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Test & Measurement World

THE MAGAZINE FOR QUALITY IN ELECTRONICS

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19

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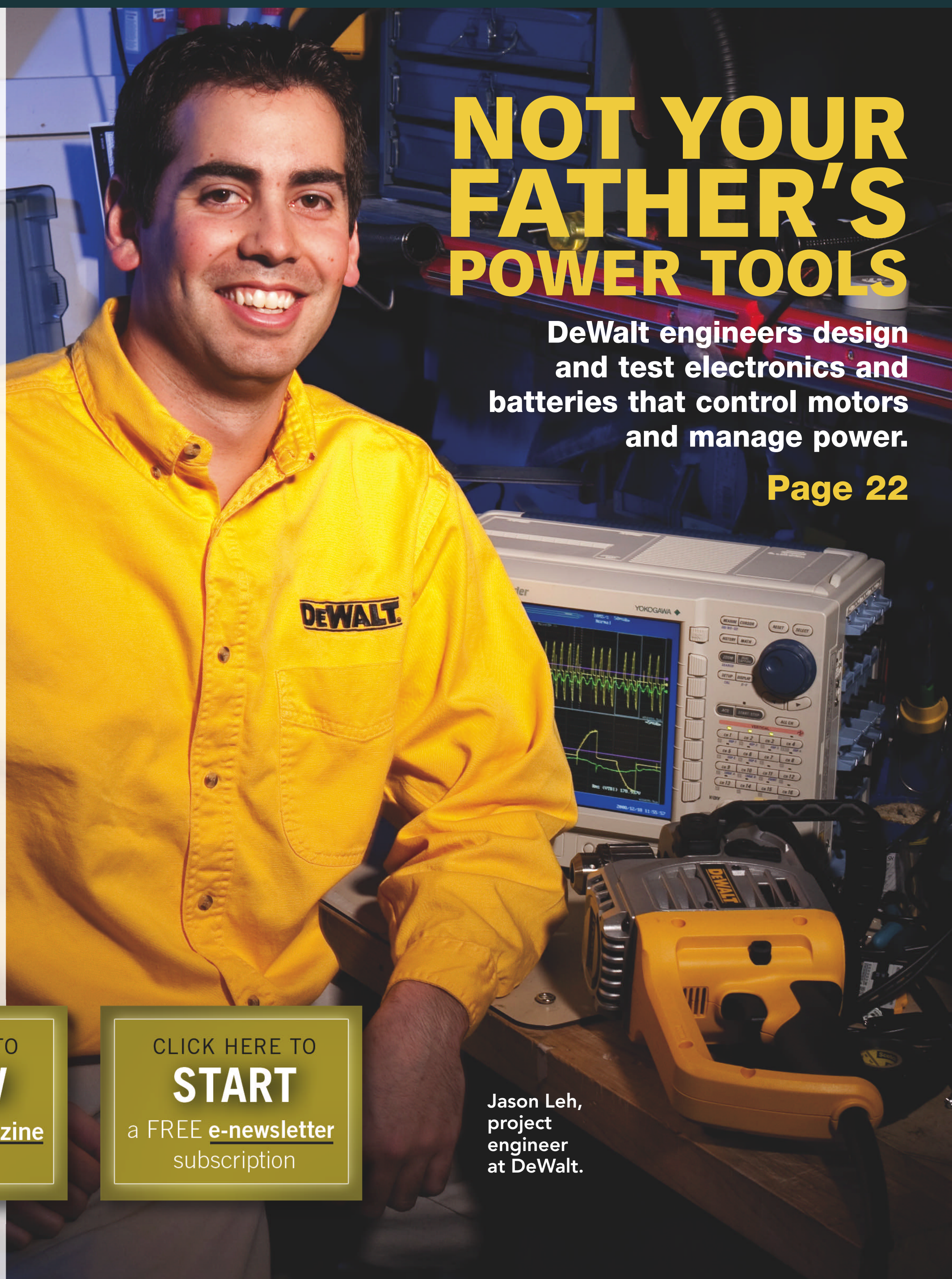

NOT YOUR FATHER'S POWER TOOLS

DeWalt engineers design and test electronics and batteries that control motors and manage power.

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Jason Leh, project engineer at DeWalt.

FEBRUARY 2009
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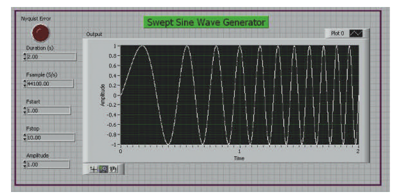

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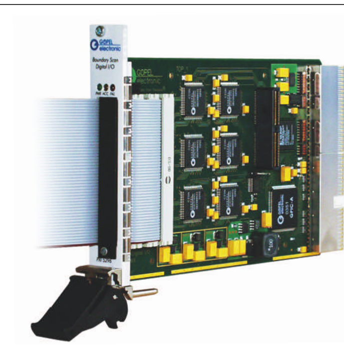

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ONLINE
www.tmworld.com

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

Movie night at *T&MW*

The *T&MW* Web site now features videos that explain how to measure a power supply's loop transfer, diagnose setup-and-hold times, and calibrate an RF test system. We also invite you to upload videos you want to share with other engineers—show off your technical expertise and become a film star at the same time.

www.tmworld.com/videos

EDN Innovation finalists

EDN has announced the finalists for its 19th annual Innovation Awards. Cast your votes for the winner in 26 product categories, including oscilloscopes and design for test, and then vote for the Innovator of the Year.

www.edn.com/innovation

Take a T&M Challenge

Answer our latest Oscilloscope Challenge question correctly, and you could win a prize courtesy of Agilent Technologies. New questions every month.

www.tmworld.com/challenge

Read any good articles lately?

Check out "*T&MW*'s top articles of 2008" to read the most popular features, Web exclusives, and blog postings on www.tmworld.com during 2008. Topics include communications test, PCB test, NASCAR, oscilloscopes, and our annual salary survey.

www.tmworld.com/2008_top_articles

Blog commentaries and links

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- Four technologies that could save Detroit
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- How do you automate RF/wireless tests?
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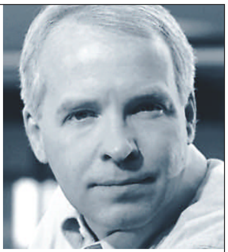
RICK NELSON
EDITOR IN CHIEF



Software's role in test

Software will take on a growing importance as a key differentiator in semiconductor-test solutions. That's a view I share with Debbora Ahlgren, who last month joined OptimalTest as VP of sales and marketing. Ahlgren said OptimalTest provides this differentiation through its station-controller test-automation, adaptive-test and parts-average-testing, and yield-learning tools.

Ahlgren, who most recently served as VP and chief marketing officer for Verigy, said she became familiar with the relatively young company (founded in 2005) through participation on panels (some of which I moderated) with Dan Glotter, OptimalTest's CEO and cofounder; through joint projects between Verigy and OptimalTest; and through the pages of *Test & Measurement World*.

"Core differentiation will increasingly come…from software implementations."
Debbora Ahlgren

In a phone interview, Ahlgren said that she believes OptimalTest is well positioned to make a contribution to the test industry, despite the current economic turmoil. "I've been looking at where the industry is going, and as we emerge from this downturn, things are going to be fairly dramatically different." The change, she said, will focus on differentiation through software rather than through ongoing efforts to simply commoditize test hardware.

She did note that she believes that "Verigy's hardware is very nicely differentiated." She added, though, that test customers in general are looking for a different approach.

Verigy's acquisition of Inovys was one effort at such an approach, although that approach—which links Inovys software with the Verigy V93000 tester—remains hardware-centric.

Hardware differentiation in the test industry won't go away, Ahlgren said, noting, "You will have niches of differentiation that are highly hardware-dependent, but the core differentiation will increasingly come, in my opinion, from software implementations."

As for OptimalTest's role, she said, "If we look at the IDMs [integrated device manufacturers], they have all implemented one form or another" of the software approach OptimalTest takes in an effort to optimize their return on invested capital. And today, she said, "You've got Qualcomm, for example, ranking in the top 10 of the semiconductor industry. So, it's no longer the case that the fabless guys are the little guys who can be ignored. They're equally challenged to optimize their operations." And, she added, "Even the biggest of the IDMs is now going fab-light or is outsourcing, so the notion of home-brew solutions simply fails to work in that environment."

Software has become increasingly important to test—and to design as well. One of the first firms to recognize that may have been National Instruments, which recognized that software running on low-cost computers could implement flexible "virtual instrument" systems. Software's importance now extends from design tools from EDA firms through computational lithography and onto production test and test-analysis tools. These tools will become increasingly interrelated. I asked Ahlgren what role OptimalTest can play with regard to the design space. That's still being worked out, she said, concluding, "The potential for feed-forward and feed-backward and yield learning is definitely there. Those are things that will be enabled on the roadmap over time." T&MW

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

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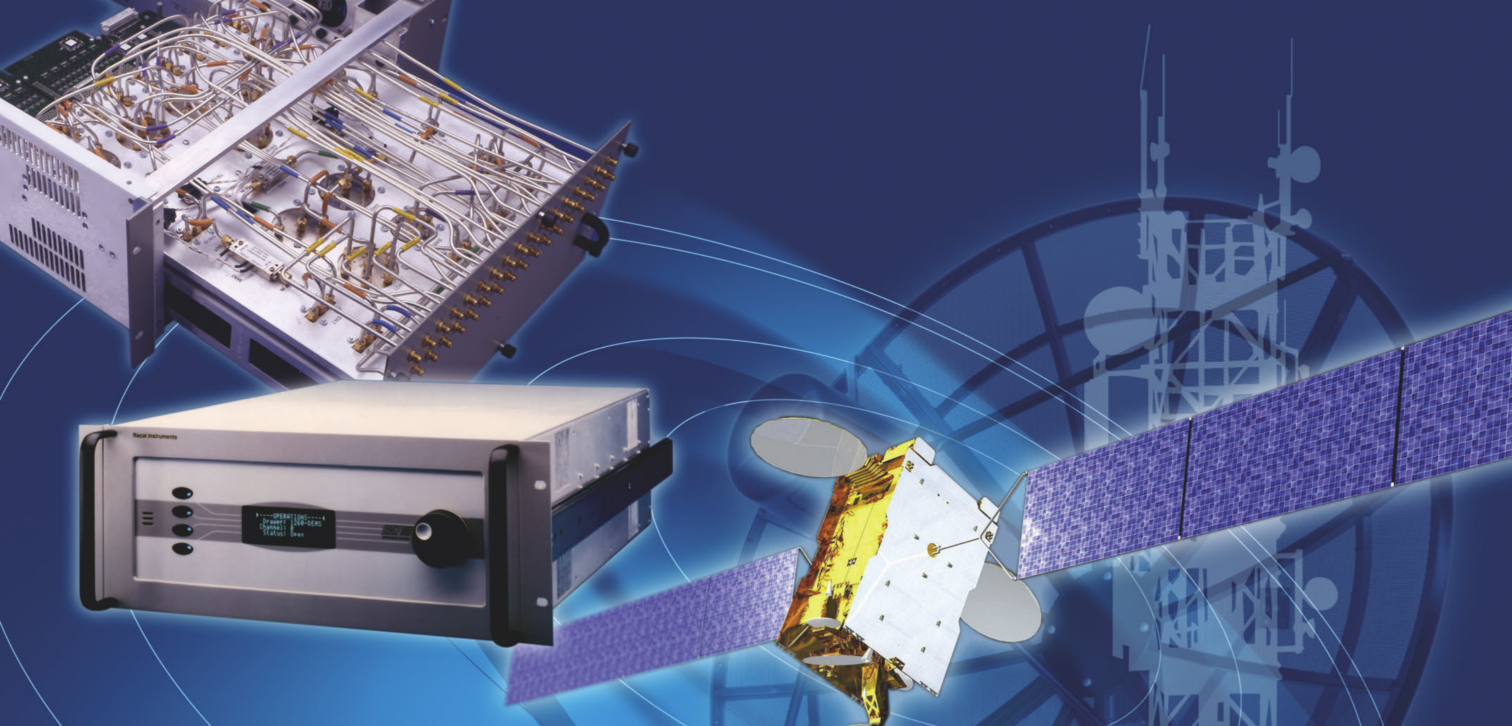

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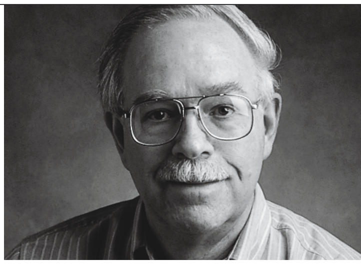


Make mine melamine, part 2

I received several replies to "Make mine melamine" ("Test Voices," December 2008/January 2009). A reader who maintains broadcast equipment offers the following comment:

"Search Google for conductive brown glue and see what we have been fighting for years. Whenever I fix something electronic, that glue becomes the first suspect…. Sony Broadcast VTRs used this glue under passive low-pass video filters that often malfunctioned. After replacing a few filters at $300 each, I investigated and found the glue was conductive. Removing the glue fixed the problems. The filters were never defective. A Sony tech bulletin described it as "chloroprene glue," but who knows what else was in it."

Another reader commented, "I briefly worked at a computer case company in Taiwan near the end of 1997. At that time, case vendors—basically metal stamping operators—added value by including a power supply (PS) in each case…. Since the metal stampers had no electrical knowledge, they'd just buy any PS from one of their friends without providing specifications or performing incoming QC testing. This led to quite a few product returns to the US office, which cost a lot of money…."

A Google search for "conductive brown glue" finds more than 100,000 references, some of which mention the glue's role in various CRT display problems and its use in consumer audio equipment. Searching for "chloroprene adhesive," Google finds 56,000 references, including one from a Sony division that contains the following cautionary note: "The products…contain chloroprene rubber…. Prolonged standing in a high-temperature environment…may cause thermal dechlorination, possibly resulting in the corrosion of metal parts nearby, or in a loss of insulation resistance. Please be sure to avoid any use of these materials in electronic components that are to be energized electrically to prevent tracking or similar problems."

