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Test & Measurement World

THE MAGAZINE FOR QUALITY IN ELECTRONICS

Alfred Binder, test-handling manager at Austriamicrosystems.

HANDLING QUALITY

A vision-alignment technique positions Austriamicrosystems' devices for test while the company positions itself as a key supplier in communications, industrial, medical, and automotive markets.

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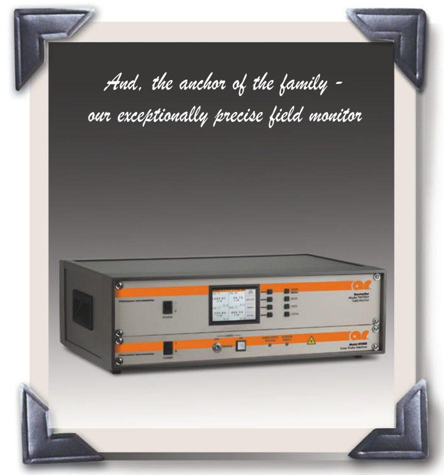
The Bigger Picture!



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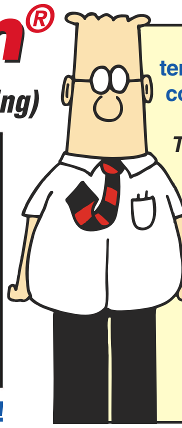

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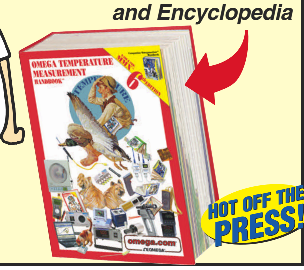

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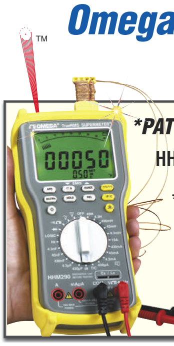

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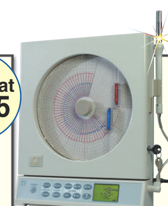

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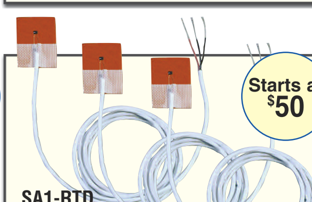

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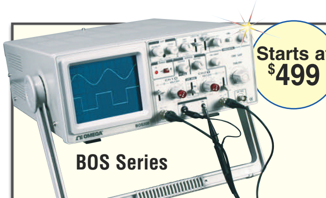

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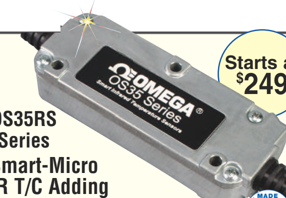

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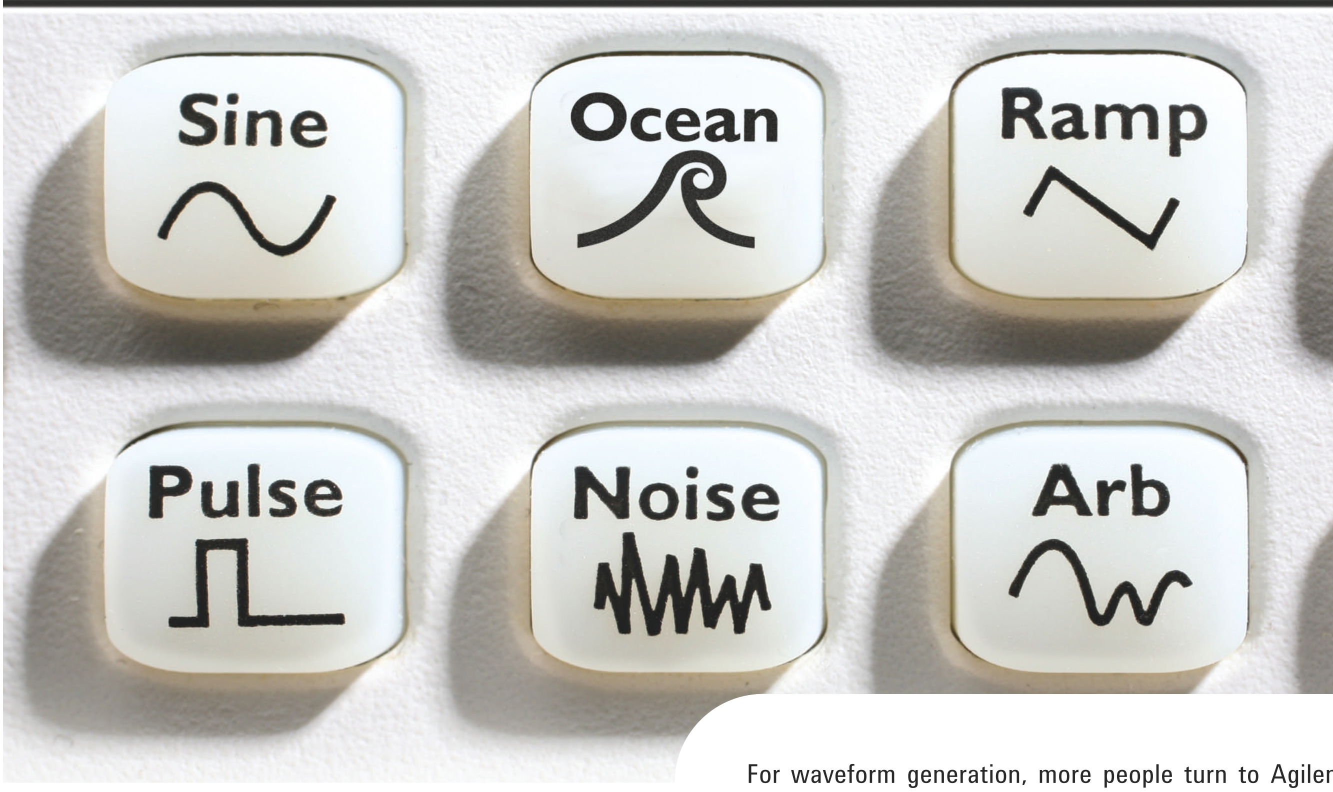

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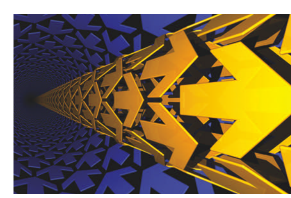

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Glenn Woppman, president and CEO of Asset InterTech, and Billy Fenton, Asset's chief technologist for CPU emulation, discuss how Asset's acquisition of International Test Technologies helps break down the barriers between structural and functional test in an exclusive online interview.

www.tmworld.com/asset_itt

Blog commentaries and links

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Rick Nelson, Chief Editor

- Are you electrosensitive?
  A new study on cell phones' effect on sleep will give the tinfoil hat crowd something to worry about.

Rowe's and Columns

Martin Rowe, Senior Technical Editor

- Excel 2007 has 16 times more rows
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There's still time to vote!

Read about the 2008 Best in Test winners and then cast your ballot for the Test Product of the Year. Voting deadline: February 15.

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From the archives

- **Color enhances inspection results**
  For most machine-vision applications, gray-scale images provide sufficient information, but in some cases, color images add an extra "dimension" that improves inspection results, as contributing technical editor Jon Titus explains in an article from our November 2006 issue.

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RICK NELSON
CHIEF EDITOR

Standards beneficial, but no panacea

2007 would seem to have been a good year for standards, both formal and *de facto*. PXI turned 10 years old, and PXI-based instrument sales are growing at double-digit annual rates, according to Frost & Sullivan research. LXI-equipped instruments achieved $200 million in sales just two years after the standard's 2005 introduction. Although several industry observers have questioned the significance of that figure—wondering exactly how many of compliant instruments' LXI ports actually get used—it seems clear to me that LXI's cost and form-factor advantages and its ubiquity will accelerate its use. Even the venerable VXI is hanging on. Although Frost & Sullivan expects VXI revenues to tail off gradually, new VXI instruments, such as ZTEC Instruments' ZT4610 VXI digital oscilloscopes, were introduced in 2007. In addition, a new VXI-LXI developer's kit from VXI Technology enables hybrid test systems that make the best of both standards.

"A healthy tension drives standards evolution."

On the semiconductor test front, the Semiconductor Test Consortium has not been successful in getting big-iron ATE makers other than Advantest to build OpenStar-compliant test systems, but it has been successful in broadening the consortium's appeal—attracting the attention of companies like LTX—with the STIX initiative, which addresses the mechanical interfaces that surround a tester in a test cell.

The machine-vision industry, too, is riding a wave of successful standards, including Camera Link, GigE Vision, and the DCAM FireWire spec. As for *de facto* standards, data from the VDMA (German Engineering Federation) presented at Vision 2007 shows that sales of standard user-configurable systems, including smart cameras, are growing, while sales of custom single-application systems are falling (see p. 59).

But some events and comments in 2007 highlighted the limitations of standards. Consider smart cameras. Smart cameras from several vendors include standard processors and operating systems, but that doesn't make them standard enough for National Instruments. NI is not averse to supporting third-party cameras—it resells GigE Vision and FireWire cameras from Basler. But the company decided to create its own smart-camera line-up in order to ensure the cameras would represent a true LabView target that NI engineers would have complete control over, according to NI vision product manager Matt Slaughter (p. 57).

Consider, too, the semiconductor EDA-to-ATE interface. Ajay Khoche of Verigy and Wu Yang of Mentor Graphics comment on the benefits of such a standard on p. 45. But despite efforts such as the Semiconductor Test Consortium's STIL initiative, a commercially feasible standard EDA-to-ATE interface remains elusive. That, in part, motivated Verigy to acquire Inovys. Larry DiBattista, the senior manager at Verigy responsible for the Inovys initiative, said that Verigy and Inovys needed much tighter levels of integration with each other's respective tools to help isolate root causes of failures detected by a V93000 tester. "We really needed to establish a much tighter loop with the Inovys software," he said, adding, "The Verigy purchase of Inovys made sense as the optimum way to provide the much tighter level of integration we needed."

These counterexamples represent not a repudiation of standards efforts—they rather suggest a healthy tension that will drive standards' evolution as individual vendors strive for competitive advantages with proprietary approaches. T&MW

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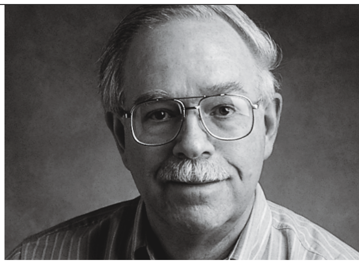

Sometimes, a voltmeter is all you need

Two days before Christmas, our two-year-old Toshiba DVD player refused to play. Its 90-day warranty had long expired, and even if I could find a service shop, repairs would cost far more than a new player. Like most consumers, I immediately thought about purchasing a replacement. Venturing into holiday traffic and retail madness, however, didn't appeal to me. Surely, my collection of state-of-the-art (circa 1994) test equipment could see me through the repair process?

On the minus side, I had no schematic diagram for the DVD player. And given manufacturers' propensity to pack ever more functions into custom-designed, fine-pitch "jungle" ICs, a major component failure would be irreparable.

Gaining access to the DVD player's innards proved surprisingly easy. I removed three screws and a thin sheet-metal cover, revealing three subassemblies—a single-sided power-supply board, a disc transport, and a double-sided multifunction board. I connected the player's audio outputs to my workbench audio amplifier and loaded Miles Davis' "Kind of Blue" CD. The disc spun and music played, albeit weakly and with great distortion—Miles sounded as if he were spitting in his horn.

Thinking that a solder joint had failed, I tapped and wiggled components on the multifunction board, with no effect. Then I recalled the First Axiom of Troubleshooting: Always check the power supply. Fortunately, the supply board's silk-screened component legend specified the voltages conveyed via ribbon cable to the multifunction board.

Reaching for a voltmeter, I quickly discovered that the –12-V output read zero volts. Unsoldering a Zener diode didn't restore the voltage, but unsoldering a 470-µF, 16-V electrolytic capacitor did. I found a replacement in my component collection, and minutes later Miles sounded like Miles should. Incidentally, the failed capacitor appeared perfectly normal, with no bulging ends or leaking electrolyte common to counterfeit capacitors.

So, even if your normal workday takes you far away from electronic hardware, don't be afraid to tackle the next piece of malfunctioning consumer electronics in your household.

Sometimes, a voltmeter is all the instrumentation you'll need. T&MW

WHAT TO DO WHEN YOU DO IT YOURSELF (DIY)

Consumer-goods manufacturers vary greatly in the quality of their post-sales support, but it's always a good idea to visit the manufacturer's Web site and review a copy of the user's manual for a malfunctioning product (if available).

If you've never attempted to service anything electronic, begin by visiting Sam Goldwasser's Repair FAQ Web site:
www.repairfaq.org/sam/wiserfaq.htm

Proceed to the main table of contents:
www.repairfaq.org/REPAIR/F_Repair.html

…and carefully review these safety notes here. Household electronics can kill you!
www.repairfaq.org/sam/safety.htm

This forum offers user-oriented posts for specific product-failure complaints:
forum.eserviceinfo.com

Sams Technical Publishing, founded by the granddaddy of service-information providers, Howard W. Sams, offers schematics and service information for many home-entertainment products:
www.samswebsite.com

If you decide NOT to DIY, you can locate a service shop by visiting the following site. Unfortunately, the NESDA shop closest to our rural New Hampshire home is 52 miles away:
www.nesda.com

These are difficult times for independent electronics service shops caught in a squeeze between the high cost of doing business and the low selling prices of products. For a view from a small service company, go to:
www.consumeraffairs.com/home_electronics/elec_service.html

Not every warranty yields a successful repair. Ripoff Report offers consumer protection information and also a litany of horror stories, many involving large-screen TV receivers:
www.ripoffreport.com/consumer_resources.asp

Credence shrinks to maintain profitability

Credence Systems has reported that it achieved profitability for its fourth quarter and for its fiscal year that ended November 3, 2007. That marks a milestone the company hadn't expected to reach until the end of 2008, according to Lavi Lev, Credence's president and CEO. In an effort to maintain profitability, the company announced a retrenchment that will cause it to shrink by about 30%. The move will result in about 500 job cuts in Europe and North America; about 100 jobs will be added in Armenia and East Asia as Credence augments R&D efforts and regroups to better serve its Asian customers.

In a phone interview, Lev said that the retrenchment will focus the company on the consumer semiconductor test market. "We have a pretty strict filter" that defines the consumer space, Lev said. "We want to go after markets that are constantly growing, and we want to make sure there are multiple customers for our products. Dependency on a single customer is not healthy for a company of our size."

The company will target consumer applications with its ASL, Diamond, and Sapphire (except for the Sapphire DPI) platforms, which represented 53% of Credence's business in 2007, Lev said. He cited the ASL platform (pictured) as a particularly successful one, with more than 3000 systems deployed worldwide and with an estimated 6000 engineers worldwide trained on it. www.credence.com. (*To read our complete interview with Lev, see www.tmworld.com/credence_lev.*)

JDSU acquires Westover Scientific's FO division

JDSU recently acquired the fiber-optic division of Westover Scientific, which manufactures specialized fiber-inspection microscopes that are used to detect dirt and other contaminants in fiber-optic networks. Westover Scientific's fiber test business includes approximately 80 employees and had calendar 2007 revenues of more than $15 million. Its products will be integrated with JDSU's Communications Test & Measurement business. www.jdsu.com.

EADS receives US Navy contract

EADS North America Test & Services has been awarded a multiyear performance-based logistics (PBL) contract for the support of US Navy aircraft engine test systems. The contract is for material support, global repair services, and obsolescence management of the test systems, which are used to test jet and turboshaft engines on Navy fighter aircraft and helicopters.

Awarded by the Naval Air Warfare Center Aircraft Division at Lakehurst, NJ, the contract covers the US Navy's Jet Engine Test Instrumentation (JETI) and Shaft Engine Test Instrumentation (SETI) systems. To date, 32 JETI and four SETI systems have been acquired by the Navy for deployment aboard aircraft carriers and in land-based installations.

