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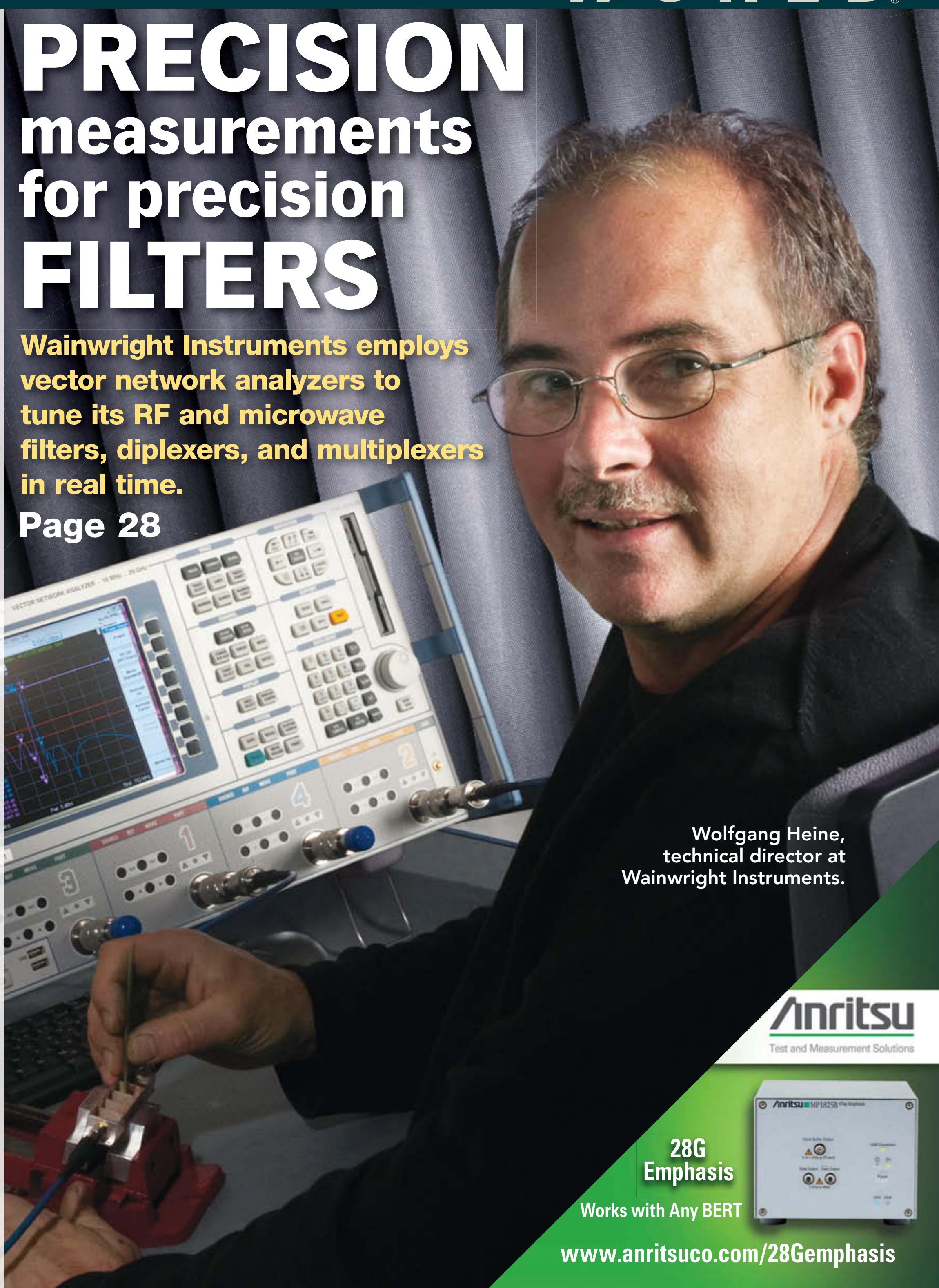

Wolfgang Heine, technical director at Wainwright Instruments.

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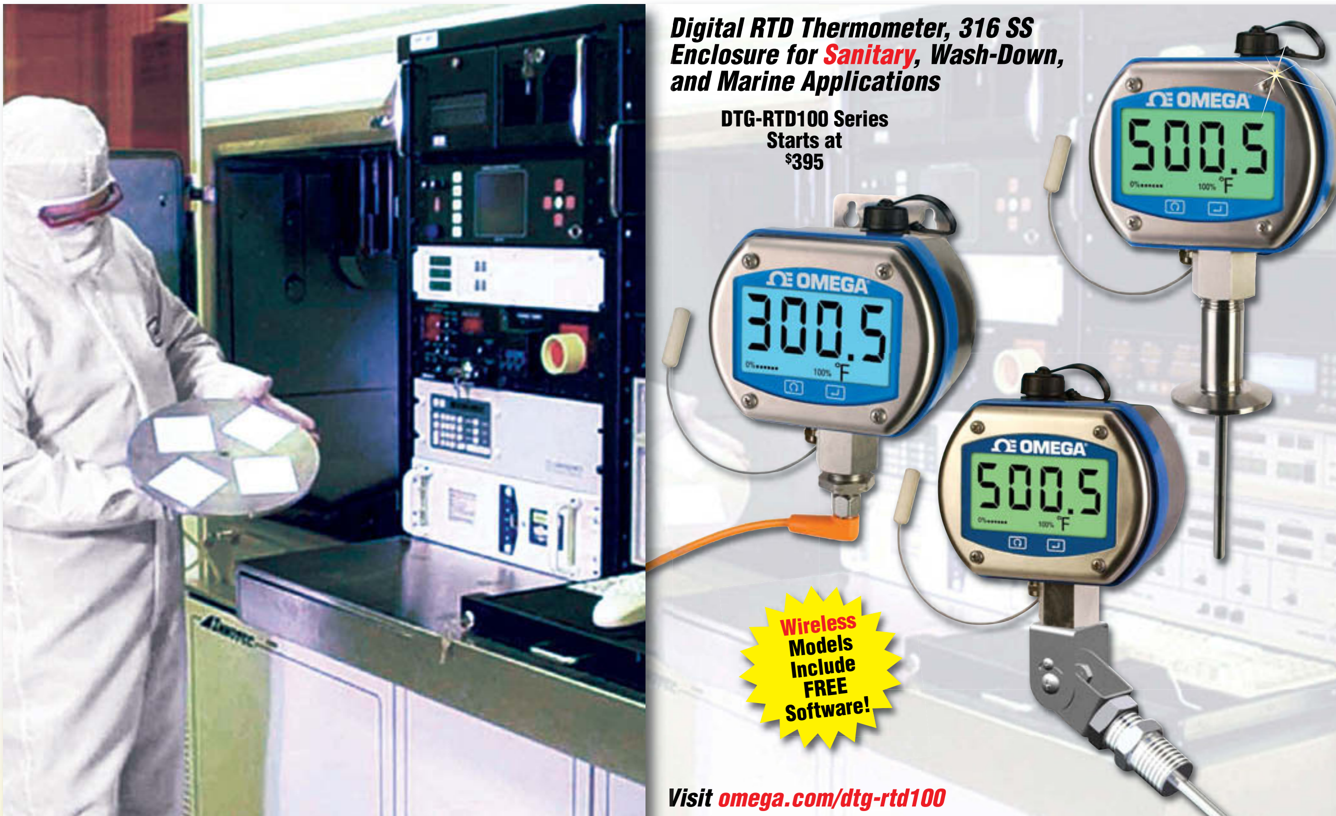

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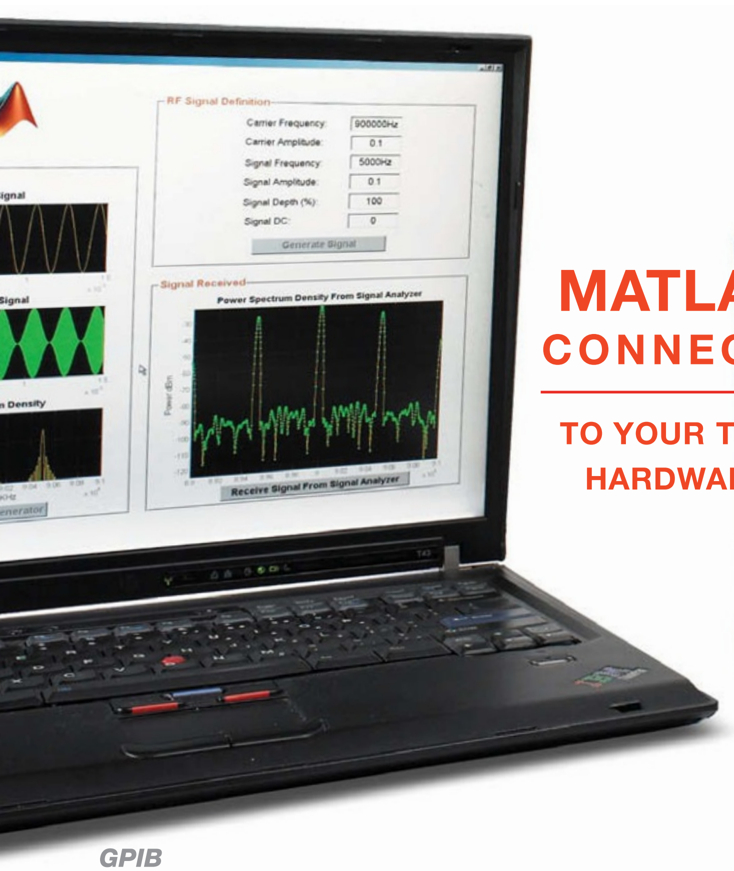

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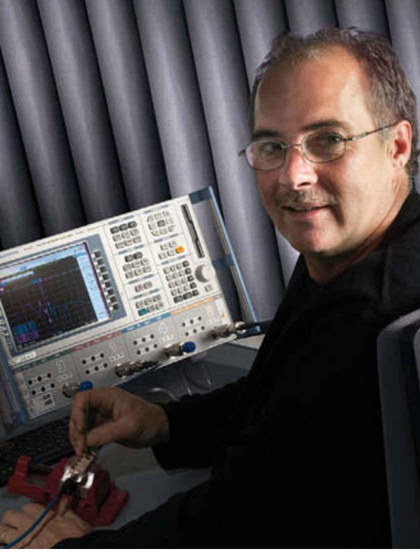

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Check out these exclusive features on the *Test & Measurement World* Website:

UNH-IOL adds blog to *T&MW* site

The UNH-IOL (University of New Hampshire Inter-Operability Lab) is well-known for conducting plug-fests at which manufacturers of data-communications products can test how well their products conform to networking standards and whether they interoperate properly with products from other vendors. Now, representatives of the lab will be blogging about their work on the *Test & Measurement World* Website. In their "Testing the Limits" blog, the bloggers will discuss their experiences in testing networking and data-storage technologies and will also provide their perspective on ways for cost-effectively complying with network-interoperability and network-conformance requirements.

bit.ly/jLNsQg

Build a tester around a microcontroller

While many engineers use a PC-based test system for functional test, sometimes such a system is too expensive or impractical. Some test applications call for embedded intelligence built into a test fixture or stand-alone custom tester where test operators don't need a PC. When those circumstances arise, consider building a microcontroller-based tester. Overton Claborne, president of Overton Instruments, explains how.

bit.ly/mzv6JD

T&MW blogs

Rowe's and Columns

Martin Rowe, Senior Technical Editor

- Buy a pulse generator, get an iPad2
- Test engineers save the weekend
- Are you embedded?

www.tmworld.com/blogs

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Richard Quinnell, Contributing Technical Editor

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RICK NELSON
EDITORIAL DIRECTOR

From DuMont oscillograph to iPad app

Contributing technical editor Richard Quinnell waxed nostalgic about old-fashioned instruments in "The thrill is gone" in *T&MW*'s May 2011 *Modular Instrument Test Report*, prompting an e-mail rebuke from a reader appreciative of today's models. As Quinnell reported, "I was once the proud teen owner of my very own DuMont cathode-ray oscillograph with sweep-frequency and voltage-gain knobs you could twiddle in an attempt to freeze the trace of a repeating signal so you could study its structure….The thrill of seeing the electronic signals I had been working with while building a short-wave receiver was immense."

Modern instruments might be missing the ability to inspire a teenager to pursue an EE career.

Quinnell's commentary prompted this response from Jimm Hoffmann, executive partner at Instrument Engineers: "Maybe I misunderstand your intent, but the test engineer's job has always been to efficiently complete his test. Waxing [nostalgic] for untriggered oscilloscopes in an era of pinpoint triggering that quickly locks into a viewable and measurable result is like fondly remembering a rotary dial phone."

Hoffmann added that today's engineers are "overloaded with tasks that tie them to the lab for hours beyond quitting time, and newer instruments can get them out of the lab in 10 hours instead of 12…." He also said that technology is constantly improving, concluding, "If it wasn't, I would have sent you a telex instead of this e-mail."

Of course, as Quinnell noted in his column, "There are many good and compelling reasons why test technology is shifting as it is." He elaborated in a follow-up note to Hoffmann: "I must admit that some of my nostalgia arises because it is not tempered by the need for efficiency that you mention. I have no on-going test responsibility; I simply monitor the advance of test technology, so the relief the new interfaces provide is not something I personally experience. Of course, I was not fondly remembering how well my old 'scope worked but the feelings of control and insight that working with it offered me. I think it might be the connection between my physical action and the information that resulted—working with my hands as well as with my mind. That connection is simply not as strong for me with today's instrumentation."

What occurs to me is that what might be missing from today's instruments is the ability to thrill the tinkering teenager sufficiently to inspire him or her to pursue a career in electrical engineering. Of course, as Hoffmann suggested, the thrill would evaporate by the end of a 12-hr day in the life of the practicing electrical engineer who would no doubt appreciate the ease-of-use, speeds, resolution, flexibility, and advanced triggering capabilities of today's instruments.

As for our hypothetical teenager, perhaps minimally capable iPad oscilloscope apps and add-ons can provide the inspiration that the DuMont oscillograph provided to Richard Quinnell.

What do you think? Visit my blog at the link below to add your comments. Or send me a telex. T&MW

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

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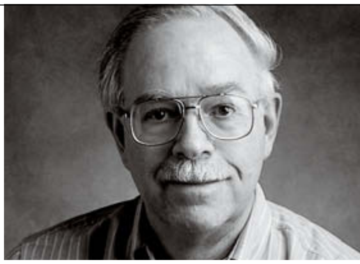

Click, click, click…

At age 12, I collected rocks, messed with a Gilbert chemistry set, and dismantled anything electronic that fell into my hands.

Atop the pyramid of my lust for all things scientific, a Geiger counter ranked second only to a multimeter. It was 1956, and the small-print ads in *Popular Electronics'* back pages promised "…$10,000 rewards for finding uranium…." Surely, with a Geiger counter in hand, I could bring home the bacon.

