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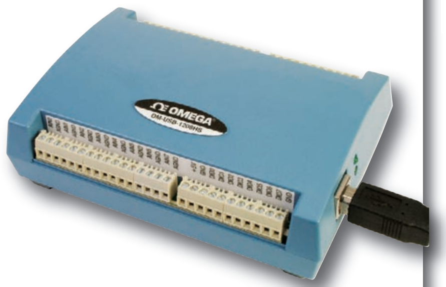

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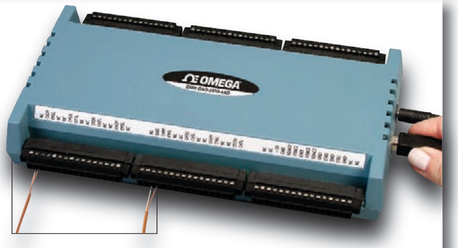

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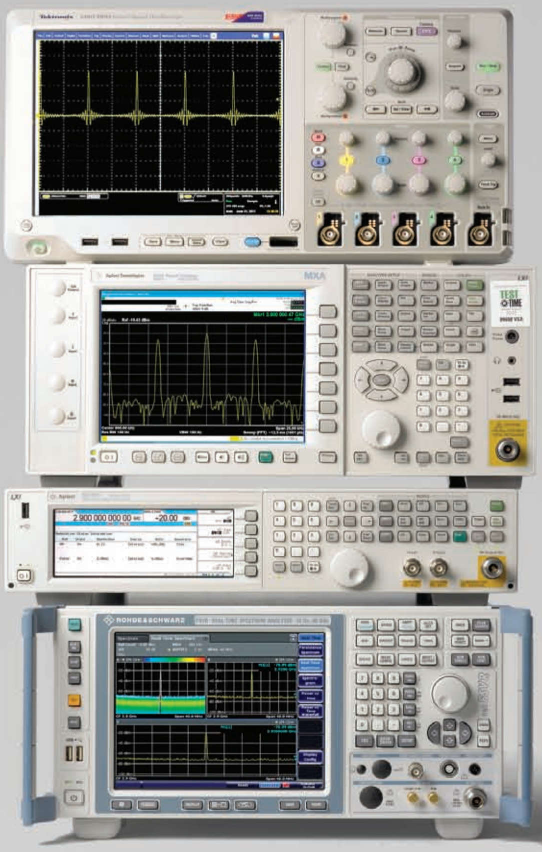

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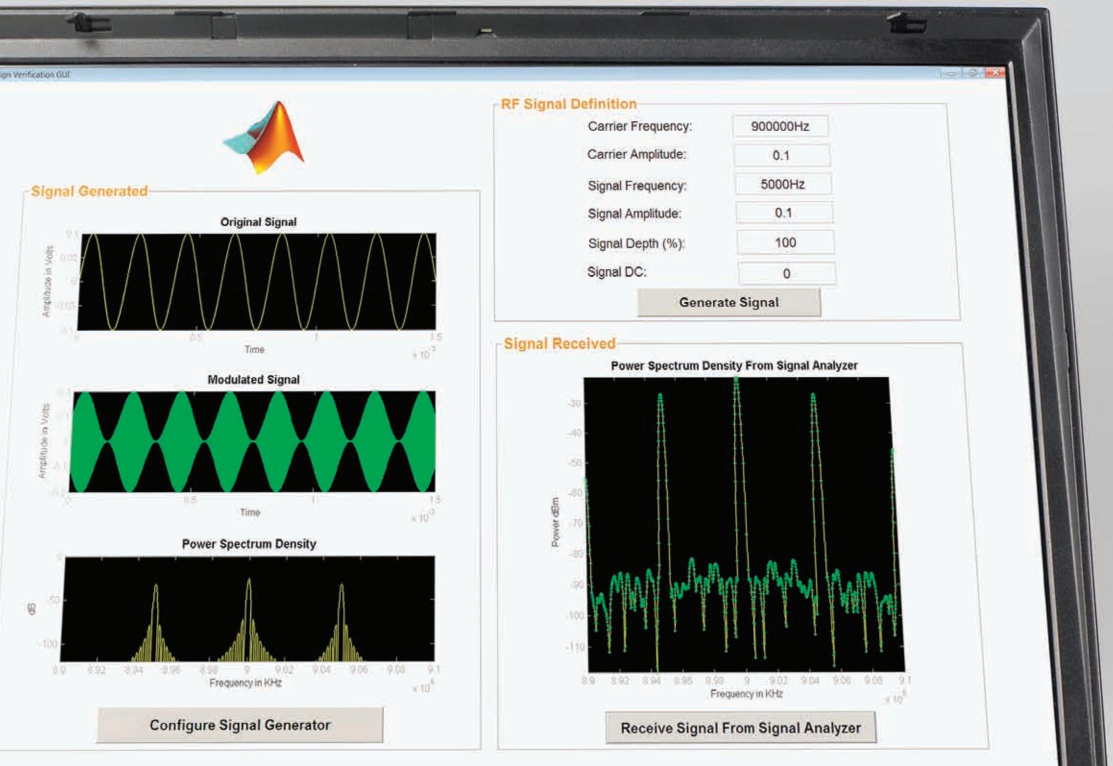

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Signal Frequency: 5000Hz
Signal Amplitude: 0.1
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Signal DC: 0

Test & MEASUREMENT WORLD®

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TEST DIGEST

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

Serial standards keep test engineers on edge

Join the conversation! Ransom Stephens says that in the last decade, high-speed-serial specifications have taken us on a thrill ride. Emerging multigigabit-per-second specifications like the 3rd generations of PCI Express, USB, and SAS/SATA, plus the 100-Gbit Ethernet locomotive, require test engineers to learn many new tricks. What have you had to learn?

bit.ly/xMoWt8

Another test-system bus

According to the National Instruments *Automated Test Outlook 2012* report, PCI Express will become the external interface bus of choice for automated test systems. The report goes on to proclaim that new PCs will come with Thunderbolt ports, which combine PCIe and DisplayPort video protocol.

bit.ly/wCGQaf

Product tryout: Oscium WiPry

Martin Rowe reports on his tryout of the Oscium WiPry, a spectrum analyzer/power meter for Wi-Fi. The WiPry connects to an iOS device and helps users troubleshoot interference on wireless networks.

bit.ly/xkjqNp

Testing op amps, part 2

In part 2 of a series about testing op amps, David R. Baum and Daryl Hiser of Texas Instruments explain how to test input bias current, and they present the sources of errors you must consider when testing the devices.

bit.ly/xNmIMt

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MARTIN ROWE
SENIOR TECHNICAL EDITOR

A new face

In his article "User Interface—The next battlefield—Part 1," Alvin Wong predicts that user interfaces and ease of use will become a consumer's primary reason for selecting an electronic product (Ref. 1). In making his point, Wong argues that well-designed features will become ubiquitous. He points to the touch screen and speech recognition as two interfaces that have replaced keyboards and mice.

Rakesh Kumar goes a step further, predicting that gestures have the potential to dominate how people command industrial systems such as machines (Ref. 2). He also predicts that machine operators will be able to log in not with a user name and password, but with face recognition.

These alternative user interfaces have the potential for use with test equipment.

Most box test equipment relies heavily on mechanical buttons or wheels as the primary user interface. Instruments such as oscilloscopes use a combination of knobs, buttons, and menus. Some bench oscilloscopes, particularly those with embedded PCs, let you add a keyboard or a mouse. Others use touch screens that let you navigate menus. Some let you zoom in on a signal with a mouse or touch screen. Yet, all bench oscilloscopes still have knobs, because engineers have insisted on them.

Tablet computers and smartphones, with their touch screens, are at the beginning stages of showing us that they can be used to control instruments. I think the idea of using two fingers to zoom in on a waveform is too intuitive to ignore. I can envision an instrument on which the entire user interface is a smartphone or tablet computer: The oscilloscope, meter, or other measurement system will communicate over a wireless connection to the phone or tablet that you take with you.

Gesture control, which is just starting to appear, could take instrument control to yet another level. Kumar opens by commenting on how much we already accomplish with gestures: "By holding out a hand, palm forward, we can stop a group of people from approaching a dangerous situation; by waving an arm, we can invite people into a room." If instruments had gesture-control interfaces, you wouldn't have to reach across your bench to a front panel to change an instrument setting. Eliminating the reach would minimize the chance that you'd accidentally disturb the test setup. For some of us, eliminating that reach could literally save our backs.

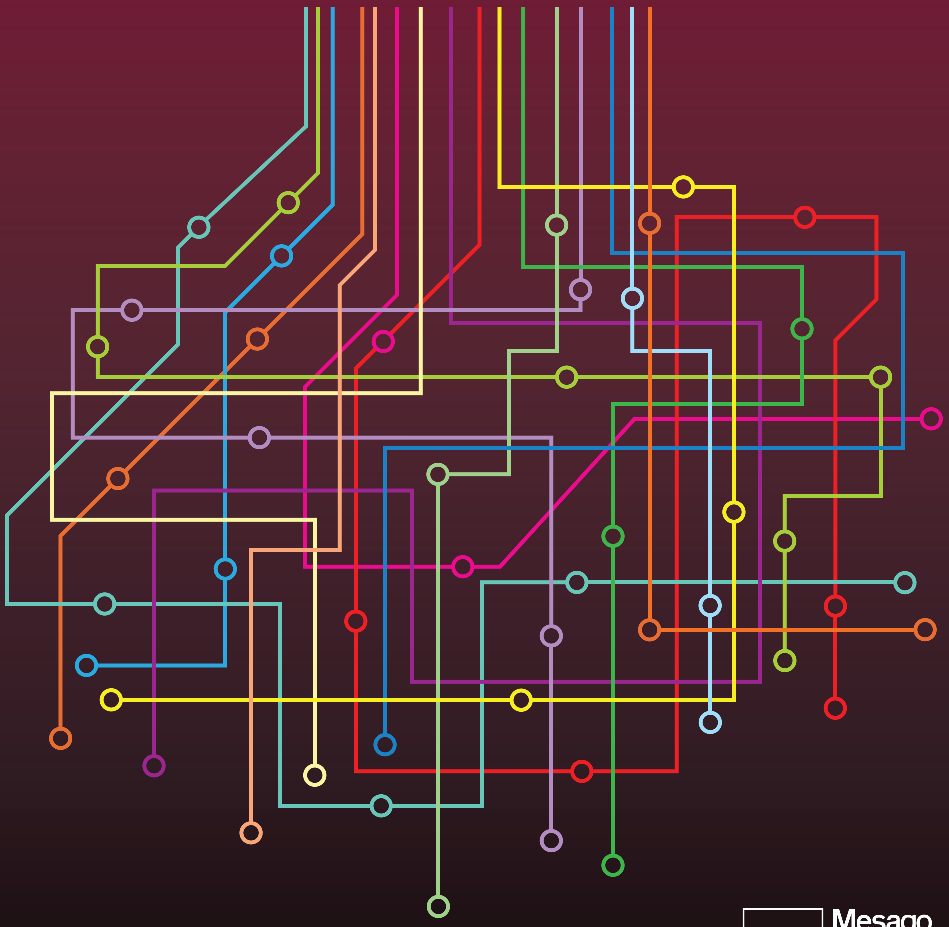
For automated test systems, which often have touch-screen interfaces, a gesture or voice-recognition interface could, as Kumar notes, reduce the maintenance costs of cleaning or repairing touch screens. But gestures, words, and accents vary widely. A gesture that's common in one culture is offensive in another. Different cultures, even different parts of the same country, use different words for the same thing: A "highway" on the East Coast is a "freeway" on the West Coast; a "rotary" in New England is a "roundabout" everywhere else. The software used to control gesture and voice-recognition interfaces will need considerable refining and customization.

