



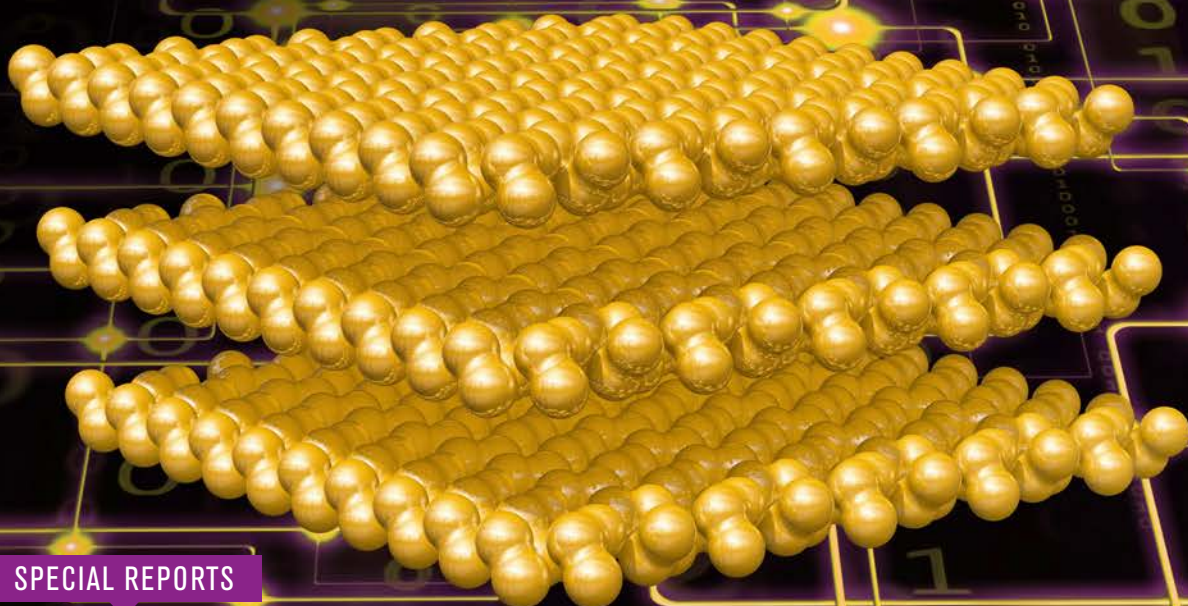
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EDITOR'S NOTE

NOT YOUR PARENTS' POWER SUPPLY

▶ The programmable power supply has often been considered an afterthought. You may need to upgrade your communications test set regularly to meet the latest Wi-Fi or 3GPP standards, or you may need a new oscilloscope with higher bandwidth, but when it comes to power supplies, volts are still volts and amps are still amps, right?

If this truism were ever correct, it's becoming more and more outdated as applications such as the IoT and renewable energy and enabling technologies such as wide-bandgap power semiconductors come to the fore. As Ron Wilcox, senior director of power test engineering at Analog Devices Inc., put it, "Twenty-five years ago, I did not think one would be concerned with microvolts and picoamps in power semiconductor test, but we now find ourselves measuring just those, and often in the face of challenges like > 100 VCM or in noisy environments."

"Power supplies continue to become more specialized," said Bill Griffith, who works in product marketing at Keysight Technologies. "Research and design engineers working on the bench want a quiet power supply with multiple outputs and a large display. Bench power supplies need to have a fast transient response to simulate a battery. System engineers want a high-density power supply that requires very little space in their ATE rack."

Griffith added that engineers can struggle to simulate and characterize real-world devices. "Power supplies often require higher output bandwidth along with better measurement systems for accurately characterizing devices," he said, adding by way of example, "IoT devices pull current in short bursts that are difficult to measure accurately. Underestimating the power in each burst can lead to overstated run times."

He added, "The need to test 2-quadrant devices such as batteries and bidirectional converters and inverters is increasing. Having a single solution that can source and sink

current simplifies test setups."

In addition, he said, "For sink-mode applications requiring 5 kW to hundreds of kW or more, regenerative power supplies provide higher efficiency and a smaller footprint. A regenerative power supply needs less space as it recycles power back to the grid instead of dissipating the power locally."

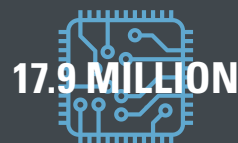
EA Elektro-Automatik managing director Eric Turner commented on the benefits wide-bandgap technology brings to power supplies. "EA Elektro-Automatik's latest generation of SiC switching devices uses magnetic components with distributed air gaps and profile winding technology resulting in a reduction in size that is truly remarkable," Turner said. He added that control circuitry is continuing to move from analog to digital. "Digital architecture using FPGA-based controls to the amplifier improves load-regulation response and opens the door for additional features like arbitrary waveform generation and advanced measurements," he said.

Flexibility in a power-supply system can be as important as performance, efficiency, and size. "System flexibility is important since many of the eMobility and renewable applications are in their early stages of development," said Turner. "Often enough, existing and certainly future requirements are not fully understood, so customers want flexibility and modularity."

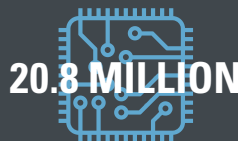
Griffith also sees a need for flexibility. "Most automated tests benefit from a modular solution that allows the customization of individual outputs," he said. "Modules allow quick reconfiguration to meet the needs of an evolving test plan."

So if you have some old programmable supplies in your lab, it may be time to reevaluate them with respect to performance and size as well as features like bidirectional operation. For more, see our reports on power semiconductor test and power supplies and loads in this issue. **EE**

BY THE NUMBERS



Potential number of wafers per year of new IC capacity to be added in 2020

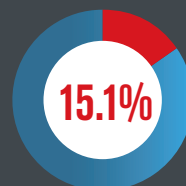


Predicted number of wafers of new IC capacity in 2021

Source: IC Insights



Estimated global printed electronics market in 2024

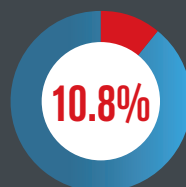


Expected CAGR of global printed electronics market from 2019 to 2024

Source: ResearchAndMarkets.com



Worldwide sales of semiconductors in November 2019



Year-over-year decrease in semiconductor sales in November 2019

Source: SIA

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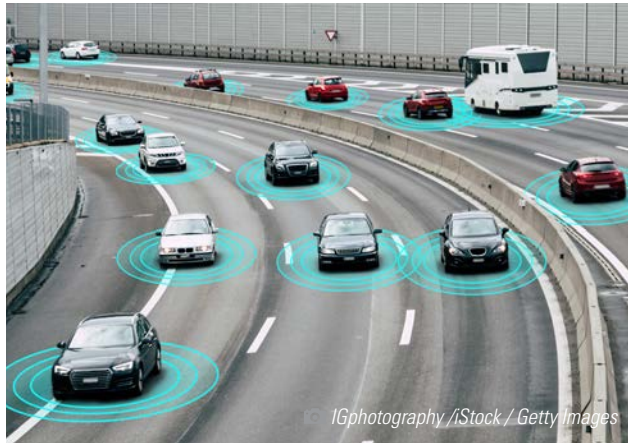
2020 will be year of Continuous Intelligence in the IoT analytics market

In 2020, there will be greater adoption of Continuous Intelligence (CI) technologies, which will elevate IoT data analytics way beyond traditional operational levels and have a greater impact on strategic planning and organizational change, states global tech market advisory firm ABI Research in a recent whitepaper, *54 Technology Trends to Watch in 2020*.

“The concept of Continuous Intelligence (CI) will be consolidating in the IoT analytics market, enabling more advanced analytics in near-real time,” said Kateryna Dubrova, M2M, IoT, and IoE analyst at ABI Research. Since the emergence and expansion of streaming analytics and streaming technologies, the ability to continuously analyze and extract value from the IoT data is growing. The CI application will be possible because vendors are offering E2E platforms, expanding their capabilities through digital twinning, big-data technologies, and ML algorithms.”

Four companies currently supply most of the hundreds of LTE-M and NB-IoT products now available. HiSilicon, MediaTek, Qualcomm, and RDA (UNISOC) dominate. Jamie Moss, M2M, IoT, and IoE research director at ABI Research, said that the situation will only compound as we move toward Release 16 and the full coexistence of LTE-M and NB-IoT with 5G NR, i.e., the ‘official’ start of the mMTC market.

INDUSTRY REPORT



Report: Cellular vehicle-to-everything market to exceed \$800 million by 2025

The cellular vehicle-to-everything market is predicted to exceed \$800 million by 2025, according to a report by Global Market Insights Inc. The report sees the strong growth spurred by increases for safe and reliable road transportation, increased use of autonomous vehicles, and more adoption of vehicle telematics by logistics and transportation companies. Also cited were the smart-city and IoT initiatives in developing countries, which impact roadside infrastructure.

Advancements in cellular networks for the adoption of 5G networks, with their enhanced bandwidth capabilities, contribute to cellular vehicle-to-everything market growth. Low latency with 5G will help in the fast response needed for autonomous driving, as well as in reducing accidents. The report also points out that low latency will enhance reliability over extended communication ranges, improved non-line-of-sight performance, and less interference from other devices.

The V2I communication segment is expected to grow at a CAGR of over 12% over the forecast period due to the increase in the adoption of smart traffic infrastructure. The smart traffic infrastructure involves smart traffic signals and smart surveillance cameras. Traffic congestion can be alleviated through alerts and suggested alternative routes to connected vehicles, through projects such as one underway on a 537-mile network in Colorado that employs V2X technology.

Hardware, including chipsets, modules, on-board units, and roadside units are expected to hold a major share in 2025, but the autonomous-driving application is expected to show the fastest growth over the forecast period.



Huawei to help with UK's 5G despite U.S. pressure

On Jan. 28, the British government announced that it will permit the Chinese company Huawei to help construct its 5G networks, in a move that could damage intelligence and trade connections with the United States.

In a statement from the government, the UK will be permitting mobile operators to Huawei equipment, but it will not allow Huawei access to “security critical” core areas. The U.S. has been exerting pressure for a total ban on Huawei products, citing security risks and potential cyberattacks, and advising that UK-U.S. intelligence sharing could be rescinded.

UK wireless networks already contain a weighty presence from Huawei, which has had security agencies keeping a watchful eye on the company since 2003.

Although Chinese law says that Chinese companies can be ordered to work under the direction of Beijing, Huawei has denied that it would cooperate with spying.

Huawei said in a statement that it was “reassured” that it would be able to continue working with its UK customers on 5G, albeit in a restricted role.

“We agree a diverse vendor market and fair competition are essential for network reliability and innovation, as well as ensuring consumers have access to the best possible technology,” Victor Zhang, a vice president at Huawei.

DOE selects site for electron-ion collider

On Jan. 9, the U.S. Department of Energy (DOE) named Brookhaven National Laboratory on Long Island in New York as the site for building an Electron-Ion Collider (EIC), a one-of-a-kind nuclear physics research facility. This announcement, following DOE's approval of "mission need" (known as Critical Decision 0) on Dec. 19, 2019, enables work to begin on R&D and the conceptual design for this next-generation collider at Brookhaven Lab.

"The EIC promises to keep America in the forefront of nuclear physics research and particle accelerator technology, critical components of overall U.S. leadership in science," said U.S. Secretary of Energy Dan Brouillette. "This facility will deepen our understanding of nature and is expected to be the source of insights ultimately leading to new technology and innovation."

"America is in the golden age of innovation, and we are eager to take this next step with EIC. The EIC will not only ensure U.S. leadership in nuclear physics, but the technology developed for EIC will also support potential tremendous breakthroughs impacting human health, national competitiveness, and national security," said Under Secretary for Science Paul Dabbar. "We look forward to our continued world-leading scientific discoveries in conjunction with our international partners."

The EIC will be funded by the federal government through the DOE Office of Science, drawing on expertise from throughout the DOE national laboratory complex

and at universities and research institutions around the world, including Stony Brook University, a managing partner of Brookhaven Lab. International participation is also anticipated. Thomas Jefferson National Accelerator Facility (Jefferson Lab) in Newport News, VA, is expected to be a major partner in the project and make significant contributions. Expertise and participation from across the national laboratory complex will be required to implement the facility successfully.

"The Electron-Ion Collider will open up a new frontier in nuclear physics that will expand our knowledge of the fundamental constituents of the atoms that make up all visible matter in the universe today and the force that holds it all together," said Brookhaven Lab Director Doon Gibbs. "We look forward to working with Jefferson Lab, other DOE labs, universities, and the worldwide EIC user community—about 1000 scientists from 30 nations—to deliver the EIC and advance this important field of science."