In retrospect, I may have wanted a Geiger counter for a darker reason. We lived 30 miles away from a Strategic Air Command bomber base—a key Cold War target. In the event of a nuclear attack, we were taught to "duck and cover" beneath our desks to avoid flying glass when the blast wave blew out our school building's windows, and we wore dog tags to identify our charred little bodies. If my parents survived, the Geiger counter could tell them when it was safe to emerge from the basement root cellar.

My birthday gift that year was a Geiger counter—an Allied Radio Knight-kit model S-242—that I eagerly assembled. It didn't work. After considerable assistance from my dad and correction of my cold solder joints, the S-242 worked, clicking reassuringly and infrequently via its headphones as it sat on the workbench.

I still recall the S-242's tube complement: a fragile Victoreen 1B85 thin-wall Geiger-Mueller tube and a 1T4 audio amplifier. The power supply comprised a 1½-V D cell and a 22½-V battery for the 1T4's filament and plate supplies. To generate high voltage for the 1B85, I pressed an SPST normally-open, momentary-contact switch that shunted the voice-coil winding of a plate-to-loudspeaker transformer across the D cell. The plate winding developed a high-voltage spike that jumped across a spark gap and charged a storage capacitor. At its best and with a fresh battery and careful adjustment of the spark gap, this scheme worked imperfectly.

Fast-forward to today, with Japan's ongoing earthquake-induced nuclear disaster in the news and growing concern about the integrity of the US's aging fleet of nuclear power plants and its still unsolved long-term spent-fuel storage problem. Are we about to see a resurgence of interest in personal radiation-detection instruments? T&MW

To read past Test Voices columns, go to www.tmworld.com/testvoices.

YES, WE ARE!

A survey of Websites offering Geiger-counter kits revealed that due to heavy demand from Japan, many kits were either sold out or back-ordered. This site describes a Geiger-counter add-on for the Arduino microprocessor technology:

www.engadget.com/2011/04/18/arduino-geiger-counter-brings-open-source-radiation-detection-to

A (TWO-HEADED) CHICKEN IN EVERY POT, AND A RADIATION DETECTOR IN EVERY PHONE?

Start with the disclosure that the iPhone4 contains a geographic-location function…

cellphonetrackers.org/iphone-4-track-user-whereabouts-silently.html

…add a radiation-detection function…

www.newsweek.com/2008/09/26/my-blackberry-as-a-bomb-sniffer.html

…and you have the makings of a nuclear-fallout mapping system. There are a few bugs to be worked out, though, chief among which are the effects of nuclear radiation on the iPhone bearers and the likelihood that an electromagnetic-pulse event associated with a nuclear explosion would fry the cellphone infrastructure.

D-I-Y RADIATION DETECTORS

If you want to build your own Geiger counter, check out these sites:

www.galacticelectronics.com/GeigerCounter.HTML

www.rhunt.f9.co.uk/Electronics/Geiger/Geiger_Page1.htm

www.geotech1.com/pages/geo/projects/geiger/geiger_150.pdf

As an alternative to locating a Geiger tube, consider restoring or constructing a scintillation counter. When struck by ionizing radiation, certain transparent crystals and liquids emit flashes of light. A photomultiplier tube detects and amplifies the light emissions:

home.comcast.net/~prutchi/index_files/scint.htm

I/Q digitizer optimized for OFDM testing

ZTEC Instruments has announced its ZT8450 I/Q digitizer, which functions as a baseband VSA (vector signal analyzer) from DC to 300 MHz. This new baseband VSA provides the signal fidelity and real-time processing capabilities necessary for measuring parameters such as EVM (error-vector magnitude), ACLR (adjacent-channel leakage ratio), and IM3 (third-order intermodulation distortion); the instrument also addresses complex MIMO applications. The ZT8450 provides the combination of high instantaneous bandwidth, high dynamic range, high linearity, and low phase noise necessary to test and characterize the latest RFIC components.

Key features of the ZT8450 I/Q digitizer include VSA functionality and the ability to demodulate OFDM (orthogonal frequency-division multiplexing) waveforms, two differential inputs (I/Q or dual IF), two 14-bit 400-Msamples/s ADCs, 512-Mbyte deep memory, 300-MHz analog bandwidth, 0-dB to 30-dB programmable I/Q input gain, onboard DDC (digital downconverter) with fractional resampling, and a programmable un-aliased DDC instantaneous bandwidth to 160 MHz.

The ZT8450 I/Q digitizers come in two- and four-channel PXI, PCI, VXI, and LXI versions. They expand on ZTEC's ZT8440 IF digitizers by adding differential baseband I/Q input functionality. ZTEC says that whereas the ZT8440 series is most suited as an IF processing engine in combination with an RF downconverter, the ZT8450 series is optimized for differential I/Q testing of baseband RFIC components. www.ztecinstruments.com.

Spirent demonstrates test solution for NTAF spec

Spirent Communications reports that it has demonstrated the first commercially available test solution based on specifications from the NTAF (Network Test Automation Forum). The company showcased an NTAF-based integration between its TestCenter platform and its iTest test-automation tools during Interop Las Vegas 2011 (May 8–12).

The NTAF was formed in March 2010 to promote the interoperability of commercial testing tools and test infrastructure for the data communications and telecommunications industry. Spirent, which is a founding member of the organization, has contributed to the group's specifications.

"Our customers are telling us clearly that standards-based interoperability of test systems and test beds are important to them," said Todd Law, product manager at Spirent and VP of NTAF, in a prepared statement. "We share that vision and are pleased to be the first to implement this latest integration based on the open NTAF specification."

Spirent acquired the iTest automation tool when it acquired The Fanfare Group in February of this year. "Following Spirent's acquisition of Fanfare, we reaffirmed our commitment to an open-standards-based approach, giving our customers greater flexibility in their test system selection and test bed setup," added Law. www.spirent.com.

(continued)

Editors' CHOICE

LeCroy offers 12-bit general-purpose oscilloscope

LeCroy's WaveRunner HRO 6 Zi features 12-bit resolution and 256 Mpoints/channel of memory. Designed for the medical, automotive, and power markets, the WaveRunner HRO (high-resolution oscilloscope) features a 12-bit ADC architecture that provides 55-dB SNR and ±0.5% DC vertical-gain accuracy.

The 256-Mpoints/channel deep memory permits the capture of 30 s of data sampled at 10 Msamples/s (shorter capture times are available at the highest resolution of 2 Gsamples/s). This performance is augmented by an offset and time-base delay adjustment to allow easy signal and amplifier performance assessment and to permit zooming in on signal characteristics.

A pivoting display permits users to view signals vertically or horizontally. LeCroy reports that the vertical mode is advantageous when users view up to 36 channels using the mixed-signal option, when the instrument is operating in the frequency domain with the spectrum-analysis package, or when users are viewing decoded waveforms for the embedded and communications markets.

LeCroy, www.lecroy.com.

CALENDAR

Semicon West, July 12–14, San Francisco, CA. *SEMI, www.semiconwest.org.*

International Symposium on Electromagnetic Compatibility, August 14–19, Long Beach, CA. *IEEE, www.emc2011.org.*

Autotestcon, September 12–15, Baltimore, MD. *IEEE, www.autotestcon.org.*

International Test Conference, September 18–23, Anaheim, CA. *IEEE, www.itctestweek.org.*

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

Editors' CHOICE

Analyze lab or production audio

Covering a frequency range of 5 Hz to 80 kHz (plus DC), the Flexus FX100 audio analyzer can perform level, FFT, frequency, phase, THD, THD+N, gain, and crosstalk measurements. The FX100 has several measurement modes including meter mode (numeric display), glide sweep for production measurements, and stepped sweep for more detailed engineering measurements.

The FX100 chassis holds two-channel input and output modules. A pair of modules provides four channels. Optional switching modules add another four input or output channels to the system. An optional impedance module adds speaker measurements. Accessories include microphones, a two-channel power amplifier, a calibrator, and a rack-mounting kit.

The instrument runs under PC software control through a provided application, or you can develop your own application. Optional Prosound software analyzes signals for speaker buzzes and rubbing voice coils.

Price $8800, *NTi Audio, www.nti-audio.com/flexus.*

DFT contends with DFM at circuit-assembly show

>>> IPC APEX Expo, April 10–14, Las Vegas, NV, www.ipcapexexpo.org.

A "cage match" pitting a DFT (design-for-test) team against a DFM (design-for-manufacturing) team was a highlight of IPC APEX Expo 2011. Paul Windsor of **Acculogic,** Brian D'Amico of **MIRTEC,** and David Lehmann of **GE Measurement & Control Solutions** made up Team DFT, while Dale Lee of **Plexus,** Greg Caswell of **DfR Solutions,** and Russell Nowland of **Alcatel-Lucent** made up Team DFM.

The match (in the form of a panel discussion moderated by *T&MW* editorial director Rick Nelson) concluded with an uneasy truce: The DFM team recognized the necessity of test while noting that DFT insertion provides additional failure opportunities. Both teams—along with commenters from the audience—agreed that cross-disciplinary cooperation and training can help get high-quality products containing complex, dense circuit assemblies to market fast.

On the show floor, **Everett Charles Technologies** and **CheckSum** demonstrated an in-circuit tester prototype employing ECT's Pure ZOOM technology. **Digitaltest** demonstrated boundary-scan and flying-probe integration in conjunction with **Corelis.**

Universal Instruments debuted the Advantis 3 scalable platform for cost-sensitive circuit-assembly applications. The company also introduced the high-end Genesis Series 2 platform for what it calls "extreme surface-mount applications."

Dale Lee of Plexus, Greg Caswell of DfR Solutions, and Russell Nowland of Alcatel-Lucent made up Team DFM at the APEX DFT vs. DFM "cage match."

Courtesy of the IPC.

Aegis unveiled an iPhone/iPad application for manufacturing operations. **Agilent Technologies** demonstrated its TS-8900 automotive functional-test system. **Texmac** highlighted the Takaya probers it markets in the US. **Nordson Dage** exhibited its 4000Plus pad-cratering inspection system.

Viscom highlighted its new vVision user interface. **Aster Technologies** exhibited its TestWay Express integrated design-to-production DFT software. **Seica** showcased its Pilot flying probers and compact TK in-circuit-tester. T&MW

Scope strategies charted at embedded design show

>>> Embedded Systems Conference Silicon Valley, May 3–5, San Jose, CA, esc.eetimes.com/siliconvalley.

National Instruments and **Tektronix** staked out their respective turf when it comes to the digitization of signals from devices under test. The companies are cooperating with each other, as was evidenced by the NI PXIe-5186 5-GHz, 12.5-Gsamples/s digitizer, which contains Tektronix-designed ASICs, on display at NI's booth. But while NI will manufacture and market modular instruments for automated-test applications, Tektronix is targeting the benchtop.

In other scope news, **LeCroy** demonstrated its WaveRunner HRO 6 Zi, which features 12-bit resolution and includes a pivoting display that permits viewing signals vertically as well as horizontally. **Rohde & Schwarz** highlighted the digital-trigger capability for its R&S RTO scopes.

WinSystems announced its EPX-C380 EPIC-compatible Atom-based single-board computer for I/O-intensive applications. The EPX-C380 uses either an Intel Atom single-core N450 or dual-core D510 processor running at 1.66 GHz. **Averna** introduced its Proligent Analytics 2011, which adds 100 new preset reports and implements a dynamic environment that allows users to navigate through report data to facilitate root-cause analysis.

Atego launched the Aonix Perc Ultra 6 compiler and graphical console for live application analysis. Aonix Perc Ultra 6 replaces the legacy just-in-time and ahead-of-time compilation technology with a new low-level virtual-machine compiler. The firm also announced it has acquired HighRely, thereby adding avionics-certification capabilities.

Veridae Systems demonstrated its Corus FPGA-based system-validation and debug tool suite, which provides a synchronized view of all system serial I/O ports, buses, and software code while providing a view inside the FPGAs as well. **IBM Rational** highlighted its software strategy for facilitating designs containing millions of lines of code and offered as an example how its software and simulation tools helped GM engineers design and develop the software in the advanced control systems on the 2011 Chevrolet Volt. T&MW


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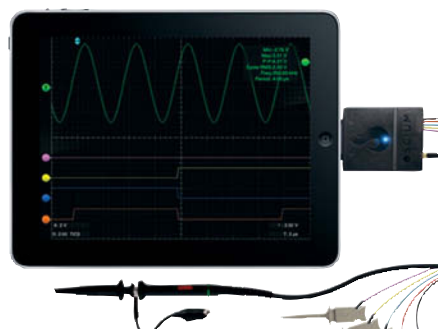
iPad or laptop: You have a choice

In February, I wrote about how tablet computers such as the iPad could drive changes in the user interfaces on test instruments (Ref. 1). I wrote that column after seeing a demonstration of an iPad oscilloscope app that used the iPad's built-in microphone as a signal source; the demonstration took place during a children's lecture on sound and vibration (Ref. 2). You can see a video of the lecture and the iPad oscilloscope from a link in the online version of this column (www.tmworld.com/2011_06).

That video sparked a call from Oscium, a company that manufactures a mixed-signal oscilloscope for the iPad. The iMSO-104 lets you add one analog channel and four logic channels to an iPad.

Brian Dipert, my colleague at *EDN*, has written a review of the iMSO-104 (Ref. 3). Dipert questioned the $297.99 price of the iMSO, given its 5-MHz bandwidth and 12-Msamples/s capture rate. You can compare the iMSO to USB oscilloscopes from Link Instruments, Syscomp Electronic Design, and Pico Technology. The Link Instruments MSO-19 gives you one analog channel and eight logic channels for $249 (Ref. 4). The analog channel runs at speeds up to 200 Msamples/s, far in excess of the iMSO-104, and you can download the MSO-19's software at no cost, just as you can with the iMSO-104's software.



The iMSO-104 turns an iPad into a single-channel oscilloscope with four logic inputs. Courtesy of Oscium.

The CircuitGear CGR-101 from Syscomp gives you two analog channels that sample at 20 Msamples/s for $189. Although it doesn't have logic inputs, the CGR-101 has a built-in 2-MHz function generator. I've written an extensive review of this product (Ref. 5).

At around $245, you can get the Picoscope 2203, a 5-MHz, two-channel USB oscilloscope from Pico Technology. It samples at 20 Msamples/s on two channels or 40 Msamples/s on one channel and is the low end of a range of USB oscilloscopes from the company.

Clearly, iPad scopes are still in their infancy compared to PC-based USB models. But if you can live within the bandwidth and channel limitations, you can use the iPad's screen and its popular user interface to display waveforms. Yes, PC-based USB scopes offer more bandwidth, but you have to connect them to a laptop PC, which is larger and heavier than an iPad, takes longer to boot, and likely has a shorter battery life.

