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Test & MEASUREMENT WORLD®

THE MAGAZINE FOR QUALITY IN ELECTRONICS

Colin Ross, manager of SQA automation at Crossbeam Systems.

TESTING TOWARD SECURE NETWORKS

At Crossbeam Systems, testing ensures that the company's platforms run security applications that keep networks safe.

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COVER BY: MARK WILSON

Test & MEASUREMENT WORLD®

MAY 2008
VOL. 28 NO. 4

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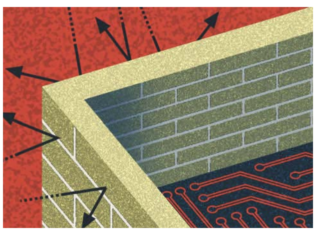

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Acquiring flight-test data

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www.tmworld.com/pcb_flight

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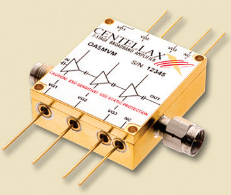

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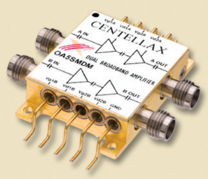

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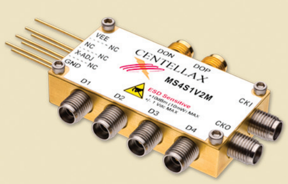

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RICK NELSON
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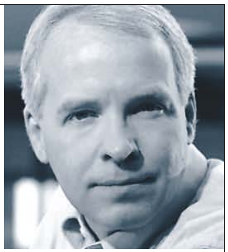

Should intelligence be hidden?

Are embedded systems becoming too embedded? That's a feeling I get from two contrasting shows in San Jose last month. The Embedded Systems Conference (ESC, www.embedded.com) presented one view, showing how sophisticated today's designers have become at hiding intelligence within products such as the Gibson self-tuning guitar and the Sony Rolly dancing MP3 player.

But perhaps they have gone too far. Perhaps people would rather have their intelligent products look intelligent—that is, take on a humanoid form. That's the message I took away from an exhibit titled "Robots: Evolution of a Cultural Icon" at the San Jose Museum of Art (SJMOA). While the ESC showed robotic technology as it is, the SJMOA exhibit presents an almost plaintive look at what might have been: "We were promised robots" is the lament of the artist Michael A. Salter in a statement that serves as a subtitle to the exhibit (which will run through October 19).

"People are looking for friendship from their robots as much as utility."

So what, exactly, was promised that wasn't delivered? According to an exhibit handout, many people "…grew up imagining a future populated by friendly humanoid robots that would help us with our homework, mow our lawns, [and] even cook our meals."

The crux of that statement is that people were looking for friendship from their robots as much as utility. After all, computers can help with homework, intelligent microwave ovens can cook our meals, and a product called RoboMower can mow our lawns. The problem, it seems, is just that none of those devices is particularly friendly.

As for what is on display at the museum, some artists seemed to perceive people's need for artificial companions. Alan Rath's "I Like to Watch" uses its ghostly, moving CRT eyes to try to establish rapport with the viewer. Jason Van Anden's robot pair Neil and Iona engages the viewer with body language, facial expressions, and weird sounds. Both these exhibits were strangely compelling. Perhaps engineers looking for a killer app should simply build everybody an electromechanical, humanoid best friend.

As for the traditional hardware and software engineers who have designed today's embedded systems—they may have no brighter future than the humanoid artificial beings imagined by visionaries from Mary Shelley to Isaac Asimov have had thus far. At an ESC panel titled "Addressing Embedded Challenges with ARM Technology," participants suggested that emerging design tools would enable domain experts—people skilled in medical applications, for example—to develop embedded systems without needing to rely on experts skilled in C++ programming and multicore embedded architectures.

Do such new design tools make traditional engineers obsolete? I put that question to Mike Santori, business and technology fellow at National Instruments. He said that indeed some domain experts will be able to use off-the-shelf tools to design medical and other relatively low-volume applications, but he said that specialized embedded-system designers will continue to have a role to play in optimizing iPhones and other high-volume designs.

I'll elaborate on Santori's views on classical engineering's potential obsolescence in my blog "Taking the measure" at www.tmworld.com/blogs and in "Innovators," a special supplement to be included with the June 26 issue of sibling publication *EDN*. T&MW

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

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[An exclusive interview with a test engineer]

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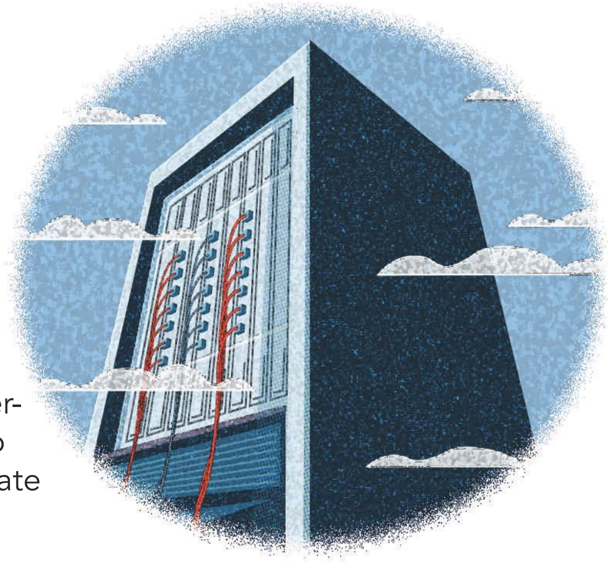


DANIEL GUIDERA

John Anians is a senior engineer at Tellabs (Naperville, IL), where he and others perform product evaluations on digital cross-connects. Telecom carriers use digital cross-connects to integrate new equipment into networks containing previous generations of equipment. The cross-connects contain electrical and optical interfaces that run at speeds from T1 (1.544 Mbps) to OC-48 (2.5 Mbps). Anians does his best to emulate network configurations that customers will use.

Q: How do you develop a test bed and test plan for a cross-connect system?
A: I start with a product definition from marketing, which I use to begin planning a test bed. The project's lead engineer will write an overview of the product. Systems engineers will then develop documents and specifications on how the product will work. From those documents, I estimate the time required to test a product. If we deem the test time is excessively long, we won't design the product.

Q: Once a product is in development, how do you proceed?
A: I make it a point to understand how a new feature will work, then I develop a strategy for how our customers will use the product. I test a product from an applications perspective. I emulate how the cross-connect will grow at the customer's site because you can never make a test bed too big.

Q: How does a cross-connect system "grow"?
A: Customers grow a cross-connect system by increasing the number of cross-connects, adding blades to a "shelf" [chassis] and by adding new shelves to the system as their needs grow. For example, in a previous project that involved cell-site aggregation, I started by emulating a few cell sites in a test network, then added cell sites until I had as many as a customer might use. I kept adding blades, and I tried to duplicate the new shelf's life cycle.

Q: What does a test bed contain?
A: Test networks contain call generators and SONET/SDH communications-performance analyzers. We use our own equipment and commercial test equipment to generate traffic. I automate the test bed by writing Tcl/Tk scripts.

Q: What's involved in a test?
A: I run as much traffic as possible in a test, and I analyze performance by conducting bit-error-rate measurements. A product must run error free to be acceptable. I also test for redundancy—traffic must be protected (facilities, blades, intra-system networks, etc. are all designed to protect traffic in the event of a signal or equipment failure). A customer must also be able to remove and replace blades while the system remains online.

Q: How long do you spend testing a new design?
A: Initial test plans and scripts take about two months to complete with a final evaluation taking about four additional weeks. Following a test, we produce a report that highlights the number of tests passed, tests failed, and defects found. System and design engineers use that data to make design changes.

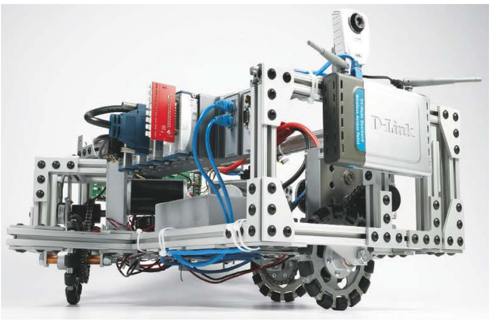
Q: What are the greatest test challenges you face?
A: The first challenge of my job comes in learning how our customers will use our products. I don't want disappointed customers. Beyond that, I'd like my test equipment to let me view all the data paths in a system simultaneously. That is, I want the ability to look at all tributaries in a data stream. For example, while evaluating a DS3 stream, I want to look at all of its DS0 tributaries. T&MW

The online version of this article contains a photo of a cross-connect chassis, www.tmworld.com/2008_05.

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

FIRST partners with NI to provide students with CompactRIO

The FIRST (For Inspiration and Recognition of Science and Technology) organization has selected National Instruments' CompactRIO embedded control platform as the robot controller for its FIRST Robotics Competition. By engaging students in programs that will help them develop engineering skills, FIRST works to encourage young people to become leaders in science and technology. Founded by Dean Kamen, president of DEKA Research & Development, FIRST conducts several robotics competitions: Junior FIRST Lego League, FIRST Lego League, FIRST Technical Challenge, and FIRST Robotics Competition. "Our goal is to have a FIRST team in every high school and to change the culture in our communities to celebrate excellence in science and engineering the same way we celebrate sports," said Kamen.



High school students will begin to use the CompactRIO platform during the 2009 FIRST season. They will have access to a 400-MHz PowerPC and FPGA-based I/O for creating advanced robots that they can program in either NI LabView or ANSI C.

NI is making a multimillion dollar donation of materials over the next five years to FIRST to provide the CompactRIO system to participating teams. Several organizations have collaborated with NI to provide the components required to build the CompactRIO control system, including Analog Devices, Boston Engineering, ChipX, Dove Electronics, Freescale, MSI, Texas Instruments, TTI, Westak, Wind River, Worcester Polytechnic Institute, and Xilinx. www.usfirst.org; www.ni.com/academic/k12.

Test firms take honors at *EDN* Innovation awards

The editors of *EDN* recognized the technical accomplishments of test-equipment makers Agilent Technologies and LeCroy during their 18th Annual Innovation Awards ceremony held April 14 in San Jose, CA. Agilent received an award in the category "Test & Measurement (Power Technology)" for its N6705A DC power analyzer—an instrument that also captured *Test & Measurement World*'s 2008 Test Product of the Year award. In the category "Test & Measurement (General Purpose)," LeCroy was honored for the WaveExpert 100H sampling oscilloscope. The Innovator of the Year award was presented to Intel's 45-nm innovation team.

EDN, a sister publication to *T&MW*, hosts its Innovation Awards ceremony each year during the week of the Embedded Systems Conference. Other awards categories include analog ICs, sensors, and EDA. www.edn.com.

Thermal imaging goes handheld

Editors' CHOICE

Handheld infrared thermometers can give you a noncontact temperature, but for a single temperature only. Extech's i5 handheld infrared camera goes beyond this capability to let you produce, store, and play back high-resolution thermal images so you can easily pinpoint problem areas. The i5, which weighs 12 oz and has a 3.5-in., 80x80 block LCD screen (6400 individual measurement points), produces thermal images with 2% measurement accuracy and 0.1°C thermal resolution. Temperature range is –10°C to 350°C. You can use the i5 to locate hot spots in electronic or mechanical devices for maintenance and troubleshooting.

The unit comes with a 512-Mbyte mini-SD memory card that lets you store images in .jpg format, and it comes with an adapter for connecting the card to a PC. You can also connect a USB cable to the camera's handle and download images to a PC. Using the QuickReport software (included), you can analyze images and read a temperature at any point on an image. The handle also holds a Li-Ion rechargeable battery. The i5 will run for 7 hr on a battery charge.

Price: $2995. *Extech Instruments, www.extech.com.*

EXFO expands through acquisitions

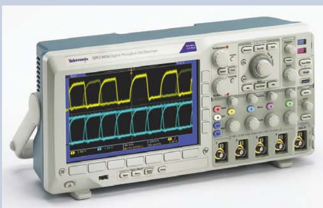
EXFO Electro-Optical Engineering has increased its share of the Internet Protocol (IP) test market through two recent acquisitions. In late March, EXFO announced that it had acquired Navtel Communications, a Toronto-based manufacturer of IP Multimedia Subsystem and Voice-over-Internet Protocol test products. Navtel will be integrated into EXFO.

In April, EXFO reported it had acquired Boston-based Brix Networks, a provider of hardware and software products used to monitor converged IP networks. The company will be renamed EXFO Service Assurance. www.exfo.com.

Editors' CHOICE

Small-footprint scopes debug buses

The Tektronix DPO3000 lunchbox-sized, two- and four-channel 100-, 300-, and 500-MHz-bandwidth oscilloscopes provide more than three times the screen area and 500 times the waveform-memory depth of the company's TDS3000 series. The DPO3000s incorporate Tek's Wave Inspector technology, which facilitates searching through long waveform records for anomalous events. In addition, the new units trigger from, and decode the activity on, five embedded-system buses: serial peripheral interface (SPI), inter-IC (I2C), RS-232, controller area network (CAN), and local interconnect network (LIN).



The DPO3000s incorporate 800x480-pixel wide-screen video-graphics adapter displays, which measure 9-in. diagonally. All models can capture 2.5 Gsamples/s/channel, and all provide a memory depth of 5 Msamples/channel. The screen-update rate is 50,000 waveforms/s. The units feature an Ethernet port and two USB ports—one for memory devices and one for connection to a PC. For bus debugging, the display switches to a text-only mode.

Price range: two-channel 100-MHz unit—$4450; four-channel 500-MHz unit—$10,900. (Prices include National Instruments' LabView SignalExpress, base version, which you can upgrade to the complete Tek Edition for $699.) *Tektronix, www.tektronix.com.*

SFP interfaces pass interoperability tests

The Ethernet Alliance reports that several of its members, including AMCC, Avago Technologies, Broadcom, Finisar, Intel, JDSU, and Vitesse, successfully conducted interoperability testing of Small Form Factor Pluggable (SFP+) short-reach (SR) and long-reach (LR) optical interfaces. The tests, which were conducted at the University of New Hampshire Interoperability Lab, demonstrated multiple SFP+ SR and LR optical transceivers and physical layer (PHY) ICs interoperating over 270 m of OM3 multimode fiber and 10 km of single-mode fiber.

The group also demonstrated multiple SFP+ SR and LR optical transceivers and PHY ICs interoperating with XENPAK, X2, and XFP optical transceivers over the same distances. SFP+ modules are optical transceivers intended for datacom applications, including 10 Gigabit Ethernet. SFP+ modules and PHY ICs are being developed in accordance with IEEE 802.3ae-2002 and IEEE 802.3aq-2006. www.ethernetalliance.org.

CALENDAR

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

International Microwave Symposium, June 15–20, Atlanta, GA. Sponsored by IEEE Microwave Theory and Techniques Society (MTT-S), www.ims2008.org.

Semicon West, July 14–18, San Francisco, CA. Sponsored by SEMI. www.semiconwest.org.

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

Test, inspection technologies target PCB quality

> > > APEX, April 1–3, Las Vegas, NV, IPC, www.goipcshows.org.

Agilent Technologies introduced a new Medalist sj5000 automated-optical-inspection (AOI) platform. The company also showcased its VTIP v2.0 Powered Cover Extend technology for the i3070 in-circuit testers and highlighted its SP50 high-speed, 3-D solder-paste inspection system, its Medalist x6000 automated 3-D x-ray inspection system, its Medalist i1000 low-cost in-circuit test system, and process-control software that closes the loop between manufacturing and test.

CheckSum demonstrated what it called the first onboard gang programming system, the MultiWriter pps, which uses Checksum's Concurrent Programming technology to program up to 24 parts each of up to 16 different types simultaneously—up to 384 chips at one time.

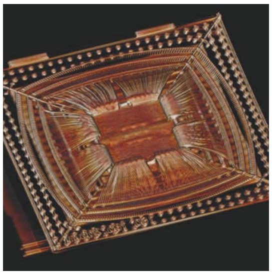
Texmac, the distributor of Takaya flying probers in North America, launched the Takaya APT-9600 double-sided flying-probe system and also demonstrated the APT-820S low-cost fixtureless in-circuit tester, designed to complement AOI. In addition, Goepel electronic and Texmac demonstrated the integration of Goepel's Cascon Galaxy software and ScanFlex hardware into the Takaya APT-9411 flying-probe system.

Asset InterTech said that its µMaster is the first CPU emulation test and diagnostic system to support Intel's new low-power Atom processor.

One year after announcing its ECOsystem concept, **Sunstone Circuits**, a printed-circuit-board (PCB) prototype provider, launched the Sunstone ECOsystem Design Environment, which it calls a one-stop resource embodying the capabilities needed to produce a PCB.

Seica debuted its Pilot V8 double-sided flying prober, which employs the vendor's vertical board-under-test architecture while accommodating eight electrical-flying-test probes, four per side. In addition, the Pilot V8 accommodates two (one per each side) Openfix capacitive probes, two (one per each side) power flying probes, and two (one per each side) CCD cameras.