Report: Wearables market to hit \$61.4B by 2025

A report by Global Industry Analysts predicts that the wearable electronics will burgeon to \$61.4 billion by 2025, spurred by easy access

to inexpensive sensors, miniaturized microchips and processors, low-power light components, and the expansion of applications. Smartwatches are at the top in popularity within the market. Evolving designs include smart glasses, goggles, bracelets, headbands, armbands, belts, and shoes. According to the report, medical-grade wearables are positioned to make the biggest impact, potentially revolutionizing personalized digital healthcare, providing physicians better monitoring of patients' health.

Prediction: Market for artificial intelligence in cars will grow 1,200% in next six years

The market for artificial intelligence in the automotive industry will go from \$1 billion today to \$12 billion by 2026, according to a report from the prognosticators at Global Market Insights Inc. The increase is due to the push for more assistive and autonomous features for improved driving comfort and safety, as well as realizing the goal of self-driving cars and trucks. AI-powered features are already being developed, tested and offered on consumer vehicles. These include lane assistance, adaptive cruise control and automated parking.

For instance, Toyota announced the launch of driver assistance for future cars that will get to level 4 of self-driving. One such feature, automatic valet parking, was jointly developed by Toyota and Panasonic; will provide affordable parking help to Toyota customers.

There are several companies currently developing AI for vehicles. They include Audi

AG, Daimler AG, Ford Motor Co., Harman International Industries, IBM, Microsoft, Alphabet Inc., BMW, Didi Chuxing, General Motors, Honda Motor Co., Tesla, Uber Technologies and Volvo Car Corp.

These companies are primarily focused on long-term contracts and strategic collaborations to develop AI for the automotive market. Technology providers such as AMD, Intel and NVIDIA are constantly upgrading and introducing new features and energy-efficient hardware that will function in cars and consume little power.



North American semiconductor equipment billings surge

North America-based manufacturers of semiconductor equipment posted \$2.49 billion in billings worldwide in December 2019 (three-month average basis), according to the December Equipment Market Data Subscription (EMDS) Billings Report published Jan. 23 by SEMI. The billings figure is 17.5% higher than the final November 2019 level of \$2.12 billion, and is 17.8% higher than the December 2018 billings level of \$2.11 billion.

Monthly billings of North American equipment manufacturers reached a level not seen since June 2018," said Ajit Manocha, president and CEO of SEMI. "The December surge in equipment billings reaffirms the strength of leading-edge logic and foundry investments." ■

SPECIAL REPORT

POWER MEASUREMENTS SPAN IOT TO GRID SIMULATION

By Rick Nelson, Contributing Technical Editor

▶ The gamut of electronic and electrical products from low-power mobile handsets and IoT devices to electric vehicles and photovoltaic inverters is placing considerable emphasis on fast and accurate power sourcing and measurement. Companies are offering a variety of programmable power supplies and loads, plus some fixed supplies, that can be applied to the task. APEC, March 8-12 in New Orleans, will provide an opportunity for vendors to showcase their products.

“eMobility was our largest growth market in 2018 and 2019,” commented Eric Turner, managing director, EA Elektro-Automatik Inc. “eMobility includes hardware-line battery chargers, drivetrains, HV inverters, switches, cables, power-distribution systems, and batteries. We’re also seeing increased activity in fuel-cell applications.”

Turner expects to see demands for higher power density and compact unit size coupled with a rugged mechanical design with liquid cooling for harsh environments. “An increased DC voltage range up to 2,000 V will be needed for solar PV simulation, eMobility, renewable energy, and high-voltage test equipment for automotive applications,” he said. “High flexibility at the system level is needed

for power scaling up to > 2 MW.”

Turner continued, “Over the course of 2019, EA Elektro-Automatik released three new lines of the autoranging 10000 4U Series, our latest SiC-based-generation programmable supplies and loads. The three series comprise a programmable DC supply, programmable regenerative load, and programmable bidirectional DC supply (2-quadrant). Power levels range from 30 kW to a massive 2 MW and up to 2,000 VDC—all standard commercially off-shelf availability.”

The 10000 4U Series also offers a water-cooled (WC) option that offers a complete sealed chassis. “The water-cooling architecture removes 95% of the overall heat, and the remaining 5% is dissipated within the chassis,” Turner said. “A 240-kW 42U rack with 95% efficiency has only a total of 12.6 kW of heat loss through the WC cold plate, so only 600 W is dissipated within the chassis. As a side benefit, the reduction in subjected heat to internal components improves product reliability. When expanding into the 2-MW power range, the reduction in losses becomes a massive benefit for our customers.”

Turner cited other products as well, including the PSB 9000 and 10000 Series of bidirectional (2-quadrant) DC power supplies. “2-quad is the ability to both

source and sink power with zero cross-over deadtime,” he explained. “Hardware like EV/PHEV chargers, batteries, and HV inverters are just a few examples that require the ability to source and sink power. While in sink mode (load mode) the PSB returns up to 95% of the energy back to the localized AC grid, which greatly reduces operational costs. Using a high-efficiency power stage allows EA to pack up to 30 kW in a single-rackmount 4U chassis.”

He described EA Elektro-Automatik’s ELR 9000 and 10000 Series as a subset of the PSB and as a standalone programmable regenerative DC load. “Like the PSB, the ELR returns up to 95% to the grid. Other than being a ‘green solution,’ the ELR packs up to 30 kW in a 4U chassis, which is a 65% reduction in size compared to traditional air-cooled loads.” He emphasized, “Yes, you read that correctly—a 65% reduction in size which saves you valuable rack or lab space.”

Turner added, “High-power systems (30 kW+) are generally a multichassis solution that requires integration and system build into 19-in. racks. Customers need to maintain focus on their product development and not worry about designing and sourcing material to build up the system. EA Elektro-Automatik helps customers

by offering turnkey, off-the-shelf solutions up to 2 MW and 2,000 VDC with no NRE design costs.”

Kai Li, product manager at Mean Well, identified several



◀ EA Elektro-Automatik PSB 10000 Series bidirectional (2-quadrant) DC power supply.

recent trends, including increased power density due to the increasing number of electric vehicles and industrial robots. He also noted that improvements in battery technology are driving requirements for higher power to charge them at faster rates. "GaN and SiC technologies are definitely contributors to increasing power density," he said. "The main challenges are probably GaN and SiC packaging and design maturity for high-power applications (10 kW+). For lower power adaptors and power supplies, the GaN utilization is already widely adopted, but more time is needed until GaN and SiC become fair game for all power-supply manufacturers."

With respect to Mean Well supplies, Li said the company offers off-the-shelf products ranging from 0.5 W to about 25.6 kW. "Mean Well serves almost all industries that require power supplies," he said. The company has recently launched the PHP-3500 3,500-W water-cooled power supply, which achieves fanless operation with the help of a water-cooled baseplate.

According to Brian Hsu, USA product marketing manager at Preen AC Power Corp., the company recently released the ADG family programmable high-power DC power supplies, which deliver up to 2,000 VDC or 2,500 A. He said the systems are suitable for new-energy, EV, and energy-storage-related DC testing. He added that the AFV-P and AFV Series programmable AC power sources are cost-effective programmable AC power supplies that can help manufactures implement production-line and burn-in test. The company allows custom modification based on customers' requirements.

Hsu noted that the company serves general electronics test, appliance test, chamber power, grid simulation, military power, ground power, motor testing, transformer testing, and shore power applications. He cited a trend toward the use of GaN and SiC technology to make supplies smaller. In addition, he said that due to the growing new energy, energy storage, and electrical vehicle industries, "...the DC testing voltage is getting higher and the some of the test applications require bidirectional or regenerative type DC power supplies," he said. "And also

for simulating the grid system, there is a trend in requiring larger programmable AC power supplies with the fault-ride-through testing features."

He also noted that the AFV-P Series programmable power source offers 150% overload capability, which can be useful for motor or other inductive loads with high inrush current. The source also offers an overcurrent hold-back function that can start a motor from lower voltage. The AFV Series products have the output isolation transformer that can provide galvanic isolation between the input grid system and output UUT.

At APEC, Preen will highlight its programmable DC power supplies (ADG-L and ADG-P Series) as well as its programmable AC power supplies (AFV-Plus, AFV, and AFV-P Series).

For its part at APEC, PPST Solutions will feature products from manufacturers including Pacific Power Source, Adaptive Power Systems, Cinergia, and Zenone, said Herman vanEijkelenburg, director of marketing. "On display will be an all-new range of regenerative AC and DC power supplies and AC and DC loads from Adaptive Power Systems as well as Pacific Power's new LMX Series AC sources," he said.

He noted that Adaptive Power Systems just launched a series of AC and DC programmable electronic loads. "These 3C Series loads support AC input voltages up to 480 VAC line-to-neutral and frequencies from 45 Hz to 440 Hz," he said. "In DC mode, the input voltage increases to 700 VDC." Power levels start at 1,850 W per load and extend to 33 kW for 3-phase applications, with support for crest factor and power factor programming in AC mode, he added.

"As for power-source products, Pacific Power Source just announced the availability of a new line of advanced linear technology based programmable AC power sources," vanEijkelenburg said. "Available as single and 3-phase models covering a range of power levels from 500 VA to 30 kVA, these LMX Series linear AC sources offer high-performance programmable power with modern control interfaces like LXI-compliant LAN and USB."

Kikusui offers products including the PCR-WE/WE2 Series AC and DC power supplies and PLZ-5W/5WH2 Series electronic loads. A company spokesperson commented, "We see more demand for higher current and power, but space is also critical for our customer." Consequently, the company has endeavored to minimize the footprint and increase power density with its products.

The company's new AC power supply can provide single-phase, split-phase, and 3-phase as well as DC outputs with maximum power of 144 kVA in 3-phase configuration and with frequencies up to 5 kHz, the spokesperson said, adding that the company's "...electronic loads provide the market-leading slew rate.

The company sees demands for its AC power supplies in applications involving avionics/military test as well as IT server test, EV charger test, grid simulation, motor test, EMC test, and function test (system integration), said the spokesperson, also noting a trend toward low-voltage, high-current POL (point of load) test.

At APEC Kikusui will highlight its supplies and loads as well as the TOS9300 Series electrical safety tester.

In related news, AMETEK Programmable Power in October extended its Asterion line of power sources. The Asterion 12K3 supplies AC and DC output power up to 12,000 VA or 12,000 W, and the Asterion 18K3 supplies up to 18,000 VA or 18,000 W. Both units come in a 14U chassis and can supply single- or 3-phase output power. The company said the key to the Asterion line's performance is AMETEK Programmable Power's iX2 current-doubling technology. With iX2, as the output voltage decreases from the maximum value to one-half the maximum value, the available output current increases up to two times the rated output current, allowing Asterion to maintain maximum power through a wide range of voltages.

Power instrumentation

Several traditional manufacturers of broad lines of instrument classes count power supplies and loads as key products in their portfolios.

For example, Keysight Technologies offers a variety of power-supply and load

products. For IoT and low-power applications, the Keysight X8712A can correlate RF and DC events to power consumption. “At the heart of the X8712A is the popular N6705C and an SMU that can measure dynamic currents from nanoamps to amps in a single pass,” said product marketer Bill Griffith. “While the N6705C has been able to characterize battery run time accurately, the X8712A helps engineers understand the actual events that draw a higher current.”

Keysight also serves HEV/EV and PV test applications with the regenerative RP7900 Series, including 5,000- and 10,000-W bidirectional models, and customers can stack multiple units to achieve higher power. “The regenerative capability enables the energy consumed to flow back onto the grid cleanly, saving costs from energy consumption and cooling, while not interfering with the grid,” Griffith said.

Yet another application that Keysight serves is battery cell formation and testing. “The Keysight BT2200 charge-discharge platform is cost-effective and easily configurable for Li-ion cell forming,” Griffith said. “Modular configurations support cells requiring maximum currents ranging from 6 A to 200 A, with 8 to 256 cells or user channels per chassis. You can easily deploy different channel configurations as your cell requirements and capacities change.”

He added, “Keysight’s BT2100 Series

self-discharge measurement solutions provide a revolutionary reduction in the time to measure and characterize the self-discharge performance of Li-ion cells. These lithium-ion self-discharge measurement solutions determine a cell’s self-discharge by directly measuring its self-discharge current.”

Keysight also offers the N6790 Series 100- and 200-W DC electronic loads, which add the ability to sink current to the N6705C DC power analyzer and N6700 Series 1U system power supply for ATE applications. “The ability to source and sink current from a single mainframe simplifies tests and reduces rack space in an ATE system,” said Griffith. “A sophisticated measurement system digitizes voltage and current at 200 kS/s.”

