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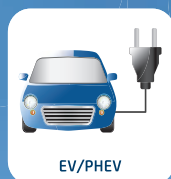
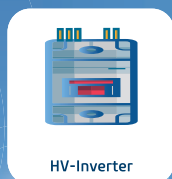
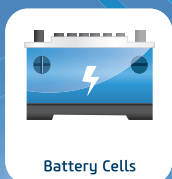
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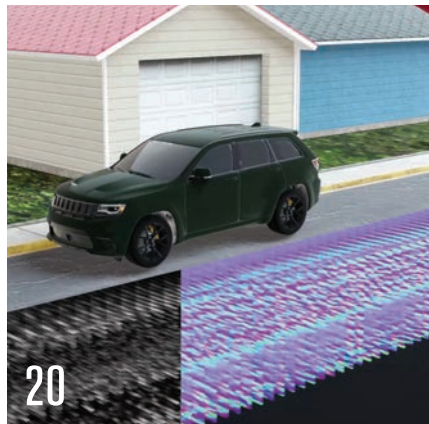


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EDITOR'S NOTE

COMBINING FORCES

Greetings. Some of you may have seen my face on *Electronic Design* where I have been for the last 20 years. While I am still Editor of *Electronic Design*, I am also the Senior Content Director for *Evaluation Engineering (EE)*, *Electronic Design (ED)* and *Microwaves & RF (MWRF)*. All three can be found online and in print.

All three publications are now part of Endeavor Business Media. There are quite a few more publications under this umbrella, and we share our expertise and insights to improve the information we provide to you, our readers.

While I am currently taking the helm with *EE*, we are still going to have articles and insight from Rick Nelson, who has guided *EE* as Editor. As a contributing editor, Rick will continue to write the special reports that are central to each print issue. We have some new contributing editors as well, including Steve Taranovich and Alix Paultre. Their content is on the website already and will be showing up in the print pages in future issues.

and racing technology. Some of the test related articles will be gracing the pages of *EE*.

As part of this project we are holding a contest (See Page 32) so that one of you can win a pair of tickets to the 2020 Indianapolis 500. This includes access to the pits, so check out our Join Us in the Pits pages on our websites. It's free, and one lucky winner will join us at the "Brickyard" for the 104th running of the Indianapolis 500.

Special Reports and Tech Features

Rick was rather busy this month cranking out two special reports and a pair of technology feature articles.

The electrical safety testing (EST) industry is one we cover in *EE*. It addresses everything from consumer appliances to medical equipment. It is the target of our first special report, *EST Instruments Provide Safe Environment to Assure Compliance*.

The *RF/microwave Switching Adds Flexibility to Diverse Applications* article switching technology and applications from PCI eXtensions for Instrumentation (PXI) and LAN eXtensions for Instrumentation (LXI) that are standards for test equipment board interfaces to wideband matrix switching systems.

Software Boosts Power Applications targets programmable power supplies. These are key tools for diagnostics especially hardware-in-the-loop (HIL) testing. They provide the flexibility needed to address a range of test environments.

The *Ground-penetrating Radar Offers New Sensor Modality for Vehicles* article dives into technology from WaveSense. Its ground-penetrating radar can be used to improve the sensing capabilities of self-driving cars.

Keep an eye out for new and interesting things on our websites and in print. We have a series of bootcamps online at bootcamp.electronicdesign.com. The latest was on 5G with a heavy emphasis on test and measurement. **EE**



▲ *Machine Design* and *Electronic Design* are sponsoring DragonSpeed's IndyCar #81.

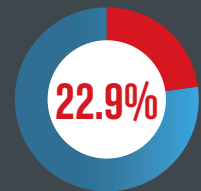
Indianapolis 500, IndyCar and DragonSpeed

One advantage of a combined venture is the ability to address more ambitious projects, like sponsoring an IndyCar. The *Electronic Design* and *Machine Design* logos are now decorating DragonSpeed's #81 IndyCar. We have landing pages on all of our sites that point to articles on DragonSpeed, IndyCar

BY THE NUMBERS

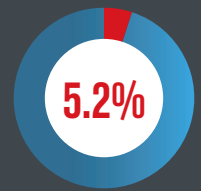
\$2.34 BILLION

North American semiconductor billings in January 2020

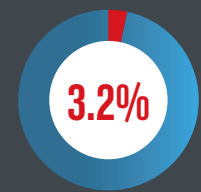


Increase in North American semiconductor billings over January 2019

Source: SEMI



Decrease in North American PCB shipments in January 2020 over January 2019

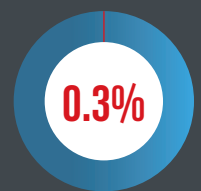


Increase in North American PCB bookings in January 2020 year-over-year

Source: IPC

\$35.4 BILLION

Worldwide sales of semiconductors in January 2020



Year-over-year decrease in semiconductor sales in January 2020

Source: SIA

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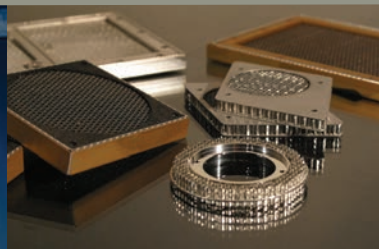
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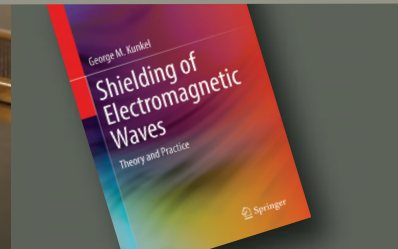
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Report: 5G connections in manufacturing to reach \$10.8B by 2030

An analysis report from ABI Research predicts that the market for 5G cellular connections in manufacturing will reach \$10.8 billion by 2030, at a compound annual growth rate of 187%. "But, to capture the value at stake,

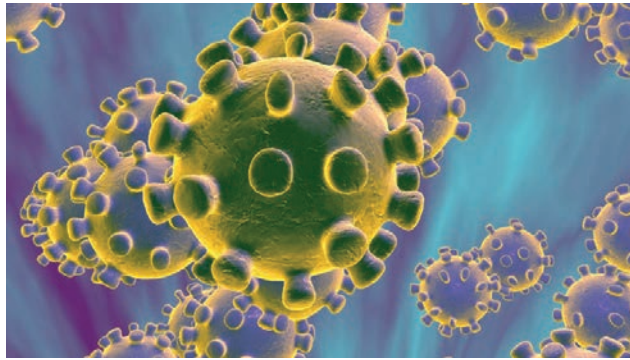


ecosystem stakeholders will first need to evaluate how to measure the impact of 5G and edge deployments," says Don Alusha, Senior Analyst at ABI Research.

With greater reliability and data speeds that will surpass those of 4G networks, a combination of 5G and local edge compute will pave the way for new business value. Commercial benefits will accrue along three broad aspects: agility and process optimization; better and more efficient quality assurance and productivity improvement. "The implications for solution providers such as Ericsson, Huawei, Nokia and ZTE are that they must enhance their "value add" by complementing their deep technical expertise with business expertise including vertical industry knowledge, new functional expertise (sales, marketing, and accounting) and solution design and consulting expertise tailored at niche use cases," Alusha said.

These findings are from ABI Research's 5G and Edge Networks in Manufacturing application analysis report. This report is part of the company's 5G Core & Edge Networks research service, which includes research, data, and ABI Insights.

INDUSTRY REPORT



Coronavirus expected to cause five-week product shipment delays, says electronics manufacturing industry

According to a survey conducted by the global electronics manufacturing association IPC, electronics manufacturers are looking at a five-week product shipment delay from suppliers, at the minimum, as a result of the burgeoning coronavirus epidemic. IPC says that already there are shipping delays for manufacturers due to the spread of the coronavirus outbreak in China and other countries.

Among manufacturers, about 65 percent report that their suppliers are predicting roughly a three-week delay, but the manufacturers fear that greater delays might be lurking in the future, with executives forecasting shipment delays of at least five weeks.

"The delays will likely have ripple effects for the rest of the year," John Mitchell, IPC's president and CEO said in a press release. "The longer China is affected by the epidemic, and the more it spreads to other parts of the world, the supply chain will experience more and varied strains and disruptions."

More than 80 percent of electronics manufacturers and suppliers are expressing concern over the potential impact of the coronavirus outbreak on their business operations. Potential impacts in the manufacturing chain could involve factory downtime, higher costs, transportation issues, delayed sales, necessity of alternative sourcing, and delayed prototyping, according to the IPC. "In most cases, it's not easy for manufacturers to switch suppliers, if that's what turns out to be necessary," added Mitchell. "Securing alternate sources requires an investment of significant time and money that must be weighed against the value gained."

The survey was conducted Feb. 11-16, 2020.

SEMICON[®] SOUTHEAST ASIA

SEMICON Southeast Asia 2020 postponed

On March 4, SEMI announced that it is postponing SEMICON Southeast Asia 2020 from 12-14 May to Aug. 11-13, due to concerns related to the ongoing coronavirus outbreak. The venue for the event will remain the Malaysia International Trade and Exhibition Centre.

"After close consultation with our stakeholders, which include partners, exhibitors, industry peers and the general community, we have made the necessary decision to postpone SEMICON Southeast Asia 2020," said Bee Bee Ng, president of SEMI Southeast Asia. "We want to ensure that SEMICON Southeast Asia 2020 achieves its primary objective of forming connections and collaborations for exhibitors and visitors, both regionally and globally. It remains our mission and commitment to make the show highly successful and impactful."



HUAWEI

Huawei makes big bet on EU market, despite pressure from Trump

According to a report by Bloomberg, Chinese telecommunications giant Huawei is ramping up its presence in Europe, in defiance of Trump administration pressure, by filing more patent applications

in Europe than any other firm in 2019. The company filed 3,524 applications, more than 600 more than filed by No. 2 Samsung Electronics Co. Most of Huawei's applications were in digital communications, specifically aimed at 5G. The Trump administration has urged European countries to desist from doing business with Huawei, over claims that the company is affiliated with the Chinese Communist Party, and that its 5G equipment could potentially be used for spying. Huawei has consistently denied the allegations.

500th F-35 fighter jet delivered to Air Force

The F-35 Joint Program Office and prime contractor Lockheed Martin recently recorded a historic milestone for the single-seat, single-engine fighter jet: Delivery of the 500th production F-35 fighter aircraft to the Burlington, Vt. Air National Guard Base. The jet is a U.S. Air Force F-35A with a full complement of radar and electronic-warfare (EW) systems. The 500 aircraft include numerous variations for different types of missions, for U.S. and international customers alike: 354 F-35A conventional takeoff and landing

(CTOL) fighters, 108 F-35B short takeoff/vertical landing (STOVL) fighters, and 38 F-35C carrier variant (CV) aircraft. The 500 F-35 variants have amassed a total of 250,000 flight hours, including training and developmental test jets.

"These milestones are a testament to the talent and dedication of the joint government, military and industry teams," said Greg Ulmer, vice-president and general manager of Lockheed Martin's F-35 program. "The F-35 is delivering an unprecedented 5th Generation combat capability to the warfighter at the cost of a 4th Generation legacy aircraft."