Dage Precision Industries announce its XiDAT XD7500NT digital x-ray inspection system with submicron inspection capability and sealed-tube technology for maintenance-free operation. T&MW



X-ray computed-tomography systems able to produce 3-D images of semiconductors and other devices were on display at APEX.

Courtesy of Dage Precision Industries.

Test vendors address WiMAX, LTE at wireless show

> > > CTIA Wireless 2008, April 1–3, Las Vegas, NV, CTIA, www.ctiawireless.com.

Rohde & Schwarz exhibited its CMW270 WiMAX tester as well several LTE test offerings, including the CMW500 UMTS LTE protocol analyzer. The company highlighted software options for its signal generators and analyzers that support LTE uplink and downlink measurements as well as a software option that supports physical layer tests on HSPA+ receivers, baseband modules, and RF front ends. An additional software option for the SMU200A and SMATE200A vector signal generators and AMU200A baseband signal generator supports assisted GPS (A-GPS) test.

R&S also noted that it has added MIMO precoding and channel coding to its LTE signal generators. In addition, the company demonstrated a 2x2 MIMO receiver test using an SMU200A RF signal generator, an AMU200A baseband generator, and a fading simulator. The combination supports WiMAX test for LTE, WiMAX, WLAN, and HSPA+.

Agilent Technologies demonstrated its WiMAX and 3GPP LTE test portfolio. WiMAX tools on display included signal creation and analysis software for Wave 2 Mobile WiMAX and MIMO development using Agilent Infiniium oscilloscopes and MXG signal generators. Also on display was Wave 2 MIMO testing capability (featuring the E6651A WiMAX tester), the N8300A wireless networking test set, the J7910A WiMAX signaling analyzer, and the Agilent WiMAX drive test system. 3GPP LTE analysis tools on display included a new 3GPP LTE protocol development offering based on the Agilent E6620A wireless communications test set and **Anite**'s SAT LTE protocol development toolset.

Anritsu focused on LTE and HSPA+ products, highlighting its MD8480C signaling tester, which supports HSDPA/HSUPA test; its MG3700A vector signal generator, which provides analysis capabilities for orthogonal frequency division multiple access (OFDMA) and MIMO LTE test; and the MS269xA signal analyzer, which supports LTE measurements. The company also introduced three software packages for its MS269xA signal analyzers: the MX269020A LTE downlink measurement software, the MX269021A uplink measurement software, and the MX269908A LTE IQproducer software.

See the online version of this article at www.tmworld.com/2008_05 for our full coverage of APEX and CTIA.

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Electrons remain important in electronics test

Test engineers are struggling to optimize printed-circuit board (PCB) test and inspection strategies as board complexity increases and manufacturing gets outsourced. Finding the right mix of test and inspection technologies was the topic of the Test and Inspection Summit panel held April 3 at the APEX show in Las Vegas (see p. 15).

In the panel discussion, which I moderated, Chad Hankinson, president of Everett Charles Technologies' fixture services group, addressed outsourcing, noting that in many parts of Asia sufficient talent isn't available to support the growth rate of manufacturing. "Consequently, when we do a fixturing program for the China market, Everett Charles personnel have to install the system, run the first lot of boards, and provide ongoing support to ensure success."

John VanNewkirk, president and CEO of CheckSum, echoed that point, saying, "You have to buy equipment that is extremely stable so that the fixturing program you set up in your NPI [new product introduction] center is going to run the same at your production facility."

Steve Case, chairman and founder of CyberOptics, commented on process control's role in producing high-quality products. You have to make sure all steps of the assembly process—such as solder-paste deposition—are done correctly, he said, noting that increased connectivity between pieces of equipment will become increasingly important.

Deciding what equipment to deploy—from automated optical inspection (AOI) systems to device programmers—is key. Jack Rozwat, a GM at Agilent Technologies, summed up the problem this way: "The good news is there are a lot more technologies to choose from. The bad news is that you've got to make some tough choices." He noted that what people want is a program that employs process and yield simulations and fault spectrum information and determines a test strategy. Unfortunately, he said, he doesn't have such a program to sell.

Glenn Woppman, president and CEO of Asset InterTech, commented, "No one is going back to DIP packaging technology." Instead, he said engineers will increasingly face what he calls SIP, PIP, POP issues—ones dealing with system-in-package, package-in-package, and package-on-package devices—as designers cram more functions into silicon. These devices, he said, look like PCBs, with interconnects between die, but the only way to access the interconnect may be through boundary-scan's JTAG port. But boundary scan won't soon displace other test techniques. Said VanNewkirk, "In the late '80s, a lot of people thought that boundary scan was going to take over for in-circuit, but now most people realize that these are complementary technologies."

The PCB production cycle may include inspection and electrical test as well as complementary device-programming capability delivered by systems such as the MultiWriter pps. Courtesy of CheckSum.

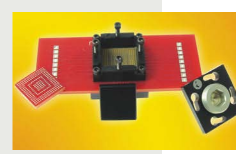
Don Miller, president of YesTech, agreed that a balanced approach is necessary. "The fault spectrum that AOI and x-ray address is huge," he said, noting that AOI in particular can find defects early in the production process so they can be corrected. But, he added, "At the end of the day, there is still place for electrical test." Or as VanNewkirk put it, "You can learn a lot about a pizza by looking at it, but there is no substitute for taking a bite. Electrons are a very important part of electronics." T&MW

ZMD standardizes on V93000

Verigy has announced that ZMD has standardized on the V93000 SOC Series tester for wafer sort and final test of its high-end signal-conditioning devices. ZMD has added incremental V93000 capacity to its test floor for dedicated, highly parallel wafer sort—testing 16 devices simultaneously. Said Ralf Petzoldt, test manager at ZMD, "In reference to the ITRS [International Technology Roadmap for Semiconductors], we achieve a mixed-signal wafer multisite efficiency of 91% with the V93000." www.verigy.com, www.zmd.biz.

LGA sockets for 0.65-mm-pitch devices

Ironwood Electronics has introduced the XG-LGA-7000 sockets for 0.65-mm-pitch LGA devices. Designed for a 12-mm package size and operating at bandwidths to 40 GHz with less than 1 dB of insertion loss, the sockets also dissipate several watts without extra heat sinking and can handle up to 100 W with custom heat sinking. Base price: $1397. www.ironwoodelectronics.com.



Himax deploys Teradyne LCD driver test system

Teradyne has announced its new D750Ex LCD driver test system, which is designed for testing high-definition LCD driver devices. Himax Technologies, a fabless IC driver design company in Taiwan, has selected the platform for testing its next-generation column and mobile driver devices. www.teradyne.com, www.himax.com.tw.

JON TITUS
CONTRIBUTING TECHNICAL EDITOR
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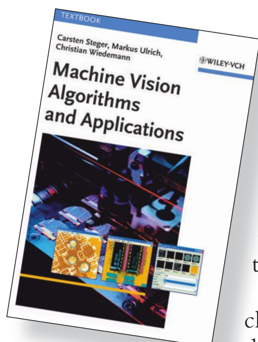
Vision algorithms by the book

Many engineers who work with machine-vision software might not care to know how algorithms process images to produce useful inspection data. Some engineers, though, like to know how these algorithms work, or they may need to understand algorithms so they can write custom vision software.



If you want to learn more about how vision software works "under the hood," you may find value in the new book *Machine Vision Algorithms and Applications* (Ref. 1), which covers machine vision in three main chapters. The longest chapter covers vision algorithms, while the remaining two address vision applications and hardware (lenses, cameras, and lights). If you lack experience working with vision software, peruse an elementary machine-vision book before you tackle this one.

Although the authors claim readers need little knowledge of mathematics to use the book, a review of calculus, sets, and Boolean algebra might help. In many cases, though, the authors simply present equations and do not expand upon them in the text. But even without worked-out math examples, the algorithm explanations will help you better understand how vision operations find edges, measure circle parameters, match templates, and so on.

This book has an academic tone—Wiley sells it as a textbook—so in places it sounds pedantic. The conversion from German has some rough spots: The translators use the word discretize, for example, in place of digitize. (And, some of the references cite German publications, which can be difficult to find in North America.)

I found the material on camera calibration particularly useful because the authors thoroughly discuss sources of measurement errors and how to adjust for or correct them. Again, readers get a lot of math equations, but the figures and text by themselves provide useful information. Although commercial vision software usually includes some calibration capabilities, engineers and designers can benefit from a better understanding of error sources and calibration techniques.

The book's applications chapter offers software examples that work with the free student version of Halcon 8.0, a vision-software package from MVTec Software. The book's preface provides the download Web address and registration details. After registering, you can download the Halcon software and the book's examples and test images. Stand-alone files give you access to many documents—from a basic introduction to reference and programming manuals.

Access to these programs and files is worth the price of the book. You can create only one student license per book, but this license lasts for two years. The Halcon software runs under the Windows, Linux, and Solaris operating systems. T&MW

REFERENCE

1. Steger, Carsten, Markus Ulrich, and Christian Wiedmann, *Machine Vision Algorithms and Applications*, Wiley VCH, Weinheim, Germany, 2008. 370 pages. $60. www.wiley.com.

Blue-violet laser modules

Photonic Products has introduced 35-mW and 60-mW versions of its 405-nm (blue-violet) photon laser-diode modules with TTL modulation. They target OEMs, industrial imaging, and inspection markets. The modules produce an elliptical output beam measuring 3.5x2 mm; the input accepts signals from DC up to 1 kHz, which can be used to enable, inhibit, or modulate the laser. The glass AR-coated aspherical lens may be adjusted to produce either a collimated beam or a focused spot. www.photonic-products.com.

Basler adds gamma correction, binning, debouncing

Basler is adding new features to its scout and pilot cameras. A new gamma correction feature modifies image brightness to improve image perception by the human eye—a useful feature for inspection applications involving human operators. A new binning feature increases a camera's response to light by summing the charges from adjacent pixels. And finally, a debouncer feature discriminates between valid and invalid signals on the camera's digital inputs. www.baslerweb.com.

Cognex packs vision system in tiny package

The next-generation In-Sight Micro from Cognex is a full vision system that is the size of a remote-head camera, suitable for mounting in tight spaces on robots, production lines, and machinery. Its small package is just 30x30x60 mm. Five In-Sight Micro models cover a range of price, performance, and resolution levels, including a 2-Mpixel model. In-Sight Micro includes the Cognex vision tool library to handle a broad range of vision applications. www.cognex.com.

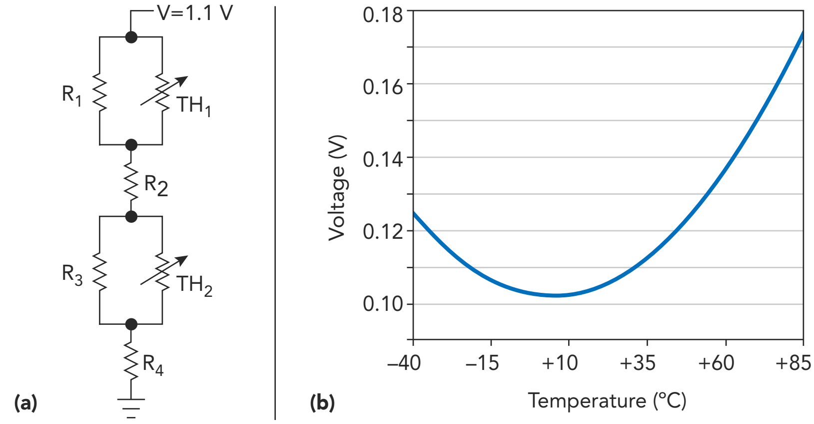
DATA ACQUISITION

Genetic algorithm solves thermistor problem

Given the circuit topology in Figure a, find the resistor and NTC thermistor values that generate the voltage vs. temperature curve shown in Figure b, using only standard resistor values. That's the problem Craig Lyon, a senior member of the technical staff and strategic applications engineer at Maxim Integrated Products, presents in an article posted at EDN.com.

Some engineers, Lyon writes, may be able to solve the problem using a scratch pad and numerous equations, while others would probably painstakingly plug values into a spreadsheet and try to adjust them to obtain the desired characteristic.

A better, quicker alternative, he writes, is to employ an optimization algorithm that mimics a genetic process to find an optimal solution to a multivariable problem. He notes that other optimization algorithms can be faster than the genetic algorithm, but he explains that they are often more complicated to program and will frequently converge on a local minimum—difficulties the genetic algorithm avoids.



A genetic algorithm can determine the circuit values (a) that match a specific voltage/temperature characteristic (b).

Lyon presents a simple routine he developed using a free Visual Basic compiler. To learn more about Lyon's approach, visit the complete article at www.edn.com/CA6542464.html. The article includes a link to the source code and an executable file.

Rick Nelson, Editor in Chief

BOOK REVIEW

Measuring phase and amplitude at microwave frequencies

Fundamentals of Vector Network Analysis, 2nd ed., by Michael Hiebel, Rohde & Schwarz (www.books.rohde-schwarz.com), 2007. 420 pages. €68.

Why vector network analysis? That's the question posed by author Michael Hiebel near the beginning of this hefty hardcover book that answers the easy as well as the difficult questions regarding RF measurements. The simple answer to Hiebel's question is, of course, that vector network analyzers (VNA), unlike their scalar counterparts, measure phase as well as amplitude, but he goes on to elaborate: A VNA can perform full system error correction, it yields results that can be unambiguously translated into the time domain, and it supports embedding and de-embedding.

Hiebel begins by applying a VNA to a simple frequency converter, deriving Smith chart and other graphical representations of the circuit's performance. He goes on to describe the transmit and receive architecture of a VNA test set, commenting on the role of phase-locked loops (PLLs) and temperature-compensated crystal oscillators (TCXOs) in generator operation and on the role of the heterodyne principle and digital signal processing in receiver operation.

After covering the basics, Hiebel moves on to provide a chapter on measurement accuracy and calibration, providing details on random and systematic measurement errors, calibration standards and traceability, error models, and measurement uncertainty. Additional chapters show how to make linear and nonlinear measurements as well as time-domain measurements. Appendixes provide a review of complex numbers and matrix operations and, not surprisingly, list Rohde & Schwarz VNA models (which are used in measurement examples throughout the book).

The first edition was published in 2005 but didn't come to my attention at the time, so I can't comment on what's been revised. Unlike some vendors who write handbooks that they distribute free, Rohde & Schwarz charges for this one, but the €68 price tag (about $110) seems modest for a book providing this level of useful information. The book is currently available in English, German, and Chinese.

Rick Nelson, Editor in Chief

WEBCAST

Test methodologies for high-speed serial designs

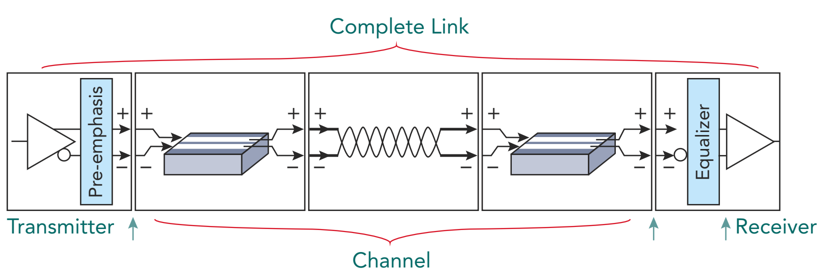
The first generation of serial standard applications is already well established, and the move to the second and third generation is underway, says Randy White, high-speed serial-applications technical marketing manager at Tektronix, in the Webcast "Overview of the Latest Test Methodologies for High Speed Serial Designs." Time to market is critical, he adds, noting that delays of product introductions usually have big financial consequences.

Making delays more likely, White says, is the fact that engineers face greater technical challenges to be solved, as they deal with design elements such as pre-emphasis effects at the transmitter output and the equalization employed to compensate for signal loss at speeds above 2.5 Gbps. In short, they must understand all the interactions between transmitter, channel, and receiver (**figure**), and they must also understand the effects that their measurement systems will have on performance.

During the Webcast, White provides details on digital validation and debug, serial data link analysis (SDLA), receiver testing, and signal integrity and compliance testing. In particular, he notes that SATA, PCI Express, and Gigabit Ethernet, for example, now require S-parameter measurements in their compliance test procedures, and he describes S-parameter measurement tools based on a time-domain reflectometer (TDR) that are accurate and easy to calibrate and that deliver high throughput.

In addition, White describes how to apply limit, stress, and compliance tests for receiver designs. You can view the archived version of this Webcast, presented live on March 17 and sponsored by Tektronix, *Test & Measurement World*, and *EDN*, at www.tmworld.com/webcasts. A video demonstration of an automated compliance test is also available.

Rick Nelson, Editor in Chief



When designing high-speed serial communications links, engineers must understand all the interactions between transmitter, channel, and receiver.

