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Test & MEASUREMENT WORLD®

THE MAGAZINE FOR QUALITY IN ELECTRONICS

R. James Duckworth, electrical and computer engineering professor at Worcester Polytechnic Institute.

An RF-based locator system may someday help fire departments pinpoint firefighters in trouble.

FINDING FIREFIGHTERS THROUGH HEAVY SMOKE

Page 22

Tabor's New WS8101/2 Arbitrary/Function Generators

The Wave Standard Series is a family of single and dual channel arbitrary / function generators, designed to provide superior performance at a low price. The new series incorporates Tabor's award-winning "best of both worlds" technology, having both memory-based, true arbitrary waveform generator architecture for accurate, jitter-free waveforms alongside a DDS-based generator to create all the standard modulation formats. Packed into a compact and efficient 2U -rack size box, all in one easy-to-use high performance unit, makes the Wave Standard series, by far, the best in its category (AFGs) for size, price and performance.

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MODEL	Tabor WS8101/2	Agilent 33250a	Tek AFG3102/2
Channels	1 I 2	1	1 I 2
Architecture	True Arb + DDS	DDS Only	DDS Only
Max Frequency (Sine/Square/others)	100MHz I 100MHz I 12.5MHz	80MHz I 80MHz I 1MHz	100MHz I 50MHz I 1MHz
Max. Sample Clock	250MS/s	200MS/s	250MS/s I 1GS/s
Max. Memory Size	512k	64k	16k to 128k I 2 to 16k
Vertical Resolution	16 bits	12 bits	14 bits
Max Amplitude (into 50W)	16Vp-p	10Vp-p	10Vp-p
Rise / Fall Time	< 5ns	< 8ns	< 5ns
Square Wave Jitter (rms), typ.	< 100ps	< 100ps	< 200ps
DC Levels (into 50Ω)	-8V to +8V	-5V to +5V	-5V to +5V
Modulation	AM, FM, FSK, PSK, Sweep	AM, FM, FSK, Sweep	AM, FM, PM, FSK, PWM, Sweep
Connectivity	LAN, USB, GPIB	RS232, GPIB	LAN, USB, GPIB
Warranty	3 years standard	1 years standard	3 years standard
Strating from Price	$3,750 I $4,950	$4,571	$3,760 I $4,960

Specification compiled from Tabor 8101/2 data sheet, Agilent 33250a data sheet 5968-8807EN, March 14, 2005 and Tektronix AFG3000 data sheet 76W-18656-3, 12 November 2007. Prices are taken from the vendors websites.

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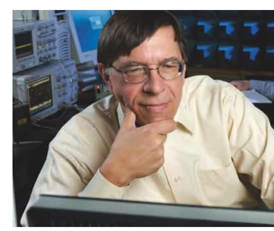
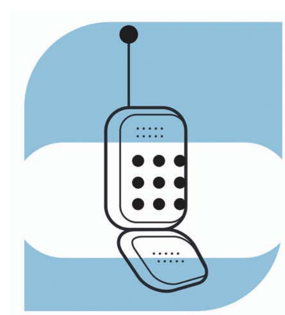
CONTENTS

FEATURES





Show highlights / Page 13

DEPARTMENTS

TECH TRENDS

TEST DIGEST

TEST REPORT SUPPLEMENT

ONLINE www.tmworld.com

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

The Vision Show 2009: The sun shines on

Much of the activity at The Vision Show 2009 seemed driven by solar, medical, and homeland security applications. Dana Whalls, managing director of the Automated Imaging Association, which produces the show, said this year's event drew strong attendance from Argentina, Chile, and Mexico, as well as large delegations from locally represented giants such as Intel. Read our recap:

www.tmworld.com/2009_visionshow

APEX highlights test and inspection

The IPC APEX Expo, held March 31 to April 2 in Las Vegas, gave exhibitors the opportunity to present boundary-scan tools, vectorless test capabilities, software suites, optical and x-ray inspection systems, and functional, flying-probe, and in-circuit testers. Read our coverage from the show floor as well as a transcript from this year's Test and Inspection Summit:

www.tmworld.com/2009_apex

Blog commentaries and links

Rowe's and Columns

Martin Rowe, Senior Technical Editor

- It's the network, really
- HP-35 wins IEEE award
- Download a driver or write your own?
- DOS lives

Engineering Education and Careers

Puneet Lakhi, Contributing Editor

- i, RoboWaiter
- Learning with...Legos?
- Testing GPS on treacherous trails
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Test & MEASUREMENT WORLD

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RICK NELSON
EDITOR IN CHIEF

Finally time to Twitter

Peruse any source of media these days, and you'll see or hear something about the perilous position of media in today's depressed economy and in the face of ever-changing Web tools. Can traditional print newspapers and magazines—like *Test & Measurement World* and *EDN*—survive the challenges posed by blogs, Twitter, LinkedIn, and so on?

I think the survival question is the wrong question to ask—it posits a competition among various types of media, when in fact the question that should be asked is: How can the different types of media complement each other? We've had success with blogs from editors who use them to report news, solicit input, and complement our feature coverage in print or on our Websites.

> **Twitter is a well-publicized service that's available now, and there's no reason not to add it to our reportorial toolbox.**

Of course, Web media evolves rapidly, with blogs having reached late middle age and even the comparatively new Twitter already reaching maturity. The question arises, does a technology like Twitter have anything to offer traditional media companies?

Maureen Dowd at the *New York Times* doesn't seem to think so. In the recent column "To Tweet or Not to Tweet," she recounts asking Twitter cofounder Biz Stone this question: "I would rather be tied up to stakes in the Kalahari Desert, have honey poured over me and red ants eat out my eyes than open a Twitter account. Is there anything you can say to change my mind?"

Stone had a ready reply: "Well, when you do find yourself in that position…you might want to type out the message 'Help.'"

Dowd doesn't say whether this argument wins her over, but we do have on staff one editor who has changed her opinion. That's Suzanne Deffree, managing editor for news at *EDN*, who is posting her own tweets at www.twitter.com/EDNmagazine. She says she first checked out Twitter for *EDN* in early 2008 and "shrugged it off as a fly-by-night waste of time that did little more than share the mundane blips of life."

She notes, though, that she had also written off e-mail and blogging, and—just as she modified her position on those tools—she has now reconsidered her position on Twitter. She says, "Twitter is far from perfect. But don't write this tool off as a pre-teen sensation that will be over and done with faster than the next boy band. There's real value here in making connections, delivering information, and staying informed." She doesn't see Twitter as a news reporting mechanism but rather as a way to complement the more traditional reporting that takes place on our Websites, blogs, and print magazines.

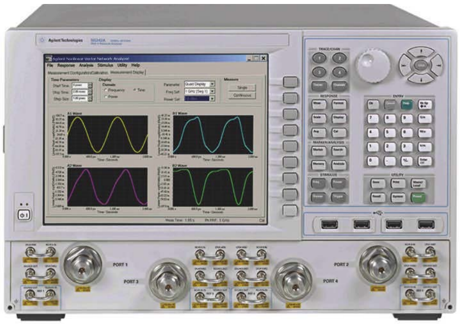
So, will Twitter turn out to be a long-term, invaluable tool for traditional media practitioners? Who knows? Maybe, lacking a revenue model, it will quickly fade into obscurity. What we do know is that it's a well-publicized service that's available now, and there's no reason not to add it to our reportorial toolbox.

Check out Suzanne's tweets. She assures you, "Your time will not be wasted with insignificant blurbs. You will not be overrun with 50 tweets a day. You have better things to do—we get that. Be assured that our Twitter messages will be held to the same high standards we here at *EDN* hold all of our editorial products to."

By the way, I'm joining Suzanne on the Twitter bandwagon. Follow me at twitter.com/Rick_editor. T&MW

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

Agilent, Maury Microwave support nonlinear measurement



Agilent Technologies has introduced an arbitrary load impedance X-parameter option—Option 520—for its PNA-X nonlinear vector network analyzer. When used in conjunction with Maury Microwave tuners and software, the new option provides the capability to measure and simulate nonlinear component behavior at all load impedances.

The addition of Option 520 to the PNA-X (pictured) allows R&D engineers in the wireless communications and aerospace/defense industries to extend X-parameter design cascadeability to arbitrarily large load mismatches; measure and predict dynamic load lines at input and output ports under arbitrary loading conditions, even under very large compression; measure and simulate magnitude and phase data at the input and output for each fundamental and harmonic frequency as nonlinear functions of power, bias, and arbitrary load impedance; and model devices as well as design multistage Doherty or other complex amplifier circuits within Agilent's ADS (Advanced Design System) software.

X-parameters are mathematically correct scattering coefficients for active components. They provide an automated process for capturing nonlinear component behavior over arbitrary complex impedances, input powers, and DC biases across various frequencies. Engineers can use the PNA-X nonlinear vector network analyzer to measure X-parameters and create X-parameter models that can be imported into Agilent's ADS to simulate actual linear and nonlinear component behavior.

The behavior of a device under large-signal operating conditions can be captured and modeled in ADS using Agilent's new NVNA option, an external Maury load tuner, and Maury's load-pull software. Option 520 is priced at $8000. The Maury ATS (Automated Tuner System) software begins at $17,500, and a single Maury ATS tuner begins at $22,500. www.agilent.com; www.maurymw.com.

Editors' CHOICE

Optical sampling for the next network

With optical network speeds about to increase to 40 Gbps and then to 100 Gbps, the PSO-100 series of optical oscilloscopes can show the signals to you. The Models PSO-101 (one-channel) and PSO-102 (two-channel) oscilloscopes connect to your PC through a USB port. They use a sampling technique that optically captures and time stretches repetitive signals, creating a time-stretched copy of the original signal. The scopes convert elongated samples to electrical form before digitizing them. Using this technique, the instruments can use a sample rate in the tens of megasamples per second while maintaining 500-GHz overall bandwidth.

A PSO-100 series oscilloscope captures samples by using a short pulse that opens an optical gate to capture light. The instrument then converts the optical signal to electrical form and digitally processes the captured signal, measuring jitter (RMS and peak-to-peak), rise time, fall time, eye amplitude, duty-cycle distortion, extinction ratio, and other parameters. Both models let you analyze signals that use return-to-zero and non-return-to-zero modulation. The PSO-102 adds DPSK, DQPSK, and D8PSK complex modulation formats with the use of a demodulator. The instruments use software-based clock recovery and thus don't require an external trigger.

Price range: $124,500 to $157,500. *EXFO, www.exfo.com.*

Averna acquires broadband test competitor

Montreal-based Averna has acquired DAQTron, a developer of communications test systems. In addition to giving the company a US headquarters in Atlanta, GA, Averna says the acquisition will bring greater functionality to its Universal Receiver Tester that supports radio, video, and navigation signals.

DAQTron's products include a DOCSIS 3.0 RF protocol analyzer, the Mercury and Jupiter manufacturing and design-verification test systems, and the Trident software for simulating and testing digital signals.

"We believe that the convergence of radio, video, and navigation content into mobile devices will continue to fuel demand for multifunctional test instruments and systems," said Pascal Pilon, president and CEO of Averna. He added that acquiring DAQTron "concentrates our strengths and positions Averna to lead the trend towards computer-based instrumentation." www.averna.com; www.daqtron.com.

Editors' CHOICE

Compact spectrum analyzers reach 26.5 GHz

Aeroflex 3250 Series spectrum analyzers offer RF frequency ranges spanning 1 kHz to 26.6 GHz and serve engineers working in military, communications, satellite, radar, and PMR (portable mobile radio) applications. The compact instruments weigh just 24 to 29 lbs.

The 3250 Series includes four spectrum analyzer models, each measuring a frequency range beginning at 1 kHz, with the 3251 ranging up to 3 GHz, the 3252 to 8 GHz, the 3253 to 13.2 GHz, and the 3254 to 26.5 GHz. All models have a Windows XP operating system, a removable hard disk, and a 7-in. touch-panel screen. Three traces can be displayed per window and as many as nine markers can be selected with a marker table viewable in an alternate window. The instruments support remote control via LAN, GPIB, and RS-232C interfaces.