The F-35 is the result of design and production teamwork by leading U.S. and international manufacturers. For example, while Lockheed Martin is the prime contractor, Northrop Grumman and BAE Systems contribute the design and construction of center and aft fuselages, respectively, along with expertise on advanced electronic tactical systems. The F135 the world's most powerful fighter engine. The F-35 operates from 23 bases worldwide. More than 985 pilots are trained to

fly and over 8,890 engineers/technicians are trained to maintain the aircraft.



Global fab equipment spending poised to set record in 2021

Global fab equipment spending is expected to experience a modest recovery this year after a lackluster 2019, paving the way for a robust year of investments in the semiconductor industry in 2021, according to a report by SEMI.

Over the near term at least, look for no big bounds in average fab equipment spending, according to the latest update of the SEMI World Fab Forecast report. The forecast shows a 3% year-over-year (YoY) growth to US\$57.8 billion recovery in 2020. SEMI is predicting that the picture will brighten in the second half of this year as a recovery starts to take hold.

Despite expected interference from the coronavirus outbreak, China equipment spending will grow about 5% YoY to over US\$12 billion this year and surge 22% YoY, or US\$15 billion, in 2021. Investments by Samsung, SK Hynix, SMIC and YMTC will drive the growth.

In 2021, Taiwan is expected to be the top region in spending in 2020 with nearly US\$14 billion, but sink to third in 2021 with US\$13 billion. Korea is expected to be the top spender in 2021 with a 26% increase to US\$17 billion.


Southeast Asia (mainly Singapore) will also register robust growth of 33% YoY, to US\$2.2 billion, in 2020 and 26% in 2021.

Lagging the pack, the Americas will spend less in 2020 than in 2019, with fab equipment investments plunging 24% to US\$6.2 billion, and extend the downturn with a 4% decline in 2021.

TE Connectivity acquires majority share of First Sensor AG

TE Connectivity Ltd., a global industrial technology company in connectivity and sensing solutions, completed its public takeover of First Sensor AG (XTRA: SIS). TE now holds 71.87% shares of First Sensor.

First Sensor, founded as a technology start-up in the early 1990s, is a global player in sensor technology. With its expertise in chip design and production, as well as microelectronic packaging, it develops and produces standard sensors and customer-specific sensor solutions in the fields of photonics, pressure and advanced electronics for applications within the industrial, medical and transportation markets. It has six German locations along with development, production and sales sites in the USA, Canada, China, the Netherlands, Great Britain, France, Sweden and Denmark, along with a worldwide partner network.

In combining the First Sensor and TE portfolios, TE will be able to offer an even broader product base, including innovative, market-leading sensors, connectors and systems plus best-in-class capabilities, that supports the growth strategy of TE's sensors business and TE Connectivity as a whole. 



The 500th F-35 multiple-role fighter aircraft was built for delivery to the Air National Guard in Burlington, Vt.

 Lockheed Martin



▲ Chroma Systems Solutions 19036 wound-component electrical-safety-testing analyzer.

SPECIAL REPORT

EST INSTRUMENTS PROVIDE SAFE ENVIRONMENT TO ENSURE COMPLIANCE

by Rick Nelson, Contributing Technical Editor

▶ Designers and manufacturers of electrical products—from consumer appliances to medical equipment—need to ensure that their customers can use the equipment safely and that the products will comply with relevant industry standards. Consequently, the designers and manufacturers will rely on instruments

such as hipot testers, ground-bond testers, leakage-current testers, and insulation-resistance testers to ensure their products' quality and safety. In this report, participants in the electrical safety testing (EST) industry comment on their product offerings, applications areas, challenges, and trends.

Challenges

Chad Clark, VP of sales at Vitrek, said a key challenge is ensuring a safe test environment. Yet another challenge is making sure to perform all tests required to comply with applicable safety standards. "This is particularly important when the product is sold/used in multiple global

markets with differing standards requirements,” he added.

Said Jamie Pederson, product marketing manager at B&K Precision, “One of the key challenges for a customer is ensuring compliance with requirements that may differ from country to country and finding a safety tester to meet that need. Choosing a hipot tester with programmable capabilities is key to supporting a wide range of testing requirements.”

Nick Piotrowski, Ikonix USA product manager, identified functionality vs. price point as a key challenge. “EST is driven by standards-based testing (IEC, UL standards, etc.). As a result, it covers a wide variety of products, and not everyone’s requirements are the same,” he said. “Additionally, standards groups (technical committees that create the standards) don’t always collaborate between industries.” For instance, TC66 (Technical Committee for the IEC 61010-1 standard family—Laboratory Equipment) might not collaborate on standards writing with TC108 (IT & Video/Audio Equipment). “This creates discrepancies between different standards even though there is a great deal of crossover between these industries and safely testing similar products,” he said. “As a result, the manufacturer or vendor is forced to offer a product that covers full-spectrum EST. This is more expensive to manufacture and thus becomes more expensive for the customer.”

Piotrowski also cited resistance to upgrading/change, noting that industrial EST equipment innovations tend to lag consumer electronics, for several valid reasons. First, “New equipment is expensive,” he said. “A customer might not have the budget to upgrade EST equipment every few years, yet the rate of change of technology is moving at a quicker pace than ever.”

Second, Piotrowski cited qualification. “In many industries (for example, medical) changing equipment in a testing/manufacturing process requires a complete revalidation of the system,” he said. “This is a time-consuming and expensive process. As a result, customers try to hold onto their equipment if possible, to avoid these changes.”

Finally, Piotrowski cited geopolitical barriers. “Not every country (and thus market) has the same set of requirements on technology,” he said. “Sometimes, there are separate and/or additional requirements. It falls on the manufacturer to contend with complex international requirements if they want to compete in a global market. This is time consuming and expensive.”

Dan Carter, EST marketing product manager at Chroma Systems Solutions, said product safety testing is becoming more complex with the growth of battery, EV, and regenerative-power applications. Consequently, the company has broadened its range of electrical safety test instrumentation beyond basic hipot and ground-bond testers and placed an emphasis on education as part of the sales process, he said.

Carter cited as an example of the expanded product range the new 11210 battery-cell insulation tester.

“On rare occasions, an electrical short can develop inside the cell after passing production tests due to burrs or particles on the positive electrode reaching the negative electrode after inflation occurs,” he explained. “If these cells that are susceptible to failure pass through to the end user, the results could be catastrophic. The 11210 provides a solution for manufacturers to mitigate these occurrences in the dry-cell stage.” The company offers a white paper on the subject.¹

Gregory Smith, U.S. director of sales at Instek America Corp., cited lack of knowledge regarding the various compliance standards and test parameters as a key challenge—as well as a lack of understanding of the engineering concepts behind the tests, especially in some unique application areas. The company can provide large companies with individualized product training, he said.

Products

According to Clark at Vitrek, the company offers electrical safety test products including the V7X Series compact and economical electrical safety/hipot testers, the 95X Series high-power, high-resolution hipot and ground-bond testers, the 964i high-voltage switching system, the 98x Series precision insulation resistance testers, and QT-Pro test-automation software. The company also supports the calibration typically required by Nationally Recognized Testing Labs (NRTLs). “Vitrek instruments include a calibration cycle commonly used on a daily basis,” said Clark. “Vitrek is an accredited ISO 17025



▲ Vitrek V7X hipot safety tester.

calibration lab and offers this service to its customers.” A white paper addresses calibration and other electrical product safety test issues.²

Carter at Chroma described the company as a one-stop source for electrical safety test products, offering instruments from basic, standalone hipot and ground-bond testers to impulse winding testers, LCR meters, and more in addition to the battery-cell insulation testers. “At the forefront of our offerings are fully automated test systems that can incorporate safety tests with many other electrical tests that are often required by OEMs,” he said. “Our instruments are built for automation, and we are experts in integrating them into turnkey solutions for a wide variety of test requirements.”

Specific products in addition to the 11210 include the 19036 hipot, IR, DCR, and impulse-winding test combination

unit for the EV space and the recently introduced 19311-10 for the lead-acid battery industry. “We love tackling new applications and learning more about budding requirements in new and growing industries,” he said.

Carter said Chroma offers a range of accessories and soft panels to help set up a complete solution; its CaptivATE automation software supports automated hipot, leakage-current, and functional tests. “For medical device manufacturers, CaptivATE supports IEC60601-1 test requirements and provides IQOQ protocol documentation,” he added.

Ikonix offers EST products from its Associated Research (AR), SCI, and Associated Power Technologies (APT) divisions. “Both the entire AR and SCI product offerings are designed and manufactured for electrical safety testing,” said Piotrowski. “The APT AC power sources are commonly used to provide power for functional and leakage current tests.” Specific products include the Associated Research HypotULTRA Series electrical safety compliance analyzer, the SCI Model 294 DC hipot tester, and the Associated Power Technologies 300XAC Series programmable AC power source.

According to Pederson, “B&K Precision’s soon-to-be-released 3600 Series programmable hipot testers combine functionality and safety in a cost-effective solution. This series features AC, DC, and insulation resistance tests along with open/short detection, which saves time by ensuring the DUT is connected properly and eliminates false positives. The GFI and



▲ Associated Research HypotULTRA Series electrical safety compliance analyzer.
 ▼ Associated Power Technologies 300XAC Series programmable AC power source.



shutdown interlock features ensure a high level of operator safety.” Pederson added, “The 3600 Series features programmable ramp up and ramp down as well as dwell time for greater control over the testing process and the ability to support many regional standards.”

GW Instek offers a variety of safety test products, including hipot testers such as the GPT-9800 electrical safety tester with 200-VA AC test capacity; the GCT-9040 40-A AC ground bond tester, which measures resistance from 1 mΩ to about 650 mΩ; the GLC-9000 leakage-current tester; and multiplex scanner boxes for safety testers.

“Our GPT-12000 electrical safety tester includes the ability to perform intuitive interactive control, and also remote/automated operation via LabVIEW software drivers,” said Smith. The GPT-12000 Series can also save test results to a text file on a USB drive, and statistics and analysis results on instrument screen shows the quality of the batch without the need for an external PC. A barcode function facilitates scanning of barcodes, for manual and automated tests on an assembly line.

Kikusui’s offering in the EST field is the TOS9300 Series electrical safety analyzer, which features AC and DC hipot, insulation-resistance, earth-continuity,



◀ Kikusui TOS9300 Series electrical safety analyzer.

and leakage-current test capabilities. A spokesperson said the company focused on minimizing the footprint, adding that a dedicated power source was designed for each test function to provide high output quality with low ripple and noise. Combining all four tests in one unit with a large LCD facilitates ease of use, the spokesperson said, adding that the product is fully programmable to support demands for system integration. A scanner option expands the test capability up to 16 channels to help save test time in production for DUTs having multiple test points.

Applications

When asked what applications—such as medical equipment, consumer appliances, lighting, industrial equipment, or communications equipment—his company serves, Smith at Instek America said, “All of the above—anything and everything that plugs into the wall.” He added that the company supports

powered component and powered sub-assembly test.

Vitrek, too, supports a similar broad line of applications, with Clark singling out cable testing. The Kikusui spokesperson cited automotive, battery, consumer-appliance, medical, component, and industrial-power-supply applications coupled with system integration.

Carter said Chroma serves application areas extending from basic lighting to complex medical test. “We serve small-level component testing to large motor testing and most things in between,” he added.

Piotrowski at Ikonix said the company’s products span the full spectrum of safety testing, catering to a variety of industries, including appliances (consumer and industrial), electrical medical devices, lighting and LEDs, laboratory equipment, consumer electronics, machinery, lead-acid and Li-ion batteries, EVs, components (transformers, capacitors, and electrical

switching equipment), and solar and wind energy.