As the second reader suggests, given informal procurement processes, it's possible that a subcontractor used inferior glue to attach components. An archived e-mail note conjectures that "...The plain gummy petroleum glue is ok over time, but [there's] a problem with a filler/bulking agent used. I agree that it goes brown with age, [so] perhaps it's a corn flour or vegetative starch filler. I doubt a mineral [filler] like talcum or French chalk would discolor to a very dark brown or become a problem...."

So the filler might yet be melamine. T&MW

WONDER GLUE

Applications for chloroprene adhesives include attachment of soles to shoes, assembly of furniture and suitcases, and as a general-purpose construction adhesive. Data sheets for the glue often lack technical details, but the data sheet for the chloroprene adhesive used by Sony (Japan) offers considerably more comprehensive information than is available for many Chinese competitors' products:

www.sonycid.jp/en/products/mc4/sc12n.html

SMOKED AUDIO

Adhering to my exploration of the glue's destructive effects, this reference highlights damaged audio equipment:

www.siber-sonic.com/audio/carnage.html

UNCERTAINTY IN (EDIBLE) COOKIES

If you're a newcomer to the concept of measurement uncertainty, perhaps this narrative will help:

metrologyforum.tm.agilent.com/grandma.shtml

ASSAULT THAT BATTERY

At a high discharge rate, how long will a 9-V battery provide power for a portable instrument? To find out, go to www.powerstream.com. Select "Technical Resources," scroll to "Designing with batteries," and select "Discharge Curves for 9V Alkaline and Carbon Zinc Batteries."

GOOD IDEAS

My colleague Martin Rowe performs yeoman service as editor of *EDN*'s "Design Ideas" column. Here are a couple of T&M-related submissions for your consideration:

"Instrumentation-amplifier-based current shunt exhibits 0V drop"
www.edn.com/article/CA6615605.html

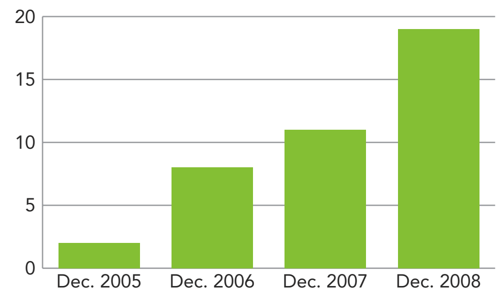
"Configure a low-cost, 9V battery-voltage monitor"
www.edn.com/article/CA6615607.html

"Synthesize variable resistors with hyperbolic taper"
www.edn.com/article/CA6625457.html

LXI Consortium names new president

The LXI Consortium board of directors has elected Von Campbell of Agilent Technologies as the consortium's new president. He takes over an organization that has grown to 53 member companies since its inception in 2005—19 of which sell a total of 665 certified LXI-compliant instruments. Annual sales of LXI-equipped test-and-measurement equipment now exceeds $200 million.

Vendors of LXI-conformant instruments



Companies recently joining the consortium include Beijing Control Industrial Computer, Bustec, Colby Instruments, Data Physics, IPTE, Kikusui Electronics, LeCroy, Magna-Power Electronics, and Thurlby Thandar Instruments.

The board of directors also elevated the Compliance Technical Work Group to Board Committee status, with Jochen Wolle, head of research and development software for spectrum and network analyzers at Rohde & Schwarz, serving as the chairperson. This committee is responsible for approving all conformance applications.

Campbell holds a bachelor's degree in electrical engineering from Purdue and a master's in electrical engineering from Stanford. He joined Agilent Technologies (then Hewlett-Packard) as a development engineer in 1982, and today he oversees the company's involvement in multiple industry consortia. During his 26 years with Agilent, Campbell has led several programs focused on general-purpose instruments, data acquisition, manufacturing test systems, connectivity software, and common instrument infrastructure. "As more and more test systems incorporate the power of Ethernet and the Web, the standardization and extended functionality offered by LXI-compliant instruments become even more compelling," said Campbell. www.lxistandard.org.

ZigBee to serve smart-energy applications

Smart energy and automatic meter reading will make up leading applications for ZigBee and related wireless sensor networks based on the IEEE 802.15.4 standard, reports In-Stat. Other growing applications include consumer electronics, building control, industrial process control, and residential automation.

"A large number of technologies are being used for countless applications, with ZigBee usage becoming more focused on the fast-growing smart-energy application," said In-Stat analyst Brian O'Rourke. "On a global basis, utilities and governments are leveraging these technologies to provision, monitor, and bill customers more efficiently while also benefiting the environment."

Recent research by In-Stat found that 802.15.4 node and chipset units will reach 292 million in 2012, up from 7 million in 2007, but only one-third of 802.15.4 chips include a ZigBee stack, demonstrating the fragmentation among competing technologies and software stacks. The $3295 report "802.15.4—a New Sense of Energy" describes the market for 802.15.4 nodes and chipsets, providing forecasts through 2012. www.in-stat.com.

Editors' CHOICE

VNA operates to 70 GHz

Able to handle S-parameter measurements on RF, microwave, and millimeter-wave devices, Anritsu's VectorStar VNA (vector network analyzer) family delivers frequency coverage of 70 kHz to 70 GHz, a dynamic range of 103 dB at 67 GHz, and a measurement speed of 20 µs/point.

The VectorStar MS4640A family offers three standard frequency ranges that go to 20 GHz, 40 GHz, and 70 GHz. For true broadband applications such as device modeling, the 70-kHz low-end provides seven octaves of additional information below the traditional 10-MHz low-end cutoff of conventional microwave VNAs.

VectorStar offers a 100-dB dynamic range at 70 GHz. Supplementing the wide dynamic range is the +10-dBm, 0.1-dB receiver compression level at 70 GHz. With the new Precision AutoCal for 70-kHz to 40-GHz or 70-GHz calibrations, residual directivity of 42 dB can be achieved at 70 GHz and up to 50 dB can be achieved at 20 GHz.

Base price: $80,950. *Anritsu, www.us.anritsu.com.*

IEEE commemorates 125th anniversary

With a theme of "Celebrating 125 Years of Engineering the Future," the IEEE is commemorating its 125th anniversary in 2009. Planned events include a competition for college students; a Webcast that will address emerging technologies; and IEEE Engineering the Future Day on May 13 that will include activities for increasing the awareness of technology advancements. www.ieee125.org.

Editors' CHOICE

Oscilloscopes reach 30 GHz

LeCroy's WaveMaster 8 Zi oscilloscopes and SDA 8 Zi serial data analyzers take the bandwidth lead to 30 GHz. Both lines consist of eight models, with bandwidths starting at 4 GHz.

The 8 Zi series consists of models with bandwidths from 4 GHz to 30 GHz, all of which are upgradeable. In addition, all models sample at 80 Gsamples/s on two channels and 40 Gsamples/s on four channels. Standard acquisition memory is 10 Msamples/channel on the oscilloscopes and 20 Msamples/channel for the SDAs with upgrades to 256 Msamples/channel on all models. You can interleave memory when using two channels to double the memory.

You can use the 8 Zi series with high-speed, 50-Ω active probes or with 50-Ω and 1-MΩ passive probes without adapters. The high-frequency connectors for the 20-GHz to 30-GHz models are microwave grade. The WaveMaster 8 Zi and SDA 8 Zi feature data analysis, triggering, a 16:9 aspect ratio touch screen, and a removable control panel. Options include expanded memory, a GPIB port, serial triggers, virtual-probing software, and compliance software for high-speed serial buses

Base prices: oscilloscopes range from $59,490 (4-GHz) to $199,490 (30-GHz); add $10,000 for serial data analyzers (all bandwidths). *LeCroy, www.lecroy.com.*

CALENDAR

OFCNFOEC, March 22–26, San Diego, CA. *Optical Society of America. www.ofcnfoec.org.*

Measurement Science Conference, March 23–27, Anaheim, CA. *Measurement Science Conference. www.msc-conf.com.*

APEX, March 31–April 2, Las Vegas, NV. *IPC. www.goipcshows.org.*

The Vision Show, March 31–April 2, Phoenix, AZ. *Automated Imaging Association. www.machinevisiononline.org.*

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

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IEEE 1588 moves into new fields

The IEEE 1588 standard protocol synchronizes time and frequency in networked measurement and factory-automation systems. The LXI Consortium adopted the clock-synchronization protocol into its instrumentation standard, and because of its nanosecond timing, IEEE 1588 is moving into other areas as well. Telecom networks, military systems, financial systems, and many other Ethernet networks may soon use the protocol.

Enhancements adopted in IEEE 1588 v2 let time-synchronization packets, called "transparent clocks," pass through switches and routers. Previously, the protocol could operate within a LAN only.

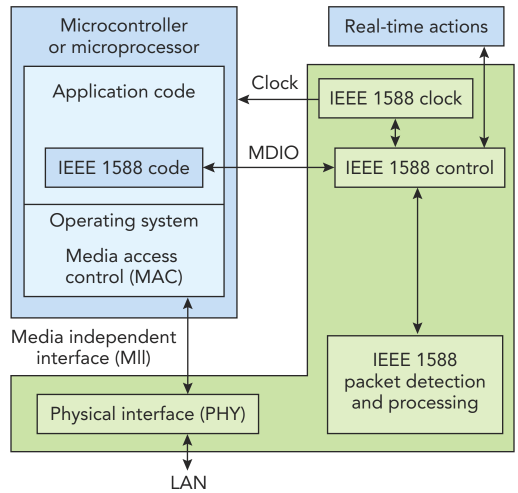
As wireless telecom carriers move from synchronous protocols to packet-based protocols, engineers at these carriers are considering IEEE 1588 as an inexpensive way to synchronize cellular base stations. Operators of wireline networks are looking into the protocol for delivering synchronized audio and video.

"Telecom network operators can reduce costs by moving to packet-based networks," said Kevin Hsu, VP of marketing for telecom at Symmetricom. "But they lose synchronization. With IEEE 1588, nodes on packet-based networks can be synchronized in both frequency and time. The protocol will let base stations pass calls to one another while keeping calls synchronized."

Jon Waters, applications engineer at IXXAT Automation, a producer of IEEE 1588 protocol stacks, noted that in rural areas, a cellular base station might use the GPS as a master clock, then use IEEE 1588 to synchronize other base stations in its area.

Home-based wireless networks can use femtocells to connect cellphones through Internet connections in homes with weak wireless signals. Hospitals and colleges may use small cells to provide communications and to locate personnel. As a result, IXXAT's protocol stack is finding its way into DSPs (digital signal processors) and NICs (network interface cards) for use in these products.

Ethernet PHY interface ICs from National Semiconductor now have embedded IEEE 1588 (**figure**). Alex Tan, product manager at the company, noted that these devices can be used in energy-automation systems: "Electrical substations can use the GPS to obtain a clock, then use IEEE 1588 to distribute it to other stations."



This Ethernet PHY IC has IEEE 1588 clock and control functions implemented in silicon. Courtesy of National Semiconductor.

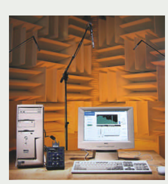
"IEEE 1588 may also replace IRIG-B for synchronizing clocks in military systems," said John Eidson of Agilent Labs. Eidson, who wrote the book on IEEE 1588 (Ref. 1), sees it eliminating the clock-synchronization wires that IRIG-B requires.

Waters also pointed out that IXXAT has received inquiries from people interested in using IEEE 1588 for timing of financial systems. "In these economic times, a financial institution must process millions of transactions a second. Networks need to know the precise order at which transactions are received. Current desktop computers synchronized with NTP [Network Time Protocol] can provide 1-ms resolution at best, so it's impossible to tell which orders came in first. IEEE 1588's nanosecond resolution solves that problem." T&MW

REFERENCE

1. Eidson, John C., *Measurement, Control, and Communication Using IEEE 1588*, Springer Science+Business Media, 2006. www.springer.com.

Acoustic lab opens



ETS-Lindgren has added a lab for measuring acoustic emissions to its test facility in Cedar Park, TX. The lab, which consists of a hemianechoic chamber, two reverberation chambers, impedance tubes, and acoustic test equipment, is ISO 17025 accredited. www.ets-lindgren.com.

Strategic Test announces PCIe digitizer cards

Strategic Test has added two-channel and four-channel, 14-bit, 50-Msamples/s PCI Express digitizer cards to its product line. The UF2e-4032 and UF2e-4031 cards provide dual-time-base sampling, synchronous digital inputs, and asynchronous digital I/O. The cards have 128 Msamples of acquisition memory, expandable to 2 Gsamples. www.strategic-test.com.

EMC seminar includes product review

The "EMC By Your Design" workshop and seminar will include an EMC review of your product design. Presented by DLS Electronic Systems, the three-day seminar followed by a one-day workshop will take place April 23, 24, 27, and 28, in Northbrook, IL. Cost: $1390 ($1090 if registered by March 23). www.dlsemc.com/1001.

COMMUNICATIONS TEST

Channel emulation supports mobile MIMO

MIMO (multiple-input multiple-output) technology stands as the foundation of next-generation mobile broadband wireless products, including those based on 3GPP LTE. MIMO technology, already in use in fixed IEEE 802.11n home wireless networks, can leverage multiple transmit and receive antennas in mobile environments as well as take advantage of techniques such as spatial multiplexing, adaptive antenna processing, and beam forming.

3GPP E-UTRA channel-model key parameters

	EPA	EVA	ETU
Maximum Doppler frequency (Hz)	5	70	300
RMS delay spread (ns)	45	357	991
Maximum delay (ns)	410	2510	5000
Number of paths	7	9	9

Bringing mobile MIMO products to market will require extensive laboratory and real-world OTA (over-the-air) testing. In the paper "Improving 4G Wireless Broadband Product Design through Effective Channel Emulation Testing," Azimuth Systems reports that lab testing produces repeatable results, while OTA testing is not generally repeatable and is expensive to perform. To bridge the gap between the lab and the real world, the paper recommends the use of channel emulators, which "replicate real world channel propagation conditions in a controllable and repeatable fashion through the use of complex channel models and multiple, programmable parameters."