EADS North America Test & Services' support initially will be provided in a three-year ramp-up phase, which is to be followed by a 10-year, full-scale PBL program. The total value of the contract is $4.1 million. www.eads-nadefense.com.

CALENDAR

Measurement Science Conference, March 10–14, Anaheim, CA. Sponsored by the Measurement Science Conference, www.msc-conf.com.

APEX and IPC Printed Circuits Expo, March 29–April 3, Las Vegas, NV. Sponsored by IPC, www.goipcshows.org.

SAE World Congress, April 14–17, Detroit, MI. Sponsored by the SAE, www.sae.org.

See our complete calendar at www.tmworld.com/events.

PCB Piezotronics creates aerospace division

PCB Piezotronics has formed a PCB Aerospace & Defense Division group at the company's headquarters in Depew, NY. The group will specialize in products and programs for the aerospace, civil and military aviation, defense, homeland security, nuclear, and test and measurement markets.

Products include space-rated accelerometers; sensors and instrumentation for unmanned aerial vehicles, helicopters, fixed-wing aircraft, and ground vehicles; high-temperature engine vibration-monitoring sensors; and launch and separation shock sensors. The group will also provide targeted applications engineering. Overseeing the new division as senior director will be Ronald J. Livecchi, a 30-year aerospace industry veteran. www.pcb.com.

Agilent wins Asian WiMAX contract

The Telecommunications Technology Association (TTA)—a test and certification institution for Asia—has awarded Agilent Technologies a contract for Mobile WiMAX Protocol Conformance Test (PCT). Headquartered in

(continued on p. 21)

News briefs *(continued from p. 12)*

Korea, TTA provides Mobile WiMAX testing and certification services and will employ Agilent's N6430A Mobile WiMAX PCT and development system in its test platform.

The N6430A provides tools for 802.16-2004/Cor2 D3 Mobile WiMAX PCT and development testing, with a scripting interface to a fully functional radio bearer. The TTA develops standards and provides testing and certification for IT products. It is also a WiMAX Forum Designated Certification Lab. www.agilent.com.

Editors' CHOICE

Spectrum analyzers process "images"

Tektronix has added its DPX waveform image processor to the midrange line of RSA3000B real-time spectrum analyzers, making it possible for you to view the time-varying characteristics of RF signals. The RSA3000B series now lets you use the same color-graded persistence available on the company's high-end spectrum analyzers and oscilloscopes.

With color-graded persistence, the RSA3000B can capture frequency-hopping signals such as Bluetooth and wireless LAN that can interfere with fixed-frequency signals. Other applications include detecting of illegal signals in a frequency band. The analyzer can process 48,000 waveforms/s. You can use the persistence mode to find interfering signals, then switch to frequency-domain triggering to capture, store, and analyze those signals.

The RSA3000B spectrum analyzers include compliance test support for ISO 18000-7, the standard that defines the air interface for RFID products. They also support compliance tests for ISO 15693-3, the standard for vicinity cards.

Base prices: $34,000–$53,000, depending on bandwidth. *Tektronix, www.tektronix.com.*

Isolate and measure EMI on cables

The ISN T8 impedance-stabilization network from Teseq lets you measure conducted common-mode electromagnetic interference (EMI) on up to four unshielded single-balanced pairs of cables. The ISN T8 can couple or decouple equipment under test (EUT) from other equipment necessary to operate the EUT. Thus, you can measure common-mode signals while running your EUT with actual loads. You can use the network to decouple equipment with Ethernet ports up to 1000Base-T from other equipment.

The ISN T8 consists of one basic network (ISN T800) with D-sub-25 connectors and longitudinal conversion loss (LCL) adapter sets for Cat-3 and Cat-5 cables. It has a frequency range of 150 kHz to 30 MHz; maximum line-to-ground voltage is 63 VAC and 100 VDC. Maximum current ratings are 400 mA per line and 800 mA per pair.

Optional connectors include prewired RJ11 and RJ45 adapters (the ADS T800 and the ADS T8x0) for common pin configurations. The ADS T800 adapter set lets you connect RJ45 sockets, and the ADS T8x0 offers changeable pin arrangements with 1-mm banana connectors for all pin combinations of RJ11 and RJ45 connectors.

Base price: $3,890. Teseq, www.teseq.com.

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MARTIN ROWE
SENIOR TECHNICAL EDITOR
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PCs change quickly; test setups don't

Personal computers have changed drastically since engineers started using them to control instruments. Ten years ago, a typical PC had two serial ports and a parallel port. Today, you may get one serial and no parallel ports. Desktop PCs used to have ISA slots. Now, PCI slots are giving way to PCI Express slots.

Today's PCs have as many as 10 USB ports and an Ethernet port. If you need a legacy port, you must buy an adapter or use an industrial computer. Of course, test engineers have been adding IEEE 488 ports to their PCs for years. Many test engineers use adapters for older buses, because change comes far more slowly to the engineering community, where test systems may operate for many years.

That's not to say that the test community hasn't adopted today's I/O ports. Many instruments use USB and require a PC for the user interface and data storage. That started in 1998 when IOtech and National Instruments introduced USB data-acquisition modules (Ref. 1). Today, USB-based oscilloscopes, digital I/O controllers, and logic analyzers are available. Many bench instruments have USB ports. For some, USB is the only I/O port, although instruments still feature RS-232 or IEEE 488.

USB gained acceptance as an instrumentation control bus once USB 2.0 ports became available. "For instrumentation, USB 2.0 was essentially USB 1.0," commented Chuck Cimino, marketing director at Keithley Instruments.

USB flash drives have replaced floppy-disk drives as the easiest way to transfer data between instruments and computers. With capacities up to 8 Gbytes (**photo**), USB flash drives can handle loads of data, and just about every engineer now carries or wears one.

Ethernet is the other major change in communication ports, and it has created a bit of a gap between generations of engineers. "The new engineers coming out of school understand networking far better than they understand GPIB and SCPI," said Brian Fetz, program manager at Agilent Technologies. "The industry is already starting to change, and the change will accelerate."

USB flash drives have become the new floppy disks. Courtesy of SanDisk.

USB and Ethernet continue to evolve. All new PCs have 100-Mbps Ethernet ports—that's plenty of speed for test applications—and some network-interface cards offer 1-Gbps speeds. USB 2.0, currently at 480 Mbps, may evolve into USB 3.0 with speeds up to 4.8 Gbps running over an optical link. USB 3.0 was demonstrated at the 2007 Intel Developer Forum, although it will be several years before that port is available on everyday PCs.

In most test applications, current PC bus speeds are adequate. Many instruments perform data reduction for you, so the PC's processor often doesn't have to process data. For example, many instruments can perform signal processing by using techniques such as fast Fourier transforms (FFTs). Board-based instruments may contain processors or field-programmable gate arrays (FPGAs) that decimate data down to just the information you need. T&MW

REFERENCE

1. Rowe, Martin, "USB Proves Ready for T&M Tasks," *Test & Measurement World*, January 1999. www.tmworld.com/article/CA187554.html.

DASYLab 10 introduced

The DASYLab 10 graphical test-programming software from Measurement Computing adds a module called Diagram, which you can configure for time-domain plotting as Y/t, X/Y, or X/t or as a data-chart recorder. Version 10 also lets you process data, such as for calculating FFTs, in any block size. www.measurementcomputing.com.

Industrial PC has multiple I/Os

Advantech has introduced the UNO-2176 industrial PC, which has four serial ports, two LAN ports, two USB ports, eight digital control inputs, and eight digital control outputs. The computer is powered by either a Pentium M or Celeron processor and runs Windows 2000/XP, Windows XP Embedded, or Windows CE. www.eautomationpro.com/us.

Strategic Test unveils PCIe waveform generator

The new Model 6110 two-channel 125-Msample/s 8-bit arbitrary waveform generator card plugs into a PC's PCI Express slot. Each channel has its own digital-to-analog converter (DAC), and the card provides 4th and 5th order Butterworth low-pass filters for waveform reconstruction, with bandwidths of 25 MHz, 5 MHz, or 500 kHz. www.strategic-test.com.

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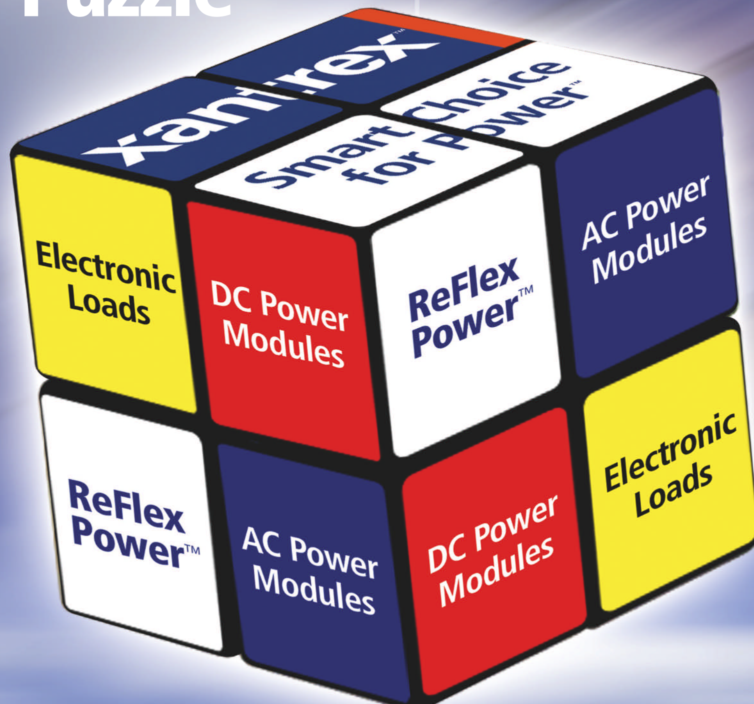

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SUJAN SAMI
SENIOR RESEARCH ANALYST, FROST & SULLIVAN
www.frost.com

Luminous growth in MEMS test equipment market

Microelectromechanical systems (MEMS) include several mechanical elements, such as sensors and actuators, that are integrated on a common silicon substrate through microfabrication technology. MEMS can also be referred to as smart matter, micromachines, or microsystems technology (MST).

The MEMS industry has witnessed large growth rates in recent years in applications including cell phones, digital still cameras, camcorders, laptops, MP3 players, and robots. The market for MEMS device test, however, has not grown significantly in comparison to the growth of the MEMS device market itself. One reason for that lack of growth remains the lack of education among end users on the importance of testing MEMS devices.

Dual testing of MEMS devices

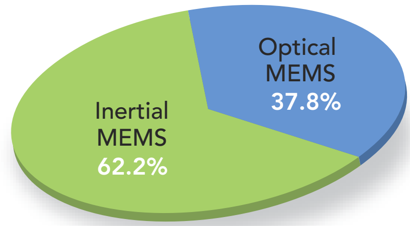
MEMS devices contain electrical and mechanical components. In today's testing environment, it is much easier to test the static electrical characteristics using test methods such as wafer probing, electrical trimming, and final test at temperature. Mechanical testing verifies the resistance to mechanical shock, stiction, and other MEMS-specific failure modes.

The vendors in the MEMS test market face a huge challenge to perform dynamic testing on the MEMS devices. A new generation of test equipment is required for testing under severe conditions—such as high temperature, pressure, and humidity—and the new equipment must account for stiction, which refers to the friction between moving parts inside a chip due to factors such as over-range of input signals or electromechanical instabilities.

Wafer-level testing

Testing of MEMS devices at an early production or preproduction stage is essential to reducing production costs and time to market. Once the packaging is complete, any test results for a failed device will lead to an increase in production costs. The market is slowly moving toward a situation where there are several solutions available for testing MEMS devices under environments such as high pressure, near-vacuum, and severe temperatures.

The testing of the sensor elements of either inertial MEMS or optical MEMS (MOEMS) is critical before the packaging is done. (MOEMS are used in applications such as IR imagers, spectrometers, bar-code readers, maskless lithography, adaptive optics, and automotive heads-up display.) But certain challenges exist when performing testing at an earlier stage, including trying to simulate the exact environment under which the device might be used at a later stage. In addition, the lack of standards and specific test equipment extends the challenge to test these MEMS devices. Currently, there is little off-the-shelf MEMS test equipment in the market.



Test equipment for optical and inertial MEMS devices generated worldwide revenues of $56.5 million in 2007, with inertial MEMS equipment making up the majority of the total.
Note: All figures are rounded.

In a recent market study, we found that the total world MEMS test-equipment market generated revenues of $56.5 million in 2007, which represented a growth rate of 10.1% over the previous year. In 2007, test equipment for inertial MEMS and MOEMS contributed approximately 60% and 40%, respectively. T&MW

PCB book-to-bill

The book-to-bill ratios for the North American rigid printed-circuit board (PCB) industry and combined rigid and flex PCB industries each stood at 1.06 in November, with both down from 1.08 in October. The North American flexible circuit book-to-bill fell back to 1.02 in November, down from 1.10 in October. www.ipc.org.

UWB market to take off

The market for ultrawideband (UWB) silicon is finally beginning to take off, reports In-Stat. Although regulatory hurdles over UWB still persist worldwide, the first UWB-enabled notebook PCs shipped in 2007, the market-research firm says in the $3695 report, "Ultrawideband 2007: PCs Finally Hit the Global Market." The report predicts that more than 400 million UWB-enabled devices will ship in 2011. www.in-stat.com.

Semiconductor equipment book-to-bill

North American-based manufacturers of semiconductor equipment posted $1.15 billion in orders in November 2007 (three-month-average basis) and a preliminary book-to-bill ratio of 0.82. The ratio (final) stood at 0.80 in October. The November bookings figure is about 2% less than the final October 2007 level of $1.18 billion and about 19% less than the $1.43 billion in orders posted in November 2006. www.semi.org.

WEBCAST

Using enterprise software to maximize test impact

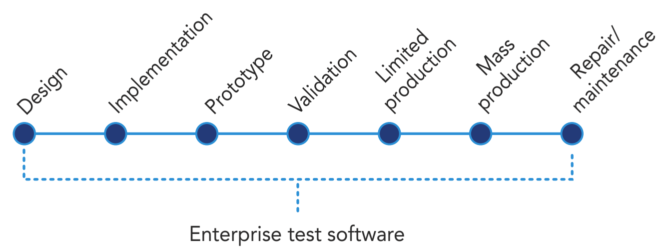
In a *Test & Measurement World* career and salary survey last year (Ref. 1), 73% of respondents cited "time pressures" as one of the three biggest challenges they face in their current jobs.

In the Webcast "Maximizing the impact of test engineering," Jean-Yves Allard, VP of R&D at Averna, explains that he and his colleagues have conducted their own research in an effort to identify how test engineers might make better use of the time available to them. Time pressure, he reports, is exacerbated by accelerated time-to-market deadlines, which in turn impinge on time available for training and for managing product and test data.

Specific key time wasters, Allard reports, include product parameter and limit updates and database-integration chores. He found that 70% of engineers rely on ubiquitous software programs like Excel to analyze test data and have no easy way of integrating their results with other programs. He says that 50% want a reporting tool integrated with their test software, while 96% would benefit from a centralized specs/limits and conditional-test-management tool.

Allard proposes the use of enterprise test software as a method of meeting test-engineering challenges across a product's life cycle and across geographically dispersed design and production locations. The Webcast, sponsored by Averna and *Test & Measurement World*, was presented live on December 5, 2007. You can view the archived version at www.tmworld.com/webcasts to see examples of how Harris employed such software to launch a new RF product line, while Nortel used a similar approach to manage version control, correlate product lines, and enhance test coverage.

Rick Nelson, Chief Editor



Enterprise test software can support product life-cycle management from the design phase to the repair and maintenance phase.