All of these alternative user interfaces have the potential for use with test equipment. But old habits die hard, and it could be many years before anything replaces knobs and buttons. And because test equipment has a long life compared to consumer products, by the time your bench instrument is ready for a new face, that face itself may be obsolete. T&MW

REFERENCES

1. Wong, Alvin, "User Interface—The next battlefield—Part 1," February 9, 2012. bit.ly/wraynP.

2. Kumar, Rakesh, "Wave hello to the natural user interface," January 24, 2012. bit.ly/zqfto8.



TESTVOICES

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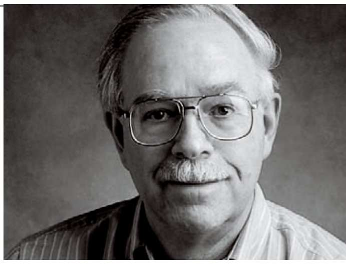
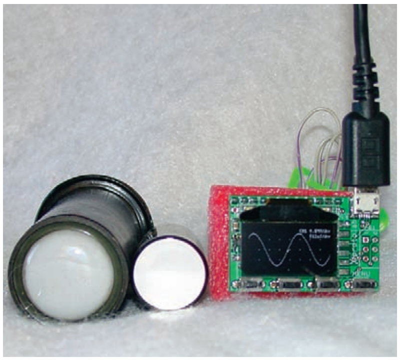


One-inch wonders

Introduced by RCA (Radio Corporation of America) in November 1936, the 913 CRT (cathode-ray tube) created a minor stir in the electronics community. RCA initially priced the 913 at $5.60 (approximately $87 today when adjusted for inflation), which was a bargain, considering that RCA's 3-in. 911 CRT cost four times more.

To a casual observer, the metal-jacketed 913 resembled RCA's newly introduced 6L6 beam-power tube (still in use today), but instead of a domed metal top, the 913 sported a 1-in.-diameter viewing screen coated with a green phosphor.

But what applications might exist for a 1-in. CRT? Low-cost test and measurement instruments represented an obvious market niche, but RCA likely hoped that innovative manufacturers would embed small CRTs in a variety of industrial equipment.



Late in 1936, RCA introduced the Model 151, a general-purpose oscilloscope featuring the 913. For $47.50 (approximately $740 today), the instrument delivered 1.75-VRMS vertical sensitivity over a 30-Hz-to-10-kHz range, and a horizontal sweep rate of 30 Hz to 10 kHz.

Radio amateurs quickly pounced on the relatively affordable 913 and built modulation-level monitors for their amplitude-modulated transmitters, and a design for a general-purpose oscilloscope appeared in *QST* magazine in May 1937. The amateur design likely resembled that of the RCA scope but included a sine-wave oscillator that generated a stable audio frequency for modulation-level tests.

With its 1-in. screen, the 913 might appear to represent the lower limit of oscilloscope tubes, but that's not the case. The 1DP11 nine-pin-based miniature CRT in my collection boasts (if that's the word) a 0.75-in. diameter screen, and even smaller CRTs exist. Priced in the range of $20 to $30, the 913 is still available from surplus-tube dealers.

If you're interested in embedding a tiny oscilloscope in your next test system, consider Gabotronics' $49 (that's $3 in 1936 money) XMEGA Xprotolab—an instrument comprising a mixed-signal 200-kHz oscilloscope, a logic analyzer, a swept-frequency arbitrary waveform generator, and a spectrum analyzer with a 0.96-in. OLED (organic light-emitting diode) display screen. RCA's designers of the 913 would be flabbergasted. T&MW

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

913-BASED OSCILLOSCOPES

In the mid-1930s, owning a personal oscilloscope was likely akin to owning a personal computer in the mid-1970s. National Radio Co. marketed the Model CRM to radio amateurs primarily as a modulation monitor, while RCA's Model 151 was intended for the radio-service market (scroll down the Web page listed below for an inside view); its supporting cast of tubes included a gas-filled triode (type 885) that served as a sawtooth-sweep relaxation oscillator:

www.myvintagetv.com/vintage_test_equipment.htm

It's possible that the Model 151 served as a model for many home-built variants, including the following amateur project. A dozen front-panel controls enabled flexibility, but making accurate measurements must have been challenging:

Gordon, H.W., W1IBY, "A Versatile Oscilloscope Using the 913," *QST*, May 1937, American Radio Relay League publications, Newington, CT. p. 31.

EVEN SMALLER CRTS

The metal-jacketed 913 (at left in the photo) dwarfs the 1DP11 (center), and even smaller tubes exist. Whether any of the tiny CRTs saw service in commercial instruments is unknown:

www.aade.com/tubepedia/1collection/tubepedia2.htm

D-I-Y TINYSCOPES

The 913 is still available, and you can duplicate the 1936 tubed design or use semiconductors. Or you can purchase a complete oscilloscope and multifunction instrument such as the XMEGA Xprotolab (at right in photo). Built around Atmel's ATXMEGA32A4 microprocessor, the Xprotolab also serves as a development platform and includes open-source code for all but the scope function. It is available in kit form for intrepid builders:

www.gabotronics.com/development-boards/xmega-xprotolab.htm

Test instruments take center stage at DesignCon 2012

Several exhibitors showcased innovative test products at DesignCon 2012, held January 30 to February 2 in Santa Clara, CA. Tektronix, for example, exhibited its MDO4000 Mixed-Domain Oscilloscope, which was coincidentally named as *T&MW*'s Test Product of the Year during the show (see p. 22). Agilent Technologies introduced the 86108B precision waveform analyzer module for the 86100C/D DCA wide-bandwidth oscilloscope family (see p. 32).

For its part, National Instruments introduced Multisim version 12.0 software for analog circuit simulation. Multisim SPICE simulations can run inside the company's LabView software, letting users set circuit parameters for the simulated analog circuit and run closed-loop simulations with the circuit inside a complete system.

Rigol Technologies introduced the DG4000 series of waveform generators, which includes the DG4062 (a 60-MHz unit) and the DG4162 (a 160-MHz model). The instruments can generate standard modulation signals, such as AM, FM, PSK, QPSK, and PWM signals, in addition to generating arbitrary waveforms and 150 built-in waveforms.

Rohde & Schwarz launched the ZNB network analyzer that uses a SET2DIL (single-ended-to-differential insertion loss) algorithm for testing and characterizing PCBs (printed-circuit boards) for signal losses. The algorithm is an SDD21 four-port frequency-domain measurement.

LeCroy highlighted its LabMaster 10 Zi 60-GHz oscilloscope (pictured), released on January 3. Picosecond Pulse Labs demonstrated a pulse generator capable of testing components and PCBs at speeds of 32 Gbps. For links to more information, as well as video demonstrations of some of the products, go to www.tmworld.com/designcon2012.

SIA releases roadmap

The SIA (Semiconductor Industry Association) has publicly released its 2011 ITRS (International Technology Roadmap for Semiconductors), which addresses challenges and innovations for the semiconductor design and manufacturing industry through 2026.

The SIA expects the development of DRAM technology to accelerate, which will in turn speed up the introduction of higher-performance servers and sophisticated graphics for game consoles. The SIA likewise predicts that the development of flash technology will accelerate, with the introduction of 3-D flash technology in 2016 allowing for greater memory capabilities for popular consumer electronics applications.

In addition to addressing scale and performance challenges, the ITRS presents models for enhancing the complex manufacturing and measurement processes required to achieve smaller, higher-performance, and more-energy-efficient semiconductors. The ITRS also focuses on cost-effective manufacturing and resource conservation to meet the changing needs of semiconductor design innovations.

The ITRS is sponsored by Europe, Japan, Korea, Taiwan, and the US and is overseen by the SIA. Through the efforts of chip manufacturers, equipment suppliers, research communities, and consortia, the roadmap teams identify critical challenges, technical needs and potential solutions. One of the primary challenges that the industry has identified is the need to decrease the size of semiconductors while increasing performance standards to meet consumer demands. www.itrs.net.

Editors' CHOICE

Aeroflex rolls out broadband analyzers

Three low-cost broadband signal analyzers from Aeroflex locate, record, and analyze complex communications signals for commercial, military, and aerospace applications. The new family comprises a portable instrument and two rack-mount units (pictured).

The Scout CS1104 portable signal analyzer provides RF coverage from 20 MHz to 3 GHz with instantaneous bandwidth of 40 MHz. It also packs 8 Gbytes of signal-capture RAM and a 1-Tbyte removable disk. The Hunter CS1207 and Explorer CS1247 rack-mount units let you home in on a narrow frequency range around a signal of interest and analyze it. Hunter's coverage extends from 10 MHz to 6 GHz with 70-MHz instantaneous bandwidth. Explorer provides coverage from 10 MHz to 6 GHz with user-selectable instantaneous bandwidth of 70 MHz or 400 MHz. Each rack-mount model has a 32-Gbyte signal-capture RAM and an 8-Tbyte removable disk.

Software modules supplied with each analyzer include Aeroflex's BSA Basic (spectrum and spectrogram waterfall plots), BSA Modulation Domain (calculates and displays AM, FM, and PM waveforms), and BSA Scanning Spectrum Analyzer (to view any range of spectrum instantaneously). A GPS hardware module is standard on Scout and is an option for Hunter and Explorer.

Base price: $79,000. *Aeroflex, www.aeroflex.com.*

CALENDAR

SAE World Congress, April 24–26, Detroit. *SAE International, www.sae.org/congress.*

ESC Chicago and Sensors Expo, June 6–8, Chicago. *UBM Electronics, esc.eetimes.com/chicago.*

International Microwave Symposium, June 17–22, Montreal. *IEEE, www.ims2012.mtt.org.*

EMC Symposium, August 5–10, Pittsburgh. *IEEE EMC Society, www.2012emc.org.*

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

Editors' CHOICE

Agilent doubles InfiniiVision 3000 X oscilloscope bandwidth to 1 GHz

The Agilent Technologies InfiniiVision 3000 X-series of two-channel and four-channel oscilloscopes now offers a 1-GHz maximum bandwidth with an increased maximum sample rate from 4 Gsamples/s per active channel to 5 Gsamples/s per channel. Optional features include a three-digit multimeter/five-digit frequency counter that uses the same signal leads as the oscilloscope. This option simplifies simultaneous numeric measurements and waveform display.

The company has also expanded its Waveform Builder software, which supports the built-in function/waveform-generator option. Memory depth is 4 Msamples per channel, and the maximum waveform-update rate remains 1 million waveforms/s. The company also announced the N2795A 1-GHz active probe, which has one-quarter of the input capacitance of passive probes that provide similar bandwidth.

Base prices: 1-GHz-bandwidth oscilloscope with two analog channels—$9950; upgrades from lower analog bandwidths to 1 GHz—$2340; N2795A probe—$1000. *Agilent Technologies, www.agilent.com.*

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The Evolution of Interconnect Innovation

INSTRUMENTS

Get the basics of ADCs

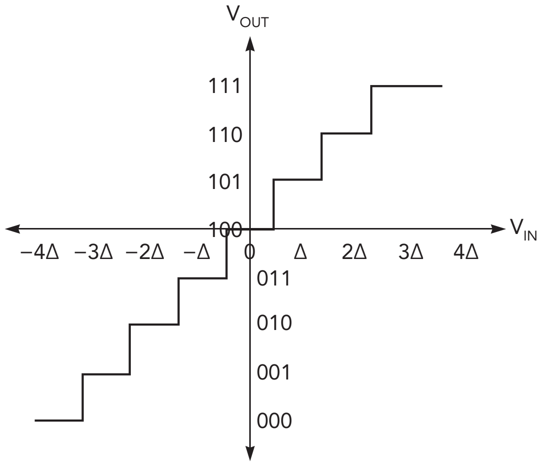
ADCs (analog-to-digital converters) are among the most commonly used blocks in embedded systems and data-acquisition systems. ADCs are used in numerous applications, including current sensing, motor control, and temperature sensing. As a consequence, you must understand the basic specifications of an ADC and select the appropriate device in order to create a cost-effective design that operates reliably.

Sachin Gupta and Akshay Phatak of Cypress Semiconductor have written a series of articles that explain the basics of ADCs and discuss the impact of various irregularities, the types of ADCs available on the market, the advantages and disadvantages of each type, and how the selection of ADCs varies from one application to the next.

The first article explains what an ADC is and how an ideal ADC works. The **figure** shows that an ideal ADC is perfectly linear. That is, each bit carries equal weight. Subsequent articles will cover more practical aspects and parameters of ADCs.