Operator safety

To ensure operator safety, an interlock function is standard on all Kikusui electrical safety testers to ensure that the test fixture is secured, said the company’s spokesperson, adding, “We also have double-hand operation remote control to offer safer test operation.”

Clark at Vitrek cited a number of high-level operator safety features, including a GFI high-speed shutdown for earth-ground leakage faults; the company’s SFI Safety Fault Interlock, which provides high-speed shutdown on interruption of a tester’s safety interlock; and Vitrek’s TLSS Test Lead Safety Sense, which clamps DUT chassis near ground by continuously verifying proper connection of test leads prior to and during high-voltage testing. The company also offers power receptacle test adaptors, IEC 320 C13 power



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socket hipot lead sets and ground bond test lead kits, and a retractable tip test pistol lead set.

Piotrowski said that to ensure operator safety, Ikonix offers personal protective equipment (PPE) accessories, including insulation mats, DUT interlocked enclosures to ensure no contact to live voltage, signal tower lights to notify operators when testing is in progress, test probes to ensure minimum approach boundaries, warning signs to post in high-voltage testing areas, dual remote palm switches to ensure that an operator cannot touch a DUT with live voltage applied, and applications consulting and operator training on proper PPE and equipment safe practices. Piotrowski added, “We offer certifications for operators to ensure they are trained equipment users.”

concerns. Our new 3600 series supports this with an interlock connection which will instantly stop the testing process when engaged. Any normally open switch connected to a door or gate, hand safety switch, or other safety device will activate the interlock. Ground-fault detection is also available to stop the test if a short to ground is detected.”


Smith cited several GW Instek product features that enhance operator safety. A zero-cross function turns off the voltage within 150 ms if a test fails, a safety-interlock feature prevents execution of test without first closing a specific circuit, and a remote on/off feature is available.

“Our newer GPT-12000 Series meets IEC 61010-2-034 design requirements, such as double insulation for input and output voltage, safe output/warn-

test signal stresses the insulation in both polarities, discharging the DUT is not necessary, and no voltage ramping is required, to name a few.”

Carter at Chroma put automation, traceability, reliability, and test repeatability at the forefront of electrical product safety testing. “We see a strong trend that more customers want a test solution that can check all of these boxes,” he said. “A major part of our business is providing automated test systems, and we pride ourselves in our ability to deliver both off-the-shelf and/or custom solutions for our customer’s exact needs.”

Piotrowski at Ikonix also cited automation as a trend, along with data and control, resulting from the move toward IoT and integration with all forms of production and manufacturing processes. “This trend includes analytics to determine trends in passes/failures and measurements of electrical safety testing equipment integrated into the overall manufacturing line for a complete picture of the production process,” he said. “For example, a user could implement integrated software to talk to multiple pieces of equipment (EST and otherwise), upload all tests and data to the system (or cloud), and analyze overall efficiencies in production.”

Smith at Instek America Corp. cited several trends in product safety test. “Instruments must always have relevant protection and safety warnings for the test operator during test execution,” he said. He also cited an increasing need for both manual/interactive operation and remote operation/automated testing as well as an increasing focus on test data collection and storage and automated statistical analysis supplied by the test equipment. “Customers don’t expect to pay additional fees for software to do all of the above,” he concluded. 

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▼ GW Instek GPT-12000 electrical safety tester.



Other safety features include a built-in equipment interlock with both software controlled I/O port and connection to hardware disabling output, Piotrowski said. A SmartGFI feature monitors leakage to ground to ensure no shock hazard posed to operator; if leakage exceeds set value (0.1 to 5 mA), the instrument output is disabled.

According to Carter at Chroma, “All of our electrical safety products feature a safety interlock, and most of our products where applicable have a ground-fault-interrupt circuit which will cut off the output if the unit senses a current imbalance.”

Pederson at B&K Precision commented, “Operator safety is one of our top

ing mechanism, post-test discharge mechanism, as well as a safety interlock feature to prevent execution of a test without first closing a specific circuit to ensure user safety during the operation,” Smith said.

Trends

According to Pederson at B&K Precision, safety standards have evolved along with the testing methods and equipment used. “Traditionally, a simple DC-only hipot tester was all that was needed,” he said. “These testers typically employ a low current useful for testing capacitive DUTs. In more recent years, AC hipot testers have increased in popularity, bringing with them several advantages: The AC

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◀ Universal Switching Corp.
MS2010A DC to 18-GHz
switch matrix.

SPECIAL REPORT

RF/MICROWAVE SWITCHING ADDS FLEXIBILITY TO DIVERSE APPLICATIONS

by Rick Nelson, Contributing Technical Editor

▶ Engineers in industries ranging from telecommunications to military/aerospace need high-performance RF/microwave switching as part of their test setups. Consequently, vendors are offering products ranging from individual switches to complete switching systems to meet customer demand. This report describes the latest available RF/microwave switching products and the applications they serve.

With nearly 30 years' experience, Universal Switching Corp. has hundreds of switching products that are focused within the RF and microwave spectrum, said Norton W. Alderson, VP marketing. "Some of the latest products actually span from DC to 50 GHz." Popular configurations are 1xN or two-dimensional NxM.

"One of our more interesting products is our MS2010A DC to 18-GHz switch matrix (NxM) that is available in sizes from

4x4 to 12x12 and can be further expanded to 33x33 with multiple units," Alderson said. "The signal path is completely passive. It provides 1:1 connectivity in a full matrix array with exceptional channel isolation and low loss, which is one of the most desired features in a wideband test matrix."

Alderson said the 2RU-sized MS2010A wideband matrix (up to 12x12) incorporates proprietary plug-in relay elements. "Should a relay be damaged by an external signal or have reached its life expectancy, a hand tool and a few minutes is all that is needed, and the relay is easily replaced by the user in the field," he said.

The company also offers its modular UC1 for test applications. "This is a flexible 1RU product that can be reconfigured in the field as test needs change (which they always do)," Alderson said. "Currently it only has 1xN (Nx1) and signal-transfer

(A:1/B:2) type configurations offered, but new configurations are in the development pipeline." He explained that the UC1 can accommodate up to two "PUC" plug-in elements that can be removed from the chassis assembly and remotely located. "Each PUC element can be removed up to 400 feet away," he said. "The UC1 includes front-panel controls, a 1-Gb/s Ethernet LXI-compliant interface, a multiserial interface, and redundant power supplies."

Alderson noted that the company offers relay contact counters so that users can monitor and anticipate EOL expectancy and plan maintenance time.

Universal Switching serves applications including military/aerospace test, telecommunications test, and consumer wireless test. Within the last few months, "We addressed a unique need by providing a modular test switch for an ATE system for a government contractor,"

Alderson said. “We designed/delivered a 36x1 self-terminating 50-GHz switch that also included some additional requested custom features. We are also delivering various switch configurations for the further development and testing of the next generation of 5G wireless products.”

“Keysight’s switch offerings range from low-cost individual switches to fully integrated application-specific switch solutions like the customizable Z2091B switch matrix,” said Matt Campbell, product marketing engineer. “We also offer instrument-specific solutions, like the E5092A multipoint test set for ENA network analyzers.”

Campbell commented on applications for the company’s switching products. “When customers test base-station or satellite antennas, they need to account for every imaginable operating condition,” he said. “They can’t troubleshoot an antenna in space.” He noted that switches let customers quickly cycle through measurements. “For example, customers can have one switch cycling transmit polarization on an antenna and another switch cycling between the antenna’s ports,” he said. “This enables them to measure the co- and cross-polarization response of each test port in just one rotation of the antenna.”

Marvin Test Solutions (MTS) designs and manufactures high-density RF switch cards in PXI 3U and 6U configurations; several are part of the GENASYS switching subsystem, said Jon Semancik, marketing director. “The GENASYS switching subsystem leverages the flexibility of the PXI 6U standard and features a compact footprint as well as the option to support both switching and instrumentation resources within a single, PXI chassis,” he said. Specific features include a modular, expandable analog matrix supporting an internal 16-wire bus for routing analog instrumentation and triggers from an instrument source to the receiver interface; a matrix architecture that can support up to 64 signal inputs, outputs, and triggers; an overall signal bandwidth of > 20 MHz (independent of switch card configuration) with dedicated switching cards offering a bandwidth of over 500 MHz; an analog/digital hybrid pin switching

architecture, offering a high-bandwidth digital signal path and providing “any resource to any pin” functionality; integration of a mass termination interface; and a comprehensive software environment for managing overall signal routing.

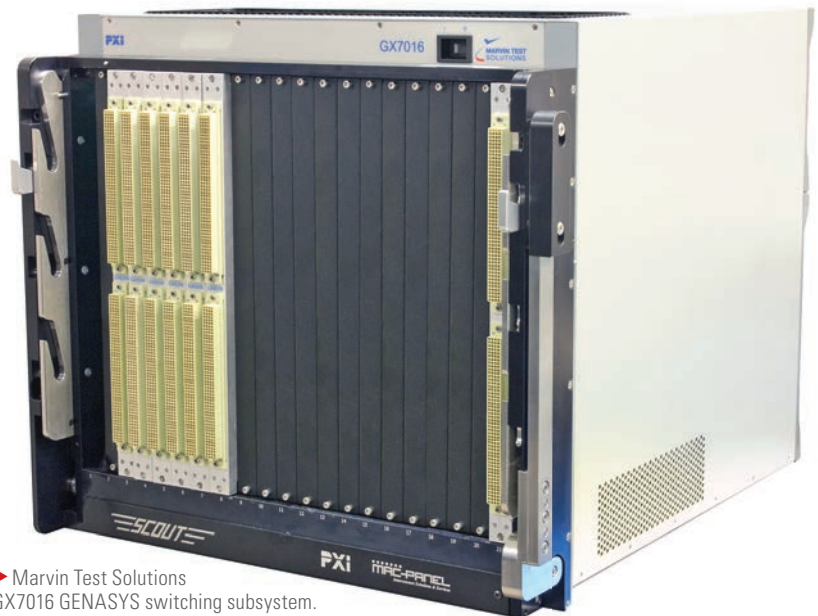
“Application-specific integrated test systems are also available which incorporate various RF switching solutions,” Semancik added. Specific products include the GX6192 GENASYS high-frequency multiplexer/matrix switch card; the GX6864 GENASYS 75-Ω RF multiplexer switch card; the GX6062 high-density RF switch card with 12 groups of 1x4 differential, nonterminated RF multiplexers in a 6U PXI formfactor; the GX6021 20-channel RF multiplexer/scanner in a 3U PXI formfactor; and the TS-960e-5G mmWave/5G production test system, including a 44-GHz switching subsystem.

scalable matrix providing connections to systems resources, multiplexed pins with support for over 4,000 interface test points, and a hybrid pin architecture supporting digital or analog test capability to each test system interface pin.”

Semancik noted that MTS’s switching systems are managed by SwitchEasy software, which allows customers to display, control, and manage overall signal routing; the software provides end-to-end signal routing by having the user define the resource and receiver pin or UUT connections.

Marvin Test switching systems serve military/aerospace test, satellite test, telecommunications test, and 5G production test, Semancik said.

According to Bob Stasonis, technical product specialist at Pickering Interfaces, “We offer a wide range of



▶ Marvin Test Solutions GX7016 GENASYS switching subsystem.