If you search online for "iPad" and "oscilloscope," you'll find other options beside the iMSO-104, although most of them use the iPad's internal microphone. An oscilloscope app from onyxapps provides software you can download from the Apple Store, but you need an adapter that connects probes to its microphone input, and you're still limited to audio frequencies. T&MW

Low-current, high-resistance measurements

An electronic handbook from Keithley Instruments, "Making Precision Low Current and High Resistance Measurements," provides tips for making leakage-current measurements, guarding measurement circuits, and reducing noise. www.keithley.com/pr/088.

USB-to-avionics bus converter

The BU-67211UX avionics tester lets you turn a USB port into an avionics bus controller. The unit contains two dual MIL-STD-1553 ports, eight ARINC-429 channels, two ARINC-717 channels, four RS-232/422/485 ports, two digital channels, and two avionics-level digital I/O lines. www.ddc-web.com.

USB data-acquisition system

Microstar Labs xDAP7410 subsystem includes 16 differential analog inputs that sample at up to 1 Msample/s per channel (8 Msamples/s overall) with 16-bit resolution. The system has an internal processor that handles measurement tasks, freeing the host PC to perform higher-level functions. Software support includes LabView drivers. www.mstarlabs.com.

REFERENCES

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MARKETTRENDS

ARBITRARY WAVEFORM GENERATORS

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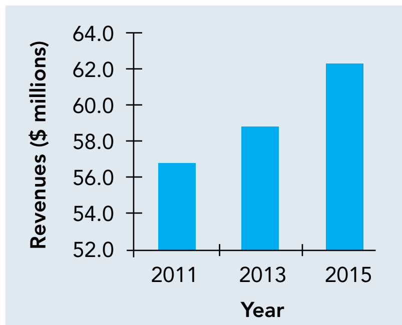
FROST & SULLIVAN

Bright future for the AWG market

Over the past few years, there has been an evolving need for test instruments that offer a wider bandwidth without compromising on resolution. Modern communications systems and products are employing a greater number of digital-modulation schemes to transport more data in the same bandwidth, which means they are more likely to generate imprecise levels of transmissions and phase angles. To test these products and systems, manufacturers need high-performance instrumentation, yet most test instruments can deliver either high resolution or high signal speed, but not both.

One key instrument for implementing such tests is the AWG (arbitrary waveform generator), and manufacturers of test equipment are now making investments to expand the bandwidth and resolution AWGs can cover. For example, in March, Agilent Technologies added a high-resolution, wide-bandwidth, 8- or 12-Gsamples/s modular instrument to its portfolio of AWGs. Under certain conditions, the instrument offers an 80-dBc SFDR (spurious-free dynamic range), which represents the highest resolution available.



Increased opportunities based on AXIe and a new generation of products enabling highly reliable signal scenarios should increase total AWG market revenues by 2015.

The potential for growth in the AWG market has been rising since the introduction of the AXIe modular instrumentation standard in November 2009. The proponents of AXIe say it improves timing, triggering, and module-to-module data movement but that its key benefit is in the power per slot that reaches 200 W. "You can integrate different instruments into one platform, so the measurement setup becomes much simpler to end users, and this is definitely a value for them," said Beate Hoehne, product manager for Agilent Technologies.

Nonetheless, there remains a strong need for instrument manufacturers to offer single boxes in order to simplify test setup, reduce uncertainty, and enable greater portability and easier sharing of test equipment than is possible with an AXIe setup. Another key priority on the high end is pure sample rate (or bandwidth), especially as researchers push the limits with wideband RF, high-speed serial, and advanced optical signals.

"Researchers see the need for more and more bandwidth. We see a lot of emphasis at the 24-Gsamples/s level to support cutting-edge development across all segments," confirmed Lawrence Wilson, product manager for Tektronix. He added that, "AWGs become especially useful when they are combined with software to simplify waveform creation and fully exploit wideband signal-generating capabilities."

Today, the AWG market is the fastest-growing segment of the worldwide market for signal generators. The AWG market is projected to exceed $56.7 million in 2011 and reach $62.4 million in 2015. The compound annual growth rate from 2010 to 2015 is estimated to be 3.9%. T&MW

Danaher test brands address $12 billion market

A $12 billion market serves as the target for Danaher's test-and-measurement brands, including Fluke, Tektronix, Fluke Networks, and Tektronix Communications, according to Amir Aghdaei, Danaher group executive and Tektronix president. In an interview May 3 at the Embedded Systems Conference Silicon Valley, Aghdaei said he expects the market to grow in the 5% to 7% range annually. Danaher's test business, he added, now accounts for about $2.8 billion in sales, with 75% of that total for instruments, 15% for services, and 10% for software. He noted that 45% of sales are to North America, 20% are to the European Union, and 35% go to the rest of the world.

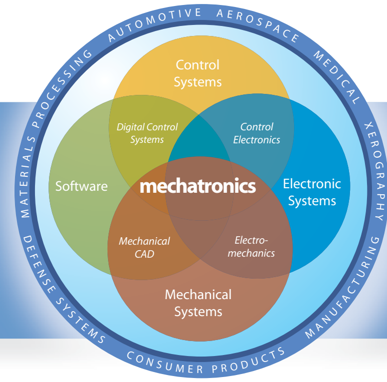
Aghdaei attributed the growth of the test market to the rapid evolution of new products and technologies, exploding bandwidth demand, growing requirements for installation and operation of digital services, and the rise of digital security threats. He said that bandwidth demand has been growing at 60% year over year for 15 years.

Specific applications Aghdaei cited included embedded design, with Danaher offering instruments to help designers contend with serial buses (used in 60% of embedded designs) and parallel buses (used in 50% of embedded designs). Another example, he said, is wireless connectivity design incorporating integrated analog, RF, and digital technologies. He noted that 60% of oscilloscope users also use spectrum analyzers and that 83% will be contending with time-varying RF signals.

Rick Nelson, Editorial Director

MECHATRONICS IN DESIGN

FRESH IDEAS ON INTEGRATING MECHANICAL SYSTEMS, ELECTRONICS, CONTROL SYSTEMS, AND SOFTWARE IN DESIGN



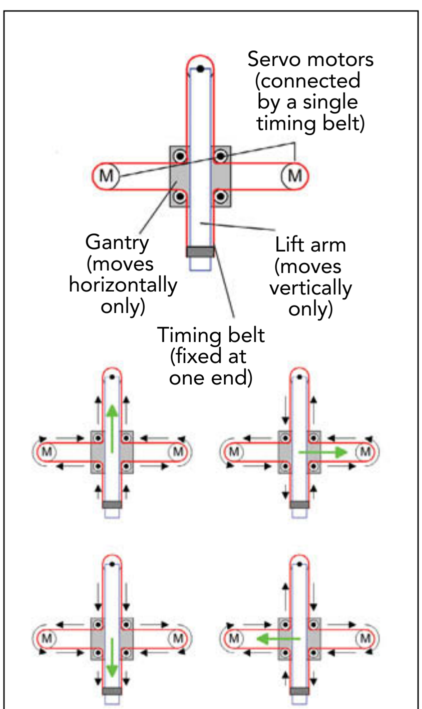
So, you want to build an H-Bot?

The H-Bot is conceptually simple; it's the design of the controls that make it amazing.

Designers of modern robotics based their systems on modularity. Instead of using one six-axis robot for all applications, mechatronics engineers design a robot for each application. This approach places more emphasis on model-based design and system integration.

The H-bot, so-named because it resembles the letter H, is an example of such a robot. This 2-D robot, a planar mechanism for positioning an object in an x-y space, such as a plane, finds use in many industrial systems, such as pick-and-place, sorting, gluing, and inspection systems. The robot is easy to manufacture because it comprises two motors, a timing belt, and two perpendicularly mounted rails (**figure**). Despite the dynamic simplicity of the design, friction, backlash, and compliance throughout the mechanism are impediments to accurate positioning and represent system-design challenges.

As in any coordinated-motion system, the computation of the position command to each motor of the H-bot is just as important as the control scheme you employ to control the robot. The successful combination of these two aspects will lead to accurate positioning, but that concept means different things depending on the application. In a system that performs point-to-point applications, such as a pick-and-place system, accurately moving to the target position is the main concern, whereas a system that performs tracking applications, such as a gluing system, requires a low number of position-following errors.



The 2-D H-bot robot comprises two motors, a timing belt, and two perpendicularly mounted rails.

Motion applications typically use a cascade-control system that comprises position, velocity, and current loops, all typically proportional-integral. Additional features, such as velocity feedforward to reduce position-following errors and acceleration feedforward to reduce velocity-following errors, are also usually part of the control architecture.

Many mechatronics engineers lack a thorough understanding of the position-command computation. Its complexity depends on the shape of the path the robot must follow. Paths with sharp corners, such as a square, are challenging to accurately reproduce with a machine. Poor implementation of the calculation of the position command causes an overshoot on the corner, yielding imperfections in the product.

One approach to mitigating this effect produces perfect corners for a square shape with an H-bot. In this approach, each side of the square becomes a segment on the motion profile, which the geometry of a square projects on x and y axes. Thus, you obtain the profile x and y axes in the Cartesian space.

You then employ the inverse kinematics of the robot to obtain the position profile at the motor shafts. Use a master axis to obtain synchronization between axes. The motion profile of this master axis plays a key role in creating perfect corners. Four segments that start and end at each corner of the square shape define this profile. To reduce machine vibration, wear, and noise, use a smooth profile, such as a fifth-order polynomial profile, to define the motion of the master axis from corner to corner.

You can find more details about the design and construction of an H-bot, including modeling, analysis, control design, and experimental validation, at www.multimechatronics.com. T&MW

Kevin C. Craig, PhD, is the Robert C. Greenheck chair in engineering design and a professor of mechanical engineering, College of Engineering, Marquette University.

For more mechatronics news, visit: mechatronicszone.com.

INSPECTION

Preventing pad cratering in PCBs

To address pad cratering, a vexing problem in lead-free assemblies that is largely attributable to problems with the resin used to make a PCB (printed-circuit board), IPC-Association Connecting Electronics Industries has released IPC-9708, "Test Methods for Characterization of PCB Pad Cratering." The new standard provides three test methods that enable product developers to determine the best material for their application.

"In the beginning, there wasn't much attention [paid] to these types of failures because they were almost unheard of," said Dr. Reza Ghaffarian, an engineer at NASA's Jet Propulsion Laboratory and the chair of the IPC SMT Attachment Reliability Test Methods Task Group that developed IPC-9708. He explained in a press release that as companies started getting products ready to ship, they began to realize they had a problem that was affecting not just one or two parts, but many. "These are catastrophic failures that are sometimes latent. The defect doesn't always show itself in testing," he said.

IPC-9708 provides test methods for evaluating how susceptible a printed-board assembly material is to cohesive dielectric failures that occur underneath surface-mount-technology attach pads. Developers can use the test methods to rank and compare printed-board materials.

"The standard will help people select, say, four materials that seem to meet their needs. Then, they can build test coupons defined by IPC-9708 and run tests on these coupons," said Satish Parupalli, an Intel engineer who helped coordinate the development of the standard. Companies that use the test methods should see cost reductions as they will reduce the burden of verification and qualification.

Mudasir Ahmad, a Cisco engineer who led the development of IPC-9708 with Parupalli, said that Cisco is setting up the infrastructure for applying the IPC-9708 tests. "Investing our time and money highlights to suppliers that we believe in this standard and its benefits," Ahmad said.

One vendor that is addressing the pad-cratering problem is Nordson Dage,

The 4000Plus system performs hot-bump-pull tests. Courtesy of Nordson Dage.

which demonstrated at APEX Expo 2011 its new 4000Plus pad-cratering inspection system, which the company says employs a patented technique for attaching a test probe to solder bumps or solder paste to perform hot-bump-pull tests in accordance with IPC-9708. The 4000Plus hot-bump-pull application uses a specialized load cartridge that can be programmed to apply a time-temperature reflow profile to individual solder bumps or bonds using a test probe.

Rick Nelson, Editorial Director

EMC

Integrator boosts inductive-probe bandwidth

Engineers have used inductive-loop probes for many years to troubleshoot high-frequency circuits and locate emissions. These probes, which can be homemade or purchased commercially, rely on mutual inductance to sense fields produced by current. Engineers also use commercial current probes to measure both intentional and unintentional current in circuits and systems.

Inductive-loop probes take advantage of the mutual inductance that exists between the probe and a nearby conductor. A changing current in a wire produces a magnetic field that couples to the probe through the mutual inductance. The voltage across the probe is expressed as follows, where M is the mutual inductance:

$$e = M\left(\frac{di}{dt}\right)$$

In conjunction with an oscilloscope, the lower-cost loop probe can produce waveforms proportional to current that match the waveforms produced by current probes, although commercial current probes usually achieve greater bandwidth. To demonstrate the capability of loop probes, researchers at Universidad Carlos III and Università di Pisa developed an integrator circuit using two op amps and a passive RC filter that lets loop probes detect current pulses at frequencies up to 50 MHz (Ref. 1). The figure in the online version of this article shows a simplified diagram of the measurement system (www.tmworld.com/2011_06).

The researchers tested the loop and integrator with a 2000-V pulse generated from a waveform generator stepped up through a high-voltage transformer. To verify the loop-integrator performance, the researchers compared results from their circuit to those measured with a high-frequency current probe and to those measured across a shunt resistor.

For further reading, visit the High Frequency Measurements Web Page, where you can read about how to construct loop probes using coaxial cables or paper clips. The site also contains papers on how to use current probes (Ref. 2).