Part 1 of the series is available at bit.ly/wCgeUd.

Martin Rowe
Senior Technical Editor



In an ideal ADC, each bit represents an equal amount of the device's input voltage.

TEST IDEA

Wireless temperature monitor has datalogging capabilities

You can use a local temperature sensor and an ASK (amplitude-shift-keying) transmitter/receiver pair to design a simple wireless temperature-monitoring system with datalogging capabilities. A microcontroller processes and displays the temperature reading. The microcontroller's onboard UART (universal asynchronous receiver/transmitter) also allows for datalogging applications.

Local-temperature sensor IC_1 detects the ambient temperature at the device (**Figure 1**). The output of IC_1 is a square wave with a frequency proportional to temperature in kelvins. ASK

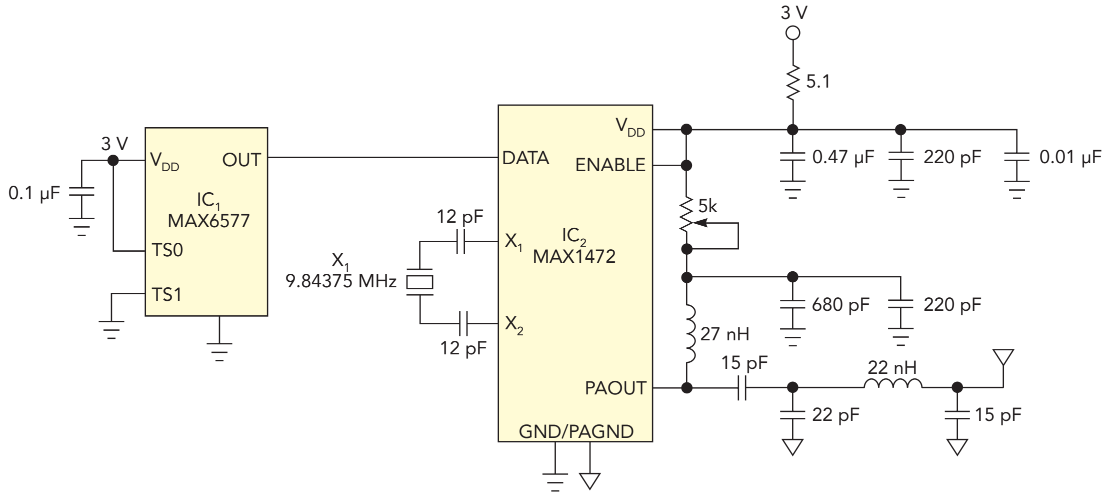


FIGURE 1. The MAX6577 temperature sensor and 315-MHz MAX1472 ASK transmitter form a wireless temperature-monitoring system.

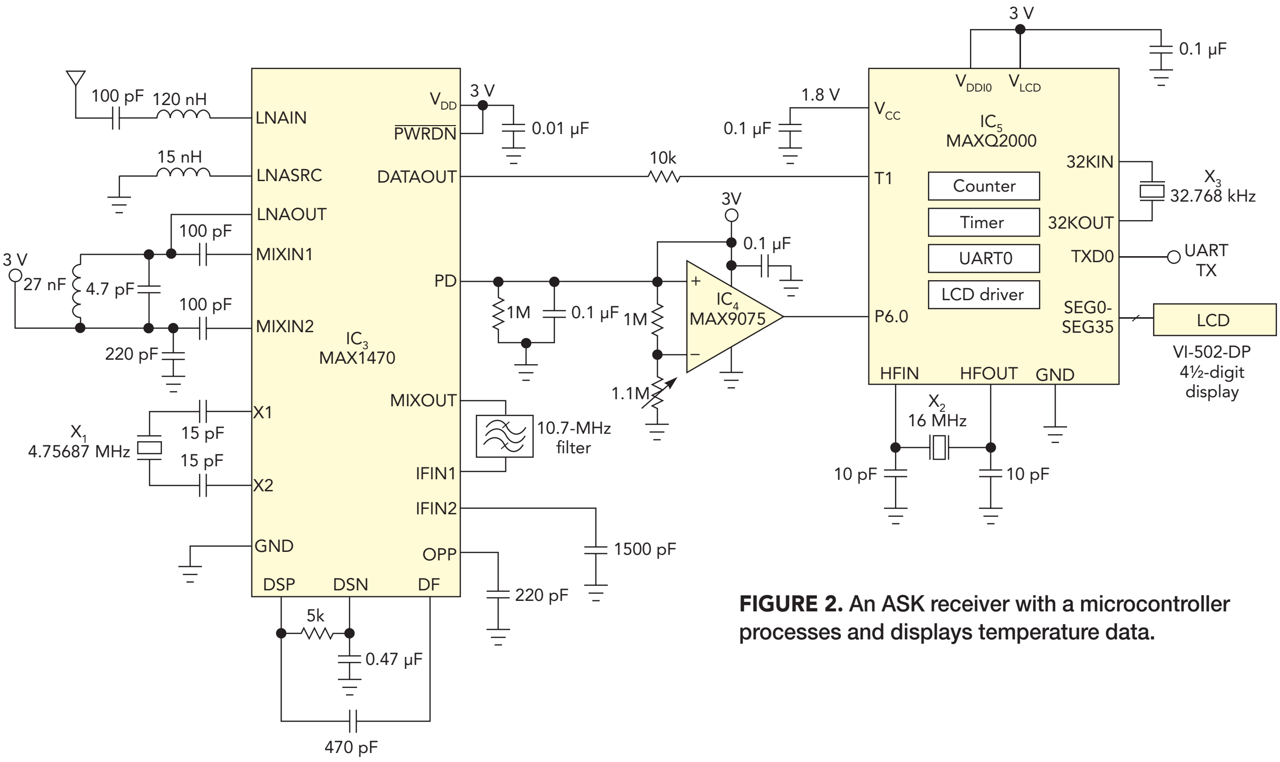


FIGURE 2. An ASK receiver with a microcontroller processes and displays temperature data.

transmitter IC_2 modulates the signal onto the carrier frequency of 315 MHz. You measure the output signal's frequency with a frequency counter. The configured scalar multiplier is 1K/Hz when the TS1 pin connects to ground and the TS0 pin connects to V_{DD}. This scalar multiplier is configurable with pins TS1 and TS0. ASK receiver IC_3 demodulates the signal at the corresponding carrier frequency (**Figure 2**).

Comparator IC_4 connects to IC_3's RSSI (received-signal-strength indicator) with an internal peak detector. The external RC follows the peak power of the received signal and compares it with a predetermined, resistor-voltage-divider-generated voltage level. Lab experiments show that a threshold of approximately 1.57 V generates a valid output on the data-out pin without receiving false readings. Adjust this threshold to the proper level for optimal performance. The comparator's output is low when the received signal is weak or invalid and high when the received signal is adequate.

Microcontroller IC_5 then measures and displays the value of the signal frequency using its integrated timer/counters and LCD-driver peripherals. A counter tracks the number of rising-edge transitions on the input temperature signal, and a timer tracks the elapsed time. After the timer's 1-s period elapses, an interrupt occurs. At that moment, the circuit reads the counter value, converts it to Celsius, and displays it on the LCD. The counter then resets to zero to restart the process. The timer automatically reloads once the timer interrupt occurs. UART0 also outputs the resulting temperature. A handheld frequency counter verifies the temperature reading.

The microcontroller monitors the signal power through P6.0, a general-purpose input pin. When the input is logic low, the LCD and UART output "no RF" to alert users of possible transmitter issues when the transmitter and receiver are too far apart from each other. The LCD connection follows the design in the IC's evaluation kit. Using a look-up table in the data segment of the assembly code enables you to preserve the internal mapping of the display's A through G segments. This preservation ensures that the display enables the correct segments. Using an RS-232 level converter, the UART output sends data to a datalogging device, such as a computer.

Use the MAX-IDE assembler software to program the device during assembly. The MAXQJTAG board operates with the MAX-IDE to load the code onto the device. You can download the project files at www.edn.com/120119dia. This design provides for a 1-s temperature-refresh rate in 1°C increments, which is within the accuracy of IC_1.

Tom Au-Yeung and Wilson Tang
Maxim Integrated Products

This article first appeared in the January 19, 2012, issue of *EDN*.

A winning combination

Working with systems design engineers, Brad Davis and his team performed design-verification testing on an innovative wireless "combo chip" targeted for mobile devices.

BY LAWRENCE D. MALONEY, CONTRIBUTING EDITOR

Scratch the surface of the economic recovery, and you'll quickly see one of its biggest drivers: mobile communications. Consumers can't seem to get enough of the latest smartphones, tablet computers, notebooks, and e-readers. "Wi-Fi enabled devices will grow from less than 1 billion units in 2010 to more than 3 billion in 2015," according to Mark Hung of Gartner Research, in a report the company published last June.

Among the world's leading semiconductor companies, California-based Broadcom is well positioned to tap what has become a global fascination with all things wireless. The firm describes itself as offering the world's largest portfolio of SOC (system-on-a-chip) and software solutions for high-performance mobile devices, computing and networking equipment, and digital entertainment and broadband access. Its 2011 revenues topped $7 billion.

With engineers making up more than 75% of its 10,000 full-time employees, Broadcom in any given year churns out a steady stream of new products. In 2011, none of its launches was more notable than that of the new BCM4330 combo chip, winner of a 2012 CES Innovations and Design Engineering Award at the Consumer Electronics Show held in Las Vegas in January.

Designed to support smartphones, tablets, and other mobile devices, the chip integrates dual-band 802.11n Wi-Fi, Bluetooth 4.0, and FM radio capability on a single silicon die. It also supports Wi-Fi Direct and Bluetooth High Speed standards, which let mobile devices communicate directly without having to connect first to an access point.

"Combination chips have gained tremendous traction as more manufacturers add multiple wireless features to mobile phones and other handheld devices," said Philip Solis, research director of ABI Research. "Broadcom already controls a significant share of the wireless connectivity market within the rapidly expanding Android market."

(continued)

PHOTO BY KIM KULISH

Test & Measurement World's annual Test Engineer of the Year award honors the special contributions that test engineers make to the quality of electronics products and systems. In our November 2011 issue, we described the accomplishments of six outstanding test engineers and asked our readers to vote for the engineer they believed was most deserving of the 2012 Test Engineer of the Year Award. The winner: Brad Davis of Broadcom.

Davis received the award on January 31 during the Best in Test awards ceremony held in conjunction with DesignCon 2012 in Santa Clara, CA. As part of his award, Davis has designated a computer lab in the Dominican Republic to receive a $10,000 grant courtesy of National Instruments, the award sponsor.

Quality seals the deal

While innovative semiconductor technology may grab the headlines, it is the reliability of these new devices that wins business from blue-chip customers like Samsung and Apple. That's why firms covet outstanding test engineers like Brad Davis, who manages Broadcom's WLAN hardware team. With experience in wireless technology that dates back to his engineering education at the University of Calgary, the 32-year-old Davis heads a seven-person team that characterizes RF performance of Broadcom's mobility chips, modules, and drivers, including the award-winning BCM4330 combo chip.

It is because of his success in managing the test flow and helping the BCM4330 get to market quickly that his co-workers nominated him to be the 2012 Test Engineer of the Year. *Test & Measurement World*'s readers agreed with his co-workers' assessment of Davis's work and voted him as the winner. Davis was presented the award at *T&MW*'s Best in Test awards ceremony held on January 31 in conjunction with DesignCon 2012 in Santa Clara, CA (see p. 22).

"The primary job of our team is to verify that the Wi-Fi system, both hardware and software, performs up to Broadcom's standards," explained Davis.

Typically, the systems design team does preliminary performance tuning of a mobility chip module, then hands the chip off to Davis's design-verification team for much more rigorous testing. This work involves exercising more chips, exercising chips produced from different process variations (split lots), and testing chips across voltage, temperature, and other environmental variations.

The team may work with a particular chip for a year or more, especially if it is a high-volume product like the BCM4330, which is produced by several contract manufacturers. "Chip packages from each fabricator must be qualified separately," said Davis. "Our job is to spot issues, then go back to the design team for resolution. There's a lot of back and forth."