“The GENASYS switching architecture is configurable to support virtually any switching requirement,” said Semancik. “The system’s analog resources are routable to the mass-interconnect receiver directly from the switch matrix for high-bandwidth RF applications or via the hybrid pin/multiplexer subsystem providing uncompromised analog and digital test capabilities for each multiplexed receiver pin.”

He continued, “GENASYS switching supports multiple topologies with a

RF/microwave products that cover the frequency spectrum, including SPDT, transfer, MUX, and matrix switches with bandwidths from 100 MHz to 67 GHz available on PXI, LXI, and USB platforms.” He added, “We offer flexible options for control communications and system architecture.” Specific products include the Model 60-801-008 50-Ω 6-channel LXI microwave multiplexer and Model 40-780A PXI microwave relay module. Continued Stasonis, “If we don’t have an off-the-shelf solution available,

our engineers can help develop one to the customers specifications.”

Stasonis said Pickering’s products come with software drivers for virtually all major OSs and application development environments. “While we supply IVI drivers as mandated for LXI instruments, we do offer a common API that interfaces with all products, regardless of the communications link to the host PC,” he added. Consequently, customers can

that connect the desired input to output without needing to manage individual switch states.”

Finally, Stasonis commented, “Sometimes the little things are the most important. For example, we provide front-panel status LEDs on all our microwave products. This makes a programmer’s effort easier as he can quickly determine if their code is making the right connections.”

the relays can be unterminated or terminated,” he said. “Many modules include up to 32 SPST low-frequency control relays for controlling external devices such as electronic RF/microwave attenuators. Two modules are nonblocking 4x4 RF/microwave matrices.”

In addition, the SMX Series includes 20 PXI Express modules having either 3.5-GHz or 26.5-GHz bandwidths, Gibson said. Modules have multiple 1x4, 1x6, 1x8, 1x16, and 1x32 multiplexer configurations with a 3.5-GHz bandwidth. The 26.5-GHz

bandwidth modules include single and multiple, independent coaxial SPDT, SP4T, and SP6T switches, pass-through adapters, and a transfer switch. “The

SMX PXI Express modules have an embedded virtual schematic control application that enables control of all relays for facilitating test setup and debugging,” explained Gibson. “This application is independent of the test protocol application software.”

Gibson described the EX7000 family as a highly flexible group of configurable systems that are LAN LXI-based in stand-alone mainframes, with bandwidths extending to 26.5 GHz and 67 GHz and beyond. “The EX7000 family has the LXI



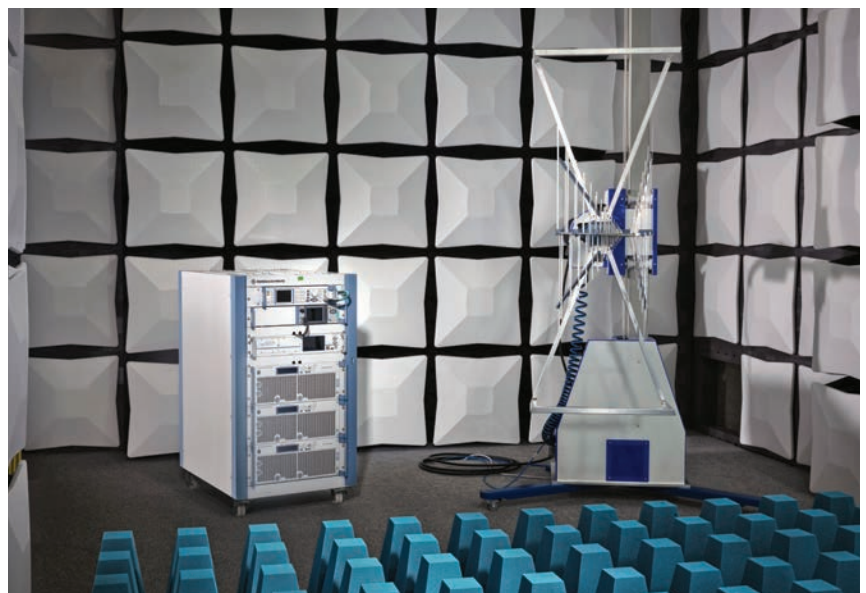
▲ Pickering Interfaces Model 60-801-008 50-Ω 6-channel LXI microwave multiplexer.

choose the platform best suited to meet a specific application requirement without needing to incorporate a new software interface. “Our drivers include soft front panels (SFP) that provide the ability to manually control the on/off state of each relay,” Stasonis said. “We have recently introduced a shared memory architecture that allows users to monitor the states of the relays on the SFP during program execution which facilitates integration debug efforts.”

Stasonis commented that microwave switch systems can be complex networks of interconnected relays, passive components, and wiring. “We have learned over the years that the integration effort can become a time-consuming task for software engineers who need to define the states of all relays required to establish a path between a test instrument and the article under test,” he said. “To help accelerate integration, our products are supported by our Switch Path Manager utility (SPM), which enables an entire switching subsystem, including all relays and external interconnects, to be virtually defined using a graphical interface. Once a switch architecture has been defined in Switch Path Manager, software engineers can simply write function calls

AMETEK VTI Instruments offers switching products including the SM7000 Series microwave switch modules, which consist of 13 C-size single and dual-slot VXI modules that range in frequency from DC to 18 GHz, 20 GHz, 26.5 GHz, and 40 GHz, according to Chris Gibson, senior product manager. “Relays are SPDT, SP4T, SP6T, and transfer switches, and

▼ Rohde & Schwarz R&S OSP Open Switch and Control Platform in an EMC testing environment.



► Keysight Technologies M9164A, M9164B, and M9164C PXI Express switch matrices.



“When customers test base-station or satellite antennas, they need to account for every imaginable operating condition. They can’t troubleshoot an antenna in space.”

— Matt Campbell, product marketing engineer, Keysight

web-based graphical user interface for switch system control,” he said, adding that the EX7000 family supports Windows or Linux operating systems; IVI-C, IVI-COM, and LabVIEW drivers provide support for LabView, LabWindows/CVI, Microsoft.NET, and other software-development environments.

“Our EX7000 LXI systems enable users to define switch-closure configurations that cannot be enabled to avoid creating switch paths that can cause damage to the system or to the DUT,” Gibson said. “These excluded configurations provide added reliability and safety for the switch systems.”

EX7000 systems can be fully customized, Gibson said, adding, “When required, systems can be built with matched phase lines. Also, when semi-rigid or rigid cables are required, cable lengths and bend radii are documented. Thus, systems can be easily duplicated.” He said the company’s RF/microwave

switching systems serve test applications primarily in the military/aerospace and wireless communication infrastructure markets.

For its part, Rohde & Schwarz offers the R&S OSP Open Switch and Control Platform. Gert Heuer, product manager for the platform, described it as a modular solution for RF switch and control tasks up to 67 GHz. “The modular R&S OSP product family can be used to perform RF switch and control tasks quickly and easily,” he said. “The new R&S OSP generation comes with an extended range of modules, allowing an even wider variety of RF wiring configurations to be implemented.”

Heuer said the R&S OSP’s modular design enables users to quickly and easily set up test and measurement configurations for applications in production, test labs, and development. Features include an external hardware trigger, a web GUI, an optional touch screen, extension

units, different housing configurations (2HU, 3HU), and the ability to install RF modules on front and rear side of the 19-in. unit. The OSP is flexible, he said, and supports higher test speeds for lower test cycle times.

“The ability to implement complex wiring configurations with a single switch and control platform is an essential prerequisite for reliable and reproducible measurements that can be automated to enable cost-efficient test sequences,” Heuer said, adding that the OSP finds use in RF-conformance, OTA, RSE, EMC, antenna, and radar-module test systems.

Switching architectures

PXI and LXI are common platforms for switching systems. “The PXI platform has the advantage of small size, modularity, and the fast PXI bus,” said Gibson at VTI Instruments. “The LXI platform offers more flexibility for switch system configurations, higher bandwidth, and easier implementation of larger switch systems.”

Keysight also offers LXI and PXI products, with the latter including the M9164A, M9164B, and M9164C PXI Express switch matrices, which operate to 6.5 GHz, 9 GHz, and 18 GHz, respectively. “At first glance, PXI and LXI seem similar—modular systems with a variety

of high-performance switches available on each,” said Campbell. “The benefits of PXI and LXI for switch applications depend on where you’re coming from and where you’re going. If you already have a PXI test station and you need general-purpose switching, it makes sense to add PXI switches to your existing setup. However, the startup cost of a new PXI system can be prohibitive if all you need is switches.”

Campbell continued, “The LXI platform enables simpler integration with your existing test setup since LXI instruments do not require a PXI chassis and controller. Also, if you have specific, advanced switching needs, Keysight offers fully customizable LXI modules to cater to your specific application.”

According to Semancik at MTS, “PXI offers a widely accepted and convenient formfactor for most switching applications.” MTS offers both 3U and 6U switching configurations, allowing users to select a solution that best fits their specific application requirements. “LXI is a common choice for RFIU solutions that require a variety of components, such as amplifiers, attenuators, delay lines, custom circuitry, etc., to be combined within the switching subsection,” he continued, adding that other control interfaces are also available.

Stasonis at Pickering Interfaces also weighed in on PXI and LXI. “For PXI, the benefit is modularity,” he said. “This is very important for a switching system with multiple functions—a simple example would be a switching system incorporating changeovers, matrices, and multiplexers.”

Stasonis said LXI does not impose the mechanical constraints of PXI, providing the ability to more easily address high I/O count applications. “The fact that LXI devices have local intelligence means less reliance on the host computer, freeing this CPU to concentrate on other instrumentation. LXI is also superior in remote test applications because of the ubiquity of Ethernet in business.”

And PXI vs. LXI deployments aren’t mutually exclusive. Continued Stasonis, “We offer our LXI/USB modular chassis that can support up to six PXI modules

and can be controlled via USB or Ethernet, bringing together the advantages of both platforms.”

As for its part, Universal Switching has chosen not to participate in the PXI market. “We prefer the stability and flexibility of the LXI platform as we can provide better solutions for our client base,” Alderson said, allowing the company to offer high-performance solutions in unique configurations without the packaging and size constraints that the board-based PXI platform demands.

Switches

At the heart of switching systems are the switches and relays themselves, including electromechanical, solid-state, and MEMS devices. The electromechanical devices still have a large share of the RF/microwave market for many applications. “Since MEMS switches and solid-state switches are still low-power components, they have limited applicability in the military/aerospace and telecom infrastructure markets that we serve,” said Gibson at VTI Instruments. Semancik concurred, saying, “Specific application requirements, as expected, continue to drive RF/microwave needs. Many intermediate and depot-level test systems require high-performance switching systems which still largely rely on mechanical devices.” And Heuer at Rohde & Schwarz expects electromechanical relays to be increasingly important of from DC to 40, 50, and 67 GHz, and he added that solid-state and high-end electromechanical relays will enable faster switching between antennas and/or IC ports.

According to Stasonis at Pickering Interfaces, “Many of the existing MEMS devices are unable to switch the signal and power levels we require for our target markets; at present, the technology is lagging behind what we require. We don’t have the confidence at this point that it is delivering to its potential. We have more confidence in solid-state switches and offer a large range; our sales continue to be steady.”

