher, the parent company?

A. Fluke is the anchor of Danaher's Electronic Test platform. Driven by new-product development and entry into new markets such as temperature measurement and calibration, Fluke has experienced tremendous growth. Fluke has been a major part of a shift in the Danaher portfolio to higher-tech, higher-growth markets, including product identification, motion, environmental systems, and medical technologies.

Q. What product lines are you responsible for as head of the Fluke Industrial and Fluke Precision Measurement businesses?

A. In my role as president of Fluke, I have responsibility for the design, manufacture, sales, and service of all industrial test and calibration product lines. This encompasses any tool we manufacture that metrologists or design and test engineers are likely to use. Within our precision-instrument business, our product lines include calibrators, reference multimeters, signal generators, bench meters, and calibration software. I also have responsibility for all handheld test tools, including our ScopeMeter test tools, portable calibrators, power-quality recorders and analyzers, thermal imagers, and indoor-air-quality tools, as well as multimeters, thermometers, and general electrical testers.

Q. Do you anticipate growth in the markets Fluke serves, or are they relatively mature?

A. Thermal imaging is a high-growth market, particularly in the industrial segment. As we continue to break the compromises associated with thermography, the market will grow. We are truly defining a new market. Likewise, we continue to experience healthy growth in the calibration, multimeter, and handheld-portable-oscilloscope markets as we explore and uncover our customers' unmet needs and dissatisfactions.

Q. What core competencies does Fluke have that contribute to the success of all these product lines?

A. There are three characteristics that combine to make Fluke the successful company it has been since our beginning in 1948. Not surprisingly, these are areas that mattered a great deal to John Fluke, Sr., our founder: an intimate understanding of our customers, the discipline and drive to identify trends that are shaping the design and test market, and a strong focus on quality.

Q. How does your experience with consumer products apply to Fluke?

A. The consumer-products sector does a great job of thoroughly understanding its customers' unmet needs, wants, and dissatisfactions. Knowing how to commercialize these insights is well practiced in most consumer packaged-goods companies. Fluke has the same quest for customer insight as most consumer-products companies.

We spend considerable time "toe-to-toe" with our customers to understand how they spend their day, what frustrations they have, and how their needs are changing. This is what allows Fluke to introduce products that the market is excited about. My experience in the consumer sector should help reinforce what Fluke already does well while bringing new tools and perspectives.

Q. What are Fluke's key strengths?

A. We have a tremendous team of intelligent, driven people who are passionate about what they do. We leverage that strength with an organizational culture that is focused on listening to the needs of customers and on operational excellence. That, coupled with an incredibly strong brand, really defines our strengths. T&MW

Barbara B. Hulit elaborates on Fluke's competitiveness and on its entry into the thermal-imaging market in the online continuation of this article: www.tmworld.com/2006_03.

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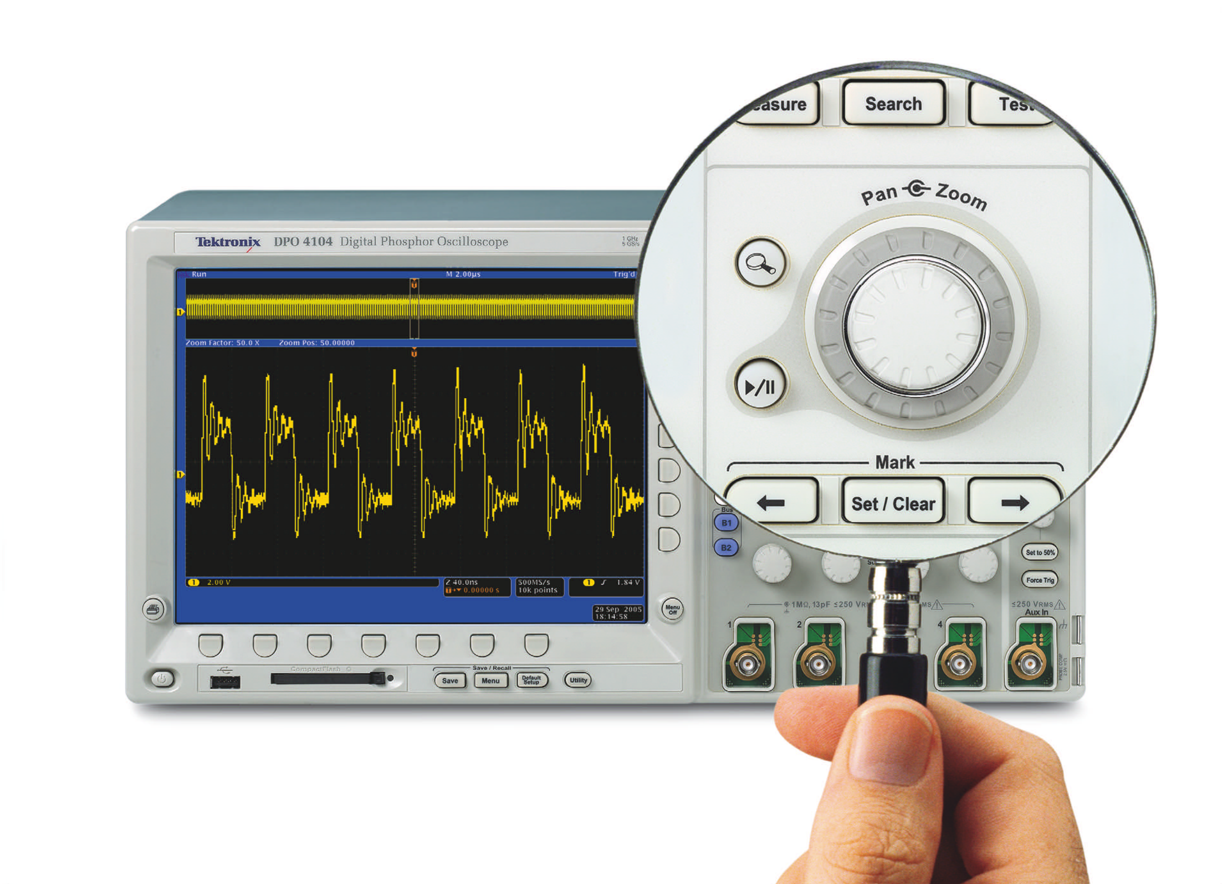