The 3250 Series includes digital demodulation capabilities for the analysis of 802.11a/b/g wireless networks. Optional measurement personalities include GSM/EDGE, WCDMA, and WiMAX, and the instruments can also perform EMC precompliance tests. An optional built-in tracking generator is available across the entire range.

Base price: $15,000. *Aeroflex, www.aeroflex.com.*

CALENDAR

International Microwave Symposium, June 7–12, Boston, MA. *IEEE Microwave Theory and Techniques Society. www.ims2009.org.*

Sensors Expo, June 8–10, Rosemont, IL. *Questex Media. www.sensorsexpo.com.*

Semicon West, July 14–16, San Francisco, CA. *SEMI. www.semiconwest.org.*

Design Automation Conference (DAC), July 26–31, San Francisco, CA. *IEEE, ACM, EDA Consortium. www.dac.com.*

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

Broadband demand continues

> > > OFCNFOEC conference and exhibition, March 23–26, San Diego, CA, www.ofcnfoec.org.

Philippe Morin, president of Metro Ethernet Networks at Nortel, Canada, told attendees at the plenary session of the 2009 OFCNFOEC conference that the current economic downturn is a challenge, but bandwidth demand continues to increase. "The economic downturn is actually accelerating bandwidth growth because people are staying home and they want their entertainment delivered. Electronic devices and connectivity have moved from 'nice to have' to a necessity."

Lawrence Lessig of Stanford Law School told the audience that today's copyright laws need to be revamped for the digital age. He said that "machines" such as TV and radio changed us from what he called a "read-write" society to a "read-only" society. Prior to radio and TV, people used to sing songs and be artistic. "In the 21st century," he predicted, "we will become a producing culture again" as people now remix audio and video into their own work, which leads to copyright issues that today's laws don't address.

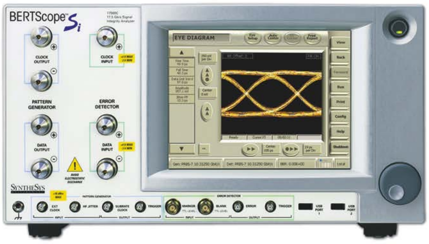
Anritsu introduced several instrument cards for its tester mainframes: a 10-Gbps Ethernet plug-in module for its MD1230B Data Quality Analyzer and a module for its MP1590B Network Performance Tester that supports testing of SDH, SONET, OTN, PDH, and DSn interfaces. **Centellax** introduced a multichannel signal-integrity test system that uses up to five 10-Gbps pods to produce PRBS (pseudorandom bit sequence) patterns for performing BER (bit-error rate) tests.

Synthesys Research displayed its 17.5-Gbps BertScope that decomposes jitter and displays it in a map form. **Yokogawa** demonstrated its transport analyzer, which provides insight into WDM (wavelength-division multiplexed) optical signals

Agilent Technologies showed its N4391A optical modulation analyzer, based on the Infiniium 90000 series oscilloscopes. The company's N7700A photonic application suite of software performs high-speed optical measurements, and a new PXI optical communications analyzer module analyzes serial data streams at rates from 155 Mbps to 10.518 Gbps.

JDSU added AMCC's enhanced FEC (forward-error correction) to its TestPoint 10-Gbps line of testers used for Metro Ethernet and carrier-grade Ethernet applications. **Picosecond Pulse Labs** exhibited the Model 8020 optical splitter for its line of pattern generators. **Polatis** introduced the Series 2000 80x80 optical switches.

Inphi demonstrated a reference design for making BER measurements at speeds up to 28 Gbps. The reference design uses Inphi's 5080MX multiplexer. **General Photonics** demonstrated the PMD-1000 polarization-optimized PMD (polarization-mode dispersion) source. **ILX Lightwave** announced the LDC-3700C series of laser-diode controllers. T&MW



The 17.5-Gbps BertScope decomposes jitter and displays it in a map form.
Courtesy of Synthesys Research.

Measurement quality remains important

> > > Measurement Science Conference, March 26–27, Anaheim, CA, www.msc-conf.com.

At the keynote session of the 2009 Measurement Science Conference (MSC) on Thursday, March 26, MSC president Arman Hovakemian of NSWC Corona welcomed attendees, stating, "Test and measurement is key to all aspects of commerce in this historic time."

Richard Turner, executive director of the USATA (US Army Test, Measurement, and Diagnostic Equipment Activity) gave the keynote address, during which he discussed the Army's measurement capabilities. "We have to be traceable [to NIST] or we'll fail," he said. Turner noted that the metrology community is aging and there's a need for new talent to replace aging metrologists.

On the exhibit floor, **Fluke** displayed its AC and DC current shunts. The company's Hart Scientific division introduced the Model 4181 infrared temperature calibrator for calibrating infrared thermometers and thermal-imaging cameras. The 4181 features software that compensates its temperature readouts for differences in emissivity between itself and a thermometer under test.

Guildline Instruments exhibited the 6622A resistance bridge. **Ectron** displayed its Model 1140A thermocouple thermometer and calibrator. **Tegam** introduced the Model 1830A RF power meter for metrology. It supports calibration of thermistor RF power sensors from Agilent Technologies. T&MW

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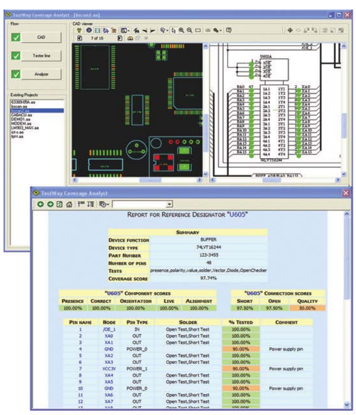
APEX: Panelists tout test and inspection

Industry executives scrutinized the evolving role of PCB (printed-circuit board) test and inspection during the Test and Inspection Summit held April 1 as part of IPC APEX Expo 2009 in Las Vegas. Building on the 2008 Test and Inspection Summit, participants commented on test challenges and the technologies that are emerging to deal with them, including



Agilent highlighted its partnership with Aster Technologies to enable integration of Aster's TestWay Coverage Analyst across Agilent's Medalist i3070 and i1000 printed-circuit-board assembly-test platforms. Courtesy of Agilent Technologies.

electrical test, optical inspection, x-ray inspection, and boundary-scan test.

David Buhrkuhl, president of SPEA America, kicked off the discussion, citing cost of test as a key concern. "At APEX this year, we are introducing [the SPEA 4040 Multimode] flying-probe low-cost tester, knowing that cost control this year is more critical than ever."

Peter van den Eijnden, president of JTAG Technologies, presented boundary scan as a way to control costs. "With boundary scan, you don't need as much in-circuit test. And boundary-scan equipment is far less expensive than in-circuit test."

Mark Harding, director of sales for North America at Digitaltest, which provides flying-probe and other board-test systems, said his firm partners with JTAG Technologies to integrate boundary scan. He sees a continuing role for in-circuit test, noting, "In-circuit test won't go away, though many say that it is fading. In a high-mix, low-volume environment, in-circuit remains a useful test."

Jack Rozwat, general manager of SST Americas Field Operations at Agilent Technologies, concurred with the need for boundary scan, saying, "People are reducing budget amounts set aside for test. In electrical test, built-in testability, such as boundary scan, is necessary. And we should take advantage of any type of validation test that can be built into silicon." On the APEX exhibit floor, Agilent highlighted its work with Aster Technologies to measure the test coverage afforded by electrical test, boundary-scan, and inspection techniques.

Rozwat's firm recently exited the inspection business, citing, in part, the high cost of x-ray systems. When asked if x-ray is too expensive, Carsten Salewski, president and CEO of Viscom, countered with, "In fact, the real question is: What is the cost of failure?" He added, "The more you know about the process of electronics manufacturing, the better you can know what types of test fit. To do it right, rather than doing it again, is the goal. DFT [design for test] moves the process during the beginning."

Phil Vere, managing director for Bond Test at Dage Precision Industries, which makes x-ray and bond-testing systems, agreed, saying, "Designing a product to be tested should be an integral part of NPI [new product introduction]. Virtual simulation models aren't enough, though. You need to have test strategies ready for products early on."

Buhrkuhl concluded, "As the panel said last year, there's no one system that solves all problems...if you need a critical electronics product, let's say a pacemaker, you probably want all types of tests, including vision, functional, and everything else available here from all the panelists." T&MW

See the online version of this article for links to an edited transcript of the panel discussion and a summary of the 2008 summit: www.tmworld.com/2009_05.

Goepel debuts ATPG, TIC

Goepel electronic at APEX highlighted an ATPG (automatic test-program generator) for hierarchical test at the board level based on the company's System Cascon boundary-scan software platform. The company also launched the TIC02/LV TAP interface cards. These members of the company's ScanFlex boundary-scan platform, which serve low-voltage and ultra-low-voltage applications, support GTL (Gunning transceiver logic) interfaces. www.goepel.com.

ECT presents 2-D spring pins

Everett Charles Technologies Contact Products Group presented its next-generation patented spring-probe technology, the Z-Axis Interconnect Pin, or ZIP. The ZIP's 2-D design features sliding planar contact surfaces, maximizing surface area for reliable contact. The 2-D geometry allows the company to employ efficient reel-to-reel fabrication and assembly processes to control costs. www.ectinfo.com.

Manufacturing software gets upgrade

Aegis Software unveiled the third major release of its Version 7 Manufacturing Operations Software, known as R3. R3 incorporates customer-driven enhancements that support process planning, paperless delivery, product tracking, quality collection and repair, dashboards, and analytics. www.aiscorp.com.

LARRY MALONEY
CONTRIBUTING TECHNICAL EDITOR
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Ordering from the vision menu

With capital investment funds at a premium, companies can ill afford to make a mistake on machine vision. "Very often when I get called in, companies are fairly certain about what they want to do, but I have to talk them out of it because the approach just isn't right for their application," said Perry West, founder and president of Automated Vision Systems, San Jose, CA.

With 30 years of experience in the field, West always asks companies to first state in a single sentence what will constitute success in the vision system they plan to install. For some, it might be labor savings or scrap reduction; for others, it could be an increase in inspection throughput. Only with a goal in mind, said West, can you start to define the actual specifications of a system.

West also has devised a simple taxonomy (see **figure**) that helps companies get closer to their ideal system. "In broad terms, R&D people gravitate to general-purpose vision systems because of the flexibility," explained West. "End users, such as a semiconductor fab, often look for application-specific systems that have proved successful throughout their industry."

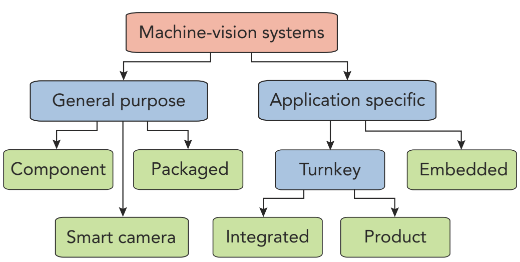
What's the best option among general-purpose solutions? West offered this perspective on the three primary choices:

- **Component.** While it may offer cost savings and greater flexibility, a component-based system can be difficult to implement because you must buy a PC, frame grabber, camera, software, and light source. Integrating these elements can baffle vision newcomers.
- **Packaged.** To avoid the complexity and compatibility issues of component systems, some vendors integrate vision components into modules that include, at minimum, a camera, a processor, and an operator interface. The downside of these packages: higher costs.
- **Smart cameras.** Because the image processor is typically built into the camera, users get an easier-to-implement system with a smaller design footprint. Overall, it's a cheaper alternative to both the component and packaged approaches.

When general-purpose machine vision won't do, West suggests three alternatives that deliver application-specific solutions:

- **Integrated.** Here, a system integrator tailors a complete vision system, including programming, to a specific end-user application. The outside expert may also provide engineering for parts handling, robotics, and motion control. At first blush, this solution might appear expensive, but it can substantially reduce risks—and costs—in complicated applications.
- **Product.** You gain cost advantages with this approach because you're buying a catalog item, typically a plug-and-play vision module that can be dropped into a manufacturing line. These products often include part-handling or conveyor capability.
- **Embedded.** A prime example would be an OEM designing a smart camera into a machine programmed for a specific task, such as inspecting leads for integrated-circuit packages.