Alderson at Universal Switching said, “We build many solid-state switching products but, in our experience, most ATE test engineers prefer a relay-based

product due to the characteristics provided by a relay such as low loss, zero distortion, and high isolation—all of which affect test measurements of a UUT. In our opinion, the limited availability of MEMS components and their associated cost/performance do not yet make them a viable technology to use in the automated-test-equipment arena.”

And Campbell at Keysight commented, “As testing moves from connectorized devices to wafers, customers need fast, long-lived switches for automatic test systems. Modern solid-state PIN and FET switches are becoming popular for low-power measurements of RFIC components, handheld power amplifiers, and SAW filters.”

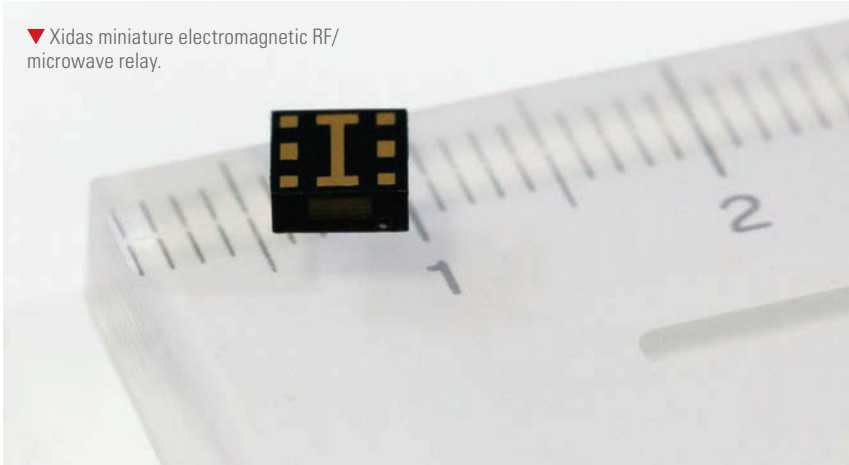
Campbell added that the company’s electromechanical switches feature a wiping motion that clears debris from the conductor every time the switch moves.

“Our electromechanical switches offer the best isolation performance in the market,” Campbell said. “In addition, Keysight released the first 67-GHz switch (SPDT) back in 2011, and it is still one of the highest-performance 67-GHz switches in the market now.”

Xidas has been at work since 2015 developing what Sourabh Dhillon, director of business development, called “the industry’s first miniature electromagnetic RF/microwave relay.” The work is based on a \$20 million investment and 15 years of micro-engineering research at the University of California, resulting in several patents and an IP portfolio.

Dhillon said the company has just finished engineering evaluation units and will phase both SPST and SPDT versions into production in the third quarter of this year. Dhillon cited several features of the devices, including footprint, density, and weight. “We can ‘hot’ switch up to 5 W of power at 6 GHz in a 4-mm x 4-mm x 2-mm footprint,” he said. “Hot switching is a key requirement for automated test, since it’s not practical to switch on/off instrumentation prior to moving to the next channel in your test.” He said solid-state CMOS or traditional MEMS relays of the same size cannot hot switch and are primarily intended for integration with digital amplifiers where the amplifier can be switched on/off to enable cold-switching

▼ Xidas miniature electromagnetic RF/microwave relay.



From automotive to IoT

Gibson at VTI Instruments identified trends for switching systems in the automotive space. “With all the advances in automotive technology such as advanced driver assistance systems and autonomous vehicles, suppliers of these systems to the automobile manufacturers will require RF switching in their test systems,” he said, adding that cars will have multiple high-frequency systems including lidar, microwave radar, Bluetooth, and Wi-Fi.

“With the increased integration of modern devices in the face of IoT, manufacturers have to perform a wider variety of tests, often involving different instruments,” said Campbell at Keysight. “Switches give them a way to streamline these measurements by routing multiple instruments to one DUT, minimizing the number of connections they have to make.” **EE**

to avoid degrading the relay’s lifetime. He added that in addition to automated test, the relays can serve in military/aerospace test, telecommunications test, and consumer wireless test.

The relays’ RF performance extends to 8 GHz, Dhillon said, and they have been designed to provide seamless transmission

throughout the signal path, avoiding transmission losses from the relay to the circuit board, thereby improving overall switching system VSWR. He commented, “Our relays become part of the RF strip-line!” He added that the low-power devices are bistable latching relays that don’t require power to stay in an on or off state.

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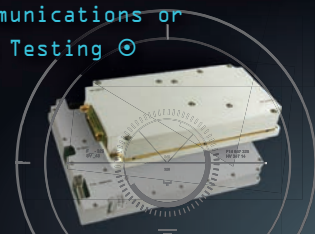
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Parking-garage application for ground-penetrating radar.

GROUND-PENETRATING RADAR OFFERS NEW SENSOR MODALITY FOR VEHICLES

By Rick Nelson, Contributing Technical Editor

▶ Sensors are key components for autonomous vehicles as well as vehicles with advanced driver-assistance systems. As I commented in my November 2019 Editor's Note,¹ the typical radar, lidar, and vision sensors may not be enough, and ground-penetrating radar offers an intriguing alternative.

WaveSense, founded in 2017, describes itself as the first company to offer self-driving vehicle navigation based on ground-penetrating radar at commercial scale. The company is the worldwide exclusive licensee of IP generated at MIT Lincoln Laboratory, where the technology was developed for military applications

and deployed in Afghanistan in 2013. The technology allowed 9-ton military vehicles to stay on previously mapped routes despite unmarked lanes and poor visibility from sand and dust.

Tarik Bolat, cofounder and CEO, described how the technology works. "Rather than using satellites or looking



Mapping

Tracking



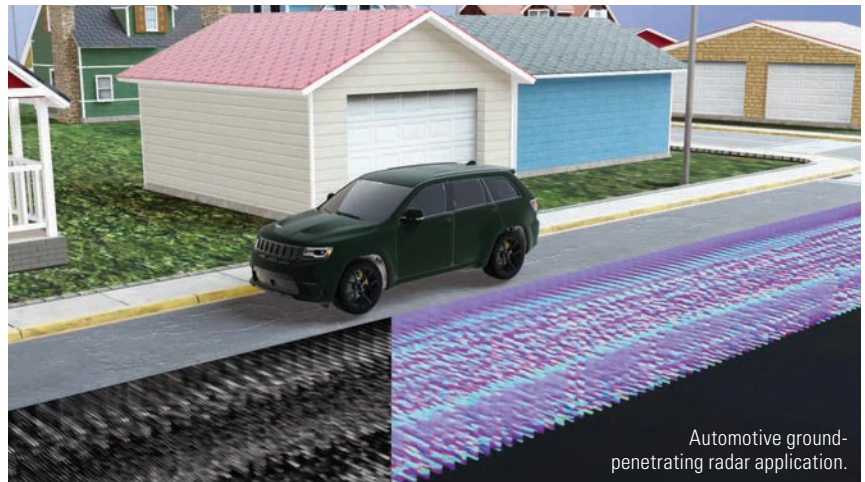
▲ Mapping in clear conditions (left) and tracking in snowy conditions (right).

around using lidar or a camera, we use something called ground-penetrating radar, which is radar that goes underneath the vehicle and maps the subsurface, typically 10 feet into the ground, getting reflections off things like changes in soil type, density, rocks, cavities, and utility infrastructure,” he said in a recent phone interview. GPR, he added, “...generates a very unique, very differentiated, very stable fingerprint that you can use to navigate...” after the mapping has taken place.

He said the need for reliable, precise positioning for autonomous cars, trucks, and robots as well as vehicles with ADAS is skyrocketing, with passenger vehicles increasingly featuring autonomous parking, active lane keeping, and other positioning capabilities in all sorts of conditions.

GPS, he added, can be unreliable and unstable. And with lidar- and camera-based approaches, you need three things to be true: you need a lot of roadside features, which may be lacking on an open highway; you need differentiation, which may be lacking in a parking garage with repetitive columns; and you need the mapped environment to be static over time, which may not be possible because of changes in foliage or inclement weather.

With ground-penetrating radar, “...



Automotive ground-penetrating radar application.

looking into the ground, we are able to satisfy all those conditions,” he said, adding that the subsurface is very rich in features, highly differentiated like a fingerprint, and static over time (with some obvious exceptions). City environments in particular, he said, are highly dynamic, and it’s difficult to keep maps based on lidar and cameras from going stale. He said the company is doing a lot of work in parking garages, where other sensors can have difficulty determining what level a vehicle is on.

WaveSense hasn’t set pricing yet for the technology, but Bolat put the BOM cost

at less than \$100 per vehicle. He said the ground-penetrating radar could knock out some of the lidar cost. The unit itself measures 2 feet by 2 feet by 1 inch and delivers a finished position. He said the trucking sector might want to retrofit existing vehicles, but the company’s primary targets are automakers’ future vehicle platforms. Pilots in conjunction with automakers are ongoing, he said. [EE](#)

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SOFTWARE BOOSTS POWER APPLICATIONS

By Rick Nelson, Contributing Technical Editor

▶ Programmable power supplies and loads are evolving to best serve a variety of applications as they leverage technologies such as wide-bandgap semiconductors, as described in our March special reports on the topics.

Those reports focused on hardware, but software—ranging from simulation to instrument control—has a role to play as well.

MathWorks offers simulation and modeling tools for programmable

power-supply design. “MathWorks provides Simulink software that lets engineers model digital control algorithms and the analog circuit together, before beginning detailed circuit design with a SPICE circuit simulator,” said Tony



“The benefit of HIL testing is that engineers can validate their control code for a full range of operating and fault conditions without damaging prototype power supplies.”

▲ Keysight Technologies E36200 Series 200- and 400-W autoranging power supplies.
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Lennon, market manager for power electronics control design.

Lennon identified a trend over the past year toward advances in hardware-in-the-loop (HIL) testing.¹ “HIL testing helps engineers validate the control software they program on a microcontroller or FPGA,” he said. “The HIL test system consists of a computer with appropriate I/O that runs the analog components as a real-time simulation.” The real-time simulation model consists of code generated from a model developed in Simulink and other software, he said, adding, “The benefit of HIL testing is that engineers can validate their control code for a full range of operating and fault conditions without damaging prototype power supplies.”

Lennon cited several challenges in power-supply design. “Power supplies are often required to operate in conditions with varying loads and sometimes fluctuating power inputs,” he said. “Simulink lets engineers design their digital control algorithms in models where these varying conditions can be simulated.” He pointed out that fault conditions can also be simulated. “Using simulation helps engineers uncover errors in their control algorithms before they move to prototype testing,” he said.

MathWorks serves a variety of application areas. “Simulink can be used to model most electrical systems, and the models can generate code that can be run as a real-time simulation,” Lennon said. “This means that engineers can begin validating the control code for their power supply against a real-time simulation of an electric-vehicle drivetrain, a solar-panel system, a microgrid, etc.”

Keysight Technologies offers a variety of software solutions, ranging from simulation to test automation. “Our PD1000A Power Device Measurement System for Advanced Modeling paired with our Advanced Design System (ADS) simulation solution enable thermal simulation of complex power-converter designs,” said Ryo Takeda, power semiconductor solution architect; Bernhard Holzinger, power semiconductor technical architect; and Mike Hawes, power solution consultant. The combination targets industries such as HEV and EV manufacturers who are migrating their power-conversion designs to wide-bandgap devices.