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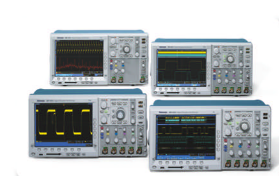

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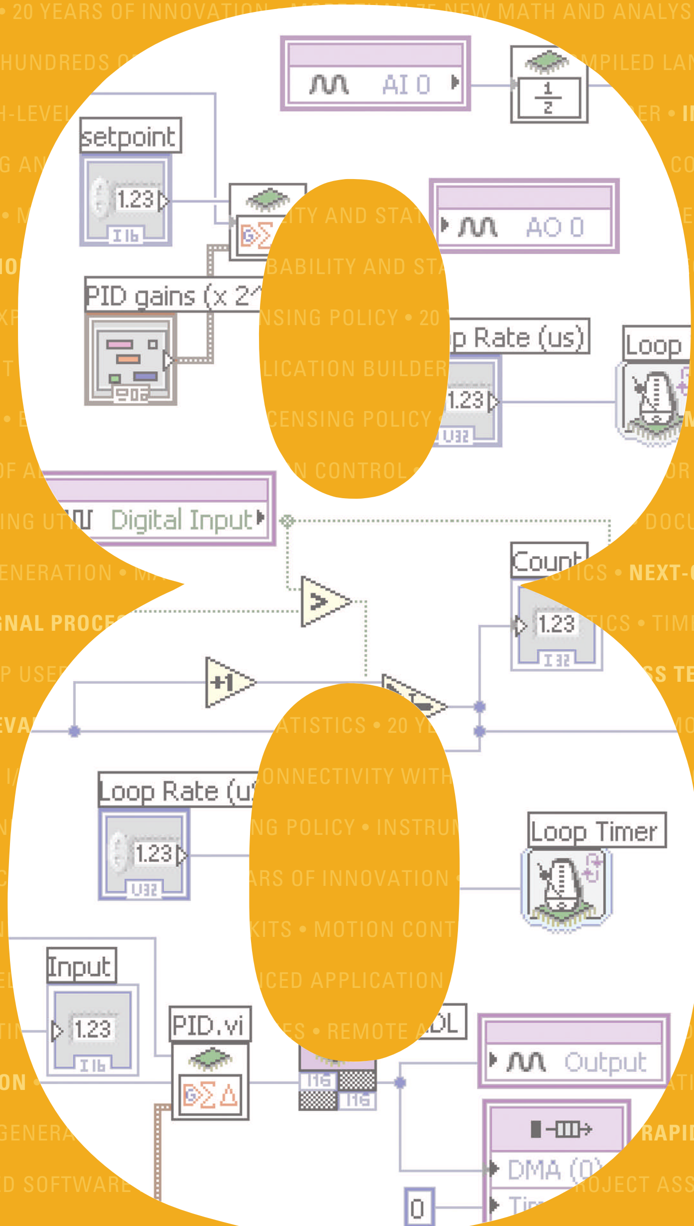
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