REFERENCE

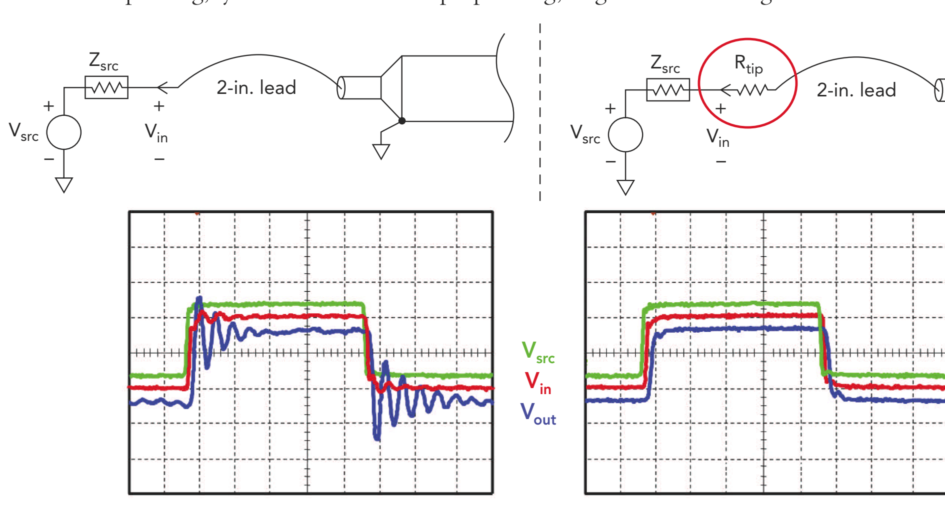
"Salary survey 2007," *Test & Measurement World*, www.tmworld.com/salary_2007.

WEBCAST

Oscilloscope probe hints

An oscilloscope is useless without the probes necessary to get signals from a device under test (DUT) to the instrument. And probes themselves are far more complicated than simple, ideal conductors that transmit those signals. For effective probing, you'll need to know when to deploy passive or active probes, how to check for probe loading, how to compensate probes, how to deal with resonance, and how to make low-current and floating measurements.

In the Webcast "Six hints for better scope probing," Agilent Technologies product manager Jae-yong Chang covers all these topics. He notes, for example, that passive probes suffice up to 600 MHz, while active probes operate to 13 GHz. He demonstrates a two-probe technique that indicates probe loading. He recommends that probe impedance



If you need to add a wire to a probe tip to make a measurement in a crowded environment, you can use a resistor measuring 100 Ω or so to damp resonance.

Courtesy of Agilent Technologies.

be at least 10 times source impedance and that probe bandwidth be at least five times signal bandwidth.

In addition, Chang provides sample waveforms that suggest when you need to compensate your probes, and he describes how to adjust a probe's RC network divider to maintain an appropriate attenuation ratio over the entire probe bandwidth. He provides details on using AC/DC current clamp-on probes to make the low-current measurements necessary to characterize and troubleshoot the signals common to ubiquitous battery-operated consumer products, noting that it's best to degauss and perform offset adjustments on these probes before each measurement.

He also covers measurements on high-power DUTs, describing how to use differential probes and isolation transformers. Finally, he describes a nifty method of using a probe-tip resistor (**figure**) to damp resonance.

You can view the archived Webcast (presented live December 12, 2007, and sponsored by Agilent Technologies and *Test & Measurement World*) at www.tmworld.com/webcasts.

Rick Nelson, Chief Editor

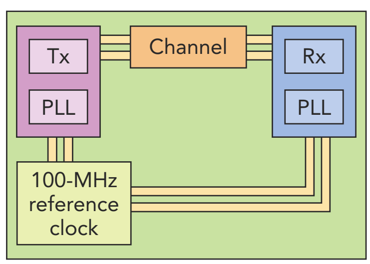
WEBCAST

Achieving PCI Express physical-layer compliance

With the emergence of the PCI Express 2.0 specification, data-transfer rates doubled from 2.5 GT/s to 5.0 GT/s. To develop effective receiver and transmitter tests for this faster rate, you'll need an understanding of PCI Express specifications as well as knowledge of system architectures, receiver tolerance measurements, stress elements, and transmitter PLL response.

In the 1-hr Webcast "Pass PCI Express physical layer compliance testing the first time," Bent Hessen-Schmidt, VP of business development at SyntheSys Research, covers these topics and describes trends in jitter compliance methodology.

Schmidt cites evidence of the difficulties of migrating to PCI Express 2.0: During the first half of 2007, only 10% of 2.5-GT/s PLL designs failed, while 60% of 5-GT/s implementations did. He notes that it is important that both the transmitter and receiver in a common-clock PCI Express design (**figure**) should track the single reference clock nearly identically to prevent clock jitter from contaminating data. He describes using a spectrum analyzer and a clock PLL analyzer to characterize PLL, contending that the clock analyzer provides better accuracy and repeatability.



Path length differences in this common-clock-architecture-based PCI Express design can contribute up to 12 ns of delay. Other factors that can degrade transmitter (Tx) and receiver (Rx) performance include dispersion resulting from low-cost circuit-board material, crosstalk, and reflections.

Schmidt ends by describing dual-port measurements and saying that test methods are evolving to favor the use of sampling instruments as PCI Express speeds move toward 8-GT/s, with the concomitant 20-GHz fifth-order harmonics.

The Webcast, sponsored by *Test & Measurement World, EDN,* and SyntheSys Research, was presented live December 11, 2007. You can view the archived Webcast, which provides detailed descriptions of practical jitter-measurement techniques, at www.tmworld.com/webcasts.

Rick Nelson, Chief Editor

PROJECTPROFILE

DATA ACQUISITION

Flying tests

DEVICE UNDER TEST
Jets and propeller-driven aircraft used by individuals, corporations, and the military.

THE CHALLENGE
Measure aircraft performance following an engineering change. Develop a system that flight-test engineers can use to measure temperature, fuel pressure, oil pressure, air speed, and strain. Customize the hardware and software for each test.

THE TOOLS
- GE Fanuc: ARINC bus interface card for laptop computers. www.gefanucembedded.com.
- Honeywell: pressure transducers with RS-232 outputs. www.honeywell.com.
- National Instruments: signal-conditioning chassis, strain-gage conditioning card, thermocouple signal-conditioning card, data-acquisition card, graphical programming language. www.ni.com.
- Omega Engineering: thermocouple and RTD temperature probes. www.omega.com.
- Paro Scientific: pressure transducers with RS-232 outputs. www.paroscientific.com.
- Vishay: strain gages. www.vishay.com.

PROJECT DESCRIPTION

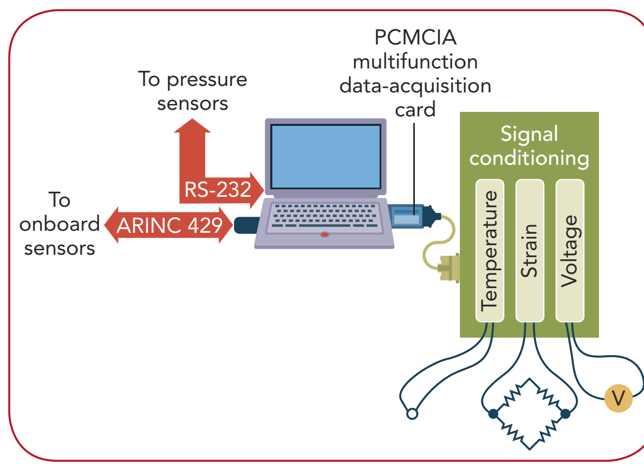
Like many manufacturers, aircraft manufacturer Hawker Beechcraft (Wichita, KS, www.hawkerbeechcraft.com) must make small changes to its products to improve quality or replace obsolete parts. Senior electrical engineer Rex Pawlak and other instrumentation engineers have developed flexible data-acquisition systems that flight-test engineers use in flight to evaluate such design changes.

Flight-test engineers use the systems to measure parameters such as air speed, altitude, fuel pressure, and oil pressure using either the aircraft's built-in sensors or independent sensors. Each system includes a notebook computer and, when needed, a signal-conditioning chassis for the independent sensors (**figure**). "We prefer to use sensors with digital outputs over those with analog outputs," said Pawlak. "Digital outputs require fewer wires." A test may include measurements using strain gages mounted on a wing spar or other structural component.

When a design engineer requests a test from the instrumentation group, the instrumentation engineers will first investigate whether they can make the measurements using sensors already built into the aircraft. The investigation includes comparing sensor accuracy to measurement requirements. If the built-in sensors meet the requirements, Pawlak will configure a system that retrieves data from the aircraft's ARINC 429 bus. "Sensors used in aircraft are getting accurate enough for test work," noted Pawlak.

If test requirements go beyond the capabilities of the built-in sensors, then additional sensors will be fitted to the aircraft. The engineers will connect thermocouple and RTD probes for temperature measurements and strain gages for mechanical measurements to a chassis containing signal-conditioning modules. In addition, they may also connect pressure sensors to the computer through an RS-232 link configured in a daisy-chain topology.

A test may require 20 to 30 pressure transducers, although some need only two to five. After engineers specify the sensors, technicians install them in a test aircraft. Installing additional sensors often requires a technician to install tubes and connectors to systems such as fuel lines. Engineers will also customize the PC software to capture, display, and record the specified data. "We will customize the software to best match the needs of a flight-test engineer," said Pawlak. "For example, some prefer analog [dial] displays, while others prefer digital [numeric] displays."



A flexible data-acquisition system makes in-flight measurements on aircraft.

During a flight, a test engineer monitors the measurements on the screen and records data when the aircraft is "on condition." For example, if a test plan calls for pressure, temperature, or strain measurements at 35,000 ft, the test engineer won't record data during ascent and descent. Often, a test plan calls for test engineers to record data during multiple conditions.

LESSONS LEARNED

"When designing a data-acquisition system, always look for the simplest solution that meets the test requirements," said Pawlak. "RS-232 is the least invasive and most convenient solution, followed by monitoring the ship's internal bus. Use external sensors and signal conditioning only when needed."

Martin Rowe, Senior Technical Editor

Alfred Binder, test-handling manager, poses at Austriamicrosystems' headquarters in front of a photomask display that illustrates the diversity of products the company has produced over the past 25 years.

HANDLING QUALITY

BY RICK NELSON, CHIEF EDITOR

A VISION-ALIGNMENT TECHNIQUE POSITIONS AUSTRIAMICROSYSTEMS' DEVICES FOR TEST WHILE THE COMPANY POSITIONS ITSELF AS A KEY SUPPLIER IN COMMUNICATIONS, INDUSTRIAL, MEDICAL, AND AUTOMOTIVE MARKETS.

UNTERPREMSTÄTTEN, AUSTRIA. Pursuit of excellence is a key motivator for Austriamicrosystems, a provider of mixed-signal ICs for power-management, sensor, and mobile-entertainment applications. The company employs innovative test and test-handling techniques to ensure the quality of the devices that it sells into communications, industrial, medical, and automotive markets.

Moritz Gmeiner, Austriamicrosystems' director of corporate communications, said the company focuses on highly integrated low-power and high-accuracy analog devices. The company, he said, has in its 25 years in business developed a significant amount of IP that it employs in the design and production of both standard ICs and custom ASICs. Available IP building blocks include ones dedicated to power-management, mobile-entertainment, wireline-communication, bus-system, car-access, metering, sensor, sensor-interface, medical, and high-voltage applications as well as general-purpose analog and digital functions.

ASICs, Gmeiner said, have historically made up the bulk of Austriamicrosystems' business, outpacing standard products by 80% to 20% five years ago. That's changing, though, as the company identifies high-volume opportunities for new standard ICs, which now make up close to a 40% share of the company's business.

In addition to providing standard and custom devices, the company also offers foundry services. In December 2007, Fingerprint Cards (www.fingerprints.com) became one of the most recent companies to take advantage of that service, announcing that Austriamicrosystems would manufacture its FPC1011C 30x18x2-mm fingerprint sensor chip that it uses in products ranging from fingerprint sensors and biometric processor ASICs to complete biometric submodules.

For its foundry customers, Austriamicrosystems offers the High Performance Interface Tool Kit (HIT-Kit), which is based on Cadence or Mentor Graphics design environments and supports all of Austriamicrosystems' process technologies. The HIT-Kit comes with silicon-qualified standard cells, periphery cells, and general-purpose analog cells such as comparators, operational amplifiers, and low-power analog-to-digital and digital-to-analog converters. The kit also includes physical verification rule sets for use with the Cadence Assura and Mentor Calibre design rule checkers, as well as circuit-simulation models

STEFAN KRISTOFERITSCH/NPN WORLDWIDE

that enable rapid design starts of mixed-signal and RF ICs. In addition to standard prototype services, Austriamicrosystems also offers analog IP blocks, memory (RAM/ROM) generation services, and packaging services in ceramic or plastic.

As part of its foundry offerings, Austriamicrosystems offers fast prototyping through its Multi-Project-Wafer (MPW) service, as well as offering full production, assembly, and test services. In 2008, Austriamicrosystems will offer more than 150 MPW start dates, made possible through cooperative operations with research organizations such as CMP-TIMA (tima.imag.fr) and Fraunhofer IIS (www.iis.fraunhofer.de) and with prototyping services such as Europractice (www.europractice-ic.com) and MOSIS (www.mosis.com).

To take advantage of the MPW service, customers deliver their completed GDSII data at specific dates, and Austriamicrosystems then supplies untested packaged samples or dies within a short lead time—typically eight weeks for CMOS and 10 weeks for 0.35-μm high-voltage CMOS, SiGe-BiCMOS, and embedded flash processes.

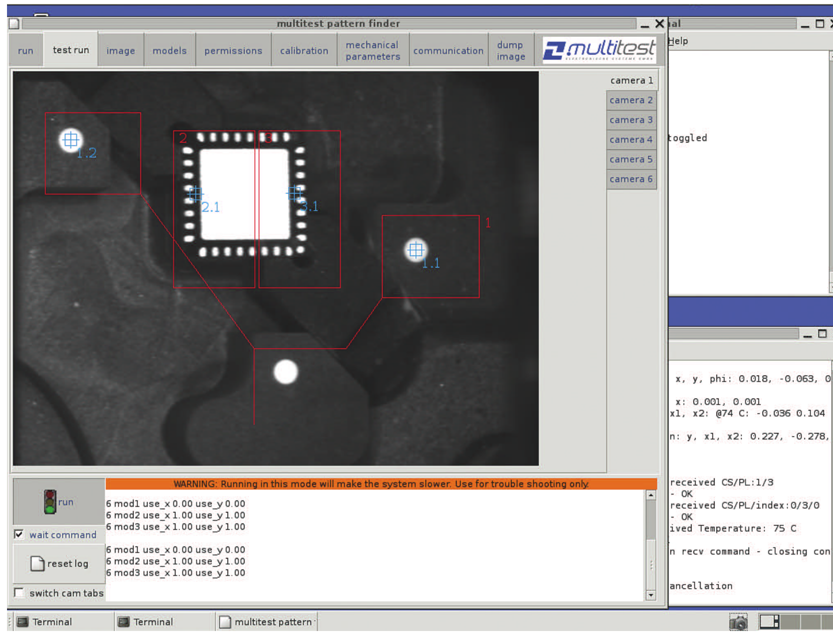


FIGURE 1. High-speed vision-alignment technology enables a pick-and-place handler to accurately position a device for insertion into a test contactor. Courtesy of Multitest.

From mobile entertainment to automotive safety

The company's own designs find use in power-management and lighting-management applications in mobile devices such as cell phones. For mobile entertainment, the company makes a single-chip media player system as well as audio front ends that provide power management to support long play times—while also implementing digital rights management.

For the medical imaging field, Austriamicrosystems makes sensors and sensor interfaces that provide the accuracy and image-acquisition speed necessary to minimize patient x-ray doses in computed-tomography and digital x-ray equipment. For the automotive market, Austriamicrosystems makes bus-system chips as well as sensor and sensor interfaces and car-access devices. Gmeiner said that the company is a leader in FlexRay transceivers, and he explained that Austriamicrosystems is a pioneering company in time-triggered architectures (TTA) for safety-related x-by-wire (for instance, brake-by-wire or steer-by-wire) applications. He added that Austriamicrosystems is in a development partnership with Fujitsu (Ref. 1) related to TTA applications, under which Fujitsu is integrating Austriamicrosystems' AS8221 FlexRay physical-layer high-bandwidth bus-transceiver technology with Fujitsu's 16-bit and 32-bit automotive microcontrollers.

The company also makes magnetic rotary encoder ICs that provide up to 12-bit resolution for industrial and automotive applications. Gmeiner noted that these products can serve in electronic stability control applications and can monitor gearbox and gas-pedal positions.