In addition, Keysight offers the E36200 Series 200- and 400-W autoranging supplies, which provide a variety of voltage and current combinations in a small bench power supply, Griffith said. For the highest voltage and current, customers can internally combine two outputs into a single one providing 40 A or 120 V.

According to Philipp Weigell, director, product management, power products, at Rohde & Schwarz, the company’s newest additions are the 2-quadrant R&S NGL200 and R&S NGM200 power supplies, which are optimized for testing battery-powered devices and battery-management systems. “As soon as the externally applied voltage exceeds the set

nominal voltage, the power supply automatically switches from supply mode to load mode; current flows into the power supply,” he said.

He also commented that the supplies offer up to four galvanically isolated, floating channels. “The circuitry of each single channel is completely isolated from the others; there is no connection to the ground chassis,” he said. “This makes it easy to combine the channels to drive bipolar circuitries that might need +12 V/-12 V, for example, and avoids any ground problems in complex DUTs.”

Weigell elaborated on applications. “For an increasing number of mobile devices, the battery life is a critical factor,” he said. “Our specialty power supplies R&S NGL200 and R&S NGM200 include battery-simulation features, fast load recovery, and low ripple and noise, to assist engineers to analyze and optimize their designs.”

Weigell added, “In the next few weeks, our next big introduction will take place. Without revealing too much, it will boost your efficiency for higher power applications.”¹

Weigell elaborated on the company’s DC power-supply portfolio for test and measurement applications. “As one of the leading T&M suppliers for the wireless market, our products address mobile handset applications as a high priority,” he said. “The demands of T&M for electric cars, including 48-V technology, is increasing rapidly. For high-speed digital design with high power demand on many input lanes for modern FPGAs the R&S HMP4040 is ideal.”

Keithley products include recently released mid-level power supplies in the company’s Series 2230G product offering. The products help fill out the company’s offerings of multichannel supplies, now ranging from 45 W to 375 W, according to Brad Odhner, technical marketing manager.

“For the IoT space, I’d highlight our 2281S battery simulator, a favorite tool for users developing battery powered products in the IoT space,” Odhner said. “The 2281S has turned into a favorite for engineers to simply emulate a variety of batteries, either as a means of spot checking their product anywhere along the battery’s life, or for testing their device



▲ Keysight Technologies E36200 Series 200- and 400-W autoranging power supplies.

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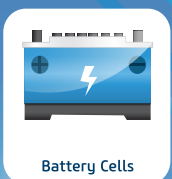
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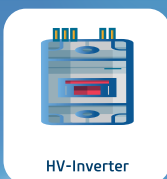
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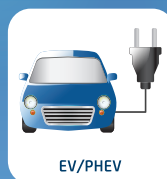
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as it continually discharges (and charges again) its battery.”

Odhner said that at APEC, Keithley will showcase its answers to problems in power-supply design like *in situ* double pulse characterization, wide-bandgap device testing, and EMI compliance testing.

Odhner commented on challenges facing customers. “Some of the major pain points we have been hearing from our customers have been related to form factors of power supplies, especially in the validation and production stages of the workflow,” he said. “Customers are also looking for more density, better accuracy, modularity, and better connectivity options. Cables and connections become a difficult thing to manage when dealing a large number of test instruments in a confined space.

RIGOL offers products such as the DP831A programmable DC power supply and the DL3031A electronic load. “Engineers require more flexibility in their power supplies and electronic loads,” said Chris Armstrong, director of product marketing. “New applications in IoT battery simulation and testing require instrumentation to quickly and easily change modes to replicate the effects on a battery of on a device drawing power. RIGOL provides power supplies and loads capable of advanced programming that gives designers better insight into the power requirements of their products, whether they are in a design phase, manufacturing, or failure analysis. RIGOL power instruments can also be used with our power-analysis oscilloscopes to further analyze and capture power conditions.”

SIGLENT recently introduced the single-channel SPD1305X power supply as well as the SDL1000X and X-E Series of electronic loads, according to Jason Chonko, applications marketing manager at SIGLENT Technologies North America. When asked about challenges that such instruments can help customers meet, he said, “The biggest technical hurdle is creating a design with fast rise/fall times and rock-solid stability while creating an easy-to-use programming interface. Electronic loads should easily allow a user to create complex charge/discharge sequences as well as simulate faults in order to fully test complex battery and charging systems.”



▲ Vitrek DL Series digital programmable DC load.

Chonko added, “In 2019, our electronic-load applications focused around battery testing as well as battery charger characterization. An electronic load can test batteries, but it is also an excellent tool for exercising battery-charger designs as well as testing overlimit conditions for safety ratings.”

Vitrek has introduced the DL Series digital programmable DC loads, designed to support the testing requirements for the latest generation of off-line power supplies, DC/DC converters, and LED drivers. The DL Series is also equipped to handle a range of battery testing requirements. The devices are offered in three power ratings (125 W, 250 W, and 500 W), each with input voltages of 0 to 150 V or 0 to 500 V.

According to Chad Clark, sales manager at Vitrek, “Programmable electronic loads with increased transient loading capabilities are required to accurately test performance of power converters using high-speed (GaN and SiC) switching devices.” He continued, “DSP technology provides exceptional flexibility and performance. High-resolution touchscreen displays are a hallmark of Vitrek instruments.”

Clark noted that at APEC, Vitrek will exhibit its DL Series loads as well as the company’s power analyzers and electrical safety (hipot) testers.

B&K Precision offers power supplies and electronic loads for general electronic test applications, according to David Holt, senior director of product management and sales. “We also provide power supplies addressing specific applications, such as our PVS Series with a built-in SAS (Solar Array Simulation) function and the 9115-AT model, which is capable of generating automotive power

test waveforms compliant to DIN 40839 and ISO 16750-2 standards to simulate common test conditions for electrical and electronic devices installed in automobiles,” he said. “All of our programmable AC sources can simulate grid faults, voltage dips, and other power-line disturbances.”

He added that recently the company upgraded the 8500 Series DC electronic loads to the new 8500B Series. “The 8500B Series improves on all aspects of its predecessor while maintaining dependability at a value price point,” he said. “The new 1696B Series of 200-W DC power supplies feature improvements to the list mode, basic SCPI commands, and protections, all based on customer feedback.”

B&K Precision also offers the 1680 fixed-output supply, delivering 13.8 VDC at 6 A peak and 4 A continuous. “The low ripple and noise, foldback current protection, and reasonably priced MSRP of \$78, make this product perfect for automotive applications,” Holt said.

PXI and rackmount

Marvin Test Solutions offers the GX3104 4-channel PXI SMU. “The GX3104 is a precision 3U PXI module that forces and senses both voltage and current over a range of ± 20 V and up to ± 1 A (channel 1) with channels 2 through 4 capable of supplying up to 500 mA per channel,” said Jon Semancik, marketing director. He explained that total available output current from the module is 1 A and that the four channels are electrically isolated from the PXI power supply and share a common, isolated ground.

The GX3104 employs 18-bit DACs for the sourcing of voltage and current, he said, adding that seven current ranges extend from $\pm 2.5 \mu\text{A FS}$ to ± 1 A FS. “Measurements employ a 24-bit ADC with programmable resolution from 18 to 24 bits,” he said. “Each output channel includes SMU output connections, Kelvin (sense) connections, and a driven guard connection for low-level current measurements.”

Semancik also commented on the company’s GX1838 precision DC source PXI card. “The GX1838 is a multichannel programmable DC source providing multiple discrete outputs for avionics, automotive, industrial testing, and other ATE applications,” he said. “The GX1838 provides eight

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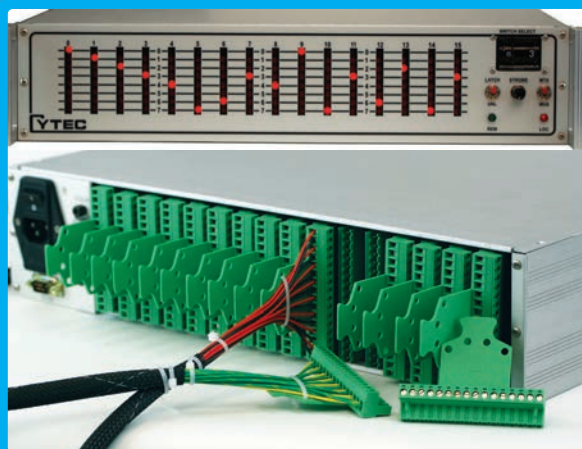


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output channels that can either be set as open or switched to any of the three voltage rails. Each of the three voltage rails can be programmed to output -10 VDC to +32 VDC or -20 VDC to +20 VDC with 14-bit resolution.”

Semancik added that MTS also offers a PXI power interface card that provides the user with access to the PXI +3.3 V, +5 V and ± 12 V outputs. “These outputs are fused and software controlled,” he said. “This card is a good economical fit for applications requiring a limited number of low power fixed voltages for unit under test (UUT) or interface test adapter (ITA) circuitry.”

According to Tom Goodman, product manager at TDK-Lambda, customers face challenges requiring better technical specs (for constant-voltage and constant current modes), higher power density (to reduce unit height and depth), and lighter weight (to increase portability, ease integration, and reduce shipping cost). Customers also want integrated advanced front-panel and remote features, multiple built-in interfaces (including Modbus-TCP and EtherCAT for industrial automation) with isolation, and easy software interfaces (with respect to both GUI and drivers), and easy paralleling (to support higher power levels as application power consumption increases). They also want an effective calibration strategy that minimizes measurement uncertainty and reduces costs associated with manufacturing defects.

TDK-Lambda has recently introduced several products in rackmount configurations that help meet these challenges, including the GENESYS+ 1U half-rack 1.5-kW platform (which Goodman described as offering the highest power in half-rack configuration); the GENESYS+ 1U full-rack 1.7-kW, 2.7-kW, and 3.4-kW platforms; and the FLEX-HV 2U full-rack high-voltage programmable power supplies, which will be on display at APEC.

Goodman noted that the GENESYS+ products offer a variety of features: multifunctional front-panel display with embedded user menus, an arbitrary waveform generator with auto-trigger capability, a constant-power limit mode (autoranging), internal resistance simulation, programmable slew-rate control (up/down for voltage/current), wide-range 400 VAC/480 VAC

inputs, built-in communication interfaces (LAN, USB, RS-232/RS-485, and isolated analog), protection functions (including CV or CC foldback and OCL), an enable/disable function with polarity selection, an internal pre-load ON/OFF control, a blank front panel option, and an air-filter kit accessory.

From modules to systems

Acopian offers power supplies including modules and rack-mount systems. The products find use in a variety of applications, including electronics test, manufacturing, R&D, battery simulation, automotive test, military/aerospace test, electric drivetrain test, renewable-energy test, and grid simulation as well as in medical, audio, and telecom industries, according to Alex Karapetian, VP of sales. Specific products the company offers include touch-safe linear encapsulated power modules, 1U rack and benchtop power supplies up to 720 W (to be on display at APEC), and 2U rack and benchtop power supplies up to 1,400 W.

Karapetian commented, “A few features that stand out include 2-quadrant power supplies, digital communication interfaces, as well as the ability to design drop-in replacement for legacy products to help our customers.”

Karapetian added, “A challenge we see is the ever-changing specifications of our customers and their requirements. Oftentimes, a standard product doesn’t meet their specifications. We address their challenges by designing a custom unit or modifying standard units to meet their needs for application-specific power supplies.”

Chips, IP, and software

Analog Devices’ Power by Linear family of Silent Switchers and uModules includes products that operate with very low conducted and radiated EMI. This, in conjunction with their high efficiencies make them well suited to test and measurement applications, the company said.

Several new parts from the company are targeted at bidirectional high-power supplies. One example where these parts can be used is in battery formation and test. For example, the LT8228, which operates as a buck converter in one direction, and a boost in the reverse direction.

Intellectual property is the focus of

CogniPower, an IP licensing firm that holds more than two dozen patents relating to more efficient and more capable power converters. “We actually do some things differently from standard practice, and we put an effort into teaching what and why,” said Thomas Lawson, founder and president.

This year, the company will be attending its 12th consecutive APEC exhibition. “We are presenting techniques for building ultralow standby-power flyback and buck converters,” Lawson said. “By ultralow standby power we mean under 1 mW.”

He added that minimizing vampire power requires simplifying the circuitry. “Simpler designs are more cost effective and can have excellent efficiency, even at low loads,” he said.

“We will be running a live demo at APEC of Predictive Energy Balancing (PEB). PEB is a superior method for controlling almost any switched-mode power converter.”

Finally, software has a key role to play in power applications—from simulation to instrument control. With respect to the former, said Tony Lennon, market manager for power electronics control design, “For designing the software for programmable power supplies, MathWorks provides Simulink software that lets engineers model digital control algorithms and analog circuits together, before beginning detailed circuit design with a SPICE circuit simulator.”