Bill Griffith, who works in product marketing at Keysight, commented, “Keysight’s DC power solutions combine custom hardware and software to solve industries’ toughest test challenges. Examples include IoT battery-life testing, photovoltaic (PV) string inverter testing, HEV/EV testing, and single- and 2-quadrant high-power testing with a regenerative power supply.”

He added that application-specific software allows high-performance power supplies to test a variety of devices. The software includes distributed solar array simulator control platforms for testing PV string inverters in real-world conditions as well as for implementing

industry-standard test-automation strategies in accordance with the EN 50530 standard² for PV inverter MPPT (maximum power point tracking) efficiency tests.

Specific Keysight offerings include the DG9000A advanced/multi-input PV inverter test software. “Distributed solar array inverters are difficult to test,” said Griffith. “Missing test points leads to an inaccurate representation of energy conversion.” Keysight’s DG9000A can test multiple input inverters and manage up to 12 separate MPPT operations simultaneously, he said.

The company also offers Solar Array Simulator (SAS) Control Pro as part of its BenchVue software, which automates static and dynamic EN 50530 MPPT test. Simply input the test parameters, and click “Start Test,” said Griffith, adding, “Once the test is complete, SAS Control Pro creates a report formatted to the EN 50530 standard.”

Griffith also said, “Keysight has formed an automotive and energy group to continue building DC power solutions with state-of-the-art hardware and software. Keysight PathWave Test 2020 software suite enables 5G, IoT, and automotive engineers and managers to streamline product development processes and facilitate rapid decision making.”

Finally, Tektronix’s recently released I-V tracer software allows the Keithley 2400 Series Graphical SourceMeter instruments to behave as modern replacements to old Tek curve tracers like the 370 and 576, according to Wilson Lee, technical marketing manager, Americas. “We developed this software in collaboration with several customers to address needs in areas like failure analysis and incoming inspection, where benchtop instrument use and immediate feedback is a must,” he said. “One of the great benefits of the software is that it exists on the SMU itself, so you can easily transport a curve tracer around a lab under your arm!” [E3](#)

REFERENCES

1. *Hardware-in-the-Loop Testing for Power Electronics Control Design*, White Paper, MathWorks, 2019.
2. *Overall efficiency of grid connected photovoltaic inverters*, EN 50530, European Standards, 2010.



NON-DESTRUCTIVE ANALYSIS OF TO-247 STRUCTURAL DEFECTS

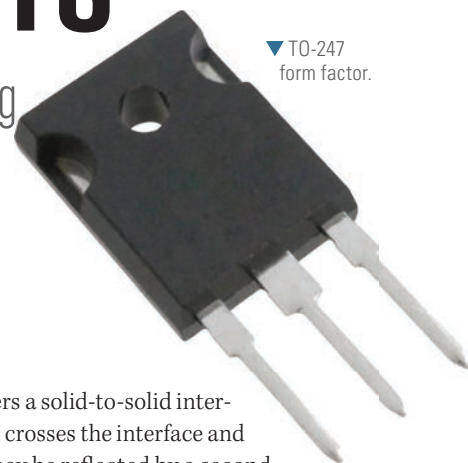
The TO-247 is a popular electronic form factor, so doing non-destructive analysis of possible structural defects could come in handy during the design process.

by Tom Adams, Enes Ugur

▶ A single pulse of ultrasound fired into the polymer encapsulant of a TO-247 device travels through the polymer at a speed around 3,000 m/s. Its mission is to characterize any internal material interfaces that it encounters. It will be partly reflected by any material interface, but most strongly—virtually 100%—by the interface between a solid and an air gap, and less strongly by solid-to-solid interfaces.

When a pulse encounters a solid-to-solid interface, a portion of the pulse crosses the interface and travels deeper, where it may be reflected by a second interface. A solid-to-air interface reflects virtually 100% of the pulse, and no ultrasound crosses the interface.

The reflected ultrasound returns at its original speed to the receiver housed with the transducer that launched the pulse.



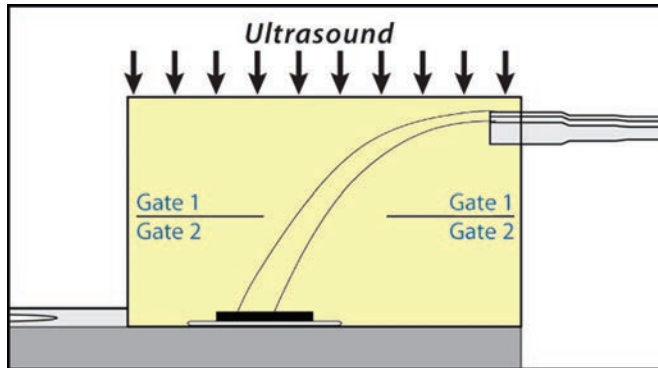
▼ TO-247 form factor.

Its round-trip time will be measured in nanoseconds. The returning echo can carry information about the depth of the interface, the acoustic impedance (density times acoustic velocity) of each of the two materials at the interface, and the change—positive or negative—in acoustic impedance in crossing the interface.

The instrument pulsing the ultrasound and producing the images is an acoustic micro-imaging tool. The images shown here were made by C-SAM tools in Nordson SONOSCAN's laboratories.

Side View

While scanning horizontally above the TO-247's surface, the transducer repeats this routine many thousands of times a second, each pulse delivering information about interfaces directly below a single x-y location. **Figure 1** is the diagrammatic side view of a TO-247. The row of arrows represents the thousands of pulses that the



▲ **Figure 1:** This diagram shows a side view of the TO-247 and the gates set for each viewing depth.

the highest amplitude echoes, which will be white pixels in the acoustic image, while the interface between two solids, where reflection amplitude may range from near zero to around 60%, is some shade of gray. If the pulse is fully attenuated before it can complete its round trip (unlikely in a TO-247), there will be no echo and the pixel will be black. In an acoustic image using a color map, any other colors can be used, although structural defects such as delaminations or voids are often shown in red.

transducer will launch in each of many scans across the device. Echoes will be returned from interfaces between the mold compound and the internal features (leads at top right, die face, die attach, and heat sink) as well as from interfaces with air.

At a single x-y location, the information in the echo is turned into a single pixel in the acoustic image. An interface where a solid meets an air gap produces

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Front View

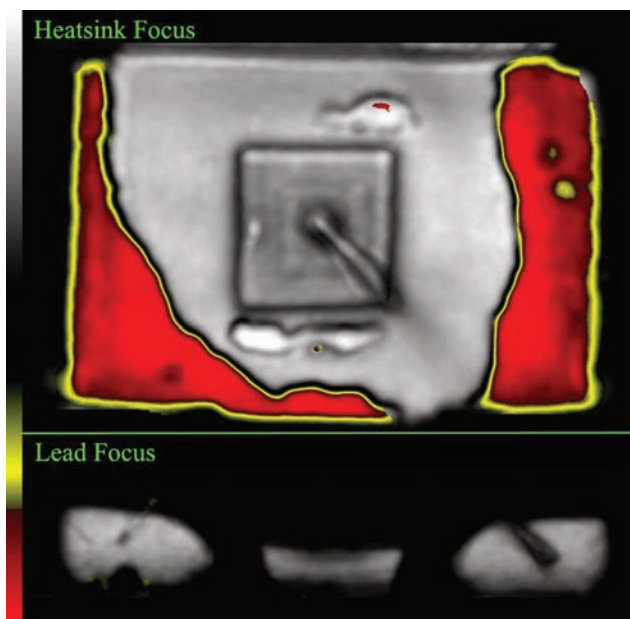
In a TO-247, a completed acoustic image made from the front side will reveal the die, any extruded die-attach material around the die, any delaminations of the mold compound from the heat sink, any voids in the encapsulant, as well as the leads and the wires bonded to the leads. The leads are imaged separately because echo collection by the receiver is generally gated on (i.e., restricted to) a specific depth range of interest. A gate wide enough to encompass vertically both the leads and the die in a TO-247 would likely be out of focus at one of those depths.

Figure 1 shows approximately where each gate may lie. Except where they're bonded (or not bonded), the wires produce few echoes because their curved surface scatters ultrasound in various directions.

Figure 2 is the Gate 2 topside image of a TO-247 imaged by a 15-MHz transducer having a focal length of 0.75 inch. The die and much of the heat sink are within the image at the top of **Figure 2**. The most obvious defect is the red areas marking delaminations of the encapsulant from the heat sink. The delaminations may contain air or possibly a vacuum, both of which block ultrasound from crossing the gap, even if its vertical extent is a tiny fraction of a micron.

Acoustic evaluation of TO-247s and other high-power components considers the likelihood of expansion of structural defects. In this device, the delaminations are already substantial and could conceivably reach the die. Red was used to color them because the the air-to-solid (mold compound) produces the highest possible echo amplitude (>99.9%). Red is at the bottom of the color map along the left side of **Figure 2**.

Red regions mark negative reflections, where the pulse encounters a material of higher acoustic impedance (= density × acoustic velocity) followed by a material lower acoustic



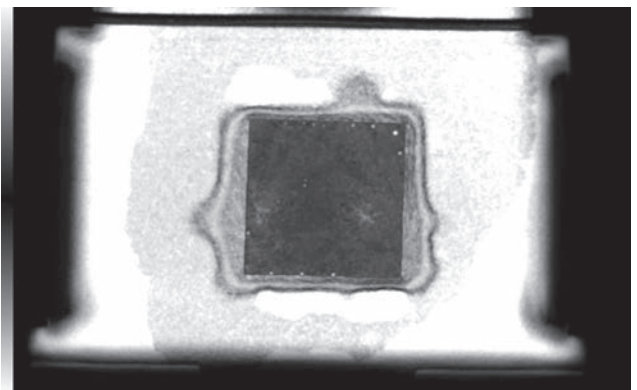
▲ **Figure 2:** Made with echoes originating in Gate 2, this image shows the die and heatsink.

impedance. In this color map, the reverse situation—positive polarity—would be white.

There are additional defects above and below the die. The white features aren't voids but rather excess—a foreign substance that somehow was incorporated during assembly of the device. They're white because an arriving pulse went from a material (mold compound) of lower acoustic impedance to a material of higher acoustic impedance. This reflection has positive polarity.

The lower feature has a tiny red void next to it. The upper feature has a tiny area that appears red, not because it's a void, but because the curved surface of the excess die-attach material is round enough to scatter the arriving ultrasound.

Using a shallower gate (Gate 1), the leads to which the wires from the die are attached were also imaged (bottom of **Figure 2**). The wire at left has the desired image: a light region near the edge of the lead, and a darker region below it. The light region indicates good bonding. The wire on the lead at right may be less securely bonded, although there are no red areas that would indicate an air-filled delamination.



▲ **Figure 3:** This image, created with echoes from Gate 1, shows the wires on the leads.