Martin Rowe, Senior Technical Editor

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Circuit lets you isolate and measure current

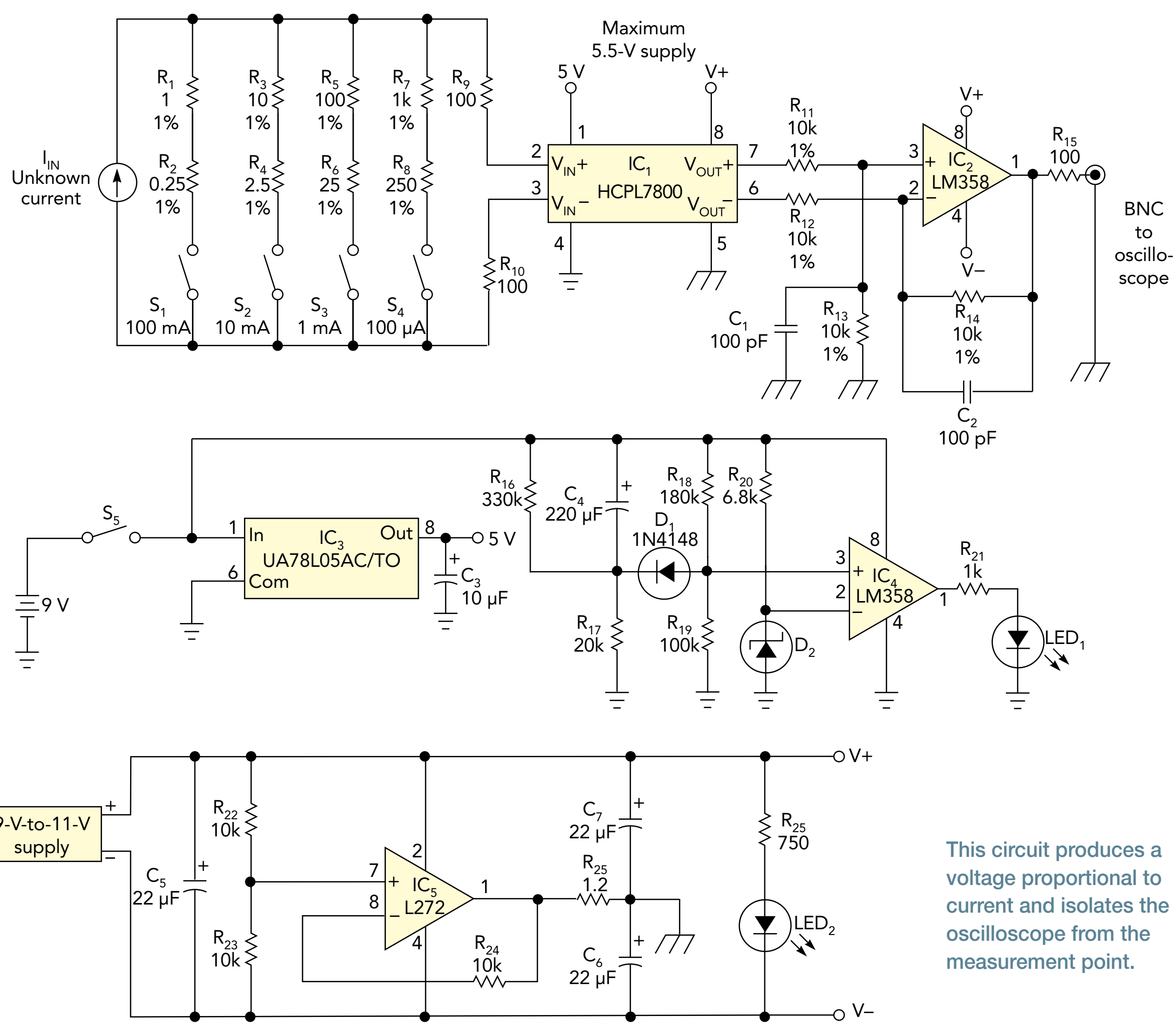
Isolating a circuit under test from an oscilloscope lets you measure current with a grounded probe.

By Anton Mayer, Murr, Germany

You often need to measure current during circuit design and debugging. You can perform that task by breaking a path, inserting a shunt resistor, measuring its voltage, and converting the voltage to current. Unfortunately, that approach is sometimes impractical with an oscilloscope because one side of an oscilloscope probe connects to ground. Thus, you need to isolate the oscilloscope from the circuit under test.

The circuit in the **figure** produces a voltage proportional to current and isolates the oscilloscope from the measurement point. The circuit uses IC_1, an HCPL7800 isolation amplifier, which adds input-to-output isolation of as much as 890 V. It also amplifies its input voltage by eight. The **table** shows the overall gain for each input range. The circuit's bandwidth is typically 100 kHz.

A set of switches lets you select a range of current to measure by inserting resistors into the circuit. Use resistors with 1% or less tolerance to minimize errors. For example, when you close S_4, you select the 100-μA range. The unknown current



This circuit produces a voltage proportional to current and isolates the oscilloscope from the measurement point.

Switch	Gain	Maximum input current
S_1	1 V / 100 mA	160 mA
S_2	1 V / 10 mA	16 mA
S_3	1 V / 1 mA	1.6 mA
S_4	1 V / 100 μA	160 μA

Gain for each input range.

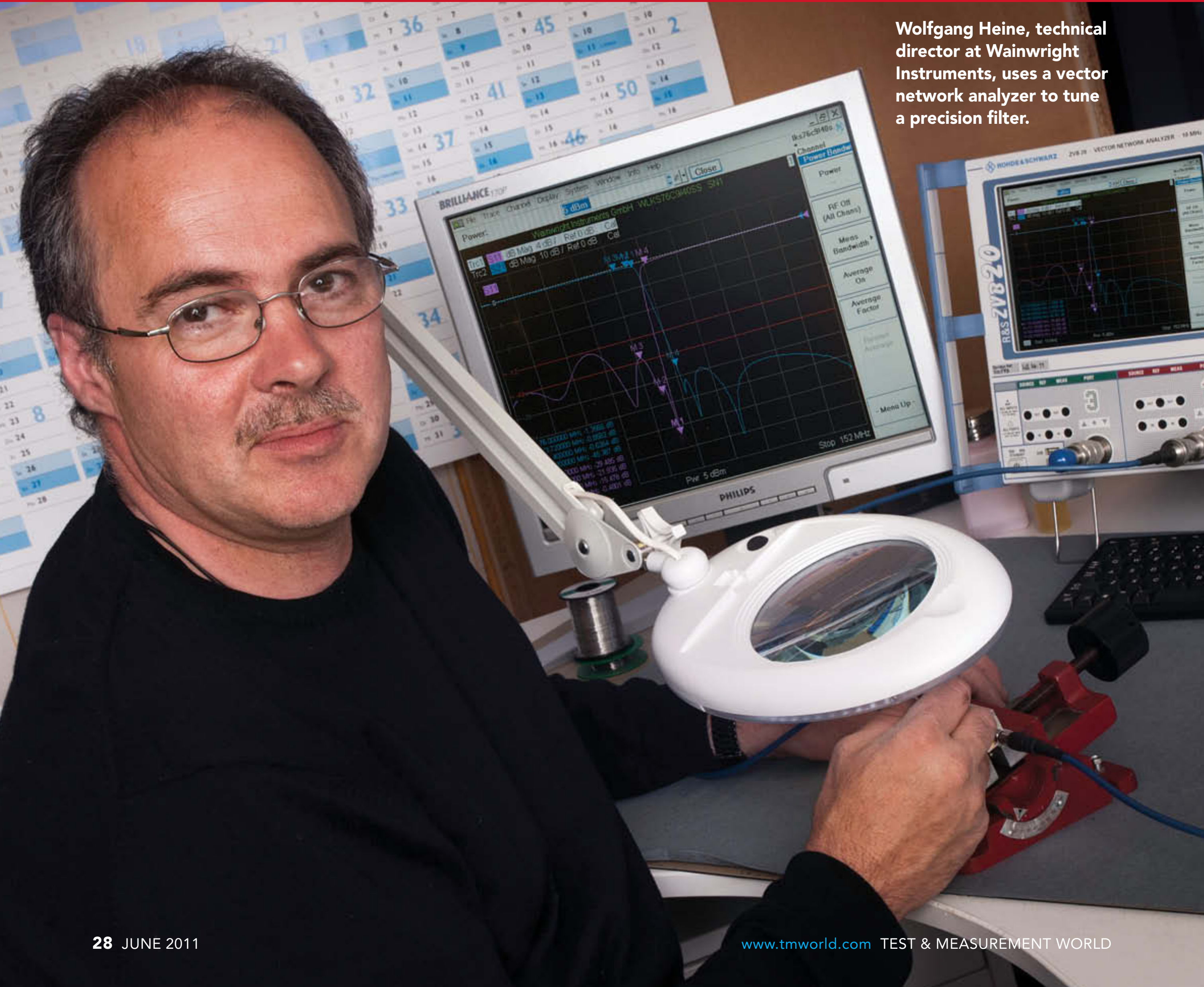
passes through serial resistors R_1 and R_2, which have values of 1 and 0.25 Ω, respectively. Thus, the voltage at IC_1's inputs is $I_{IN} \times 1.25$ kΩ; if the input current is 100 μA, the voltage at IC_1 is 125 mV. The circuit has a gain of eight, yielding 125 mV × 8, or 1 V. The LM358 acts as a unity-gain differential amplifier. For best linearity, the input voltage at IC_1 should not exceed ±200 mV.

The HCPL7800 has a 3% tolerance. When you are using resistors with 1% tolerance, the 3% tolerance dominates the overall uncertainty of the circuit. The circuit uses two independent voltage supplies. A 9-V battery supplies the input part of IC_1. A stabilized 9-V-to-11-V wall-wart power supply powers the output side of IC_1 with IC_2, an LM358 successive amplifier.

When battery switch S_5 closes and the voltage of the battery is sufficient for the circuit, LED_1 illuminates for approximately 3 s. The duration of this illumination minimizes drain on the battery. LED_2 is on when the 9-V-to-11-V power supply is operating. IC_5, an L272, provides an additional ground potential halfway between the supply voltage. With this split supply, you can measure both positive and negative currents. T&MW

This article originally appeared in the September 23, 2010, edition of EDN.

Precision measurements for precision filters



Wolfgang Heine, technical director at Wainwright Instruments, uses a vector network analyzer to tune a precision filter.

Wainwright Instruments employs vector network analyzers to tune its RF and microwave filters, diplexers, and multiplexers in real time.

BY RICK NELSON, EDITORIAL DIRECTOR

EUROPHOTO.US

ANDECHS–FRIEDING, GERMANY. If you are in the market for precision filters, you could consider the offerings of Wainwright Instruments. The company specializes in filters, offering a variety of low-pass, high-pass, band-pass, band-reject, notch, and diplex filters, including L/C filters, filters with helical and cavity designs, tunable filters, and filters for high-power applications. Wolfgang Heine, technical director, said Wainwright's filters find use in prototypes and in laboratories in a variety of application areas, mainly in telecommunications but also in automotive, medical, military, and aerospace (see "An abundance of filters," p. 31).

Wainwright Instruments focuses on quality, not quantity. Christel Wainwright, who until recently served as managing director, said Wainwright Instruments will make anywhere from one or two to a few thousand pieces. Christel Wainwright assumed management of the company after the death of her husband, Claire, but now Terry Wainwright, who studied international business rather than follow his father's path to electrical engineering, has taken over the management role after pursuing international business investment opportunities for 16 years in several Asian countries.

Christel Wainwright described the filter business as exciting but with many challenges. Building filters has an addictive quality, she said, in which you experience successes and failures very quickly. That, she said, is unlike designing a complete instrument, which may take months—after which you learn whether or not your product is successful or whether your competition got to market first. But the test challenges are no less daunting: "With regard to test protocol, what a company has to do for a big instrument, we have to do for every filter," Heine said.

The challenges involved in building filters range from economic and business ones to technical ones related to the design, manufacture, and test of the esoteric filters Wainwright Instruments offers. The company must, of course, comply with relevant standards and regulations: Wainwright Instruments is certified to ISO 9001 (for quality), OHSAS 18001 (for occupational health and safety), and ISO 14001 (for environmental management); all its products are manufactured in compliance with the RoHS directive. Other business challenges, Christel Wainwright said, include interpreting contracts from a worldwide base of customers. Furthermore, the strength of the euro presents difficulties. "This is a high-cost country," she said, compared with countries in Asia, for example, where workers are paid less, "so we have to be always on our toes and come up with something special" that companies in countries with lower costs can't make.

Wainwright Instruments' personnel perform the calculations and do the machining and adjustment necessary to build filters that meet customer requirements in a process that can take from minutes to days, depending on the filter complexity. Except for the silver plating and powder coating, all the steps in the manufacture of the filters can take place at the Wainwright Instruments factory, Heine said.

Heine emphasized that producing the filters requires careful machining as well as painstaking, precision hand tuning. He said one of his key employees is more like a watchmaker than a typical electronics technician. Heine added that a key challenge in producing Wainwright's line of products is to precisely tune the filters and see the results of that tuning in real time. To do that, the company deploys VNAs (vector network analyzers) ranging from 9 kHz to 40 GHz and including the Models ZVRE, ZVM, ZVK, and ZVB20 from Rohde & Schwarz.

(continued)

When you want to test a wide range of products, you need a versatile instrument, Heine said, adding that technicians need to see measurement results immediately when they build filters with 10, 20, or more resonators. They need quick measurement results when adjusting parameters such as pass band, reject band, and return loss. He pointed to a VNA screen as a technician made an adjustment to a filter under test: "As you can see, the instrument is very fast." The technician can make an adjustment and see the results immediately. Without that speed, Heine said, it would be nearly impossible to tune the filters in a reasonable amount of time.

American founds company

Wainwright Instruments is located in Andechs–Frieding, noted for the picturesque Andechs Abbey. But while American tourists might travel to Andechs to visit the abbey, the American electrical engineer and entrepreneur Claire Wainwright had business in mind when he moved there in 1972 to found Wainwright Instruments.

Terry and Christel Wainwright address the management challenges of producing precision filters while expanding and relocating their company. EUROPHOTO.US

On the occasion of Claire Wainwright's death in April 2007 at the age of 81, Jack Browne, writing in *Microwaves & RF* (Ref. 1), summarized Claire Wainwright's work history, which included training in electronics in the US Navy; studying electrical engineering at the University of Illinois at Champaign/Urbana; and serving a stint at P.R. Mallory in Indianapolis, IN, where he designed sweep generators and took an interest in filter design. He founded his own American firm, Telonic Industries (which made sweep generators) in Indiana and later Telonic Engineering (which made

Vector network analyzers

Unlike their scalar counterparts, VNAs (vector network analyzers) measure phase as well as amplitude, allowing users to fully characterize RF and microwave devices such as filters. A typical VNA includes an RF generator, receivers, and a test set (Ref. A). The test set routes incident waves to a DUT (device under test) and to a receiver reference channel, and it routes transmitted and reflected waves to receiver-measurement channels, thereby providing sufficient information for the instrument to derive S-parameters (Ref. B) for the DUT. An onboard computer handles tasks such as system error correction as well as embedding and de-embedding, and it can display measurement results in a Smith chart (Ref. C) or in other graphical formats.

VNAs are complex instruments, and using them correctly requires detailed understandings of topics such as measurement accuracy and calibration, random and systematic measurement errors, calibration standards and traceability, error models, and measurement uncertainty. Nevertheless, the instruments are powerful and flexible RF/microwave measurement tools, and they can make linear and nonlinear frequency-domain measurements as well as time-domain measurements.

A VNA example is the R&S ZVB, which Wainwright Instruments uses to tune its filters and generate the datasheet curves it sends to its customers. The ZVB offers frequency ranges from 300 kHz to 4 GHz, 8 GHz, 14 GHz, and 20 GHz; it comes with two or four test ports to support multiport and balanced measurements.

A key feature of the ZVB is high speed—measurement time is less than 4.5 ms for a 201-test-point frequency sweep, switching time between channels is less than 1 ms, switching time between instrument setups is less than 10 ms, and data transfer time is less than 0.7 ms for 201 test points. The instrument permits simultaneous measurement of more than one DUT.