What's hot among these vision choices? "Clearly, it's the smart camera," said West. He also sees strong interest in turnkey vision systems that meet the needs of specific high-volume applications, such as semiconductor manufacturing. T&MW



R&D specialists gravitate to general-purpose vision systems because of the greater flexibility, while end users often seek application-specific solutions tailored to their industry.

Camera tackles tough conditions

Changing light intensities and reflective surfaces won't hurt the performance of the latest Giant-Dragon GigE industrial camera from Toshiba-Teli America. The model CSGS15BC23 camera provides 1280x1024 resolution at 15 fps, while operating in the visible, UV, and NIR portions of the light spectrum. It can inspect products for blemishes, surface artifacts, or defects not observable in standard lighting conditions. www.toshiba-teli.com.

SOC targets vision applications

The Swiss Center for Electronics (CSEM) has developed a smart sensor for machine vision that integrates a DSP (digital signal processor) with a CMOS imager. The single-chip "icycam," designed to minimize costs and power consumption, features a new compression algorithm that uses mixed-signal processing to extract features from video streams. www.csem.ch.

Frame grabber sports PoCL interface

The PCIe-CPL64 PCI Express x4 frame grabber from Adlink Technology has a PoCL (Power over Camera Link) interface and accommodates two Camera Link base configuration cameras with data transfer rates of up to 4.0 Gbps and pixel clock rates of up to 85 MHz. The board provides two TTL/LVDS trigger inputs (to synchronize the image acquisition process with an external encoder or position sensor) and two programmable trigger outputs. www.adlinktech.com.

POWER METERS

Power meters gear up for Smart Grid service

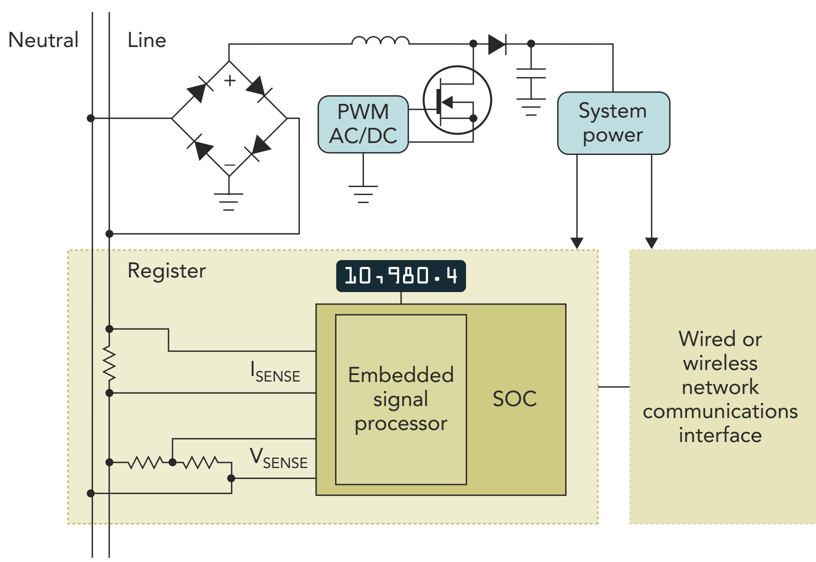
Most residences and commercial buildings in the US use old-style electromechanical utility power meters to track electricity use. The meters are reliable and cheap but are inadequate for use by a power-distribution system that requires accurate, repeatable power metrics as well as wired or wireless communications—in other words, the coming Smart Grid electrical-power-distribution system.

The Smart Grid depends on smart meters with sophisticated communication capabilities to monitor energy usage and allow residential and business consumers alike to make informed choices about how much energy to use and when to consume it. The Smart Grid faces difficulties, though. Although Washington has passed legislation such as the 2007 energy bill and the 2009 stimulus plan that encourage widespread use of the Smart Grid, utilities actually deploy power on a state-by-state basis, so the technology won't be fully deployed until each state takes action. California and Texas are the states most aggressively moving toward smart metering in preparation for the Smart Grid.

Regardless of whether the Smart Grid in some form will proceed at the national level smoothly and seamlessly, enough individual utilities are purchasing and installing electronic power meters to make this market significant. Utility companies could replace 500 million meters worldwide over the next 10 years.

Current transformers, Rogowski coils, and resistive shunts make up the three main types of current-sensor technology for power meters. To make a smart meter, current sensors team up with power-meter ICs, which can perform some digital signal processing calculations on voltage waveforms, communicate the information to a display, and store the information to be sent over a wired or wireless communications interface. To learn how to select smart power meter components, read the full article in our sibling publication *EDN* at www.edn.com/article/CA6643364.html.

Margery Conner, Technical Editor, EDN



Smart power meters comprise a microcontroller with onboard analog-to-digital and digital-to-analog conversion, a sense component for both voltage and current, an AC/DC-power converter, battery backup, and wireless or wired communication capability.

RF TEST

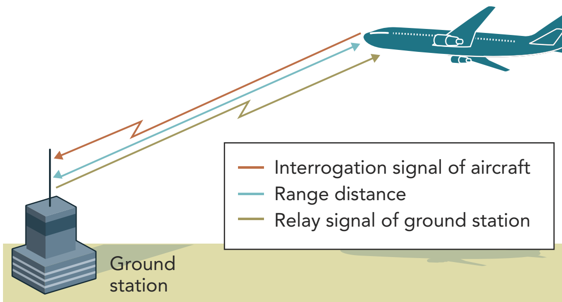
Signal generator, power sensor test DME

DME (distance measuring equipment) provides a way for a civilian aircraft to measure its distance from a land-based transponder. DME is often paired with VOR (VHF omnidirectional radio) to determine azimuth. TACAN (tactical air navigation) is a military variant that determines azimuthal direction as well as distance.

With DME, a plane transmits shaped double pulses to a ground station, which replies after a set delay. A receiver on the plane uses the pulse round-trip time to determine distance.

The ICAO (International Civil Aviation Organization) specifies DME parameters that must be checked at regular intervals, and DME manufacturers and station operators may specify additional parameters. Such parameters are usually tested using BITE (built-in test equipment), but the BITE itself may fail and deliver false measurement results, leading to system malfunction.

In the application note "Test of DME/TACAN Transponders," Rohde & Schwarz presents an external-measurement approach using an R&S SMA100A signal generator connected to an R&S NRP-Z81 wideband power sensor. To make DME measurements, the signal generator feeds DME interrogation pulses via a coupler to a DME ground-station receiver. The power sensor, via an additional coupler, detects the transponder's reply



With DME, a plane transmits shaped double pulses to a ground station, which replies after a set delay. A receiver on the plane uses the pulse round-trip time to determine distance. Courtesy of Rohde & Schwarz.

pulses. Signal-generator software analyzes the detected pulses, and the generator display indicates measurement results.

The setup can measure reply delay, reply efficiency, ground-station pulse-repetition rate, transmit-pulse power, pulse shape, pulse spacing, receiver sensitivity, and receiver bandwidth; it can also test decoder and monitor-alarm functions. Adding a second signal generator permits measurement of receiver recovery time and receiver sensitivity with load.

The 34-page application note (a link appears in the online version of this article at www.tmworld.com/2009_05) provides details on making each of these measurements and offers more information on DME/TACAN operation.

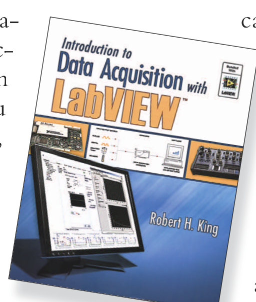
Rick Nelson, Editor in Chief

BOOK REVIEW

A LabView short course

Introduction to Data Acquisition with LabView, by Robert H. King, McGraw-Hill Higher Education, New York, NY (www.mhhe.com), 2009. 288 pages. $115.63.

The cover of this book tells you everything you need to know about it: It's a textbook on using LabView for data acquisition. If you have a National Instruments data-acquisition card (as shown on the book's cover) and you use the NI-DAQmx driver, you can learn how to automate your measurements. You can also use this book with other National Instruments data-acquisition hardware that uses the DAQmx driver, such as the company's USB-based instruments. But the book won't help you if you use GPIB instruments.



The author, who uses the book in his college-level course, uses a temperature-measurement application to walk readers through the steps involved in data acquisition. He explains how to develop code and how to display measurements with clean, usable interfaces. Readers will learn about timing, state machines, arrays, shift registers, and charts, as well as how to use LabView's DAQ Assistant graphical interface and other time-saving tools.

King does a superior job of explaining how to use LabView through programs and examples that readers can use right away. So, if you have or can get a National Instruments data-acquisition card and you need to learn how to make measurements, this book is for you. Readers who lack an NI data-acquisition card will be in trouble after chapter 1, where King explains how to write a simple LabView program. I enjoyed that experience, but I have an instrument connected to my computer through GPIB, and there isn't enough information in the book to learn how to make measurements over that bus and get data into LabView.

Martin Rowe, Senior Technical Editor

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Product Selection Chart

	Model	Summary	Analog Input Features			
	Model	**Summary**	**# of Channels**	**Throughput**	**Resolution**	**Input Range**
Simultaneous High Speed	DT9832A	Simultaneous, 2 A/Ds @ 2.0MHz each, 500V isolation	2SE	2.0MHz per channel	16-bit	±10V
	DT9832	Simultaneous, 4 A/Ds @ 1.25MHz each, 500V isolation	4SE	1.25MHz per channel	16-bit	±10V
	DT9836	Simultaneous, up to 12 A/Ds @ 225kHz each, 500V isolation	6 or 12SE	225kHz per channel	16-bit	±5V, 10V
Temp.	TEMPpoint	Thermocouple, voltage, or RTD inputs, A/D and CJC per input, high accuracy	8-48	10Hz per channel	24-bit	±1.250V (0.15mV LSB)
	DT9805 DT9806	7 thermocouples, 1 CJC, temperature applications, 500V isolation	8DI/16SE	50kHz		±20mV, 100mV, 1V, 10V
Sound & Vibration	DT9837 DT9837A	4 IEPE (ICP) sensor inputs, tachometer, simultaneous A/Ds				V, 10V
	DT9841-VIB	8 IEPE (ICP) sensor inputs, simultaneous A/Ds with DSP, 500V isolation				0V
High Speed	DT9834	High-speed, up to 16 analog inputs, 500kHz, 16-bit, 500V isolation				±1.25V, 2.5V, 5V, 10V
	DT9834-32	High-speed, up to 32 analog inputs, 500kHz, 16-bit, 500V isolation	32SE		16-bit	±1.25V, 2.5V, 5V, 10V
	DT9801 DT9802	Multifunction analog I/O, 100kHz, 12-bit, 500V isolation	16SE/8D	100kHz	12-bit	0-1.25V, 2.5V, 5V, 10V; ±1.25V, 2.5V, 5V, 10V

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Program resistance in a bridge circuit

A programmable amplifier lets you find an unknown resistance for measuring temperature or strain.

By Alexander Bell, Infosoft International, New York, NY

Sensors such as strain gages, RTDs (resistance temperature detectors), and thermistors produce a resistance that's proportional to force or temperature. If you measure a sensor's resistance, you can calculate the physical parameter. Circuits such as resistance bridges can help you measure the unknown resistance.

Figure 1 shows a typical bridge circuit where R_T is the unknown resistance. By substituting a programmable amplifier for R_{EQ}, you can balance the bridge. Resistance R_{EQ} can force V_{BRIDGE} to 0 V, from which you can calculate R_T and convert its value to units of force or temperature.

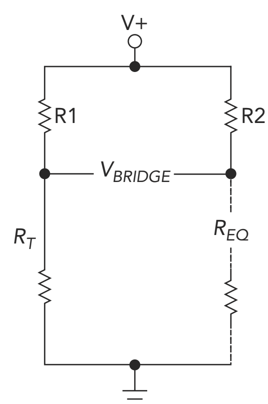


Figure 1 By measuring V_{BRIDGE} and adjusting R_{EQ}, you can balance a bridge circuit and calculate R_T.