The paper notes that successful LTE channel emulation requires high dynamic range and a low noise floor—for example, an emulator may have to accommodate a PAPR (peak to average power ratio) greater than 10 dB and support better than 20-dB signal-to-noise ratio for a 64QAM signal. In addition, an emulator must not degrade a unit under test's EVM (error vector magnitude), the term that best describes signal quality. Also, an emulator must be able to provide fast fading conditions that mimic real-world effects.

Channel emulation should also support multiple antenna connections for MIMO spatial multiplexing, STC (space time coding), and MRC (maximal ratio combining) techniques as well as AAS (adaptive antenna systems). Finally, channel emulation should be sufficiently flexible to accommodate channel models such as the 3GPP EPA (extended pedestrian A), EVA (extended vehicular A), and ETU (extended typical urban) models. The **table** lists the key parameters for the channel models in 3GPP E-UTRA (evolved UMTS terrestrial radio access).

You can download the full paper at www.azimuth.net/company-white-papers.htm.

Rick Nelson, Editor in Chief

PRODUCT TRYOUT

An MSO for your computer

MSO-19 USB mixed-signal oscilloscope with eight logic inputs and one analog input, Link Instruments, www.linkinstruments.com. Price: $249.

Read a hands-on review of this instrument in Martin Rowe's blog at www.tmworld.com/martin_USB.

With just one analog channel, the MSO-19 is really a logic analyzer with an analog input rather than a true mixed-signal oscilloscope. Although it has just one analog channel, the MSO-19 is useful for bench, field, and even hobby applications where you need to troubleshoot logic circuits and microcontroller-based systems. Its 200-Msamples/s sample rate provides enough sampling to handle a wide range of applications.

The MSO-19 connects to a PC through a USB port. The software is easy to install, and you never have to worry about losing the install disk because Link Instruments lets you download the software from its Web site. Every instrument maker should provide free software for instruments that can't run without it.

The instrument has some useful features such as the ability to save waveform screens and instrument setups. It lets you trigger on oscilloscope or logic channels. You can display a stored waveform and then display a live waveform over the static one. That's great for comparing a device-under-test's waveforms to "golden" waveforms. The scope also lets you trigger on the analog channel or a combination of logic channels.

Like most instruments, the MSO-19 has a few oddities. For example, the vertical scale doesn't follow the usual 1x, 2x, 5x pattern. It also has one hardware issue that, while not detrimental to the instrument's operation, needs to be addressed. The online review of the MSO-19 discusses this and other issues in detail (www.tmworld.com/martin_USB).

Martin Rowe, Senior Technical Editor

The MSO-19 lets you view one analog and eight digital signals.
Courtesy of Link Instruments.

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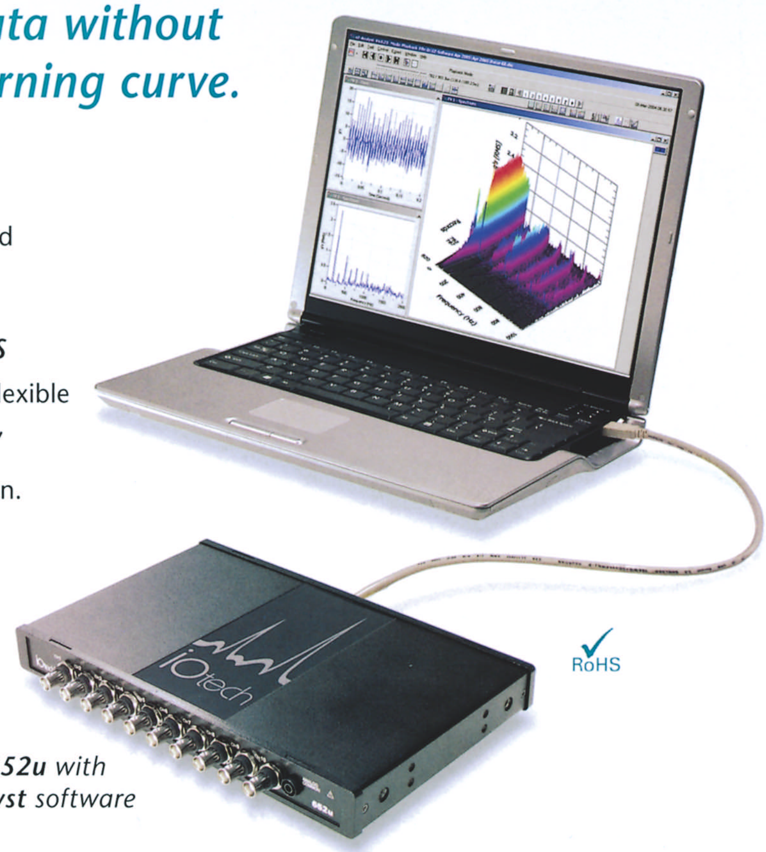

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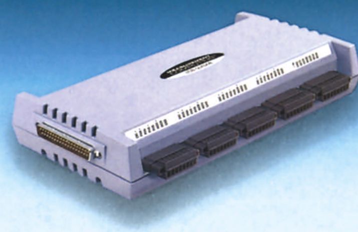

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Generate a swept sine in LabView

Test audio devices by producing a signal on a data-acquisition card.

By Sean McPeak, University of California, San Diego

Swept sine waves let you test a device over a wide frequency range. To implement a swept sine wave with a multifunction data-acquisition card, you need to generate the data points and send them to the card. You can create a swept sine function in National Instruments' LabView with just one VI (virtual instrument) that can control start and stop frequencies, sample rate, and sweep duration. Using the signal, I tested an acoustic transducer used in a research project for measuring wave propagation in the open ocean.

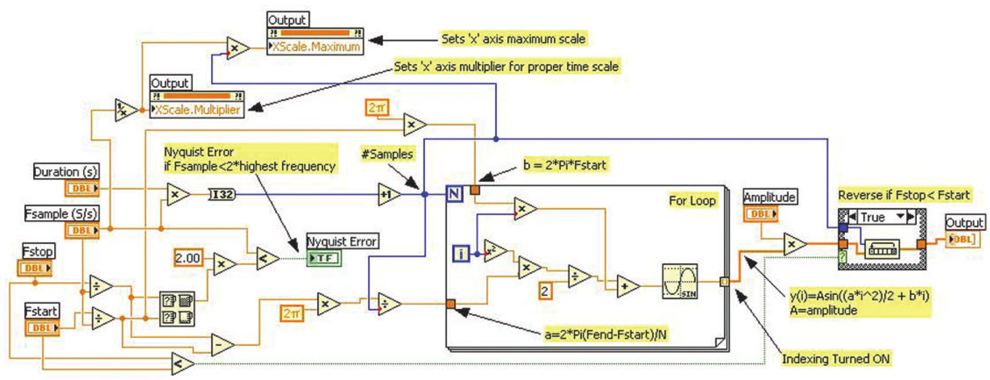

Figure 1 A LabView VI uses an array to calculate the points in a swept sine wave.

The LabView VI (**Figure 1**) calculates an array of numbers that represent the swept sine wave at each sample point as the frequency increases or decreases. To implement a swept sine wave, you must change frequency on a point-by-point basis (Ref. 1) using this equation:

$$y(i) = A \cdot \mathrm{Sin}((a \cdot i^2)/2 + b \cdot i)$$

where $y(i)$ is the amplitude of the swept sine wave as a function of sample point, i is the integer that steps through the time series, and A is the signal's peak voltage.

Variables a and b are defined as:

$$a = 2\pi \cdot (\mathrm{Fstop} - \mathrm{Fstart}) / n$$

$$b = 2\pi \cdot \mathrm{Fstart}$$

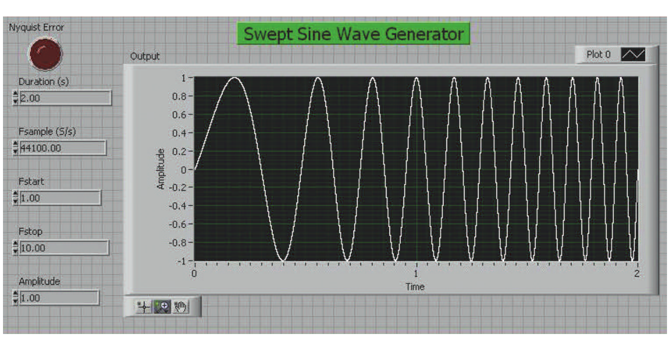

Figure 2 The user panel shows the swept sine waveform, start frequency, stop frequency, duration, amplitude, and Nyquist error indicator.

where n is the number of samples, Fstart is normalized start frequency, and Fstop is normalized stop frequency.

To normalize the start and stop frequencies, you must change the unit to cycles per sample. Do that by dividing the Fstart and Fstop frequencies in Hertz by the sample rate. A good rule of thumb is to use a sample rate of 10 samples/cycle at the highest frequency.

My LabView VI uses array manipulation and a For loop. The inputs are Duration (s), Fsample (samples/s), Fstop (Hz), and Fstart (Hz). The VI converts the start and stop frequencies to cycles/sample by dividing them by the sample rate. A "Max Min" block takes the normalized Fstop and Fstart and determines the maximum frequency input by the user. The VI doubles that value and compares it to the defined sample rate. From the comparison, the VI determines if the sample rate meets the Nyquist criteria for the highest frequency in the signal.

The block's output is a simple Boolean function that tells the user if the sample rate meets the Nyquist criteria. The For loop in the center of the VI diagram runs through the total number of samples that it must calculate, which it finds by multiplying the duration in seconds times the sample rate in samples/s.

To guarantee that the For loop processes all of the samples, you must add 1, because the For loop will stop at N – 1. The For loop implements the output function with algebraic operators and a sine block. The output is an array that goes to the right side perimeter of the For loop. You must enable "indexing" at this node, which lets each element in the array be acted upon individually at the output.

A gain stage after the loop sets the signal's peak-to-peak value. Finally, a case structure uses a "Rotate 1D Array" block to flip

the array around if Fstop is less than Fstart, which lets the VI produce a swept sine wave of descending frequency.

I implemented two property nodes for the graph that set the "x" scale multiplier and the maximum value. These nodes let the plot of the resulting waveform display the proper time scale and maximum value (**Figure 2**). I set the program for a sweep from 1 Hz to 10 Hz over a 2-s duration with a sample rate of 44,100 Hz. The graph palette at the lower-left corner of the graph in Figure 2 lets me zoom in on portions of the sine wave and verify the proper frequency.

I tested the VI with a spectrum analyzer by comparing the signal generated with a multifunction data-acquisition card to that from an arbitrary waveform generator (a waveform generator has this function built in). I also listened to both signals through an audio amplifier and speaker. I found listening useful in determining sweep rate, duration, and stop and start frequencies in the audible range.

You could make several modifications to the VI for increased functionality. For example, you could use this VI with NI data-acquisition hardware to generate a looping up and down frequency sweep. You can also keep track of the output samples and, when finished sending them to the data-acquisition card, reverse the frequency sweep array and feed the data back into the data-acquisition system's output.

Depending on the max/min frequencies, sweep duration, sample rate, and available PC memory, you may not be able to flip the array and configure the data-acquisition system quickly enough to not miss a sample. In that case, you can fill a frequency sweep array for a set number of passes. These modifications would let the sweep continue up and down in frequency for a set period of time. You can also add a real-time FFT (fast Fourier transform), which lets the user see the sweep in the frequency domain. You may find this especially useful for verifying proper start and stop frequencies as well as sweep duration. T&MW

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1. Rowe, Martin, "Generate a swept sine test signal," *Test & Measurement World*, October 2000. www.tmworld.com/article/CA187440.html.

NOT

Project engineer Jason Leh performs voltage, current, temperature, and other measurements to test motor controls.

TOWSON, MD—DeWalt power tools such as drills, saws, and grinders help contractors worldwide build just about anything. Not long ago, power tools were electrically simple—a variable-speed power switch provided power to a motor. Today, electronics control motors, charge batteries, monitor a tool's health, and add control features. Electronics testing is now just as important as mechanical testing in making a reliable tool.

At DeWalt headquarters near Baltimore, engineers design and test electronic modules for AC- and DC-powered tools. Instead of the mechanical switches used in older power tools, new tools have microcontrollers, triacs, and MOSFETS that provide pulsed power to motors. Electronics also contribute heavily to battery monitoring and management, especially as lithium-based batteries have begun replacing NiCd (nickel-cadmium) batteries in cordless DC-powered tools.

"With digital controls, we can monitor current, voltage, and temperature in a tool," said engineering director Bhanu Gorti. "We can use the information to control the power applied to a motor based on load." Today's tools also record usage profiles that engineers can use to test tools by using them the way contractors do.

Project engineer Jason Leh and senior project engineer David Beers were part of a team that developed a method for controlling motor speed in grinders. "When

YOUR FATHER'S POWER TOOLS

DEWALT ENGINEERS DESIGN AND TEST ELECTRONICS AND BATTERIES THAT CONTROL MOTORS AND MANAGE POWER.

BY MARTIN ROWE, SENIOR TECHNICAL EDITOR

contractors use our tools, they tend to run them into the ground," noted Leh. "We found that tools often fail when their motors overheat."

Unfortunately, reliability, manufacturing challenges, and added cost wouldn't let DeWalt engineers use a motor-temperature sensor. To prevent overheating, they developed microcontroller code that estimates a motor's temperature based on current and time.

Initially, they wrote code such that if the temperature exceeded a limit, the microcontroller would shut down the motor and wouldn't restart it until the motor cooled to safe levels. Leh and Beers learned, however, that the heavy users don't want a tool to remain off while the motor cools, as this could prevent them from finishing their work on time.

Leh changed the microcontroller code to give the user the ability to restart the tool by simply cycling the switch regardless of tool temperature. The user receives a warning that the tool may potentially overheat but still has the option to finish the job after the motor cools for several seconds. If the user immediately applies a heavy load to the tool, the microcontroller will shut down the motor to prevent damage.

Figure 1 shows how the microcontroller controls power in an AC-powered tool. A triac, under microcontroller control, conducts and applies voltage to the motor for a portion of an AC cycle only. In Figure 1, that occurs between the 60° and 180° points in the positive half cycle and between the 240° and

JOSHUA ROBERTS/GETTY IMAGES

360° points in the negative half cycle.