The R&S ZVB20 vector network analyzer, which Wainwright Instruments uses to tune its filters and generate the datasheet curves it sends to its customers, comes with two or four test ports to support multiport and balanced measurements. Courtesy of Rohde & Schwarz.

Rick Nelson

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filters) in California. It was on a business trip to Germany on behalf of Telonic that he met Christel, whom he would marry and with whom he would move permanently to Andechs.

Christel Wainwright said that to her knowledge, Telonic was the first company to offer filters as separate products and to customer specifications. Previously, filters were part of larger circuits or products, such as the sweep generators from Telonic. "It was practically impossible to purchase a filter in those days or even specify one," she said, adding that after Claire Wainwright realized he could not find anyone who would sell him a band-pass filter, he recognized an opportunity, leading him to found Telonic Engineering. In one key innovation, he provided a clear, concise method of allowing customers to specify filters—a method that can be found in most filter catalogs to this day.

An abundance of filters

Wainwright Instruments offers standard filters whose guaranteed specs you can find in the many datasheets posted on the company Website (www.wainwright-filters.com).

The company offers low-pass Chebyshev filters with cutoff frequencies to 16 GHz, low-pass Cauer filters with cutoff frequencies to 1 GHz, high-pass Chebyshev filters with cutoff frequencies to 10 GHz and with an upper pass band to 26.5 GHz, high-pass Cauer filters with cutoff frequencies to 1 GHz, narrow and wide L/C band-pass filters, and very wide high-pass/low-pass combinations. The company also offers a variety of cavity-design fixed frequency and tunable band reject and notch filters as well as wide and narrow band-pass filters—fixed and tunable. Also available are diplex/duplex-filters and multiplexers in L/C and cavity designs, including band-pass/reject diplexers.

Wainwright Instruments will also develop filters to meet a customer's requirements. Using an online form, you can specify parameters such as pass-band upper and lower frequencies, pass-band loss, return loss, VSWR, reject-band frequencies, reject-band attenuation, and storage and operating temperatures. You can also specify power-handling requirements, mounting provisions, and the types of connectors you want, and the company will try to accommodate any dimensional restrictions you may have. —*Rick Nelson*

Attracting skilled employees

The technical challenges that Wainwright Instruments faces include attracting skilled employees. "We need people who are neither fish nor meat," who have the skill sets of mechanics and electrical engineering, Christel Wainwright said. "There are no integrated circuits or transistors here," she added, and prospective employees trained in electrical engineering might feel out of place.

The present filter-building and customer-service teams, she said, consist of experienced employees who have been with Wainwright for 10 or even 25 years, and she added that several talented new technicians are being trained to enable the company to expand.

To compete with larger prospective employers, Wainwright Instruments has been flexible and innovative in providing a good place to work—establishing a 36-hour work week spread over four days, for example. Christel Wainwright emphasized, however, that customers can contact the office every business day.

Of course, the employees, too, need to be adaptable. "Sometimes a customer will place an order for a lot of filters, keeping the staff working Fridays and Saturdays, only to suddenly not need so many filters," she said. That customer, she said, has always been replaced by another, and the company tries to maintain sufficient flexibility to meet shifting demand. In general, business is good, she said, with the company having posted a record year in 2010. The company is looking to expand and is in the process of building a new facility a few kilometers away.

Wainwright Instruments doesn't employ a sales force or make use of distributors. The Website is the company's primary selling tool, where each datasheet lists full price information, in euros. The company used to provide US dollar prices as well, including import/export fees, but found it became impractical to update the datasheets as currency-exchange rates fluctuate. US customers may pay in euros and assume import and freight charges themselves, or they can ask for a quote in US dollars.

"The Internet changed everything," Christel Wainwright said, adding that previously, the company spent a considerable amount of money printing catalogs that would likely be out of date by the time they reached their worldwide destinations. "Now, we don't print anything." She added, "By selling to the user directly, our service department keeps close contact to the customer's engineers and helps them identify and solve their filter problems, even if they need only one filter."

The challenge of RF engineering

Good RF engineers who can design and build filters are hard to find. Explained Heine, "You can never learn all you need to know at school. You need a mentor—someone who works with filters all the time and can show you all the tricks. That's the only way to learn it."

Filter-design software has its place, he said, but the software is limited, and an accomplished filter designer must "understand what is actually happening in the metalwork and what effect his physical manipulations have on filter performance. What will happen if you bend a wire like this or like that," he said, trying out a few configurations on a sample filter. Beginners must not only learn how to use complex instruments like VNAs, they must also learn the basics through experience: "Don't touch the silver plating, don't over-torque the screws, handle the connectors with care, etc., etc.," Heine said, concluding that when building filters, "It's important to be very, very careful, because with RF devices, any small thing you do can affect performance." T&MW

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Prepare signals for microcontroller ADCs

BY SEAN NEWTON AND ALEC BATH, STMICROELECTRONICS

Microcontrollers contain ADCs so all you need is signal conditioning to digitize analog voltages.

Many microcontrollers have built-in ADCs (analog-to-digital converters), which means you can use a single device to both digitize analog signals and manipulate the results. Once the ADC digitizes a signal, you can take advantage of the microcontroller's I/O lines to analyze the data, sound an alarm, or control the measured quantity.

For most applications, you must condition the voltages to bring them within the ADC's input-voltage range. Signal conditioners range from simple resistor-divider networks to amplifiers and filters. You'll also have to plan for signal frequency and sampling rates when using an ADC. For AC signals above the audio range, you may need a microcontroller that contains an SAR (successive-approximation register) ADC, which can sample at rates of 1 Msample/s (see "Inside an SAR-type ADC," p. 35).

Preparing the signals

Before connecting an analog signal to a microcontroller, you must take into account the input-voltage range of the ADC. Consider an STM32 microcontroller as an example. The microcontroller has power pins specifically for the V_{DDA} and V_{SSA} of its ADC, where V_{DDA} is the positive supply. The ADC's input-voltage range is between 0 V and V_{REF+}, where V_{REF+} can be the same as or lower than V_{DDA}, but not lower than 2.4 V. If V_{REF+} is equal to V_{DDA}, then V_{REF+} can go up to the maximum value of V_{DDA}, which is 3.6 V.

The ADC has 12-bit resolution, which provides 4096 counts: 0 to 4095 decimal or 0x000 to 0xFFF hex. Because V_{REF+} ranges from 2.4 V to 3.6 V, it will govern the

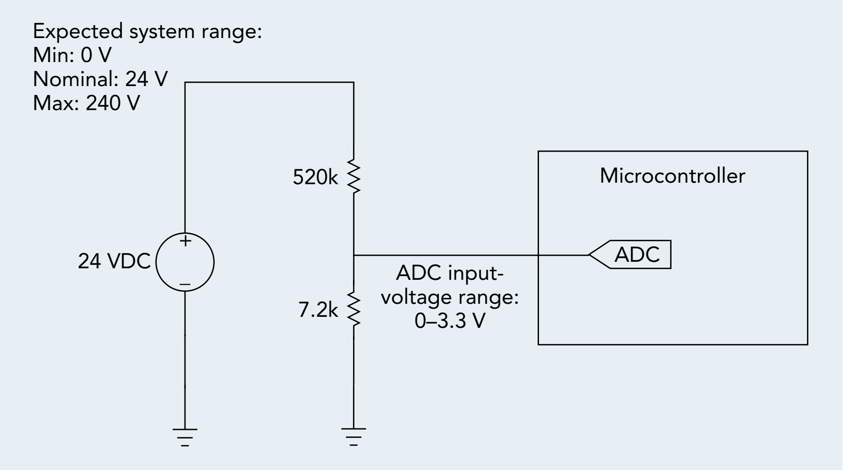


FIGURE 1. A resistive voltage divider may be all you need to condition a voltage to within an ADC's input range.

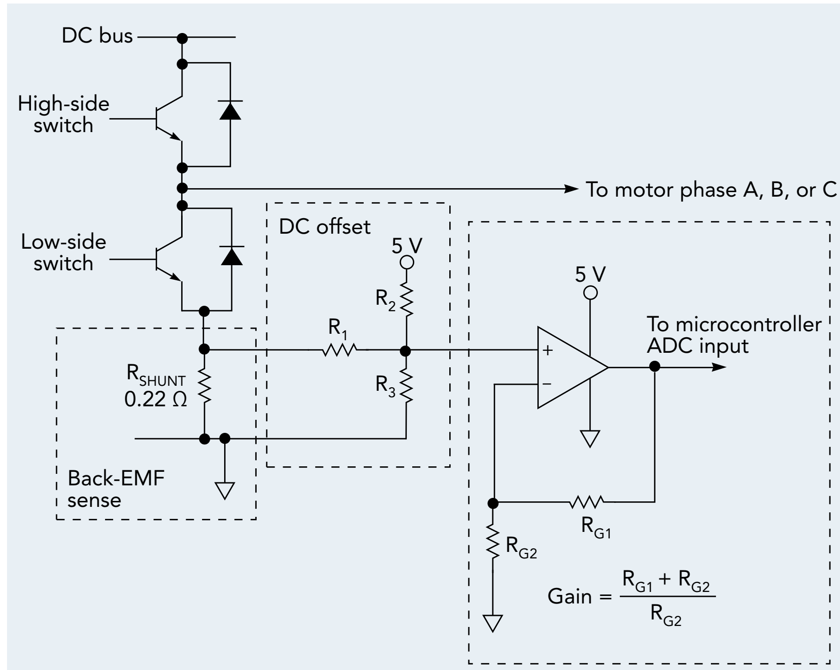


FIGURE 2. Shunt resistors in series with motor windings provide voltages that you can amplify and measure with an ADC.

volts/bits ratio of the ADC. **Table 1** shows the voltage-per-bit for several values of V_{REF+}.

The microvolts/bits ratio is important because you can get finer resolution as you decrease the value of V_{REF+}. Once the ADC input voltage is in digital form, you can use a software look-up table or an equation to convert the raw bit count to volts. Then, you can use another conversion routine to convert volts into your desired unit of measure, such as degrees Celsius.

Assume that you have a temperature sensor with a range 0 V to 2.4 V where the output is linearly proportional from –20°C to 200°C. In that case, an ADC count of 0 represents –20°C and an ADC count of 4095 represents 200°C if V_{REF+} equals 2.4 V. Once you know the volts/bits ratio, you can design signal-conditioning circuits that convert the analog-input signal to the appropriate input-voltage range for the ADC.

Two examples help illustrate how you can design a signal-conditioning circuit. For the first example, suppose you need to monitor a DC bus voltage using a microcontroller's ADC input. During normal operation, the bus voltage is fixed at 24 VDC. For this example, the ADC will accept a maximum input voltage of 3.3 V. The signal-conditioning circuit need be only a simple voltage divider (**Figure 1**).

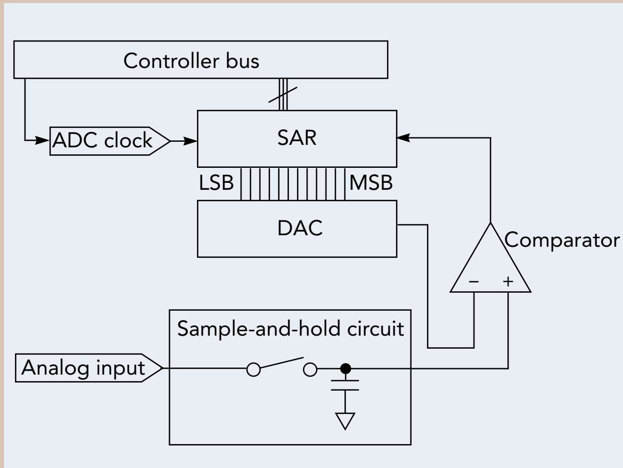
To protect against an overvoltage condition, the design requires you to set the maximum peak bus voltage threshold to 10 times the desired bus voltage, or 240 V. A resistor divider with a 520k resistor and a 7.2k resistor will give a maximum analog input voltage of 3.3 V when the DC bus voltage is 244 V. At 24 V, the analog input voltage will be 328 mV, which is 407 counts in this application. A conversion algorithm or look-up table can convert the digital count into volts for display or other action.

For the second example, imagine you have an AC-measurement application that requires you to sense the rotor position in a three-phase PMSM (permanent-magnet synchronous motor). The motor uses a permanent magnet in the rotor, and it uses digital commutation instead of brushes and copper-commutator segments.

You can find the rotor position using sense resistors in one or more of the three motor windings, from which you can calculate the commutation angle and motor speed. **Figure 2** shows that you can add the sense resis-

Inside an SAR-type ADC

An SAR (successive-approximation register) ADC provides relatively high-speed sampling with enough resolution for many measurement applications. A typical SAR-type ADC consists of a successive-approximation register, a DAC (digital-to-analog converter), a comparator, and a sample-and-hold circuit (see **figure**). The comparator, sample-and-hold circuit, and the output of the DAC contain the analog parts of the ADC, while the SAR and the digital input of the DAC contain the digital parts of the circuit.



An SAR-type ADC consists of a successive-approximation register, a sample-and-hold circuit, a comparator, and a DAC.

The sample-and-hold circuit samples the analog input signal for a defined period, called the sample time. At the end of the sample time, the analog input signal disconnects from the sample circuit and the capture voltage is held for conversion.

The SAR starts by setting the MSB (most-significant bit) of the DAC to 1, driving the DAC to $V_{REF}/2$. The output of the DAC drives the comparator, whose result is a digital 0 or 1 depending upon whether the analog input voltage is greater than or less than the DAC output voltage. If the analog input voltage is less than the DAC output voltage, the current bit is reset and stored in the ADC's end-of-conversion register.

For each successive ADC clock pulse, the next bit of the SAR is set and compared against the analog input voltage. The comparator sets its output high or low depending on the results of the comparison. The process continues until the comparator samples the LSB (least-significant bit) and the complete digital value is stored in the end-of-conversion register. Upon completion, the ADC typically triggers an event to signal that the conversion is complete.

The ADC contains digital and analog portions that separate into two domains: the analog domain, which is powered by the voltage differential between V_{DDA} and V_{SSA}, and the digital domain, which is powered by the voltage between V_{DD} and V_{SS}. Separating the digital and analog power supplies provides isolation and helps reduce switching noise induced by the digital side of the circuit. Along with a separate analog power-supply voltage, an external analog-reference voltage (V_{REF+} and V_{REF-}) is available that lets you adjust the input-voltage scale.—*Sean Newton and Alec Bath*

tors between the low-side switch and ground.

When the motor's phase is inactive, you can measure the back-EMF (electromotive force) with an ADC. You need three of these circuits to make the three-phase measurement.

To make the PMSM measurement, you need a simultaneous-sampling ADC because you need to measure all three motor-winding voltages at once. The sense resistor typically has a value of less than 1 Ω. Thus, windings develop only small voltages, and you'll likely need an op amp to boost the voltage to around 3.3 V (or perhaps slightly less).