Lennon continued, “One area that has grown popular in the last year is the advances in hardware-in-the-loop (HIL) testing. HIL testing helps engineers validate the control software they program on a microcontroller or FPGA.”

He said that MathWorks will join its partner Speedgoat at APEC and demonstrate HIL systems for testing power electronics.

A subsequent article will have more on software for power-supply and load applications. 

REFERENCE

1. “Boost your efficiency with our new generation of power supplies,” Rohde & Schwarz. https://www.rohde-schwarz.com/products/test-and-measurement/boost-your-efficiency_252163.html

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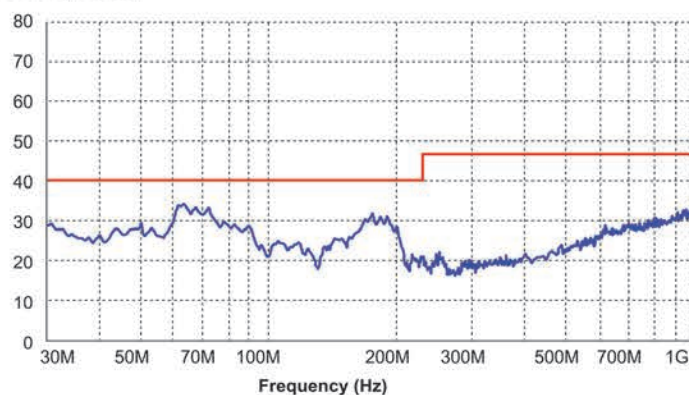
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SPECIAL REPORT

EFFECTIVE TEST AND MEASUREMENT DRIVES WIDE-BANDGAP DEVICE APPLICATIONS

By Rick Nelson, Contributing Technical Editor

► Power semiconductor test presents many challenges, requiring the accurate measurement of electrical parameters in various environmental conditions. Thermal test, specialized and general-purpose electronic instrumentation, and high-speed, high-current interconnect all have a role to play in bringing high-quality wide-bandgap devices to market and driving their penetration into applications ranging from renewable energy to electric vehicles. And power silicon devices continue to have a role to play.

Thermal test specialist

TotalTemp Technologies focuses on thermal test, and John Booher, CTO, pointed out that customers have a lot of choices in that field. “Are all those choices really necessary?” he asked. “They are not really required, but in a world where every aspect of work has the more, better, faster mindset, thermal testing is definitely no exception. Any old temperature chamber around the lab can perform a thermal test, but it’s likely going to be far from optimal.”

In contrast, he said, “TotalTemp provides thermal testing solutions that are optimum for your testing requirements. Thermal Platforms by nature are faster and offer access to the device at temperature. Convection shrouds and traditional convection temperature chambers also have their place as good choices.” He added that TotalTemp uses the Synergy Nano controller to provide solid functionality, remote and local programmability, and many time/cost-saving options, including

▼ TotalTemp Technologies Inc. SD49-N thermal vacuum platform system.



alarms, remote notifications, advanced control algorithms, logging, and network printing.

Booher pointed out that thermal testing remains important for high-power wide-bandgap devices. “Devices exposed to harsh thermal environments such as aircraft systems or cell-tower base-station gear need to be verified for the environment they are expected to perform in,” he commented.

He said his company offers a line of high-performance customizable benchtop

convection temperature chambers, new sizes of thermal platforms with more capacity (with sizes up to 450 square inches), hybrid benchtop chambers with the combined benefits of a thermal platform and a temperature chamber (“cutting test times in half from thermal platforms that are already pretty speedy,” he said), a humidity control option for the hybrid benchtop chamber, and new and improved clamping systems. He added that device temperature sensors and optional advanced control software optimize settling times

and setpoint verification. Specific products include the SD49 cryogenically cooled thermal platform.

Booher cited a key trend. "Everybody needs to get more with less (time) in our competitive economy," he said. "Thermal platforms let techs perform efficient and verifiable testing, completed in less time, resulting in more reliable products." Customers need speed as well as verifiable reports delivered, he emphasized.

Electrical measurements

According to Ron Wilcox, senior director of power test engineering at Analog Devices Inc., "Twenty-five years ago, I did not think one would be concerned with microvolts and picoamps in power semiconductor test, but we now find ourselves measuring just those, and often in the face of challenges like > 100 VCM or in noisy environments."

He continued, "A big trend continues to be achieving higher power density—the ability to deliver more power from a smaller package. This continues to drive package evolution to manage thermal and current density issues to get the power to the load."

Wilcox added, "Power semiconductor test [presents] myriad challenges involving ever-increasing accuracies in voltage, current, and time measurements, with headwinds of higher currents, faster edges, and greater risk associated with controlling high-energy events. Increasing digital content for control and metrology of power semiconductors requires advanced mixed-signal test capabilities, and subnanosecond events require RF techniques in the hardware design of test circuits. Almost every specialized test discipline is necessary to properly test modern power products. Add the element of danger, and one needs the Harrison Ford of test engineers!"

Wilcox continued, "The ability to change loop response in 'VIs' or 'SMUs' helps decrease test time and prevent possible DUT damage. Clean transitions during mode and range changes is also paramount to preventing 'walking-wounded' devices being generated by test, and possibly shipped to customers."

Focused Test Inc. has recently introduced several offerings for power-semiconductor test, including a dynamic $R_{DS(ON)}$ test station for the FTI-1000 test system. It performs dynamic $R_{DS(ON)}$ (also known as current collapse) tests on GaN HEMTs1 with a measurement delay time of < 1 ms.

The company also introduced an inductive switching test station for the FTI-1000 test system; it performs reverse-bias safe operating area (RBSOA), E_{ON}/E_{OFF} (energy loss), and other switching tests on GaN and SiC discrete devices.

Also for the FTI-1000, the company debuted a multidiode test option for wafer-sort/circuit-probe (CP) testing of MOSFET wafers, supporting up to 16 die in parallel, including adjacent die test capability. It performs DC and unclamped inductive switching (UIS) tests to 1,000 V, 100 A.

The company also supports high-voltage SiC transistor test with a DC power source to 5 kV and UIS avalanche voltage > 3 kV, and it offers a gate-charge (Q_G) calibration technique for power transistors with $Q_G < 1$ nC. The company will be highlighting these capabilities at APEC.

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Peter Hancock, president of Focused Test, identified some key applications the company addresses: GaN HEMT test for power conversion to 1,000 V, GaN IC test for power conversion, GaN IC test for lidar applications in autonomous vehicles, and SiC test for power conversion and motor drivers > 2,000 V. Key challenges, he said, include minimizing stray capacitance to perform dynamic $R_{DS(ON)}$ test of GaN HEMTs with less than 1 ms of measurement delay as well as minimizing stray capacitance and drain-gate crosstalk for timing tests of GaN HEMTs with t_{ON}/t_{OFF} less than 1 ns at V_{DS} greater than 800 V.

Hancock cited several trends. The need for improved efficiency is driving power semiconductor technology for cloud computing centers and solar installations, whereas consumer products benefit from efficiency improvements as well as reduced size and cost. And electric and autonomous vehicles require efficiency plus reliability.

As for what customers are looking for, Hancock said, key factors are ease of use and open software that allows users to modify test routines without the support of the test vendor. Also important is a willingness to partner. "Wide-bandgap tests are not yet well-defined, and test needs are changing fast. Customers need the test vendor to partner and respond quickly to new requirements." In addition, he noted, "OSAT's have limited test capability in wide bandgap. Focused Test offers a 'Flex Capacity' program for OSAT's geared towards wide-bandgap applications."

Focused Test will present the FTI-1000 in many configurations at APEC, March 8-12 in New Orleans.

IGBTs, Si MOSFETs, and SiC devices

Keysight Technologies has recently introduced the PD1500A dynamic power-device analyzer/double-pulse tester, along with software, fixtures, and probes. "It is a complete double-pulse test solution for IGBTs, Si MOSFETs, and SiC devices, according to Ryo Takeda, power semiconductor solution architect; Bernhard Holzinger, power semiconductor technical architect; and Mike Hawes, power solution consultant.



▲ Focused Test Inc. FTI-1000 tester with $R_{DS(ON)}$ test station and DUT board.

"Repeatable and reliable measurement is the key challenge to designing a double-pulse test system for WBG devices," they said. "Because of the quicker switching speeds and faster edges, any parasitic inductance and capacitance in your power loop along with gate-loop design of the circuit can significantly affect your measurement results. In turn, this will provide unrepeatable and incorrect parameter extraction from these waveforms."

They added, "Because of the higher power applications for WBG devices (for example, solar inverter, traction inverter), thermal management is critical to the design of power converters. Keysight's PD1500A enables DPT parameters to be determined over a controller temperature range."

Keysight focuses on key end-use applications including electric-vehicle power-converter test and alternative-energy power-converter test. In addition to the power-semiconductor dynamic characterization requirements, thoroughly testing the efficiency, performance, and reliability of these power converters is critical to supporting the growth of these markets, said Takeda, Holzinger, and Hawes. "Keysight supplies additional solutions for EV power converters and grid-edge power-converter applications," they added.

"The biggest trend in power semiconductors is the introduction of new wide-bandgap power semiconductor technologies," they said. "They have significant advantages over Si-based [solutions] (that is, switching speeds, efficiency, thermal properties, higher voltages), but they are not as well developed and characterized. Therefore, the reliability is not sufficient for some applications. There will be a lot of focus on improving the reliability of the WBG semiconductors, so mission-critical applications (EV, alternative energy) will transition to these new technologies."

The key capability is repeatable and reliable dynamic characterization (DPT) of faster switching, higher voltage power semiconductors, they said, adding, "A complete DPT solution will significantly improve customer's experience in characterizing the dynamic parameters of power semiconductors. Effective and repeatable DPT design is surprisingly difficult."

The design of a DPT system presents many challenges because of the combination of high frequency and high power. "RF effects need to be considered, which is not typical for power-converter designers," they said. "Minimizing parasitic inductance and capacitance in the power loop and the gate loop is critical

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for repeatable and reliable measurements. Additionally, high-frequency current measurement is extremely difficult with no perfect solution.”

At APEC, Keysight will demonstrate products including B1505/6A static device analyzer/curve tracer, the PD1500A dynamic device analyzer/double-pulse tester, and the PD1000A power-device measurement system for advanced modeling. Keysight will also present a paper regarding the challenges presented by testing high-frequency power semiconductor technologies (IGBTs, SiC, GaN).

SMUs and analyzers

Keithley, a Tektronix company, has introduced several products for power semiconductor test. For high-power semiconductor characterization, the company debuted the Keithley 2470 High Voltage SourceMeter, which offers a 1.1-kV output, 10-fA resolution, and 0.012% basic measurement accuracy.

“As SiC and GaN devices drive the need for more efficiency, characterizing their $R_{DS(ON/OFF)}$ behavior becomes more critical,” said Wilson Lee, technical marketing manager, Americas. “The 2470 fills a vital position for engineers either in a production setting or for benchtop work.”

Lee said the company also recently launched two SMU modules for its 4200A-SCS parameter analyzer. “These SMUs address the needs of modern production environments, where high capacitances of test setups become unavoidable but low current measurements are still required,” he said. “Low currents get harder to measure as you increase capacitance due to increased time constants requiring longer settling times. The 4201-SMU and 4211-SMU modules offer greater max capacitance specifications to meet the needs of future testing.”

The company has also launched a wide-bandgap reference test system. “This reference design represents an optimal system for making critical in-circuit, real-time measurements on GaN and SiC power semiconductors,” Lee said. “It addresses the needs for high-bandwidth, high-voltage, high-common-mode-rejection measurements that prove extremely difficult with these fast rise-time devices in

half-bridge and full-bridge topologies. The system is available as a kit; however, most users customize it to fit their specific applications. The system includes a 5 Series oscilloscope with a power measurement and analysis package installed and IsoVu optically-isolated differential probes to enable fast rise-time measurements while eliminating common mode noise.”

Lee added that the Tektronix 4/5/6 Series 12-bit oscilloscopes offer the higher vertical resolution that allows engineers to make accurate measurements over the higher dynamic ranges becoming commonplace as switching voltages increase with GaN and especially with SiC. He said the company has also “...added the ability to synchronously observe time- and frequency-domain activity, which is valuable for EMI troubleshooting made more challenging by fast, high-voltage switching. We call this ‘Spectrum View.’”

The company also offers an arbitrary/function generator with double pulse testing. “To measure turn-on and turn-off characteristics, the new AFG31000 now comes with the ability to generate double-pulse test signals from the front panel,” Lee said. “Test signals are specified by voltage level and the on-time and off-time for the two pulses. This makes the AFG31000 the first such AFG with this functionality built-in.”