Supporting the production of this plethora of products are six design centers in Austria, Italy, Switzerland, and India as well as a 200-mm wafer fab here. The company has a 0.35-μm CMOS base process as well as modular specialty processes for high-voltage CMOS, SiGe, and embedded-flash/EEPROM fabrication. Production capacity is 8000 wafer starts per month. A cooperative effort with Taiwan Semiconductor Manufacturing Co. (www.tsmc.com) ensures access to state-of-the-art processes for both partners. In addition, Austriamicrosystems in 2007 began cooperating with IBM in the development of a 0.18-μm high-voltage CMOS process that is expected to yield products in 2009.

STEFAN KRISTOFERITSCH/NPN WORLDWIDE

MORITZ GMEINER: THE COMPANY FOCUSES on highly integrated low-power and high-accuracy analog standard and custom solutions.

Product diversity imposes test challenges

Austriamicrosystems offers more than 80 package types—ranging from small outline ICs to ceramic pin grid arrays with up to 447 leads. The diversity of products that Austriamicrosystems makes poses significant test challenges with respect to functionality as well as packaging. A look

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Measurement Type	analog input (simultaneous)	analog input (simultaneous)
Number of Channels	6 single-ended	8 differential/ 8 single-ended
Throughput	225 kHz	250 kHz
Resolution (bits)	16	16
Voltage Ranges	±5V, 10V	±10V, ±5V, ±2V, ±1V
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at devices introduced in the fourth quarter of 2007 illustrates the diversity of the Austriamicrosystems product line's functionality and package styles:

- the AS1341 20-V step-down DC/DC converter in a 3x3-mm TDFN eight-pin package,
- the AS3693 and AS3694 LED drivers for LCD backlighting applications in TQFP64 packages,
- the AS1542 1-Msample/s, 16-input, 12-bit ADC in a 28-pin TSSOP package,
- the AS5305 high-speed, high-resolution magnetic linear motion encoder IC in a lead-free TSSOP20 package,
- the AS1358/59 and AS1361/62 LDO regulators in a five-pin TSOT23 package and a six-pin TSOT23 package, respectively,
- the AS1528/29 micro-power, 10-bit, 150-ksample/s ADCs in eight-pin 3x3-mm TDFN packages, and
- the AS1538 12-bit, eight-channel, low-power ADC in a 16-pin TSSOP package.

To ensure the quality of the products it produces, the company has test centers in Austria and in Calamba, the Philippines, that use high-end testers from LTX, with 45 testers deployed in Austria and 10 deployed in the Philippines, according to Wolfgang Peisser, director of backend operations. Peisser said Austriamicrosystems chooses to rely on one test vendor, for which it can serve as a technology driver. A single test vendor, he said, helps the company leverage its test IP across the many types of devices. Further, he noted, a single vendor provides the consistency demanded by automotive customers.

But although the company relies on a single test vendor, Peisser described the test facility as a "mixed floor," with each tester able to serve in wafer test, final test, and test development. This mixed approach, he said, helps ensure that personnel are knowledgeable about all the platforms, thereby enhancing stability within the test process.

In addition to the LTX testers, the company has chosen Multitest as its handler supplier; Austriamicrosystems deploys 13 pick-and-place handlers and 13 gravity handlers in Austria plus five pick-and-place and 11 gravity handlers in the Philippines. Peisser said the company's mix of packages—ranging from tiny small outline transistor (SOT) devices to large ball-grid arrays (BGAs), complicates the test and handling process, requiring close cooperation among Austriamicrosystems, LTX, and Multitest. He expressed support for the mechanical-interface standardization efforts of the Semiconductor Test Consortium's STIX committee (Ref. 2), but he added that interfacing a tester and handler is a complex problem that won't soon yield to standardization efforts.

Handling many package types

"Customer requirements are driving us to have such a broad portfolio of different packages, ranging from the smallest QFN to the largest BGA," said test-handling manager Alfred Binder, who explained that customer requirements for the smallest, thinnest packages present significant test challenges. For Austriamicrosystems' smallest parts—such as 3x3 QFN (quad flat no-lead) packages—a simple mechanical handling operation no longer suffices. For such devices, Binder employs a Multitest MT9510 pick-and-place handler equipped with Multitest's vision-alignment technology (**Figure 1**). The technology can handle Austriamicrosystems' 0.5-mm-pitch devices, and Binder said it will extend to 0.4-mm and even 0.3-mm pitches.

The vision-alignment technology employs multiple cameras to scan and align up to four devices simultaneously (for quad-site test) before the stroke-to-test-contactor operation occurs. Each device

STEFAN KRISTOFERITSCH/NPN WORLDWIDE

Alfred Binder contends with package styles ranging from tiny QFNs to large BGAs as he works to interface testers, load boards, and handlers.

is scanned and positioned separately, and all devices being contacted in parallel in multisite applications are aligned individually—without alignment information being transferred from one device to another. Without that alignment process, Binder said, yield can fall off two to three percent or more because of package tolerances.

The Austria test area, Binder explained, is 25 years old, and as it has grown, different generations of testers and handlers have appeared. "We have one of the first Synchromasters in Europe," which was acquired 20 years ago, he explained. The LTX Synchromaster testers have subsequently been augmented with new LTX Fusion systems.


STEFAN KRISTOFERITSCH/NPN WORLDWIDE

WOLFGANG PEISSER:

AUSTRIAMICROSYSTEMS chooses to rely on one tester and one handler vendor, for which it can serve as a technology driver.

Austriamicrosystems has been working with Multitest for 16 years and has some vintage MT850 gravity handlers installed, Binder said. The company has recently added MT9510 pick-and-place handlers. Binder explained that for some applications, he finds pick-and-place systems to be more reliable than gravity-feed machines because they avoid problems associated with tiny singulated devices sticking together. He said Austriamicrosystems is one of the first Multitest customers to employ a pick-and-place handler for use with 3x3-mm QFN packages.

Binder added that many gravity machines are dedicated to specific package styles—so, if a company purchases a dedicated gravity handler for a package that doesn't generate projected sales, it could be stuck with a €250,000 handler it has no use for. With the Multitest pick-and-place handler, he explained, a simple €20,000 change kit is all that's needed to adapt the handler for a new package. Then, should volumes be sufficient, a gravity handler can augment the pick-and-place machine.

Temperature is another critical issue, Binder said, with respect to both temperature range and accuracy. Automotive parts, such as the automotive version of the company's new AS5140H contactless magnetic rotary encoder for accurate angular measurement over 360°, must be fully qualified to AEC-Q100 standards and specified for an extended ambient temperature range of –40°C to +150°C.

But apart from temperature range, maintaining proper device temperature during test also presents challenges. "For devices such as automotive devices, it is very, very critical to test them at the right temperatures," said Binder. He explained that a key problem is the low thermal inertia of very small parts, and that such devices' temperature can shift several degrees because of heat conduction through leads and test sockets. A simple heat chuck and nozzle arrangement won't suffice to accurately control temperatures, he said, adding that Multitest's temperature-chamber approach provides adequate soak time for multiple parts to ensure temperature stability and accuracy without compromising throughput.

Binder, who has followed many changes over his 17-year career at Austriamicrosystems, expects to see more challenges in the future—with part sizes and lead pitches shrinking further and temperature ranges increasing. But he expressed confidence that ongoing cooperative efforts among Austriamicrosystems and its customers and equipment suppliers will be able to meet those challenges head on. T&MW

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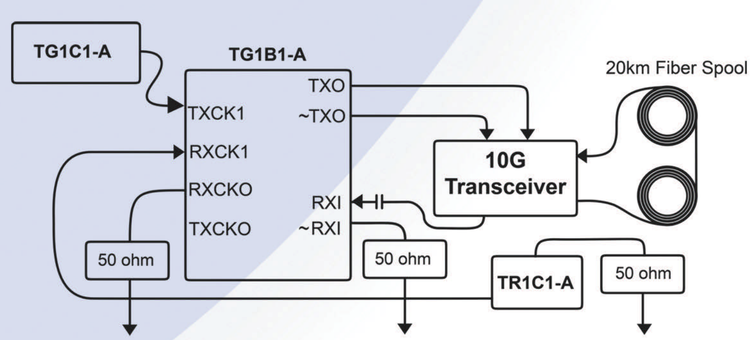

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ACCELERATE *and* SIMPLIFY SERIAL DATA TESTING

BY MARTIN ROWE, SENIOR TECHNICAL EDITOR

Engineers show how to improve jitter and BER testing for SerDes devices.

Serial data streams continue to increase in speed while error specifications tighten, which makes testing for jitter tolerance and bit-error rate (BER) ever more important. Several engineers have tackled the problem in different ways but with similar results—they have all cut test time and equipment costs.

David Andres, a design engineer at Marvell Semiconductor, developed a method for accelerated BER testing of serializer/deserializer (SerDes) receivers. Chung Wu, product definer at Maxim Integrated Products, uses eye templates to define SerDes receiver performance, and Christopher J. Loberg, senior market development manager at Tektronix, uses a waveform generator to create test signals. (You can download papers describing Wu's and Loberg's setups from the online version of this article at www.tmworld.com/2008_02.)

Andres has spent several years evaluating SerDes receivers. During that time, he has developed a technique that lets him cut receiver test time from hours to minutes when testing dozens of devices. He has also found ways to simplify test setups and cut costs when building additional evaluation systems for other Marvell engineers.

Although some customers have requested that Andres test for BER down to 10^{-18} (less than one error for every 10^{18} bits), most customers require BER verification for every 10^{12} bits. At those error ratios, a full BER test at 2.5 Gbps can take 6 min, 40 s. To attain a 99% confidence level that a bit error wouldn't occur, Andres would need to run a BER test at least 100 times per device for a total test time of more than 11 hrs.

Because Andres typically tests as many as 50 individual devices—for new designs, designs that have changed, or designs that need spot checking—he needed to shorten the test

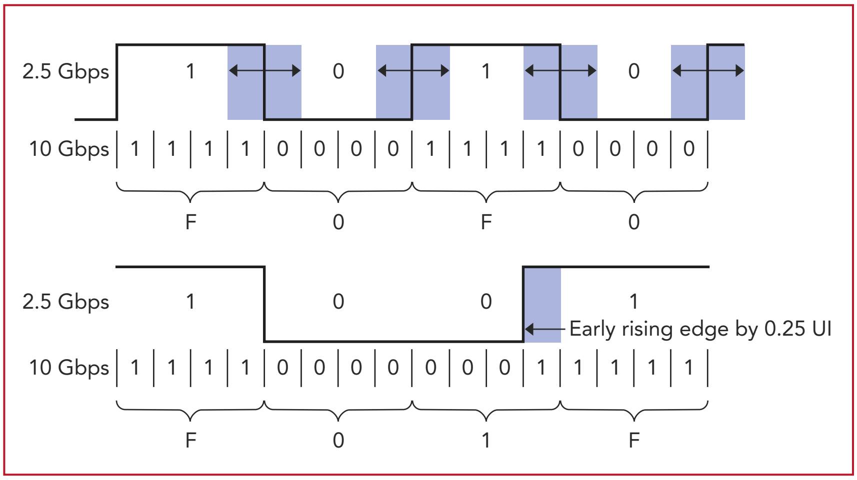

FIGURE 1. Four consecutive bits of the same polarity produce a data stream at ¼ of the highest bit rate (top trace). Changing the timing of an edge changes jitter in 0.25 UI increments, producing early or late edges (bottom trace).

time. By setting up a test that increases the probability that a bit error will occur, Andres can reduce test time to a few seconds per device. This accelerated testing gives him enough confidence that the device under test (DUT) will achieve acceptable BER performance.

Adding timing variation

To accelerate his testing, Andres adds a controlled amount of timing variation (jitter) to a data stream so the jitter overlaps with an eye-mask specification. In one application, he produces four edges inside the eye mask for every 127 bits using a 7-bit pseudorandom bit sequence (PRBS7). The added jitter produces enough timing violations to predict a receiver's performance. He also uses PRBS23, PRBS31, and other bit patterns.

Andres combines two techniques to add controlled jitter to serial data streams: oversampling and mixing. Oversampling involves using a pattern generator that is four times faster then the bit rate of interest. He uses a 10-Gbps pattern generator to build a 2.5-Gbps PCI Express (PCIe) Generation 1 data stream.

To make a stable 2.5-Gbps data stream from a 10-Gbps signal, Andres uses four consecutive 1's (or a single F in hex) to make a single 1 bit at 2.5 Gbps. A 0 bit at 2.5 Gbps is made of four consecutive 0 bits at 10 Gbps. He then shifts the edge timing to create jitter.

"With a 10-Gbps pattern, I can change the timing of any rising or falling edge by 0.25 unit intervals [UIs]," said Andres. "Using both edges, I can add 0.5 UI of jitter to a signal. I can change the location of the worse-case jitter in the pattern. I can check many different locations and then provide feedback to the designers where the weak points in a pattern occur. A DUT can handle more jitter in one direction than in the other."

Figure 1 shows how Andres does it. The upper trace shows four bits (1010) at 2.5 Gbps with no jitter added (no edges shifted). At 10 Gbps, the pattern is represented by F0F0 hex. The lower trace is a series of four bits (1,0,0,1) at 2.5 Gbps, but the rising edge between the 0 bit and the following 1 bit occurs 0.25 UI early.

Andres accomplishes that by using 1 hex (0001 binary) at 10 Gbps instead of 0000 binary followed by F hex (1111 binary). By repeatedly changing the bit patterns, Andres can create jitter in the 2.5 Gbps stream.

Listing 1 shows code that Andres uses to develop a PRBS7 pattern. The four underlined digits in Pattern Data Line0002 represent bits that are shortened or lengthened by 0.25 UI. For example, the "8" represents a late falling edge of the preceding bit and the "E" represents an early falling edge of the following bit.

The oversampling process doesn't provide enough jitter for Andres to reach the 0.65 UI of jitter required for testing the PCIe receiver. **Figure 2** shows that when bit edges intrude on the eye mask (diamond), bit errors will occur. Andres uses mixing to add sinusoidal jitter (S_j) to cover the rest. In fact, he can produce enough timing variation to completely close the eye.

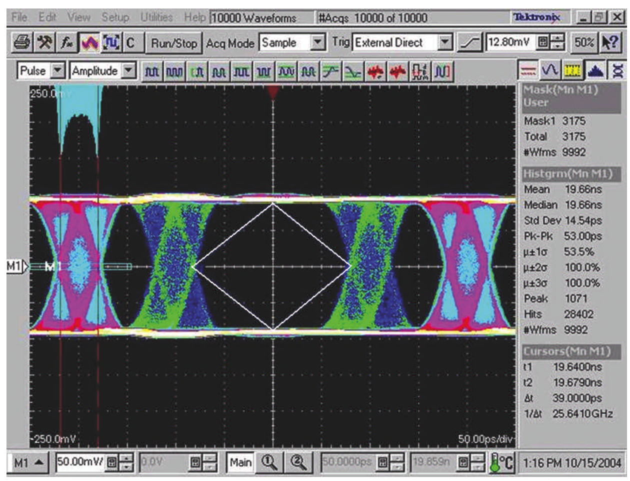

FIGURE 2. Adding jitter to a data stream can force it into the limits at the corners of an eye mask. Courtesy of Marvell Semiconductor.

The cursors that mark the width of a closed eye in Figure 2 correspond to 39-ps time between bit edges and indicate eye closure. A histogram above the waveform indicates the distribution of the edge timing. The range of jitter covers about 53 ps, with the remaining 14 ps of jitter coming from data-dependent jitter (DD_j) and random jitter (R_j). "I don't like random jitter because it's so difficult to quantify and debug," said Andres. "Random jitter grows the longer you make measurements."

Figure 3 shows the current iteration of a test system that Andres uses to evaluate SerDes receivers. The DUT resides on an evaluation board. An RF signal generator produces a 10-GHz signal that becomes the system clock. A waveform generator supplies the frequency-modulation (FM) signal that represents S_j. An RF delay line modulates the 10-GHz signal with the S_j signal.