Setting the sample rate and input resistance

Once you've conditioned the ADC's input voltage to the proper levels, you must set the ADC's sample rate. The ADC on an STM32 microcontroller, for example, can sample at rates up to 1 Msample/s. You must take into account the measured signal's analog characteristics to find the best sample rate. Slow-changing signals such as temperature and pressure don't need a high sample rate; sample rates of 1 s to several minutes may be sufficient. Fast-changing signals, however, need higher sample rates.

At 1 Msample/s, a signal's highest frequency component must be less than 500 kHz to meet the Nyquist criteria. Otherwise, aliasing will produce unwanted artifacts. For an accurate signal representation, you should use a sample rate that's 10 times the measured signal's highest frequency, which could limit your signal to 100 kHz. Audio applications fit nicely within this limitation. Ultrasonic applications, though, could soon overrun the ADC's sampling ability, resulting in poor digital-signal definition.

The ADC's input impedance relative to that of the signal source is also important because it can limit the ADC's maximum sample rate. Capacitance associated with the internal ADC circuitry of the microcontroller, combined with the resistance to the incoming signal source, forms a low-pass filter. The filter's RC time constant affects the time needed for the signal to stabilize before the ADC can sample it. If the signal changes rapidly over time, the low-pass filter can distort a signal and thus its digital equivalent.

You can compensate for high source resistance by adjusting the ADC's sample rate. A slower sample rate provides more time for a signal to settle, if you don't sample too slowly and produce aliasing. **Table 2** shows the relationship between the sample time and the signal-source input resistance for an STM32.

Table 1. Voltage weights per bit of a 12-bit ADC.

V_{REF+}	μV/bit
2.4	586
2.6	635
2.8	684
3.0	732
3.3	806
3.6	879

Table 2. Sample time increases with source resistance.

Signal source resistance (kΩ)	Sample time (μs)
0.4	0.11
5.9	0.54
11.4	0.96
25.2	2.04
37.2	2.96
50	3.96

You must also consider other ADC parameters such as accuracy, linearity, and resolution before connecting an analog circuit to a microcontroller. But a basic understanding of the ADC's voltage input range, sampling frequency, and input-resistance requirements can get you started connecting analog circuits to a microcontroller's ADC.

Handling the data

After a microcontroller's ADC digitizes analog signals, what do you do with the data? Depending on the sample rate and processing speed of the microcontroller, you may be able to process and act upon the data in real time. For example, you can use software to process the data using digital filters, or you can operate control loops with the microcontroller's digital I/O lines.

Most 32-bit microcontrollers include a DMA (direct-memory access) controller, which lets you move data directly into system memory. A DMA controller can relieve the microcontroller's CPU core from transferring data into memory, which increases performance.

In its simplest form, a DMA controller consists of three parts: a memory source, a memory destination, and a trigger. The ADC's data register is usually the memory source. An array of data in the microcontroller's RAM is the destination, and the ADC's conversion-complete flag is the trigger. Because you usually want to capture a large number of samples without overwriting any data in memory, you need to increment a data-array pointer for each new DMA transfer. You can configure either the source or destination memory locations for auto-increment with the STM32. Other DMA options may include the ability to move different data types, such as bytes, 16-bit half-words, or 32-bit words into memory.

Microcontrollers may have several communications peripherals. Traditional communications ports include I^2C, SPI, and USART (RS-232). Advanced communications ports include CAN, USB, and Ethernet. Communications ports let you move data to networked devices or to a local PC.

Microcontrollers also contain storage memory (typically 32 kbytes to 512 kbytes) of flash and EEPROM. If you need more storage, you can connect the microcontroller to an SD (secure digital) memory card that you can easily remove or replace. External memory controllers provide access to large amounts of flash memory. Through a USB port, you can connect to a flash drive or hard drive and store your data for analysis. T&MW

Sean Newton *is a field applications engineer in STMicroelectronics' marketing organization supporting microcontrollers. He has worked at the company since 2001 supporting microcontrollers, microprocessor units, and smart card products. Prior to ST, Newton worked in several manufacturing facilities with Electronic Data Systems. He graduated with a degree in electrical engineering and computer science from the University of Nevada, Reno.*

Alec Bath *is a field applications engineer in the microcontroller division of STMicroelectronics. He has worked at ST since 2000 supporting microcontroller and memory products. Prior to ST, Bath worked for Motorola. As an avid adventure racer and ultra marathoner, he has been tinkering with home-brew microcontroller-controlled LED headlamp systems.*


LeCroy
Beyond the Limits

T&MW announces award

BY *TEST & MEASUREMENT WORLD* STAFF

ON MAY 4, during a ceremony held in conjunction with the Embedded Systems Conference Silicon Valley (May 2–5, San Jose, CA), the staff of *Test & Measurement World* announced the winners of the 2011 Best in Test and Test of Time awards, which honor important and innovative products and services in the electronics test, measurement, and inspection industry.

In our December/January issue, we announced the finalists in 16 categories for the 2011 Best in Test awards and asked our readers and editors to vote for their favorites. The 2011 Best in Test winner in each category is listed below. Of these, the overall top vote getter was named the 2011 Test Product of the Year: This year's winner is the V93000 HSM3G Production Test System from Verigy.

For the annual Test of Time award, which honors a product that continues to provide state-of-the-art service five or more years after its introduction, we named 10 finalists in our December/January issue. The winner of the 2011 award, chosen by a vote of our readers and editors, is Agilent Technologies' Model 3070/i3070 In-Circuit Tester.

Also during the ceremony, we presented the 2011 Test Engineer of the Year award to Henry Huang, a technical specialist and supervisor for the SYNC platform QA group at Ford Motor Co. in Dearborn, MI. We first announced Huang as the winner in our May issue (see "Always a car guy," *T&MW,* May 2011, p. 26).

For more information about the *Test & Measurement World* awards program and to read about all of the finalists and winners, see www.tmworld.com/awards.

2011 Best in Test Award Winners

ATE/production test
Neptune 2 Automated Drive-Test System
Teradyne

Bus analyzers
TLA7SAxx Series Logic Protocol Analyzer
Tektronix

Compliance/environmental test
ONYX Electrostatic Discharge Simulator
Haefely EMC

Data acquisition
ProDAQ 3416 Analog Input Module
Bustec

Design for test and boundary scan
TIC020 TAP Interface Card
Goepel Electronic

Instruments, handheld and bench
PocketPico Picoammeter
Ix Innovations

Instruments, modular
M9018A PXI 18-Slot Chassis
Agilent Technologies

Machine vision and inspection
TOM In-Line Optical Inspection System
Goepel Electronic

Network and fiber-optic testers
TestCenter for Mobile Backhaul
Spirent Communications

Network test software
TestShell 4.3
QualiSystems

Oscilloscopes
WaveMaster 8 Zi-A
LeCroy

RF/microwave test
M9392A PXI Microwave Vector Signal Analyzer
Agilent Technologies

Semiconductor test
V93000 HSM3G Production Test System
Verigy

Signal sources
WaveXciter Series Arbitrary Waveform Generators
Tabor Electronics

Wafer probing
V93000 Direct-Probe Solution
Verigy

Wireless test
Field-to-Lab Solution
Azimuth Systems

The recipients of *T&MW*'s annual awards gathered with editorial director Rick Nelson (front row, without plaque) for a group photo at the conclusion of the awards ceremony.

WINNERS for 2011

2011 TEST PRODUCT OF THE YEAR AWARD WINNER

TEST PRODUCT OF THE YEAR

V93000 HSM3G
Production Test System
Verigy

The Verigy V93000 HSM3G is designed for low-cost volume production test of DDR3, DDR4, and beyond. The production tester performs accurate at-speed testing and is scalable to 2.9 Gbps. Verigy says that a multigeneration growth path via economical upgrades up to a data rate of 6.8 Gbps provides an outstanding return on investment. Due to its memory-ATE (automatic test equipment) per-pin architecture, the V93000 HSM3G can provide test-time savings of up to 20%. It delivers fully parallel pattern execution, fully parallel DC tests, and eye-width measurements, which provide high multisite efficiency.

The V93000 HSM3G achieves a native 2.9-Gbps data rate and true 256-site DDR3 parallel testing over the entire speed range without test-time overhead or compromises to accuracy, functionality, test coverage, and yield. Due to its native speed head room, the HSM3G addresses all mainstream DDR3 speed bins as well as high-end gamer DDR3 and the first two DDR4 volume speed grades.

2011 TEST OF TIME AWARD WINNER

TEST OF TIME

Model 3070/i3070
In-Circuit Tester
Agilent Technologies

When it was launched in 2001, Agilent Technologies' PC-based 3070 made a significant splash in the ICT (in-circuit test) market. Working to conserve the customer's capital investment while driving continuous technology innovations, Agilent has continued to introduce major software capabilities and hardware improvements that customers can add to the system to improve test throughput and coverage, even on sophisticated PCBAs (printed-circuit-board assemblies) that offer limited access for conventional ICT methods.

Among the significant enhancements are throughput improvements of 30% or more from the i3070 Series 3 to Series 5, as evidenced by customer-validated data. In addition, Agilent has added options such as a utility card that supports in-system flash programming, boundary-scan testing, and LED testing.

The latest series of the Agilent Medalist i3070 ICT system offers test coverage for some of the most challenging PCBAs, incorporating limited-access test capabilities to help manufacturers test the electrical integrity of their board components even as test access is drastically reduced. Limited-access test features for the i3070 include VTEP and Cover-Extend. VTEP is a vectorless test technique that employs a sensor that is able to capacitively pick up signals from components or connectors under test in response to stimulus delivered via a test probe. Cover-Extend technology is a hybrid combination of VTEP and boundary scan in which stimulus signals are delivered via the boundary-scan Test Access Port.

Several USB instruments in one

The USBee RX electronic test pod combines an oscilloscope, a logic analyzer, a protocol analyzer, a signal generator, and a frequency counter in a single module. The two-channel scope has 10-bit resolution and samples at up to 100 Msamples/s. It can store up to 512 Mbytes of data in its internal buffers, which results in up to 16 Msamples of waveform data. The two scope channels also work as voltmeters with a range up to ±6 V (±60 V with 10X probes).

The module has 18 logic channels with 60-V protection, and it offers eight digital outputs that you can use as a digital pattern generator. Logic inputs can detect signals at 1.2-V, 1.8-V, 2.5-V, 3.3-V, and 5-V logic levels. Digital outputs operate at 3.3-V levels. As a protocol analyzer, the module can decode I^2C, SPI, Async, USB Full and Low Speed, CAN, SDIO, 1-Wire, SM Bus, I^2S, and custom bus signals though an application-programming interface. A seven-layer protocol decoder covers the entire protocol stack, from physical layer to application layer.

The test pod's analog signal generator can produce sine, square, ramp, triangle, and square-wave signals up to 8 MHz at voltages up to 3 V. When generating digital signals, the unit has 8-bit output at rates up to 100 MHz using 65,536 user-definable patterns. The USBee RX comes with PC software.

Price: $2245. *CWAV, www.usbee.com.*

Test for voltage dips

Teseq's VAR 3005 power supply, which has electrical performance parameters that are in compliance with IEC 61000-4-11:2004, offers two power sources that power equipment at voltages from 85 VAC to 265 VAC with current up to 16 A. The VAR 3005 works in conjunction with Teseq's NSG 3000 series of EMI testers, whose user interface controls the power-supply voltages. The company's WIN 3000 PC software also controls the power-supply voltages from a PC.

During a test, one power supply operates at a fixed output voltage while the other varies, thus supplying the equipment under test with voltage dips and rises. In accordance with IEC/EN 61000-4-11, the VAR 3005 uses variac-type AC power supplies, driven by motors, to change output voltages. Switches connect power from the VAR 3005 to the equipment under test under software control, or you can use manual switches without the need for software.

Base price: $4900. *Teseq, www.teseq.com.*

Ametek launches programmable power supplies

Ametek Programmable Power has introduced new members of its Sorensen DC programmable power supplies as well as a new California Instruments series of high-power AC/DC power systems. The Sorensen XG 1500 (pictured) is a 1500-W programmable DC power supply designed for ATE, burn-in, and R&D applications. Different versions offer output voltages ranging from 8 V (at 187.5-A maximum output current) to 600 V (at 2.5-A maximum output current). Units can be connected in parallel or series to provide higher currents or voltages.

You can control the Sorensen XG 1500 through front-panel controls, a standard USB interface, or optional LXI and isolated programmable analog interfaces. An internal sequencing function permits output-level programming at rates to 1000 steps per second.

Other features include DUT protection and auxiliary low-power, fixed-voltage DC outputs, which can power relays or other accessories. Green features include a sleep mode and variable fan-speed control, in which fan speed is proportional to the supply's internal temperature.

Ametek has also expanded its Sorensen SG Series of programmable precision high-power DC power supplies with four new output voltage offerings of 10 VDC, 15 VDC, 20 VDC, and 30 VDC to add to its current range of 40 VDC to 800 VDC. These lower-voltage units have output power specifications ranging from 4 kW to 15 kW. The 20-VDC model, for example, can supply up to 750 A in the standard 3U package, while the 10-VDC, 12-kW unit can deliver up to 1200 A in the same 3U form factor.

Finally, the company has introduced the California Instruments RS Series high-power AC/DC power systems. These units provide controlled AC and DC output for product-test applications. In AC mode, the RS Series delivers from 90 kVA up to 540 kVA of AC power. In DC or AC+DC mode, 50% percent of the AC power level is available simultaneously.

The RS Series units can make measurements as well as provide power. A DSP-based data-acquisition system digitizes voltage and current waveforms in real time. Users can trigger waveform acquisitions at any point in the waveform output, such as a specific phase angle, to allow precise positioning of the captured waveform with respect to the AC source output. With an output frequency range of up to 1000 Hz, the RS systems can serve aerospace applications, and they come with a full suite of avionics-stimulus test routines.

Ametek Programmable Power, www.programmable-power.com.

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MACHINE-VISION&INSPECTION

TEST REPORT

When vision is the best choice

By Ann R. Thryft, Contributing Technical Editor

When test and manufacturing engineers need to collect inspection information on the factory floor, they can choose from a variety of sensing options for capturing the data. Although vision sensing can be harder to use than most other types, it provides the most information, said Dan Holste, director of engineering for Banner Engineering.

Q: Besides vision, what sensing technologies are used in electronics inspection?
A: A typical photoelectric sensor is a point device. It detects the presence or absence of an object in a single beam of light, so it's very limited in nature. A fixed-field photoelectric sensor not only detects presence or absence, but also determines distance. Capacitive sensors can sense the presence of a nearby object by changes in capacitance value. Magnetic sensing works in a similar way by detecting changes in the magnetic field caused by another object. Both capacitive and magnetic sensors can detect presence or absence within a certain range, but their sensing ability is somewhat limited.