In addition, Davis's test team supports companies that want to customize a Broadcom chip, such as by adding their own power amplifiers, switches, or filters. "For larger customers, we'll even help optimize their designs, and then run their product through our test suite," said Davis.

John Ma, manager of design-verification testing for Wi-Fi modules, noted that Brad Davis is one of the rare engineers who can combine RF knowledge, test hardware and software skills, and business perspective.

Tools of the trade

A bread-and-butter tool for the team is the LitePoint one-box tester, which tests key functions of an RF chip, such as transmitter modulation accuracy and spectral mask, as well as receiver sensitivity and performance in the presence of interference. "One-box testers give us a lot of coverage very quickly," explained Davis, "and because their setup is so simple, it is much easier to add peripheral equipment."

Peripheral test modules, sometimes paired with the one-box testers, address such parameters as current consumption, temperature, and voltage control. Load-pull devices can also be added to simulate the effects of connecting a chip to various antennas. Using Python, LabView, and other software tools, Davis himself writes much of the automation code for managing the lab's test equipment and protocols, which increasingly includes more and more homegrown solutions.

"Test engineering in this field demands multiple skills," observed John Ma, manager of DVT (design-verification testing) for Wi-Fi modules at Broadcom. "You need to understand RF, test hardware, and programing for test automation. Plus, you need to be sensitive to important business perspectives. Brad Davis is one of the rare individuals who possesses all of those skills. On top of that, he just loves testing as a job."

Davis's responsibilities also demand a great deal of coordination with those outside the design-verification team. On any given day, he can be consulting with a smartphone company, a fabricator, or a test and measurement vendor looking for input on capabilities needed to test next-generation chips. He also works hand in hand with other Broadcom test teams involved with software development and data analysis.

A never-ending race

Meanwhile, the fast pace of technology places ever-changing demands on Davis and his team. The BCM4330, for example, uses the new HSIC (High-Speed Inter-Chip) digital interconnect bus, which ruled out the use of cabling in test setups. Broadcom had to design a test platform that could run the test software and also connect directly to the device under test. And because of the 4330's tiny footprint of 25.51 mm^2 (28% smaller than its predecessor), debugging is tougher. Current consumption also is so low that it is difficult to find instruments that can measure the chip in real-time fashion.

Davis pointed out that each generation of chips supports more standards. "On the 4330, we had to test IEEE 802.11a/b/g. The next generation will add 802.11ac, and each new standard requires a whole new suite of tests, which can potentially drive up your test time. Product cycles keep getting shorter, and test doesn't want to be the holdup."

To make things even more complicated, the DVT team must constantly juggle its time and resources between a chip that is close to production and newer ones emerging from design, not to mention supporting legacy products.

Despite such pressures, the payoffs of being in the right place at the right time with the right product can be enormous. Sales of the iPhone 4S, one of the 4330's early design wins, topped more than 4 million units during its first weekend of sales last October, the most ever for a phone launch, according to Apple.

Industry analysts were amazed that the 4330 began showing up in new products like the Apple iPhone 4S and the Samsung Galaxy S II as early as last fall, just a few months after its February 2011 launch. Chipworks, a Canadian reverse-engineering firm, noted that new chips usually don't show up in consumer products until 12 to 18 months after public launch.

(continued)

PHOTO BY KIM KULISH

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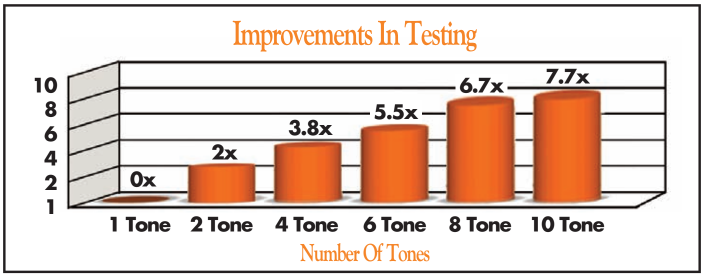

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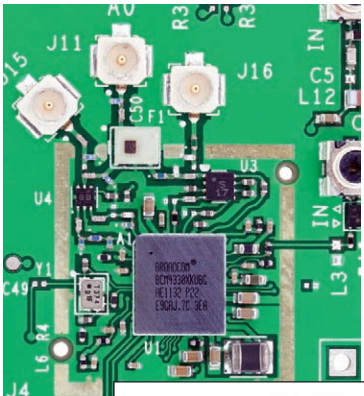
As Davis sees it, a key contribution that the test team makes to such timely product launches is its close cooperation with the systems design team. "In test, we need to hit key parameters on multiple chips very fast and then get our data back to the design team so that they can work on any problems."

In most cases, said DVT manager Ma, Davis and his team delivered overnight turnaround of essential test results to systems design engineers. "Not only that, but Brad's test results and reports are always solid and reliable, which gives him great credibility with the design team. His reports can go directly into the hands of customers, which closes the loop in a very timely fashion. He's also a very good leader, and his team devoted a lot of extra effort on the 4330. The volume of test data that they provided to design every day was simply unprecedented."



The introduction of the BCM4330 in February 2011 strengthened Broadcom's already strong position in the wireless combo chip category. The combo chip, shown here at the center of a reference board, integrates the capabilities of 802.11n Wi-Fi, Bluetooth 4.0, and FM radio. Courtesy of Broadcom.

One of the earliest, and biggest, design wins for Broadcom's BCM4330 combo chip was the Apple iPhone 4S, which notched sales of 4 million units in just three days in October 2011. Courtesy of Apple.

Added Michael Hurlston, senior VP and GM of Broadcom's Wireless LAN line of business: "Brad Davis truly exemplifies Broadcom's reputation of engineering the impossible. Since testing is considered such an important part of our overall product flow, we moved Brad from a design position to lead our verification group. In this role, he's proven that he's an invaluable engineer with the intelligence, agility, drive, and problem-solving skills that are required for success."

The pressure of keeping up with the demands of the job does take its toll, and Davis admits that his team must constantly cope with the stress of being the "middle man" between serving the needs of contract manufacturers, customers, and Broadcom's own design teams. "Something always needs to get out the door urgently," said Davis.

Even so, he gets a lot of satisfaction from solving day-to-day technical problems, which can be as simple as debugging a balky test station. Also very gratifying: formal sign-off milestones when his team can say: "We've tested this product thoroughly, and here's the evidence to support it."

Catching the wireless bug

The wireless world is clearly where Davis wants to be, and that's been the case ever since the Calgary native chose the "hands-on" field of electrical engineering over computer science. At the University of Calgary, Davis focused his master's thesis on sending wireless signals over optical links for broadband, high-speed data distribution.

"I started to get excited about wireless even as an undergrad," recalled Davis. "I took a course on wireless communications and modulation standards, as well as an RF lab course where we did traditional RF measurements and basic RF design."

It helped, too, that TR Labs, the Edmonton company that Davis worked with in his internship and master's thesis work, focused on wireless communications. After completing his education, Davis got more wireless experience at two Calgary firms: Advanced Measurements, a test and control systems integrator, and SignalCraft Technologies, a contract design firm specializing in such technologies as GPS receivers and WiMAX.

"Brad is very ambitious and always eager to take on more than is asked of him," said Mike King, who worked with Davis at Advanced Measurements and was a fellow student at the University of Calgary. "And he is very well rounded. At Advanced Measurements, he not only built test systems for clients, but also developed the software to run them." King also recalled that, while at the university, Davis performed RF design and software development work on an autonomous robot.

Sunny future for wireless

Davis, who joined Broadcom in 2009, is already testing future generations of mobility chips, as Broadcom continues to unveil products that boast even greater capability. At the January CES event in Las Vegas, for example, the company introduced its first family of IEEE 802.11ac chips. This 5G Wi-Fi product improves wireless range in the home, allowing consumers to watch HD-quality video from more devices. The chips are also three times faster than equivalent 802.11n chips, a big advantage in downloading Web content or large video files.

Davis believes that the deployment of wireless is still in its infancy. "It's only been in the last couple years that we've seen mobile wireless really take off from a data-transmission standpoint. Wireless is really changing the way consumers and business people run their lives."

Over the next five years, Davis looks forward to solving the test challenges created by the steady march of technology, while helping Broadcom build and manage test infrastructure adaptable enough to handle the large volume of tests required in the semiconductor industry. Said Davis: "What really excites me is designing test systems that enable us to stay agile in the marketplace." T&MW

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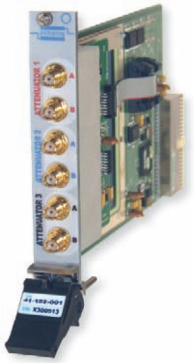

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T&MW announces winners of 2012 Best in Test AWARDS

BY TEST & MEASUREMENT WORLD STAFF

On the evening of January 31, during a ceremony held as part of DesignCon 2012, we announced the winners of the 2012 Best in Test awards. The annual awards program, which recognizes excellence in electronics test and measurement, was particularly poignant this year, which marks the 30th anniversary of *Test & Measurement World* itself.

For editors, awards ceremonies are one of the highlights of the year. It's our opportunity to recognize the achievements of our audience: the engineers and companies behind the test technologies, methodologies, and systems that ensure electronics devices work, within spec and, hopefully, on time.

For anyone who has tracked the industry as long as *T&MW* has, it's fascinating to look at the winners in each category—Best in Test, Test of Time, and Test Engineer of the Year—and see how far we have come. In the case of Redfish Instruments, which won Best in Test: Multimeters, we highlight the arrival of the Apple revolution to test, with an iPhone/iPad wirelessly enabled multimeter app, while Brad Davis of Broadcom won in the category of Test Engineer of the Year for his work on enabling test for Broadcom's multimode wireless ICs, a test problem that could hardly have been imagined 30 years ago (see p. 16).

BEST IN TEST

READ MORE
about *T&MW*'s awards:
www.tmworld.com/awards

Double kudos to Davis, by the way, who announced days after the ceremony that he'll be donating the award's $10,000 educational grant (courtesy of National Instruments) to a school in the Dominican Republic where he'll be working to put together a computer lab "to enable a world-class education in a very poor area: a great opportunity to make a real difference in people's education."

Twenty winners stood at the podium during the ceremony, but they didn't stand alone. They stood on your behalf as personifications of the perseverance exhibited by all the design and test engineers we cover, without whom none of the technology we take for granted would have made it past the prototyping board. To you and to all our winners, we offer our congratulations—and gratitude. T&MW

TEST OF TIME

2012 **AWARD WINNER**

TestCenter

SPIRENT COMMUNICATIONS

Introduced in 2005, Spirent TestCenter is a unified performance test platform employed by network equipment manufacturers, service providers, and enterprises that employ Layer 2-7 IP and Ethernet technologies.

Peter Anderson (left) of Measurement Computing accepted his company's award from Martin Rowe.

→Kumaran Santhanam accepted the Best in Test award for Total Phase.

←Steve Marks and Barbara Koczera proudly showed off the two plaques that Test Research received.

Best in Test
2012
AWARD WINNERS

ATE/Production Test
RFEM, *Aeroflex*

Bus and Logic Analyzers
Beagle USB 5000 SuperSpeed Protocol Analyzer, *Total Phase*

Data Acquisition
USB-2408 Series, *Measurement Computing*

Design for Test/Boundary Scan
SFX-TAP16/G, *GOEPEL electronic*

Embedded Test
TR5001T Tiny ICT, *Test Research*

Functional Test
TOSCA Testsuite, *TRICENTIS Technology & Consulting*

LTE Test
VR5 HD Spatial Channel Emulator, *Spirent Communications*

Machine Vision/Inspection
TR7600 SII Automated X-Ray Inspection System, *Test Research*

Multimeters
iDVM iPhone and iPad Enabled Wireless Multimeter, *Redfish Instruments*

Optical and Network Testers
IxLoad Attack, *Ixia*

Oscilloscopes
MDO4000 Mixed Domain Oscilloscope, *Tektronix*

PHY Test
PVA-3000 PhyView Analyzer, *Sifos Technologies*

RF/Microwave Test
URT-5000 Software Defined RF Player and Signal Generator, *Averna*

Semiconductor Test
T5773 NAND Flash Package Tester, *Advantest*

Signal Analyzers
PXIe-5665 VSA, *National Instruments*

Signal Sources
M8190A Arbitrary Waveform Generator, *Agilent Technologies*

Source-Measure Instruments
B2900A Series Precision Source/Measure Unit, *Agilent Technologies*

CEREMONY PHOTOS BY TRISH TUNNEY

TEST PRODUCT OF THE YEAR

2012 AWARD WINNER

MDO4000 Mixed Domain Oscilloscope

TEKTRONIX

THE MDO4000 is the first oscilloscope to include a built-in spectrum analyzer that allows engineers to look at time-correlated analog, digital, serial, and RF data to gain a complete system view of a device.