The microcontroller delivers power based on information derived from measured current and estimated temperature. If the estimated motor temperature is low, the microcontroller applies the full AC cycle to the motor. As the temperature climbs, the microcontroller decreases the amount of voltage applied to the motor in proportion to the rise in temperature. If the temperature then decreases, the voltage supplied to the motor will increase.

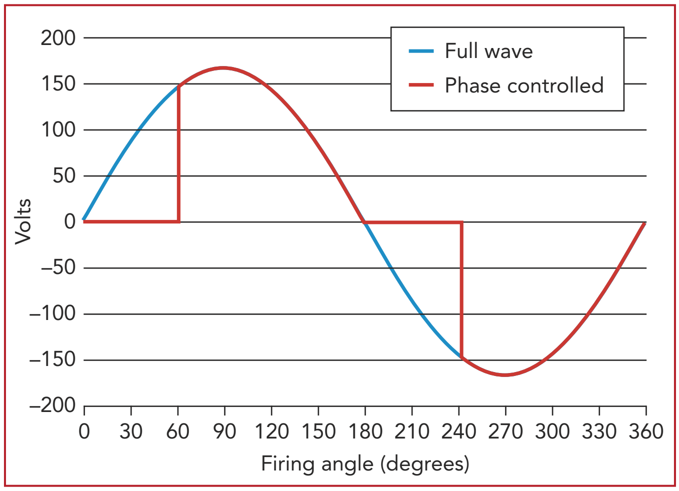


FIGURE 1. **An AC motor-control module controls motor speed by allowing only portions of an AC voltage cycle to pass through a triac.**

Leh started the design by running simulations of the motor's performance and temperature under load. From the simulations, he generated a series of curves that describe how the motor temperature changes under vary-

JOSHUA ROBERTS/GETTY IMAGES

Engineering director Bhanu Gorti oversees design and test of DeWalt motor controls, batteries, and battery chargers.

ing loads. From these curves, he derived coefficients that the microcontroller uses to estimate motor temperature. "We can use this method on other tools as well," Leh said. "We just change the coefficients that model the motor's thermal mass."

To verify the accuracy of the simulation, Leh and Beers measure motor temperature by placing thermocouples at the best possible positions near the motor. Four thermocouples, connected to a Yokogawa or Fluke datalogger, measure the temperature once per second.

The motor temperature at the instant the tool turns on is important when estimating motor temperature while the tool runs. Because the microcontroller's memory loses data when power is removed, the engineers needed a way to retain temperature. They solved the problem by placing a thermistor in the tool's control module. The microcontroller measures temperature at tool startup and shutdown, storing the data in nonvolatile memory. Upon the restarting of the tool, the microcontroller retrieves the data from nonvolatile memory and uses it in calculations.

To verify temperature estimates, Leh developed an interface board that connects to the microcontroller's SPI (serial peripheral interface) bus and converts the signals to RS-232 for connection to a PC. He can view the time-stamped data, in text format, using Windows HyperTerminal, and he can save the data to disk. Leh and Beers then time-correlated the measured and estimated temperatures and plotted them with Excel. **Figure 2** shows how closely the estimate tracks the measured motor temperature.

During the verification test, DeWalt engineers simulated actual usage profiles obtained from users. In one profile, a user ramps up the load on the motor until it reaches 10 A, holds for 1 s, then ramps up to 15 A for 15 s. The motor then turns off for 2 min, turns back on, and ramps up to 20 A for 30 s.

Production testers

Motor-control electronics reside in modules small enough to fit inside a tool. These modules need production test, and the motor-control engineering lab has testers identical to those used on the production lines. Using a bed-of-nails fixture, an in-circuit and functional tester verifies that a module is properly assembled. Known as "Tester 06," the tester also calibrates a module's internal peripherals such as the ADC (analog-to-digital converter) that makes motor current and voltage measurements. The functional tester also programs the module before potting and final test.

DeWalt engineers calibrate the internal peripherals by loading test routines into a module's microcontroller. A programmable-logic controller controls the tester's AC power supply, which delivers the voltage—through a calibrated resistive load—into the microcontroller. The microcon-

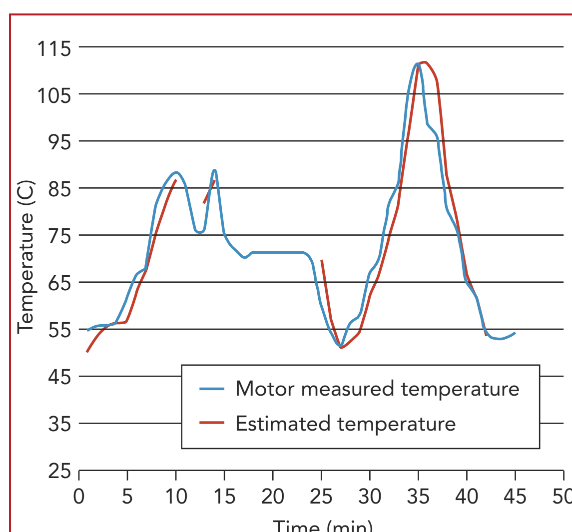
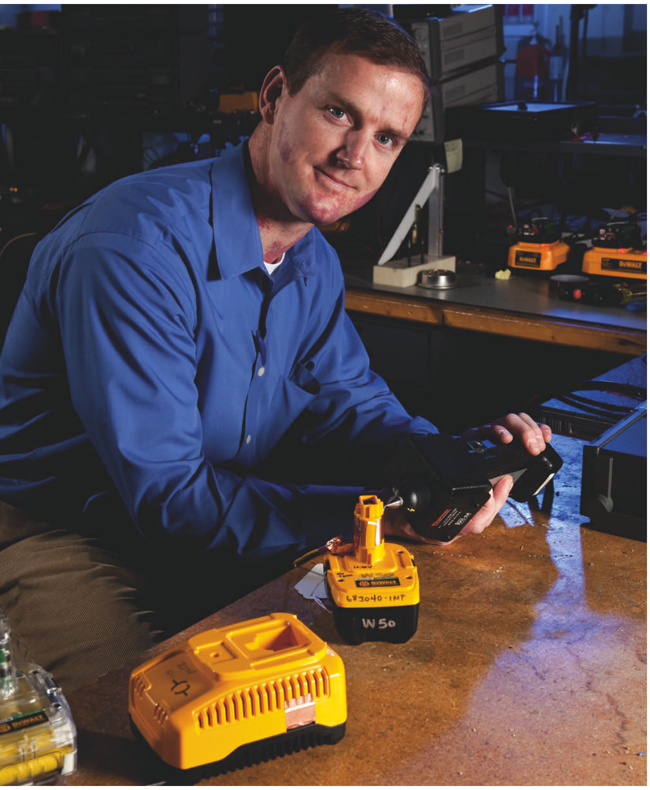


FIGURE 2. **Tests show how well a simulated motor temperature tracks a measured temperature.**



Engineering manager Dan White oversees design and test of battery packs. Here, he performs an ESD test on a battery pack.

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troller's ADC measures load current by measuring voltage across a shunt resistor, making the measurements at both a low-current and a high-current setting.

After Tester 06 verifies a proper current reading, it calibrates the other ADC channels and the microcontroller's internal oscillator. The tester compares all module measurements to its own calculated values and determines calibration values for the module (**Figure 3**). Following successful calibration, Tester 06 loads the microcontroller with its production code before it gets potted.

After potting, a motor-control module goes to final test. "Tester 02" lets engineers perform final tests in the same way as in production. Final test consists of performing hipot tests on the final assembly along with final verification of all inputs and outputs.

Unclean power

AC powered tools don't always get clean power at a construction site, so their motor-control modules must work under all electrical conditions. "Sometimes on the job site," noted Gorti, "AC-powered tools are powered by generators that have poor regulation. Because of that, we must test motor controls for voltage dips and surges. We test our tools under as many AC voltages as contractors will use."

The motor-control lab has a California Instruments programmable AC source built into a tester with AC mains sockets for US, UK, Australia, Denmark, Germany, Norway, Finland, Sweden, Switzerland, Italy, South Africa, and India. Using the AC source, engineers can vary both voltage amplitude and frequency and test for line surges, dips, and clipping. This supply is also capable of delivering up to 12 kVA, which is useful for running a variety of tools.

Engineers use the tester to verify that tools will operate over a wide range of frequencies. "We design our tools to operate from 30 Hz to 80 Hz," said Gorti.

Battery power

Because DeWalt manufactures cordless tools, the company's engineers must design and test battery packs, battery chargers, and the electronics to manage them. The company introduced its first 18-V cordless drill in 1996. Now, contractors spend more than $1 billion a year on batteries for DeWalt products.

Today, lithium-ion cells are replacing NiCd and NiMH (nickel-metal-hydride) batteries. Lithium batteries are lighter and don't contain cadmium, a heavy metal. DeWalt's lithium battery packs are backward compatible—both electrically and mechanically—with tools the company built for NiCd/NiMH batteries. A lithium battery pack will work with any DC-powered DeWalt tool, provided the tool is compatible with the battery's output voltage. That's important because it lets contractors use a battery pack of similar voltage from any DeWalt tool.

Lithium batteries (DeWalt currently uses lithium-ion phosphate technology) require electronics to monitor voltage and temperature while the battery charges and discharges. Because DeWalt's lithium battery packs must be mechanically equivalent to its NiCd battery packs, engineers had to embed the battery-management electronics in the neck of the housing. **Figure 4** and the photo at left show a battery pack and a mating charger. The neck of the battery pack inserts into tools and chargers.

Battery testing includes testing of the power-management circuits. The battery-engineering lab has automated testers that provide power and loads to battery-management modules. Other stations test the complete battery packs (electronics included) for charging and discharging.

When testing battery-management modules and battery packs, engineering manager Dan White and his team simulate loads based on actual user profiles because DeWalt tools can record data on their power consumption. Working with a DeWalt tool, the engineers capture profiles with a laptop computer and duplicate them in the lab. An automated test station running Visual Basic contains numerous power resistors that the engineers can switch to the battery pack and use to record its voltage and current.

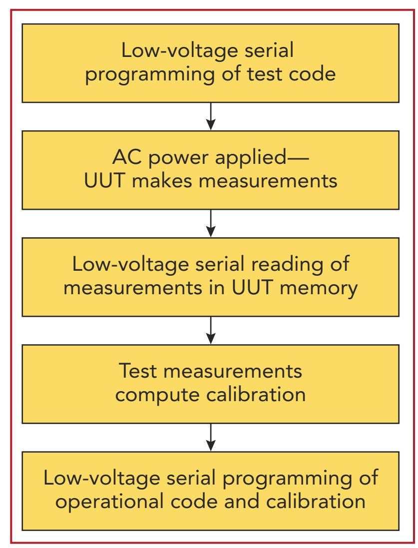


FIGURE 3. An in-circuit functional tester loads test code into a microcontroller and calibrates the module.

Another station measures battery response during charging and discharging

Chris Sanford manages numerous test labs, including a drop-test lab in the reliability center.

JOSHUA ROBERTS/GETTY IMAGES

at –10°C to 90°C, even though the published specification is 0°C to 40°C. This station, which runs National Instruments' LabView, contains several power supplies, an Agilent Technologies electronic load, and an Agilent multiplexing DMM (digital multimeter).

Engineers also evaluate batteries and control modules with a Fluke infrared temperature camera. The camera lets them pinpoint failed components. They will run tests designed to make the electronics fail. "We test it until it breaks because we want to know the conditions that our products can withstand," said Gorti.

Technician Chris Held runs qualification tests on batteries to verify their microcontroller software. He developed a test bench that measures voltage, current, and temperature through a National Instruments' data-acquisition chassis running LabView.

Using thermocouples on each lithium cell in a battery pack, Held performs measurements to verify that the power electronics properly measure voltage, current, and temperature when working in a tool. By connecting each cell in a battery pack to a channel in the data-acquisition system, Held looks for voltage differences among the cells during charging and discharging. Thermocouples and an infrared camera monitor the battery's temperature during a test. The test verifies that a battery-management module will remove battery power from a tool when an overcurrent, overtemperature, or undervoltage condition occurs. Similarly, he tests the batteries for charging conditions to make sure the battery cells don't overcharge.

Held also measures battery current under several loads. He runs a sequence of tests at 10 A and 15 A to verify that the battery electronics know how much current a load draws from the battery. An electronic load, controlled through a USB-to-GPIB interface, controls the battery's load. In addition, Held uses a LeCroy oscilloscope and current probe to measure inrush current in tools at room temperature and at 60°C. Inrush currents in tools can exceed 200 A. Held's tests verify that the battery-management module applies compensation to prevent the voltage from dropping to a level that will cause microcontroller lockup.

Like all electronics, battery-management modules are susceptible to RFI (radio frequency interference), both from external sources and from ESD (electrostatic discharge). White explained that, with the exception of the terminals, the batteries are housed in cases that are protected from ESD. Current from ESD can't reach the cells or electronics directly, but static discharges produce electric fields that can couple into PCB traces and produce current.

To perform an ESD test, White wraps a copper foil around the neck of a battery pack (over the management module), leaving a spark gap in the foil. He then uses an ESD simulator from Thermo Keytek (now Thermo Fisher Scientific) to inject ESD into the foil ring. "It's not a compliance test," noted White, "but it provides a good indication of immunity."

Charged and ready

Rechargeable batteries need charging, and engineers such as Geoff Howard design and test chargers, which provide constant current to discharged batteries. A battery charger can charge a battery in as little as 15 min, although typical charge time is 1 hr.

Chargers designed for lithium batteries differ from those designed for nickel-based batteries, because the battery electronics participate in the charge process by monitoring battery voltage. With NiCd batteries, chargers cut off current by monitoring the inflection point of the battery voltage because voltage will drop once the battery is fully charged. With lithium batteries, the management module needs to monitor voltage level and temperatures.