INSIDE THIS REPORT

Each of these technologies is best applied in certain environments. For example, a magnetic or capacitive field must be present for either of those technologies to work. In wet environments, you wouldn't want to use point photoelectric sensors, vision sensing, or capacitive sensing, but magnetics work great there as long as the surfaces are magnetic.

Q: How does vision sensing give more information?
A: Vision sensing involves a lot of single-point sensors, or pixels, arranged in rows and columns. In today's digital cameras, there are millions of pixels. With that many point sensors aimed at an object, you can determine things you can't otherwise, such as the texture of a finish, or an object's shape, contour, height, and even color. Vision sensing gives you much more information than the other sensing technologies.

In machine vision, lensing and lighting options are key variables. In fact, lighting is typically at least 90% of the equation. The most important factor is contrast: It's critical that you illuminate the objects in a manner that highlights the features of interest. A good image doesn't necessarily mean one that is pleasing to the eye. For instance, you may purposely underexpose or overexpose an object if it brings out the characteristics you want to examine.

Q: What makes vision harder to use?
A: The hardest thing about using vision isn't writing the algorithms for image analysis; in fact, that's the easiest part. The real trick, and what spells success or failure the vast majority of the time, is getting a good image. That's an art as much as a science. If you don't get a good image, you can't do a good analysis on it. There are some things you can do to enhance an image, but they're limited.

Dan Holste
Director of Engineering
Banner Engineering

Vision's advantages all come at the price of increased complexity and the need to understand the application in detail. The skill levels required for this are much higher. So, it's best to try all the other, simpler techniques before you apply vision. I would first perform an analysis of which technologies are possible for solving my inspection application, install and prototype them, and then determine whether each one will work. If those fail, then I would turn to vision. □

EDITOR'S NOTE

Too many camera interfaces?

By Ann R. Thryft
Contributing Technical Editor

Camera interfaces are in the news a lot these days. In March, the coax cable-based CoaXPress specification and Camera Link 2.0 were both approved by their respective standards bodies.

Camera Link 2.0 pulls together a handful of changes: mini-Camera Link connectors, the PoCL (Power over Camera Link) and PoCL Lite interfaces, and the Camera Link Appendix D cable specification. Meanwhile, the AIA (Automated Imaging Association) continues to work on the next-generation Camera Link HS standard, which will not be backward-compatible with Camera Link.

One might think that the more camera interface choices, the better. But there are more standards now for camera and frame grabber vendors to choose among—and spend R&D dollars on—than there have been since the beginning of machine vision: Camera Link, GigE Vision, CoaXPress, and in the near future, Camera Link HS. At least for frame-grabber development, this can be a burden for some vendors, and potentially confusing for users (p. 46).

In some very good news, the AIA reported in April that the sales of machine-vision components and systems in North America last year rose 54%, and that a majority of companies submitting data expect even better sales during the first half of 2011. □

Contact Ann R. Thryft at athryft@earthlink.net.

HIGHLIGHTS

EDT launches PCIe Camera Link boards

The DVa series of Camera Link boards from EDT (Engineering Design Team) includes PCIe x4 and x8 frame grabbers as well as a PCIe x8 simulator. The series also introduces a PCIe x4 frame grabber with fiber-optic input. EDT says the boards feature improved performance, PoCL operation, and optional memory.

The new PCIe DVa Fox fiber-optic frame grabber works with EDT's RCX C-Link remote camera extender, which the company claims shatters the Camera Link distance barrier, allowing up to 10 km of distance between the camera and the host computer. The PCIe4 DVa C-Link four-lane frame grabber and the PCIe8 DVa C-Link eight-lane frame grabber can be used as drop-in replacements for the company's DV series boards, which are being phased out of production.

The PCIe8 DVa CLS eight-lane simulator board generates simulated image data. The board, which is also a drop-in replacement for a DV series board, uses an easily modified text-based configuration script that describes the timing parameters of the camera to be simulated.

All of the boards in the DVa series come with a software-development kit and a common application-programming interface. www.edt.com.

Rudolph updates 3-D inspection system

The Wafer Scanner 3880 system from Rudolph Technologies, which replaces the company's 3840 system, provides 3-D and 2-D measurement and inspection of micro and standard bumps, TSV (through-silicon-via) nails, and RDLs (redistribution layers) used in 3-D IC packaging. Rudolph says the 3880 is ideal for high-volume manufacturing, where it can perform either random or 100% inspection.

According to Reza Asgari, Wafer Scanner product manager, "Ultra-high resolution allows the Wafer Scanner to accurately characterize small features, such as micro bumps and TSV nails, which manufacturers are using to achieve unprecedented connection densities between chips, while still preserving the flexibility to handle standard bumps and other larger features." www.rudolphtech.com.

Ultra-compact cameras reach 2 Mpixels

Expanding its Flea3 family of IEEE 1394b digital cameras, Point Grey Research has added monochrome and color models that deliver a resolution of 2.0 Mpixels. These compact 29x29x30-mm cameras offer optoisolated GPIO for industrial triggering and strobe output, 1 Mbyte of nonvolatile flash memory for user data storage, and a 32-Mbyte frame buffer.

The FL3-FW-20S4 camera is based on monochrome and color versions of the Sony ICX274 1/1.8-in. Super HAD CCD. This progressive-scan sensor runs at 15 fps and provides a resolution of 1624x1224 pixels. Like other members in the Flea3 family, the camera is equipped with a C-mount lens holder, removable optical window, and a 12-bit ADC. Additional features include automatic control of most camera properties, such as gain, exposure, and white balance; user configuration sets for defining custom power-up settings; a gamma and programmable look-up table; customizable region-of-interest settings; and pixel binning.

All Flea3 cameras comply with the IIDC V1.32 specification, which allows the use of third-party software packages. Cameras come with the FlyCapture software-development kit, which is an image-acquisition and camera-control library that provides a common interface to control Point Grey digital imaging products under both Windows and Linux. www.ptgrey.com.

Sensor holds promise for machine vision

By Ann R. Thryft, Contributing Technical Editor

An image-sensor technology targeted at consumer camera phones has characteristics that may prove beneficial for machine-vision cameras. Invented by InVisage, the QuantumFilm technology offers an adjustable bandgap as well as greater sensitivity to light and a wider dynamic range than CMOS image sensors. An associated technology, QuantumShutter, eliminates rolling shutter.

The InVisage technology is a new class of semiconductor material based on nanometer-sized quantum dots applied as the top layer on a standard CMOS wafer. "The first major problem with silicon sensors is the fact that the top layer of each pixel is usually metal, which light rays have difficulty penetrating. This can bring down pixel fill factor by up to 50% with decreasing pixel size," said Michael Hepp, InVisage's director of marketing. "The second major problem with silicon is its quantum efficiency, or electrical sensitivity to light, which is generally 40 to 60%." Because a regular, FSI (front-side illumination) CMOS sensor pixel's photodiodes are buried in silicon under layers of metal, about 50% of light is lost before it can be detected by the photodiodes.

"The quantum efficiency of our material is 80 to 90%, almost double that of silicon," said Hepp. "Moving the photodiodes to the top layer of film nearly doubles that efficiency again by exposing all of the chip's top layer, covered with our film, to light, thus allowing 100% pixel coverage."

The use of BSI (backside illumination) in standard CMOS image sensors has dramatically improved the fill factor problem, but BSI doesn't improve quantum efficiency, and it costs more because it requires more steps, said Hepp. QuantumFilm can make use of a foundry's lower-cost wafers made with older processes, since it can be painted on top of the sensor and requires no special or advanced manufacturing techniques.

Hepp said that the QuantumFilm sensors designed for camera phones will have a 1.4-micron pixel size, and next-generation devices are planned at 1.1 micron. In a traditional pixel, the "well" that stores data collected by the photodiode is inside the silicon. The bigger the well, the wider the dynamic range of every pixel. "As you make the pixel smaller, that well size also gets smaller, since it's a capacitor," Hepp said. "We can have a much larger well. . . since we're not putting the photodiodes there. In a 1.4-micron pixel, we can achieve a 12,000-electron well, compared to a 4000- to 5000-electron well in a standard CMOS image sensor at that pixel size, thus increasing dynamic range."

Because quantum dots are extremely small, their size can be changed to adjust the film's bandgap, thus tuning or optimizing the sensor to specific wavelengths, said Hepp. "For visible light, the quantum dots are under 5 nm in diameter when packed together," he said. "A larger diameter, such as more than 5 nm, lets you optimize the sensor for NIR [near infrared] and SWIR [short-wave infrared] wavelengths. SWIR and NIR sensors, however, are usually more expensive because they're currently made from gallium arsenide."

A key sensor feature needed for inspection applications is a global shutter, which requires a storage node, said Hepp. A traditional CMOS sensor doesn't have memory, but reads out data right away after receiving it. A global shutter puts a storage node inside the pixel so it can be read out later. "But that storage node must be shielded from light, which isn't possible with a standard BSI CMOS sensor pixel, so you sacrifice fill factor," he said. "There's also not enough space to contain both the storage node and the photodiode inside the same pixel." These problems don't exist with the company's QuantumShutter option. □

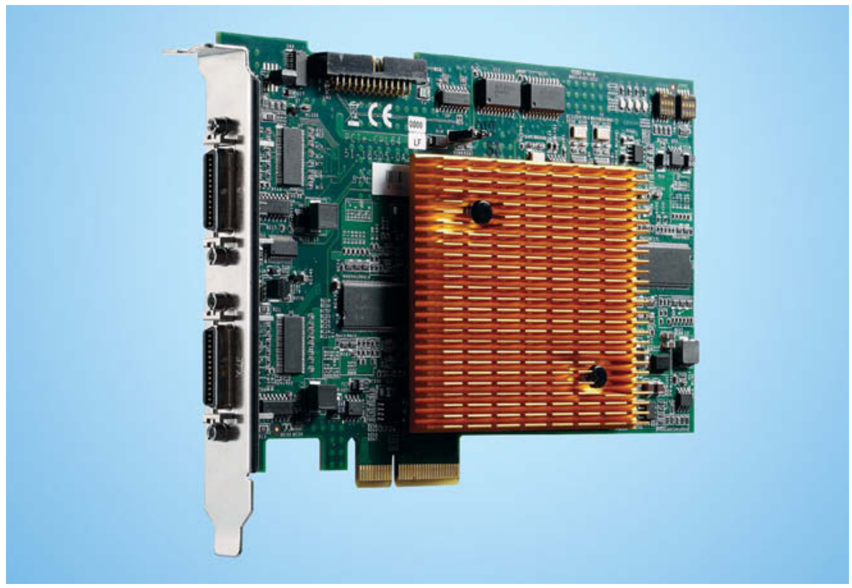
Frame grabbers ease processing burden

By Ann R. Thryft, Contributing Technical Editor

As more inspection systems run faster, use multiple cameras, and transmit huge amounts of data to CPUs for processing, many designers of vision systems are turning to image-acquisition cards, also know as frame grabbers, to manage the data flow. Frame-grabber cards help offload the host CPU by performing preprocessing and other functions. As image sensors get faster, frame grabbers may become more important, aided by bigger, smarter, onboard FPGAs.

FPGAs have been present in high-end boards before, but they have become so inexpensive that processing functions are migrating down to lower-end frame grabbers, said Mike Miethig, technical manager for Teledyne Dalsa. “At the same time, camera bandwidth is going through the roof,” he said. A third intersecting trend is the availability of faster and cheaper CMOS image sensors. Many observers, therefore, expect frame grabbers to become even more important as the speed and performance of FPGAs and CMOS image sensors improve while their prices fall, and as the migration to lower-cost, higher-bandwidth data-transmission technology continues.

With their ability to perform image-processing and preprocessing tasks, today’s frame grabbers can offload some of the computational burden from the host CPU, said Pierantonio Boriero, product line manager for Matrox Imaging. “That makes sense when you’re looking at the high data rates you can achieve with these new [camera interface] standards,” he said. “The whole goal is to perform repetitive tasks by offloading to the frame grabber the pure number-crunching algorithms that don’t depend much on image content.” That frees up the host CPU to do more of the sophisticated algorithms with heuristics that are image-content-dependent, not the brute force or repetitive algorithms.



ADLink’s PCIe-CPL64 frame grabber supports Power over Camera Link and a two-channel Camera Link base configuration and performs onboard preprocessing. Courtesy of ADLink Technologies.

In addition, camera-plus-frame-grabber systems handle much higher bandwidths than do direct-to-PC cameras. Systems that employ frame grabbers also use less CPU bandwidth to transfer data into host memory, said Miethig. “The frame grabber can do preprocessing functions like unpacking data and Bayer interpolation,” he said. “In multicamera systems, where there’s a huge amount of data to process, the frame grabber [offers] an advantage even when the cameras are lower-bandwidth models.”

Jim Blasius, solutions architect for ADLink Technologies, acknowledged that a frame grabber with an FPGA can offload some of the processing work of the CPU, but he said that the configuration you need depends on your application. “If you have smart cameras that can do the job, you don’t need frame grabbers,” he said. “If you can’t do what you need with smart cameras, then shifting to cameras with frame grabbers that do preprocessing makes sense. If you’re taking large frames at a low frame rate, you’ve used smart cameras in the past, and you can re-use the smart-camera processing software in a low-power, low-cost, multicore industrial computer, you can save some money.”

Although frame grabbers are not required in vision systems that use digital direct-connect buses such as GigE Vision or IEEE 1394 (FireWire), they provide advantages in some factory-floor applications, said Kamalina Srikant, National Instruments’ product marketing manager for vision hardware and software. Srikant explained that “many plug-in boards offer better synchronization and I/O connectivity than built-in NICs [network-interface cards], which is especially useful for online systems on the factory floor.”

Too many interfaces?

A major concern for manufacturers of frame grabbers is the growing number of interface standards, including Camera Link, GigE Vision, IEEE 1394b, USB, CoaXPress, and Camera

Link HS. "The biggest headache for everyone in industrial vision is the fact that the supply chain is too complex, and that there are too many standards," said Jacky Lin, ADLink's product marketing manager for measurement and automation. "We think that the number-one trend will be ease of use, including configurations. So, we think Power over Ethernet will be especially important."

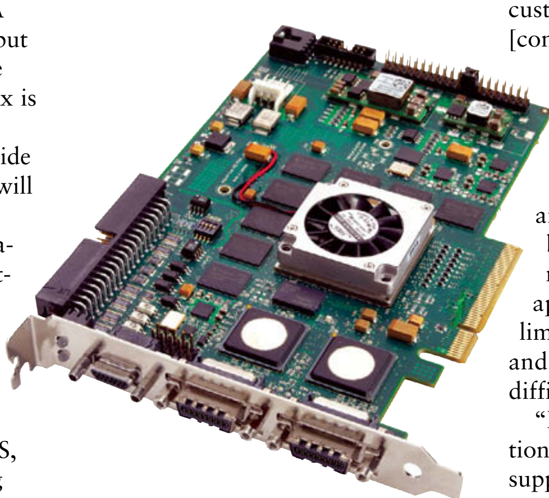
Having three main vision interface standards—GigE Vision, CoaXPress, and Camera Link HS—will complicate R&D for manufacturers of frame grabbers, said Matrox's Boriero. "A camera vendor can pick only one, but frame-grabber vendors must ensure maximum compatibility. So, Matrox is actively participating on all three fronts. The market will have to decide which one will win out or if there will be equal use of the three."