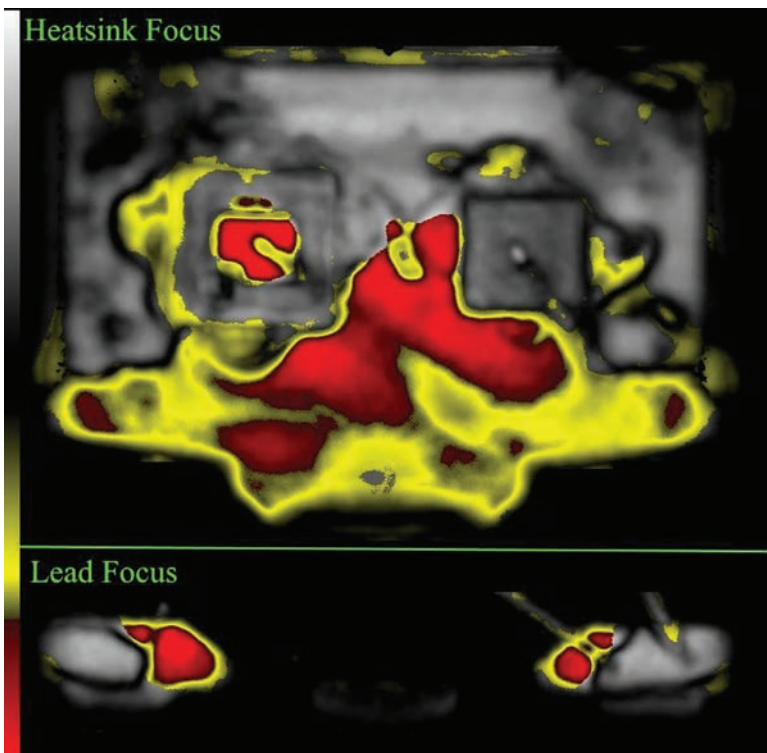
Back View

The TO-247 was then flipped right to left and imaged from its back side, through the heat sink (**Fig. 3**). Most of the regions that are red in the front-side image are white here because a grayscale color map was used. Gray areas are well-bonded. A few tiny voids are also in the die attach.

Imaging Another TO-247

The top view of a second TO-247 (**Fig. 4**) was also imaged at 15 MHz by a transducer having a focal length of 0.75 inch. The die at left, which is somewhat obscured, is slightly larger in area than the die at the right. The red regions are delaminations of the mold compound from the heat sink and (at left) the die. Yellow regions may be partially bonded or may be tilted. Both conditions will reflect slightly less ultrasound than the fully delaminated regions. In a high-power device, defects of this magnitude make early field failure very likely.

The two leads are imaged at the bottom of **Figure 4**. The wire at far right has the same appearance—a pale region near the



◀ **Figure 4:** This image displays the Gate 1 and Gate 2 images of a different TO-247.

edge—as the leftmost in **Figure 2** and is likewise well-bonded. But the red regions around the two other wires reaching these leads show that they're poorly bonded or not bonded at all.

The acoustic images in this article were made with the commonly used C-mode imaging method. Over a dozen other acoustic imaging modes can produce, for example, a non-destructive cross-section; up to 100 or more thin gates at progressive depths within the sample; a three-dimensional acoustic image; a variably sectionable three-dimensional image; or any of several other image types. Their value for TO-247s lies in identifying fabrication errors and in preventing defective devices from going into service. [EE](#)

Tom Adams is a consultant at Nordson SONOSCAN and Enes Ugur is a member of the Power Electronics and Drives Lab at The University of Texas at Dallas.



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- **July:** EMC receivers & amplifiers, Semiconductor test
- **August:** Signal & spectrum analyzers, Mil/Aero test

OUR GUIDELINES: The key for these articles is to be nonpromotional. Such articles can range from 600 to about 2,000 words. Also include any accompanying figures or imagery (high-resolution), the author's headshot, and a brief author's biography. We recommend that you send us an outline or abstract before beginning writing. If we accept your abstract, we will send you an exclusive-contributed-article agreement, and we will ask you to return a signed copy of that agreement with your completed article. In general, we need to receive your completed article about two months before the issue date.



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TECH FOCUS

EMI SUPPRESSION

Electromagnetic interference (EMI), the electrical or magnetic interference that degrades or damages the integrity of a signal or the components and functionality of electronic equipment, is the bane of electronic device designers. Suppressing EMI is a solution, through an EMI filter or other component. Here are some products related to this issue:



EMI filter for AC voltages up to 277 V

SCHURTER extended its family of EMI filters for 1-phase systems with its FMAB HV series. The new filter is suitable for applications requiring AC voltages up to 277 V, such as one phase of the 3-phase 480/277-V DC Wye system, typically used for lighting applications in North America. It is also rated for 400 V DC. Due to its high symmetrical attenuation, the filter series is particularly suited for devices using semiconductors, which regulate high outputs. Furthermore, the compact, fully enclosed housing provides optimized shielding through a very stable, flush mounting. The FMAB HV offers a current range from 1 to 20 A at 277 V ac/277 V dc according to the IEC standard, and 277 V AC and 400 V DC according to the UL/CSA standard. It has ENEC and cURus approval. Temperature range is from -40 to 100°C.

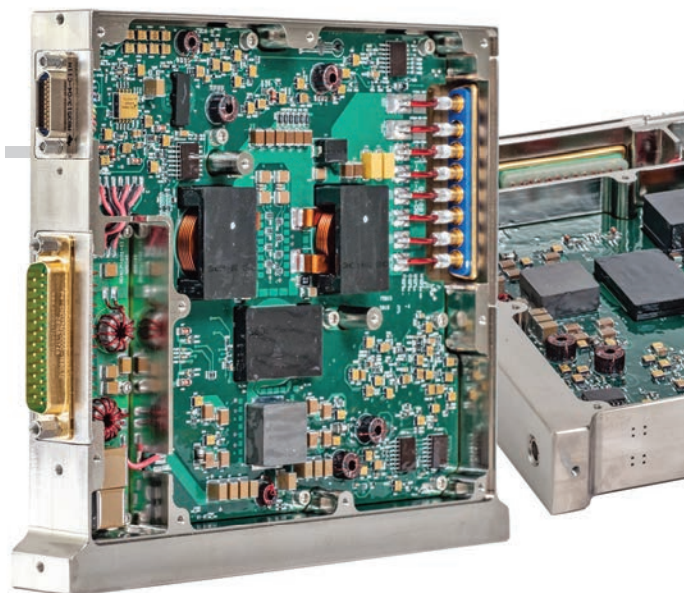
SCHURTER



High-current toroidal inductor design kit

Signal Transformer recently announced its new High Current Toroidal Inductor (HCTI) Design Kit. This kit provides a varied selection of toroidal inductors to design engineers who are looking for solutions to support EMI/RFI filtering and energy storage in industrial and consumer goods applications. The HCTI Design Kit features toroidal inductors that have an inductance range of 10 to 1000 μ H, a DC resistance range of 0.005 to 0.3 Ω , and a dc-rated current ranging from 2.4 to 20 A. Signal Transformer products utilize custom design coil construction and ferrite material to have high efficiency through reduced core loss, low magnetic radiation from self-shielding, and high energy storage with distributed air gaps.

Signal Transformer



EMI pre-compliance analysis option for spectrum analyzers

RIGOL Technologies recently announced a significant addition to its UltraReal family of real-time spectrum analyzers with the release of a new integrated EMI Application Mode for EMI pre-compliance measurements. RIGOL's EMI Measurement Application provides a complete EMI precompliance solution that enables engineers to measure, compare, analyze, and report on EMI issues throughout their design process. The EMI Application Mode allows for easy measurement setup. Features like integrated CISPR bandwidths and detectors, simple limit line construction, automated multisegment scan, and up to three simultaneous detectors make it simple to get initial scans and measurements. Advanced capabilities like real-time detector measurements, automated peak/limit searches, and simple correction table integration facilitate configuration of more complex test environments and analysis of results. In addition, comprehensive setup, storage, and report-generation capabilities make it easy to document, share, and repeat your tests.

RIGOL Technologies



Built for space, DC-DC converters have integrated EMI filters

VPT Inc., a HEICO company, has released its SGRB Series of space-qualified DC-DC converters. Using advanced gallium-nitride (GaN) technology, the SGRB is capable of very high efficiency—up to 95%—as well as radiation tolerance. A fixed-frequency, reduced voltage switching topology results in very low input and output noise, making it suitable for use in telecommunication systems. Specifically designed for applications facing the harsh radiation environments of space, the SGRB series has been characterized to total ionizing dose of 100 krad(Si), including enhanced low dose rate sensitivity, and single-event affects performance to 85 MeV/mg/cm². The SGRB Series features an integrated EMI filter, 100 V input and 28 V, 400 W output, and is rated for full-power operation from -35 to 85°C.

VPT



SH-60S-TC

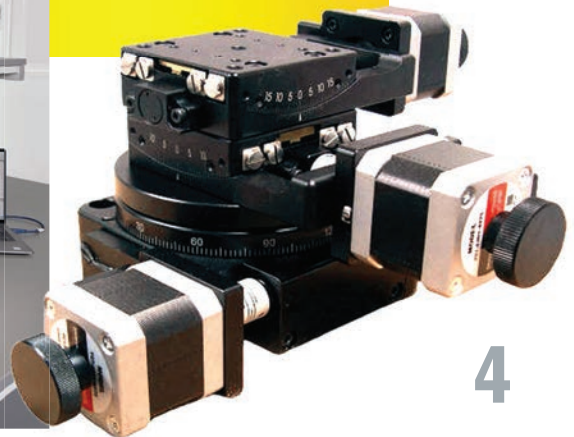
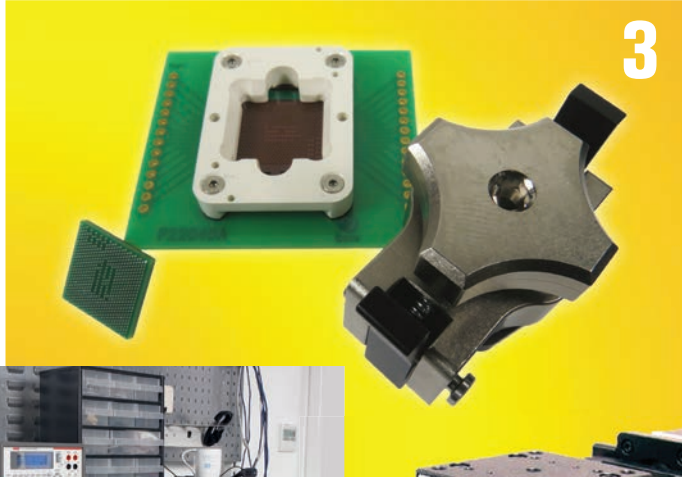
SH-60S-AOA

Handheld spectrum analyzer

Bird expands its SignalHawk family of rugged, handheld spectrum-analyzer products with the addition of the SH-60S-AOA angle-of-arrival spectrum analyzer and the SH-60S-TC, offering a balance of price and performance up to a frequency range of 6 GHz. The new SignalHawk SH-60S-TC and SH-60S-AOA provide test coverage for all major wireless systems in an easy-to-use, fully portable test instrument. A natural integration of digital maps, GPS location and signal-strength vectoring, the SignalHawk AOA provides an easy-to-use interface to not only pinpoint potential in-band interferers and “rogue” or “pirate” broadcast locations, but also perform coverage mapping and “dead spot” identification.

Bird

EVALUATION ENGINEERING'S
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1. Differential pressure sensors

Sensirion has two new product variants within its SDP800 series of differential pressure sensors. The product versions SDP821 and SDP831 are suitable for applications with high requirements when it comes to fail-safe operation. In order to guarantee these requirements, both sensors have been certified according to the GAR (Gas Appliances Regulation) standard. Therefore, they can be used in applications like gas burners. In combined gas-and-air systems such as boilers, the air/fuel ratio can be accurately and quickly regulated using a mass flow sensor. This enables the boiler to be dynamically adjusted, meaning that it can run more efficiently and adapt to changing conditions more quickly.