Bench testing of chargers lets Howard and others verify that a charger meets design specifications. Using an automated test setup, technicians measure charge current and battery voltage waveforms with a LeCroy oscilloscope. An Agilent electronic load with a capacitor across it simulates a battery. "For some tests, a resistor is enough," said Howard, "but the electronic load can switch ranges and it can create a switching waveform that can disrupt a charger. The capacitor, in parallel with the load, makes it behave more like a battery."

The test bench also includes an Agilent waveform generator that simulates a tool's power switch waveform, providing a trigger signal for the oscilloscope. Operating the oscilloscope in single-shot mode lets technicians measure spurious noise caused by a tool's power switch that interacts with the battery electronics.

Some chargers are embedded into rugged radios, which provide on-the-job music and charge tool batteries (**Figure 5**). Technicians use the oscilloscope's FFT (fast Fourier transform) feature to look at the charger in the frequency domain. Howard explained that chargers produce RF emissions from switching circuits that must not interfere with the radio. To make the RF measurements, engineer Aziz Iqbal built a "sniffer" probe from coax cable.

Battery engineers developed a failure test that uses a high-speed camera that can shoot a picture every 250 µs to show where a component will fail. In this test, an engineer forces a MOSFET—used in both battery management and motor control—into its linear region where the drain-to-source resistance is high. By pumping enough current through the device, the engineer makes the MOSFET fail. The bond wires inside the device package melt and cause the failure.

Tough tools

DeWalt's tools, batteries, and chargers must withstand all the conditions on a construction site, which include temperature, vibration, shock, torque, and airflow. "Contractors drop our products all the time," said Chris Sanford, who manages several test labs in the company's reliability center.

Electromechanical test setups subject drills to heavy torque, just as a contractor will do. As Jason Leh noted earlier, contractors run tools to the point where motors can burn out. In the torque test lab, tools are attached to discs, much like disc brakes in a vehicle. Calipers, also much like those in disc brakes, apply friction to a spinning disc, which increases the load to the point where the disc stops. Tools must be able to shut down under overheating conditions caused by too much torque. The torque tests can run overnight and on weekends. If a tool fails, the tester can make a phone call to a technician who will come in to evaluate the failure.

FIGURE 4. A lithium battery pack (right) is compatible with older NiCd battery packs. Chargers (left) can charge batteries in 15 min or 1 hr. Courtesy of DeWalt.

Sanford also runs tests on the switches designed into tools. "A tool is only as good as its power switch," he said. "If we specify that a power switch is rated for 200,000 cycles, we'll test it for 1 million cycles."

An automated tester for variable-speed-control switches looks for the weak point in a switch, which occurs at the point most likely to produce arcing across its contacts. The tester can home in on that point, then repeatedly test the switch around that point. Although DeWalt engineers test this condition for switches used in both AC- and DC-powered tools, the problem is more pronounced with DC-powered tools.

Other test labs focus on shock, vibration, sound, and airflow. The DeWalt facility includes rooms that contain wood, metal, and concrete where people spend hours cutting, drilling, and performing other tasks to test a tool's reliability. DeWalt also has a lab in which technicians test batteries by constantly charging and discharging them under high-temperature conditions.

In the drop-test lab, DeWalt staffers subject tools to shock. The lab contains a tower that can raise a tool up to 20 ft and drop it to a concrete floor. While this test is important, contractors may drop tools from greater heights. So, after a tool passes an indoor drop test, technicians will go on the building roof and drop

FIGURE 5. A battery charger built into a radio provides charged batteries and entertainment. Courtesy of DeWalt.

tools about 25 ft. "The building maintenance people keep telling us to get off the roof," said Sanford.

DeWalt's facility also includes a semi-anechoic chamber that lets engineers measure the sound a tool produces. "Sound measurements are important because European regulations require that tools not produce sound that can damage a person's hearing," said Sanford. "There are no such requirements in the US now, but they will come."

An airflow lab lets engineers analyze how much air exits a tool. The engineers also control airflow to see how much air a tool needs in order to run cool enough to minimize motor burnouts.

In the sound and vibration lab, a shaker table simulates a tool transported in the back of a truck. "Our goal is to break everything and see that our tests exceed user expectations," explained Sanford.

In addition to surviving drops, power tools used at construction sites must survive being run over by trucks. Engineers will drive a pickup truck over a battery or charger, then verify that it still works. These and other tests let DeWalt engineers learn how to improve their product so that contractors can keep on building. T&MW

New standards embrace the principles of boundary scan while extending its reach to complex ICs, PCBs, and systems.

MOVING BEYOND IEEE 1149.1

BY STEVE SCHEIBER, CONTRIBUTING TECHNICAL EDITOR

FIGURE 1. **Boards like this Mixed Signal I/O Module PXI 5296 that plugs into the PXI bus can turn a conventional PC into a multipurpose test instrument.**
Courtesy of Goepel electronic.

When the JTAG (Joint Test Action Group) standard that became IEEE 1149.1 first emerged some two decades ago, it launched a paradigm shift in the way that electronics manufacturers looked at both control and test issues on PCBs (printed-circuit boards). In the ensuing years, additional standards (and standard proposals), as well as changes in the way that companies have applied 1149.1, have improved the usefulness of boundary scan and have widened its acceptance. At the same time, JTAG-related tools and their implementation have considerably surpassed the original intent of the standard's creators.

The evolution of boundary scan

Many in the industry regard IEEE 1149.1 to be synonymous with "boundary scan." Yet, boundary scan predates JTAG, originating as LSSD (level-sensitive scan design), which was developed by IBM in the late 1960s. The technique provided a way to conduct functional tests on PCBs where the logic was no longer accessible from the edge connectors. But LSSD never received universal acceptance.

Peter van den Eijnden, president of JTAG Technologies, commented, "Boundary scan isn't a solution, it's a method. In that respect, it's like built-in self-test [BIST]. The *concept* of BIST is pretty much universally accepted. How to accomplish it is not." IEEE 1149.1 provided a standard structure for the method's implementation.

CJ Clark, president and CEO of Intellitech and past IEEE 1149.1 chair, explained, "While the focus by some has been on boundary scan, the first half of 1149.1 is the Standard Test Access Port, or TAP. The TAP has provided a uniform method for accessing on-chip test resources at the component, board, and system levels. We use the TAP to give us boundary-scan capability and the ability to emulate CPUs for functional test and silicon debug, as well as the ability to perform FPGA [field-programmable gate array] programming, flash programming, on-chip and external memory BIST, logic/PLL [phase-locked loop] BIST, and even things like system-level SerDes test. Because 1149.1 is low contact, structured, and reusable at different phases of integration, it's the only test method that can be easily embedded in the PCB and thereby give the engineer the data needed to correlate failures at these different phases."

Much of the initial clamor for adopting boundary scan and incorporating the TAP stemmed from the disappearance of conventional bed-of-nails access to PCBs for in-circuit test. Andrew Levy, director of strategic business development for Corelis, put it this way: "Boards and systems containing BGA [ball-grid array] components and other dense packaging have become dependent on boundary-scan-based structural testing because it provides electrical access even when physical access is either not cost-effective or not feasible at all."

Once IEEE 1149.1 and the TAP emerged as test tools, engineers soon found other ways to use their capabilities. "Over the years, JTAG has become the standard method for performing on-board device programming," Levy continued. "Programming flash memories, EEPROMs, CPLDs, FPGAs, and other devices after board assembly helps assure proper version control and therefore correct board function."

Other test standards emerge

Since the inception of IEEE 1149.1, additional standards have broadened engineers' ability to apply its principles in the real world (**Table 1**). IEEE 1149.4 addresses the test of analog circuits. IEEE 1149.6 covers advanced digital networks requiring high-speed interconnects. Where adding the four or five pins necessary for the TAP proves excessive—in commodity parts, for example—proposed standard P1149.7 describes a more compact version that requires only two extra pins while adding test functionality.

IEEE 1500 deals with chip-level test, aiming specifically at the current crop of systems-on-a-chip. IEEE 1532 defines unified programming commands for programmable devices (mainly CPLDs) and defines a language format for describing programming algorithms and accompanying data. Van den Eijnden commented, "Using 1532, a manufacturer can program PLDs from different vendors simultaneously, reducing the total programming time for the board."

Proposed standard P1581 offers an economical alternative to boundary scan for memory devices by minimizing the overhead required to implement it. Proposed IEEE P1687—also known as IJTAG (Internal JTAG)—specifies a methodology for automating, accessing, and analyzing the output from embedded instrument functions on the chips themselves. There is even an ongoing effort to use the TAP capabilities at the system level, although this so-called SJTAG is only in the very earliest stages. "Besides," van den Eijnden added, "it is quite feasible to perform system-level boundary-scan operations using the existing structures of 1149.1 and a variety of standard off-the-shelf system-level devices such as National Semiconductor's Scan Bridges."

Elaborating on P1687, Al Crouch, chief technologist for core embedded instruments at ASSET InterTech and vice-chairman of the IEEE P1687 working group, observed, "The latest, and perhaps the most significant, application for JTAG is emerging now as semiconductor vendors and system manufacturers embed instrumentation functionality into chips. This embedded instrumentation can be defined as logic that is designed into semiconductors and which is used for design validation, test, debug, yield analysis, and other activities. The goal of the P1687 IJTAG working group is to develop a standard way of connecting, accessing, analyzing, and describing embedded instrumentation intellectual property regardless of where it comes from, such as a chip supplier, third-party provider, EDA tool, or an in-house design group."

Intellitech's Clark provided historical perspective: "There isn't a new concept with IJTAG. We've been working with on-chip instruments for years, just with a bit more pain. What we're doing in P1687 is standardizing on the register-access mechanisms, standardizing on the hierarchical description language that describes how to access the registers, standardizing on a procedural description language for describing the scans to the on-chip registers, and standardizing on a high-level language to describe the instrument operation using Tool Command Language. The goal is to allow more automation with EDA tools and test tools, allow instrument providers the ability to provide descriptions and operational behavior at the instrument level and not the IC level, and allow plug-n-play operation for the engineer at the PCB or system level. What I see happening is more focus on using these IEEE standards for test and less on ad-hoc test methods."

"The technology of JTAG has proven an efficient and cost-effective method for accessing registers, functions, and memory inside today's microprocessors," said Levy at Corelis. "Most processors already include a TAP for CPU emulation. It is used primarily for real-time firmware debug and development as well as for device test. There are even CPU-based devices that contain a debug TAP, but the implementation doesn't provide conventional scan-chain support to permit a true boundary-scan test and is therefore technically not 1149.1 compliant. Once the processor is installed on the board, however, the TAP pins can permit control by off-board software, thereby facilitating board-level real-time software/firmware debug."

Levy added, "We proved that TAP-based structural and functional testing can be combined by seamlessly integrating boundary-scan and at-speed CPU functional testing into a development environment where the test engineer is not required to have embedded software-development skills and both boundary-scan and functional tests are generated automatically."

Such applications of JTAG principles help companies cope with the realities of manufacturing in today's environment.

Table 1. IEEE standards related to boundary scan

Number	Title	Date
1149.1	Test Access Port and Boundary-Scan Architecture	1991
1149.4	Mixed-Signal Test Bus	1999
1149.6	Testing Differential and AC-Coupled Interconnections Between ICs on Circuit Boards and Systems	2003
P1149.7	Reduced-Pin and Enhanced-Functionality Test Access Port and Boundary-Scan Architecture	Proposed
1500	Testability Method for Embedded Core-Based ICs	2005
1532	Boundary-Scan-Based In-System Configuration of Programmable Devices	2000
P1581	Static Component Interconnection Test Protocol and Architecture	Proposed
P1687	Access to Embedded Test and Debug Features Via the Test Access Port	Proposed

"Ever-shorter life cycles and a shift from making high-mix products at low volumes to high-mix at higher volumes driven by customer calls for 'customization' have spurred the drive for cost-effective test solutions, as well as higher test coverage and faster programming times," commented Raj Puri, VP of US marketing and sales for Goepel electronic.

Options for test setups

One trend driving the adoption of boundary-scan techniques is manufacturers' search for viable alternatives to "big box" testers. Companies are seeking to control costs and maintain profit margins despite the perpetual shrinking of components and their circuit features. The cost and time necessary for constructing test fixtures along with the vanishing node access discourage reliance on conventional in-circuit test, while the rising cost of test development similarly dampens enthusiasm for comprehensive functional test. The efforts expended to test complex products are adding to development times and creating bottlenecks that threaten throughput. As manufacturing cycles continue to get shorter and pressure to cut costs continues to accelerate, even desktop instruments begin to feel like luxuries.

A migration toward multipurpose and more versatile instruments provides one solution. Tools like National Instruments' LabView enable conventional PCs to perform a plethora of instrument functions using plug-in boards (**Figure 1**). Recently, system manufacturers have begun to incorporate instrument functions into the products themselves.

Glenn Woppman, president and CEO of ASSET InterTech, saw the advantages of getting his company to enter the embedded instruments arena as early as possible. "If the instrument function consists of intellectual property residing in the product itself, you can use it early on for design validation," he said. "You can then apply that same capability during manufacturing and throughout the product life cycle for such activities as functional validation, silicon debug, and structural testing. This ability to reuse the same set of tools represents a considerable cost savings over the more traditional approach where you develop one test strategy for the manufacturing step and another one for implementation after the product ships to customers."