EMC

Sealing the EMI

DEVICE UNDER TEST

Electromagnetic interference (EMI) filters used on standard and custom connectors. Made of silicone rubber, the filters fit inside connector shells and holes let pins through the filter material. Standard connectors include commercial connectors such as DB-25 and military connectors such as MIL-C-38999, MIL-C-5015, and ARINC-404.

THE CHALLENGE

Develop a tester that measures the capacitance and resistance of the rubber filters. The tester must be flexible to handle any standard or custom connector, and it must be able to automatically test several connectors in one setting. Tester must measure capacitance and resistance (1 Ω to 5 GΩ) between any two connector pins and from any pin to ground. Provide for self-calibration in each capacitance or resistance range.

THE TOOLS

- National Instruments: PXI chassis, PXI embedded controller, 7½- and 6½-digit DMM cards, switch-matrix cards, graphical programming language, test executive. www.ni.com.
- National Technical Systems: custom interconnect box and custom programming. www.ntscorp.com.

PROJECT DESCRIPTION

Quell (Albuquerque, NM, www.quell.us), a maker of silicone rubber EMI filters used in connectors, needed an automated tester that could adapt to fit any filter. A division of National Technical Systems (NTS; www.ntscorp.com) that was formerly B&B Technologies developed a PXI-based tester for the filters.

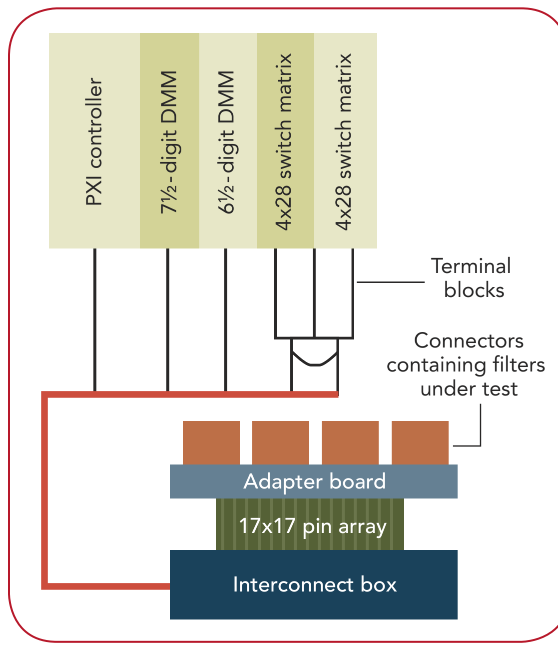
To provide flexibility, NTS system integrator Brian Shea designed an interconnect box that uses a 17x17 "bed of nails" array with 289 pogo pins spaced 0.1-in. apart in a grid. Quell engineers then design custom adapter boards with partial connectors that hold the filters under test. The number of pins in a connector determines the number of filters that a test operator can test at a time. The adapter board provides the tester with access to the required pins.

When a test begins, the tester loads an electronic data sheet for the filter. The data sheet contains capacitance and resistance specifications and pin-connection data so the system can properly route the signals.

The system performs a check on the adapter board by measuring the capacitance of open and short circuits with the 6½-digit digital multimeter (DMM) card. If the measurements are within tolerance, testing can begin. If the measurements are out of tolerance, the system prompts the operator to insert a calibration fixture with opens and shorts that lets engineers calibrate the signal path.

Next, the system measures capacitance and resistance for each of the 289 test points on the adapter card. The system stores the calibration data on each capacitance range on each pin. Once the system is operating within tolerance for each range, it begins the test. The system measures resistance with the 7½-digit DMM, then measures capacitance, compensating for errors produced by cables and switches. Switches connect the DMM cards to the appropriate pins in the array.

After measuring capacitance and resistance among all required pins and between each required pin and ground, the tester stores the results for each test point in a comma-separated variable (CSV) file. It then generates a pass report or fail report based on the test results and it generates a summary report. When a filter fails, the operator will print a failed-part report and send the part to the repair department. The system holds test data until an administrator downloads the data to read it with Excel. In the future, the system may store data in a database.



A PXI-based system measures resistance and capacitance in EMI filters.

LESSONS LEARNED

Shea encountered cabling issues when he first developed the tester. "We wanted to provide for disconnecting the interconnect box from the switch cards in case the test fixture needed repair," he said. "We tried to use a 100-pin straight-through connector, but the 1-mm pitch on the switch card connectors prevented the cable's connector from connecting to the switch card. So, we used the manufacturer's recommended ribbon cable, which is permanently attached to the switch card."

Martin Rowe, Senior Technical Editor

At Crossbeam Systems, testing ensures that the company's platforms run security applications that keep networks safe.

Testing toward SECURE netw

BY MARTIN ROWE, SENIOR TECHNICAL EDITOR

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Colin Ross, manager of SQA automation, leads a team of engineers that automate system testing by writing test scripts.

MARK WILSON

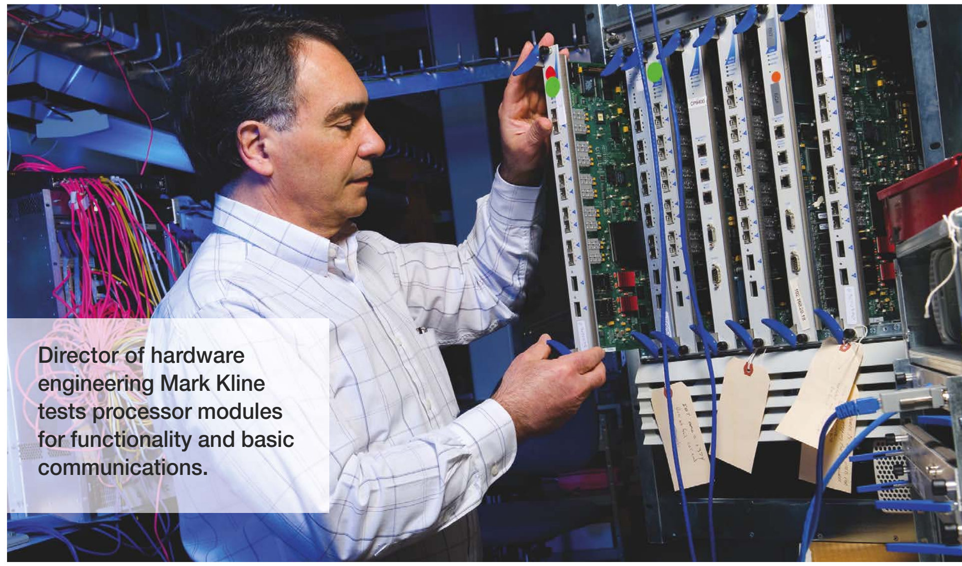
BOXBOROUGH, MA—When you make an online transaction or use a bank's teller machine, you trust that the financial institution's networks will protect your valuable information. Data centers of major financial institutions and other businesses use security platforms from Crossbeam Systems to protect their networks and your data. Financial firms such as CheckFree (now part of Fiserv) and Scottrade run security applications in their data centers on Crossbeam hardware.

Under the direction of Chet Gapinski, VP of engineering, engineers at Crossbeam test application processor modules (APMs), network processor modules (NPMs), control processor modules (CPMs), backplanes, and their communications links. Their goal: verify that the company's systems run firewall, antivirus, and other applications while minimizing network delays and data errors. Gapinski's team includes Mark Kline, director of hardware engineering; Matt Hamling, director of software quality assurance (SQA); Colin Ross, manager of SQA automation; and Raj Jain, SQA performance test engineer.

Engineers under Kline's direction test modules and backplanes, starting with basic hardware tests on the bench using in-house diagnostics. They test each component and module to verify that the communications channels send and receive signals properly and reliably.

Figure 1 shows a block diagram for an NPM board, the module that connects the Crossbeam security platforms to a customer's systems. In addition to containing an Ethernet switch, each NPM also contains a field-programmable gate array (FPGA) that adds a proprietary SerDes switch fabric used for communicating with other modules over a backplane. **Figure 2** shows a block diagram for APM and CPM boards. (See "The Crossbeam system," p. 28, for a description of Crossbeam's products.)

On the bench, engineers perform Ethernet loopback tests using predefined patterns built into the diagnostics. They also verify communications using a built-in pseudorandom bit sequence (PRBS), checking data and clock signals with oscilloscopes from Tektronix and logic analyzers from Agilent Technologies. The proprietary communications link can pass data at distances up to 24 in. over an FR4 copper backplane.



Director of hardware engineering Mark Kline tests processor modules for functionality and basic communications.

MARK WILSON

Kline's staff also runs a battery of power tests. DC-to-DC converters on the modules receive 48 V from the chassis and convert it to 1.8 V, 2.5 V, and 3.3 V. All modules must meet specifications for these voltages, ±5%, at specified current ratings.

Because a processor module contains a large number of ICs in ball-grid-array packages, the engineers also perform JTAG (boundary scan) testing. JTAG testing, however, has limitations. "We get between 60% and 80% JTAG coverage," said Kline, "because Intel-based APMs don't usually support JTAG." Kline added, "We also use in-circuit test for these boards."

Crossbeam's boards have more than 70 clock signals that must be tested for frequency, amplitude, and jitter. For most signals, engineers use a 2-GHz oscilloscope, but for slower signals, they use oscilloscopes with a bandwidth of 1 GHz or 500 MHz. A memory bus on the APM and CPM board runs at 667 MHz and thus requires a 1-GHz oscilloscope. When engineers need higher bandwidths, such as for 1-Gbps and 10-Gbps data streams, they rent a high-bandwidth oscilloscope.

Bench testing goes beyond basic electrical tests. Environmental testing, performed during hardware verification, gives engineers confidence in a module's reliability. Although Crossbeam products typically reside in temperature-controlled data centers, engineers must test modules at temperatures from 0°C to 80°C. "We design to comply with Network Equipment Building Systems [NEBS]," added Gapinski, "because some customers require carrier-class reliability."

Vibration testing also lets engineers verify reliability, and it gives engineers a chance to weed out weaknesses early. Kline explained, "We test our board until it breaks. Then, we analyze the failures and make design changes."

In addition to temperature and vibration testing, Crossbeam modules go through electromagnetic compliance (EMC) testing. The company uses local test labs Curtis-Straus and Intertek for environmental and EMC testing. "We've learned how to design for EMC," said Kline. "By following design rules, we're highly confident that our products will pass EMC tests the first time."

Test automation

The company's hardware engineers use loopback tests to verify communications at layer 1, the physical layer. Physical-layer tests verify that an Ethernet or proprietary SerDes link can reliably send and receive bits. But these tests simply send unstructured bits. Crossbeam engineers design automated tests to find the hardware's maximum throughput.

Testing must proceed up the protocol stack, moving up to layers 2 (Data Link Layer) and 3 (Network Layer). At these layers, a system needs software. Thus, Crossbeam engineers must install system software and retest the system.

At this point, Colin Ross and a team of seven engineers design and administer automated tests. "We run these tests on every new software and hardware build," said Ross. He calls the first round of tests a "smoke test." During a smoke test, which can run

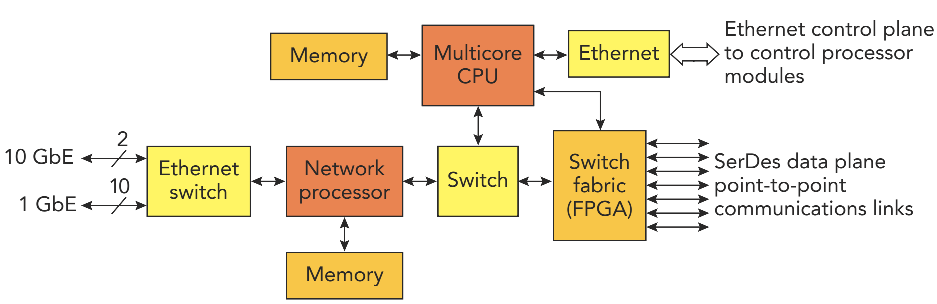


FIGURE 1. A network processor module (NPM) provides communications interfaces to customer networks through Ethernet and internally on a backplane.

for up to 18 hours, engineers collect data on throughput and they observe packets with an Ethernet tester from Ixia. The results of the test can give engineers confidence in the system's overall functionality.

To run the automated tests, Ross and his team have written more than 40,000 lines of Tcl code in 250 scripts that execute more than 600 test cases. They have created an application programming interface (API) that lets them issue a single command for each test. The code turns one of five "golden" systems into a traffic generator that tests new hardware and firmware revisions.

The smoke test includes regression testing whenever the company issues a new version of software. Regression tests prove that a new software version will interoperate with modules and systems that run earlier versions of the software. Before they implemented automated tests, the engineers could spend several weeks evaluating hardware and software design changes. Now, they perform the tests in just hours.

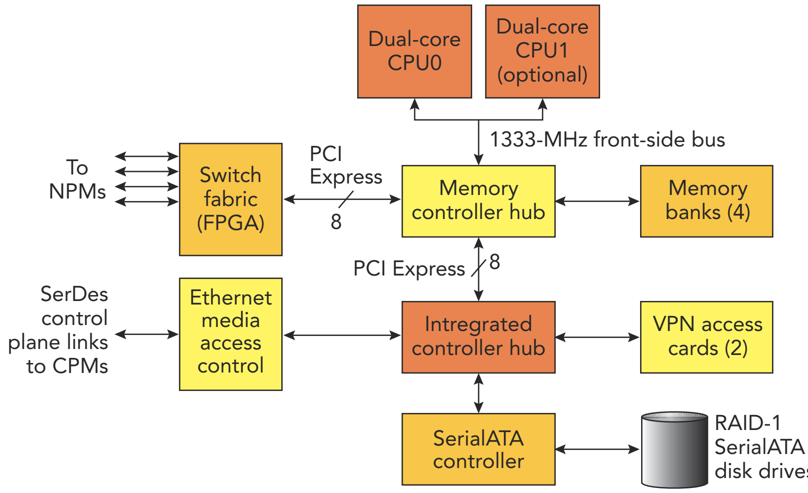


FIGURE 2. **Application processor modules (APMs) and control processor modules (CPMs) connect to NPMs through a switch fabric embedded in an FPGA.**

Testing takes place on any of five test beds that contain the golden systems. The traffic generator sends traffic to a system under test, which can run in ei-

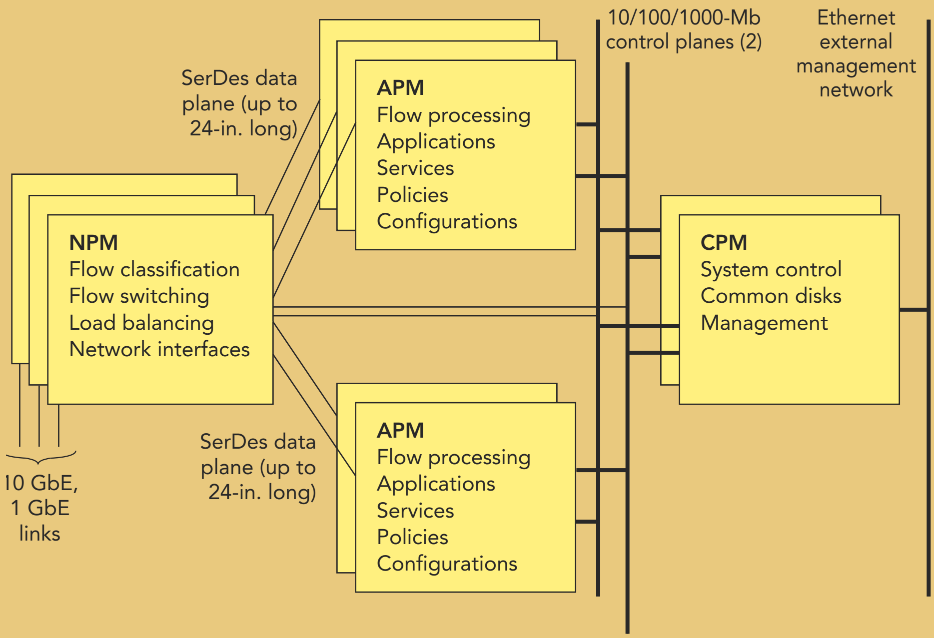
The Crossbeam system

Crossbeam Systems manufactures highly scalable hardware and software platforms that facilitate security services on networks. The hardware consists of three types of processing modules that mount in a 7-slot or a 14-slot chassis. Modules consist of a network processor module (NPM), a control processor module (CPM), and an application processor module (APM). The **figure** shows how these modules interconnect.

An NPM connects the system to the outside world. The module consists of two 10-Gbps and ten 1-Gbps Ethernet links, a 16-core MIPS64 security processor, a high-speed network processor, and an FPGA, which adds the switch fabric. The NPM connects to the chassis backplane through 3.2-Gbps SerDes links. The NPMs classify and control traffic flow. They also load-balance the network traffic among the one or more APMs in the chassis.

APMs run a hardened version of Red Hat Linux. These modules process flows from the NPM, sending them to security applications such as firewall and antivirus software. APMs contain a switch-fabric FPGA that provides 4x3.2-Gbps connectivity to the chassis backplane. Each APM runs one security application. Thus, a chassis can run several security applications, replacing multiple security appliances.