The circuit in **Figure 2a** is a programmable amplifier whose output voltage is proportional to the digital input code of the DAC (digital-to-analog converter). The DAC and amplifier A1 form a programmable inverting amplifier. The circuit actually functions as a divider because its gain, or transfer function, is less than 1. The difference between voltages V_{IN} and V_{OUT} forces a current through resistor R. You can use that value to calculate R_{EQ} in the bridge circuit. **Figure 2b** shows the equivalent circuit for the programmable amplifier.

Using a microcontroller or a PC, you can adjust R_{EQ} by programming the DAC's output voltage and then measuring the voltage across the bridge and adjusting R_{EQ} until the bridge comes into balance. Because A1 is an inverting amplifier, the circuit's gain is $K_{MDAC} = -(D_1 \bullet 2^{-1} + D_2 \bullet 2^{-2} + \ldots + D_N \bullet 2^{-N})$, where the D terms represent the values of the DAC's bits. If you use a 12-bit DAC, then $N = 12$.

To calculate R_{EQ}, you need to know the current in the circuit. If you assume that buffer amplifier A2 has infinite input impedance and zero bias current, then you can calculate I_{IN}, which is

$$I_{IN} = \frac{V_{IN} - (-K_{DAC} \bullet V_{IN})}{R} = \frac{V_{IN}(1 + K_{DAC})}{R}, \text{ and } R_{EQ} = V_{IN}/I_{IN}$$

To test this circuit, simply connect a variable DC voltage source to V_{IN} and measure the effective resistance with an ohmmeter. The online version of this article contains a table of the expected and actual resistance and the calculated error for the circuit with a 12-bit DAC (www.tmworld.com/2009_05).

The online article also contains a schematic of a circuit that uses a comparator across the bridge. You can connect the comparator's digital output to a microcontroller or PC that then can adjust the DAC's output voltage. You can calculate R_{EQ} and then calculate R_T, from which you can calculate strain or temperature based in the resistance curve of your sensor.

Using the circuit in Figure 1, you can generate digitally controlled resistor values with just one precision component, resistor R. If you need to increase the gain of the circuit, you can replace voltage-follower A2 with a noninverting amplifier configuration. T&MW

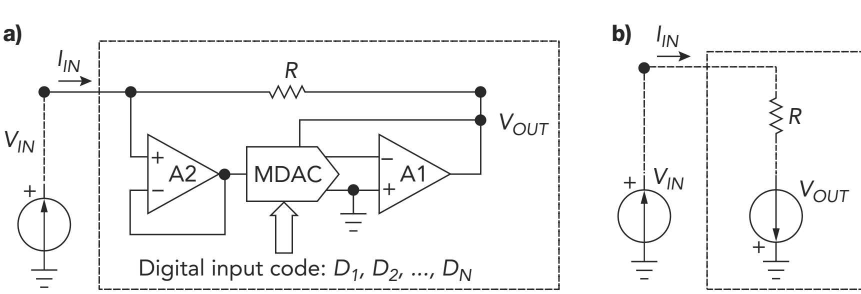


Figure 2 a) Programming the DAC's output voltage changes R_{EQ}, which can balance a bridge circuit. b) Equivalent circuit.

Do you have a test or design idea you'd like to share? Publish it here, and receive $150.

Send your ideas to: **tmwtestideas@reedbusiness.com.**

FINDING FIREFIGHTERS THROUGH HEAVY SMOKE

An RF-based locator system may someday help fire departments pinpoint firefighters in trouble.

BY MARTIN ROWE, SENIOR TECHNICAL EDITOR

WORCESTER, MA—In December 1999, six firefighters in this city lost their lives because they couldn't find their way out of a burning warehouse building through heavy smoke. Had firefighters outside the building been able to locate their lost comrades, some, if not all, might have been saved.

This tragedy led professors at WPI (Worcester Polytechnic Institute) to initiate the PPL (Precision Personnel Locator) system project in 2000. When completed, the RF-based PPL system should enable rescue teams to find injured firefighters in burning buildings. It may also have military applications.

Today, finding a firefighter in heavy smoke requires a rescue team to search each room in a building, usually by feeling around because smoke completely obscures their vision. With the PPL, an incident commander outside the building

ED MALITSKY/GETTY IMAGES

FIGURE 1. A firefighter tests the Precision Personnel Locator system, whose transmitter unit is mounted to the oxygen tank.

could direct rescuers to the room containing the firefighter in distress. That could drastically cut the time needed to find the firefighter, possibly saving a life.

ECE (electrical and computer engineering) professors R. James Duckworth and David Cyganski lead a team of graduate students who develop and test the PPL. Graduate student Vincent Amendolare works on the project as part of his PhD program. Five other graduate students and technician Bob Boisse round out the team. Duckworth and Cyganski also call on other ECE faculty members when they need additional expertise.

Boisse supports the efforts of the graduate students, who design and test hardware, firmware, and software. Through bench tests, open-field tests, and indoor tests, the students collect data that they use to make design changes and add features that improve the system's performance.

PPL at a glance

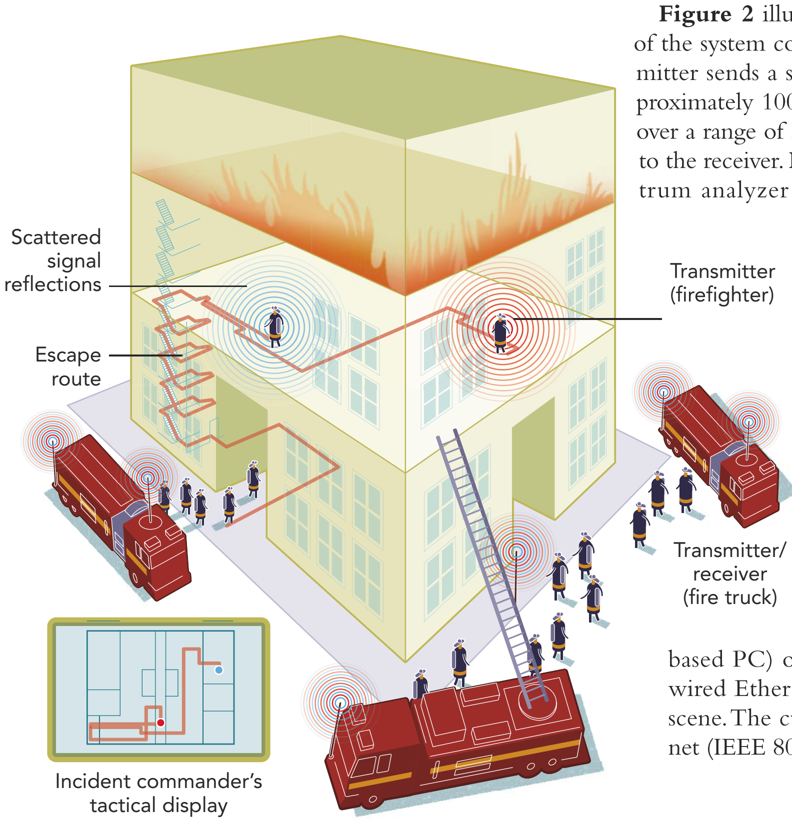
The PPL consists of battery-powered RF transmitters that are worn by firefighters (**Figure 1**), four receiver stations that can be located in fire trucks around the site, and a base station that resides in one of the trucks. The base-station computer calculates the locations of the transmitters by measuring the phase shift in transmitted signals received from up to four "bowtie" antennas per receiver. The computer then displays the locations of the transmitters.

Figure 2 illustrates the relationship of the system components. Each transmitter sends a signal consisting of approximately 100 unmodulated carriers over a range of 550 MHz to 700 MHz to the receiver. **Figure 3** shows a spectrum analyzer display of the signal. Each receiver unit downconverts the signals to a bandwidth from 30 MHz to 180 MHz. The receiver then digitizes the signals with four 400-Msamples/s ADCs (analog-to-digital converters) for each channel. After performing an FFT (fast Fourier transform) on the signals, the receiver encapsulates the frequency-domain data into Ethernet packets and sends the data to the base station (a Linux-based PC) over Ethernet. Early designs used wired Ethernet, which is impractical at a fire scene. The current design uses wireless Ethernet (IEEE 802.11).

(continued)

ED MALITSKY/GETTY IMAGES

Technician Bob Boisse (left) and graduate student Vincent Amendolare work on a receive station that contains two RF receiving (bowtie) antennas and a wireless Ethernet antenna that receives data from another receive station. The receive unit is inside the bin.



The base station runs Matlab scripts that process the data in the frequency domain. From the phase shifts, the station can calculate the locations of the transmitters and display those locations on its screen in real time (**Figure 4**), which provides enough information for firefighters. As part of the system development, researchers can analyze data in the lab for greater insight.

The transmitters are also equipped with sensors that monitor the firefighter's heart rate and temperature, sending that data to the receivers over a 915-MHz data link. Because firefighters can only find each other through touch in heavy smoke, the PPL system needs location accuracy to within 30 cm. To reach that goal, students perform bench tests, open-area tests, and building tests. From the test results, they make improvements to hardware and firmware in the transmitters and receivers, modify the software in the base station, and then repeat the tests. Thus far, tests inside buildings have shown accuracy to within 10 cm.

Professor R. James Duckworth with a receiver unit in the lab.

ED MALITSKY/GETTY IMAGES

One recent change to the design involved changing the transmitter signal bandwidth from 60 MHz to 150 MHz. Before running an open-field test, the students measured the transmitted spectrum in the lab using an Agilent Technologies spectrum analyzer. Bench testing lets the students verify the engineering characteristics of new hardware, firmware, and software. The wider bandwidth resulted in reduced errors when the students tested the system in a campus building (Ref. 2).

Open-field tests

Rather than go from performing tests on the bench to performing a test in a building, the team first conducts trials in an open area such as a football field, something they didn't do in the early stages of the project. "Several years ago, we learned not to go from the lab to a test in a building," said Duckworth. "We found some errors that needed correcting, resulting in invalid data and wasted time."

Performing tests in an open field eliminates a significant variable. In a building, multipath signals caused by reflections can produce location errors. To eliminate that variable, the team will first test the system in a field where they have line-of-sight conditions and minimal signal reflections. This intermediate step provides the team with a "sanity check" that the system is functional before testing it in a building. "Multipath is by far the greatest challenge to RF precision positioning," said Cyganski. "No matter what RF specifics are involved, multipath is a fact often overlooked by newcomers to the problem of indoor location."

Recently, the students added a wireless Ethernet link between the receiver stations and the base station, a change that created a new technical requirement: the synchronization of ADCs among the receiver units. Synchronization is crucial because of the nanosecond timing required to accurately measure signal timing delays (signals travel at about 30 cm/ns). The students needed an open-field test to verify that the system could synchronize receiver ADCs.

A clock in a receiver unit can synchronize ADCs within that unit, but it cannot synchronize the ADCs in other receivers when communicating over wireless Ethernet. Graduate student Amendolare explained how the PPL

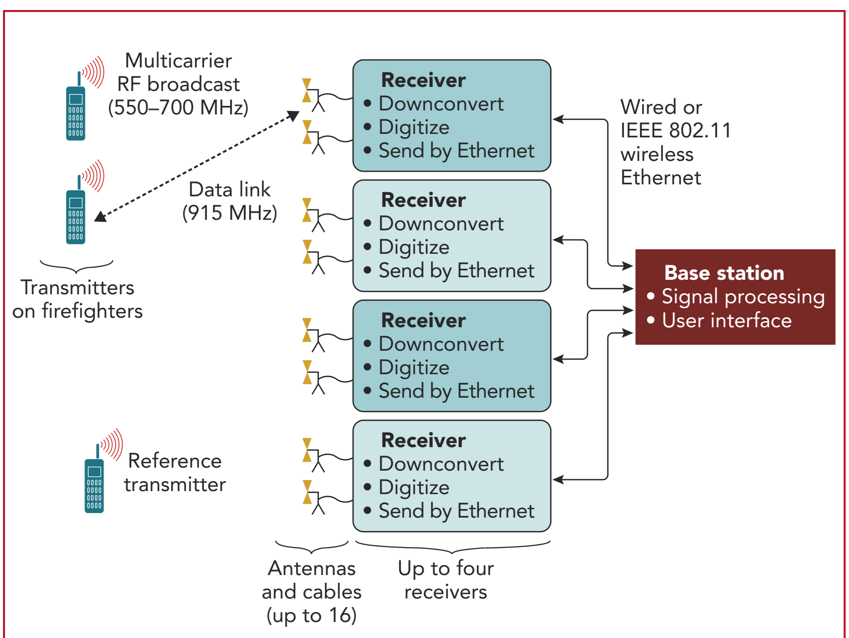


FIGURE 2. The PPL system consists of transmitters, receivers, and a base station. Firefighters carry transmitters, and the receivers are located on fire trucks.

achieves synchronization. The clocks in the receivers tend to drift relative to each other over time. A reference transmitter in the system transmits a signal that the receiver units lock onto. The system calculates the timing errors from the received data and corrects them.