The new CoaXPress standard features the trigger capabilities, low jitter, and deterministic I/O of Camera Link, while improving on that standard's bandwidth, ease of use, and cable length, said Michael Chee, Matrox Imaging's product manager. "Camera Link HS, aimed at similar goals of increasing bandwidth and increasing cable length, is still under development. Work is still being done to define data communication and triggering methods." The Camera Link HS specification is targeted for release during 2011, according to the Website of the AIA (American Imaging Association).

Although each standard has its assets and advantages, users don't always know which way to go, especially when trying to decide between CoaXPress and Camera Link HS, said Marc Damhaut, Euresys' senior VP of product management. "When both standards are out, we may start to make a decision," he said. "I would prefer not to have to develop products for both at the same time."

Over the last two years, Euresys has seen an increase in sales of medium- and full-configuration Camera Link frame grabbers, mainly for applications where there's no real high-speed alternative, said Damhaut. This has prompted the company to redesign its Grablink cards to more fully exploit the Camera Link standard while keeping the cards cost-effective. Euresys achieved this by packing as many functions as possible, including Camera Link deserializers, into a single FPGA.

In the past, Euresys integrated some preprocessing functions for linescan cameras into its frame grabbers, such as pixel compensation and shading correction, but those have now been fully integrated into the camera, said Damhaut. "Currently, we integrate some standard processing that users expect, such as Bayer-pattern decoding, a type of preprocessing, and look-up table," he said. "Look-up table processing can also be done on a PC. Bayer-pattern processing is a little more difficult to program on the PC side, so it makes sense to include this function in the frame grabber."



The Xcelera HS PX8 frame grabber uses a PCI Express host interface to allow simultaneous image acquisition and transfer with little intervention from the host CPU.

Courtesy of Teledyne Dalsa.

Protocols designed for machine vision, such as Camera Link and Camera Link HS, tend to be simpler than general-purpose protocols, such as USB and FireWire, said Teledyne Dalsa's Miethig. More importantly, they directly support features required by machine vision, such as low latency triggers or GPIO within the cable, and asymmetric data bandwidth for transferring high-bandwidth video data from camera to frame grabber and for transferring lower-bandwidth command control data from frame grabber to camera.

The FireWire standard is still around and still very strong in Asia, but it's no longer growing rapidly, said National Instruments' Srikant. Meanwhile, GigE Vision's popularity is increasing. "It uses the Ethernet infrastructure that everyone already has, so adopting it is an easy decision," she said.

"For the past 10 years, most of our customers required lower-speed base [configuration] Camera Link frame grabbers," said Damhaut. "That market segment has now been largely taken over by GigE Vision." GigE Vision cameras have taken off in Asia, the US, and Europe, so the technology has become mainstream, he said, but not everyone wants a networking approach. Bandwidth is currently limited to 1 Gbps on a single cable, and GigE Vision cameras are more difficult to set up.

"Engineers have to play with additional tasks, such as choosing power supplies and setting IP addresses," Damhaut said. "On the other hand, issues such as jitter, triggering, and CPU load have been ironed out and drivers have been optimized. Most of the applications I see now for GigE Vision use NICs, so the need for an interface card is basically the same, whether or not we call them frame grabbers."

Some frame-grabber makers also consider USB, especially USB 3.0, which is a major contender in camera interfaces, said ADLink's Blasius. "It [USB 3.0] has overcome a lot of USB's overall disadvantages," he said. "For example, USB 3.0 is a lot faster and more deterministic."

The main issue in choosing an interface standard will be software development and the problem of legacy applications. "That's why FireWire is still around, because of the software investment," explained Blasius. "It's just not that easy to convert everything to another standard: It's a major investment." □

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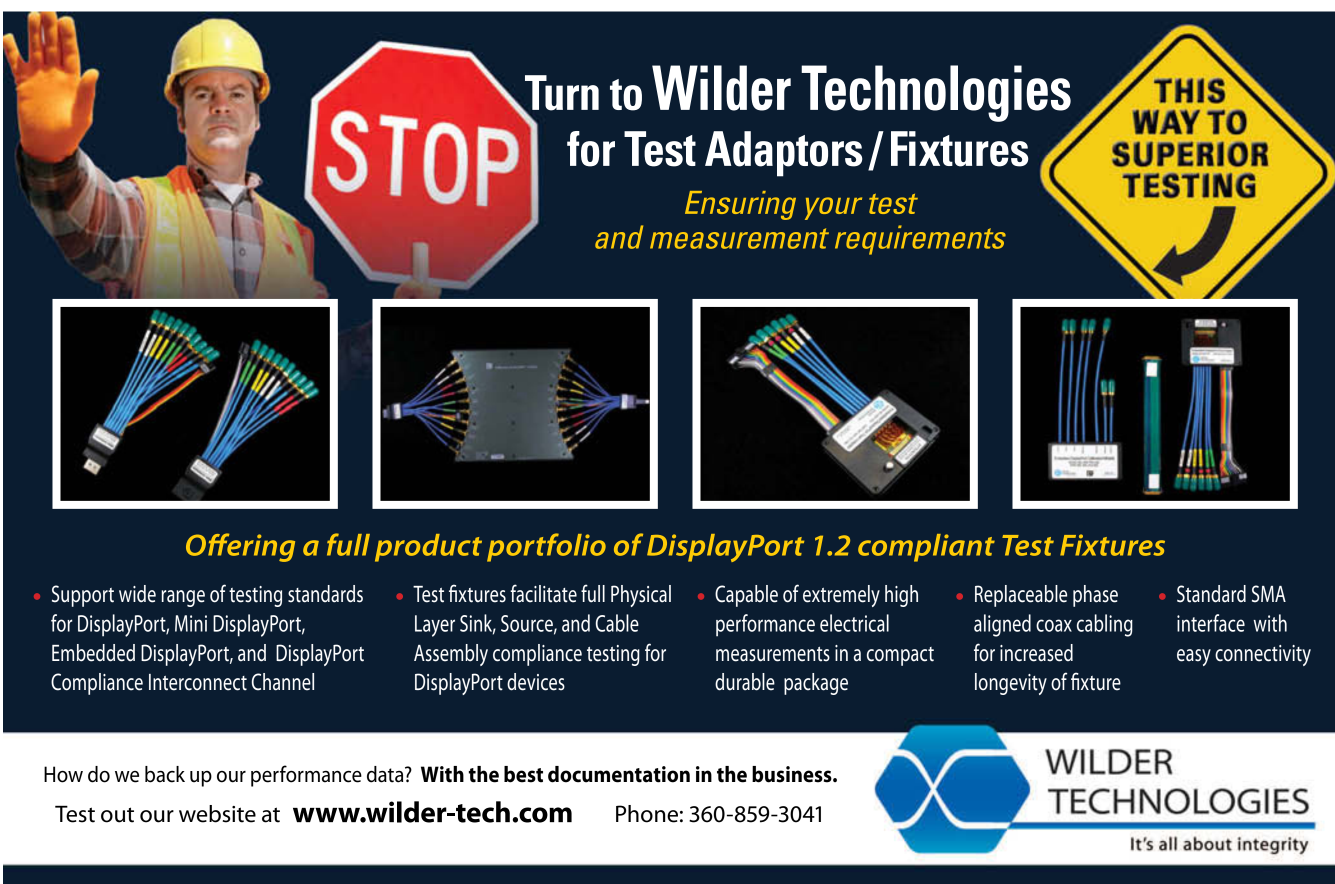

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[An exclusive interview with a technical leader]

JULIO PERDOMO
President and CEO
Centellax
Santa Rosa, CA

Dr. Julio Perdomo has more than 20 years of experience in the high-tech industry. In 2001, he co-founded Centellax, which provides both components and test instruments for high-speed communications. Prior to starting the company, he spent a decade with Hewlett-Packard and Agilent Technologies in business development, sales, marketing, and engineering. At Agilent, he led design efforts on several high-frequency MMICs (monolithic microwave integrated circuits) and managed technical-consulting services. Earlier in his career, he had extensive experience in developing test instruments at Hewlett-Packard. He holds BSEE, MSEE, and PhD degrees from Cornell University.

Contributing editor Larry Maloney conducted a phone interview with Julio Perdomo on the challenges of testing multichannel ICs for communications applications.

How to tame high-speed systems

Q: What is driving the growth in the high-speed communications market?

A: It's the ever-increasing demand for greater bandwidth for both commercial and consumer applications. Look at the Website of any company, and you're likely to see more and more videos for product demos. You also see tremendous growth in high-speed data transmission from large server centers. Wireless mobile applications are also consuming more bandwidth for data and entertainment, and the base stations that support 4G communications have huge bandwidth requirements for their wired interconnect backbone.

Q: How does Centellax serve this market?

A: Our value proposition is affordability without compromise in manufacturing test. In the multichannel BERT [bit-error-rate tester] arena, we offer affordable, high-performance products for R&D and IC characterization. Our technology includes programmable stressed pattern generation to address such issues as total jitter tolerance and crosstalk in receivers.

Q: Why is characterizing multichannel ICs so challenging?

A: High-speed chips like terabit routers can have as many as 64 channels of 10-Gbps data inputs, which employ technologies like multitap de-emphasis and receiver equalization to overcome the loss over copper. Because Ethernet is not purely synchronous, this type of design can result in many asynchronous clock domains. The extent of clock-induced simultaneous-switching noise and power-supply noise depends on the phase alignment of the multichannel inputs. You need a test system that can adjust the phase of each data generator independently to find the worst-case bit-error rate.

Q: What is the make-up of your typical suite to address such problems?

A: A good example is our new multichannel BERT for 32-Gbps Fibre Channel applications. It consists of a controller, a pattern generator, and error-detector remote heads that you can put near the device under test, eliminating long cables that degrade signal quality. This tester operates from 2 to 32 Gbps in a single band with no gaps or missing data rates, and it can generate test-rate patterns without the need for external multiplexers. Our systems offer precision alignment and can generate independent bit-rate patterns for each channel. You can also test a multichannel IC fully loaded.

Tying all this together is our Signal Integrity Studio software that allows you to control these tests from your computer. With this equipment, the engineer can analyze IC performance against such factors as electromagnetic coupling, simultaneous-switching noise, and power/ground bounce.

Q: What are some of the fastest-growing applications for your testers?

A: Good examples would be characterizing ICs, such as FPGAs, which are based on SerDes [serializer/deserializer] designs, and Fibre Channel switches. Other fast-growing applications include bus interfaces and backplane switches for servers.

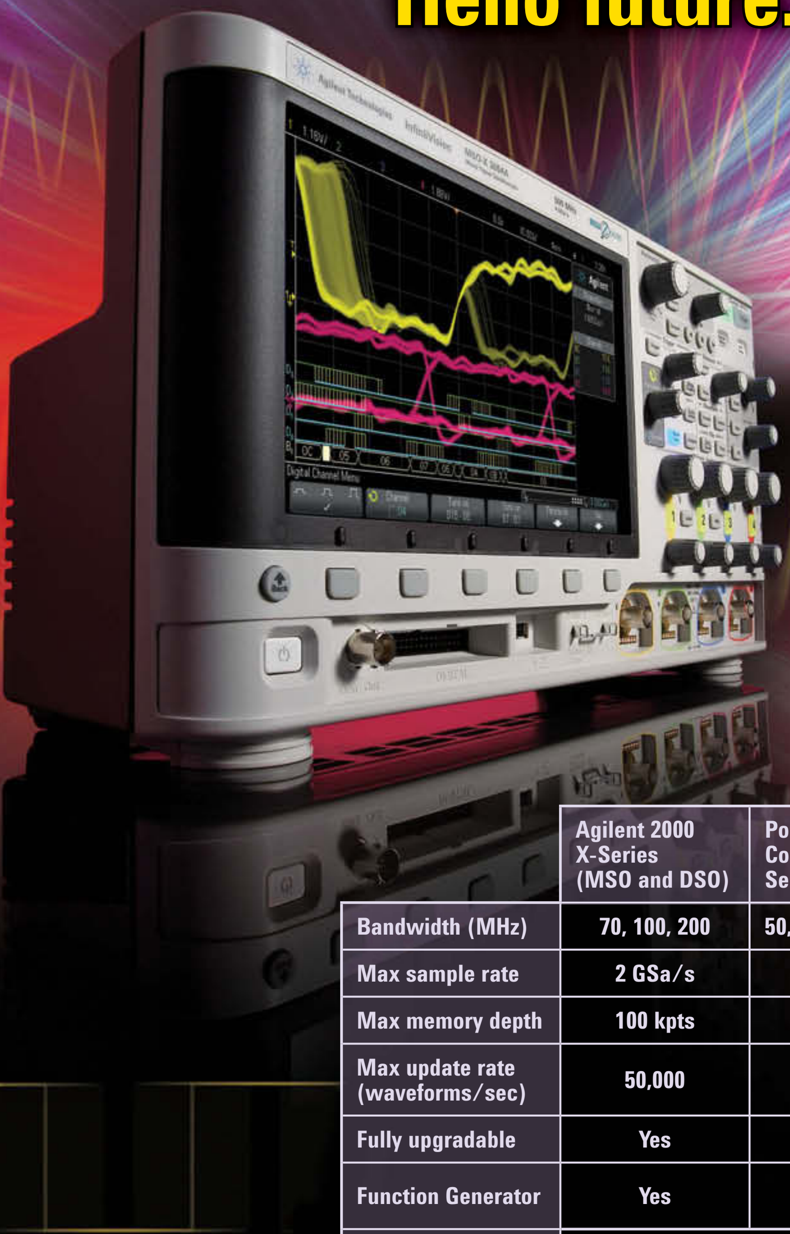
Q: How long will it be before we see widespread adoption of 100-Gbps Ethernet and SuperSpeed USB?

A: People were predicting adoption of 100-Gbps Ethernet by 2013, but we will see significant shipments of products based on that technology this year. Key applications that are driving that demand are short-haul data centers and long-haul backbone fiber-optic systems for telecom. SuperSpeed USB, with applications primarily for serial data transmission in the computer domain, also is likely to be adopted well before the 2014 time frame that many had predicted. T&MW

Julio Perdomo answers more questions on test solutions for high-speed communications in the online version of this interview: www.tmworld.com/2011_06.

To read past "Viewpoint" columns, go to www.tmworld.com/viewpoint.

Hello future.



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