CPMs manage and monitor NPMs and APMs for failures. They perform system-level diagnostics along with self-healing functionality. They include a high-speed control plane that operates at 1-Gbps speeds. Crossbeam's X-Series chassis support up to two CPMs with mirrored hard drives for redundancy.—*Martin Rowe*



NPMs communicate to other network components, while APMs run applications and CPMs manage the data and control data storage.

Ensuring Reliability in Mobile WiMAX Receivers

Testing using arbitrary waveforms and real-time signals

As companies rush to get new Mobile WiMAX™ products to market, engineers face tough challenges in testing these often complex devices. Nearly all of these devices have two receivers, and many are capable of multiple-input, multiple-output (MIMO) reception in several frequency bands, commonly 2.3 GHz and 2.5 GHz.

To achieve your time-to-market goals, the receivers you develop need to work correctly in real-world situations. You must thoroughly evaluate your designs to verify that they will operate properly in dynamic and electromagnetically harsh environments. The wide range of wanted and unwanted signals, combined with the many nested feedback loops, make receiver design one of the most difficult challenges in the Mobile WiMAX cellular system. Meanwhile, the time-to-market clock is ticking.

To help engineers solve these daunting challenges, two innovative tools can make WiMAX receiver test more efficient and less time consuming. One tool, a signal generator with an internal arbitrary waveform generator and WiMAX-specific software, creates single input, single output (SISO) or MIMO waveforms and emulated static and mobile channels. The other, a base station emulator (BSE) with parametric test, will verify the closed-loop feedback mechanisms associated with ranging and hybrid automatic repeat request (HARQ) operation. It can also verify the end-to-end throughput performance using a separate content server.

Receiver Test Parameters

Before showing the benefits of these tools, it's important to understand the test challenges involved. WiMAX receivers must demonstrate required performance in both recovering signals and sending the correct management reports to the base station (BS). The basic performance metric is a bit-error-rate (BER) of 10^{-6}, but it is converted to an equivalent packet-error-rate (PER) for nearly all practical measurements. Among the key parameters to be considered during testing:

- The target Packet Error Rate for a faded channel is 10%. The packet size is 540 bytes for AWGN, and about one tenth of that for a faded channel.
- Received Signal Strength Indication is recovered from the BS preamble. The accuracy of reports is tested with faded channels and interferers.
- Physical (and Effective) Carrier to Interference and Noise Ratio (PCINR or ECINR) reports are fed back to the base station as part of the scheduling control process. It is important to generate the correct reports, and provide them fast enough for the system response to be effective. If broadband noise is used for testing, PCINR = CINR – 10*Log (8/3) or -4.26dB.
- ECINR is a qualitative metric for the signal following all demodulation processes. It is not expressed in dB, but rather in terms of the power, modulation and coding that the BS must use for a given channel condition.
- Ranging feedback controls the power, frequency and timing of the transmission from the mobile. The receiver must provide synchronisation information for the mobile's transmitter.

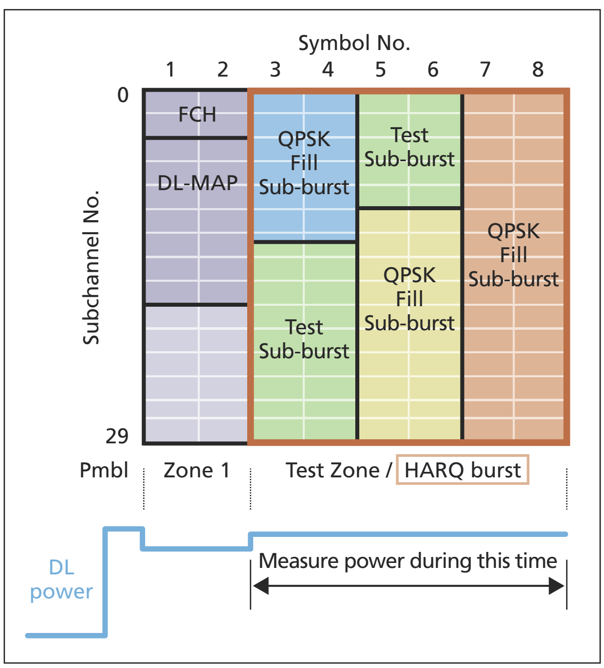


Figure1: Burst configurations for testing mobile station receiver conformance, using HARQ burst assignments. The blue power-versus-time shows the MRCT power measurement gating period.

Operation of a Dual Channel WiMAX Receiver

WiMAX receiver design can be one of the most challenging sections of the system to implement. Understanding the task and approaching it with an orderly, multi-layered test plan is critical to success.

To learn more about the basic operation of a dual channel WiMAX receiver, please visit: **www.agilent.com/find/wimaxRxBasics**. On this informative web page you will learn about major feedback loops including: gain control, tracking timing, frequency control, ARQ ACK/NACK and MAC feedback. Working through a simplified version of a typical WiMAX mobile station design will help to identify how these feedback loops impact testing.

Significant Parameters in the WiMAX Downlink Signal

The OFDMA signal also has many parameters that must be controlled for repeatable test results. First is the zone type, which determines the pilot and data subcarrier distribution. This is important because the power associated with each data subcarrier ultimately determines the BER and therefore PER, but the ratio affects broadband power measurements. The WiMAX mobile radio conformance tests (MRCT) use specific burst shapes, shown in Figure 1. It tabulates the total signal power assuming non-boosted pilots. An offset factor must be applied for practical measurements.

Partially used sub-carriers (PUSC) and adaptive modulation and coding (AMC) are the most common types of zones. After the preamble, the first zone is always PUSC, where the BS signal uses 1 in 7 sub-carriers for pilots. It contains the frame control header (FCH) and downlink map (DL-MAP), instructing the receiver where to look for the specific data bursts it needs to recover and therefore tell if it has missed a data burst, which helps HARQ operation.

The power during the downlink signal changes based on the construction of the sub-frame, so the default setting for the power shown on the Agilent N7615B Signal Studio software for WiMAX and the Agilent E6651A Mobile WiMAX test set is the power during the preamble. This means that these devices can confirm the accuracy of receive signal strength intensity (RSSI) reports. Finally, the modulation coding scheme, data coding and repetitions determine the expected demodulation performance.

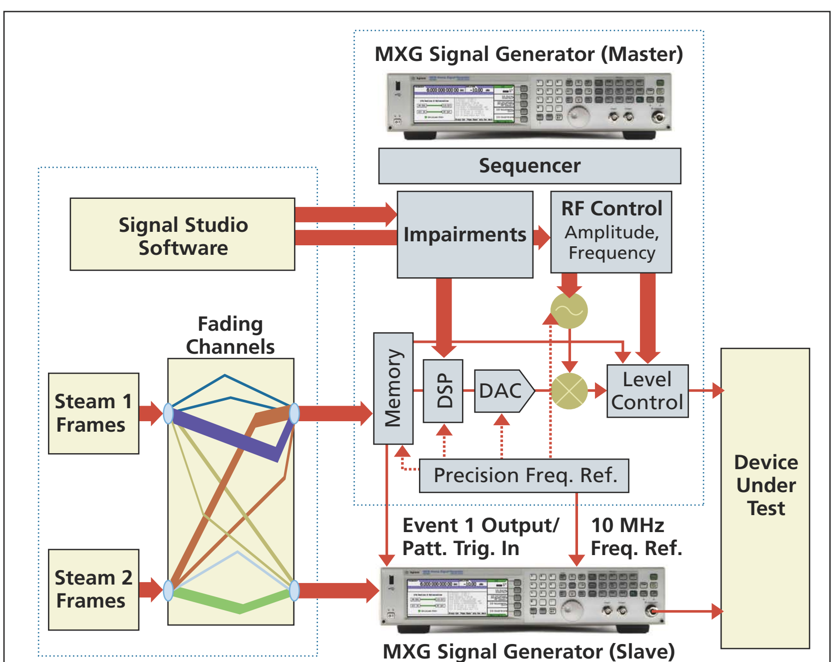


Figure 2: Arbitrary waveform test configuration for dual channel MIMO testing, showing signal construction and the addition of impairments, such as AWGN (phase noise), IQ offset & delay and RF phase.

Testing with an Arbitrary Waveform-Based Source

An advantage of arbitrary waveforms is that they can be developed during simulation and applied all the way through to manufacturing. The performance testing of feedback loops can be built up from the basics of frequency and timing synchronization to RSSI and CINR reporting.

Signal Studio software not only provides the necessary signal construction but also offers built-in interoperability testing because of its widespread use in the industry. It addresses all hardware setup issues, including: level control, RF blanking and MIMO source synchronization (see Figure 2).

Fading tests using an arbitrary waveform are a particularly cost effective way of making sure that the receiver copes with conditions more stressful than AWGN, or simple interference.

Adding a second signal generator allows MIMO testing, without the permanent commitment to the additional hardware, and provides full 6 GHz coverage in both sources. For most MIMO tests, the phase noise of the generator is so good that there is no need to phase lock the RF signals. For advanced beamforming tests, phase locking options are available.

In addition to Signal Studio software, the signal generator hardware accommodates waveforms from a number of other sources:

- Agilent Advanced Design System, which also has a specific WiMAX library

• MATLAB® using a free Waveform Download Assistant

• Agilent 89600 Vector Signal Analysis software recording function. The signal from any radio can be captured in the signal analyzer and replayed in the signal generator. So signals from radios from one vendor can be tested with another, a major step in understanding interoperability issues.

In this configuration, the device is controlled by a host processor running control software, which is specific to the vendor chipset. The test reports, such as PER, RSSI and CINR, are typically shown using the graphical UI of that software.

As noted earlier, signal design is an essential part of even basic parametric tests. Figure 3 shows the user interface of the Signal Studio software for WiMAX. To avoid misunderstanding over the specification of test waveforms, the software allows you to save and share setup files, or even the IQ waveform itself, in a format that can be used with any licensed signal generator. For digital baseband development use, this includes the pattern generator in the 16700 logic analyzer.

Figure 4 shows results obtained using an arbitrary waveform generator (AWG). It displays the expected

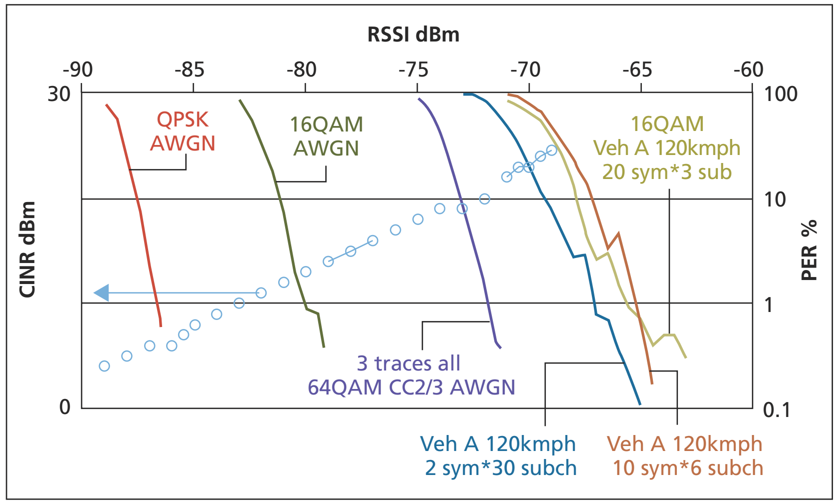


Figure 4: Sample receiver performance results using a variety of channels, modulation formats and burst sizes.

variation in RF level needed for a specific PER with different modulation types. Unexpectedly, it identified an error in the CINR reporting. The reports were several dB high.

A specific burst design is adopted for conformance testing. This is because the effect of pilot tracking in either AWGN or faded channels will give different PER results as packet length changes, even if the power per data subcarrier is kept constant. The two rightmost traces in Figure 4 show one example of the 1-2dB variation.

Built-in waveform sequencing gives a route to more advanced, dynamic testing. For sequenced tests, using power search, or increasing the automatic level control bandwidth, can help ensure the RF level is always correctly set.

Receiver Testing Using a Base Station Emulator

The use of a base station emulator (BSE) enables "over the air" tests, allowing a wide range of MAC feedback reporting mechanisms to be tested. For performance tests, Agilent's Mobile WiMAX test set transmits data bursts to the mobile, and uses the return packets on the uplink to determine PER. The uplink is assumed to be error free. Two mechanisms are available:

• Ping. Makes use of a TCP/IP function, where the host of the client radio transmits back data sent to it. The response from the radio is sent according to the UL-MAP allocation, as data bursts.

• ACK / NACK. The mobile is allocated space in the ACK channel to transmit an ACK or NACK response. The same function is part of HARQ operation, but retransmissions can be disabled to give the correct PER reading.

The second technique relies on the implementation of Hybrid ARQ, which is our final example of radio system feedback.

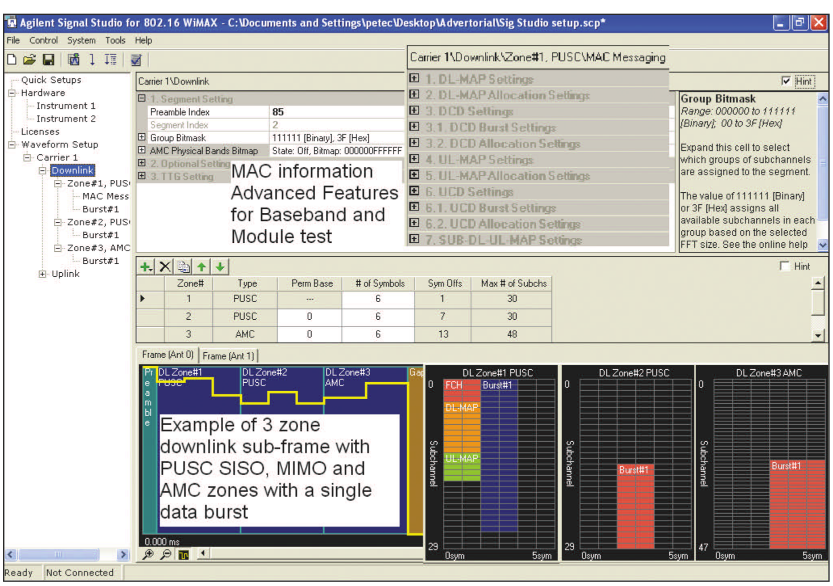


Figure 3: Signal Studio software for WiMAX user interface. Some items are overlaid to show the range of parameters available.

Benefits of HARQ

There are three options for controlling traffic flow: non-ARQ, MAC-ARQ and HARQ. Each has benefits for particular channel conditions and the quality of service (flow) required.

Operating the radio system with high (~10%) PER reduces the CINR requirement and increases the radio network's overall capacity. However, ACK-based upper layer protocols do not react quickly or efficiently to lost packets. The radio interface needs to shield protocols such as TCP from the vagaries of the RF channel. Relying only on MAC-ARQ may result in an increase in the latency jitter, degrading the performance of those streaming applications that work by regularly sending back control information to the server. Use of HARQ reduces packet timing jitter and the impact on the application. This benefits gaming and possibly VoIP.

HARQ can also help reduce the size of the TCP/IP receive window required because the packet latency is lower than with MAC-ARQ, which is good for high throughput applications. Further to latency reduction, combining the data from HARQ retransmissions in the receiver gives several dB improvement in the basic link budget.

Figure 5 shows the Mobile WiMAX test set user interface for HARQ test mode, with one example of HARQ operation. Data is divided into sub-bursts. Individually, these are sent using a simple stop-and-wait mechanism, but up to 4 ARQ "channels" can be run in parallel. Even if one channel is stopped, waiting for an ACK, the others continue.

The Mobile WiMAX test set supports three mechanisms for using a HARQ channel: ping, HARQ Test Mode and End to End. HARQ Test Mode uses PN data for the payload. All three methods add a HARQ CRC, which drives the generation of ACK and NACK responses.