Sensirion

2. PicoScope 6000E Series

Pico Technology's PicoScope 6000E Series FlexRes oscilloscopes feature eight channels with 500-MHz bandwidth, 16 digital channels, and resolution of 8-, 10- or 12-bits. The products work with PicoScope 6 application software, which takes full advantage of the latest PC performance and display capabilities, showing clean, crisp waveforms. The top-of-the-range PicoScope 6824E has dual 5-Gsample/s analog-to-digital converters and 4 Gsamples of capture memory as standard. It offers a rich set of built-in tools for embedded systems debug, including DeepMeasure that captures the measurement results of each one in up to a million cycles.

Pico Technology

3. 30-GHz BGA socket for BGA625

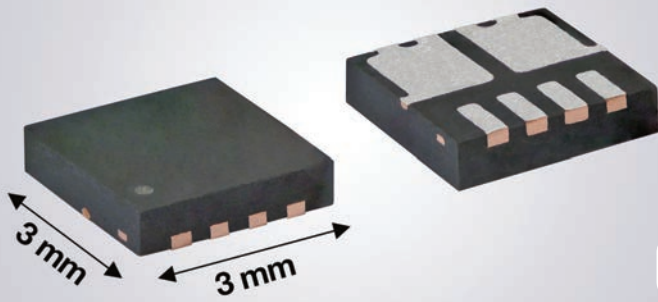
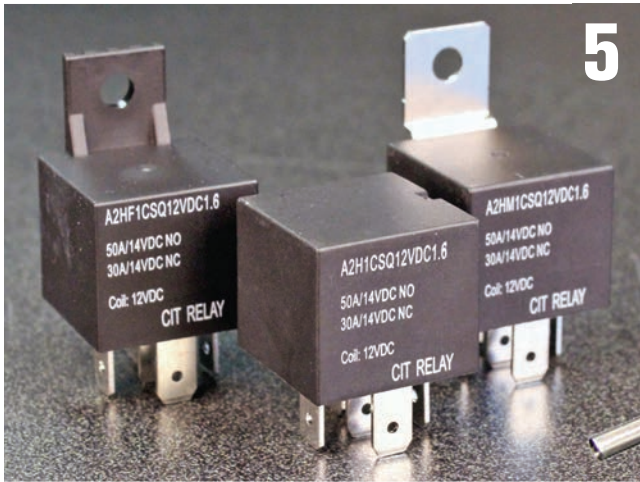
Ironwood Electronics recently introduced a new high-performance BGA socket for a 0.65-mm-pitch BGA 625-pin device. The CG-BGA-5032 socket is designed for 16- by 16-mm package sizes and operates at a bandwidth of up to 30 GHz with less than 1 dB of insertion loss. The socket is designed with an easy-open double-latch clamshell lid with integrated compression mechanism. The contact resistance is typically 20 mΩ per pin. The socket connects all pins with 30-GHz bandwidth on all connections. It's mounted using supplied hardware on the target PCB with no soldering, and has a small footprint.

Ironwood Electronics

4. Motorized yaw-pitch-roll stages

Three new high-accuracy yaw-pitch-roll stages have been introduced by OES: the YPR100-10-15-01 (driven by stepper motor; pictured), the YPR100-10-15-02 (driven by brushless servo motor) and the YPR100-10-15-03 (driven by DC servomotor). These yaw-pitch-roll stages are suitable for the precise measurement of compound angles or the curvature of an object. The yaw axis (bottom stage) is capable of rotation of large angles and features a 180:1 ratio gear. The positional accuracy is 0.05 degrees, and repeatability is ±0.01 degrees. The pitch axis (middle stage) has cross roller guides and a range of travel of ±10 degrees plus an accuracy of 0.05 degrees and repeatability of ±0.01 degrees. The rotation center height is 50 mm.

Optimal Engineering Systems



5. A2H Series automotive relay

CIT Relay & Switch now offers the 50A A2H Series automotive relay with low temperature rise. This newest addition to the CIT relay family offers an option of PC pin or quick connect mounting and two styles of mounting flanges. Contact arrangement options are 1A or 1C with coil voltage of 12 or 24 V dc. The A2H Series automotive relay is rugged in construction and offers low temperature rise at full load.

CIT Relay & Switch

6. -30 V P-channel MOSFET in PowerPAK 1212-8S package

Vishay Intertechnology Inc. has introduced a new common-drain dual n-channel 60-V MOSFET in the compact, thermally enhanced PowerPAK 1212-8SCD package. Designed to increase power density and efficiency in battery-management systems, plug-in and wireless chargers, DC-DC converters, and power supplies, the Vishay Siliconix SiSF20DN offers $R_{S-S(ON)}$ down to 10 m Ω typical at 10 V in a 3- by 3-mm footprint. This value is 89% lower than Vishay's previous-generation devices. The result is reduced voltage drops across the power path and minimized power losses for increased efficiency.

Vishay Intertechnology Inc.

7. Direct-drive linear motor

The new patented SDLM-019-070-01-01 direct-drive linear motor with integrated position and temperature sensors is the latest addition to the series of zero-backlash, zero-cogging, high-acceleration, high-speed, high-resolution, long-life motors from Moticont. This compact motor is just 0.75 in. (19.1 mm) in diameter and 2.75 in. (69.9 mm) long. Protected inside the motor housing, the linear optical quadrature encoder is directly connected to the shaft for the greatest possible accuracy. Highest throughputs are achieved by the SDLM-019-070-01-01 linear motor when operating at peak efficiency monitoring the data from the internal temperature sensor.

Moticont

8. Series of slow blow 2410 SMD fuses

Bel Fuse-Circuit Protection announces its 0680L Series of ceramic surface-mount fuses with in-rush current withstand capability in a 2410 SMD package size. These slow blow fuses are designed for automotive and other applications that require high DC voltage ratings and high DC interrupting ratings. Bel's 0680L Series fuses are compatible with the 260 $^{\circ}$, IR Pb-free solder process. They feature a current rating from 375 mA to 12 A and a wide operating temperature range of -55 to 125 $^{\circ}$ C. These fuses are also AEC-Q200-compliant, RoHS-compliant (with exemption 7(a)), halogen-free (MSL = 1), and lead-free.

Bel Fuse



This shot is of the crew working on the #81 at the Sebring, Fla. racetrack.



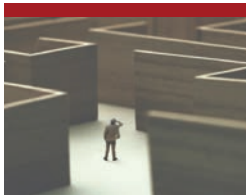
▶ You might have read about our sponsorship of DragonSpeed, one of the NTT IndyCar Series competitors. *Electronic Design* and *Machine Design* Senior Content Directors Bill Wong and Bob Vavra will be covering all the action from the pits at the Indianapolis 500 at the Indianapolis Motor Speedway (IMS) in Speedway, Indiana on May 22, 2020. We will be cheering on Ben Henley and the DragonSpeed crew.

If you're into this type of racing, then we have a treat for you. *Evaluation Engineering*, *Electronic Design*, and *Machine Design* are running a contest called Join us in the Pits. You can find the link on the *Evaluation Engineering* website (www.evaluationengineering.com) or go to the entry page at <https://design.informabi.com/2020-DragonSpeed-IndyCar-Drawing>. Yes, we have two grandstand tickets. The winner also

receives a three-night stay in Indy and a three-day pass that provides staff access to the track entry, pit, and garage areas. A \$1,000 travel voucher rounds out the winnings.

You can enter once per day to increase your chances on the Join Us in the Pits site. Just become a member of *Evaluation Engineering*, *Electronic Design* or *Machine Design*, where you can also subscribe to any of our newsletters. [EE](#)

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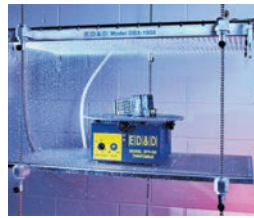


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THE BLINDFOLDS ARE COMING OFF FOR ROBOTICS

By Ken Cormier, Managing Editor

Similar in complexity to voice recognition, machine vision involves the ability of a computer to see, employing one or more video cameras, analog-to-digital conversion (ADC) and digital signal processing (DSP). The data produced goes to a computer or robot controller. Computer vision algorithms process the data before employing other system components to act upon that data.

Machine vision approaching milestone

Machine vision is a mature technology with established incumbents. However, significant advancements in chipsets, software, and standards are bringing deep learning innovation into the machine vision sector. According to a recent analysis by ABI Research, total shipments for machine vision sensors and cameras will reach 16.9 million by 2025, creating an installed base of 94 million machine vision systems in industrial manufacturing. Of that installed base, 11% will be deep learning-based.

A different breed from conventional machine vision technology, deep learning-based machine vision is data-driven and utilizes a statistical approach, which allows the machine vision model to improve as more data is gathered for training and testing. Major machine vision vendors have realized the potential of deep learning-based machine learning. Cognex, for example, acquired SUALAB, a leading Korean-based developer of vision software using deep learning for industrial applications, and Zebra Technologies acquired Cortexica Vision Systems Ltd., a London-headquartered leader in

business-to-business (B2B) AI-based computer vision solutions developer.¹

2D, 3D machine vision systems market forecast

A report by Reportlinker predicts that the 2D and 3D vision systems market will grow at a CAGR of more than 15 percent between 2019 and 2024. The report says that inspection needs amid growth in automation are translating into increased adoption of vision technology. The report cites general categories of applications in robotics, dimensional gaging operations, assembly verification, flaw detection, paint job verification and code reading.²

Machine vision eyed for counterfeit electronics detection

Defense Microelectronics Activity (DMA), an organization within the U.S. Department of Defense that provides microelectronic components and assemblies for legacy systems, has awarded contracts to Dr. Michael Azarian and Dr. Diganta Das of Maryland's Center for Advanced Life Cycle Engineering (CALCE) to test how machine vision-based imaging technologies can be employed to detect counterfeit microelectronic components, and evaluate conventional methods for counterfeit detection, in an effort to improve integrity of the supply chain for integrated circuits. "Machine-vision detection technology includes systems that leverage side-channels (also known as second-order effects) and/or machine learning algorithms to assess the authenticity of a microelectronic device," CALCE said in a statement.

A U.S.-based electronics distributor was convicted last year and sentenced to close to four years in prison for selling counterfeit

integrated circuits that ended up in a classified weapons system, according to the Department of Justice.³

Robot, do you see what I see?

Researchers at the Massachusetts Institute of Technology are engaged in a study to create a more robust machine vision architecture by studying how the human brain remembers and recognizes objects despite changing viewpoints and conditions. The study, reported in a paper by MIT PhD candidate in electrical engineering and computer science Yena Han and colleagues in Nature Scientific Reports entitled "Scale and translation-invariance for novel objects in human vision" discusses how they study this phenomenon more carefully to create novel biologically inspired networks. The paper is co-authored by Tomaso Poggio — director of the Center for Brains, Minds and Machines (CBMM) and the Eugene McDermott Professor of Brain and Cognitive Sciences at MIT. "Our work provides a new understanding of the brain representation of objects under different viewpoints. It also has implications for AI, as the results provide new insights into what is a good architectural design for deep neural networks," remarks Han, CBMM researcher and lead author of the study.⁴ EE

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