Weighing-scale design: Measure signals accurately

To create reliable weighing scales, designers must understand the basics of load cells.

BY KANNAN SADASIVAM AND SACHIN GUPTA, CYPRESS SEMICONDUCTOR

A digital weigh scale is one of the most precise analog instruments. Weigh scales, which use force sensors to measure the load offered by an object, are used in a multitude of applications ranging from point-of-sale terminals to industrial-measurement equipment.

The most common method for implementing weigh-scale designs uses a resistive load cell configured as a Wheatstone bridge. The sensor interface is complex, however, because of the precision requirements. In the load cells, the signal levels are low and the effects of noise are prominent. We will explain how to measure signals accurately to meet the precision-measurement requirements of weighing scales, and we will discuss how the parameters of a load cell can contribute to its inaccuracies.

A weighing-scale system needs more than just an analog front end to make high-accuracy measurements. It also needs a clear user interface and boost circuitry to deal with low battery conditions. Also, some weighing scales may require a communication protocol to communicate with a host controller.

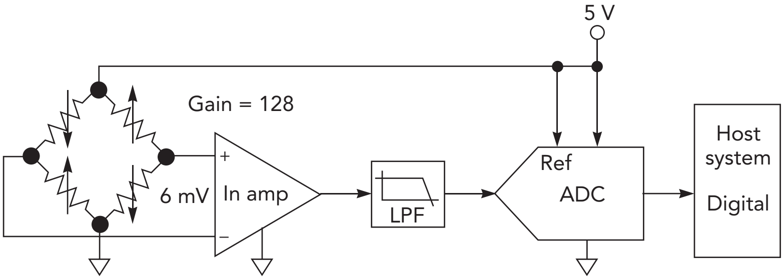

FIGURE 1. Analog front ends for weighing-scale applications typically have this basic arrangement.

Analog front end

Figure 1 shows the basic arrangement of an analog front end for weighing-scale applications. In this arrangement, the output of the transducer is amplified and then sent through a filter that removes noise resulting from power-supply and mechanical vibrations. Then, a high-resolution ADC samples the filtered output.

Load cells are nothing but resistive sensors that provide a ratiometric voltage corresponding to the load applied to them. Most commonly used load cells have strain gauges connected in a Wheatstone bridge.

Figure 2 shows a full-bridge arrangement for a load cell (also known as fully active, as all the arms have strain gauges and contribute toward the change in output) in which two strain gauges have a positive change to tension and the other two have a positive change to compression. When a load is applied on the sensor, two of the sensors increase their resistance, and the other two decrease resistance. This change in resistance causes an unbalance in the bridge, thus providing a differential output corresponding to the weight placed.

Based on their construction, material, and design, load cells have parameters that engineers must understand before designing a load-cell interface:

- *Sensitivity (rated output):* Sensitivity is one of the most important parameters of a load cell. The sensitivity of a load cell is defined as the full load output voltage in relation to the excitation voltage, and it is generally expressed in mV/V. This value corresponds to the voltage deviation caused by the load cell at full load when excited by a 1-V source. The sensitivity of load cells is very low (generally about 2 mV/V). If a system has a 3.3-V excitation voltage, then the output voltage at full load will be 6.6 mV. Thus, high-precision ADCs are mandatory for load cells.
- *Nonlinearity:* Because load cells are mechanical devices, they have their own nonlinearity based on their construction. A typical nonlinearity of a load cell is about 0.015% of the rated output, which is approximately 1 bit when the

ADC is sampling at 13 bits. But keep in mind that this is just one component of the nonlinearity of a complete system. The measurement system and analog front end also contribute to a system's total nonlinearity.

- *Hysteresis:* Hysteresis error is the change in load-cell output when a known load is reached from a lesser weight as compared to when it is reached from a higher weight. This error is caused by deformation properties of the material used in construction of the load cell. A higher weight may temporarily deform the load cell, which effectively adds a small offset that would show up when the target was reached from a higher weight.
- *Repeatability:* This specification defines the change in the load measured by the load cell when the same weight is placed multiple times on the same load cell.
- *Creep and creep recovery:* Creep is the measure of change in a measured weight over time, such as when a weight is placed on a scale for a long period of time. For example, the output counts when the weight is first placed will differ from the output counts 30 min after it is placed. This effect is based on the elastic property of the material used in the load cell. Cheaper materials can result in very large creep values, and it may take a long time for the load cell to recover from the deformation.

System precision

Most weigh-scale designs have two different resolutions: the display resolution and the internal resolution. The display resolution is the resolution of the end result displayed by the weigh scale. The internal resolution is the actual resolution on the internal analog front end.

Consider a weighing scale in which the load-cell excitation voltage is 5 V. In this case, its output voltage will be 0 to 10 mV with a 2-mV/V sensitivity. If the weighing scale has to be designed for a resolution of 5 gm and a total range of 10 kg, the weigh scale's display resolution will be 1:2000. It is standard practice for weighing scales to have an internal resolution that is about 20 to 30 times that of the display resolution. So, this weighing scale needs internal counts of 1:60000, which corresponds to a 16-bit internal resolution.

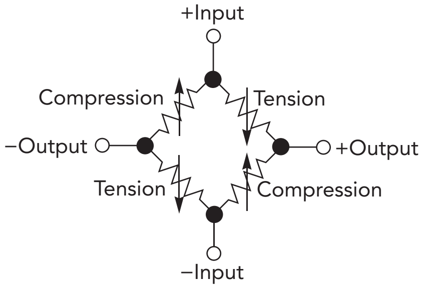

FIGURE 2. This is a full-bridge arrangement for a load cell, in which two strain gauges have a positive change to tension and the other two have a positive change to compression.

There are multiple sources of induced error in the load-cell interface, starting with errors in the sensor itself, as discussed earlier. For this reason, the internal resolution is kept higher than the display resolution so the design can compensate using some of the extra resolution.

The design would have to resolve the 10-mV range of input with a 16-bit resolution. The most commonly used method for measuring this 10-mV full-range output involves implementing a gain stage to gain the input signal to fit the ADC's input range, as shown in Figure 1, thus resolving more bits inside a smaller range. For example, to have a measurement range of 10 mV using an ADC that has a 1-V range, the user can resort to getting close to 100X gain on the signal using an amplifier-based gain stage.

Now, consider an ADC with 20-bit resolution and an input range of 1 V. The minimum input change this ADC can is resolve is 1 µV. If you used a gain stage to amplify the signal prior to applying the signal to the ADC to improve the range to 0–10 mV, the lowest resolved voltage would be as small as 10 nV. This kind of resolution would reside deep inside the noise domain. The gain stage amplifies the noise as much as it amplifies the signal. This noise renders a considerable number of bits of the ADC as unusable and reduces the ENOB (effective number of bits). Thus, designers have to pick an ADC that gives an optimum ENOB for the required gain settings.

The most commonly used ADC to measure a load cell's output is a delta-sigma ADC. This kind of ADC oversamples the signal and later decimates it to achieve high resolution. This architecture gives the ADC an inherent low-pass nature that helps in reducing the effects of noise.

Having a very good ADC, however, solves only half of the problem. You also need a gain stage. Most designs use an external low-noise amplifier as a gain stage, but some devices implement the gain stage in the ADC's input stage itself; the Cypress PSoC3 and PSoC5 are two examples. These PSoCs have an integrated input buffer in the ADC's input that can achieve up to 8X gain. The ADC itself is capable of having a gain of up to 16X in its modulator stage.

These ADCs can provide about 18 ENOBs, because they do not require an external amplification stage, so noise from external amplifiers is not an issue. But for a weigh scale, resolution requirements are generally defined in terms of peak-to-peak resolution. This is the effective resolution calculated for a system after taking out the effect of the noise as a peak-to-peak value.

The general requirement for a commercial product is 16-bit peak-to-peak resolution. This resolution would have to be achieved while measuring a full range of 10 mV. One major concern would be dealing with system noise, thus bringing down the effective resolution.

Another major concern is that a load-cell interface is prone to gain error because the output signal range is dependent upon the excitation voltage. Any variation in the excitation voltage can cause a similar percentage of gain error in the measurements. This can be avoided if the signal measurements are made as a ratio against the excitation voltage. This can be achieved by two means.

One option is to measure the signal and excitation voltage separately and calculate the ratio, thus taking out the gain error. Unfortunately, this requires the multiplexing of the ADC between the two signals. Another problem is that the signal you are measuring is in the 10-mV range, and the excitation voltage would be in the volts range. This would require dynamically changing the gain settings and ADC range parameters, which might not be advisable in an analog system. In addition, changing these parameters dynamically would raise questions of mismatch between the two independent measurements.

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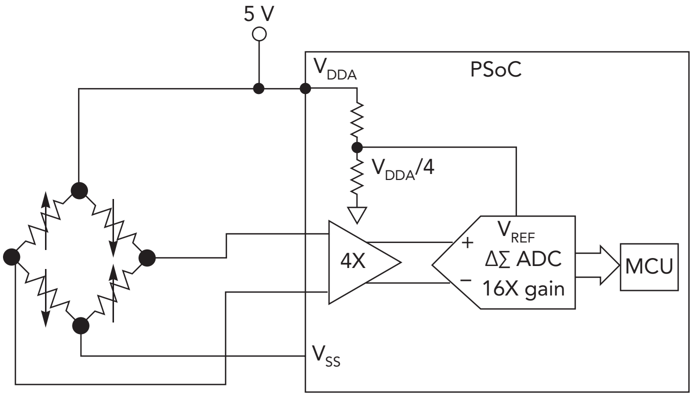

FIGURE 3. A load-cell interface circuit can be used to make ratiometric measurements.

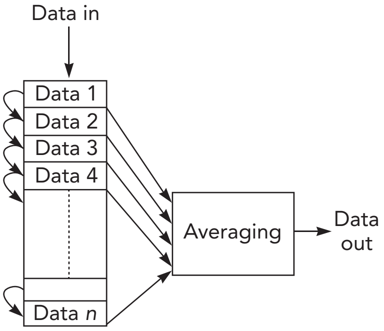

FIGURE 4. Moving-average filters such as this are easy to implement. At any given time, the output of the filter is the average of all of the elements in the array.

In the second option, you can use the reference to the ADC itself to make the signal measurements as a ratio against the excitation voltage (**Figure 3**). ADCs generally have a reference pin to connect to an external reference. The input range of the ADC is defined as a factor of the reference voltage. Thus, every measurement made in the ADC is made with respect to the reference. If you provide the excitation voltage or a divided derivative of it as a reference to the ADC, you can achieve a ratiometric measurement for the signal. Since the load measurement in the load cell is a ratio of resistors, this approach is the better option. Also, any variations in the excitation voltage would be unnoticed in the measurements since the ADC reference is affected in the same way.

Noise reduction

There are some redundant characteristics of the frequency response of delta-sigma ADCs that can be used to reduce noise. Being a primarily averaging ADC, a delta-sigma ADC has a low-pass nature, which provides considerable noise reduction. Most delta-sigma ADCs, however, have a specific frequency response like the sinc response on the PSoC3 and PSoC5 ADCs. This response has specific nulls in certain frequencies that are multiples of the sampling frequency.

Hence, you can align the ADCs sampling rate to a specific value and eliminate a specific noise band. This can be particularly helpful when trying to eliminate noises sources like 50/60-Hz noise.