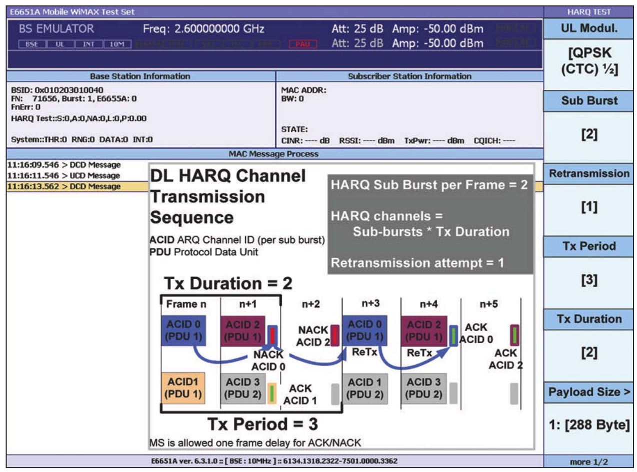


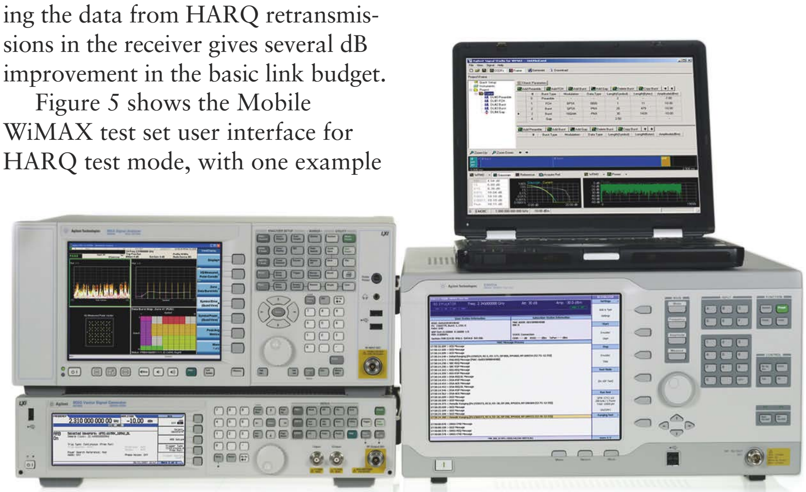
Figure 5: Mobile WiMAX Test Set HARQ test mode user interface, with inset showing an example of four HARQ channels in operation.

Solutions to Take WiMAX Forward

WiMAX receiver design teams face one of the hardest tasks in modern radio design. They need to deal with hardware performance and current consumption to memory and algorithm complexity constraints, while recovering some highly complex MIMO signals suffering from linear and non-linear distortions. Addressing the task requires an orderly, multi-layered approach. Agilent offers two powerful tools for meeting this challenge head-on: the MXG Vector Signal Generator with Signal Studio software for WiMAX, and the Mobile WiMAX test set with base-station emulation.

As a world leader in test and measurement solutions, Agilent Technologies is at the forefront of emerging communication standards such as WiMAX. Agilent provides the most complete set of WiMAX tools, from R&D, design verification and pre-conformance, conformance, manufacturing, through network deployment and service assurance – for Fixed and Mobile WiMAX, WiBro, including support for Wave 2 and MIMO. So as you take WiMAX forward, Agilent clears the way. ■

Peter Cain, Wireless Solution Planner, Agilent Technologies, authored this report. (peter_cain@agilent.com)



To ensure that your Mobile WiMAX designs perform as they should in real-world conditions, turn to a test solution that combines the Agilent E6651 Mobile WiMAX Test Set and the Agilent MXG Vector Signal Generator with Signal Studio Software for WiMAX.

5989-8437EN

ther a 7-slot or a 14-slot chassis connected through an Ethernet switch (**Figure 3**). An automation test harness communicates to the chassis and the traffic generators. Engineers use a Web interface to select tests and enter test parameters. The test bed will then run the tests and generate reports.

"The Web reporting system logs error messages," said Hamling. "With this system, we can usually isolate the cause of an error within a few hours. Prior to using this system, we might take days to find the cause of an error."

One of the tests, which runs for four hours, looks to uncover software errors and redundancy problems. Because the modules are hot swappable, the test checks for redundancy to ensure that a backup module will take over should a primary module fail. Other tests include traffic, connectivity, and pinging.

Currently, the five test beds operate independently from each other, but that should soon change. Ross is evaluating an Apcon Layer 1 switch that will connect the test beds. The switch will allow Ross to share resources among the five beds, and he's excited about the possibilities this will create. He looks forward to developing new test cases and to simulating cable breaks, which he describes as "an important piece to automate."

MARK WILSON

SQA performance test engineer Raj Jain spends several weeks testing each new software release at protocol layers 4 through 7.

Coming to life

After Ross' team certifies that a new or revised module has passed layers 1 through 3 tests, they hand it off to SQA performance engineer Raj Jain, who loads the module with a full operating system—a hardened version of Linux. At this point, the module becomes aware that it is part of a larger network.

With an operating system, a module can run security applications such as firewall and antivirus software. Whenever a new product or "first release candidate" of software needs testing, Jain will spend from eight to 12 weeks in the lab running performance tests. From the test results, he produces the performance numbers that the marketing department will publish.

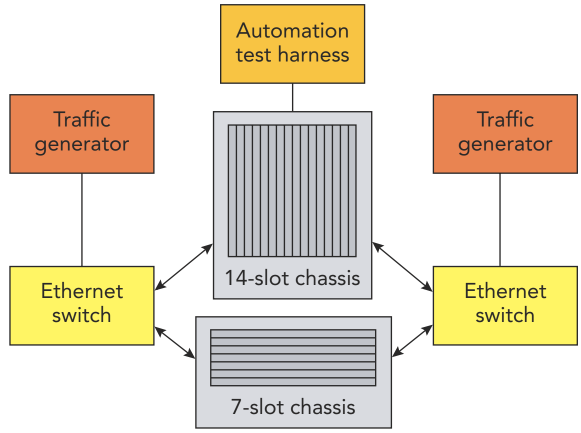


FIGURE 3. A traffic generator runs Ethernet traffic through modules in either of two chassis.

Jain and others run test cases at protocol layers 4 through 7 (Transport, Session, Presentation, and Application). At these upper layers, Jain uses a network tester from Spirent Communications. "We can use either the Ixia or the Spirent tester on all protocol layers, but we prefer to use each one where it best suits our needs," he said. "We also like to use the same test equipment that our partners and customers use."

Throughput is perhaps the most important test. "Improvement in throughput improves overall performance," noted Hamling. When testing throughput, Crossbeam engineers send traffic in 64-byte packets, the smallest possible with Ethernet. "A 64-byte packet has the least amount of data compared to the header," added Ross. "That creates the most interrupts, which places the most stress on a processor." On average, a module handles 1.2 million Ethernet frames/s with a firewall running. (Crossbeam doesn't supply application software such as firewalls to customers, but it does test and certify security software from its partners, the software publishers.)

In a firewall test, Jain sends real traffic through a system. That traffic includes HTTP pages, domain name server (DNS) calls, and e-mail messages. Jain's testing revolves around monitoring performance as a firewall's complexity builds. He measures latency as he applies an increasing number of rules and policies to a firewall. "Customers typically ask for performance measurements with one, 100, or 1000 rules," he said.

Latency occurs when a network element delays the transfer of data. To perform a latency test, Jain will exercise the system with user datagram protocol (UDP) traffic (Ref. 1). He's looking for latency of less than 50 μs. A latency test typically lasts for 120 s. Then, Jain will exercise the system to make and break 200,000 transmission control protocol (TCP) connections per second. He also tests to find the maximum number of TCP connections that the system can sustain while the chassis maintains 40-Gbps throughput over its SerDes backplane.

The NPM in a chassis performs load balancing across two or more APMs so that no single APM handles an undue burden of the processing (**Figure 4**). The

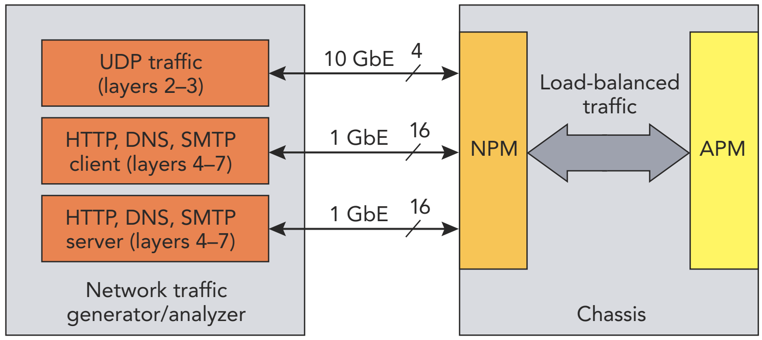


FIGURE 4. A network traffic generator/analyzer tests modules by sending and receiving data at all protocol layers.

APMs might all run the same application or they may run different applications. Jain will test with up to 10 blends of applications. Regardless of the number of applications, the test-system network topology remains the same.

In one test, Jain will add APMs, all running the same application software, until a 14-slot chassis has eight of them. As Jain adds APMs, system throughput should scale linearly. This kind of test lets him verify that Crossbeam's custom drivers and FPGA code function properly.

Load balancing, however, makes consistent testing difficult, because it dynamically changes the load on each module. "We need testing that's consistent with our partners," noted Jain. "We need to keep our throughput numbers within 2% each time to maintain consistency. Anything outside of this is considered a failure."

Crossbeam engineers also strive for test consistency with customers and partners through the use of standard test methods. For example, they follow RFC 2544 (Ref. 2) for system performance and RFC 3511 (Ref. 3) for firewall performance testing. They share test data with the partners who provide the security applications to Crossbeam customers, which enables consistent testing. This extensive network testing that goes into Crossbeam's products gives engineers confidence that the modules will protect host networks. T&MW

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3. RFC 3511, "Benchmarking Methodology for Firewall Performance," Internet Engineering Task Force, 2003. www.rfc-archive.org/getrfc.php?rfc=3511.

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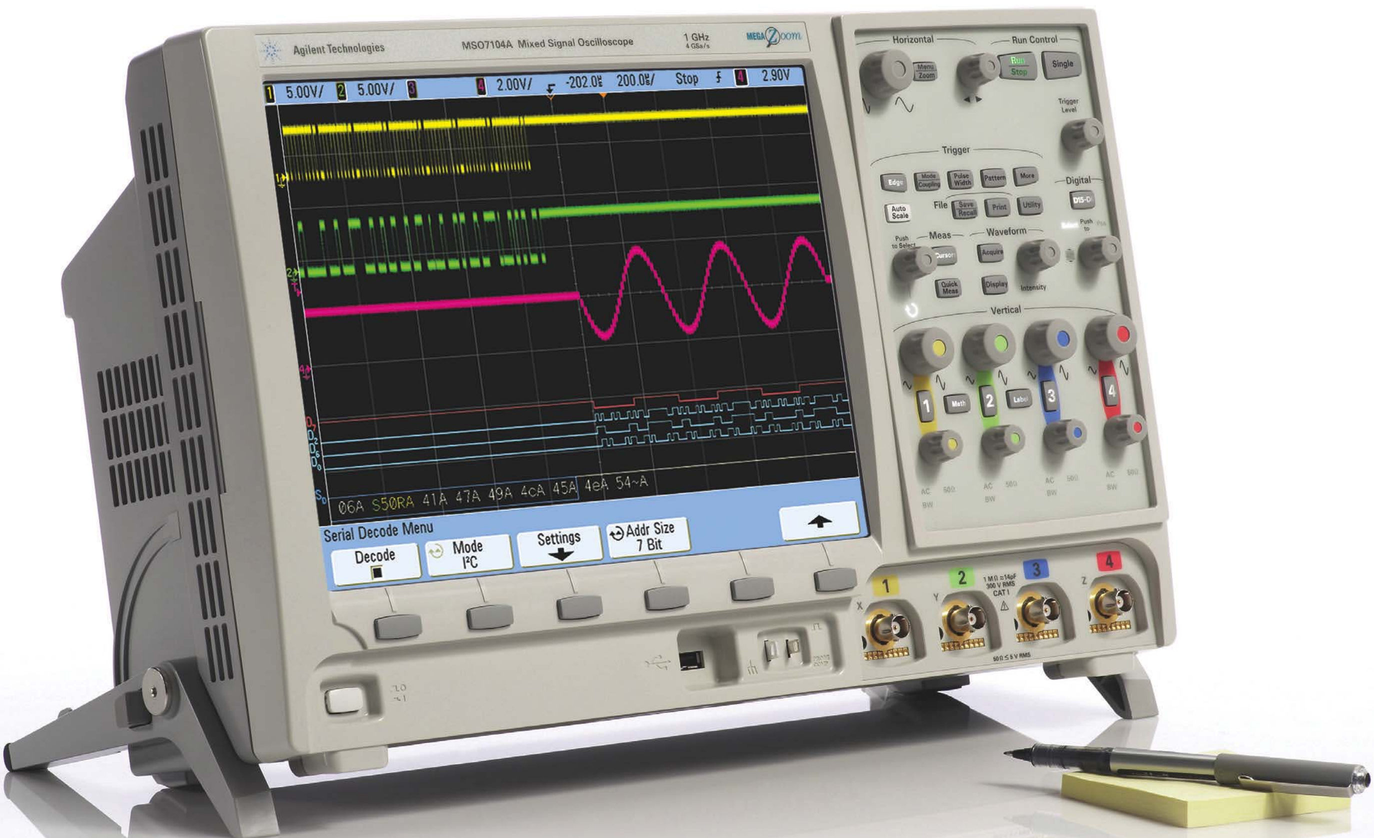

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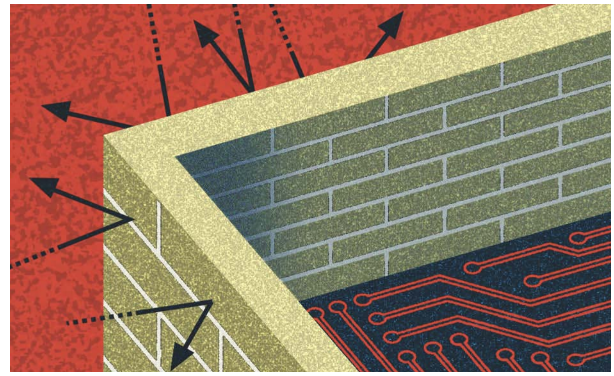


DANIEL GUIDERA

Modified THERMAL CHAMBER CUTS EMI

A modified commercial chamber shields devices from unwanted signals during temperature tests.

BY ROSS KULAK, TEXAS INSTRUMENTS

FIGURE 1. A modified thermal chamber contains a shielded adapter for RF cables and digital control cables.

RF ICs such as GSM system-on-chip (SOC) devices must operate within power and frequency limits over a specified temperature range. Testing requires an environment that attenuates unwanted signals, yet subjects the SOC to required temperatures. Guarding against unwanted signals and testing at specified temperatures are both easy to do, but not at the same time.

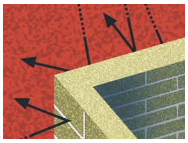
Because our RF SOCs contain both RF receivers and transmitters, we needed to eliminate interference from sources such as cellphone repeaters in our building. We also needed to route high-speed digital control signals to the SOCs and transfer test data to a computer. When we couldn't find a thermal chamber that sufficiently shielded the SOC from unwanted signals and provided a viable digital interface, we modified one with help from the manufacturer.

Test limitations

Engineers have, with limited success, used two methods of testing devices in thermal chambers while shielding against electromagnetic interference (EMI). One method puts the device under test (DUT), RF test equipment, and thermal chamber inside a shielded RF enclosure or screen room. Unfortunately, screen rooms are large and costly, and they require significant resources such as power, heat, and air conditioning. Also, the inside of the screen room can be a relatively noisy EMI environment because of the RF test equipment.

The second method involves placing the DUT inside a semi-shielded metal box and forcing air through the box. The shielding performance of the box depends significantly on the expertise of the person putting the system together. You can't get tight temperature control unless you place a thermocouple on the DUT and feed the signal back to a temperature controller. Furthermore, the thermocouple can radiate noise from the temperature-control system to the DUT.

(continued)



Thermal chambers typically let you route RF signals into the box through SMA connections. They let you provide DC power through filtered connectors and low-speed data through filtered D-sub connectors. But they lack entry ports for high-speed data signals.

A more elegant solution would incorporate temperature control into an RF-shielded environment. At a minimum, such a test chamber must

- provide enough space for the DUT,
- provide electric power from the AC mains to reach the DUT,
- provide interfaces for RF signals, DC power, and high-speed digital signals between the DUT and the test equipment,
- provide reliable temperature control, and
- provide a defined shielding capability.

We searched for a commercial system that would meet all of our requirements, but after reviewing several options, we concluded that none could adequately control temperature with the required shielding effectiveness while providing the necessary digital interface. One manufacturer, though, had a history of modifying its chamber to shield against outside EMI. Votsch Industrietechnik's chamber provided some of the necessary shielding effectiveness but needed further modifications for our application.

The chamber (**Figure 1**) is relatively small and portable and operates on standard line voltage. It is equipped with a customer-defined entry port containing bulkhead SMA connectors that we used to route RF signals from a signal source to our receiver circuit board. It also contains filtered and shielded banana plugs to provide DC power to the UUT. Filtered and shielded D-sub connectors support low-speed data signals.

We found, though, that the chamber lacked the connectors for a high-speed data digital bus. We needed a 38-MHz digital interface to let our boundary-scan (JTAG) test equipment communicate with the processors within the SOC. Our application also required a 34-bit bus to transfer data between the DUT and a PC. The DUT needed clocked-data speeds up to 50 MHz. This requirement created two major challenges:

- The interface could not degrade the integrity of the digital signal. Both the JTAG and data-capture equipment have cables designed to maintain the digital signal integrity. The interface must not add discontinuities into these transmission lines, so the cables must be kept intact between the sources and destinations.
- The interface must not degrade the shielding effectiveness of the thermal chamber. This requirement is extended beyond just the interface. Our goal was to maintain the specified shielding capability with a live system; that is, with all of the connections both internal and external to the chamber terminated and operating according to the application.