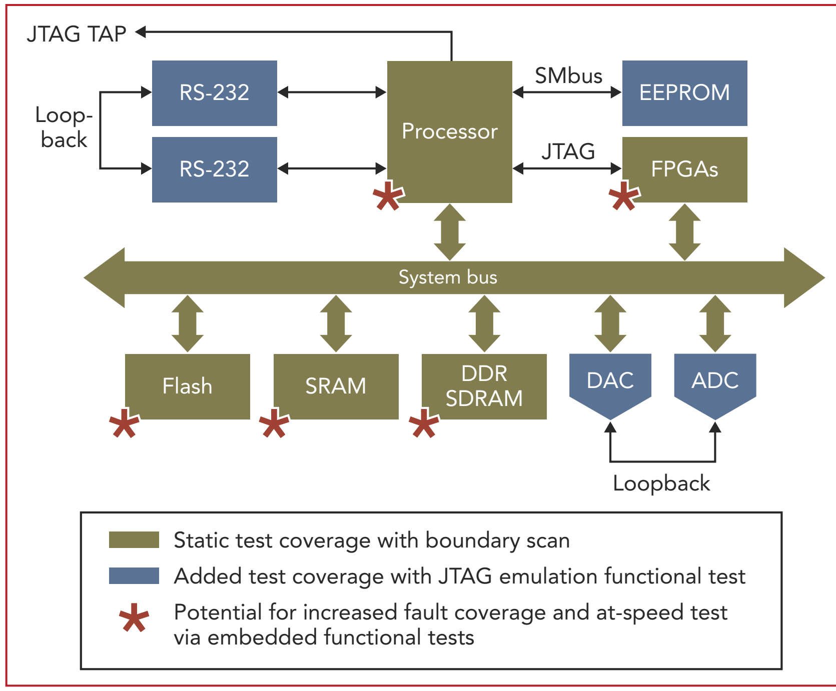


FIGURE 2. Even noncompliant microprocessors often include a TAP that can be used to emulate the function of an entire board. Courtesy of Corelis.

Levy at Corelis commented, "In fact, test commonality means that anyone's contributions to the product's test or debug become intellectual property that can be used by everyone throughout the life cycle. The ability to use such tools for field repair can reduce those costs considerably, such as by reprogramming and repairing units in the field while at the same time cutting the number of faulty boards that you have to ship back to the factory for rework."

Simon Payne, CEO of XJTAG, emphasized the advantages of interoperability and reuse from very early in the design cycle. "Suppose you have created a design and it is ready to send for layout. Ideally, you would like to accurately assess test coverage before committing to the manufacture of physical boards.

"It could prove disastrous if, say, your scan-chain circuitry is hooked up incorrectly, particularly for those who rely on the JTAG chain for debugging, testing, and programming. If you don't discover such an error until you get the hardware back, a respin of the board may be required that—when added to long component lead times—could set your project back for months. Since software teams generally depend on having a physical board to complete software development, that delay pushes their portion of the project time line back as well. If before the boards are manufactured you could say to the vendor, 'the test-data-input and test-data-output lines are wrong. Can you uncross them for me?' That simple step substantially reduces your development cycle."

Payne continued, "By providing reusable code, tests can be developed rapidly to cover both JTAG and non-JTAG devices. That way, by the time you get the prototype back from the vendor, you have already written the tests—not only for verifying that the design is valid but [for] giving you a means to test the components installed by contract manufacturers."

Another approach takes a page from in-circuit emulation, which in generations past exercised a microprocessor-based board by overriding or replacing the processor's functions. Although today's boards do not permit such indignities, boundary-scan architectures allow engineers to use the existing TAP on even noncompliant processors to provide the same level of control (**Figure 2**).

JTAG Technologies' van den Eijnden put it this way: "If microprocessors and

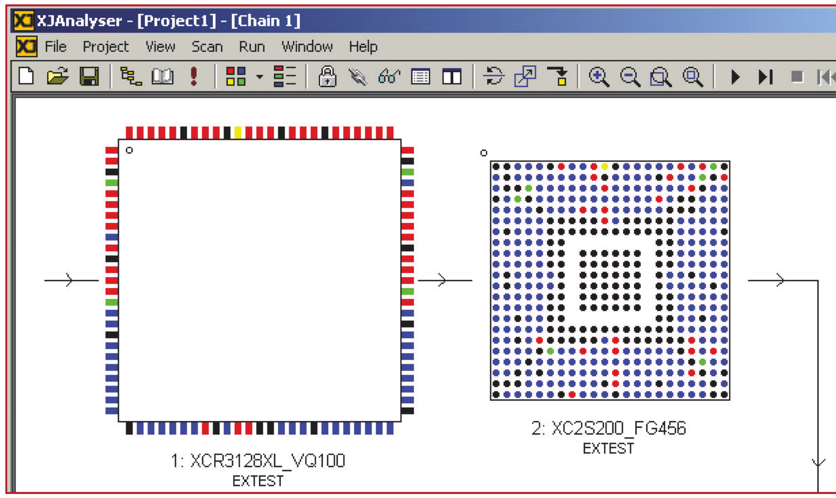


FIGURE 3. **This graphical visualization of a BGA chip comes from XJTAG's XJAnalyser.**
Courtesy of XJTAG.

complex peripheral devices were equipped with boundary-scan registers, emulation test would not be necessary. The peripherals, including all I/O, could easily be tested by manipulating the interconnected boundary-scan cells. But when a boundary-scan register is not available, testing for proper connections—that is, manufacturing defects—is only possible through a quasi-functional test that uses the microprocessor to write to and read from the peripheral devices in a controlled way.

"At the same time," he continued, "a processor that includes a boundary-scan register permits more extensive testing of that portion of the board. And if the peripheral devices, including memory devices, are JTAG compliant as well, the testability level increases dramatically. With a relatively small investment in silicon, chip vendors could have a major beneficial impact on board-level testability."

Where boundary scan is headed

Critical to the success of JTAG-based standards is their acceptance by designers as well as manufacturing people. Yet, designers still resist any constraints on their creations that look like test. "Designers have knowledge that can be useful to test engineers," Payne commented. "If testing starts with what you already know at the design stage, it gives you a head start. We have clients who have achieved test coverage of over 90%."

He added, "XJTAG has taken several steps to get designers onboard. We've abstracted the process away from 'test vectors' in favor of the more familiar environment of a programming language. We are so convinced that boundary scan is the future of hardware debug and testing that we allow engineers to freely try our system. That way, they can see firsthand what is possible using the JTAG scan chain on their own designs [**Figure 3**]. To increase awareness, we have produced a large number of case studies with design companies and contract manufacturers to demonstrate the benefits of using boundary scan throughout the product life cycle."

Likewise, Woppman at ASSET InterTech sees the teaming of boundary-scan companies with EDA vendors as critical. "In terms of embedded instrumentation, it is very critical for us to partner with EDA vendors, and that's what we've done with all three of the big EDA companies," Woppman said. "The EDA suppliers are at the beginning of the embedded instrumentation ecosystem, and tool vendors, like us, facilitate the effective deployment of embedded instruments later in the cycle."

Goepel's Puri emphasized the flexibility of the hardware and software test architectures to accommodate the new standards as they emerge. "The architecture has to be designed from the ground up to be scalable, modular, and integrated. At the same time, providing a single synergistic open platform is key. You partner with IC manufacturers, EDA companies, and ATE suppliers to find solutions for all stages from design validation to field repair."

Van den Eijnden speculated, “Boundary-scan equipment must also be able to deal with reduced pin count and mixed 1149.1 and 1149.7 chains, including the system-level characteristics of systems-on-a-chip, where a single device might include multiple TAPs.

“Internal JTAG—P1687—tries to standardize access to instruments embedded in silicon,” he continued. “That effort resembles development of the SCPI [Standard Commands for Programmable Instruments] language that unified instrument commands in the days of IEEE 488. SCPI allowed commands to become independent of the instrument vendor. P1687 will have to define a similar approach.”

Levy predicted tighter coupling of boundary-scan capability into other test equipment. “Boundary scan has existed primarily independent of other board-test steps. Better integration will make it easier for customers to justify purchase of those larger test systems. There is still room to further optimize integration with IC and board testers to leverage the respective strengths of the boundary-scan and the host test systems.

“In general, more IC manufacturers are including test-access ports because their device packages prevent other approaches to structural testing. They are also adopting IEEE 1149.6, which supports testing AC-coupled and differential signals. As a result, boundary scan will find its way into a number of applications that until now have resisted it.”

Van Eijnden concluded, “Of course, it is important to understand the capabilities of any standard, but you also have to keep its actual application in mind. Ultimately, deciding to adopt a standard or a combination of standards should be based on the application, not on the standard itself. What may prove useful to you or your tools vendor for one application may turn out to yield no benefit somewhere else. In the final analysis, your judgment should always depend on what is best for your company and your customers.” T&MW

FOR FURTHER READING

For more about the history of the standards mentioned in this article, see:

Bonnett, David, “IEEE 1149.1 yields new standards,” *Test & Measurement World*, April 2002. www.tmworld.com/article/CA202501.html.

Ethernet switch supports IEEE 1588

Test and industrial-automation equipment can use the IEEE 1588 protocol to obtain synchronized clocks for precise measurement timing within a LAN. The SyncSwitch TC100 1U-sized Ethernet switch from Symmetricom acts as a "transparent clock," letting synchronization packets pass through it from a grandmaster clock to network nodes. The switch supports both E2E (End-to-End) and P2P (Peer-to-Peer) transparency, which the 2008 revision of the IEEE 1588 standard defines.

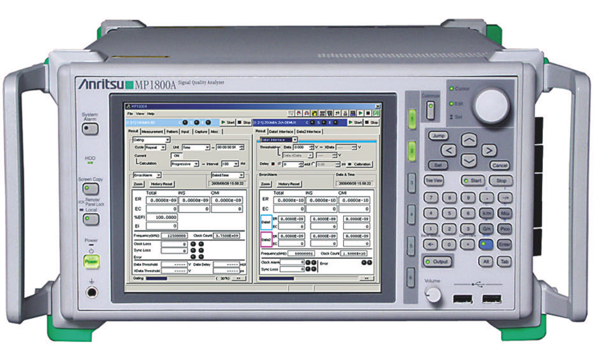
Equipment that supports IEEE 1588, such as LXI Class A and Class B instruments, can use the protocol to synchronize measurements. The SyncSwitch TC100 has eight 10/100BaseT/TX copper ports, but you can replace up to two ports with 100BaseFX single-mode or multimode fiber.

Although the SyncSwitch TC100 can plug into a network without needing to be configured, you can customize the switch through a Windows GUI to configure it for ring topologies, eliminate unnecessary multicast traffic, and provide remote management and monitoring.

Base price: $5195. *Symmetricom, www.symmetricom.com.*

Analyze the highest speed signals

Anritsu has introduced several I/O cards for its MP1800A signal analyzer that let you analyze optical signals for IEEE 802.3ba, the draft standard for 40-Gbps and 100-Gbps Ethernet. The instrument now has single-channel and dual-channel 28-Gbps mux and demux cards, a 14-Gbps PPG/ED (pulse-pattern generator/error detector), and 14-GHz clock distributor cards. You can combine 25-Gbps lanes to create 100-Gbps or 40-Gbps Ethernet implementations for testing systems and components to IEEE 802.3ba. With the MP1800A, you can measure bit-error rate and measure timing and skew across the lanes. The PPG/ED card generates PRBS (pseudorandom bit sequence) up to PRBS 2^{31}–1 (PRBS31) and shorter patterns (PRBS7, 9, 10, 11, 15, 20, and 23). You can also add all 0's and all 1's to PRBS patterns up to PRBS23 for performing CDR (clock data recovery) tolerance tests.



Base price: $40,000. *Anritsu, www.us.anritsu.com.*

SemiProbe announces LA-150 Lab Assistant probe system

SemiProbe has created a low-cost multifunctional probe system suitable for university and industrial R&D applications that involve simple probing operations yet require system stability, flexibility, and reliability. The LA-150 Lab Assistant comes in both DC and RF/microwave configurations, both of which allow individual manipulator or probe-card contact to the DUT (device under test).

The standard configuration comes with two DC manipulators; a trinocular, stereo zoom microscope; a 150-mm vacuum chuck; and a platen that provides 360° of manipulator placement. Manipulators are magnetic-based and are supplied with coaxial probe arms and a clamping collet to securely hold the probe needle. The microscope is mounted on a boom pole, allowing the scope to be swung away from the probing area during setup. The large platen has a removable front panel to allow for easy loading and unloading while still providing full front manipulator positioning capability.

Built into the platen is a standard 4.5-in. probe-card holder. The hinged platen allows for a simple break-contact operation for all probes and also allows for adjustable platen planarity. The system features a full 25 mm of adjustable z-axis movement and 360° of theta rotation. Gross positioning of the 150-mm chuck is accomplished using a magnetic mount-and-release system. The system may be upgraded to add x-y linear stages (chuck and microscope), a CCTV system, vibration isolation, a thermal chuck, and additional manipulators with a variety of probe arm and base choices.

The 60-lb system comes in a single crate and can be ready to use in less than an hour.

Base price: less than $10,000. *SemiProbe, www.semiprobe.com.*

AC electronic loads deliver up to 4500 W

Chroma's 63800 series of AC electronic loads is intended for testing UPSs (uninterruptible power supplies), batteries, off-grid inverters, AC sources, and other power devices such as switches, circuit breakers, fuses, and connectors. Each load can simulate conditions under high crest factor and varying power factors with real-time compensation, even when the voltage waveform is distorted. This feature provides real-world simulation and prevents overstressing to obtain unbiased test results.

The series comprises two models. The Model 63803 provides 1800 W of power at 0 to 15 A RMS (45 A peak, continuous) and 50 V to 350 V RMS. The Model 63804 provides 4500 W at 0 to 45 A RMS (135 A peak, continuous) and 50 V to 350 V RMS. These units let you measure critical timing parameters, such as battery discharge time, trip time for fuse and breaker testing, and UPS transfer time.

You can also simulate nonlinear rectified loads using the 63800's RLC mode, which improves stability by detecting the impedance of the UUT (unit under test) and dynamically adjusting the load's control bandwidth to ensure system stability. Other measurement functions allow you to monitor the output performance of the UUT. Additionally, voltage and current signals can be routed to an oscilloscope through analog outputs.

The instruments' GPIB and RS-232 interface options enable remote control, while built-in digital outputs can be used to control external relays for short-circuit (crowbar) testing. A fan speed control ensures low acoustic noise.