At an indoor line-of-sight test on December 22, 2008, on the WPI campus, the students ran a test to verify synchronization of the ADC clocks. The test, conducted in a 15-m^2 area, proved that software synchronization could bring the clocks to within 0.5 ns of each other.

A 15-m^2 test area is good enough for a small building. But the project's current sponsor hopes to use the system at a much greater distance, perhaps up to 1 km^2 as a vehicle locator. So, the team set out to try the system on a 200-m^2 grid at a former military airstrip on March 17, 2009. I attended that open-field test, the first one conducted off campus.

Test prep

Prior to the field test, the students simulated the increased transmission distance at the 15-m^2 test. Amendolare explained that they simulated the greater distance by reducing the transmitter's power using RF attenuators. Those tests gave them confidence that the system could work at the larger test site.

The team must conduct a survey of the test site before bringing in the PPL equipment. On March 16, several students conducted a spectral survey of the airstrip test site with an Agilent spectrum analyzer. The PPL operates in the 550 MHz to 700 MHz band, which is currently used for broadcast TV. (The team needs a temporary FCC license to conduct an open-field test or a test in a building.) Depending on the results of the spectral survey, the team may need to avoid using carriers at certain frequencies. Students can change the waveform with a command over the wireless Ethernet link, but the mobile locators must be reprogrammed over a cable.

Students also performed a site survey where they formed a grid by placing a mark every 20 m on two adjacent sides of the runway. The PPL team had several plans for this test:

- Check that the wireless Ethernet links between the receivers and the base station functioned properly, which they did.

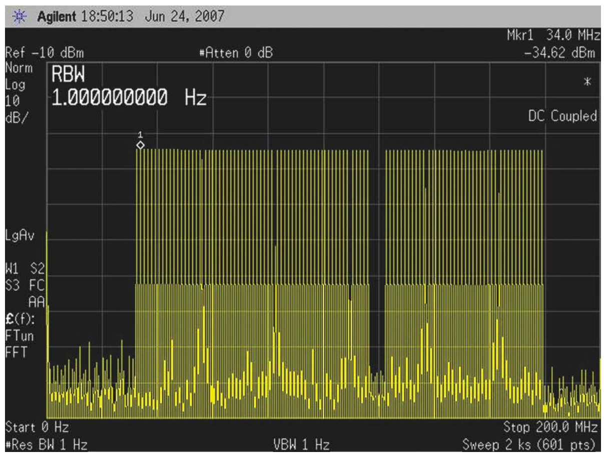


FIGURE 3. Transmitters worn by firefighters broadcast about 100 unmodulated carriers over a 150-MHz bandwidth.

- Verify the integrity of the tripods that hold the receiving antennas to see if they needed guy wires to prevent them from tipping in the wind. (There was virtually no wind on this day.)
- Test the system with eight RF receiving antennas instead of 16 to simplify setup and reduce costs.
- Test the accuracy of the locator on the larger grid by placing a transmitter at each of the 20-m marks along the grid, transmitting a signal, and then moving the transmitter to the next marked location.

The students arrived early on March 17 to set up a receive station at each corner of the grid. The tripod for each of the four receive stations held two bowtie RF antennas connected to a receiver unit. Each receiver unit's Ethernet port connected to an Ethernet switch, which in turn connected to a wireless Ethernet transmitter on the tripod. A gas-powered generator at each corner of the grid provided power to the receivers and base station. (The online version of this article contains a diagram of the test site and photos of the site's equipment: www.tmworld.com/2009_05).

Three of the four receivers communicated to the base station over wireless Ethernet. The receiver at the corner closest to the base used a wired connection. Because three of the stations needed a wireless link to the base, the students needed three data-link receive antennas at the base station.

They placed two of the three wireless data-link receive antennas on a fifth tripod containing one bowtie antenna, which is used for the reference transmitter. Boisse mounted the third wire-

ED MALITSKY/GETTY IMAGES

Professor David Cyganski (foreground) advises graduate students such as Vincent Amendolare (background) on RF technology.

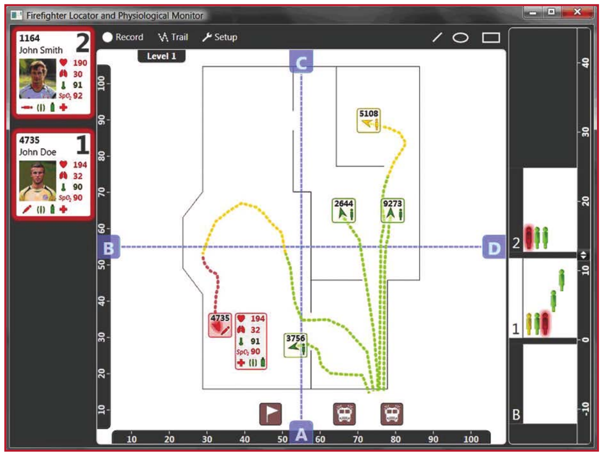


FIGURE 4. With the base station's display, an incident commander can view the location of firefighters and monitor their physiological conditions such as temperature and heart rate.

less data-link receive antenna on the tripod for the receive station that was wired to the base station. Each wireless data-link receive antenna was pointed to a different corner of the grid.

At the March 17 field test, the project team encountered a problem. At the longer (200-m²) distance, the system couldn't find the reference transmitter's signal. Students experimented by moving the reference transmitter across the grid, but they were still unable to get a strong enough signal.

Before leaving for the day, student Jorge Alejandro used an Agilent spectrum analyzer to measure the signal strength from the reference transmitter. Amendolare wanted the measurement to see if the reference signal was in fact strong enough to use on the large grid, as his bench tests had indicated. "We need to verify if the problem is with signal strength or if our software is not properly detecting the signal," he said. The students left for the day, intending to return the following week to test the system again, but my schedule prevented me from returning with them.

During a typical open-field test, students check how accurately the system locates a transmitter at known locations. If the displayed locations are within tolerance, a student will move the transmitter around the grid to unknown locations by walking around. In the case of the 200-m² test site, the transmitter will be on a truck. The base station's display should be able to keep up with the transmitter as it moves. Early versions of the PPL system lacked that feature. "Adding the real-time display saves a great deal of time," said Professor Duckworth. "At first, we had to go back to the lab to process and analyze the data."

Back at the lab

Even with the real-time display, students still process and analyze the data in the lab. Over the course of a week following an open-field test or building test, Amendolare will adjust parameters and compare results. For example, he can adjust the spatial density of the scan. That provides greater resolution on the display, which lets him see how finely he can measure displacement. Increasing spatial density slows the processing speed.

Amendolare compares the results to get an idea of how the system performs under different conditions. For example, he can remove half the bandwidth from the transmitters and check location accuracy or remove the data from half of the RF receive antennas to see how that affects location accuracy. He performed that analysis on the data from the December 22 open-field test, which led him to believe that the system could perform satisfactorily with eight antennas.

The students have also performed PPL system tests in buildings, which is the real test. They started in a WPI lab and have since moved to a house on campus. For the past few years, they've conducted these tests as part of a workshop on the system. They've even conducted building tests with Worcester firefighters, who are eagerly awaiting a system they can use. T&MW

REFERENCES

1. Technical papers and presentations containing design and test details and a history of the PPL project are available at www.ece.wpi.edu/Research/PPL.

2. Amendolare, Vincent, D. Cyganski, R.J. Duckworth, S. Makarov, J. Coyne, H. Daempfling, and B. Woodacre, "WPI Precision Personnel Locator System: Inertial Navigation Supplementation," IEEE Position Location and Navigation Symposium, May 2008. www.ece.wpi.edu/Research/PPL/Publications.

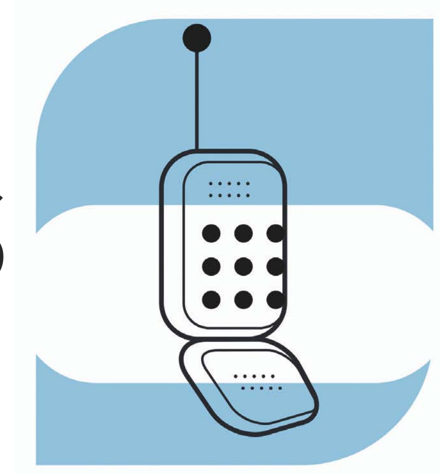
ON THE **WEB**

Information on the December 1999 fire in Worcester, MA, that took the lives of six firefighters is available from the *Worcester Telegram:* **www.telegram.com/static/fire**

Complete information about the history of the PPL project is available on the WPI Web site: **www.ece.wpi.edu/Research/PPL**

Visit the online version of this article to see a diagram of the PPL test site as well as photos of the equipment and the project team: **www.tmworld.com/2009_05**

Testing DigRF for 3G HANDSETS



The MIPI Alliance's DigRF interface standards can simplify the design of cellphone handsets, but they challenge test engineers to find ways to reduce test-time overhead.

BY ED SENG, TERADYNE

DigRF stands poised to replace the two main forms of data-communication paths between RF and baseband semiconductor devices: analog signaling and design-specific, proprietary digital signaling (parallel or serial). With the DigRF (Digital Radio Frequency) standards, the MIPI (Mobile Industry Processor Interface) Alliance is striving to replace the assortment of I/Q (in-phase/quadrature-phase) signaling interfaces with a common digital, packet-based serial interface. A MIPI Alliance working group has developed DigRF specifications for the 2.5G and 3G mobile standards, and a follow-on revision with increased data throughput to support 4G standards is expected.

The use of a standard interface like DigRF provides designers with more flexibility in component selection. A designer, for example, may want to purchase an expensive baseband IC (which tends to be one of the more expensive chips in a cellphone) from one vendor while buying RF, power-management, and other devices from others. Yet, the very flexibility of the DigRF technology that leads to versatile products also creates challenges that affect your test strategy.

The main goal of the test engineer during RF receive tests remains the same as before DigRF—capture the I/Q information, execute custom digital signal processing algorithms on the resulting data set, and log the parametric result to determine whether the device passes or fails. But compared to previous generations of RFICs, DigRF devices can add significant overhead to production test. Finding ways to minimize this overhead is the major challenge for engineers designing an automated production test system.

Understanding the interface

DigRF 3G defines a minimum number of signals required to implement the interface; only six wires are needed in a basic handset configuration (**Figure 1**). The RxData/TxData signals transfer the digital representation of I/Q data as well as the control and status messages in a packet protocol.

Data transferred on the DigRF signals is encompassed in protocol packets, or frames. Each frame comprises three pieces: sync, header, and payload (**Figure 2**). The beginning of every packet consists of the same 16-bit synchronization sequence, used by the digital receive circuit for real-time strobe-phase alignment on every frame.

The subsequent eight bits make up the header, defining the purpose and content of the payload. The header itself is made up of three sections: three bits for the payload size, four bits to describe the LCT (logical channel type), and one bit for a CTS (clear-to-send) signal. *(continued)*

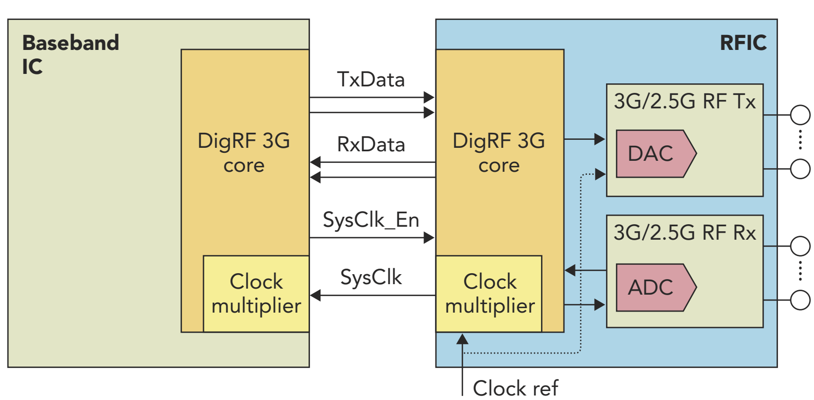


FIGURE 1. The basic DigRF handset configuration requires only six wires.