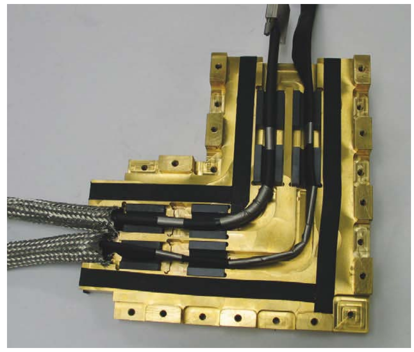


FIGURE 2. The shielded adapter contains ferrites that surround the cables, providing EMI suppression.

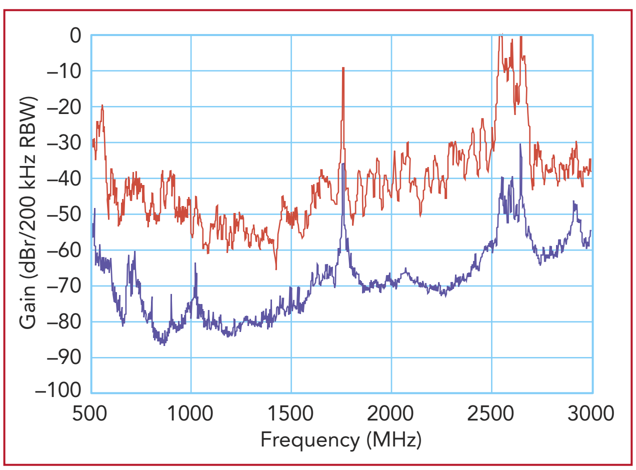


FIGURE 3. The upper trace (red) represents the measured gain of the chamber relative to the equipment noise floor (blue).

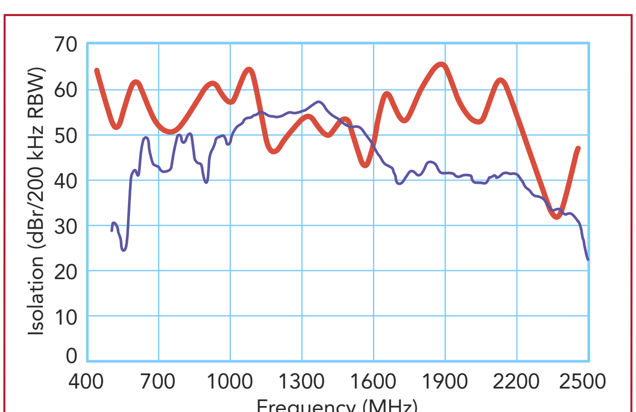


FIGURE 4. After modifications, the chamber still provides better than 35 dB of isolation across the frequency range (blue trace). The red trace indicates the manufacturer's specification prior to modification.

The thermal chamber met our requirement that it let us control the ambient DUT temperature, and it partially met our requirement for shielding, because the manufacturer provided enough EMI shielding of the electrical interfaces.

In modifying the chamber, our two main objectives were to shield the digital cabling with the braided tubing and the shielded adapter and to dissipate as much of the conducted RF energy as possible with the various ferrites.

To help us meet these objectives, Votsch added an additional blank entry panel that we could modify to support the 38- and 50-MHz digital signals. We planned to run the digital cables through a shielded adapter attached to the blank entry panel. We encapsulated each digital cable with flexible ferrite tubing, four ferrite cable clamps, and four pieces of ferrite tape. We selected the different ferrite products to provide EMI attenuation at several frequency bands.

We then placed metal-braided tubing over the digital cables on top of the ferrite tubing. **Figure 2** shows the cable mounted in the shielded adapter that mounts on the chamber. Half of the shield is removed to show the cables.

Verifying the chamber's capabilities

To determine the impact of the modifications and to meet our requirement for a defined shielding capability, we brought the modified thermal chamber to a facility equipped with an anechoic room and with equipment that could measure the chamber's ability to attenuate incoming signals. We placed the chamber on a rotating platform with a transmitting antenna inside and a receiving antenna outside the chamber but still inside the anechoic room.

The receiving antenna supported two polarizations and a variable height adjustment. With this method, we could generate known signal levels inside the thermal chamber and measure their levels outside. That would tell us the shielding effectiveness of the chamber, or its ability to attenuate outside signals.

We measured the combined energy of the two polarizations (horizontal and vertical) at two angles relative to the horizontal plane of the thermal chamber. We placed a live DUT inside the thermal chamber and connected it in accordance with the application.

Prior to measuring the thermal chamber's shielding effectiveness, we needed to quantify the transmit-to-receive gains associated with the antennas, cables, amplifiers, and free-space loss. We used gains as the 0-dB reference level in a spectrum analyzer. We then referenced all subsequent measurements to this level.

Table 1. Chamber leakage at different rotations, antenna angles, and signal levels

	Signal level			
	824 MHz to 960 MHz		1708 MHz to 1980 MHz	
Thermal chamber position	Antenna angle			
	0°	30°	0°	30°
0°	7.2 dB	5.0 dB	1.7 dB	0.7 dB
90°	5.6 dB	0.0 dB	1.2 dB	0.0 dB
180°	6.3 dB	11.0 dB	0.3 dB	0.9 dB
270°	6.0 dB	6.7 dB	0.3 dB	0.1 dB

We wanted to determine how the high-speed digital-signal entry port modified the basic thermal chamber isolation. Thus, we defined a nominal equipment noise-floor level of –50 dBr. Noise floor levels higher than –50 dBr would produce questionable final isolation measurements. There are peaks in the noise profile at 500 MHz, 1750 MHz, and 2500 to 2700 MHz, where the measurements are invalid. These peaks are due to nulls in the transmitting antenna that we numerically added to the measured signal to create the 0-dB reference. These peaks limit the isolation measurements at those frequencies.

We started by performing a frequency sweep between 500 and 3000 MHz over eight combinations of antenna angles and sides of the thermal chamber. We had to determine if the worst-case isolation occurred at frequencies of interest: the 824- to 960-

MHz and the 1710- to 1990-MHz cellular frequency bands. **Figure 3** shows the worst-case gain of the thermal chamber for all eight conditions listed in **Table 1** (four chamber positions and two antenna angles). Figure 3 also shows the ambient noise level where the measurements are invalid.

Discounting the areas where the measurement system was insufficient, we determined that the thermal chamber can achieve better than 35 dB of isolation. **Figure 4** compares the chamber manufacturer's isolation specification versus the worst-case isolation after we modified it.

After measuring the emissions from the thermal chamber, we tried to determine which of its sides produced the greatest leakage. We integrated the sweep data at each measurement angle over both the low and high cellular frequency bands to determine relative leakage. Table 1 provides the results of the comparison.

With the receive antenna at a 0° angle, the front of the chamber was the primary leakage source. With the receive antenna at a 30° angle, the chamber rear (180°) became the primary leakage source. The difference in measured emissions in the 824- to 960-MHz cellular bands is rather significant: 11 dB versus 6.3 dB.

Arriving at precise conclusions from this information was difficult. Because the side faces are peripherally observed from both the front and rear observation points, they don't appear to contribute to the leakage observed at the front and rear faces. The most physically apparent leakage point(s) are the power transformer ventilation holes on the top of the chamber. Additional effort is required to localize the higher leakage levels observed at the front and rear of the chamber.

Modification efforts continue

While the modified thermal chamber does not provide the 80-dB to 100-dB isolation typical of RF screen rooms, it does shield the test process from the cellular repeaters. We continue to work on this project.

Although we took care to minimize the thermal conductivity of the shielded adapter, we had concerns that it might degrade the thermal chamber's temperature performance. Subsequent use of the chamber proved that the thermal conductivity was minimal.

Even though we've qualified the modified thermal chamber, we still don't know the level of interference observed by the devices inside the chamber. A site survey will determine the ambient level of interference in the laboratories.

We still need to identify the 11-dB variation in leakage described in Table 1. To do that, we must make localized measurements with a small dipole antenna. Corrective action will depend on the exact cause of the variation. T&MW

Ross Kulak *is an RF characterization engineer with Texas Instruments. rkulak@ti.com.*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Chipsets are emerging that add WiMAX capability to mobile PC and cellphone applications, while lab and production test equipment evolves to keep pace.

BY RON WILSON, EXECUTIVE EDITOR, *EDN*, AND RICK NELSON, EDITOR IN CHIEF

WiMAX stands poised to extend coverage in PC networking and mobile phone communications as semiconductor makers roll out WiMAX chipsets and as test-equipment vendors offer the lab instrumentation and production ATE systems necessary to test the chipsets and the products they populate.

WiMAX has been suggested as a technology for cellular telephony, but Paul Argent of Aeroflex said he expects WiMAX to initially bring broadband wireless access to laptops. Over the next two years, Argent said, WiMAX will primarily provide high-speed data access to PCs in coffee shops as well as in moving vehicles. (See "WiMAX markets and opportunities," p. 46.)

The N6430A WiMAX protocol conformance test and development solution provides a suite of test solutions for 802.16-2004/Cor2 D3 Mobile WiMAX protocol conformance test (PCT) and protocol development testing. Courtesy of Agilent Technologies.

Jennifer Stark, WiMAX business team lead at Agilent Technologies, cautioned though that WiMAX should not be considered a replacement for other broadband wireless access technologies. She segments wireless technologies by range—with personal area networks operating at 10 m or less, WLANs communicating over 100 m or less, and WiMAX operating over maximum distances of 3 to 10 miles, or possibly more.

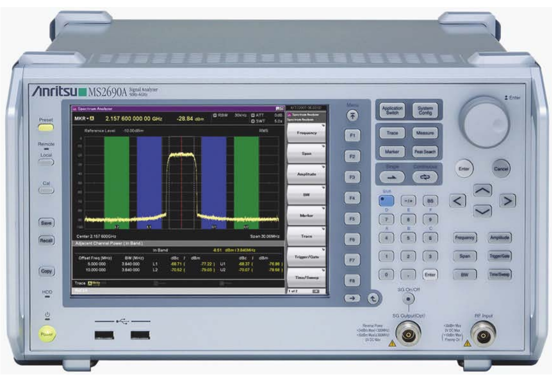
As for WiMAX competing with WLANs, she expects them rather to complement each other, with appliances making the most effective connection based on the conditions of the moment. For instance, she said that WiMAX will be the choice if you're on a train going 50 mph, but if you later find yourself in a stationary situation, WLAN might be the best choice.

WiMAX chip test

To test WiMAX chips in production volumes, ATE makers are adapting their RF-capable systems to handle WiMAX test requirements, while makers of bench and rack-mount test equipment

are tailoring their instrumentation to handle a potential onslaught of components, modules, and WiMAX-compatible appliances; these vendors are also addressing the test needs of service providers who will be installing and maintaining WiMAX infrastructure.

Keith Schaub, RF product engineer at Advantest, said WiMAX combines cellu-



The M2690A/M2691A signal analyzers operate from 50 Hz to 6 GHz and can measure the transmit power of mobile WiMAX devices. Courtesy of Anritsu.

lar performance requirements with the need to test multiple transceiver/receivers (MIMO) at WiFi bandwidths. "In essence," he said, "it merges all of the test requirements into a single chip."

Adam Smith, a business development engineer at Verigy, said WiMAX test represents an evolutionary step from WLAN test, with WiMAX imposing stricter requirements as designers try to cram ever more features into a tighter space. "From a test equipment point of view," he said, "your equipment needs to have very good noise performance—it needs to be very sensitive." Agilent's Stark added that WiMAX's underlying orthogonal frequency division multiplexing (OFDM) modulation scheme results in high peak-to-average power levels, putting a premium on highly accurate power-amplifier measurements.

Controlling test cost

If WiMAX is going to reach wide acceptance, test costs—including the cost of silicon overhead to support testing—have to be as small as possible. Ultimately, said Smith at Verigy, someone will want to fit WiMAX capability within a $99 mobile device.

When asked whether performance or cost is the most important aspect of a WiMAX test regimen, Schaub at Advantest responded, "Both, unfortunately. The cost has to be similar to today's WiFi products." He commented on WiMAX going into a laptop: "We as customers already have an expectation of cost, so it can't be too far out of alignment. Additionally, a lot of companies intend to use WiMAX to extend their cellular networks. It saves them a ton of money in infrastructure cost." And, he added, there is an expectation that the cost of a cellphone will be low in many poorer countries. As for performance, he said, "All of this must work while riding in a car, on a train, etc. So, the performance requirements are similar to today's cellular phones."

Performance is only one of the factors that militate against a fast, comprehensive test procedure. The WiMAX standard is still not mature, and small adjustments still happen. More important, the standards only attempt to ensure interoperability at the systems level. They make no specific demands on the implementation approach or on the signals passing between functional blocks in the implementation.

Even more troubling, you may find that you don't have access to signals between functional blocks. Ken Harvey, senior product technologist at Teradyne, pointed out that as WiMAX chips become increasingly integrated, you'll find you might not have direct access to I/Q signals—"You'll go straight from RF to bits," he said.

Lacking standards against which to test the signal between the RF mixer and the ADC, for example, and potentially lacking access to that signal, you'll have to rely on system-level requirements, such as the error vector magnitude (EVM) of the resolved signal and bit-error rate of the data stream. Stark of Agilent elaborated on this point. She divides the WiMAX market into four segments: chips and components, modules (for which chip-maker reference designs sometimes substitute), appliances, and service providers. She concurred that EVM is a system-level spec that must be measured at the appliance level but cautioned that designers must beware of component and module EVM (of a power amplifier, for example), so they can stay within an overall EVM budget.

Ultimately, Stark said, test will play a key role as vendors try to differentiate their components in terms of features, RF performance, and power consumption. She pointed out that, fortunately, WiMAX appliance vendors won't be creating brand new devices that we've never seen before. The use case for WiMAX, she said, is to add WiMAX to existing devices, such as laptops, PDAs, and cellphones.

But just how a particular system, no matter how familiar, reaches adequate system-level performance standards will vary depending on the baseband software, the system design, and the intended operating environment of that system. There is no straightforward translation between WiMAX's system performance specifications and testable behaviors on WiMAX silicon.

That said, the testing problem is easier in some functional blocks than in others.

The CMW270 single-instrument production tester makes signaling and nonsignaling measurements of WiMAX mobile stations and customer premises equipment. Courtesy of Rohde & Schwarz.

From a testing point of view, the digital baseband is just another fast signal processor. In a written response, an Intel engineering spokesperson said, "WiMAX silicon is not very different from any other SOC [system-on-chip] testing we perform at Intel. The part goes through Intel's strict product reliability and qualification guidelines that include wafer testing, ESD [electrostatic discharge] stressing, burn-in, and analog/mixed signal testing across a broad range of temperature, environmental, and power supply variability conditions. WiMAX silicon can use the same DFT [design-for-test] techniques and hardware structures that are common in SOC design, such as at-speed scan, ATPG [automatic test-program generation], and logic and memory BIST [built-in self-test]. The process also includes package qualification and silicon performance testing on multiple skew lots, as well as normal silicon lots."

As one old chestnut has it, you test digital circuits, but you characterize analog ones.

Basically, the baseband silicon is a specialized, but still programmable, signal processor. It is working correctly or it isn't. It's the software that needs to be adjusted to the specifics of a particular application, and that's not a testing problem.

Analog space

If you talk to a vendor of RF silicon, though, you get a rather different view. In the digital world, chip variations don't alter the functionality of the device until they get so severe that they actually break the circuit. In the RF and analog domains, variations in the chip are variations in the functionality. As one old chestnut has it, you test digital circuits, but you characterize analog ones.

"WiMAX is all over the place right now," said Tom Gratzek, business director for the WiMAX silicon program at Analog Devices (ADI). "There are different frequency bands, different bandwidth requirements, different baseband filtering schemes—everyone has an approach."

ADI offers WiMAX front-end silicon that includes the RF stages, mixers, ADC/DAC, and some digital filtering. Gratzek said that the digital portions of the chips get tested the way any other digital circuitry would be: with scan-based BIST. But from there, things get more complex.

"We have to examine the analog signal chain for defects," Gratzek said. "That by itself requires hundreds of milliseconds of test time. After that, the only approach we have found to predict how the chip will work in the customer's system is to stimulate the silicon at-speed." But it is not, Gratzek explained, a full characterization. Rather, the test program is an artful compromise, based on the full characterization of skew lots done in the engineering lab, on the ability of test engineers to elegantly check many degrees of freedom with a few tests, and on continuous feedback from ADI's applications engineers, working on customer designs.

The solution ADI has found is to drive the receiver with multiple gigahertz-band test signals and to drive the transmitter with corresponding digital vectors. "We sweep three frequencies in each band," Gratzek said. "Unfortunately, that forces us onto mainframe RF testers, and it adds seconds of test time."