Moving average filter

One of the final steps you must take to achieve a noise-free output in a weigh-scale design is to use a firmware-based mathematical filter to average out noise. An easy filter to implement is a moving average filter (**Figure 4**). It uses an array where the input values keep getting streamed in from one side, and the oldest values fall off from the other side. At any given time, the output of the filter is the average of all of the elements in the array.

The moving-average filter is an easy, yet effective, filter for achieving higher noise-free bits from the measurement system. Note that this filter imposes a constant delay that is proportional to the depth of the array used. That means for a moving-average filter with "n" elements, every change is going to take "n" cycles to reflect itself in the output. This can be misleading if there are larger variations and the output slowly catches up.

This condition can be avoided by having a threshold condition check on variations. For example, if the input varies more than a threshold at a specific point in time, the whole filter is flushed and new data is copied into the filter and also into the output, thus reducing the latency for larger variations. The filter size you need to select depends on the required resolution, the ADC's sample rate, and the response-time specification of the weigh scale.

System design and integration

So far, we have addressed the design of the analog front end as well as various considerations for improving performance. But a weigh-scale solution involves more than just the analog front end. Based on the application, every weigh-scale design could have varying integral components ranging from communication interfaces to user interfaces. **Figure 5** shows a typical implementation of a weigh-scale design.

Apart from implementing the analog front end for a load cell, the system might

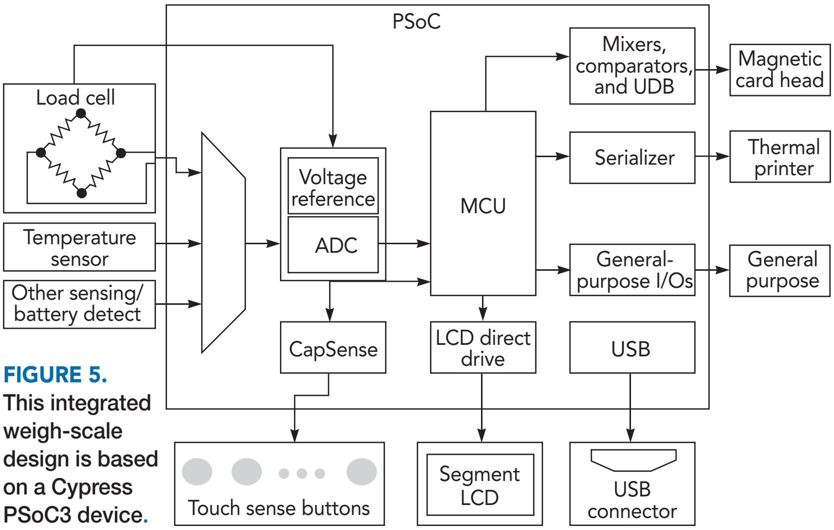

FIGURE 5. This integrated weigh-scale design is based on a Cypress PSoC3 device.

also take measurements from other analog sensors. Some high-precision weigh scales may require temperature monitoring to compensate for drifts in the load-cell parameters with temperature. This could require the designer to implement a thermistor interface. If the entire assembly is to be portable, then the design might also need a battery-charger interface. This would require an ADC for voltage and current monitoring and separate comparators for overvoltage and current-protection circuits. There are application-specific devices available in the market that implement battery charging, but the same function could be integrated into the SOC with a programmable device like the PSoC3.

As far as user interfaces are concerned, inputs can be simple tactile buttons. With current touch technology, some designs might be good candidates for a capacitive-sensing interface. Also, the outputs would be LCDs, and because of extreme cost pressure, most designers resort to directly driving LCDs to avoid the cost of LCD drivers.

Communication interfaces could range from a simple USB link to the host processor to an SPI/I2C link to another wireless communication device. Integrating these interfaces in the design can reduce the cost of the system.

In addition to the basic components needed for most weigh-scale designs, weigh scales like those used in point-of-sale terminals might also need an integrated thermal printer and a magnetic-card-reader interface. You can build a thermal-printer interface using nothing but a serializer similar to an SPI interface, a motor-driver circuit, some analog components to measure the printer head's temperature, and a paper sensor. Many programmable SOCs have a digital array that can be programmed to integrate a thermal-printer interface.

A magnetic-card reader is a more complicated analog function that is often implemented in an ASIC platform. But SOCs like the Cypress PSoC3 can integrate this function, so you can realize significant bill-of-material savings. Programmable SOCs allow different resources to be reconfigured at runtime, such as the ADC's specifications (including input range and resolution) and the connections between different peripherals. In weighing-scale applications, all the operations (measurement, printing, and card reading) are not done at the same time. So, all the resources on the chip can be used in a time-shared basis to provide a highly compact and cost-effective approach. T&MW

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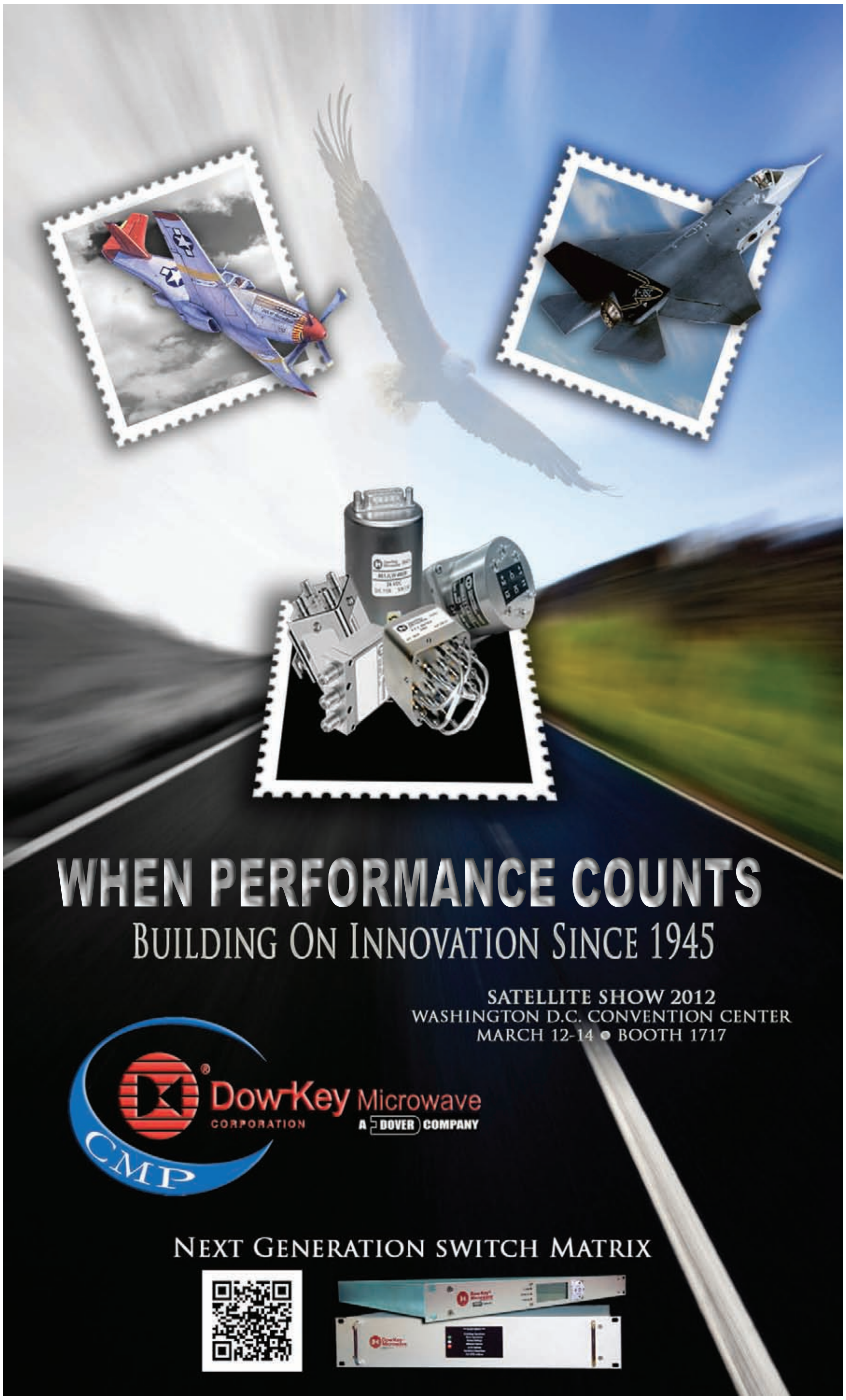


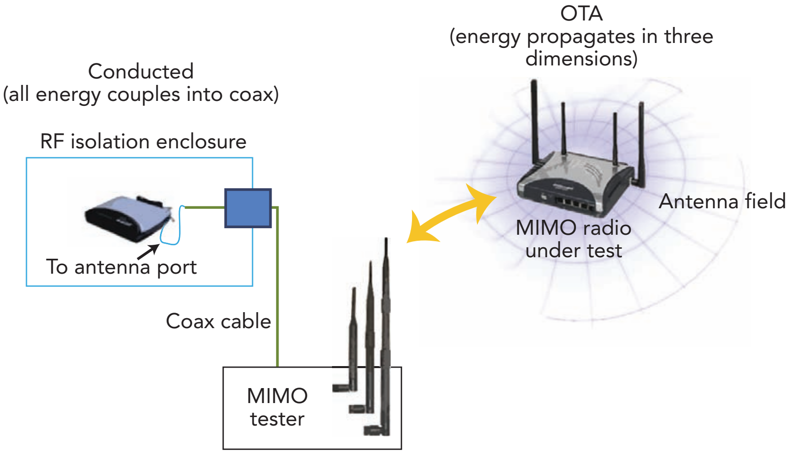


FIGURE 1. (Left) A traditional conducted test setup involves disconnecting the antenna from the DUT (device under test) and connecting coaxial cabling to the antenna port of the DUT. (Right) An OTA test setup requires coupling the DUT antenna field into the test equipment with measurement antennas.

Test MIMO Wi-Fi and LTE radios over the air

OTA testing can simulate conditions such as reflections and fading in a controlled environment.

BY FANNY MLINARSKY, OCTOSCOPE

Radio technologies such as IEEE 802.11 and 3GPP (3rd generation partnership project) LTE rely on MIMO (multiple input, multiple output) techniques to increase the range and data rates of radio transmissions. Using digital-signal processing, MIMO radios sense the conditions in the channel on a packet-by-packet basis and make instantaneous decisions on whether to employ 802.11 or LTE techniques. Tests of MIMO radios require OTA (over-the-air) measurements and simulations of transmission channels that are more complex than those needed for single-radio systems.