The pattern generator's output, which contains the jittered data stream, feeds the DUT. A clock output triggers a sampling oscilloscope to capture the waveforms and produce eye diagrams. An error detector counts bit errors from the receiver DUT's output.

Andres uses his technique to evaluate receivers for timing variations. He delib-

```
[Bert Pattern File]
Pattern File Name = "PRBS07x4+-250mUI.BPF"
Pattern Label = "PRBS07x4"
Number of Bits = 508
Number of Ones = 252
Number of Zeros = 256
Pattern Data Line0001 = "0000 000F FFFF F0FF FFF0 0FFF
 F0F0 FFF0 000F F0FF F0F0 0FF0 00F0 F0FF 0000 0F0F"
Pattern Data Line0002 = "FFF0 00FF F0FF 0FF0 0F00 F0F0
 0F00 00F0 0FFF 00F8 FF0E 0007 001F F00F F0F0 F0F0"
```

LISTING 1. Using this code, David Andres of Marvell Semiconductor develops a PRBS7 pattern.

erately introduces as little amplitude variation as possible because amplitude variation will also affect receiver performance.

Reducing the amount of test equipment

Andres started with more test equipment than he now uses, but he found ways to simplify the test setup each time he needed to create a new system. "When I started working here, I was the only one who needed a 12-Gbps BER tester," said Andres. "Now, there are 12 to 15 engineers who use them. At $150,000 each, that's a lot of money, so I look for ways to reduce the amount of test equipment we use in each setup."

Andres uses a delay line that lets him reduce the cost of a system because he can use an RF signal source that lacks an FM modulator. A delay line typically costs a few hundred dollars, but an FM modulator adds about $10,000 to an RF signal source. He also said that he can modulate an RF signal with sine waves up to 80 MHz with a delay line as opposed to 20 MHz with an FM modulator. The bad side of the delay line is that the amount of delay variation is typically limited to a few hundred picoseconds, while FM can produce variation of tens of nanoseconds at lower frequencies. Thus, he will use an FM modulator when necessary.

To further reduce costs, Andres purchases used equipment whenever possible. He noted that some BER testers include an integrated delay line, so you may not need to purchase an external one.

His first test setup included an FR4 stripline between the pattern generator's output and the DUT. That adds loss to the signal. Andres eliminated the stripline in later test setups because bit errors caused by backplane loss are difficult to debug. In addition, Andres said that you need a different stripline for each data rate, which reduces the flexibility of a test setup and adds to the cost. He also eliminated a real-time oscilloscope but will use it when he needs to debug a design.

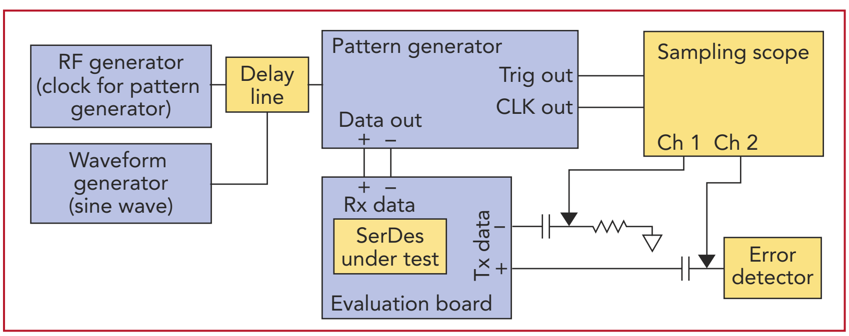

FIGURE 3. David Andres of Marvell Semiconductor uses this test setup to test SerDes receivers for BER in the presence of jitter.

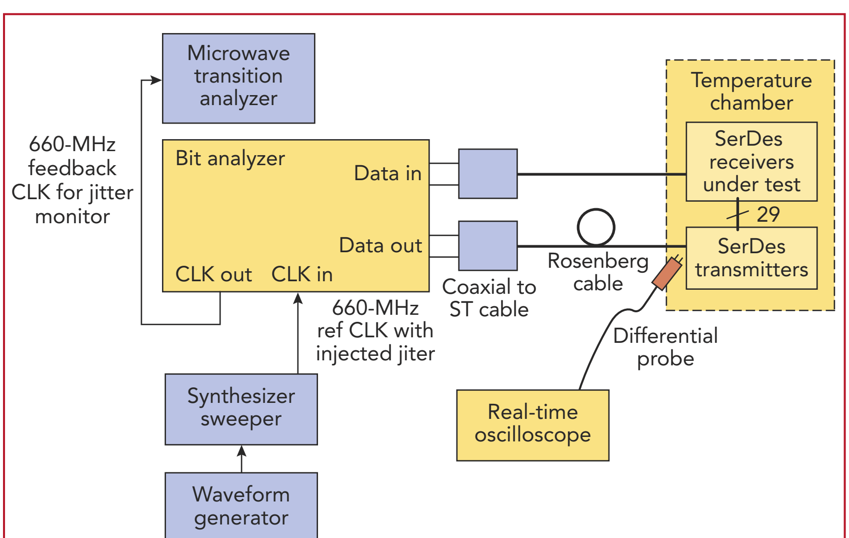

FIGURE 4. A test setup used by Chung Wu of Maxim Integrated products uses a synthesizer sweeper that generates a modulated clock signal for a bit analyzer.

ON THE WEB

To learn more about the test methods that Chung Wu and Chris Loberg use, you can download their papers from the online version of this article.

If you have a different test method for performing jitter and BER testing, we'd like to hear about it. Contact senior technical editor Martin Rowe at mrowe@tmworld.com or post a comment to the online version of this article.

www.tmworld.com/2008_02

Using eye-pattern templates

Chung Wu of Maxim Integrated Products also evaluates SerDes receivers for jitter performance. In a paper entitled "Eye-pattern templates help evaluate serializer/deserializer performance," Wu describes how he measures bit errors versus timing variations (jitter) and amplitude. The paper provides test results—in tabular and eye-diagram form—that show how temperature and cable length affect the amount of jitter that a receiver will tolerate before producing bit errors.

To evaluate a receiver for jitter, Wu's test system generates a controlled sinusoidal jitter. The synthesizer sweeper (an RF signal source) FM modulates its RF signal by the sinusoidal output of the waveform generator. Wu adjusts the amplitude of the signal at the receiver.

Wu's paper explains the process he follows: "When signal swings are larger than an observed threshold, the deserializer performance is determined mainly by jitter. We then perform a series of tests on a 5-m cable at a serial-data rate of 660 Mbps, and determine the maximum jitter the deserializer can tolerate for each given level of signal amplitude."

Wu sets the amplitude to 100 mV_{p-p} at 25°C but needs 200 mV_{p-p} for devices at 95°C. He then varies the jitter to find the greatest amount that produces no errors for 2 min.

The test setup in **Figure 4** shows that Wu uses a system similar to Andres, but all injected jitter is sinusoidal. The RF synthesizer generates a clock signal, and the waveform generator produces the modulation sinusoid signal. A microwave analyzer measures the output clock from a bit analyzer and controls the waveform generator. Wu's test setup uses more test equipment than Andres' setup (Figure 3) because Wu performs temperature testing and varies signal amplitude.

Creating test signals with AWGs

Chris Loberg of Tektronix suggests that you can simplify serial tests by using an arbitrary waveform generator (AWG) to generate signals for tests of serial receivers. Loberg argues that a direct-synthesis AWG (with a sufficient sample rate) can replace the noise generator, sine wave generator, and pattern generator used in traditional test setups.

Loberg's paper, "Direct approach to signal generation promises simpler compliance measurements for serial receivers," explains how to use an AWG to create the entire test signal—jitter and all. Loberg acknowledges that serial devices expect to see digital waveforms, but he says that the sample points in an AWG's memory "can define essentially any wave shape, including digital pulses."

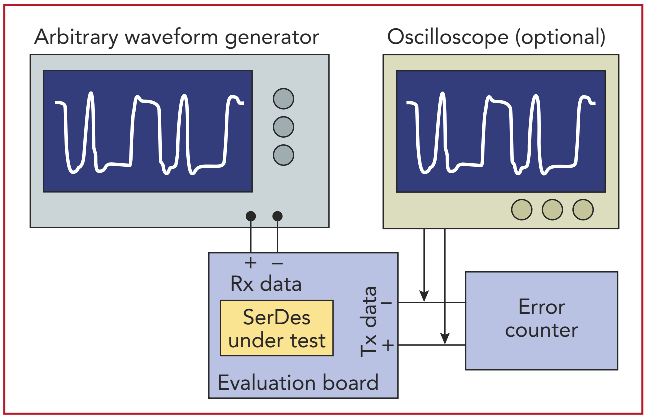

FIGURE 5. Chris Loberg of Tektronix has found that an arbitrary waveform generator can reproduce a digital bit stream and add analog signal characteristics.

Figure 5 shows the test setup that can perform a Serial ATA compliance test. The oscilloscope is optional, but useful for troubleshooting.

These three applications demonstrate how you can accelerate BER tests, use eye masks to predict SerDes receiver performance, and simplify your test setup. Unless you are required by a standard to perform a test in a particular way, you have the freedom to improvise. T&MW

DFT, ATE DRIVE YIELD IMPROVEMENT

Automated test equipment is becoming a yield-metrology tool that works in conjunction with yield-analysis software.

BY AJAY KHOCHE, VERIGY, AND WU YANG, MENTOR GRAPHICS

As advances in IC technology have resulted in geometry and process variations, manufacturers have encountered a drop in both initial and mature yield and an increase in yield ramp-up time. Systematic design-process interactions are now the dominant yield-loss mechanisms, and their effect is exaggerated by design complexity. Manufacturers can address the new yield-loss mechanisms by using a combination of automatic test equipment (ATE) and design-for-test (DFT) software to capture and analyze defects during high-volume production and reduce process problems on the manufacturing line.

The new role of production testing

The use of scan-based test structures has become prevalent in DFT applications. In addition to using at-speed test to check for stuck-at faults, manufacturers can use the technique to find timing-related defects in nanometer technologies. Also, newer fault models such as bridge (Ref. 1), N-detection (Ref. 2), false-multicycle (Ref. 3), and small-delay-defect (Ref. 4) along with new pattern-generation tools make it possible for manufacturers to detect defects in sub-90-nm designs.

The increased challenges of yield management at the submicron level have resulted in a new role for ATE. Previously, ATE was limited to applying tests to perform a simple quality screen, and testers collected only pass/fail statistics. Now, manufacturers are finding that newer, flexible ATE systems can collect failure data on the scan cell nodes inside a chip (**Figure 1**) and provide that data to diagnosis tools, which in turn can perform defect analysis that leads to process and design improvements (**Figure 2**). Essentially, the ATE becomes a yield-metrology tool as well as a quality-screen tool.

Defect diagnosis roughly consists of two phases. In the first, engineers must analyze a sufficient number of failed die to identify a failure trend. In the second, they must select a group of die that may represent the failure trend and perform further analysis, which may include refined diagnosis and linking to physical layout data followed by physical failure analysis. The goal is to find the defect location, identify the failure mechanism, and characterize the failure behavior.

Failure diagnosis data requirements

An ATE system that will be used in a failure-diagnosis and yield-improvement process must collect the following sub-die-level data:

- *Voltage and current measurements.* These traditional measurements remain important and need to be correlated

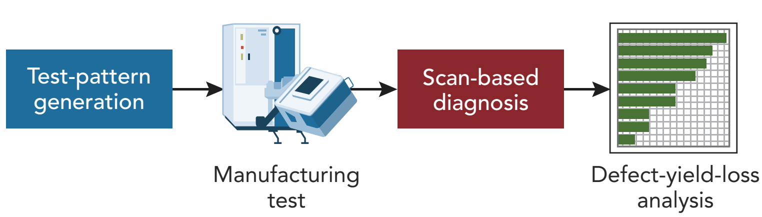

FIGURE 1. Volume test data collected during manufacturing can help support failure diagnosis.

with other sub-die-level measurements during statistical analysis.

- *Digital test results from (compressed) scan/BIST test patterns.* The logic-diagnosis software needs to know the exact position of a fail bit from the scan chain in order to identify the root cause.
- *Memory test results from built-in self-test or built-in self-repair (BIST/BISR).* Information from BIST/BISR is required for monitoring silicon processes and optimizing redundancy schemes.

The fact that the above data needs to be collected during high-volume manufacturing test puts additional demands on the ATE's performance. In particular, the following conditions must be satisfied by the ATE to make volume diagnosis viable:

- *Low test-time impact.* The data collection time for volume diagnosis typically must be less than 5% of the device test time.
- *Low data volume.* The data volume typically must be kept to about 5 kbytes per device without compromising diagnosis capability, leading to the need for intelligent data collection.
- *Efficient data flow.* The system should be able to support the diagnosis of more than 100,000 faulty devices per day.

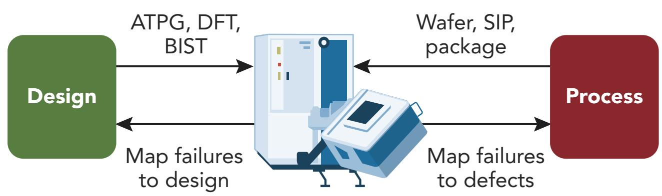

FIGURE 2. ATE acquires a diagnostic role when combined with yield-analysis software.

Diagnosis software requirements

Scan diagnosis is a viable approach for identifying the cause of physical defects. By correlating logic simulation information, physical layout data, and test results from defective devices, diagnosis software can identify a failure site quickly.

After the software determines the first-level correlations, you can take additional steps to isolate the location of a defect. These steps include regenerating scan patterns based on diagnosis results, re-testing, and re-running diagnosis routines. Once you locate a physical defect, you can use traditional physical failure-analysis methods to analyze it more fully.

Combining hardware and software

To help customers with their defect-diagnosis and process-improvement programs, our companies integrated the Verigy V93000 SOC (system-on-chip) tester with the Mentor Graphics YieldAssist software tools. Although you could use products from various companies to set up a yield-improvement system, we will explain how such a system can work by describing our setup.

To begin, the ATE system feeds links to information on netlist and test patterns—along with the test results from devices that have failed in production—into the diagnosis software. The software performs some consistency checks on the data to help ensure accuracy and then performs a series of statistical-analysis steps to identify a failure signature and provide for symptom separation, suspect type classification, suspect scoring and ranking, and net, cell, and pin location.

The results are fed into a test debug and logic-visualization tool that identifies the logical location of the failure and into a physical-verification tool that provides a hierarchical visualization of the device's physical design. By correlating the logical type and location of the failure to the physical location of the failure, the engineer can rapidly determine if the failure is due to a layout "hot spot," such as interconnects subject to bridging or pinching.

Because scan testing is based on the direct stimulation and response of the actual internal logic (vs. external functional testing), it provides the best information for pinpointing the cause of systematic and random yield loss resulting from manufacturing process variability.

When choosing scan test and diagnosis technology, engineers should look for these capabilities:

- a smooth fit into the yield-improvement flow via flexible interfaces and controls;

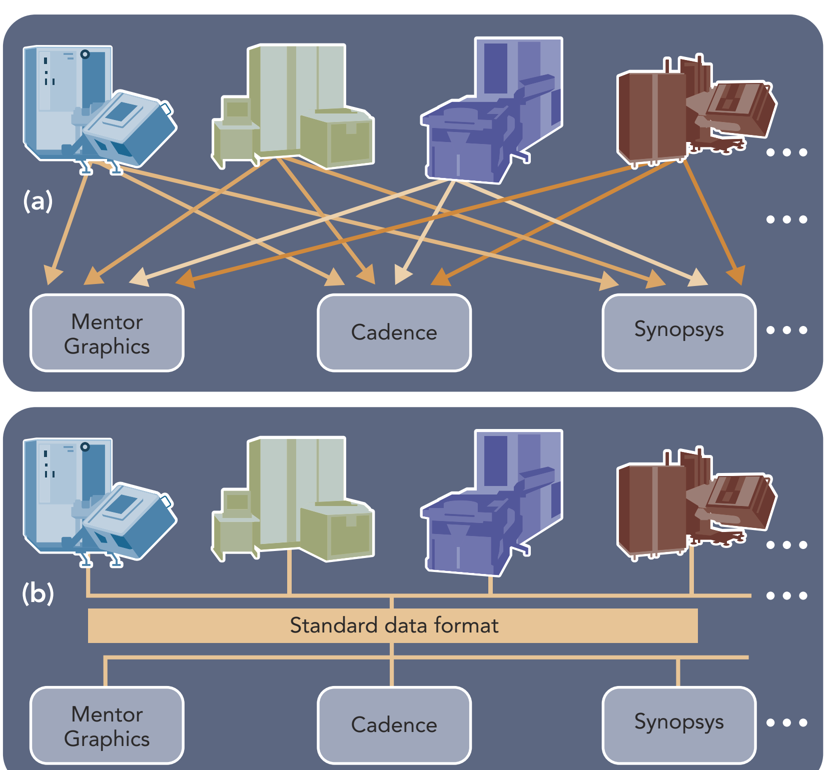

FIGURE 3. (a) Typical ATE-to-EDA datalog flows involve custom data formats on a per-tester and per-tool basis. (b) An improved flow employs a standard format.