At APEC, the company will present a variety of focused application demos—including power semiconductor characterization, wide bandgap power conversion, a 3-phase motor drive, EMI debug, double pulse test, and power integrity.

Newark offers the Keithley 2470 High Voltage SourceMeter, and James McGregor, global head of Test and Tools, elaborated on its capabilities; “It offers 4-quadrant precision voltage and current source/load coupled with measurement on a touchscreen user interface. The 2470 SMU adds capabilities in measurements such as breakdown voltage, leakage current, isolation testing, hipot, and dielectric withstanding tests. With the 2470’s 1,100 V and 10 fA capability, it is optimized for characterizing and testing high-voltage, low-leakage devices such as SiC and GaN wide-bandgap power semiconductors.”

McGregor called the 2470 SMU just one example of a product in the distributor’s Test and Tool range, which has expanded by over 4,000 products globally in the last year. “Newark remains committed to equipping its customers with the very best products from leading suppliers and has invested over \$5 million in Test and Tools alone in 2019,” he said.

Newark also offers options for power-semiconductor test. “The Keithley Model 8010 high-power device test fixture provides safe and easy connections for testing packaged high-power devices up to 3,000 V and 100 A. It also provides connections for Keithley’s source/meter units. ... Newark’s portfolio of test equipment is all inclusive; engineers can find solutions to all their test needs in one place.”

McGregor added that the very low leakage currents measured in power semiconductors impose challenges related to sufficient noise immunity at the low currents. “It may be necessary to use special triaxial cables, of which Newark offers several options, to overcome this,” he said. “In addition to triaxial cables, special safety probes are needed when measuring high voltages typical of power semiconductors. Newark offers a variety of low-noise triaxial cables and high-voltage safety probes from manufacturers such as Keithley, Keysight, and Pomona, supporting engineers as they overcome these challenges and enabling them to test safely and confidently.”

Scopes and options

Rohde & Schwarz offers several products for power semiconductor test, including R&S RT-ZHD high-voltage differential probes; R&S RT-ZPR20 and R&S RT-ZPR40 power-integrity probe; and the R&S RTx-K31 power-analysis option and R&S RTx-K36 Bode-analysis option for the company’s oscilloscopes.

In addition, “The R&S RT-ZD10 active differential probe, together with the R&S RT-ZA15 external attenuator, permits the measurement of voltages up to ± 60 VDC/ ± 42.4 VAC (peak) at a bandwidth of 1 GHz,” said Marcus Herdin, market-segment manager for industry, components, research, and universities at Rohde & Schwarz.

Herdin emphasized EMI. "There are many challenges, but meeting EMI compliance has become a key challenge for designing wide-bandgap semiconductor converters as switching times and therefore unwanted emissions increase," he said. "Debugging designs early in the design phase has become increasingly important. Oscilloscopes that can assist in EMI debugging are very relevant."²

When asked about features, Herdin said customers value the 16-bit HD mode of the company's R&S RTE, R&S RTO, and R&S RTP oscilloscopes as well as advanced analysis capabilities like flexible math mode and PWM track functionality. The oscilloscopes plus an EMI receiver and 4-line LISN for conducted EMI tests will be on display at APEC. Topics Rohde & Schwarz experts will discuss at the event include EMI debugging and compliance, control-loop analysis (Bode plot),

and general-purpose power-electronics test with oscilloscopes.

Interconnect

Samtec positions its new mPOWER ultramicro power connectors as suitable for high-current delivery in several applications. The company currently offers board-to-board solutions and has cable-to-board options under development, according to Terry Emerson, product marketing manager. Samtec's mPOWER UMPT/UMPS Series connectors come with several options, he said, including number of blades (two to five), a number of stack heights (5, 7, 10, and 12 mm), tin or gold plating, and optional weld tabs for added ruggedness.

mPOWER products find use in applications such as mobile-device charging, motor control, automotive, industrial, green energy, and grid control. "Since mPOWER

can be used with a wide variety of signal connectors or as a standalone unit, it has found a home in applications from industrial to medical," Emerson said.

When asked about industry trends, he said, "System form factors are getting denser. Engineers want to cram as much power delivery into as small space as possible." He added that mPOWER can carry up to 21 A per blade in a small form factor.

"For connectors, it really comes down to size vs. efficiency of power delivery," Emerson said. "Customers want to dedicate as little PCB space to power delivery as possible while being confident that their application won't have issues. mPOWER checks all of those boxes." 

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FAHRENHEIT'S MERCURY THERMOMETER CEDES FIELD TO TCS, RTDS, THERMISTORS

Data recorders, sensor transmitters, and I/O modules bring temperature measurement and control into the digital world

By Rick Nelson, Contributing Technical Editor

► Mention temperature measurement to average persons, and they will likely visualize a mercury-in-glass thermometer. They might not know that it was invented in the early 18th century in Amsterdam by Daniel Gabriel Fahrenheit, but they will be familiar with Fahrenheit's temperature scale, which, after some fine-tuning, places water's freezing point at 32°F and its boiling point at 212°F, or 180°F higher than the freezing point.

Fahrenheit's scale continues to hold sway in the United States, although the Celsius scale predominates elsewhere. But alas, the mercury-in-glass thermometer, which had represented the state-of-the-art since its invention in 1714, is being phased out in the 21st century because of mercury's toxicity. As a sign of the mercury thermometer's demise, NIST reports that it began an active mercury-reduction campaign in 2007 and stopped calibrating mercury thermometers entirely on March 1, 2011.¹

NIST emphasizes that it continues to offer thermometric calibration services for nonmercury devices, including organic-liquid-in-glass thermometers, which you can still purchase. Curiously, Fahrenheit is credited with having helped to perfect an alcohol-in-glass thermometer before turning his attention to the mercury-based instrument.

Of course, liquid-in-glass thermometers—organic or mercury—have never been ideal for the types of experiments conducted in an electronics test lab or environmental test chamber. Liquid-in-glass thermometers are fragile, they have slow equilibrium and response times, and they don't offer electrical outputs that could serve as inputs for old analog chart recorders or that could be digitized at fast update rates for modern data loggers and computer analysis. The attention has turned to devices such as thermocouples (TCs), resistance temperature detectors (RTDs), and thermistors.

Thermocouples and Seebeck

Although not as old as liquid-in-glass thermometers, thermocouples are not new. Their existence extends back to observations in 1821 by the German physicist Thomas Johann Seebeck that a temperature gradient across a conductor induces an electromotive force. In a thermocouple, the bare ends of two insulated wires of dissimilar metals are welded together to form a tip, which can be affixed to a device under test whose temperature is to be measured. The same temperature gradient across the different wires will induce a different voltage. Consequently, the voltage differential measured at the other end of the equal-length wires at a

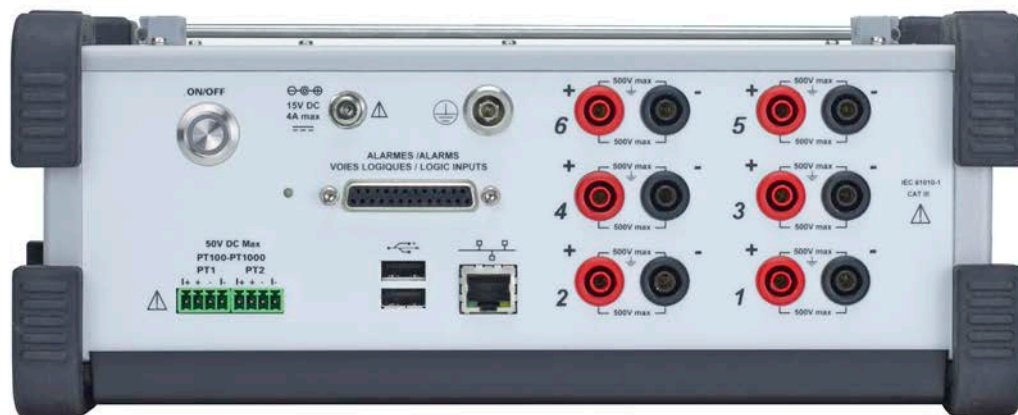
controlled reference temperature (the cold junction) can then be used to calculate the DUT temperature.

Thermocouples can operate over extreme temperature ranges—for example, NIST reports it calibrates these devices from -196°C to 2,100°C.² One drawback is the need for a controlled reference temperature, which could be provided by a 0°C ice bath. If a fluctuating ambient temperature is used as a cold junction, an additional temperature sensor will be needed to report the ambient temperature at the time of the measurement.

Thermocouples come in a variety types (each designated by a letter) with different pairs of metals. Type J, for example, combines iron and constantan, the latter being a copper-nickel alloy. Commonly used types in addition to J include B, E, K, N, R, S, T, and C, whose makeup and characteristics are in accordance with standards set by ASTM International.³

RTDs and thermistors

RTDs and thermistors are conceptually easier to understand. RTDs, such as platinum resistance thermometers (PRT), take advantage of the fact that the resistance of a metal (platinum, for example) increases with temperature. They lack the extreme temperature ranges of thermocouples. For example, NIST reports that



► Views of B&K Precision's DAS60 data recorder showing Pt100 and Pt1000 inputs (top) plus optional thermal printer (bottom).

it calibrates these devices from -196°C to 550°C .⁴

RTDs tend to have low resistances. The Pt100 PRT, for example, has a resistance of $100\ \Omega$ at 0°C (hence the 100 following the periodic-table symbol for platinum in the designation), and NIST notes that a conventional PRT may have a resistance of about $80\ \Omega$ at -50°C and $120\ \Omega$ at 50°C , for a sensitivity of about $0.4\ \Omega/^{\circ}\text{C}$. With low PRT resistances, measurement lead-wire resistance can introduce significant errors. National Instruments describes 3- and 4-wire configurations that can minimize errors due to lead resistance and lead-resistance inconsistencies.⁵ An alternative is to use a Pt1000 PRT, which has a resistance of $1,000\ \Omega$ at 0°C , making measurement lead resistance less of a factor.

Finally, thermistors employ semiconductor materials instead of metals like platinum and can offer positive or—more typically—negative temperature coefficients (resistance falls as temperature increases). They can offer higher sensitivities than RTDs, albeit over a narrower

temperature range. For example, NIST reports calibrating these devices from -50°C to 100°C .⁶ Thermistors can serve in thermocouple applications to accurately monitor the cold-junction reference temperature for use in calculating the DUT temperature.

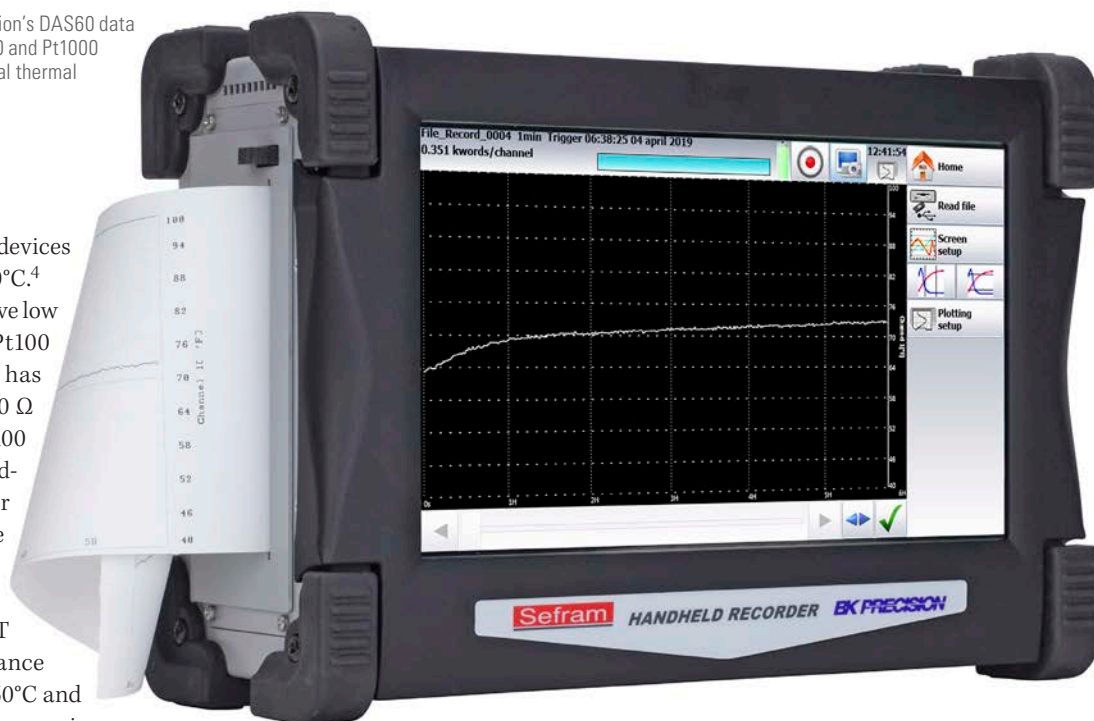
Recording and control

Once your sensor has measured temperature, you'll want to do something with the result. You may want to record it, for example, for later analysis. If your sensor is in a remote location, you may want to transmit its output elsewhere. Finally, you may want to take some action based on measured temperatures. Three new

products introduced in December 2019 cover all three bases.