The payload may vary in size from packet to packet, resulting in different levels of encoding overhead. The LCT defines "what" the payload contains and can be categorized into control or I/Q data. The CTS allows the RF device to control data flow from the baseband device during RF transmission.

The remaining *N* bits of the frame contain the actual data to be transferred; for example, in the nondiversity mode of DigRF 3G, the RxData frame will use data channel C and 256-bit payloads consisting of alternating 8-bit I-data and Q-data.

DigRF 3G supports three timing modes for digital transfer, determined by the type of RF information being transferred (**Table 1**). The DigRF standard also supports three common input reference-clock frequencies (19.0, 26.0, and 38.4 MHz); the clock is passed to the baseband over the SysClk signal. Independent of the speed mode, the DigRF processor manages the data flow with a local FIFO buffer, leading to an unpredictable timing of when the frame is transmitted.

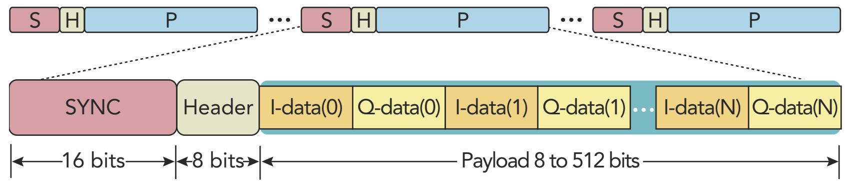


FIGURE 2. A DigRF 3G data frame begins with a 16-bit synchronization sequence, followed by an 8-bit header and I and Q data.

Production testing challenges

The key to successfully testing devices that use the DigRF protocol is finding a way to manage the nondeterministic behavior of RxData packets during RF receive tests. During RF receive tests on DigRF products, the resulting behavior of the RxData signal is viewed at multiple levels of uncertainty:

- phase timing,
- frame timing,
- frame type, and
- data in payload.

A 312-Mbps data rate is derived from a 1/4 divider from a 1248-MHz master clock, typically generated with a PLL (phase-locked loop). In the production test system, the device clock input should be provided by RF instrumentation, considering the importance of phase-noise performance affecting the RF front end. The start-up phase of this clock source is usually not controlled relative to the normal digital subsystem. The combination of the unknown input clock phase of the DUT (device under test) and the phase-uncertainty generated by the PLL multiplier/divider results in RxData output timing that is unpredictable—both between device power cycles and between different devices in a multisite parallel test setup.

A production tester should have the ability to keep the digital subsystem running while making the necessary tester-hardware and DUT changes between tests. This enables the tester to preserve the strobe timing relative to the DUT output, saving test time by avoiding the need for strobe-phase realignments during the job run.

The next major test challenge is finding a way to handle the multiple levels of nondeterministic packet transfer behavior. As depicted in **Figure 3**, during each of the DUT's RF receive tests, the tester will not know on which tester cycle each packet will be transmitted, what type of packet it will be, or if the packet type is expected (for example, the RFIC could generate an unsolicited control status message).

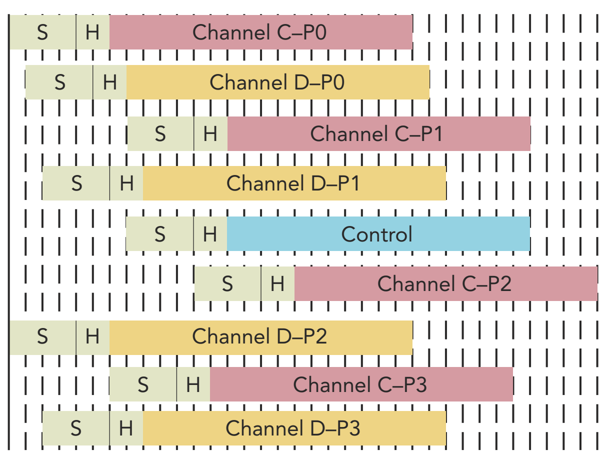


FIGURE 3. Because of packet nondeterminism, during each of a device's RF receive tests, the tester will not know on which tester cycle each packet will be transmitted, what type of packet it is, or if the packet type is expected.

It is immediately clear that the test program cannot use fixed-cycle strobes in a digital test pattern to isolate the desired I/Q data. Similarly, digital match loops on the sync or header cannot flush through an ATE instrument's pipeline fast enough at DigRF speeds, nor can the instrument perform the real-time recognition and decision making of the header information.

Comparison of ATE strategies

Traditional production test systems have static-strobe timing and a primitive compare functionality (for instance, H, L, X, M, V, store), so they do not inherently have the strong alignment necessary for addressing the nondeterministic behavior expected from DigRF devices. The digital instruments in such testers do, however, have the necessary digital-capture capability, which is commonly used for ADC (analog-to-digital converter) output data or DUT register-read actions. As a result, you can preserve your investment in this equipment and address the RF receive test challenges of DigRF by employing a block-capture-and-post-processing test strategy.

For RF receive tests, 1-kbyte to 4-kbyte I/Q samples are common for CW (continuous-wave) tests, while the increasingly common system-level tests using modulated waveforms use 16-kbyte to 32-kbyte I/Q samples. Note the conversion to actual serial bits:

1k I/Q = 1024 • [8 bits (I) + 8 bits (Q)] • protocol_overhead = number of serial bits

To address the nondeterministic behavior in real time, the tester must provide digital logic coded specifically for

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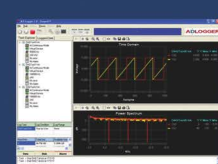
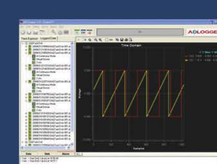


Start logging for online analysis

4



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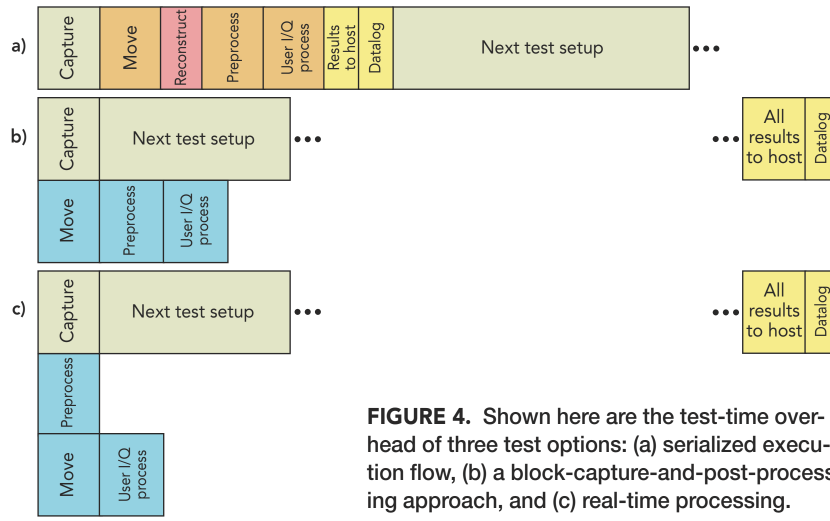

FIGURE 4. Shown here are the test-time overhead of three test options: (a) serialized execution flow, (b) a block-capture-and-post-processing approach, and (c) real-time processing.

DigRF 3G between the DUT and the digital capture. The goal is to mitigate all the timing and data uncertainty while the capture is taking place, before the data reaches the tester's DSP (digital signal processor).

One test option is to design an FPGA (field-programmable gate array) circuit on the DIB (device interface board) itself. This approach would enable you to provide custom logic in an inexpensive component, but it introduces three obstacles:

- interfacing and providing support signals to the circuit will be much more complex,
- there is an increased risk of adding a digital noise generator so close to these sensitive RF signals with limited ability for isolation and shielding, and
- adding components to each device load board will increase cost and test development time.

As another option, you could use a digital test instrument that offers an embedded real-time capability, which would reduce costs while simplifying the DIB complexity. The downside to this approach is it lacks the flexibility needed by test engineers who must test a proliferation of communication protocols. Providing a solution solely for DigRF may not be practical.

In this option, the test program captures a large block of data on the RxData bus when it is known that RF receive data is available; the block must be sized to reliably capture enough packets that a sufficient number of I/Q samples will be present for postprocessing algorithms. The data is moved from the digital instrument's capture memory to a DSP engine, where a preprocessing algorithm executes a three-step process:

- find the start index of each packet,
- analyze the header of each packet, and
- sequentially de-interleave the embedded I/Q samples in the payload and store into new individual arrays.

Table 1. DigRF timing modes for digital transfer

Speed mode	Speed	Usage
Slow	SysClk / 4	2.5G (interface start-up)
Medium	SysClk	2.5G RxData
Fast	312 Mbps	3G and 2.5G (diversity, etc.)

Once the data is preprocessed, the user's custom processing algorithms can execute the desired I/Q data sets or export them to other ATE software tools that will perform tests for properties such as EVM (error vector magnitude).

The success of this method relies on the data-move time and the efficiency of the required processing step. The key to minimizing overall test time is to avoid unnecessary host-PC interactions that require the test program to pause execution of the DUT tests. If the tester possesses the ability to move the data during the pattern capture, the entire time to transfer the data to the DSP is hidden in the background, resulting in a zero test-time penalty.

If the tester does not have this capability, the test engineer would have to find ways to reduce the amount of data moved. One option would be to only capture fail data, but this would add a new processing step for reconstructing the original data in the DSP; this unnecessary step alone could add multiple milliseconds of critical test time.

A complete DigRF solution needs to execute both the preprocessing algorithm and the I/Q processing completely in the background. Thus, a third option would require the tester architecture to support dedicated processors to execute the digital signal processing algorithms, allowing the test program to immediately begin the setup of the next test once the capture of the DUT signal is complete. Additionally, multisite testing requires high parallel efficiency of this background processing.

Figure 4 illustrates the possible test-time impact of the three options. In the first option, the lack of background processing creates a serialized test flow, resulting in the longest test time. The third option, which employs real-time processing, seems most ideal, as it addresses the test challenges in the most efficient manner with full background processing.

Yet, the block-capture and post-processing approach can also have a low test-time overhead, as long as the data move takes place in the background and the processing is performed efficiently—without wasted steps and on separate multisite parallel processors. With the appropriate system capabilities, the preprocessing time can reach less than a few milliseconds in an octal-site program, good enough to remain hidden behind a typical RF setup time. T&MW

FOR FURTHER READING

"Dual Mode 2.5G/3G Baseband/RFIC Interface v3.09.04 (DigRF)," MIPI Alliance, www.mipi.org.

Ed Seng *is an applications engineer in the Semiconductor Test Division of Teradyne, with seven years of experience in the ATE industry focused on high-speed digital, serial, and mixed-signal applications, along with new product development. He has a BSEE from Pennsylvania State University. edward.seng@teradyne.com.*

PXI

TEST REPORT

PXI pulls military duty

By Richard A. Quinnell, Contributing Technical Editor

At first glance, PXI, which was originally developed for a benchtop environment, does not seem like a promising candidate for military test systems. Yet the military test market is a large part of where instrument developer Giga-tronics targets products such as its recently released PXI signal-switching starter kit. I spoke with Malcolm Levy, the company's VP of sales and marketing, to learn more about the role PXI can play in military test applications.

Q: Where is PXI fitting into military test applications?

A: Everywhere. There are a whole slew of applications where PXI can have a role, from depot-level repair facilities to front-line system test in Humvees.

Q: Really? PXI can pull front-line duty?