MIMO technology uses multiple synchronized radios—up to four for 802.11n and LTE and up to eight for the emerging 802.11ac—to adapt to continuously changing conditions in the wireless channel. MIMO radios use any of four techniques to extend range and data rates:

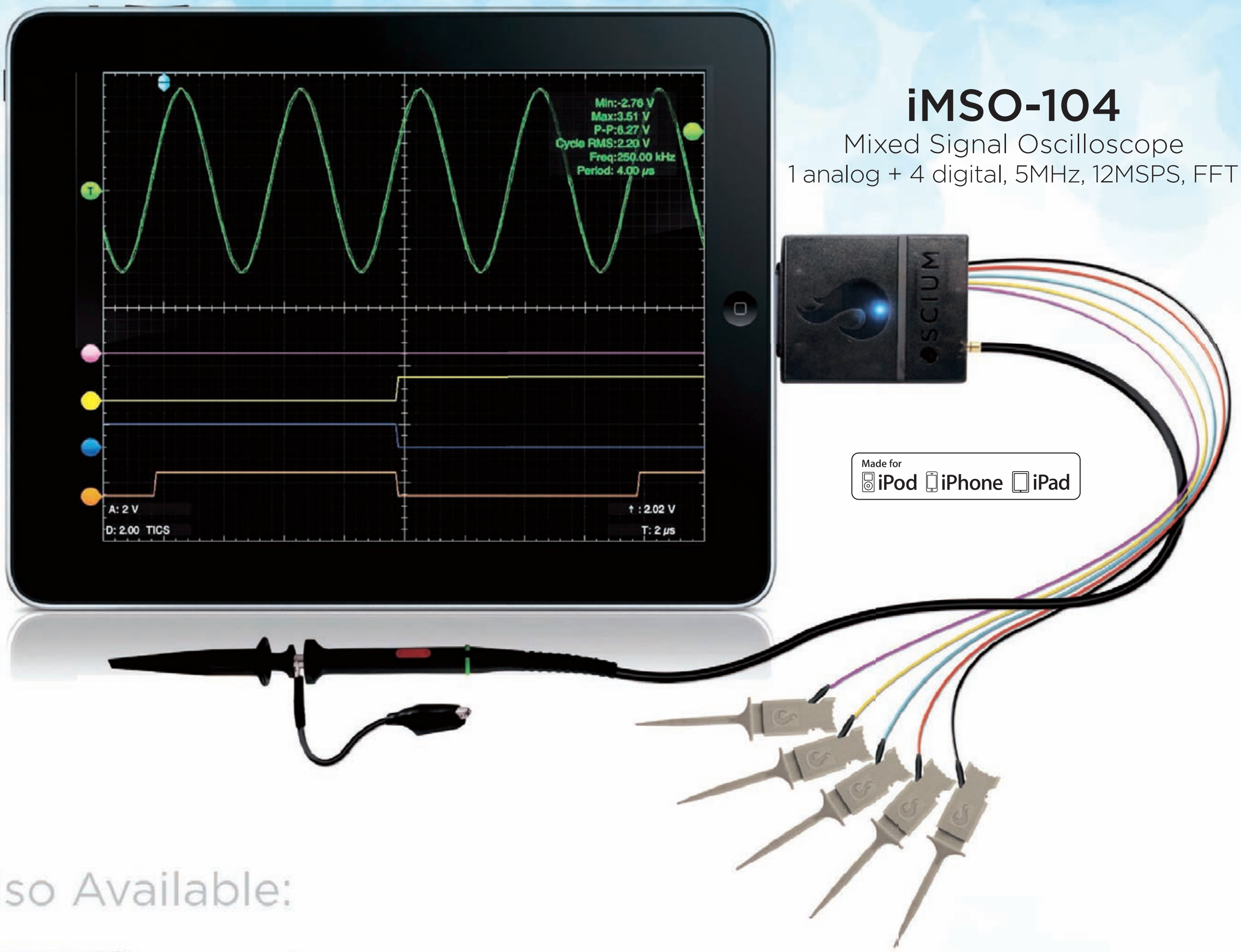
- *TX (transmit) and RX (receive) diversity,* which adds robustness when channel conditions are challenging (e.g., low signal-to-noise ratio or high multipath conditions);
- *Spatial multiplexing,* which increases throughput by sending multiple simultaneous streams when channel conditions are favorable;
- *Beamforming,* which extends the range or enables multiple users to share the wireless channel; or
- *MU-MIMO (multi-user MIMO),* which enables multiple stations to transmit simultaneously in the same frequency channel by focusing the antenna pattern.

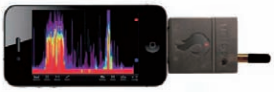
In the past, engineers could test radios in a conducted environment by disconnecting the antennas and replacing them with coaxial cabling that guided the signal to the controlled test circuitry (**Figure 1,** left side). Today's sophisticated MIMO techniques, including TX diversity and beamforming, require OTA test methods (Figure 1, right side). An IEEE 802.11 task group has developed a draft document that specifies test metrics and methods for conducted and OTA test environments (Ref. 1).

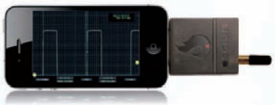
Controlled and uncontrolled OTA test methods

Many engineers consider conducted test environments to be controlled environments and consider OTA environments to be uncontrolled. OTA testing can, however, be performed under both controlled and uncontrolled conditions.

Uncontrolled OTA test methods include using a typical house or outdoor


Min:-2.76 V
Max:3.51 V
P-P:6.27 V
Cycle RMS:2.20 V
Freq:250.00 kHz
Period: 4.00 µs
A: 2 V
D: 2.00 TICS
↑: 2.02 V
T: 2 µs
OSCIUM





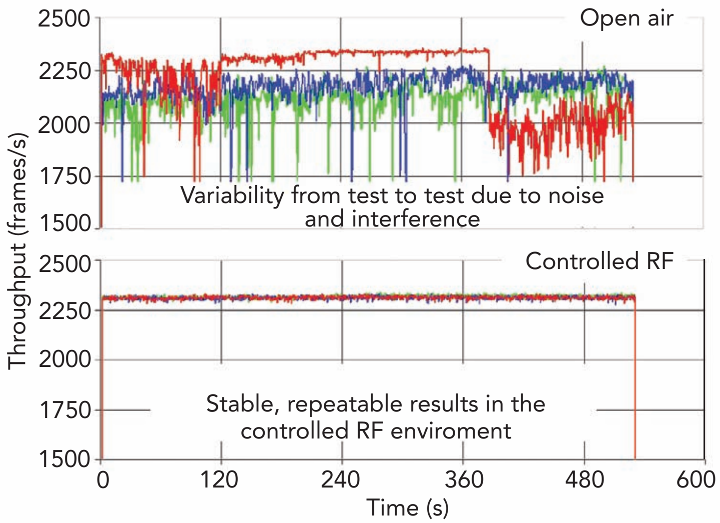


FIGURE 2. (Top) Measurements obtained in an uncontrolled test environment can be highly variable. (Bottom) Measurements obtained in a controlled environment, which can be conducted or controlled OTA, are stable and repeatable. The accuracy of the measurements depends on proper calibration.

setting to measure the throughput and range of the devices. Controlled OTA testing is typically performed in an anechoic chamber. Uncontrolled environments result in measurements that can vary over time, while controlled environments (either conducted or OTA), when properly implemented, produce repeatable measurements (**Figure 2**).

Because wireless devices now use sophisticated MIMO and beamforming algorithms that involve antenna arrays, conducted environment testing is quickly becoming inadequate. OTA test stations that use small anechoic chambers (**Figure 3**) can remove outside interference from MIMO tests and can create a controlled environment.

The key difference between traditional walk-in anechoic chambers and a new generation of anechoic test stations is that in a traditional chamber, engineers typically sit inside the chamber to work with the test equipment. New chambers are smaller: Only the DUT (device under test) and the test setup are placed inside. The engineers can comfortably work at a nearby lab bench or at a desk.

For these small anechoic test chambers, all the power, control, and data

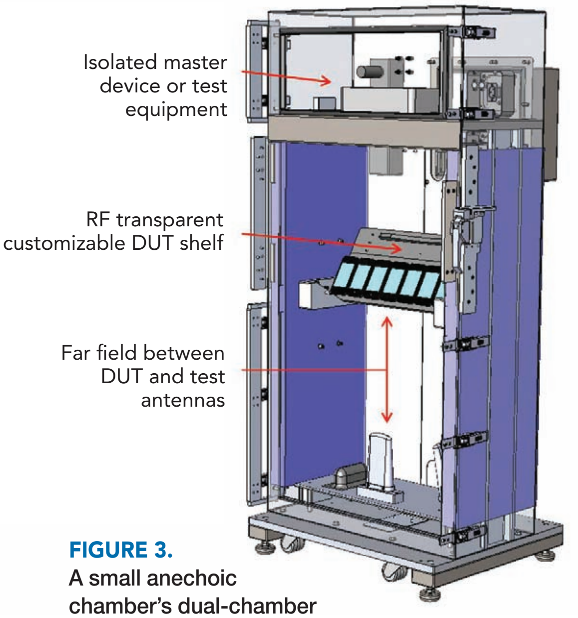


FIGURE 3. A small anechoic chamber's dual-chamber design houses test equipment, measurement antennas, and DUTs.

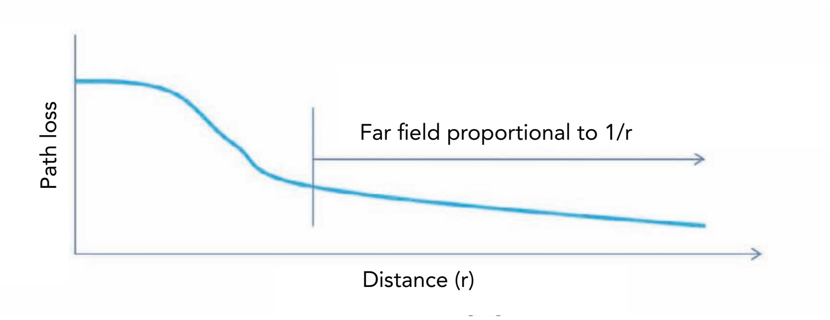


FIGURE 4. **Far-field conditions ensure measurement stability. A far field can be established by plotting path loss vs. distance and should be measured at different orientations of the DUT, because the antenna pattern is affected by the mechanical form factor of the DUT.**

cabling enter the chamber through specialized feed-through filters. Without the filters, copper cables will act as antennas, which will let outside interference disturb the test. High-speed USB or Ethernet data filters maintain the integrity of the data signals while attenuating RF frequencies and, thus, keeping interference away from the test environment inside the chamber. For traditional, large anechoic chambers, only power cables are typically filtered, because all equipment and data cabling are positioned inside the chamber.

In an anechoic (non-echoing) environment, absorptive material covers the metal walls of the chamber to dampen any reflections and eliminate uncontrolled multipath conditions. Multipath conditions cause time-variable signal fading due to standing waves, and this affects the accuracy and repeatability of the measurements.

Another important consideration for small anechoic chambers is finding a way to create far-field conditions for the measurement. While engineers may disagree as to the definition of "far field," they generally accept that far-field antenna radiation is characterized by path loss proportional to 1/r (**Figure 4**), whereas near-field radiation is characterized by path loss proportional to $1/r^2$ or $1/r^3$.

A far-field distance between the measurement antennas and the DUT ensures that the OTA measurements will be stable and repeatable. The 3GPP TS 34.114 document defines "far field" as the highest value of these variables: $2D^2/\lambda$, 3D, or 3λ, where D is the maximum extension of the radiating structure and λ is the signal's wavelength (Ref. 2).

To summarize, a small anechoic test station must ensure RF isolation, absorption, and far-field conditions in order to create a stable and repeatable test environment. Once the OTA environment is stable, the test needs controlled channel impairments—multipath and Doppler fading, noise, and interference—for testing the MIMO algorithms.

The 3GPP is currently developing a MIMO/OTA test methodology standard, TR 37.976 (Ref. 3). This methodology, although being developed currently for LTE devices, will also be applicable to 802.11 radios. T&MW

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3. 3GPP TR 37.976, "Measurements of radiated performance for MIMO and multi-antenna reception for HSPA and LTE terminals," 3GPP Specification series. www.3gpp.org/ftp/Specs/html-info/37-series.htm.

Fanny Mlinarsky is president of octoScope, a manufacturer of small anechoic test stations. The company focuses on IEEE 802.11 wireless and 3GPP 3G/4G technologies and standards. fm@octoscope.com.

PRODUCTUPDATE

SPECIAL FOCUS: Modular Test

Digitizer runs 16 bits at high speed

Alazar Tech's ATS9625 digitizer card contains two analog-input channels that simultaneously sample at speeds up to 250 Msamples/s. Each lane of the eight-lane PCI Express card can move data at up to 2.5 Gsamples/s to a host processor. Up to four cards can be connected in a master/slave configuration.

Each analog front end has its own isolation transformer and 250-Msamples/s, 16-bit ADC. Analog bandwidth ranges from 1 MHz to 150 MHz; input impedance is 50 Ω. Each ATS9625 card also includes two onboard FPGAs.

Software includes AlazarDSO software. A development kit supports C/C++, C#, Matlab, and LabView, and optional Linux drivers are available. For FPGA programming, the company offers the ATS9625-SDK development kit. Applications include optical-coherence tomography, radar signals, beamforming, and automated test.