- capabilities for scan-chain (Ref. 5), logic, and memory diagnosis;
- the ability to handle large volumes of test data and automation of the analysis process;
- support for suspect classification, score, ranking, net name, and pin identification;
- links to physical-verification and design-for-manufacturing (DFM) tools;
- support for a variety of failure file formats to accommodate production testing systems; and
- direct diagnosis from both compressed (Ref. 6) and uncompressed test results.

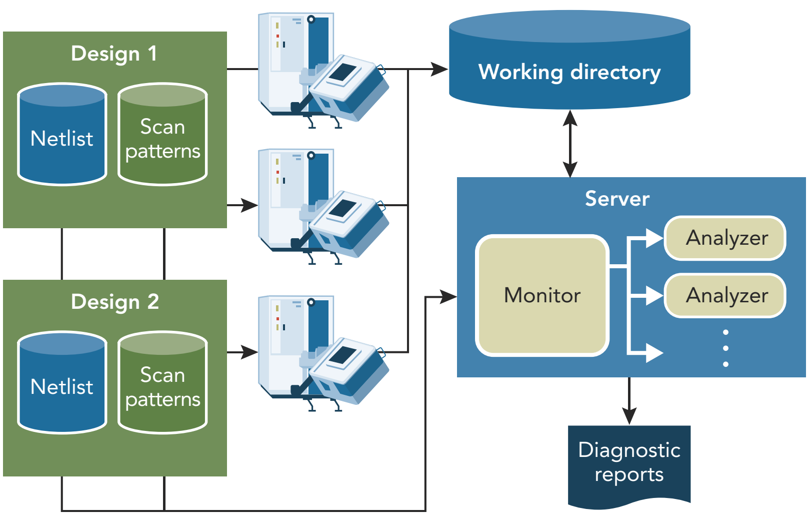

FIGURE 4. The scan-diagnosis automation mode supports multiple designs and multiple testers.

The increasing volume of test patterns required to perform high-quality testing on sub-90-nm ICs has led to widespread adoption of test-pattern compression. Scan test-pattern compression allows high-quality tests to be run while maintaining costs and time to test (Ref. 7). In the context of failure diagnosis, an important issue is whether the compressed patterns can be used for diagnosis without losing important information.

ATE requirements

To support the volume diagnosis environment shown in Figure 2, the ATE system must be accurate enough to exhibit low or no self-induced yield loss. In addition, it must support multiple DFT architectures so it can collect the sub-die-level fail information from scan-chain testing, and it should permit selective capture of relevant information from the test process so the available memory can be used efficiently. Because test is a cost- and time-sensitive operation, the ATE must collect and transfer failure data with minimal impact on throughput. The ATE must address data capture in single- and multiple-device test environments:

- *Fail data capture for a single device.* This can be measured as fails captured per second. An efficient ATE system will have zero or close-to-zero overhead for the information collection.
- *Fail data capture in multisite flows.* Multisite testing presents a challenge as well as an opportunity for yield improvement. On the challenge side, multisite testing adds extra data volume and requires synchronization across sites. On the opportunities side, ATE can take advantage of multisite testing to hide the data collection on the failed dice behind the test time for the passing dice, thus reducing the effects on throughput.

In addition, datalogging efficiency depends on the ATE system being able to support adaptive datalogging and on its being able to provide a fast communication medium to transfer the collected fail data to the diagnosis tools.

As data is transferred from design to test to design, the ATE must provide a means for data integrity and data synchronization. Specifically, the tester needs to

- preserve information on any transformations that take place on any piece of data during the test-program generation as well as during data collection,
- perform data-integrity checks at regular intervals so the downstream analysis tools can ascertain that the data has not changed since the last synchronization point, and
- support standard data formats for multitool, multivendor environments.

This last point is important for customers with ATE from multiple vendors on the test floor. Supporting custom formats on a per-ATE and per-tool basis is a tedious process that is prone to errors. **Figure 3a** shows the complexity of transformations. Ideally, all the ATE and analysis tools should use a standard format, as shown in **Figure 3b,** for greater efficiency and accuracy.

Automating volume diagnosis

Figure 1 shows a volume diagnosis flow for a single design using a single tester. In reality, a single design may have to be tested using multiple testers, and different designs may get tested on one test floor. **Figure 4** shows an automated volume scan-diagnosis flow that our companies devised for such a test environment. A diagnosis server session called "monitor" captures failure data from multiple testers assigned to different devices, each with its own working directory. If there are existing failure files in a working directory, the server automatically checks data consistency on the new data.

Once data passes the consistency check, the monitor process distributes work to analyzer processes that perform fault diagnosis. Multiple analyzer processes can be assigned to a device data stream. Each analyzer corresponds to one diagnosis engine. If all failure files have been diagnosed, the server remains in an idle state waiting for new failure files. The results of analysis can be output in standard scan-diagnosis report format, in CSV tables, or potentially in other database formats. The results can be encoded or non-encoded.

Accurate diagnosis depends on input-data-consistency checks, a full simulation of passing and failing patterns, a complete test failure log, and access to physical design (layout) data. Experiments performed with the Mentor software found that compressed pattern diagnosis performs almost as well when compared to diagnosis with uncompressed patterns (Ref. 8). Comparisons of results from compressed and uncompressed patterns show a correlation of 92%, demonstrating the feasibility of a diagnosis flow based on production testing using compressed test patterns.

Advances in technology are demanding a new approach to yield learning using volume diagnosis. Therefore, while various test methods and compression technology are necessary to maintain high-quality and meet low-cost test needs, it is also critical to be able to identify defects quickly and reduce the yield ramp-up process to diagnose a significant volume of failed devices.

The role of ATE is expanding to meet these new requirements of yield improvement, thus closing the loop between DFT and diagnosis. Yield-friendly scan diagnosis can handle large data volumes automatically and efficiently. In addition to pinpointing the location of defects, scan diagnosis provides a learn-failure mechanism through logic simulation and enables physical-layout analysis based on failure data. This will greatly facilitate failure analysis and reduce the yield-learning effort. T&MW

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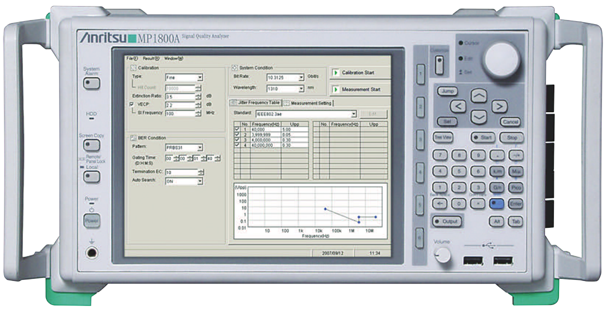


Analyze optical receivers

Anritsu's MP1800A signal-quality analyzer combines hardware and software to perform stressed-eye tests on optical receivers. The measurement suite consists of an MP1800A analyzer configured with a built-in synthesizer, a pulse pattern generator, and an error detector combined with stressed-eye measurement control software, a stressed-eye transmitter, and an optical receiver.

The transmitter supports 1310- and 1550-nm wavelengths, and the control software supports power-penalty tests, jitter-tolerance margin measurements, and jitter sweeps for jitter tolerance go/no-go tests for signals from 100 Mbps to 12.5 Gbps. You can make optical modulation amplitude (OMA), extinction ratio, and vertical eye closure penalty (VECP) measurements with a ±0.3-dB power penalty.

Base price: $46,500. *Anritsu, www.us.anritsu.com.*

USB-controlled true RMS RF power meter

The 6-GHz NI USB-5680 true-RMS power meter features high measurement accuracy and wide dynamic range packaged in a size similar to a typical power head. In automated test applications, the small size frees up rack space without sacrificing performance. Powered solely from the USB cable, the new power meter consumes only 100 mA of current.

Traditional power meters feature a power sensor or head located close to the unit under test and connect via cable to an accurate analog-to-digital converter (ADC) located in conventional instrumentation housing. In contrast, the USB-5680 combines both the sensor and the ADC in one package occupying less than 9.6 in^3. The USB-5680 connects directly to an available USB port on any PC or PXI controller. Features include an 8.5x3.0x5.6-cm size, a 50-MHz to 6-GHz frequency range, a 63-dB dynamic range, and a ±0.18-dB amplitude accuracy.

The USB-5680 comes with a full-featured, executable soft front panel and easy-to-use software libraries to help engineers set up their systems. Engineers who need to measure continuous wave RF signals up to 6 GHz can use the USB-5680 in a stand-alone configuration with a VXIplug&play-compatible executable soft front panel to facilitate interactive control. To incorporate the USB-5680 in an automated test and measurement system, engineers can use the application programming interface (API) with their programming environments of choice, including NI LabView and LabWindows/CVI and the Microsoft .NET environment.

Base price: $2499. *National Instruments, www.ni.com.*

Handheld vibration spectrum analyzer uses Windows Mobile

The VSA-1225 vibration spectrum analyzer (VSA), which works with the Windows Mobile/Pocket PC platform, joins Datastick's line of Palm-based VSAs in enabling companies to use portable vibration analysis in machine-condition monitoring, predictive maintenance, and routine troubleshooting. The VSA-1225 consists of Datastick hardware and software, plus the Hewlett-Packard iPAQ handheld computer, and one or more sensors.

The VSA-1225 hardware module attaches to an HP iPAQ hx2400-series or hx2700-series handheld. The iPAQ supplies the computing power and 128 Mbytes of data storage, while the Datastick VSA hardware module supplies the sensor power, Datastick electronics, and interface. SD (Secure Digital) memory cards (up to 2 Gbytes each) provide auxiliary storage.

For the handheld computer, the Datastick Spectrum software suite includes Datastick Spectrum and Datastick Review software. New Version 1.8 of Datastick Spectrum software records and shows vibration fast

Fourier transform (FFT) spectra in acceleration, velocity, and displacement displays, as well as in a new vibration decibel display. In addition, Spectrum provides time-domain acceleration waveforms and records and displays overall vibration with color-coded ISO (or custom) alert levels.

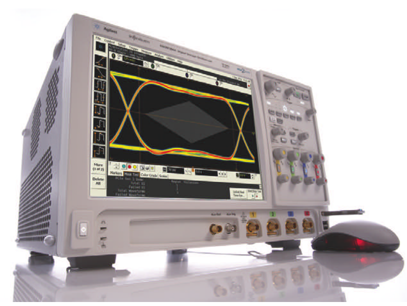
Datastick, www.datastick.com.

Oscilloscopes trigger with record memory

With an optional 1 Gsample of waveform memory per channel, Agilent's Infiniium DSO/DSA 90000A series holds the current memory record for oscilloscopes. The 90000A series consists of six digital signal oscilloscope (DSO) and six digital signal analyzer (DSA) models, with 10 Msamples of memory standard on the DSOs and 20 Msamples on the DSAs. Several memory options of up to 1 Gsample per channel are available.

The 90000A series builds on the low-noise 80000B series, but adds triggers such as edge-then-edge, timeout, and window. With a window trigger, you can draw a box on the screen and set the oscilloscope to trigger whenever a signal enters that space.

Besides having deep memory, the 90000A series features high bandwidth, ranging from 2.5 GHz to 13 GHz. The 2.5-GHz, 4-GHz, and



6-GHz models sample at 20 Gsamples/s on all channels, while the 8-GHz, 12-GHz, and 13-GHz models sample at 40 Gsamples/s. All models except the 13-GHz unit are bandwidth upgradeable. Noise levels range from 147-μV RMS at 2.5 GHz to 389-μV RMs at 13 GHz. All models feature 29 application-specific measurements covering serial data streams such as PCI Express and Ethernet, plus jitter analysis and mask testing.

Base price range (for DSOs): $29,000–$102,000. *Agilent Technologies, www.agilent.com.*

PXI and USB modules support MOST bus

Goepel electronic has introduced MOST (Media Oriented Systems Transport) communication modules for electronic control units (ECUs) in PXI and USB form factors. The new modules include the PXI card 3060 and a USB stand-alone controller named basicMOST 3060.

PXI 3060 and basicMOST 3060 target applications such as test of vehicle control units. The modules are configurable as master and slave. The new controllers guarantee sending/receiving functions on the MOST bus Control Channel and Packet Channel, and they can read out all MOST bus data.

Furthermore, the controllers can send and receive application protocols, data packages, and control messages. Trigger inputs and outputs are provided by means of the front connector. In addition, the PXI 3060 and basicMOST 3060 have analog inputs and outputs.

Goepel electronic, www.goepel.com.

BV Systems puts together WiMAX analysis bundle

Berkeley Varitronics Systems now offers a complete 700-MHz WiMAX propagation analysis package consisting of its Gator Class A transmitter, Coyote modular receiver system, and Forecaster GPS mapping coverage software. The bundle is available in configurations for 700-MHz, 2.5-GHz, and 3.5-GHz bands.

Forecaster allows Coyote users to plot and view coverage of wireless networks in tabular or graphical windows and also gives them the ability to create HTML reports of base stations and antennae coverage and RF overlap reports. It combines real-time Coyote measurements, GPS geocoding accuracy, and PC analysis.

Berkeley Varitronics Systems, www.bvsystems.com

ZTEC introduces LAN-based oscilloscopes

The new ZT4610 oscilloscopes from ZTEC Instruments are 1U height, half-rack width, rack-mountable instruments designed for ATE, aerospace and defense, and embedded applications. The oscilloscopes are available in two- and four-channel versions and offer a 1-GHz analog bandwidth, up to 4 Gsamples/s real-time sampling, and up to 64-Mpoint record lengths. An Ethernet interface enables users to remotely control the oscilloscopes over the Internet.

Instrument drivers are available for programming environments such as LabView, LabWindows/CVI, Matlab, COM, Visual C/C++, and Visual Studio. Additionally, the company's free ZScope control and display software, which offers a soft panel that simu-

lates a bench instrument, displays acquired waveforms, math waveforms, and waveform parameter data.

ZTEC Instruments, www.ztecinstruments.com.

RTD thermometer has 48 dedicated ADCs

The DT9872 from Data Translation is a PC-based resistance-temperature detector (RTD) thermometer that features a dedicated analog-to-digital converter (ADC) for each channel. The unit's front panel accepts up to 48 four-wire RTD probes,

making it useful for lab and factory applications. The dedicated ADCs let you simultaneously sample all channels at up to 7.5 Hz. You can select from platinum 100 Ω (Pt100), platinum 500 Ω (Pt500), or platinum 1000 Ω (Pt1000) probes. Temperature range is –200°C to 850°C (–328°F to 1562°F).

The instrument connects to a PC through a USB or Ethernet port. PC software lets you capture and plot data without programming, and you can export data to Excel for analysis.

Price: $7995. *Data Translation, www.datatranslation.com.*

Analyzer measures true OSNR in ROADM networks

JDSU has improved the measurement analysis for the in-band optical spectrum analyzer used in its T-BERD/MTS-8000 test platform. The OSA-320 module measures the true optical signal-to-noise ratio (OSNR) in reconfigurable optical add/drop multiplexer (ROADM) networks. It employs an optical polarization splitting method for measuring OSNR inside the optical channel (in-band OSNR), providing an accurate, true measurement.