A: I'm not aware of any PXI systems at the front line yet, but there are older VXI systems in place, and PXI has enough options available that it can replace the VXI systems and be equally reliable. The Marine Corps, for instance, has the VXI-based TETS (Third Echelon Test Set) in vehicles to provide a go/no-go test of a vehicle's other equipment. There is no reason that PXI cannot do the same thing. It is a natural progression as companies move out of VXI to the next generation, and PXI is the next generation.

Q: How should PXI vendors prepare their products for military applications?

A: There are no stringent requirements to concern PXI vendors with. Typically, the prime contractor for the military system takes on the task of adding any ruggedization needed by doing things like mounting the system inside shock-proof boxes.

That is easier for PXI than for VXI because PXI is more compact and so the bounce factor is easier to handle. And there are different levels of ruggedization. A standard rack won't pass the harshest requirements but can be suitable for many other environments such as the repair depot.

Q: What role does PXI have at the depot?

A: The depot is platform agnostic. They [the depot commanders] don't care how it's done, they just want the best solution. PXI is a convenient platform to use, especially as the current VXI-based instruments go obsolete. So, if the functions they need are available in PXI, that's what they will use.

Q: Are there any restrictions in the depot environment?

A: The size of the ATE requirement might have an impact. For instance, if there are thousands of switching lines to configure to test equipment under a variety of configurations, PXI might need two or three racks to provide the right number of switches. In that case, PXI might not make sense. But for smaller-scale testing, PXI can handle it.

Q: Are the military opportunities for PXI growing?

A: There is a new opportunity becoming available: supplying military R&D labs. We developed our starter kit for those labs to get them into PXI and understand how it can be used for lab repair.

There are also a number of programs today that are upgrades of existing systems, and the prime contractors are looking for solutions. They will consider PXI, and as the PXI world grows, there will be more opportunity in the military market. The restriction is that the military wants to buy solutions—not a DMM here and a digitizer there—and all from one source. Test equipment companies need to make it really clear to the prime contractors what capabilities they have. □

Malcolm Levy
VP of sales and marketing
Giga-tronics

INSIDE THIS REPORT

GUEST COMMENTARY

PXI instrumentation rivals benchtop performance

By Boyd Shaw, Director of Sales & Marketing, ZTEC Instruments

Originally, modular instruments, including PXI, did not have all the performance or comprehensive feature sets of benchtop units. Because of this, modular instrumentation was used primarily for automated testing, while benchtop instruments best served the needs of users performing manual tests in the lab.

That is quickly changing, however, as many of today's PXI instruments match, and in some cases exceed, the performance and feature sets of their benchtop counterparts. To achieve these high levels of performance and advanced functionality, some PXI instruments take advantage of the latest hardware technologies including ADCs (analog-to-digital converters), DSPs (digital signal processors), and FPGAs (field-programmable gate arrays).

For example, by using the latest ADC chipsets, 8-bit PXI oscilloscopes and digitizers now have specifications as high as 1-GHz analog bandwidth and 4-Gsamples/s real-time sampling rates. Similarly, using onboard DSPs, PXI oscilloscopes perform the same waveform math and analysis functions as benchtop units. Onboard DSPs enable fast calculation of waveform parameters, waveform math, frequency-domain analysis, waveform filtering, and more.

Other advanced features, like segmented memory and automated mask generation for pass/fail testing, have existed in benchtop scopes for years and are now showing up in some PXI oscilloscopes. The ability to take an instrument's long acquisition memory and partition it up into thousands of segments lets users capture many waveforms, overlay them, and see how the acquired waveforms change over time. With automatic mask generation, the oscilloscope starts with a "golden waveform" and then generates upper and lower waveform limits around the golden waveform. Subsequent waveforms are compared to these masks—waveforms that completely fall inside the mask pass, while waveforms that fall outside the mask fail.

When combined with powerful software, an intuitive GUI, and the latest controllers, these full-featured PXI instruments can be used for manual testing, much like benchtop instruments. These same instruments are also still used in their traditional role within automated test systems. □

Boyd Shaw *holds BS degrees in electrical engineering and business administration from the University of Colorado, Boulder, and has 10 years of experience in test and measurement. bshaw@ztec-inc.com.*

HIGHLIGHTS

PXI system performs WLAN tests

National Instruments has introduced a WLAN test system that the company says can generate and analyze RF signal measurements four times faster than other modular systems and up to 10 times faster than traditional box instruments. The system combines NI's new WLAN Measurement Suite software with its 6.6-GHz PXI Express RF hardware, enabling engineers to test for compliance with IEEE 802.11a/b/g. NI says the software-defined system can also be reconfigured for GPS, WiMAX, Bluetooth, and RFID testing.

The WLAN Measurement Suite comprises NI's WLAN Generation Toolkit and WLAN Analysis Toolkit for LabView and LabWindows/CVI. The PXI Express hardware consists of a 6.6-GHz vector signal analyzer (NI PXIe-5663), a 6.6-GHz vector signal generator (NI PXIe-5673), an 18-slot chassis (NI PXIe-1075), and a dual-core controller (NI PXIe-8106). Engineers can generate 802.11a/b/g signals with data rates from 1 Mbps to 54 Mbps with the WLAN Generation Toolkit. Using the WLAN Analysis Toolkit, engineers can perform PHY layer measurements such as power, EVM (error vector magnitude), and spectrum mask margin. www.ni.com.

Pickering unveils two PXI chassis

The 40-922 (eight-slot; pictured) and the 40-923 (19-slot) PXI chassis from Pickering Interfaces provide support for a three-slot embedded controller or a PCI-to-PXI interface. Pickering says that the use of a temperature-controlled variable speed fan gives each chassis a high cooling capacity with low acoustic noise.

An intelligent chassis-management system monitors power-supply voltages, internal operating temperatures, and fan-speed status. Optional rack-mounting kits ensure the chassis can be quickly mounted into rack systems. The 40-923 permits the use of an external 10-MHz clock, enabling instrumentation in the chassis to be easily frequency-synchronized to other instruments in an ATE system. www.pickeringtest.com.

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Reduce test costs with careful PXI design

By Richard A. Quinnell, Contributing Technical Editor

As the economic downturn increases pressure on companies to reduce test costs, engineers may find that the configurable nature of PXI test systems offers a cost advantage over stand-alone instruments. Developers can trim costs further by fully assessing their test needs, carefully planning the system architecture, and selecting versatile, low-power components.

One of the first steps in cost optimization is evaluating how a system will address both present and future needs. Mike Dewey, senior product manager at Geotest—Marvin Test Systems, said "Don't over-design your system by putting in too many features for possible future use. Narrow it down to just what you need now. Future requirements may be totally different from what you expected, and with PXI, you can always swap modules later."

This does not mean you should completely neglect future needs; in fact, many vendors recommend leaving expansion room in your PXI chassis. "In chassis selection, the number of slots gives a tradeoff between expandability and cost," said Matthew Friedman, PXI platform manager at National Instruments and PXI Systems Alliance marketing co-chair. "You will want to leave some space for upgrades."

Aeroflex's PXI product manager Tim Carey agreed. "Expansion is a good thing to plan for. It's false economy to minimize the number of slots in a system. The cost of the chassis is only a small fraction of the system cost, especially in RF, but the rework effort that would be needed to change the chassis can be substantial."

Vendors also suggest caution when assessing current needs. "Developers sometimes focus on minimizing test time," said Geotest's Dewey, "but they need to look at that issue closely to avoid paying too big a penalty. Run the numbers to compare asset cost versus test time cost. A cheaper configuration may be a good tradeoff."

Dewey also pointed out that requirements may have declined. "With sales dropping off a cliff, for instance, a semiconductor manufacturer may not have enough production volume now to justify the cost of the highest test throughput."

Placing the processing power

With requirements in hand, you can plan an architecture that keeps costs down while permitting easy and inexpensive upgrades. One of your main decisions will be what type of system controller to use. The controller can be an external PC that bridges into the PXI chassis system or an embedded processor card residing in the chassis. This controller can be responsible for all of the data processing, or it can simply provide a data display and user interface while other modules handle data processing, or it can operate somewhere in between those extremes.

Cost and flexibility vary significantly among the options. Carey said that using an embedded controller yields several advantages, including a more compact system and nearly 40% better data throughput than you get by bridging to a PC. On the other hand, he noted, an external controller PC can be less expensive for a given performance level, can allow you a wider choice of suppliers, and can be more readily upgraded than an embedded module. Using PCI Express instead of PCI as the bridge would help recover the lost data throughput. Thus, the optimum choice may be application specific.

The same sort of ambiguity applies in deciding how much of the system's data processing the controller must provide. Richard Soden, product marketing manager for the signal networks division at Agilent Technologies, said that having individual modules provide substantial onboard data processing lessens the requirements on the controller's performance, allowing designers to use a less-expensive unit. But he added that this choice may increase the cost and complexity of the other modules, so you should evaluate total system cost not just individual boards.

A rough rule of thumb calls for the system controller to handle processing when the design has general-purpose applicability and modest performance needs, according to Pat Cupo, president of test system developer Instrumentation Engineering. Highly targeted applications, those requiring the highest performance, or those dealing with complex waveforms, said Cupo, are better handled with dedicated on-module processing. "A single controller just can't keep up," he said.

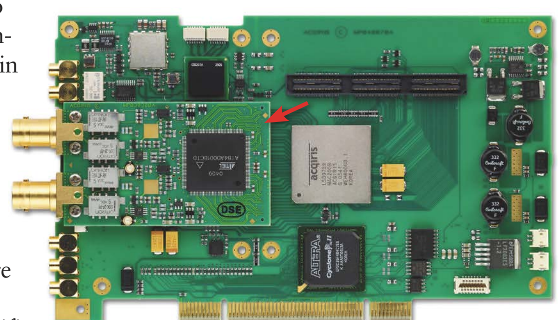


Fig. 1 Modules that support simplified upgrade and repair, such as those that employ mezzanine boards (indicated by arrow), can reduce long-term system costs. Courtesy of Agilent Technologies.

Developers should also evaluate the impact on system flexibility when deciding where processing should occur. NI's Friedman pointed out that using the system controller to handle data processing makes it easier for developers to create custom functions and algorithms than when processing occurs on a module. Aeroflex's Carey noted that local processing on a module can reduce system flexibility: "Onboard processing puts a wrapper around a module, defining what it can do and making it more like a boxed instrument rather than remaining configurable for new or different tasks."

Another way to reduce costs lies in making modules or even the entire system perform multiple roles. Developers should "map resources to needs in order to get double or triple duty out of their boards," according to Geotest's Dewey. "Do you need a DMM module, or does your digitizer offer adequate performance?"

IE's Cupo gave as an example of such architectural multitasking a custom system that his company designed

Fig. 2 By reducing development effort, off-the-shelf chassis, such as this enclosure with a built-in cable tray, may provide more in savings than they add in acquisition costs.

Courtesy of Geotest—Marvin Test Systems.

that tested two different devices concurrently using a single PXI rack. The multiplexer and DMM served both tests while other modules were dedicated to a specific device. The design filled an 18-slot cage but proved highly cost effective. "The customer couldn't afford two independent test stations," said Cupo.

Blending systems can save

You may also save on costs by leveraging PXI's ability to blend with other buses. "Not all of your test functionality needs to be in PXI," said Carey. "Custom or proprietary elements such as RF switching, for instance, may be more cost effective and yield quicker time to market than trying to reconfigure an off-the-shelf PXI module." Agilent's Soden added, "You can also avoid buying new hardware and [can] create a hybrid system using other instruments you already have."

Once the system architecture is planned, developers can further hold the line on costs through their choice of individual modules. Power requirements are one area to consider, said Soden. "Using lower-power cards can allow the chassis to also be low power. This saves on the power supply as well as on cooling, and reduces direct electrical cost during operation."

How readily a module can be repaired or upgraded can also be a factor. Agilent, for instance, has introduced a series of PXI digitizer cards on a common base that use a mezzanine card to carry the front-end electronics (**Figure 1**) that dictate function and performance. This allows the company to develop new variations more quickly and at lower cost, reducing upgrade and repair costs for customers.