Base price: $7995; FPGA development kit—$995. *Alazar Tech, www.alazartech.com.*

Scope module characterizes 32-Gbps designs

Agilent Technologies recently introduced a waveform-analyzer plug-in module for its 86100C/D DCA wide-bandwidth oscilloscope family. With residual jitter of below 50 fs, channel bandwidths to 50 GHz, and integrated clock recovery to 32 Gbps, the Agilent 86108B waveform analyzer assists engineers testing IEEE 802.3ba, Optical Internetworking Forum CEI 3.0, INCITS T-11 32G Fibre Channel, and high-speed proprietary systems. The unit's integrated precision time-base and clock-recovery design has typical residual jitter below 50 fs rms.

Continuous data-rate coverage from 50 Mbps to 32 Gbps, peaking control, and adjustable loop bandwidths to 20 MHz also allow the clock-recovery circuit to provide PLL response for device characterization. An auxiliary clock-recovery input circuit allows engineers to analyze extremely low-level signals, or signals that have been closed due to intersymbol interference, by triggering the scope using a separate synchronous data (or clock) signal connected to the 86108B's auxiliary CR input.

Agilent offers the 86108B with bandwidth options of 35 GHz and 50 GHz and clock-recovery data-rate options of 16 Gbps and 32 Gbps. Both options are upgradeable.

Base price: $80,000. *Agilent Technologies, www.agilent.com.*

LIN interface module family gains PXI unit

Goepel Electronic has expanded its range of LIN communication controllers for testing ECUs (electronic control units) with the introduction of the PXI 3078, a module that provides two LIN bus or K-Line interfaces and supports LIN specifications 1.3, 2.0, and 2.1. Bus communications includes all LIN-typical message types and diagnosis services like event-triggered frames, sporadic frames, unconditional frames, and diagnostic frames.

Configured as a K-Line interface, the module supports the diagnosis protocols KWP 2000, KWP 1281, and ISO 9141 (Ford). Extended command sets such as stimuli/response runs, ramps, or table functions are available as software add-on modules.

Goepel Electronic, www.goepel.com/en/index.html.

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VIEWPOINT

[An exclusive commentary from a technical leader]

Memory BIST for shared-bus applications

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Technical Marketing Manager
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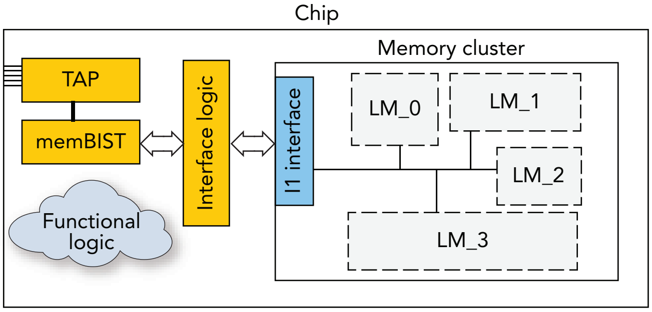
Ron Press is the technical marketing manager of the Design for Test products at Mentor Graphics. The 20-year veteran of the test and DFT industry has presented seminars on DFT and test throughout the world. Press has published dozens of papers in the field of test and is a member of the International Test Conference Steering Committee. He earned his BSEE from the University of Massachusetts.

Read past Viewpoint columns at www.tmworld.com/viewpoint.

BIST (built-in self-test) provides a thorough test capability for embedded memories. A key value of memory BIST is that the high-quality tests are structural and are usually independent of their design embedding. A current trend in processor core designs, however, is to provide a high-performance shared-bus interface to embedded memories. Adding traditional memory BIST directly to these memories would impact the timing and performance of the shared bus. To use the shared bus to test multiple memory die, you can add memory BIST outside of the shared bus.

A typical application of memory BIST includes a BIST controller to generate algorithms and verify results and includes MUX logic local to each memory to provide test stimulus to the memories. Thus, in shared-bus applications, not only would the BIST interfere with the performance of the functional path to the memory with a MUX delay, but it would also bypass the functional path during BIST tests.

Design blocks with a shared bus and with memories on the bus (memory clusters) have a functional interface to the bus (see the **figure**). The critical timing and pipelines for the shared bus are located inside the memory cluster. The other side of the memory cluster interface often has relaxed timing. Thus, a logical solution is to place the shared-bus memory BIST controller, interface logic, and TAP to control it outside of the memory cluster. MUX logic used to access the memories is implemented in the BIST interface outside the cluster. This approach preserves the performance of the shared bus while ensuring the benefits of self-test, repair, and debug you get with memory BIST.

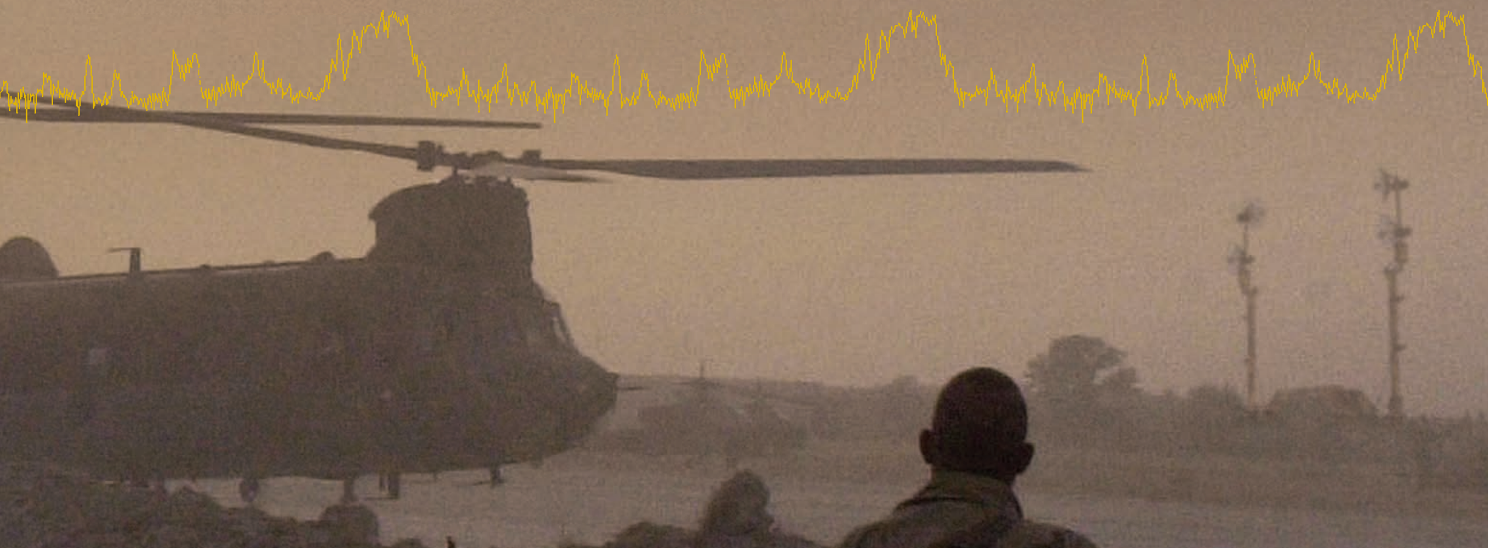


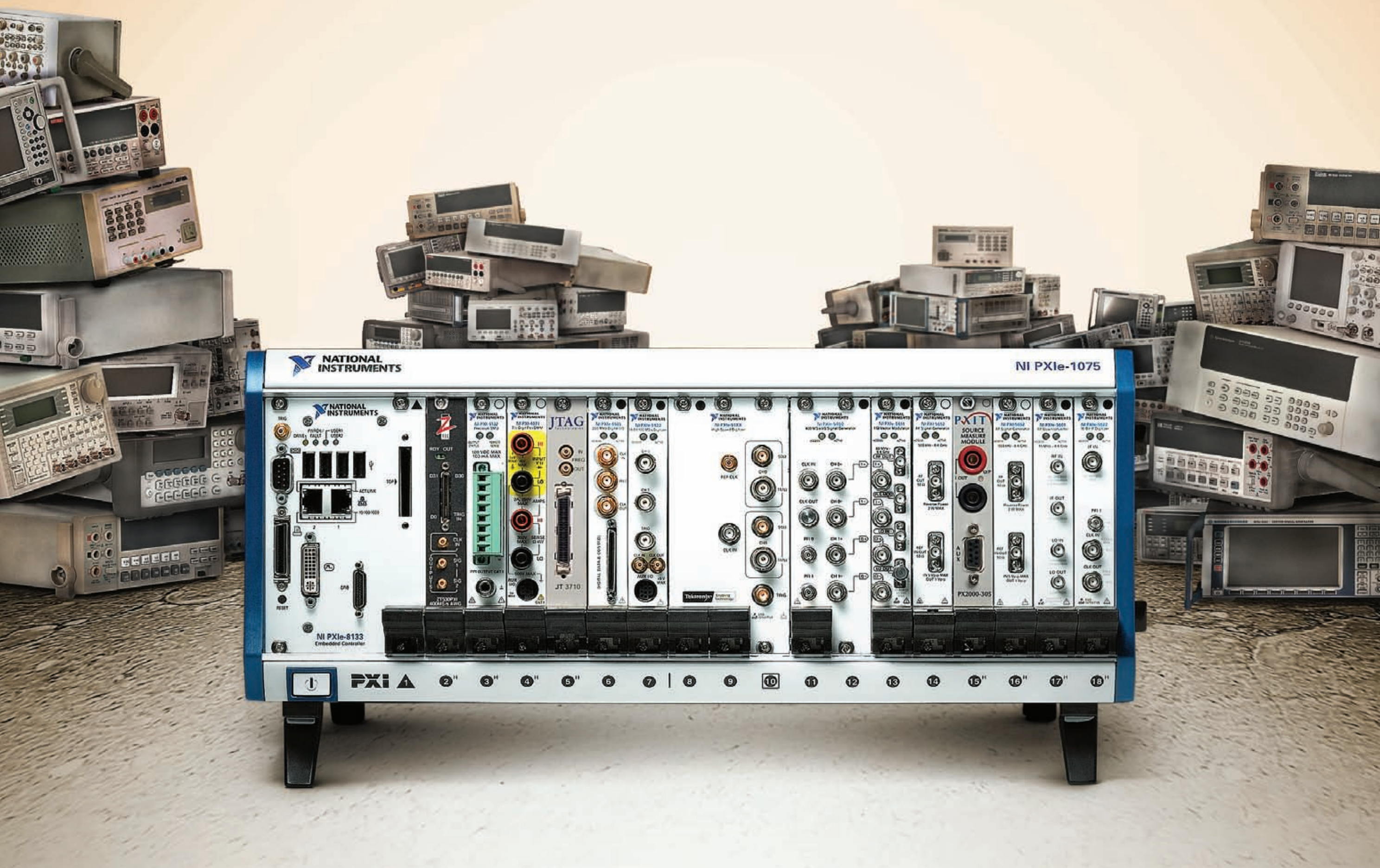
Shared-bus memory BIST has a special structure because it doesn't interface directly to the memories it is testing. It treats each logical memory as a separate test target, regardless of the number of actual physical memories within them. Automation for this type of memory BIST insertion and operation exists with just a few additional files that let the memory BIST tool understand the structure of the shared bus. These files include a memory cluster library file to describe the shared-bus interface port, a logical memory file, and a physical memory file. The logical memory represents a complete address space as seen from outside the shared-bus interface. Knowledge of the physical memory information is necessary for memory repair.

Built-in self-repair is also supported with shared-bus applications. The self-repair registers, however, are located inside the memory cluster, since they directly drive the memory repair ports. This is acceptable because the registers are not located on the shared bus or other performance-critical paths. A separate serial port is used to load the self-repair registers. A shadow of the repair registers is located outside of the memory cluster local to the BIST controller to avoid routing congestion of controller data that is used to write repair information for a repair efuse.

Not only does the shared-bus memory BIST approach preserve the performance of the shared bus, but it also tests the functional interface to the memories. Since the BIST MUXes are outside the memory cluster, at-speed memory BIST tests will propagate through the functional shared-bus path.

Shared-bus memory BIST can be used in applications where the functional path to the memory performance is critical and where there is a higher-level interface to a collection of memories. All the advantages of memory BIST are available along with the ability to test through the functional paths without any performance impact on the memory functional paths. T&MW

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