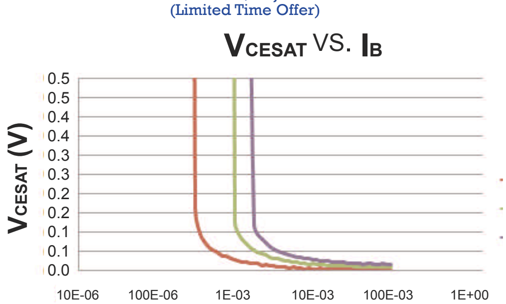
JDSU, www.jdsu.com.

Software works with EMI test receivers

Rohde & Schwarz has released the ES-SCAN Windows software for performing electromagnetic interference (EMI) tests with the company's ESPI3 and ESPI7 test receivers. The ES-SCAN software performs EMI measurements in accordance with commercial electromagnetic compliance (EMC) standards. Preconfigured test setups can set parameters (such as transducer factors for antennas) as specified by the EMC standard selected by the user. The user can also generate and store custom configurations.

EMI peak values are determined automatically with user-defined thresholds, and frequency lists created by the user allow measurements to be performed at detected (or suspected) interference frequencies.

Rohde & Schwarz, www.rohde-schwarz.com.



Handheld data recorder samples at 40 kHz

The Dash 2EZ+ portable data recorder from Astro-Med can record two channels of analog voltage along with one TTL event input to CompactFlash media at sample rates up to 40 kHz per channel. The HV-EZ+ isolated high-voltage module accepts inputs up to 250 Vrms, and the BR-EZ+ isolated DC bridge input module connects to most sensors, strain gages, and transducers.

A meter function provides a numeric readout of data simultaneously with waveform data. Built-in digital signal processing for each channel allows you to program low-pass, high-pass, band-stop, and RMS filters. A 5.7-in. color display allows users to view waveforms in real time The unit also contains a 3.1-in. strip-chart recorder. Data can be uploaded to a PC via Ethernet or USB 2.0.

Base price: $2995. *Astro-Med, www.astro-med.com.*

Protocol tester supports wideband AMR

The 6113 Air Interface Monitor Emulation (AIME) base station protocol test system from Aeroflex now offers wideband adaptive multi-rate (AMR) support, which is related to the 3GPP TS45.003 test specification.

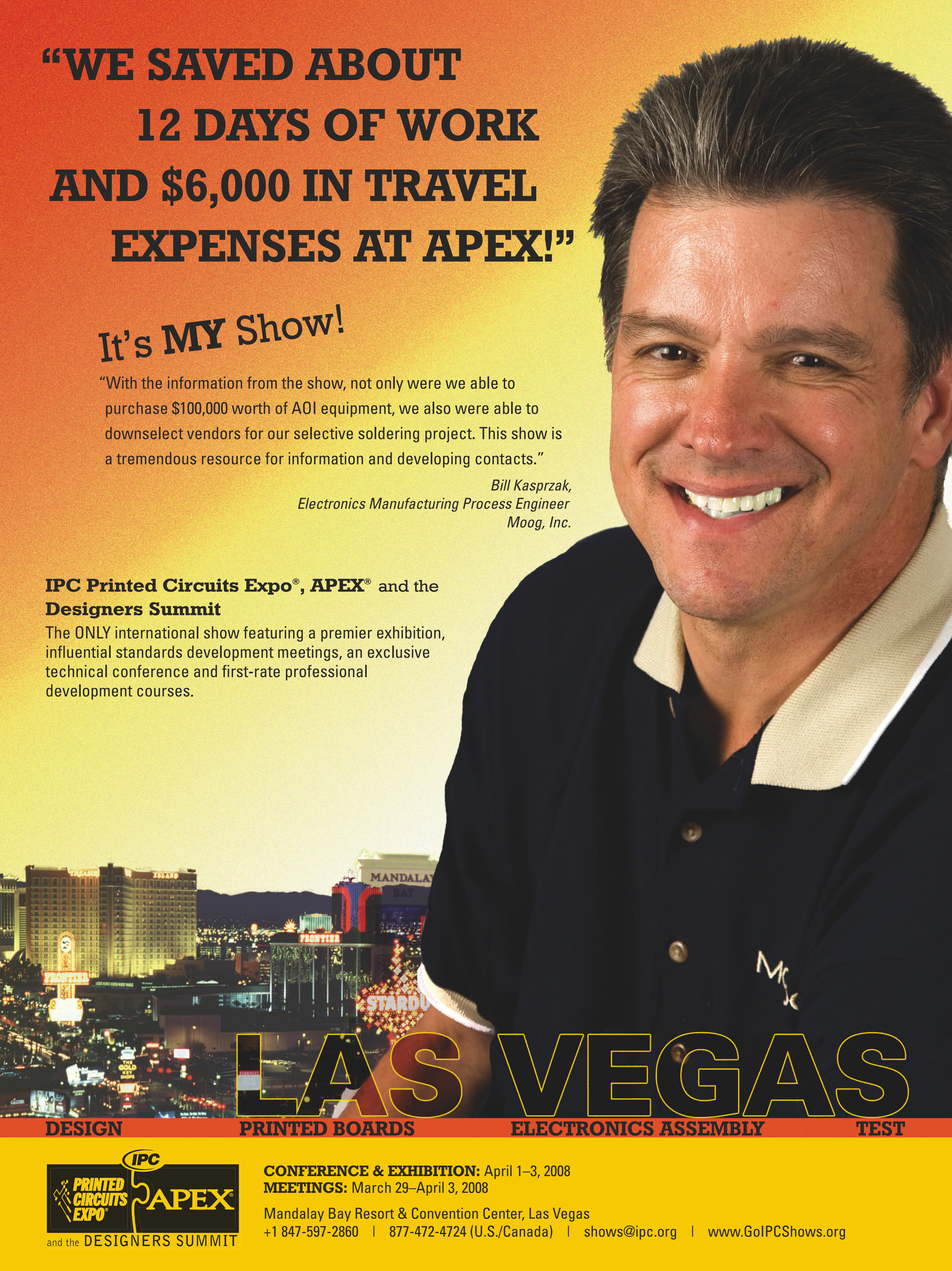
By combining the 6113E test set with the 6113E AIME software package, you can monitor, debug, and fault-find the layer 1 and protocol interchanges on the Um interface with a fully decoded display of layer 2 and layer 3 messages. The 6113 AIME protocol test system also offers script editing, debugging, execution, and automation facilities, as well as logging of all air interface signaling and traffic frames.

Aeroflex, www.aeroflex.com.

Test platform gains optical loss test module

EXFO has expanded its AXS-200 SharpTester line of handheld testers for telecom access networks with the launch of the AXS-200/350 test module, an optical loss test set (OLTS). The module is designed for testing fiber-to-the-home (FTTH) deployments as well as for assessing coarse wavelength division multiplexing (CWDM) and dense wavelength division multiplexing (DWDM) networks. It offers easy pass/fail threshold configuration, 40 calibrated wavelengths within the 800-nm to 1650-nm range, and a power range of +26 dBm to –55 dBm.

EXFO Electro-Optical Engineering, www.exfo.com.


"WE SAVED ABOUT 12 DAYS OF WORK AND $6,000 IN TRAVEL EXPENSES AT APEX!"
It's MY Show!
"With the information from the show, not only were we able to purchase $100,000 worth of AOI equipment, we also were able to downselect vendors for our selective soldering project. This show is a tremendous resource for information and developing contacts."
Bill Kasprzak, Electronics Manufacturing Process Engineer Moog, Inc.
IPC Printed Circuits Expo®, APEX® and the Designers Summit
The ONLY international show featuring a premier exhibition, influential standards development meetings, an exclusive technical conference and first-rate professional development courses.
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and the DESIGNERS SUMMIT
CONFERENCE & EXHIBITION: April 1–3, 2008
MEETINGS: March 29–April 3, 2008
Mandalay Bay Resort & Convention Center, Las Vegas
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Smart cameras serve as LabView targets

By Rick Nelson, Chief Editor

Matt Slaughter
NI Vision product manager
National Instruments
Courtesy of National Instruments.

National Instruments' monochrome VGA NI 1722 and NI 1742 smart cameras have 400-MHz and 533-MHz PowerPC processors, respectively. NI Vision product manager Matt Slaughter commented on NI's entry into the smart-camera market in an exclusive interview.

Q. When did NI introduce the two smart cameras?

A. We had a preannouncement at NIWeek last summer, where we showed off some of the features during a keynote demo, but the official announcement occurred at Vision 2007 in November.

Q. NI is reselling some third-party cameras—why not take that approach with the smart cameras?

A. We have GigE Vision and 1394 [FireWire] cameras from Basler that we are reselling, and there certainly are other smart camera vendors out there—some of whom ship their cameras with our software. But we wanted to make sure that our smart cameras represent a true LabView target that we had complete control over.

GigE Vision and 1394 cameras comply with set standards, so regardless of what third-party camera we are using, our back-end software can stay the same. That's not the case with smart cameras, and we had to do a lot of driver development to get our smart cameras to work with all the software we have.

Q. Can you give an example of these cameras' compatibility with NI software?

A. For NIWeek, we like to do run-throughs a month early to make sure everything goes smoothly, and I didn't have a new smart camera available to use to develop the demonstration. So, I used a monochrome analog camera with the same 640x480-pixel resolution. I wrote my entire application in LabView using a standard driver, and I was able to directly port that application over to the smart camera with minimal changes.

Q. Your smart cameras have two Ethernet ports. Are they GigE Vision compliant?

A. No, we are emphasizing that they are not GigE Vision cameras. One port will be used for reporting results and maybe for reporting failed images back to your main host. The other port is typically going to be used for one of two things: The first is troubleshooting, in which you can walk up and plug in a laptop via crossover cable and do troubleshooting without ever pulling the camera off the line. The second thing that most people will probably do with this second port is communicate with other devices, like PLCs or our CompactRIO platform.

Q. Will you ever add GigE Vision?

A. That's something that's been brought up a few times. But the purpose of a GigE Vision camera is of course to return images as quickly as possible, and you typically would not go with a $2000 smart camera to do that. So, I don't think we get much value added by turning this into a GigE Vision camera. But I'm not going to say it will never happen.

Q. This is NI's first foray into the smart camera market—is it the last?

A. No, it's not just these two cameras we are releasing; it's going to be an entire family of cameras. You can expect to see an announcement about every quarter. □

This article is a condensed version of the interview, in which Slaughter commented on CCDs vs. CMOS, choosing camera processor speeds, and using smart cameras for motor control. Read the complete interview in the online version of this article at www.tmworld.com/2008_02.

INSIDE THIS REPORT

EDITOR'S NOTE

Inspection vies with test at APEX

By Rick Nelson, Chief Editor

Inspection has long had a place in the production of printed-circuit boards (PCBs), as shrinking component sizes, multiple layers, and hidden solder balls hinder the access necessary for electrical test. And optical and x-ray inspection techniques not only make up for a lack of test coverage, but they can also uncover problems such as solder-paste deficiencies or missing components early in the production process.

Of course, inspection alone isn't sufficient. Few would opt to ship a product that hasn't undergone structural, in-circuit, or functional electrical test. To that end, boundary-scan tools and electrical test systems have evolved to provide enhanced test coverage.

What's been missing as inspection and test tools evolve, however, has been a recipe for deciding how much of each you'll need. To help you make sense of the choices, the IPC at APEX will present a panel of executives representing Agilent Technologies, Asset InterTech, CyberOptics, CheckSum, Everett-Charles, and YesTech, who will discuss how to mix and match test and inspection technologies. I will moderate the panel, scheduled for 10:15 am on April 3 at APEX in Las Vegas.

You won't get a formal recipe, but you'll learn valuable information that will help you sort through these firms' x-ray inspection, optical inspection, boundary-scan, and electrical-test offerings. More important, you'll have a chance to make your comments heard. □

Contact Rick Nelson at rnelson@tmworld.com.

HIGHLIGHTS

Rudolph purchases IP and assets from RVSI Inspection

Rudolph Technologies, a provider of process-characterization equipment and software used in wafer-processing and semiconductor manufacturing, reports that it has acquired all intellectual property and selected assets from RVSI Inspection of Hauppauge, NY. Rudolph said it expects the addition of RVSI's industry-standard WS-3800 3-D bumped wafer inspection system to its product portfolio will strengthen its presence in the advanced packaging market. Terms of the transaction were not disclosed.

The WS-Series wafer inspection system is used by back-end manufacturers, particularly for bump applications. The system performs 3-D bump-height and coplanarity measurements, and with proprietary Micro-Map 3-D laser-based triangulation, it is designed to achieve required inspection speeds without compromising defect detection.

"We will be adding an excellent technical team to our Rudolph organization and expect to quickly and efficiently fold the RVSI operations into our existing inspection business," said Nathan Little, executive VP and GM of the Inspection Business Unit. "With a high level of customer overlap, combined with our existing global applications and service support network, our goal is to make this transition as seamless as possible."

Rudolph will maintain a technology center for the wafer scanner products in Hauppauge but will relocate the manufacturing activities to Bloomington, MN. www.rudolphtech.com.

Call for papers: The Vision Show

The Automated Imaging Association is seeking presentations for The Vision Show 2008, scheduled for June 10–12 in Boston, MA. Possible topics include machine-vision lighting and software, 3-D vision, nonvisible imaging, and smart cameras. www.machinevisiononline.org.

Quest chooses Lattice FPGAs

Lattice Semiconductor has announced that Netherlands-based Quest Innovations selected the LatticeECP2/M field-programmable gate arrays (FPGAs) for use in its next-generation Raptor series of Gigabit Ethernet cameras. Quest has integrated its QuadCore IP multicore parallel pixel processing unit into the Lattice FPGAs, which incorporate the LatticeMico32 open-source soft microprocessor core, 840-Mbps high-speed low-voltage differential signaling (LVDS) I/O, a pre-engineered DDR2 memory interface, and full-featured digital signal processor (DSP) blocks.

By connecting 10 QuadCore IP cores, Quest can process and transfer images at 1 Gbyte/s. The latest version of the Raptor camera system will support more than 2 Mpixels, 500 fps, and 8 Gbytes of memory; the camera will also perform preprocessing and store up to 24 s of high-speed image data.

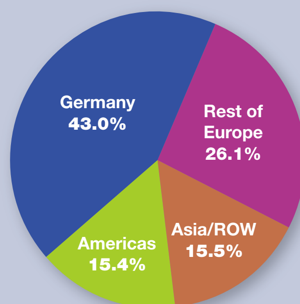
"The LatticeECP2/M FPGA family proved to be an excellent platform for integrating our high-performance QuadCore scalable pixel processing IP into our Raptor camera systems," said Richard Meester, president and CEO of Quest Innovations. "The combination of the Lattice FPGAs and IP cores, combined with our expertise in machine-vision systems, has allowed Quest Innovations to develop a truly industry-leading, user-programmable camera system." www.latticesemi.com.

Stuttgart show highlights vision market

The worldwide machine-vision industry is showing considerable strength, based on activity at Vision 2007, held November 6–8, 2007. The Stuttgart event gave the German machine-vision industry an opportunity to tout its particular strengths.

At a November 6 press conference kicking off the show, Thomas Walter, division director of industrial solutions for Messe Stuttgart, noted that the Vision show celebrated its 20th anniversary by convening for the first time in the New Stuttgart Trade Fair Centre adjacent to Stuttgart Airport. "It is hard to believe, but Vision 2007 has attracted 281 exhibitors," he commented, adding that the number represented "an increase of 31% compared with 2006, when we exceeded the 200 mark for the first time, with 214 exhibitors."

Walter noted that the exhibitors hailed from 27 countries, with 42% coming from abroad: "The largest contingent of foreign exhibitors comes from the USA, followed by the United Kingdom, Canada, Japan, Switzerland, the Netherlands, and France." Also represented, he said, were exhibitors from the Republic of Korea, Finland, Greece, and Hungary. He had estimated that the 2007 show would have 5500 attendees, with 25% of them coming from abroad; in fact, the show enjoyed about 6000 visitors, with 32% of them coming from outside Germany.



Although domestic sales represented the largest single segment of the German machine-vision industry in 2006, exports accounted for more than half of the revenues.