First, B&K Precision announced the expansion of its data-recorder line with the new DAS30/50/60 family, developed by B&K Precision's subsidiary Sefram in France, which specializes in the design and manufacture of data-acquisition instruments and other test and measurement solutions.

The DAS30/50/60 data recorders feature two, four, or six analog input channels, a sampling interval of $1\ \mu\text{s}$ ($1\ \text{MS/s}$), an input range of $\pm 5\ \text{mV}$ to $\pm 500\ \text{V}$, and internal solid-state memory of up to 64 GB. Combined with the CAT III isolation rating, these instruments are suited for a





▲ Opto 22's GRV-CCANI-2 and GRV-ITM-12 modules for its groov EPIC platform.

range of applications from sensor signal logging to electrical power analysis. A built-in power-analysis application measures and records voltage and current on both single- and 3-phase networks. The results are displayed as a harmonics graph, Fresnel diagram, or oscilloscope waveform.

Specifically for temperature measurement, B&K Precision offers Pt100 and Pt1000 inputs as a factory option on the DAS30 and DAS50 models and as standard for the DAS60. An integrated thermal printer is a factory option on all three models.

Sensor signal transmitter

For transmitting a signal, OMEGA introduced its XW Series wireless sensor/transmitter system, which provides seamless connectivity across the company's catalog of sensors. The devices can serve demanding industrial applications indoors and survive harsh outdoor environments. The electronics are protected in a rugged weatherproof NEMA 4 (IP65)-rated housing and are easy to set up using a standard USB cable in conjunction with free SYNC configuration software. A variety of compatible probes and sensors mate quickly and easily with robust M12 connectors.

The XW series provides options for compatibility with both digital and analog

sensor types. The XW-ED accepts a variety of smart digital probes and accommodates pulse and process inputs. The

XW-EDA model supports a range of thermocouples, RTDs, and precision process inputs.

Pro versions feature two additional configurable discrete inputs/outputs, which enable edge-control capability. The product can be configured to use local sensor data to provide closed-loop control

to local equipment, as well as sounding alarms or monitoring door switches.

"I am pleased that we have created a high-performance wireless platform that supports more than 80% of Omega's sensor portfolio, including our extensive line of thermocouples and RTDs," said Peter Schwartz, senior product manager for IIoT, in a press release. "These products are ideal for both new sensor installations and adding IIoT connectivity to existing ones."

Programmable control

Finally, Opto 22 announced two additional modules for its groov EPIC edge programmable industrial-controller platform. For system integrators and engineers, the new I/O modules provide more options for bringing field bus networks into groov EPIC as well as meeting requirements for temperature-control applications with high I/O count. GRV-CCANI-2 (with serial communication, two channels, CAN 2.0B, and channel-to-channel isolation) is the first module in the groov EPIC platform to provide hardware support for an industrial field bus, the company reported. This new module enables existing CAN networks to be brought into IIoT applications using groov EPIC's fluid IT/OT connectivity tools, like Ignition Edge, Node-RED, and MQTT. groov EPIC also supports

integrating CAN data into control applications using IEC 61131-3 languages, and it enables mobile visualization of CAN data using groov View. Up to eight CAN buses per processor at network speeds up to 1 Mb/s are supported.

GRV-ITM-12 (analog input, 12 channels, and thermocouple or millivolt inputs) provides a high-density, low-cost temperature-sensing option with two isolated zones and six channels per zone. Each channel is software-configurable to one of seven millivolt ranges or eight thermocouple types (B, E, J, K, N, R, S, T). GRV-ITM-12 is accurate to 0.1% of the configured range over 20-bit resolution for V/mV sensing, with accuracy ranging from 2.0 to 5.0°C for thermocouple sensing.

The new modules complement three modules introduced in October, including the 8-channel analog-input GRV-IRTD-8, which increases options for accuracy and I/O density in temperature applications, the company reported. It provides eight channels for 2- and 3-wire RTD inputs, with a maximum range of -200°C to 850°C. Users can take advantage of multiple fixed ranges or one of two autoranging methods to simplify configuration. The GRV-IRTD-8 can also be used for high-resolution resistance measurements, with accuracy ranging from 4.2 Ω at the 8-kΩ input range to 0.058 Ω at the 10-Ω range for 3-wire RTDs. [EE](#)

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TEST KEEPS PACE WITH FIBER DEPLOYMENTS

By Rick Nelson, Contributing Technical Editor

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▶ Optical technology innovations extend from photonics integrated circuit wafer-level test to field-test applications and the cloud-based ecosystem. Effective optical test has implications for fields including edge computing, 400G/800G Ethernet, and 5G. Instrumentation extends from handheld optical-fiber multimeters to real-time and sampling oscilloscopes. OFC, The Optical Networking and Communication Conference & Exhibition, scheduled for March 8-12 in San Diego, will provide an opportunity to delve into these and other topics. Two companies who will participate in the event have highlighted their recent optical-test product introductions and previewed their plans for OFC.

Speaking for EXFO, Olivier Tremblay-Lavoie, portfolio marketing leader at the company, said, “Through 2019, we launched a series of new test solutions as well as improvements in terms of features and options both into our lab and field optical testing portfolios. I would especially highlight three specific aspects of our solution which are a direct reflection of EXFO’s DNA.”

First, Optical Explorer, released June 2019, is a handheld solution that evaluates the quality of fiber links in seconds, he said, adding that it closes the gap between traditional troubleshooting methodologies based on a power meter and VFL (visual fault locator) and methodologies based on more advanced test

equipment, such as optical time-domain reflectometers (OTDRs), which require more expertise.

Tremblay-Lavoie said the accelerating pace of fiber deployments is causing a major transformation in approaches to testing. “Optical Explorer has been designed from the ground up to tackle the challenges ahead and simplify testing,” he said. “Optical Explorer allows streamlined procedures that reduce delays and escalation costs in the field while freeing up expert technicians to focus on more relevant tasks.”

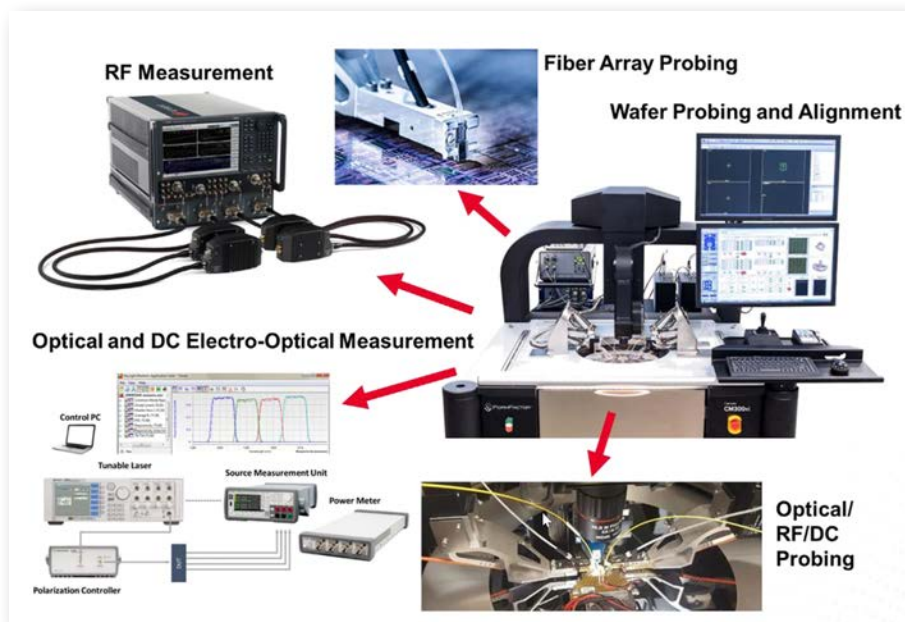
He described Optical Explorer as “...the industry’s first optical fiber multimeter (OFM), a new purpose-built category of tools empowering frontline techs to effectively carry out installation, activation, and repair operations. Optical Explorer speeds up link health verification with embedded fault tracking—all in one single-ended test that’s quick and easy.”

Optical Explorer has been designed from the start to equip large crews of frontline technicians to cope with the increasing volume of fiber being rolled out, he said. “It is optimized for utmost user experience, being highly intuitive and easy to use for any technician regardless of experience in fiber optics or other technologies (such as copper or DSL),” he added. It is designed to reduce total cost of ownership (TCO) throughout the product life cycle by cutting all hidden costs.”

Second, he cited Optical Wave Expert,

which combines a DWDM (dense wavelength division multiplexing) channel checker and OTDR functionality. “The Optical Wave Expert integrates channel power validation and reflectometry characterization on a single port,” he said. “This means that technicians can automatically identify faulty channels and follow through with fault location by leveraging intelligent OTDR capabilities. The integration of channel checker and OTDR capabilities on a single port means less unnecessary manipulation of the optical fiber and improved field efficiency. This translates into faster mean-time-to-repair and makes the trial and error approach—which can disable nodes—obsolete.” He described the tool as suitable for MSOs (multiple system operators) working in converged fiber architectures having to deploy DWDM networks in the context of fiber-deep (the effort to drive optical technology as close as possible to the customer) and remote-PHY architectures.

Last, he cited Optical Power Expert and a general expansion of the company’s ecosystem of cloud-connected essential optical test equipment. “A power meter represents one of the most basic tools to any fiber technician,” he said. “With the release of the Optical Power Expert, we proposed an updated version of our best-selling power meters, while adding Bluetooth connectivity, a wide touchscreen, and best-in-class optical performances. This state-of-the-art test device



▲ Keysight measurement solution for integrated photonics.

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serves essential basic needs, but is now ready to cope with today's reality, including cloud-based connectivity for reporting, automated results storage, and job management."

He continued, "This represents further proof that EXFO constantly invests in its traditional product lines, but with a clear vision to make field handheld devices more and more connected to enable new types of functionality made possible through the cloud and to drive better efficiencies in the field and higher quality networks. With these recent additions to our portfolio, we can claim we have the most connected fleet of optical test equipment that covers all essential optical testing needs, from fiber inspection probes (FIPs), to power meters, optical fiber multimeters (OFM), optical loss test sets (OLTS), and optical time-domain reflectometers."

You can now access your test data in real-time and provide automated results processing in accordance with standardized methods and procedures across all your field teams, either for in-house or subcontracted jobs, he said, adding, "In the end, data is power, and gaining visibility and control over fiber infrastructures in terms of quality, performance, and readiness for future generation applications (video, edge computing, 5G, etc.) is paramount."

Tremblay-Lavoie noted that EXFO will be exhibiting at OFC this year. "OFC is a major event for EXFO and has been always very successful for us," he said. "Given our broad portfolio of test and measurement solutions offerings, covering multiple applications from R&D, labs, and field, it is a perfect place to showcase our 35-plus years of expertise."

For the 2020 edition, he said, EXFO will showcase its T&M portfolio within key categories, the first being solutions for network equipment vendors. This first category covers applications including passive optical component test as well as 400G/800G

test and addresses an approach to testing optical transceivers at every step of their lifecycle.

Second will be solutions for high-speed optical transformations. "Here we can think of test scenarios covering datacenter applications, interconnect—anything from core to edge," he said. "The various technologies now available in a context of 5G transformation bring an unseen level of complexity in the optical transport layer. This is where we will demonstrate the interoperability between various systems and show the flexibility and ease of use of EXFO solutions in the process." He added that once again the company will partner with other Ethernet Alliance members in specific

interop events to demonstrate switching and mixing from different line rates (25G, 50G, 100G, 200G, 400G, and beyond) with different protocols, including Ethernet, CPRI (Common Public Radio Interface), eCPRI (enhanced CPRI), and RF over CPRI.

Still addressing the second category, he said, "Related to 5G networks, we will be demonstrating interoperability related to X-haul architectures with Xilinx." He further explained, "As a foundational 5G topic, we see that operators and network owners are joining forces to re-use their fiber assets to expand the network capacities and allocate fibers previously used for FTTH/PON (fiber to the home/passive optical network), or in a metro ring, to now support the distribution of fiber bandwidth to 5G antennas. In such context, the use of DWDM technology is ramping up, and so EXFO will be presenting all its portfolio of xWDM test solution for fiber-deep and fiber-convergence applications—in this case, mainly optical spectrum analyzers (OSA) and channel checkers."