This is not a unique approach. Infineon engineers report that they generally stimulate their WiMAX silicon at-speed as well. They use a standard 64 QAM 2/3 modulation of a 3.5-MHz-bandwidth signal, sampled at 4 MHz, as a starting point. But Infineon is seeing increasing pressure for customers with video-over-broadband applications to expand the bandwidth to 10 or even 20 MHz, causing changes from the silicon on up through the testing program.

Even moving to mainframe RF ATE isn't the whole solution, though. Gratzek said that ADI has augmented its testers' already formidable hardware with some custom spectral-analysis gear. There are also some proprietary design features built into the silicon and the device-under-test card to increase coverage and reduce test time. This allows the test team to sweep frequencies for an end-to-end test: On the receive side, for instance, they can drive the antenna inputs to the low-noise amplifier and analyze the output stream from the ADC for EVM and noise figures.

These top-line numbers give ADI a go/no-go indication on each die, and they let the engineers infer the signal-to-noise ratio and linearity of the ADC from the end-to-end test. But the test team can extract even more detailed information as well, due to the high degree of digital configurability of the RF design. *(continued)*

"We can manually control the automatic gain control loop, and we do so during test," Gratzek illustrated. "We can also disembed the digital filters on the output of the chain to examine the raw digital data. And we can force the analog filters to specific characteristics, step through the gain settings on the LNA [low-noise amplifier], and so forth." This allows the test team to move, if necessary, from the end-to-end test to an almost diagnostic level of examination, while still on the production test head.

This flexibility comes in handy. "We are delivering WiMAX chips to all sorts of customers' evaluation boards, and they use the silicon in many ways," Gratzek said. "Our applications engineers feed use data back to the test team, and we try to adjust the tests to anticipate the sensitivities of a particular customer application. For instance, many customers change the filter settings to get the EVM they want on a particular board and antenna configuration. We try to adapt to that." This requires the applications support team to reserve time on the test floor for development purposes.

Tailoring test systems

Of course, commercial test companies are working to streamline WiMAX test. ATE vendors including Advantest, Teradyne, and Verigy are tailoring their systems to test WiMAX devices in multisite configurations.

Adam Smith of Verigy said there is nothing magical about WiMAX. He said that while ultrawideband (UWB) is dealing with new spectrum, WiMAX aims to make more efficient use of spectrum that's already been allocated. WiMAX test, he said, is well within the capabilities of his firm's Port Scale RF instrument for the V93000 system. Similarly, Advantest's 12GWSGA RF module, introduced last fall for the company's

WiMAX markets and opportunities

Embedded mobile WiMAX in mobile PCs will drive the emerging WiMAX chipset market through 2012, says In-Stat in a report titled "WiMAX Chipset Market: Faith in Mobile WiMAX Drives Expected Volume Growth Worldwide." The market-research firm predicts that Intel's combination Mobile WiMAX and Wi-Fi Echo Peak module, which will launch as an option to the company's Montevina mobile processor platform in 2008, will drive the adoption of embedded WiMAX into mobile PCs. WiMAX customer premises equipment (CPE), external clients, and dual-mode cellular/WiMAX handsets will also help drive WiMAX chipset volumes through 2012, the firm reports.

"The total WiMAX user terminal chipset market will reach almost $500 million in 2012, growing from $27 million in 2007," said Gemma Tedesco, In-Stat analyst, in a press release. "Furthermore, WiMAX base station semiconductor revenues are expected to be approximately $1.4 billion in 2012, compared to $130 million in 2007."

In a separate report ("Complement or Threat—WiMAX Strategies for Mobile Operators"), In-Stat says that from a mobile operator's perspective, mobile WiMAX provides more of a service complement than a competitive threat. The firm notes that the mobile standard for WiMAX has been the subject of debate since its inception, with debaters falling into two camps.

"One camp led by select equipment vendors with no stake in WiMAX has taken an either/or approach to discussing mobile WiMAX," said Daryl Schoolar, In-Stat analyst, in a press release. "Any gain by WiMAX comes at the expense of other 3G data technologies. In the other camp, infrastructure vendors like Alcatel-Lucent, Motorola, and Nokia Siemens see a world where multiple mobile wireless broadband technologies will coexist. In-Stat believes that the latter camp's view will prevail."

Source: In-Stat (which is owned by *Test & Measurement World*'s parent company). www.instat.com.

T2000 test system, and Teradyne's UltraWave, introduced in March, will handle WiMAX chip test.

Semiconductor ATE systems have typically focused on high throughput without necessarily providing the performance of bench and rack-mount instrumentation, but the advent of WiMAX is changing that, said Harvey of Teradyne. Measurement requirements are becoming so stringent, he said, that ATE instruments must approach bench and rack versions in measurement capability. He cited an additional advantage of high-performance ATE: It lets you characterize silicon on the ATE itself, smoothing the transition to high-volume production test.

Kyle Klatka, product manager for Teradyne's Wireless Business Unit, added that UltraWave "can deliver up to 16 universal RF ports. By 'universal,' we mean that every RF port on the instrument has the same capability." In previous instruments, he said, some ports might include features such as an on-board noise source while others might not, complicating the test engineer's task. "We decided to take those variables off the table to make life easy on test engineers when they are designing their DIB [device interface board]."

Companies that provide test equipment for WiMAX modules and appliances as well as components include Anritsu, Agilent, Aeroflex, Tektronix, and Rohde & Schwarz, all of which make general-purpose test and measurement equipment that can perform tests on WiMAX systems as well as on dedicated WiMAX boxes and software.

In addition, Keithley Instruments signaled its interest in WiMAX by joining the WiMAX Forum in January. Mark Elo, Keithley marketing director for RF products, said the company's Model 2920 vector signal generator and the Model 2820 vector signal analyzer support the OFDM and MIMO technologies necessary for WiMAX test, and he added that Keithley has been working with WiMAX chipset and appliance vendors.

For its part, Tektronix offers the K1297-G35 WiMAX protocol analyzer, which provides for protocol simulation, emulation, and monitoring. In addition, Tektronix offers for its real-time spectrum analyzers the RSA-IQWIMAX software, which can help detect, diagnose, and resolve WiMAX design errors.

Rohde & Schwarz offers the CMW270 single-instrument production tester as well as the TS8970 WiMAX radio conformance test system. Anritsu offers signal-generation and signal-analysis bench instruments, such as the MS2690A signal analyzer and MG3700A vector signal generator, as well as the handheld MS2724B spectrum analyzer, which can make fixed and mobile WiMAX measurements in the field.

Argent of Aeroflex said his company offers WiMAX test equipment in PXI and traditional rack-and-stack formats for testing WiMAX base stations and mobile devices "from birth to death." He noted that before vendors submit their WiMAX devices to WiMAX Forum certification labs, they would benefit from doing their own precertification tests to help ensure their devices pass the first time. When WiMAX Forum labs are charging around $500 per hour, he said, customers will want to have maximum confidence that their products will pass quickly.

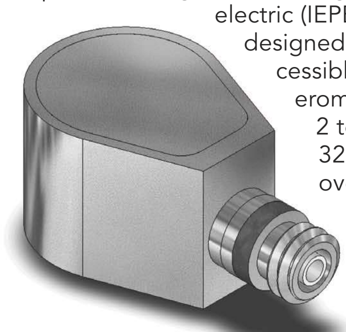
Stark of Agilent noted that her firm's offerings extend from the EEsof division's Advanced Design System (ADS) design and simulation software to WiMAX drive-test systems. Along the way, the company offers a complement of signal-generation and signal-analysis equipment, which can link to ADS via Agilent's Connected Solutions technology, as well as WiMAX protocol analyzers and logic analyzers for baseband development and troubleshooting.

At the end of the day, test cost will be paramount—for chips, modules, appliances, and infrastructure installation and maintenance. Gratzek of ADI summarized the cost issue from a chip maker's perspective: "On our GSM product line, we were able to substantially reduce the test cost as the market matured," he said. "We aren't at that stage yet with WiMAX, but we have planned for it. We designed our ATE strategy from the beginning with an end cost-point in mind and a path to get there. We may well reduce the test cost by a factor of three as the technology matures." T&MW

A version of this article appears in the April 3 issue of EDN.

Miniature teardrop accelerometers

Dytran Instruments has introduced two high-sensitivity accelerometers that feature a miniature teardrop design. The Models 3225M23 and 3225M24 are low-profile, voltage-mode, integrated electronics piezoelectric (IEPE) accelerometers designed to mount in spaces inaccessible to other types of accelerometers. Both operate from 2 to 10,000 Hz; the Model 3225M23 delivers 50 mV/g over a ±100-g range, while the Model 3225M24 delivers 100 mV/g over a ±50-g range.



Featuring a titanium housing and weighing 1 g, these units are suitable for the measurement of shock and vibration of small, lightweight specimens such as printed-circuit boards (PCBs) and board-mounted components. Designed for adhesive mount, the 3225M23 and 3225M24 fit in spaces only slightly greater than 0.25 in. wide. The height is 0.215 in. These units also feature a coaxial connector that mates with the vendor's model 6003AXX replaceable coaxial cable (where XX is the cable length in feet).

Base price: $403. *Dytran Instruments, www.dytran.com.*

Credence debuts high-density instrument for Diamond testers

Credence Systems has introduced the DD1096-32 digital instrument with 32-Mbit deep reconfigurable parallel vector memory for use with the company's Diamond IC testers. Using the 96-channel DD1096-32 within the 10-slot Diamond 10 offers customers up to 768 channels, each with 32 Mbits of parallel vector-memory depth. The DD1096-32 also enables up to 256 scan chains and more than 77 billion scan vectors. For massive multisite use in high-mix, high-volume production applications, the 40-slot Diamond 40 with the DD1096-32 scales up to 3072 channels with up to 1024 scan chains and more than 309 G scan vectors. This scan capability is configurable from narrow to wide "broadside" scan for efficient test coverage.

The instrument's 100-MHz pattern sequencer can provide 200-MHz clocks and drive data rates up to 200 Mbps. The DD1096-32 comes with a flexible instruction set to support conventional functional tests, along with STIL-based EDA integration for applying structural test methods. It can handle any combination of input or output chains such as those required for BIST-enabled devices. Moreover, a two-bits per scan-output-cycle capability allows masking of failing scan cells to improve customers' debug productivity. Other features include algorithmic pattern generation for development and debug of embedded memory tests, field-upgradeable firmware, integrated time-measurement capability, high-speed scalable data transport, flexible point-to-point triggering, and pattern-speed synchronization with other instruments in the system.

Base price: less than $600/pin. *Credence Systems, www.credence.com.*

USB module measures sound, vibration

Sound and vibration measurements are integral parts of any environmental test. To get measurements, you can use the DT9837 four-channel USB data-acquisition module from Data Translation. The module uses a dedicated delta-sigma analog-to-digital converter (ADC) for each of its four channels, and it has a 1-MHz tachometer input that you can use to measure frequency and period and to synchronize the analog inputs. It also contains an analog output channel that you can use to track any of the analog inputs. A read-back channel from the analog output lets you correlate all signals with the input stream, the output stream, and the tachometer.

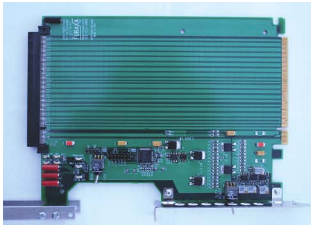
Each analog input channel has an integrated electronics piezoelectric (IEPE) signal conditioner, which uses a 4-mA current source. Maximum sample rate is 52.7 ksamples/s. An external trigger lets you trigger a measurement on analog voltages from 0.2 V to 9.8 V. Analog input range is ±10 V.

The board is compatible with Data Translation's DT-Open Layers for Microsoft .NET as well as the company's Measure Foundry and quickDAQ software. In addition, it works with 32-bit Windows drivers, LabView, and Matlab. The DT9837 is available in a packaged version and in an OEM version for integrating to larger equipment.

Price: $1795. *Data Translation, www.datatranslation.com.*

Hot swap your PCI Express boards

The PCIeExt16HOT PCI Express (PCIe) live-insertion bus extender board lets you test and debug PCIe boards without powering down your computer. It installs into any PCIe x16 motherboard slot and is compatible with x1, x4, x8, and x16 boards.



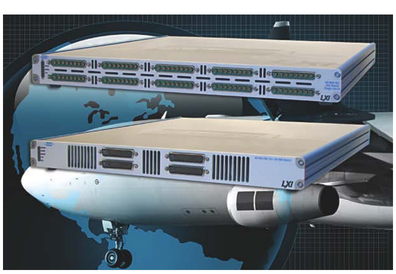
The extender board has current-sensing shunt resistors and instrumentation amplifiers on the +3.3-V, +12-V, and +3.3-V auxiliary power supplies that provide voltages proportional to the current drawn by the board under test. You can use the 1-V/A outputs to connect to oscilloscopes and meters so you can monitor current. The PCIeExt16HOT also has overload LEDs that illuminate when a board under test draws excessive current. If any power supply exceeds 4.9 A for more than 0.5 s, the extender will cut power to the board.

The extender board contains a three-way switch that directs it to deliver either full 3.3-V and 12-V supply voltages to the board under test, or to deliver 95% or 90% of these values, which lets you identify questionable boards.

Price: $495; quantities of two or more—$445.50 each. *Furaxa, www.furaxa.com.*

LXI switches cover high current or high density

Pickering Interfaces recently added two LXI switch matrixes to its product offerings. The 60-600 is a 256-relay crosspoint matrix with a 10-A rating capable of switching voltages up to 30 VDC or 250 VAC. You can order



the 60-600 in any of five one-pole matrix configurations: single 16x16, single 32x8, single 64x4, dual 16x8, and dual 32x4. It is housed in a full-rack-width 1U enclosure, and you can connect to it through any of its eight-way high-power D-type connectors.

The 60-552 is a 4096-relay crosspoint matrix with a 2-A rating capable of switching voltages up to 220 VDC or 250 VAC. It is available in 12 configurations from a single 16x64 matrix to a dual 32x64 matrix. It uses 78-way D-type connectors for you to connect your devices and test equipment.

Software support for both models includes IVI and direct I/O drivers. Both models are LXI Class-C compliant.

Prices: 60-600—$12,190; 60-552—$36,895. *Pickering Interfaces, www.pickeringtest.com.*

Switching - Power or Channel Count?

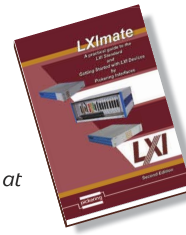
That decision can be answered by one name – Pickering Interfaces. Announcing the newest additions to our growing family of LXI switching systems: The 60-552 Electro-Magnetic Relay (EMR) Matrix features 2 Amp, 220 V dc/250 V ac switching with up to 4,096 cross points in a compact 1U high chassis. The 60-600 High Current Matrix features 10 Amps, 30 V dc/250 V ac switching and up to 256 cross points in the same 1U rack space. Both are fully LXI Compliant and are backed by the most experienced switching company in the world. Contact Pickering and learn how LXI can address your switching needs.

See Pickering's complete range of LXI switching systems at ***www.pickeringtest.com***

LXI

LXImate

Want to Know more about LXI? The second edition of our LXImate is now available. Get your free copy by registering at ***www.pickeringtest.com/lximate***



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Hybrid addresses RF test

By Richard A. Quinnell, Contributing Technical Editor

The Synthetic Multifunction Adaptable Reconfigurable Test Environment (SMART^E) from Aeroflex, which received a 2008 Best in Test award from *Test & Measurement World,* targets complex RF/microwave test challenges using an LXI framework with the ability to incorporate PXI, GPIB, and other test instrument types from various vendors. Dr. Francesco Lupinetti, CTO for Aeroflex Test Solutions and VP and GM for Aeroflex's Powell, OH, System Division, recently provided insights into the role of hybrid systems and PXI in high-performance testing.

Q: What challenges were you trying to solve with SMART^E?

A: The idea for SMART^E came from our desire to take technology from our radar group and apply it to test. We had fast, general-purpose tunable upconverters and downconverters and signal processors in VXI that we wanted to use to increase test throughput as compared to rack-and-stack systems. We originally developed a system based on a custom chassis with the upconverters, downconverters, local oscillator, and such, but we wanted to move that design into a hybrid architecture that could include a commercial-off-the-shelf (COTS) component. We initially developed the system for use in testing advanced reconfigurable ground combat systems (ARGCS), and then we expanded to include satellite payload testing, RF/microwave test, and radar transmit/receive module testing.

INSIDE THIS REPORT

Q: What motivated the incorporation of both PXI and LXI in your design?

A: We were seeing creeping obsolescence in VXI elements in the system that we needed to upgrade, such as the arbitrary waveform generator and the digitizers. We found we could transfer those design elements to PXI and achieve price and performance improvements. Also, the move to PXI gave us access to additional technologies and a range of selections we really liked for other system elements. In addition, PXI offered us very nice functionality and an increase in interface speed compared to VXI.

The local oscillator and RF and IF upconverters and downconverters are in LXI because they need lots of onboard computing power. In addition, we use LXI because both control and data interfaces can use high-speed Ethernet, like the rest of the system elements in SMART^E.

Q: What challenges did you face in creating this hybrid system?