Source: VDMA.

Dr. Dietmar Ley, CEO of Basler and chairman of the VDMA (German Engineering Federation) Machine Vision Group, presented specifics related to the German machine-vision market. He said that the German machine-vision industry remains on target for solid growth. In 2006, it increased the sector's revenue by 9% to €1.1 billion. In 2007, the companies surveyed by VDMA are expecting an increase in revenue totaling 6%, with a further increase of 6% also predicted for 2008.

He said that worldwide demand helped German manufacturers of machine-vision cameras to increase their revenue by 29% in 2006 compared with the previous year. Other machine-vision components also gained in 2006, he said, with lights up 43%, lenses up 34%, and machine-vision software up 30%. As for machine-vision systems, Ley noted that revenue for standard systems (including smart cameras and vision sensors) increased 5% in 2006, with smart-camera revenue jumping 157%. In contrast, he said, sales of custom, single-application systems fell 4%.

"Despite the solid domestic business, the foreign market remains the most important engine for growth," Ley said. He said that German vision firms are well positioned in the foreign markets, with 57% of 2006 revenue coming from abroad—8% higher than the previous year. More than a quarter of the revenue was achieved in Europe (excluding Germany), he said, while Asian and American markets accounted for 15% each (**figure**).

Lay also reported some European Machine Vision Association (EMVA) machine-vision data for all of Europe. According to EMVA market research, he said, the European suppliers recorded an overall growth of 11% in 2006 and expect 9% growth for 2007. □

Machine-vision focus shifts with application

By Rick Nelson, Chief Editor

Dalsa sales and marketing VP Philip Colet commented on hot topics in the machine-vision industry in this interview with *T&MW.*

Q. What are the key issues facing the machine-vision and inspection industry?
A. When I look at machine vision, I look at the different components: lighting, optics, sensor technology, camera technology, data-acquisition technology, and image analysis and processing. Depending on the type of application a customer has, we will stress different components in different ways. In terms of illumination for semiconductor applications, as line widths get smaller and smaller, we want to start talking about ultraviolet (UV) and deep UV, and that has implications for optical technology and sensor technology. And since the data rates are so high, there are also implications with respect to camera speed and data processing.

Q. Where is the emphasis on printed-circuit board (PCB) inspection applications—on frame rates and resolution or on algorithms that can do more with less data?
A. In automated optical inspection [AOI] applications, the throughput of a machine is a competitive advantage, so the faster that machine works, the better. The machine must, of course, analyze the images it acquires, but it all comes down to how quickly it can scan a PCB and how many PCBs it can do in an hour. So, the AOI OEMs are asking for higher resolution, and they are asking for higher frame rates.

Q. Dalsa recently introduced the Falcon 1.4M100 area-scan camera. What are some of its features?
A. Its resolution of 1400-by-1k pixels is good for a variety of machine-vision applications. Also, the size of the sensor ties in nicely to the size of available lenses, so you can use a relatively inexpensive lens, and you can get relatively close to your object.

But the unique feature about this camera is the speed—the ability to go to 100 fps at that resolution. And that speed of image acquisition can be useful in, for example, the populated PCB AOI we were just discussing. It can also find use in the high-speed chip shooters that are populating PCBs.

Philip Colet
Sales and marketing VP
Dalsa
Courtesy of Dalsa.

Q. Is it a CMOS or a CCD camera?
A. It's a CMOS sensor that provides very good quality images with quite a good signal-to-noise ratio as well as quite good CCD-quality light-gathering capability. The whole debate about CMOS vs. CCD is to us almost irrelevant. To us, the image quality we can get with a CMOS sensor is just as good as what we can derive with many CCD imagers on the market today.

Q. So CMOS will replace the CCD?
A. CCD won't go away. There will continue to be niche applications for CCD—for example, for applications requiring backside thinning. Backside thinning is a lot easier to do with CCDs than with CMOS.

A second example is the TDI [time delay and integration] sensor. Dalsa makes a lot of TDI sensors, which are essentially line-scan sensors where you have this bucket brigade in which you are dumping charge. With CMOS, that just doesn't happen, because you don't have a charge anymore, you have a voltage, and you can't really accumulate voltage the way you can accumulate charge.

So our feeling is, CCD will stay in these niche applications, but CMOS will take over in terms of image quality.

Q. What's happening with image processing—is it still taking place on a dedicated image-processing board, or is it migrating to the PC?
A. If you go back 15 years, you had relatively lame computers, and all of the processing had to occur on special image-processing hardware. But then two things happened. Number 1, the PCI bus became popular, and it allowed you to dump raw data down to a PC. And number 2, we saw a corresponding rise in the processing power of the PC. It was those two things happening at the same time that enabled a transfer of processing responsibility from an onboard architecture down to a standard PC architecture.

Q. So, the embedded architecture is dead?
A. No way. Because people are always pushing the envelope. The kinds of sensors that are coming out right now, the data rates they are running at, and the complex algorithms that people want to execute can still over-

whelm even a quad-core PC, so you still have to do some processing on the board. Where do we find those applications? They tend to be in anywhere you are generating a lot of data—such as semiconductor wafer-inspection applications—or they tend to be in real-time applications, where I do not have the ability to accumulate data and then process it.

Q. What will be the hot topics in machine vision in 2008?

A. The debate will continue between CCD and CMOS, and I expect CMOS to continue to progress in terms of image quality and light sensitivity. In terms of camera technology, I expect the issues to have more to do with the interconnect as opposed to what's in the camera itself.

The hot subjects there would be where we are in terms of 10 GigE Vision and where we are in terms of Camera Link and its limitations. We have the mini-Camera Link connector now and Power over Camera Link, which are real benefits to OEMs, but what comes next?

Camera Link will bring you up to about 680 Mbytes/s maximum, but we are talking about sensors that will be going at 1 Gbyte/s or even 2 or 3 Gbytes/s. What interconnect technology are we going to be using for them? We will be looking at PCI Express to see what it can do for us.

In terms of software technology, there will be continued work on pattern recognition and on color. Today, color is complicated because there are a lot of ways to look at color, and color tools now are somewhat antiquated in how they force people to think about color. New color tools should simplify the life of the OEMs so they are not forced into thinking in one domain or another. □

This article is a condensed version of the complete interview, in which Colet elaborates on FPGA programming, discusses the differing requirements for bare- and loaded-PCB AOI, and comments on application areas ranging from traffic control to medical imaging. Read the transcript in the online version of this article at www.tmworld.com/2008_02.

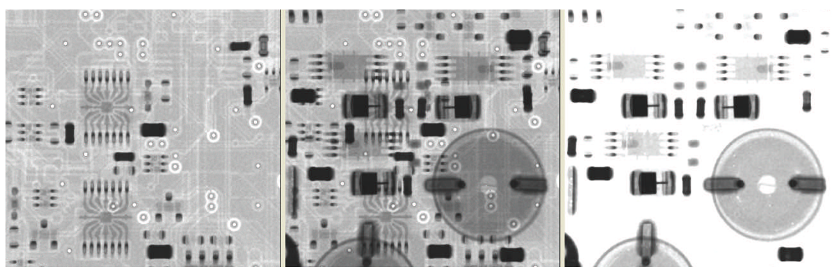
Transmissive 2-D x-rays speed PCB inspection

By Rick Nelson, Chief Editor

Building high-speed, low-cost automated x-ray inspection systems that are easy to program is the goal of MatriX Technologies, according to managing director Eckhard Sperschneider. In an interview at Productronica 2007, he said the company also works to link automated optical inspection (AOI) and automated x-ray inspection (AXI) data to find defects and correct their causes in real time. Sperschneider said the German company, founded in 2004, targets OEMs serving the automotive, telecom, and other industries where maintaining high production throughput is critical.

To build systems that achieve high speeds at low cost while performing x-ray inspection of double-sided printed-circuit boards (PCBs), MatriX avoids using expensive, slow tomosynthesis techniques, according to Sperschneider. Instead, the company employs its Slice Filter Technique (SFT) to augment standard, high-speed transmissive 2-D x-ray analysis. At Productronica, MatriX introduced the X2.5 addition to its AXI product line, which adds a 0 to 45° angle-shot capability that Sperschneider said can work with SFT to guarantee 100% test coverage of double-sided PCBs.

SFT, which in conjunction with the X2.5's new angle capability discerns hidden or overlapped joints, employs a proprietary algorithm to separate image data for each side of a double-sided PCB without requiring the use of 3-D laminography techniques. Sperschneider explained that SFT combines software with a knowledge of the x-ray dynamic-absorption characteristics of specific PCB materials to acquire top-side and dual-side images and then derive a bottom-side image (**figure**).



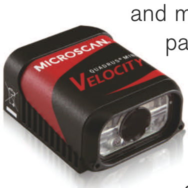
The proprietary Slice Filter Technique (SFT) supports the inspection of solder joints on double-sided assemblies: (left) the top side of a PCB before assembly of the bottom-side components; (middle) an x-ray of the fully assembled double-sided PCB; (right) the bottom-side solder joints after SFT-based image reconstruction. Courtesy of MatriX Technologies.

To implement the AOI-AXI link, MatriX uses its MIPS_Process software, which in its latest release includes a module that can correlate different inspection points in the SMT line—for example, on encountering a solder defect, the software can call up paste-inspection results and initiate corrective measures.

MIPS_Process can also be used as a Web interface tool. Sperschneider said that MIPS_Process acquires results from AOI systems from companies such as Viscom with the goal of locating problems such as joints with insufficient solder and locating the process step that results in the defect. "Finding defects is one thing," he said, but the goal is to eliminate them. □

Mini bar-code imager handles high-speed production

Microscan Systems has released the Quadrus MINI Velocity autofocus imager, which can read linear and 2-D codes moving as fast as 100 in./s. The imager helps manufacturers track data and monitor production parts and processes during high-speed production.



The Velocity reads linear and 2-D codes on a variety of items, such as printed-circuit boards, automotive parts, and packaging. With its autofocus technology, the imager can provide continuous reading performance across varying line speeds, code distances, and code types. The Velocity also includes Microscan's Easy Setup Program (ESP) software, which simplifies data collection through programmable features such as multisymbol reading, match code, trend analysis, symbol-quality reporting, and multiple I/O programming.

Microscan Systems, www.microscan.com.

Machine-vision cameras provide FireWire interface

The Sony Electronics XCD series of machine-vision cameras comprises three sets of cameras offered in VGA, SXGA, and UXGA resolutions and in either monochrome or color versions. The cameras include an IEEE 1394b (FireWire) interface, and a 1394b software driver delivers reliable daisy chaining of up to 62 cameras with an optional external power supply, according to the company.

A bus-synchronization feature permits cameras on the same bus to acquire images simultaneously without an external synchronization signal. With the broadcast delivery feature, users can simultaneously change the settings of all cameras on the same bus with a single command.

Sony Electronics, news.sel.sony.com.

JAI unveils compact cameras

JAI has launched four new digital cameras in its Core Camera Concept (C3) Compact family, an entry-level series with a small form factor and a single-tap, high-frame-rate architecture. The CM-140GE and CB-140GE deliver 1.4-Mpixel resolution (1392x1040 pixels) in monochrome and raw Bayer color, respectively. The CM200GE and CB200GE offer 2-Mpixel resolution (1628x1236 pixels) in monochrome and raw Bayer color.

The CM-140GE and CB-140GE operate at 31 fps, while the CM-200GE and CB-200GE run at a rate of 25 fps. All four cameras provide partial scanning and binning modes, as well as GigE Vision and GenICam interfaces.

JAI, www.jai.com.

Adimec introduces 1-Mpixel GigE cameras

The ONYX-1000 GigE CCD camera from Adimec provides excellent linearity over the full dynamic range of 63 dB, according to the company. The camera delivers 60 fps and offers features such as global shutter, channel matching to below noise level, automatic black and shading, and defect pixel correction. The ½-in. CCD area array sensor provides a 1024x1024-pixel resolution.

Adimec, www.adimec.com.

X-ray inspection system available in two configurations

The Verifier H series of horizontal-beam x-ray inspection systems from FocalSpot is designed for industrial, automotive, and medical applications. The systems provide manufacturing quality assessment and defect detection of components such as automotive sensors, electronic modules, and medical assemblies.

The Verifier H, which includes a four-axis, 360° manipulator, is offered in two configurations: 75 kV for general-purpose applications and 90 kV for applications requiring additional power to penetrate dense materials.

FocalSpot, www.focalspot.com.

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VIEWPOINT

[An exclusive interview with a technical leader]

JIM MAGINN
CEO and Senior VP
AR
RF/Microwave Instrumentation
Souderton, PA

After starting his career in 1975 as a radar systems engineer at the DoD's Naval Air Development Center (NADC), Jim Maginn moved on to defense-related engineering management posts at Veda and FMC Corp. In 1992, Maginn joined Amplifier Research (now AR) as an engineering manager. He was promoted to VP of engineering and manufacturing in 1994 and to senior VP and COO in 1998. In 2006, Maginn was named senior VP and CEO, overseeing development and manufacturing of AR's broadband RF amplifiers and related RF and microwave devices. He holds a BSEE from Villanova University and a Master's in Industrial Engineering from Texas A&M.

Contributing editor Larry Maloney conducted this interview with Jim Maginn on trends in EMC and RF test applications.

New solutions to compliance headaches

Q: What is AR's niche in the test field?

A: Our heritage product is the broadband power amplifier, which we offer in frequencies from DC to 45 GHz and from 1 W to 10 kW. These instruments are used in countless applications, such as communications, physics research, component characterization and testing, and calibration of meters and probes, to name a few. But our key niche is really electromagnetic compliance (EMC) test. Any product containing electronics, whether it be an airplane or a child's toy, can require EMC certification.

Q: How are the changing needs of your customers shaping product development at AR?

A: Test engineers are faced with an ever-increasing need for more power and higher frequencies. Our amplifiers have always been designed with the maximum possible bandwidth. This gives engineers the product longevity they need as test frequencies increase. Our "subampability" design concept allows addition of subamps to a given product to increase power output by two, three, or four times as requirements grow.

Q: What technical challenges do you face with the rapid proliferation of wireless systems and devices?

A: What we call "frequency creep" provides us with the challenge of developing solid-state products that go up to 20 GHz now and up to 60 GHz in the very near future. We have acquired the clean-room facilities and design resources to apply microelectronic technology to the problem. That has resulted in our new line of 20-GHz amplifiers, which provide the same performance as our lower-frequency amplifiers and offer an alternative to the current traveling wave tube (TWT) technology.

Q: How is AR responding to the demand for easier-to-use products?

A: For our conducted immunity customers, we have designed the CI00250 and CI00400 test systems, which provide a much simpler approach to full calibration and testing. For example, the CI00250 contains all the instruments needed to perform conducted immunity testing to the IEC 61000-4-6 specification. Equipment includes a signal generator, a two-channel power meter, a 75-W minimum AR amplifier for 10 kHz to 250 MHz, plus control software. Everything is contained in a single housing, which eliminates setup issues. In short, you reduce test time and boost productivity, while achieving superior accuracy.

Our SW1006 EMC test software and the TG6100 Automatic Transient Generator are also designed for ease of use. Both of these products feature embedded automatic protocols that comply with IEC, MIL-STD, and automotive test procedures and specifications.

Q: Are more customers asking to have AR products assembled into test systems?

A: Several years ago, we noticed a change in the nature of customer requirements from one of exploratory testing to one of following the requirements of standards and preparing to pass compliance testing by a certified test organization. This led us to develop our line of precompliance test systems.

More recently, we have seen the need to put together "amplifier systems," particularly in the 1- to 40-GHz range. Heavy losses in waveguide from amplifier to antenna make it almost a necessity to put the whole amplifier/antenna package inside the test chamber and close to the test item. For example, we designed our new AS40000 system to house amplifiers and antennas covering 800 MHz to 40 GHz in two air-conditioned, EMI-shielded equipment racks. We mounted the equipment racks and antenna mast on a rolling skid to create a portable field generation platform. We'll continue to explore such system solutions for customers. T&MW

Jim Maginn discusses more new products and technology development at AR in the online version of this interview: www.tmworld.com/2008_02.