The third category addresses the company's field-testing portfolio, test-automation, and the cloud-based ecosystem. "This represents most of our optical portfolio designed for field applications," he said. "This is a trend we are leading in the market, and we will be focusing on showing the benefits of leveraging the cloud in day-to-day test processes."

Finally, he mentioned a T&M Center PIC (photonic integrated circuit) testing demonstration. "One of the interesting collaborations EXFO will be involved with at OFC this year will be our participation with MPI Corp. and HPE to present a true wafer chipset production test leveraging our photonic integrated circuit testing solutions (CTP10). Hosted at the T&M Center, this demonstration will be a replica of a real manufacturing use case. People will definitively be impressed by the dimensions of the demo setup, realizing the paradox in between the size of the system required to produce what is in fact, the smallest piece of optical components (PIC)."

From analyzers to scopes

For its part, Keysight Technologies has recently introduced several optical-test products, including the N4372E 110-GHz lightwave component analyzer, the N4391B 110-GHz optical modulation analyzer for terabit coherent communication, and the 110-GHz Infiniium UXR-Series real-time oscilloscope, according to Dr. Joachim Peerlings, VP and GM of Keysight's Network and Data Center Solutions group. He also cited the N77xxC family of optical component test products, the A400G-QDD Layer 1 BERT and KP4 FEC multiport test system, and the N1092A DCA-M sampling oscilloscope with integrated clock recovery. He also mentioned the N4377A lightwave detector, which offers high speed for frequency-domain and time-domain applications.

"The 110-GHz lightwave component analyzer enables parametric electro-optic S-parameter test of optical receivers and detectors, transmitters, and modulators targeted for 50 to 100 Gbaud transceivers," he said. "The 110-GHz optical modulation analyzer solution implements standard-conforming error vector magnitude (EVM) measurements according to ITU G.698.2 and the latest draft of OIF 400ZR standards. It provides high resolution and low EVM for the testing of 128-Gbaud QAM64 and beyond in 1.2-Tb/s transmission."

All of these products will be on exhibit at OFC, he said, adding that to help customers deal with the complexities, Keysight will provide at OFC the short courses "Hands-on: Test and Measurement for Signals with Complex Optical Modulation" and "Test and Measurement for Data Center/Short Reach Communications."

Peerlings also noted that in November, Keysight, FormFactor Inc., and CompoundTek announced they have joined forces to accelerate integrated photonics (or silicon photonics) innovations. The three companies have jointly developed an advanced photonics on-wafer testing solution that delivers capabilities including automated alignment as well as simultaneous optical-optical and optical-electrical device tests, which will be demonstrated at OFC.

The joint solution, to be offered by CompoundTek, includes these products:

- the FormFactor CM300xi-SiPh, with automated wafer level photonics positioning combined with Keysight's industry-standard IL/PDL engines and N7700A Photonics Application Suite (PAS), to support wavelength repeatability of ± 1.5 pm at 2-way sweeps up to 200 nm/s within 1,240 nm to 1,650 nm to ensure accuracy and repeatability from O-band to L-band;
- Keysight's N4373E 67-GHz lightwave component analyzer, which delivers the necessary bandwidth for both optical receiver testing and optical transmitter testing with guaranteed specifications for electro-optical S-parameter measurements for device traceability;
- Keysight's PathWave software platform, which provides a consistent user experience as well as common data formats and control interfaces; and
- FormFactor's SiPh software, which enables automated calibrations and alignments and simplifies integration with

Keysight's PathWave software platform, as well as optical instrumentation, to ensure ease of use.

"Innovation in optics is critical to connect the world and help the industry to monetize 5G, as well as datacenter and telecom services," said Peerlings. "Advancing in speed as well as power and cost efficiency requires a tightly connected ecosystem to jointly solve the challenges ahead."

CompoundTek plans to establish a state-of-the-art silicon photonics testing services hub in Singapore. The company's chief operating officer, K.S. Ang, commented in a press release, "With added on-wafer level, automated Si photonics optical/electrical/RF testing with this solution, customers will be able to limit packaging costs to avoid module packaging-level testing turnaround time losses. This test solution complements our current services in mass-production volume with fast cycle-time ..."

"FormFactor's industry-leading silicon photonics wafer test capability allows our customers to obtain repeatable, consistent results with unsurpassed throughput," added Claus Dietrich, vice president and general manager of the Systems Business Unit at FormFactor. "The system's automated and high-speed calibration and optical alignment, as well as precision measurement capability in collaboration with Keysight, enable CompoundTek to offer customers faster time to market."

CompoundTek and FormFactor, as well as Keysight, are scheduled to exhibit OFC. [EE](#)

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WIDEBAND TRANSCEIVER SUPPORTS MULTISTANDARD 3G/4G/5G BASE-STATION APPLICATIONS

By Rick Nelson, Contributing Technical Editor

▶ Base-station developers face a variety of challenges as 5G arrives, according to Peadar Forbes, marketing and applications director at Analog Devices. New 5G networks will need to support three use cases—extreme mobile broadband (eMBB), massive machine communication, and ultrareliable low-latency communication. Mobile broadband users will expect 100-Mb/s data rates wherever needed with peak rates extending to more than 10 Gb/s. And broadband 5G networks will serve 10 to 100 times more devices and experience 10,000 times more traffic, compared with previous generations.

Massive machine communications will require low-cost, low-power implementations that allow devices to operate on batteries for 10 years or more. And ultra-reliable communication applications will require latencies of 1 ms or lower.

Forbes said Analog Devices' base-station customers experience several pain points with respect to time to market and a huge increase in portfolio complexity and cost pressures. They are contending with multiple variants with respect to formfactors, frequency ranges, software variants, and antenna count, with high-density radios putting pressure on system size, weight, and power (SWaP).

Wideband transceiver

To help meet the challenges, Analog Devices in November 2019 introduced

▶ Analog Devices' ADRV9026 wideband transceiver, part of the company's RadioVerse design and technology ecosystem.



a new wideband transceiver in its RadioVerse¹ design and technology ecosystem. The ADRV9026 is designed to support base-station applications including single and multistandard 3G/4G/5G macrocell base stations as well a massive MIMO (M-MIMO) and small-cell systems.

Forbes called the ADRV9026 the smallest, lowest power transceiver for base-station applications, describing it as a highly integrated, high-performance software-defined radio. Applications, he said, include macrocells, small cells, and

massive MIMO architectures. He further described it as a common-platform design for 3G and 4G as well as 5G—thereby reducing complexity, development cost, and time to market.

Forbes said the ADRV9026 offers twice the integration and half of the power consumption of its predecessor, the ADRV9009. He said the ADRV9026 also supports FDD and TDD on a single chip to simplify development, whereas the ADRV9009 implementation required two chips for FDD.

Specifications include quad transmitters, quad receivers, and dual observation receivers with two inputs each, vs. dual transmitters, dual receivers, and one observation receiver for the ADRV9009.

Receiver bandwidth is 200 MHz; transmitter bandwidth and observation receiver bandwidth are 450 MHz. Tuning range is 650 MHz to 6 GHz.

Other features include a 16-Gb/s JESD204B/C interface, vs. 12-Gb/s JESD204B interface for the ADRV9009. Power consumption for the ADRV9026 is 5 W (under specified operating conditions), half that of the ADRV9009. The transceiver comes in a 14 x 14 BGA.

Forbes said Analog Devices offers several design resources for the ADRV9026, including 2.8-GHz to 6-GHz and 650-MHz to 2.8-GHz evaluation kits, carrier platforms, software (including a Windows GUI, API, and firmware), design-file packages (including EVB schematics, layout, BOM, Gerber, BSDL, IBIS, and S-parameter models), design tools (including JESD204B/C Framework IP, FPGA Interoperability Report, and Filter Wizard, all to be available in 2020), and customer support through the ADRV9026 EngineerZone Forum.

Forbes outlined the ADRV902X family roadmap, which includes the addition over time of 25-Gb/s SerDes support, an extension of the LO frequency range down to 75 MHz, support for an external LO, fast frequency hopping, and a filter wizard.

He said that in June 2020, an enhanced version from the ADRV902X family will be released with integrated DPD and CFR (crest factor reduction), reducing FPGA requirements and lowering total system power and cost. Also in June, he said, the company will launch an ADRV902X partner and reference design ecosystem.

The ADRV9026, ADI's fourth-generation wideband RF transceiver, offers quad-channel integration with the lowest power, smallest size common-platform solution, the company said. The new software-defined transceiver supports both frequency-division duplex (FDD) and time-division duplex (TDD) standards, simplifying design and reducing

system power, size, weight, and costs for 3G/4G/5G applications.

The RadioVerse design and technology ecosystem offers a one-stop radio design environment focused on simplifying the radio development process for a range of markets and applications. The RadioVerse ecosystem includes rapid prototyping platforms, chip-level

evaluation systems, simulation tools, and development kits as well as a global partnership network that provides multiple levels of design support. [EE](#)

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THE BURN-IN WITH TEST COMPANY



The worldwide leader in test with burn-in systems, Micro Control offers solutions for high-power burn-in test applications requiring individual temperature control and logic/ memory burn-in test applications for lower power devices.

Micro Control Company's burn-in systems feature a pattern zone per slot, multiple temperature zones and independent temperature control per DUT. With up to 64 M of vector memory behind all 128 independent I/O channels, Micro Control systems can handle many different functional tests.



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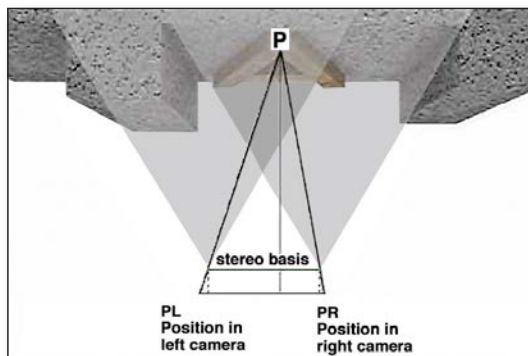
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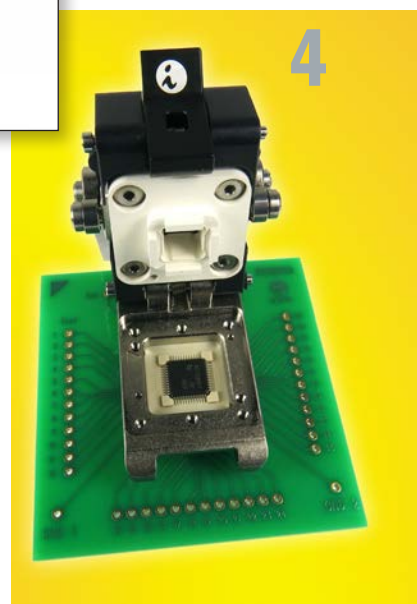
EVALUATION ENGINEERING'S FEATURED TECH



2



3



4

1. GNSS/INS localization solution

The OpenRTK330L triple-band RTK/GNSS receiver has built-in triple redundant inertial sensors. Designed to replace the expensive and bulky precision RTK/INS systems used in today's autonomous systems, this compact navigation solution meets the performance, reliability, and cost requirements of the automotive market along with the needs of robot, drone, construction, and agriculture systems. The OpenRTK330L integrates a precise 2°/h IMU to offer 10 to 30 seconds of high-accuracy localization during full GNSS denial. This enables autonomous system developers to safely deliver accurate localization and position capabilities in their vehicles at prices that meet their budgets.

ACEINNA

2. 53-Gbaud clock recovery unit

A clock recovery unit (CRU) option for the BERTWave MP2110A sampling oscilloscope supports trigger clock generation from a 53-Gbaud PAM4 optical signal. When combined with existing oscilloscope functionality, the new 53-Gbaud CRU allows the MP2110A to serve as an all-in-one solution that can cost-effectively and efficiently evaluate various PAM4 optical modules during development and manufacturing, compared with solutions requiring external sampling oscilloscopes. The BERTWave MP2110A can be used by engineers to efficiently evaluate the physical layer of 25G to 400G optical transceiver modules and equipment components such as optical cables.

Avritsu

3. 3D camera system

Large machinery depends on smooth operation of ball and roller bearings. To detect abnormalities, 100% inspection is required. Chromasens reports that system integrator Active Inspection has developed a bearing inspection system based on the Chromasens 3DPIXA 3D stereo line-scan camera and Chromasens Corona II LED illuminator. Engineers at Active Inspection customized a version of the company's aiUltimate Max 3d inspection system so it can check virtually any type of ball or roller bearings and detect microscopical defects to 3 µm. The image shows 3D data calculated from the stereoscopic images, providing co-ordinates for all object points in three dimensions.