Consistency in choosing suppliers can also reduce long-term costs, IE's Cupo pointed out. "When you expect to be designing multiple platforms," he said, "it pays to standardize on one source for stimulus generators, one for measurement, and so on. Otherwise, each tester design looks a little different and adds cost downstream in software development and maintenance."

Other system elements can also represent an opportunity for savings, especially if developers discuss their needs with vendors to learn what's available. Geotest, for instance, has more than 30 chassis types with built-in features such as mass termination receivers and cable trays (**Figure 2**). "We offer lots of options so developers can be further up the system-integration curve right out of the gate. Having the cable tray integrated into the chassis, for instance, saves developers from having to design and fabricate their own cable-management solutions," said Dewey.

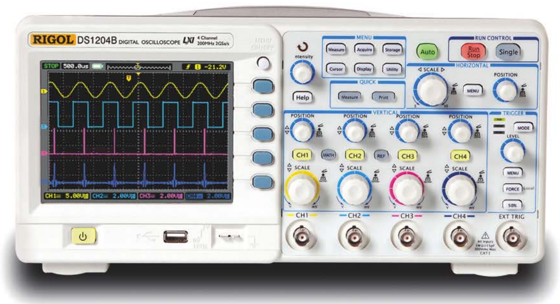
Software support significant

As important as evaluating hardware costs, though, is examining the software support available. "A big part of the cost in creating a test system is the implementation and deployment of software," said Agilent's Soden, "so you don't want to spend a lot of time getting the system going."

NI's Friedman agreed: "Developer productivity is an important consideration, yet the cost for development and integration of a system is often missed when evaluating design options."

Vendors recommend that developers verify the availability of drivers for the operating system they are using and look for tools and programs for module configuration, calibration, and maintenance. IE's Cupo, for instance, looks for modules that have .IVI driver support because he uses direct driver calls from NI's TestStand test executive to speed software development by eliminating a programming layer. Cupo underscored the importance of calibration routines in the support package: "Most customer metrology groups are not set up yet for handling PXI systems, and calibration can be a large hidden cost if not addressed up front."

Ultimately, cost optimization for PXI systems depends on your making decisions based on the total cost for acquisition, development, deployment, and lifetime operation. In some cases, this may mean spending more up front to garner savings downstream. "People can get hung up on a few hundred dollars," said Friedman. "You need to look at the impact on your overall test system and your overall business." □



Oscilloscopes challenge low-end market

The DS1000B series of four-channel oscilloscopes from Rigol Technologies consists of three models with bandwidths of 60 MHz, 100 MHz, and 200 MHz. Instruments in this class are commonly found on test benches, in repair depots, in field service, and on hobbyist benches. The DS1000B series uses two ADCs for channels 1–2 and 3–4. When using one channel per ADC, the oscilloscopes can sample at 2 Gsamples/s. When sharing an ADC, the sample rate drops to 1 Gsample/s. Memory depth is 16 ksamples, also shared between the two ADCs.

The oscilloscopes feature 22 automatic measurements as well as edge, pulse width, video, pattern, and alternate triggers. You can connect the instruments to a PC through an LXI-compliant Ethernet port or a USB port. You also get two USB host ports for storing data on a thumb drive.

Prices: 60 MHz—$1295; 100 MHz—$1595; 200 MHz—$1895. *Rigol Technologies, www.rigolna.com.*

Mohr adds Internet streaming to TDR cable testers

Mohr and Associates has introduced software upgrades for its CT100 series RF/microwave TDR (time-domain reflectometer) cable testers and bundled CT Viewer host PC software. The upgrades add real-time Internet streaming and remote control to allow users to leverage remote engineering expertise. The upgrade also allows CT Viewer to remotely store and replay TDR waveforms at more than 250 fps, allowing the operator to capture and analyze transient impedances remotely.

Although existing CT100 series TDRs already store TDR trace data at up to 500 fps, the software upgrade gives CT Viewer the ability to store and replay TDR waveforms over a network connection in the form of AVI videos at frame rates of more than 250 fps. The company reports that the new upgrade is suitable for analyzing intermittent cable faults, quantifying real-time switch and button performance, and exploring TDR-based geophysical sensor techniques.

The instruments offer system rise times as low as 60 ps (20% to 80%) and cursor resolution of 75 microns. The company targets the CT100 as a replacement for the discontinued Tektronix 1502C metallic TDR.

Base price: $13,500. *Mohr and Associates, www.mohr-engineering.com.*

Digitizer cards handle wide-ranging applications

Engineers often use high-speed digitizer cards for radar, communications, and disk-drive testing. The Razor series of PCI digitizer cards provide two or four channels with 16-bit resolution and sampling speeds of 100 Msamples/s or 200 Msamples/s. The 200-Msamples/s models feature 125-MHz analog bandwidth; the 100-Msamples/s models have 65-MHz bandwidth. All models feature 12-bit ENOB (effective number of bits).

The Razor cards have separate ADCs for each channel, so you can simultaneously sample on all channels. You can trigger acquisitions on an internal clock or an external clock and store 128 Msamples of data (options up to 2 Gsamples).

Software support includes drivers for Windows XP and Vista. The cards also come with GageScope Lite edition, which you can use to verify card operation and to make measurements. Standard and professional editions are optional, as are software development kits for C/C#, LabView, and Matlab.

Prices: two-channel card—$6495; four-channel card—$8995. *Gage Applied, www.gage-applied.com.*

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Test suite aimed at all-wireless networks

VeriWave is addressing the advent of all-wireless networks with the VeriWave Client Test Solution, a test suite that provides interoperability metrics that can assist in device design as well as deployment. The new offering, which enables device developers to mimic actual operation in a lab, is aimed at ensuring that wireless networks work with the variety of devices that will connect to them in real-world scenarios.

The VeriWave Client Test Solution measures the real-world behavior of a mobile device, its impact on other devices, and overall network performance, as well as the impact of the network on the device's own performance. It consists of three components: the WaveClient application, the WaveAgent software, and a set of RF isolation chambers and attenuators.

The WaveClient application runs on a VeriWave traffic generator controlling RF distance and path emulation, generating client traffic, and collecting performance metrics from the DUT (device under test). Because the application generates client devices with characteristics of various vendors' equipment, testers can see how specific combinations of devices will interact.

WaveAgent is a 64-kbyte software utility loaded onto the mobile device being tested. As the VeriWave system generates different mixes of traffic and conditions, WaveAgent measures the performance of the mobile device, and it reports performance metrics as well as the configuration state of the device back to the VeriWave system.

The RF isolation chambers and programmable attenuators provide RF distance and path simulation, allowing WaveClient users to measure the effect of varying distance and paths on client device performance.

The test suite measures the impact of varying configurations on both the DUT and the overall network so that network administrators, for example, can gauge the impact of a specific brand and model of instrument on their network. Testers can stress the network with both real-world and worst-case scenarios, and establish vendor interoperability and device-optimal configurations.

VeriWave, www.veriwave.com.

Vision Research rolls out 4-Mpixel camera

Targeting industrial, military, and R&D applications requiring high spatial resolution and high speed, the Phantom v640 digital camera from Vision Research has a 4-Mpixel sensor and boasts a 6-Gpixels/s throughput and enhanced light sensitivity. The Phantom v640 delivers a recording speed of greater than 1400 fps at its full 2560x1600-pixel resolution and of up to 300,000 fps at a resolution of 256x16 pixels. The v640 can also record at more conventional frames rates for normal use. When recording at 1920x1080 pixels, for example, you can adjust frame rates from 10 fps to over 2700 fps.

Configured with either a color or monochrome CMOS imaging sensor, the Phantom v640 supports both 8-bit and 12-bit pixel depths. The camera comes with 8 Gbytes of dynamic RAM, with the option to upgrade to 16 Gbytes or 32 Gbytes.

Vision Research, www.visionresearch.com.

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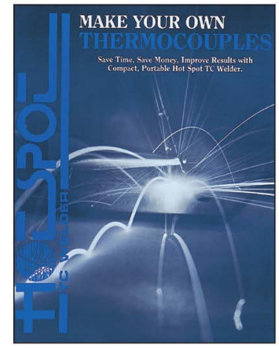

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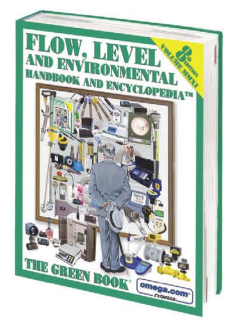

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An expert in finding solutions to IC nanometer design and manufacturing challenges, Joseph Sawicki is responsible for Mentor Graphics' design-to-silicon products, including the Olympus-SoC place-and-route system, the Calibre physical-verification and design-for-manufacturing platform, and the company's silicon test and yield analysis product line. Sawicki joined Mentor Graphics in 1990 and held previous positions in applications engineering, sales, marketing, and management. He earned a BSEE from the University of Rochester and an MBA from Northeastern University's High Technology Program.

Contributing editor Larry Maloney interviewed Sawicki by phone on the latest test technologies for preventing failure and boosting productivity in IC design and manufacturing.

Going beyond design for test

Q: How important is DFT (design for test) in IC design?

A: DFT is really the fundamental driver of the economics affecting the IC design chain. It's the primary method of eliminating defective parts. If you do a poor job of test planning or if you introduce ineffective tests, you risk damaging product quality and your company's reputation. Test costs also have a direct impact on the cost of goods sold, which is why it's essential to prevent inefficiencies in manufacturing tests that cause false rejections and reduce yield. There's a major trend toward leveraging test and diagnostic information over a product's life cycle to improve yield and company profitability.

Q: What factors are making IC test more challenging?

A: Obviously, as you increase functionality on a chip, you add to the number of test vectors needed to verify that functionality. So, we see growth in test data volume caused by growing gate counts, as well as new tests required to detect subtle defects as IC feature sizes shrink. In addition, because of high-speed serial buses and packaging limitations, there's been a reduction in the number of digital pins available for test.

Q: What are some of the new failure mechanisms that crop up?

A: Engineers encounter subtle timing-related and parametric types of defects, such as resistive shorts and opens, resistive vias, crosstalk, and other noise-related issues. As a result, at-speed scan testing has become a crucial part of test suites. This can increase test data volume by up to five times, which is driving adoption of embedded compression. By reducing the size of test patterns that need to be fed externally from the tester, compression ensures that test data can fit on the available test equipment, and it helps minimize test duration and costs. It's important to choose a test methodology and compression technology that can generate test patterns to detect hard defects and subtle issues as well.

Q: Whose responsibility is it to perform DFT?

A: The trend is to move silicon test away from the designer toward engineers who understand test, device failure mechanisms, and the impact of test strategies on manufacturing costs. With aggressive design requirements and schedules, designers are less willing to make design changes specifically for test. They rely on test engineers to implement systems and software that carry out test requirements without impacting design architectures. This puts more pressure on test engineers to maintain high test quality with minimal test access, while keeping costs manageable.

Q: What are Mentor's prime DFT products?

A: FastScan is our original test pattern generation tool, but many customers have adopted our newer TestKompress tool, which features high test pattern compression to manage growing test data volume. TestKompress provides the same test patterns as FastScan, but it also compresses the volume of test data and test application time in manufacturing by as much as 100 times.

Q: What role does your YieldAssist tool play in DFT?

A: YieldAssist analyzes test failure data and identifies systematic defect mechanisms that affect yield. This tool works directly with production test failure data from test patterns generated by TestKompress, FastScan, or MBISTArchitect. Instead of using test data only as a pass/fail defect-screening mechanism, this tool helps you to understand the cause of failures and to identify defects that affect yield. As a result, it is becoming a vital tool to help customers ramp up yield and reach their DPPM (defective parts per million) goals. T&MW

Joseph Sawicki addresses more questions on DFT and yield improvement in the online version of this interview: www.tmworld.com/2009_05.

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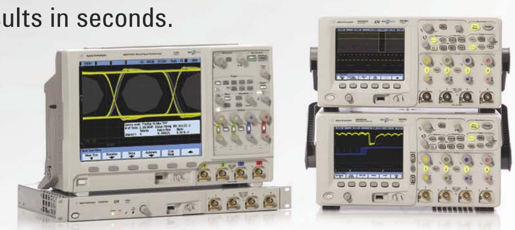

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