A: The architecture was already proven in an earlier version, but as you make changes to the configuration, there are always issues. In RF/microwave instruments, you are fighting different noise sources in every configuration due to fans, layout issues, cross-coupling, and the like. Also, you need the ability to tune the system for test-speed performance because it is mostly used in high-volume test. Adaptive radar systems, for instance, use hundreds to thousands of transmit/receive modules to control the direction of the beam, and fast testing of each of these elements and subassemblies reduces production costs. Performance is also important in satellite payload testing where millions of measurements may be needed.

Dr. Francesco Lupinetti
CTO
Aeroflex Test Solutions
Courtesy of Aeroflex.

Q: What advantages did the hybrid approach provide?

A: Hybrid modularity gives an ability to select system components and adapt the test instrument to the needs of an application. It also addresses the problem of obsolescence. For example, if you need to increase the frequency range, you can design and replace modules rather than developing a whole new instrument. The whole approach of the synthetic hybrid test environment is the way things will have to go in the future. □

GUEST COMMENTARY

Go east, PXI . . . Far East

By Bob Stasonis, Pickering Interfaces and PXI Systems Alliance

As we progress through the 11th year of the PXI standard, I thought it would be a good time to concentrate on a slightly different aspect of the PXI market—not at what we have done technically, but where we are geographically.

It is my perception that PXI is often thought of as a Western standard. Of course, the PXI Systems Alliance (PXISA) does have active members from Asia, such as ADlink and Chroma in Taiwan, but the majority of companies come from what we call the Western World.

That is starting to change. More companies in Asia are either specifying PXI products and systems or actually planning to build PXI modules of their own. Taking off my PXISA marketing hat and putting on my regular job hat, my company has seen business in Asia really take off in the last two years.

In my travels to Asia over the last decade, I initially saw hardware mostly from other platforms. What was surprising was that much of the hardware included custom designs. This was a practical solution for Asia as labor rates were very low; it was cheaper for companies to build hardware themselves than to purchase an off-the-shelf solution. As salaries have risen in recent times, that is becoming less practical. So, instrument platform standards like PXI are being embraced with an enthusiasm on a level with the rest of the world.

A telling indication of this acceptance is the PXI TAC (Technology Applications Conference), which was founded by National Instruments and includes technical presentations that demonstrate the benefits of PXI. Positioned as a showcase for PXI in test and automation, the PXI TAC is held annually in one Chinese city (Beijing and Xian are two that have hosted the event in recent years) and in Taipei, Taiwan. NI has always tried to involve other PXI members in the conference. ADlink, Advantech, Aeroflex, Pickering Interfaces, and others, along with several systems integrators, have participated in the PXI TAC. Attendance is in the hundreds and has been rising with the increased interest in PXI.

There are now many Chinese companies interested in producing PXI products. The PXISA is reaching out to them to ensure that they have the assistance they need and that their products meet the standard so that users will have the peace of mind that their test and automation systems will operate as planned.

As part of this outreach, the PXISA will hold its first general meeting in China on May 29, the day after this year's PXI TAC in Beijing. The purpose is to educate attendees in the implementation of PXI and discuss the platform's direction. We will also encourage these potential new members to join the PXISA and participate in technical and marketing opportunities. I can foresee that our conference calls may soon take place at different times to accommodate the many time zones that PXI now spans!

The bottom line is the PXISA is growing in terms of new ideas, more PXI products, and increased market share. As a user, you can count on more choices and better support worldwide. □

Bob Stasonis *is the sales and marketing manager for Pickering Interfaces and is a marketing co-chair for the PXISA. bob.stasonis@pickeringtest.com.*

HIGHLIGHTS

Aeroflex unveils avionics tester

Aeroflex has introduced a reconfigurable PXI-based test platform for avionics navigation and communications systems. The basic configuration of the Avionics Test Bench hardware includes a PXI chassis with a built-in controller and an Aeroflex 3025C RF signal-generator and synthesizer module. A stand-alone configuration includes the Avionics Test Studio signal-generator software. Customers can expand the basic system with other cards and functionality.

Avionics Test Studio is a collection of software-defined instruments that generate signals from 100 kHz to 6 GHz. The software tools generate and test navigation and communications signals, including airborne data link protocols such as VHF data link Mode 2 and Mode 3. Avionics Test Studio offers standard signals such as ADF, ILS, VOR, and VHF comm, and waveforms can be tailored to meet a specific need. www.aeroflex.com.

NI announces low-cost controllers

National Instruments has introduced two embedded controllers for test, measurement, and control applications. The NI PXI-8104 ($3000) is an Intel Celeron M 440 processor-based embedded controller for PXI and CompactPCI systems. It offers a 1.86-GHz processor and dual-channel 533-MHz DDR2 memory. The two-slot NI PXI-8183 embedded controller ($1500) features an 850-MHz Intel Celeron processor. www.ni.com.

SIX BEST PRACTICES TO DESIGN TEST SYSTEMS FOR SCALABILITY AND MAINTAINABILITY

SPEAKER:
Marcelo Souhami
Business Development,
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Crafting a hybrid test system

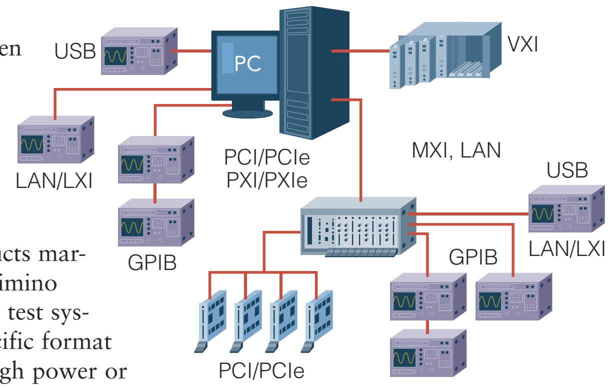
By Richard A. Quinnell, Contributing Technical Editor

Just as the "one size fits all" approach never really worked in clothing, no single test instrumentation approach fits all applications. To create systems that employ the best available instrument for each test procedure, some engineers are building hybrid systems that combine instruments from platforms such as PXI, LXI, GPIB, and VXI. Hybrid systems let engineers choose the best approach for each application, but unless such systems are crafted carefully, they may not achieve the performance the developer expects.

There are numerous reasons behind the hybrid trend. One is purely economic: Hybrid systems often allow you to use instruments you have on hand, reducing your need to buy equipment in a specific architecture. As Richard McDonell, senior group manager at National Instruments, noted, "People have a lot of existing equipment. Coming out of the tech bust in the '90s, they bought equipment at a discount, then it got put in storage due to staff cutbacks." Chris Van Woerkom, Agilent Technologies' senior marketing engineer, added, "Developers don't get to throw away their old equipment; they have to mix it with the new."

The design flexibility that a hybrid architecture allows is also an increasing draw for developers. "Test systems must adjust to new needs quickly," said McDonell, "so to get more flexibility, developers are looking to hybrid systems." He explained that the hybrid approach lets developers strike a balance between the optimized functionality of dedicated instruments and the ability of virtual instruments to quickly address new test requirements. McDonell noted that "the trend toward hybrid systems has evolved from being budget-driven to being driven by the need to keep up."

Hybrid systems also free developers from the constraints of a specific architecture, especially when the needed functionality is not available in that architecture or does not meet the performance requirements. Keithley Instruments' multi-applications products marketing director Chuck Cimino said, "Optimization of a test system may dictate the specific format for a system element. High power or extreme precision may need a GPIB or LXI instrument, for instance, while high-speed digitization may need PXI." Instrument makers acknowledge that no one instrument architecture is superior at everything.



Hybrid systems combine various architectures, allowing developers to blend legacy and optimized equipment. Courtesy of National Instruments.

Bottlenecks and synchronization

While hybrid systems may be the answer for many applications, they can be difficult to optimize. Instrument vendors report that one of the main stumbling blocks to successful hybrid system development is the creation of artificial performance bottlenecks. NI's McDonell said, "People get into trouble when they fail to think about the performance inherent in the various buses. They can end up trying to do things like sending high-speed data from a PXI digitizer over GPIB to an arbitrary waveform generator."

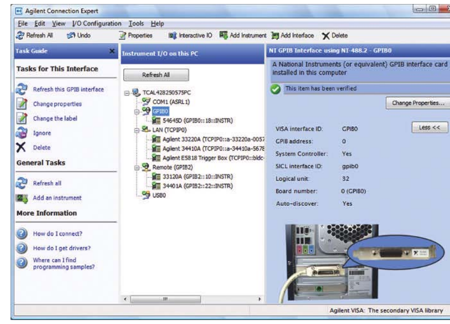
Chris Armstrong, Keithley's associate marketer for data-acquisition products, added, "It's almost always possible to get a hybrid system running, but the trick is in optimizing it. The synchronization you need to tweak the system may not be there unless you think ahead and plan it out. It's not a hacker's world."

The issue of synchronization is a close second to performance as a stumbling block. Three methods for synchronizing test events are available: direct-signal, backplane-based, and time-based synchronization.

Direct-signal synchronization involves cabling directly from one instrument to another to provide trigger and clocking signals and is available on most instruments. Backplane-based synchronization uses a shared set of lines in the backplane for such signals, as in PXI and VXI systems. Time-based synchronization depends on each instrument having access to a time-of-day clock so users can initiate events based on a schedule; clock sources for test instruments include the IEEE 1588 network-based synchronization for instruments with Ethernet connections and clocks derived from the Global Positioning System (GPS).

Because not all architectures support all three types of synchronization, developers must consider synchronization as carefully as bus bandwidth when linking instruments in a hybrid design. Otherwise, they can end up with convoluted system cabling or will have to coordinate timed events with triggered ones by inserting delays. Both results lead to added complexity and reduced performance.

An additional hybrid challenge involves the system software. "Almost all test instruments need a driver or the like for remote operation," said Agilent's Van Woerkom, "so you have to worry about versions and compatibility with operating systems, espe-



Tools such as the Agilent Connection Expert simplify the programming of hybrid systems. Courtesy of Agilent Technologies.

Creating a hybrid from page 55

cially when you are mixing older and newer devices. It's not a slam dunk that they will all work together."

Standards aid development

Fortunately, developers of hybrid systems can take advantage of existing standards to simplify development and maintenance. On the software front, Woerkom pointed to the Interchangeable Virtual Instrument (IVI) drivers as one technology that makes test instruments more "plug and play." NI's McDonell cited the Virtual Instrumentation System Architecture (VISA) specification as also helping to simplify software development.

Both IVI and VISA make it possible for programmers to write drivers that refer to a generic instrument (such as an oscilloscope) rather than to a specific model. Such abstraction not only simplifies test software development but also eases system upgrades by permitting the software to remain virtually unchanged when an instrument is replaced with a different model.

Vendors also provide resources that can help you build a hybrid system. NI, for example, maintains a library of drivers for more than 5000 instruments. Agilent offers an I/O Libraries Suite, which includes the Agilent Connection Expert tool that identifies all the ports in a system and loads the appropriate drivers. Agilent's I/O Monitor tool also helps identify when communications errors occur in a multivendor system. Keithley has developed the Test Script Processor language to help developers synchronize and automate test system behavior.

For ease of assembly, vendors have developed bridges and adapters that make it simpler to connect instrument architectures. Robert Rennard, president of the LXI Consortium, noted that there are now a variety of LXI adapters available for making GPIB, PXI, and USB connections in a way that makes the secondary architecture appear to behave like an LXI node. In addition, GPIB and Ethernet interface cards are available for PCs and PXI systems as well as for VXI, M-module, and other bus bridges.

Though the assembly and programming of hybrid systems has gotten easier, developers must still plan out their system design. Vendors recommend that developers begin by learning the basic performance characteristics and tradeoffs of each architecture they intend to use so they will be less likely to create artificial bottlenecks in the data flow. To that end, manufacturers have published application notes, white papers, and Web pages that give overviews of the various architectures (the online version of this article lists several of these publications, www.tmworld.com/2008_05).

The next step is to decide on the overall system architecture, including data flow and synchronization patterns. Keithley's Cimino recommended that developers start by defining the measurement requirements and then identifying the instruments, regardless of interface, that can meet those requirements. With that list of candidates in hand, Cimino says, developers can more accurately identify a system architecture that will meet their needs.

McDonell of NI—the company that initially developed the PXI specification—suggested that developers consider using PXI as the system architecture's foundation, adding other instrument buses as needed in a layered approach. He pointed out that PXI offers all three synchronization types, making it a logical center for coordinating test activity. The LXI Consortium's Rennard commented that in large systems a single controller may get overloaded, and so he recommended that such systems adopt a LAN backbone and segment their operation into multiple control zones, taking advantage of peer-to-peer communications to exchange information.

Whichever backbone structure is adopted, however, developers should try to keep things as simple as possible. "It's probably not a good idea to mix all the test architectures together in a single system," said Agilent's Van Woerkom. "The more different types you add, the more unstable it becomes and the harder to manage."

Despite the challenges, hybrid systems are rapidly becoming the best approach for many test requirements. They help leverage existing equipment and extend the lifetime of systems by supporting replacement of instruments without the need for reprogramming. Hybrid designs also open opportunities for embracing new capabilities as they become available.

"Companies are working to make sure that the different instrument architectures will work together as seamlessly as possible," said Van Woerkom. "You don't have to get rid of your old equipment, or be afraid to try the new stuff." □

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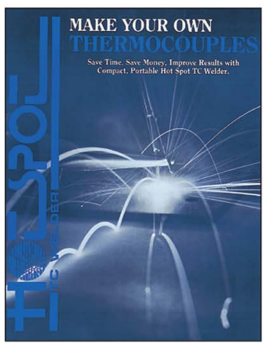

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PASCAL PILON
President and CEO
Averna
Montreal, QC, Canada

Pascal Pilon has served as a director of Averna since its inception in 1999, co-founding the test services and software company after holding executive positions at Informission Group and ATS Aerospace. He won the Entrepreneur of the Year Arista Award in 2005 and was twice nominated for the Ernst & Young Technology Entrepreneur of the Year Award. He holds a bachelor's degree in computer engineering from the École Polytechnique de Montreal and an MBA from HEC Montreal. Pilon is an active director of the Société d'Investissement Jeunesse, a nonprofit organization that supports young entrepreneurs, and also serves on the Technology Committee for the Montreal Chamber of Commerce.

Contributing editor Larry Maloney interviewed Pascal Pilon on the role of test engineering in new product development.

How test fuels product development

Q: What are the biggest challenges facing your customers?

A: Many companies face a shortage of test engineers with the skills needed to work with design teams on complex new products, particularly in such fast-growing fields as WiMAX and RF. Often, companies have to use design engineers to perform test duties. Many of these engineers are generalists, with backgrounds in electrical engineering but little experience in test. As a result, companies suffer delays in their time-to-market goals for new products.

Q: Is the growing complexity of electronic products compounding the problem?

A: It is a big part of it. Complex products often require more sophisticated test equipment and software, so you need test engineers with the know-how to make the right choices. Complex products also require more design iterations, which means that you have to frequently update test systems for these redesigns. Still another challenge comes from the fact that new designs today are often shipped to remote locations, including overseas plants, for manufacturing. OEM test engineers find themselves stuck on the phone at odd hours with a contract manufacturer who needs help with updating and debugging a piece of test equipment. It can be a nightmare.

Q: How does Averna's Proligent software address these problems?

A: It's a ready-to-use platform that enables engineers to develop software for test systems faster and easier in an environment that complements such tools as TestStand from National Instruments. Proligent automatically performs version control, so that any time you update your product design, you automatically update your test system—no matter where the test equipment is located. Finally, Proligent provides you with a complete data-management solution. As a result, each time you look at the test results and perform root-cause analysis, you will get a clear idea what software was used with respect to the devices under test, as well as the product structure and the technician responsible for the job.

Q: What other test engineering services does Averna offer?

A: Our core mission is to help OEMs accelerate R&D and new product introductions. We offer a corps of about 80 test engineers who provide customers with a full range of solutions: hardware-in-the-loop and design-validation systems, embedded software validation, pre-functional testing, automated functional test equipment, control and measurement automation, as well as test solutions for maintenance and repair. We also have expertise in such fields as RF and optics. In effect, we serve as the test engineering arm of companies such as Harris Stratex, a global provider of wireless transmission solutions. We work with customer design teams to analyze how new products should be tested and propose test equipment needed for the job. Then, we automate the test software that needs to be built.

Q: How will the acquisition of Mindready expand Averna's capabilities?

A: The acquisition positions Averna as a key player in tests associated with "telematics," the convergence of telecommunications and information processing. Telematics is especially dominant in automotive, with such devices as GPS navigation, digital radio, and hands-free cellphones. Averna acquired Mindready's hardware and software products, including the Universal Radio Tester (URT), a virtual instrument that works in conjunction with a National Instruments PXI platform and simulates 17 different protocols in automotive telematics devices. T&MW

Pascal Pilon talks about working with customers and partnering with test-equipment companies in the online version of this interview: www.tmworld.com/2008_05.

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