Chromasens

4. Open-top socket for QFP48

The new CBT-QFE-3018 stamped spring-pin socket addresses high-performance requirements for testing 48-lead quad flat pack devices. The contactor used in CBT-QFE-3018 socket is a stamped spring pin with 17-g actuation force per ball and cycle life of 10,000+ insertions. The self-inductance of the contactor is 0.88 nH, insertion loss is < 1 dB at 31.7 GHz, and capacitance is 0.03 pF. The current capacity of each contactor is 2.9 A. Socket temperature range is -55°C to +180°C. Pricing for the CBT-QFE-3018 is \$745 each in unit quantities.

Ironwood Electronics



5. 45° PCB-mount SMA connector

A new 45° PCB-mount connector joins the vendor's SMA Series. This type of connector is commonly used in test and measurement, semiconductor-test-fixture, PC-board-characterization, and networking applications. The connector is designed to operate up to 18 GHz, with a maximum VSWR of 1.30 up to a frequency of 12 GHz and a VSWR of 1.50 for 12 GHz to 18 GHz frequencies. 45° connectors are commonly used for mid-board launch in tight enclosures and board to board applications. The connector is fabricated in gold-plated beryllium copper.

Cinch Connectivity Solutions

6. Machine-vision software

The fastest and most accurate technique for the human eye and mind to detect defects is through visual comparison of images. The new INSPECTIS Overlay Assisted Inspection (OAI) leverages the company's recently released software package version 5.0 incorporating the new overlay software feature. This feature uses "Compare Windows," for example, where the operator can compare a live image to a reference picture or compare two to four still images. With OAI, a live image can be overlaid on a reference picture with timer-controlled interval display. It can identify missing components, wrong polarity, misplacements, and other defects on assembled PCBs.

INSPECTIS AB

7. Fieldbus cable assemblies

New M8/M12 cable assemblies for Fieldbus data communications complement the vendor's existing sensor/actuator cable assembly solutions for industrial networks. The new A- and B-coded M8/M12 cable assemblies comply with Profibus, DeviceNet, and CC-link protocols, offering multiple options for a variety of needs. They have 360-degree shielding against EMI for complete protection for signal and data transmission, and are rated IP67 for resistance to dust and water. The assemblies are overmolded in either PVC or halogen-free polyurethane (PUR) cables. They come with various standard cable length options from 0.5 to 15.0 meters.

TE Connectivity

8. High-power connector

The PQ50 Series connector, available in a lightweight plated plastic resin or a zinc die-cast shell, is rated up to 600 V. It has a 2-point contact design, which is beneficial when used in high-vibration industrial applications like robotics. The PQ50 Series is also suitable for precision processing machinery, nanotechnology manufacturing equipment, and wafer/LCD carrier machines. The PQ50 Series has an operating temperature range of -40 to +105°C and a rated current of 9 A per pin when all 20 pins are used or 19 A maximum in single-pin configurations.

Hirose

TECH FOCUS

PXI AND PCIe

PC-based standards on the front lines in ATE

The modular PXI and PCIe standards continue to meet today's needs for automated test and inspection equipment. In a January 2020 report, ResearchAndMarket.com stated, "In the long term, open and modular test solutions such as PXI will gain higher traction for meeting the gaps in testing needs for flexible and cost-efficient testing. Vendors will need to focus on addressing the need for high-volume, multisite, and high-parallelism testing needs while simultaneously lowering the overall testing cost for end users to achieve strong growth."

Below are some recent offerings in the PXI and PCIe arenas:

Mid-range imaging computer

Matrox Imaging has launched the Matrox Supersight Uno, an expandable mid-range industrial PC (IPC) in the Matrox Supersight series of vision controllers. With seven PCIe slots accepting full-height, full-length cards, Matrox Supersight Uno offers maximal I/O capabilities plus direct interfacing with GigE Vision and USB3 Vision cameras. The seven third-generation PCIe expansion slots in the Matrox Supersight Uno support the full range of expansion cards from one to 16 lanes. Supported expansion cards include Matrox Imaging frame grabbers—offering comprehensive support for standard camera and video interfaces such as Camera Link, CoaXPress, DisplayPort, HDMI, and SDI—and third-party boards including high-end graphics cards. An integrated motherboard delivers all the connectivity of the Matrox Supersight Solo, but at a lower price point. Enhanced system reliability and maintenance comes via quick-release, hot-swappable drive bays with RAID support. Moreover, this vision controller easily powers multiple expansion boards—with its robust 600 W power supply. With a durable steel construction and 4U rack-mount chassis, the Matrox Supersight Uno supports both horizontal and vertical mounting. Matrox Supersight Uno comes pre-installed with Microsoft Windows 10 IoT Enterprise 2019 and Matrox Imaging Library (MIL) software.

Matrox Imaging

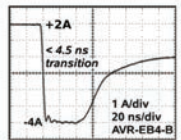
0.5-A large PXI matrix modules have up to 6,144 crosspoints

Pickering Interfaces has launched a new 0.5-A ultrahigh-density PXI matrix module family that delivers up to 6,144 crosspoints. With a switching density 39% higher than competing devices, the 40-558 allows a complete functional ATE system to be housed in a single 3U PXI chassis, and the integrated BRIC design saves on valuable chassis slots, compared to standard PXI matrix modules. Part of Pickering Interfaces' BRIC large PXI Matrices range, the new 40-558 modules are available in 2-, 4-, or 8-slot widths for matrix sizes between 64x16 and 1,008x6. The modules are fitted with ruthenium-sputtered reed relays—manufactured by sister company Pickering Electronics—which feature a long life with good low-level switching performance and contact resistance stability. Automatic isolation relay switching maximizes bandwidth and reliability. Spare relays are included with the module to facilitate easy maintenance with minimum downtime. The BRIC's internal high-performance screened analog backplane minimizes the complexity and cost of cable assemblies; Pickering has a range of standard cables available for the 40-558 and can construct custom cables for all its PXI modules. A choice of 6, 8, 12 and 16 pole analog bus widths and dual analog bus options are available.

Pickering Interfaces



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5G ROLLS INTO 2020

By Ken Cormier, Managing Editor

▶ The long-touted 5G revolution hasn't impacted the telecommunications industry as anticipated yet, but industry experts are saying that 2020 is the breakout year, as 5G-capable phones and networks become more available to consumers.

The seemingly sluggish splash that 5G has been making is vastly more energetic than the introduction of 4G a decade ago. According to Qualcomm, more than 40 mobile network providers inaugurated 5G service in 2019, in contrast with four providers launching 4G service during its first year.

T-Mobile came out with what it termed the first nationwide 5G network in December, and the other three of the Big Four are saying they will follow suit this year. 5G-accessible phone models are presently pricey—more than \$750—but are expected to be more modestly priced in the future. Of course, 5G, with its blazing data speeds and lower latency, isn't just about phones—it's about laptops, tablets, autonomous vehicles, the IoT, and “smart cities”¹ festooned with sensors.

Wireless telecom analyst Jeff Kagan said in an interview with Fox Business, “Smartphone purchases grow every year, and people use them more and more every

year. Now we're heading into 5G, then 6G, then 7G—it will keep getting faster and more convenient. We'll see more jobs, more wealth, more services for customers. ... 5G is moving into healthcare, automotive, retail—it's the core of an enormous growth engine that will continue to fuel the economy and worldwide.”²

Here are some recent news items on the subject:

New breed of startups stirring up the 5G antenna market

U.S. investment and leadership is an indication of taking a lead in mmWave 5G networks in terms of intellectual property, according to a press release by global tech market advisory firm ABI Research. The release states that “a new breed of startups and smaller companies may become serious contenders in the global patent war for the next wave of 5G networks.”

“Major innovation is happening across the market for 5G and cellular antennas as mobile operators start to focus on 5G, active antennas, and mmWave” said Dimitris Mavrakis, research director at ABI Research. “This means that incumbent infrastructure vendors and antenna

manufacturers may not be the key stakeholders for tomorrow's networks, or that merger and acquisition activity is imminent in the 5G antenna market.”

Several new startups in the cellular and 5G antenna listed by ABI Research include Airrays, Anokiwave, Artemis, Fractal Antennas, Fractus Antennas, Gapwaves, Maja Systems, Metawave, Movandi, Pabellon, Pivotal Commware, Ericsson with its Radio Stripes concept, and Satify. Some of them have pivoted to address the 5G space while new entrants are now addressing new types of innovation, mostly in the United States with mmWave.³

U.S. bill earmarks \$1 billion subsidy to spur 5G race

In January, a bipartisan group of national security senators introduced legislation to stimulate U.S. innovation in the race for 5G. The bill would provide more than \$1 billion to invest in alternatives to Chinese equipment providers Huawei and ZTE. Huawei claims to have shipped 6.9 million units of 5G smartphones as of December 2019.

“Every month that the U.S. does nothing, Huawei stands poised to become the cheapest, fastest, most ubiquitous global provider of 5G, while U.S. and Western companies and workers lose out on market share and jobs. Widespread adoption of 5G technology has the potential to unleash sweeping effects for the future of internet-connected devices, individual data security, and national security. It is imperative that Congress address the complex security and competitiveness challenges that Chinese-directed telecommunication companies pose,” said Sen. Mark R. Warner (D-VA), in a press release. “We need to move beyond observing the problem to providing alternatives for U.S. and foreign network operators.”⁴ EE

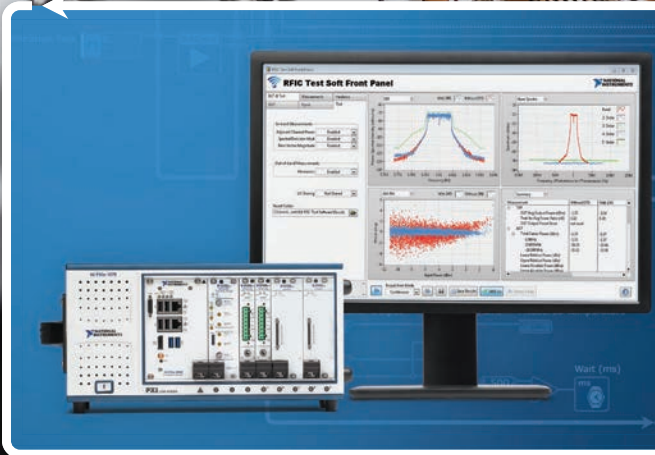
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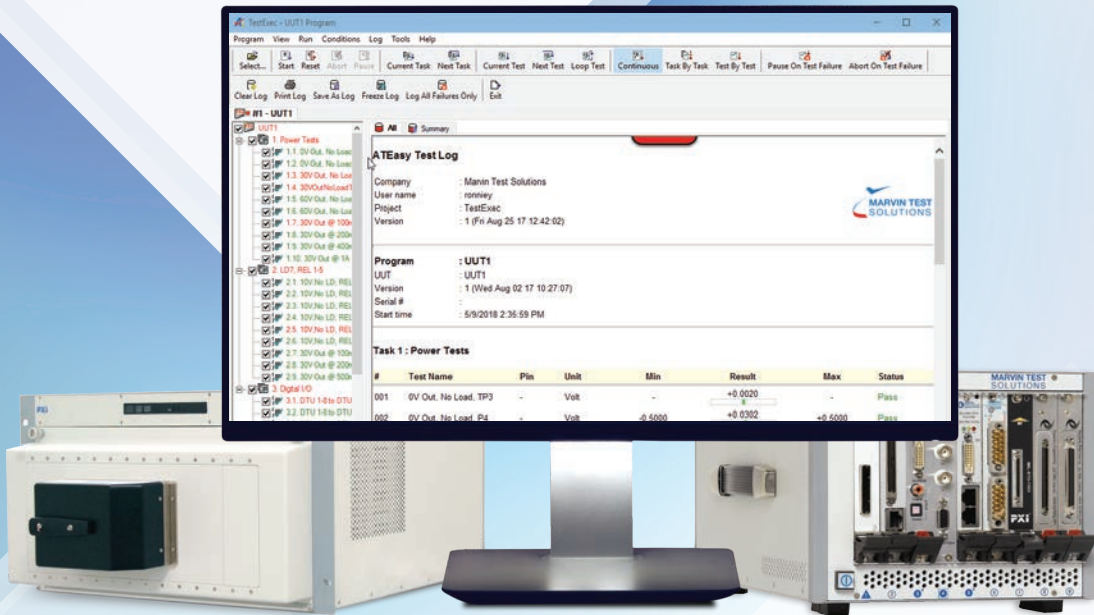
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