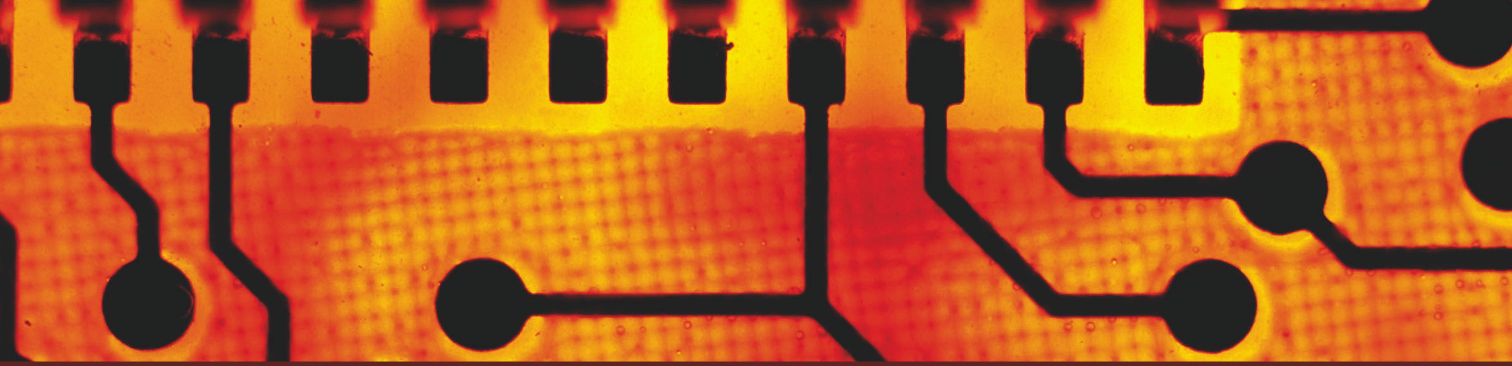
Chroma Systems Solutions, www.chromausa.com

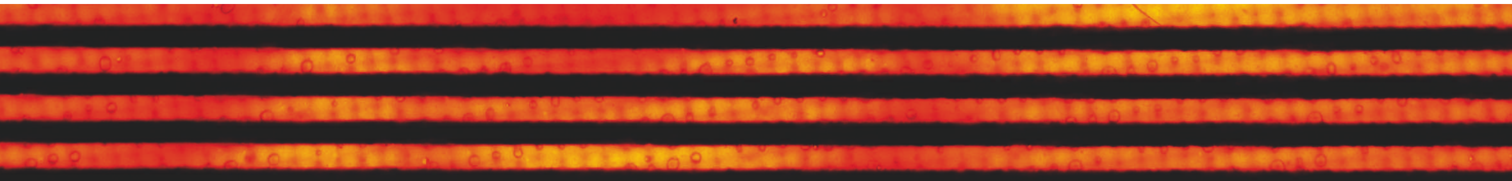
Rigol expands low-end DSO line

Adding to its family of digital storage oscilloscopes, Rigol Technologies has unveiled the DS1102E, which delivers a bandwidth of 100 MHz, a real-time sampling rate of up to 1 Gsample/s, and as much as 1 million points of long memory depth on a single channel. The company has also introduced a 50-MHz model, the DS1052E.

When using both channels of the DS1000E series scopes, you can achieve a real-time sampling rate of 512 Msamples/s with up to 512 kpoints of memory on each channel. The 100-MHz model provides an equivalent sampling rate of 25 Gsamples/s, while the 50-MHz instrument provides an equivalent sampling rate of 10 Gsamples/s. Both offer 20 automatic measurements, trigger modes, math functions, a digital filter, a waveform recorder, and USB and RS-232 interfaces.

Prices: DS1052E—$595; DS1102E—$795. *Rigol Technologies, www.rigolusa.com.*





CCD sensors boost frame rates

By Ann R. Thryft, Contributing Technical Editor

Progressive-scan cameras used in semiconductor and electronics inspection produce images of objects moving down an assembly line by imaging an entire object in one shot, a process that generates high-quality images but tends to create manufacturing bottlenecks. As engineers demand faster camera frame rates to speed up production line throughput, manufacturers of progressive-scan cameras are designing new sensors to improve camera performance. Michael J. DeLuca, marketing manager for Eastman Kodak's Image Sensor Solutions group, discussed how newly designed progressive-scan CCD image sensors can boost frame rates and image quality while lowering system costs.

Q: What are engineers looking for in progressive-scan cameras?

A: In semiconductor and electronics inspection, there's always a need for faster frame rates and higher resolution. Users also want greater sensitivity (meaning the ability to get clear images at low light levels) as well as reduced costs. On top of all this, cameras need to match standard optical formats, such as ½ in. and ⅔ in., since this increases compatibility with a wide range of lenses.

There is also a trend toward smaller lenses, since they weigh less, cost less, and take up less space than bigger lenses.

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Q: How can image sensors help improve camera performance?

A: You can improve imaging performance by reducing pixel size to get more pixels in the same area. For example, one of the new sensors in our Interline CCD family, the KAI-02050, is a 2-Mpixel, 1600x1200 device in a ⅔-in. optical format. Because it is based on a 5.5-micron pixel, about half the size of our previous-generation 7.4-micron pixel, the sensor contains twice the number of pixels in the same optical format as before.

Alternatively, you can get the same number of pixels in a smaller optical format, which helps reduce camera size and allows the use of smaller and less expensive optics. For example, another member of this family, the KAI-01050, fits 1 Mpixel in a ½-in. optical format, instead of the ⅔-in. size necessary for the previous-generation 1-Mpixel sensor.

We also increased the potential frame rate of all the sensors in this family by doubling the number of outputs, which helps improve system throughput. The KAI-02050, for example, operates at a maximum 68 fps, compared to 35 fps in the previous-generation 2-Mpixel sensor.

Michael J. DeLuca
Marketing manager
Eastman Kodak, Image Sensor Solutions

Q: What else can be done to improve progressive-scan cameras?

A: Camera makers also want the ability to leverage camera electronics across multiple models to help reduce cost. This can be achieved by basing several sensors on the same design platform, using the same ceramic package that contains the sensor chip, and using the same electrical pin definitions, making them all plug compatible. This is true of the sensors in this family. Because the sensors operate the same way, it's easy for camera manufacturers to leverage an existing design when a new sensor becomes available, bringing a new camera and its new sensor technology to market faster.

In addition, since smaller pixels can't collect as much light as bigger pixels, they aren't usually as sensitive under low-light conditions. In moving to this new technology platform, however, we made sure that key imaging parameters like sensitivity and dynamic range stayed the same. □

EDITOR'S NOTE

Vision market's ups and downs

Ann R. Thryft, Contributing Technical Editor

As the world economy has gotten rockier, the effects are playing out in machine vision along with the rest of electronics and semiconductor manufacturing and test. Research presented at the Vision 2008 show in Stuttgart (p. 45) demonstrates a mixed bag: While revenue increased last year as expected, in 2009 growth will be flat.

But holding steady these days can be considered an achievement in almost any market. Automotive and electrical/electronics applications remain the largest manufacturing-related revenue generators for machine vision in Europe and Germany. And despite tough economic times, the Stuttgart show produced improvements, in terms of larger numbers of exhibitors and attendees compared to last year.

Meanwhile, the industry is expanding into areas where it hasn't traditionally operated, such as security technology and recycling. Addressing cost-sensitive, mid-volume segments that need to automate identification tasks, the winner of the 2008 Vision Award (at right) was an open-source smart camera system that promises to drastically cut the costs of building cameras and vision systems. At the same time, the strict traceability requirements of electronics and semiconductor manufacturing and assembly processes are increasing the use of vision and imaging technologies in fields such as data acquisition and automatic identification (p. 48). □

Contact Ann R. Thryft at ann@tmworld.com.

HIGHLIGHTS

Frame grabber sports four FireWire ports

The PCIe-FIW64 PCI Express x4 frame grabber from Adlink Technology provides four IEEE 1394b (FireWire) ports for connecting multiple 1394b cameras. The $385 board offers isolated I/O and triggering and delivers data transfer rates of up to 800 Mbps.

Cameras connected to the PCIe-FIW64 draw power directly through the board, reducing wiring. Front-panel LEDs display the status of each channel. The board provides four isolated digital inputs and four isolated digital outputs to connect to external devices such as position sensors. It also furnishes four isolated trigger inputs and four isolated trigger outputs, as well as four isolated, TTL-level programmable trigger output pulses to manage trigger events, such as activating a strobe light. www.adlinktech.com.

Luxo debuts dimmable LED ring light

Maximizing light output and distribution, while preventing glare and reflections, Luxo's dimmable high-output LED ring light can be used for inspection, assembly, and rework applications. Its pure-white LED light makes it useful for inspecting circuit boards, surface cracks and defects, welds, solder joints, flux residues, and hairline stress cracks.

The Model 18743 ring light, which works with Luxo's binocular and trinocular microscope systems, employs 80 high-output LEDs that draw only 18 W of energy and produce up to 5800 fc of illuminance at a working distance of 4.5 in. The LEDs are distributed among two concentric rings of lights and are controlled using eight quadrant switches. A color temperature of 6000 K, combined with dimming to 15% output, enables the ring light to be used with digital equipment such as Luxo's System 373 trinocular microscopes. www.luxous.com.

Smart cameras gain open-source platform

The 2008 Vision Award, presented November 4 during Vision 2008 in Stuttgart, went to Supercomputing Systems, makers of the LeanXcam smart camera based on open-source hardware and software. Reto Baettig, head of the company's vision department, said that the award was made for innovation in the business model on which the camera is based.

"Cameras like this one are not new in machine vision," said Baettig. "But up to now, they have always been higher priced and sold with a complex, expensive software package." Supercomputing Systems is offering an open-source system to reduce costs and enable vision applications in mid-volume segments that require the automation of tasks such as bar-code reading or product identification. The LeanXcam is suited for use with cost-sensitive products manufactured in volumes of a few hundred to a few thousand per year, an area not currently being served, Baettig said.

The camera's hardware design has been simplified and the cost per system greatly reduced, to under 200 euros, said Baettig. Hardware includes a 60-fps, WVGA (wide VGA) CMOS image sensor, a 500-MHz DSP (digital signal processor), and Ethernet I/O. The camera can be purchased as a system, or its schematics, layout, and bill of materials list are available free of charge.

The LeanXcam runs the open-source µClinux operating system. In addition, a software framework and integrated development environment, designed by Supercomputing Systems, are distributed under the LGPL v2 open-source license.—*Ann R. Thryft*

Vision market holding steady

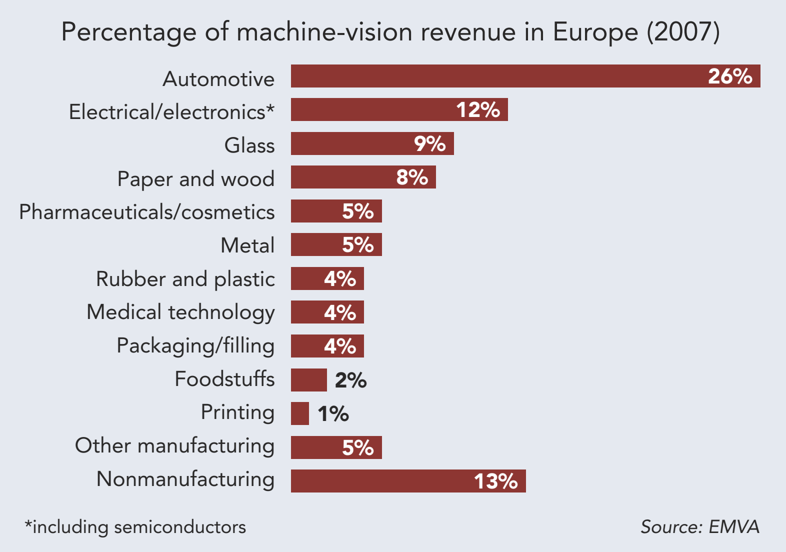
By Ann R. Thryft, Contributing Technical Editor

Despite the current global financial crisis, the European and German machine-vision industries continued to grow during 2008, although revenue will be flat next year, according to research presented by the VDMA (German Engineering Federation) at Vision 2008 (November 4–6, Stuttgart, Germany). The number of attendees and exhibitors and the percentage of exhibitors coming from foreign countries to the event continues to grow, said Thomas Walter, industry and technology area manager for Messe Stuttgart, the producer of the show.

Dr. Horst Heinol-Heikkinen, managing director of ASENTICS and member of the VDMA machine-vision executive board, said at a November 4 press conference that the German machine-vision industry remained on target with expectations for its performance in 2008. The companies that VDMA surveyed expected increases in 2008 revenue totaling 6%, bringing overall machine-vision revenue to 1.2 billion euros. But in 2009, upheavals in international financial markets will likely contribute to a flattening of revenue growth. This will halt the trend established over the past 10 years, which saw the industry more than triple its revenue.

Heinol-Heikkinen also noted that during 2007 more than 40% of machine-vision revenue in Germany came from OEM customers, and the same proportion came from end users. In Europe, the figures for those sectors were 38% and 43%, respectively. Although orders from OEMs had decreased significantly since May, VDMA expected final revenues from that sector to show an increase of 5% in 2008.

Along with the VDMA data specific to Germany, Heinol-Heikkinen presented some Europe-wide market research data from the EMVA (European Machine Vision Association). He said that automotive and electrical/electronics applications have continued to provide the bulk of manufacturing-related machine-vision revenue in both Germany and Europe. In 2007, automotive applications accounted for 29% of total revenue in Germany and 26% in Europe, while electrical/electronics applications represented around 13% in Germany and 12% in Europe.



Automotive and electrical/electronics applications provided the largest percentage of manufacturing-related machine-vision revenue in Europe in 2007.

Heinol-Heikkinen reported that a forecast from the Institute for Economic Research predicts production declines in Germany during 2009 of 1.5% in the automotive sector and 3% in the electronics and communication technology sector. In 2008, automotive production declined by about 1.5%. At the same time, however, production in the electronics and communication segment expanded by 10%.

Despite the overall market stagnation expected in 2009, Heinol-Heikkinen said that a number of new machine-vision application sectors have high market potential. These include agriculture, transportation, recycling, sports, medicine, criminology, and security technology, and he said their emergence is a response to larger "social mega-themes" such as environmental protection, resource conservation, the need for security, and demographic change.

In addition, he cited the ongoing need to reduce costs and optimize processes, which often arises in economically difficult times and has historically been achieved with automation, including machine-vision technologies. Customers' desires to increase quality and safety, as well as develop innovative and miniaturized products, can act as an additional driver for introducing machine-vision technologies into production processes, he said. □

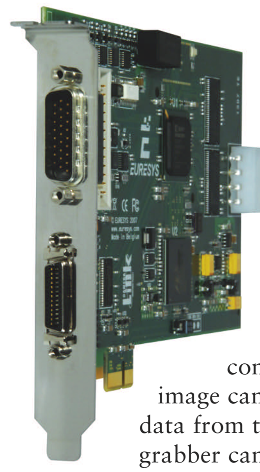
Resampling line-scan camera data

By Ann R. Thryft, Contributing Technical Editor

Line-scan cameras "build" an image by capturing one line of image data at a time as an object moves past the camera on a production line. To avoid image distortion, the camera's line rate must be synchronized with the changing speeds of items passing underneath. A motion encoder typically performs this synchronization, while an electronic shutter controls exposure inside the camera. But a synchronized camera's continually changing speed can decrease its sensitivity and increase image noise. As demand for faster speeds in electronics inspection grows, image quality is suffering, said Marc Damhaut, senior VP of product management for Euresys. "The faster the camera cycle, the shorter the exposure time and the darker the image, so the need for sensitivity is rising."

Most line-scan cameras operate best in a particular speed range. If a line-scan camera could run at a constant speed and produce a fixed number of lines per second to build up an image, and if it could maintain continual exposure without a shutter, it would create less image noise and maintain the same brightness level. These combined conditions would result in higher image quality.

A new technique developed by Euresys called ADR (advanced downweb resampling), which is employed in two of the company's frame grabbers, lets a line-scan camera operate at a fixed rate in its optimum speed range without requiring it to adjust to different speeds outside this range, said Damhaut. Instead, ADR electronics inside the frame grabber process the image and resample it at up to twice the camera's maximum speed. The motion encoder's measurements no longer control the camera. An algorithm in the frame grabber uses the encoder's speed information to continually interpolate the data to form an image.

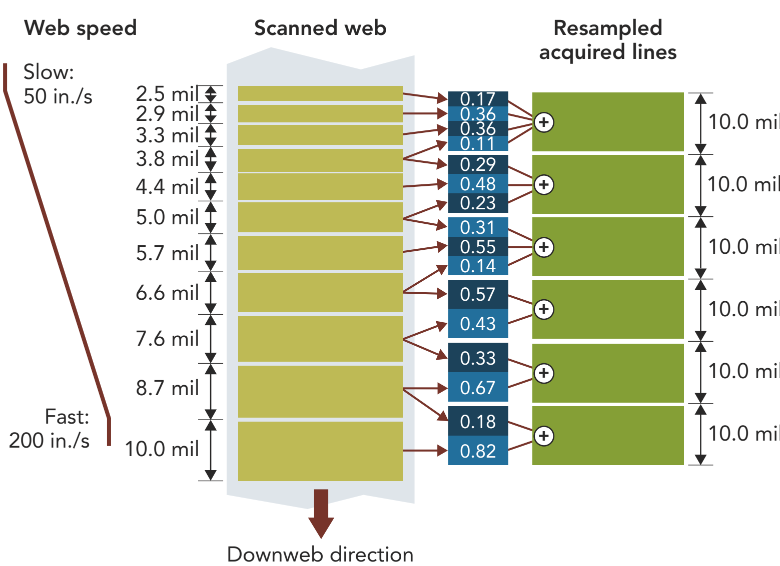


The GrablinkExpress frame grabber contains ADR (advanced downweb resampling) technology for line-scan cameras. Courtesy of Euresys.

Because the camera is constantly exposed, the image can be built out of more data from the object and the frame grabber can perform its computations in real time, so image accuracy is much greater. Image quality increases as a result of both the continual exposure to lighting and the lack of image noise from the disabled shutter's electrical pulses.

One of the main trends driving faster camera speeds is the need to take accurate images of large flat-panel displays, said Damhaut. "These require faster speeds because they are so large and they must be inspected so closely, but throughput cannot be compromised." The combination of size with the needs for close inspection and high throughput poses a challenge to line-scan cameras, which require fairly uniform illumination over the entire field of view. Line-scan cameras also require high amounts of illumination, due to very short integration times, Damhaut said.

Damhaut explained that although no cameras today incorporate the ADR technology, ADR processing could be done by the camera instead of the frame grabber. "You could put a simpler, less expensive sensor inside the camera, such as a fixed-speed CCD or CMOS sensor, implement ADR electronics in the camera, and use it with a standard frame grabber," he said. The advantages in electronics inspection would be similar to those gained from implementing ADR in the frame grabber. □



ADR technology lets line-scan cameras run at a constant speed and maintain continual exposure, which creates less image noise and maintains the same brightness level, resulting in higher image quality. Courtesy of Euresys.

Amorphous silicon x-ray detectors find PCB flaws

By Ann R. Thryft, Contributing Technical Editor

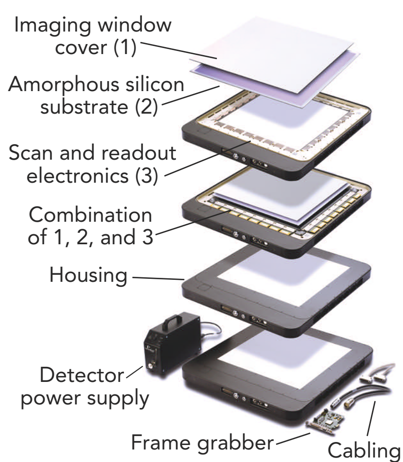
Long used in medical imaging applications, amorphous silicon x-ray detection is moving into the in-line inspection of PCBs (printed-circuit boards). Amorphous silicon, which is among the most common materials used in digital x-ray flat-panel detector technology, acts as a photodiode that converts x-ray energy into an electrical signal. "Digital x-ray detectors provide high-speed, high-throughput, real-time industrial inspection, applicable to the nondestructive testing of PCB boards," said Jeffrey Foote, VP strategic marketing and business development for PerkinElmer's digital imaging group.

Bringing this digital technology into industrial environments proved to be more difficult than it first appeared, said Foote. Although medical and industrial applications demand similar productivity, throughput, and efficiency, the two environments have major differences. "The hurdles we faced included continuous use of the equipment, more rugged operating conditions, and the need for higher x-ray doses," said Foote.

PerkinElmer and other vendors first adapted amorphous silicon digital x-ray detectors for aerospace and automotive manufacturing and inspection environments. "We changed the detector to make the machine more rugged and to make the amorphous silicon substrate last longer in these higher-energy environments," said Foote.

The next step was to adapt the detectors to PCB inspection. "Since the parts are so small, you need very high resolution, but you also need a much larger dynamic range, or contrast resolution," said Foote. "The boards are complex and dense and there are multiple layers, so you need to take image slices in three dimensions, taking 2-D images at multiple depths."

On the other hand, PCBs don't need as high an x-ray energy level as automotive applications, so the lower doses for PCBs are less damaging to the detector. "But other challenges, such as high-speed throughput, are critical," said Foote. PerkinElmer's new amorphous silicon digital x-ray detectors offer twice the output speed of its previous designs, up to 30 fps, and feature 16-bit contrast resolution.



Detectors such as the XRD 1621 N ES provide high-speed inspection for nondestructive testing of PCBs.
Courtesy of PerkinElmer.

The higher contrast resolution enables the detectors to see smaller, subtler defects in components. The size and complexity of PCBs requires a larger field of view, said Foote. The new detector's bigger, 41-cm field of view makes it useful for inspecting either one large board or several smaller ones at a time. A 41-cm field of view is also helpful for inspecting wafers, since they are increasing in size.

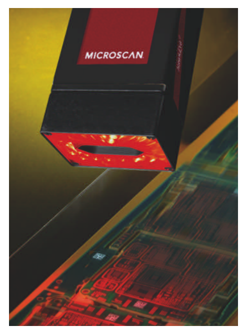
Prices of faster flat-panel detectors have come down recently as the technology has become more available, said Foote. Consequently, these digital detectors are beginning to compete with analog image intensifiers, based on CCD cameras, for the inline inspection of PCBs and wafers. □

Machine vision, data acquisition converge

By Ann R. Thryft, Contributing Technical Editor

Electronics manufacturing and assembly processes are governed by strict traceability requirements. In the most concrete sense, machine-vision technologies ensure that those processes work correctly by identifying defects in wafers, components, and PCBs (printed-circuit boards). In a more comprehensive sense, many of these technologies provide the complete traceability that the industry needs.

The tracking, tracing, and control of components and boards are three different functions in the TQM (total quality management) system a manufacturer implements, said Matt Van Bogart, product manager for Microscan's automatic identification products. "A top priority of plant managers is producing high-quality products as efficiently as possible, so you need to quickly identify a problem and quarantine it. To do that, you need a system for tracking the location of components or products at any given time, tracing where they have been previously and what happened to them there, and determining where they will be sent next, which is control. Without tracking and control, you don't have full traceability."



A HawkEye smart camera reads 2-D symbols on PCBs.
Courtesy of Microscan.

Van Bogart continued, "Item-level tracing can help determine the components and subassemblies of a specific system, and identify where they have been, creating a life-cycle history or lineage of the part. Alternately, tracing can identify problems with a particular machine. You can locate all the parts manufactured on that machine and quarantine them before they get farther down the supply chain." In the control function, auto-ID tasks determine where a part should go next in the process, based on whether it meets the criteria to continue to the next stage.

A manufacturer of data-acquisition and control products for electronics applications, Microscan also sells imaging products for automatic ID, tracking, and tracing. Examples include laser scanners and compact cameras for reading linear and 2-D symbols.

Last fall, Microscan acquired Siemens' machine-vision products, which include smart cameras, imagers, frame grabbers, and software. Siemens had acquired the product line when it purchased the assets of RVSI Acuity CiMatrix in early 2006. Acuity CiMatrix was the developer of the 2-D Data Matrix code. "The former Siemens products now allow us to provide more high-precision control functions traditionally associated with machine vision," said Van Bogart.

Using vision products for ID and inspection is becoming an increasingly important part of data acquisition and control, said Microscan president Jeff Timms. In some cases, high-end, proprietary cameras and software are being supplanted with less-expensive, off-the-shelf technologies.

For example, in a single field of view, Microscan's HawkEye 1600T smart camera reads multiple bar codes and 2-D symbols and also can detect the absence or presence of components, determine whether a part is oriented correctly, and check a component's placement coordinates. "For about $20,000, you have all of the same functions as the big AOI systems," said Timms. "Many machine-vision or track, trace, and control applications don't require the complexity of big, quarter-million-dollar AOI systems." □

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NOAM LOTAN
President and CEO
MRV Communications
Chatsworth, CA

Noam Lotan has served as MRV president and CEO since May 1990. Before that, he was managing director of Fibronics, the UK subsidiary of Fibronics International, a manufacturer of fiber-optic communication networks later acquired by MRV. Earlier in his career, Lotan held a variety of sales and marketing positions with Fibronics and Hewlett-Packard. He holds a BS in electrical engineering from the Technion, the Israel Institute of Technology, and an MBA from INSEAD (European Institute of Business Administration), Fontainebleau, France. Lotan also serves as a director for Capstone Turbine.

Contributing editor Larry Maloney interviewed Lotan by phone on the growing interest in test automation.

How to untangle test complexity

Q: How important is test automation?
A: Test automation is no longer a tool for visionaries. It has become essential to maintaining a technological edge and controlling costs. Customers tell us that they get the return on investment from our physical-layer switch in as little as six months. This is due to increased productivity in lab testing, improved ability to trace problems, and reduced complexity. All this allows companies to get products to market faster at a time when head count may be shrinking. Whenever companies must execute a repeatable test multiple times or test devices with different interfaces in layer one of a network, automated testing is the only way to go.

Q: How do MRV's physical-layer switches change test procedures?
A: Our MCC (Media Cross Connect) family of switches replaces traditional manual patch panels. Engineers can change test configurations with a single software command, eliminating the time-consuming process of physically patching and repatching cables. We call this a "wire-once" solution. It not only eliminates cabling tasks that can consume up to 80% of test work, but it also makes correcting errors easier. With the MCC, engineers can program connections between any ports within the system, and the design is modular, with versions available in 72, 144, and 288 ports.

This tool also allows test equipment to be shared—not just by engineers in a lab, but by colleagues in remote locations through Internet connections. We have network-equipment customers who have engineers in the San Francisco Bay area and in India using the same automated test lab setups on a 24/7 basis. Finally, test automation is a great tool to help resolve conflicts that occur when many engineers use the same lab. Automatic scheduling and priority allocation help you quickly and efficiently reconfigure your test protocols.

Q: Who are your prime customers?
A: First and foremost, network-equipment and storage-equipment manufacturers. They share a common need for automated testing both to speed time to market and to ensure quality in rapidly changing communications devices. Another group of customers consists of major communications carriers as well as large enterprises, such as companies or universities, that must maintain networks across multiple facilities. In all these cases, customers use our automation solutions to validate new gear before it is installed in networks. They also use our equipment to tap into live networks for performance monitoring, such as detecting failures in power or problems with data-transmission rates.

Q: How is the global recession affecting demand for your products?
A: We had a very good 2008. In fact, our network-equipment segment grew by nearly 30% in the first nine months of the year versus the same period in 2007. While we don't expect that kind of performance in 2009, we are confident that our test-automation products will remain in demand because they help companies maintain productivity despite cutbacks in personnel.

Q: Where is your technology headed?
A: We must stay abreast of the data-storage and high-speed-transmission requirements of our customers, including WiMAX and other wireless infrastructure. In November, we announced an MCC physical-layer chassis and interface blade for high-density 8-Gbps Fibre Channel test-lab applications. We are also working on automation solutions for 10-GigE physical-layer standards. Overall, we are strongly committed to test automation and see it as a growth industry. So, we will be developing products for 40-Gbps and 100-Gbps protocols, as well as new storage interface modules. T&MW

Noam Lotan addresses more questions on test automation and communications networks in the online version of this interview: www.tmworld.com/2009_02.