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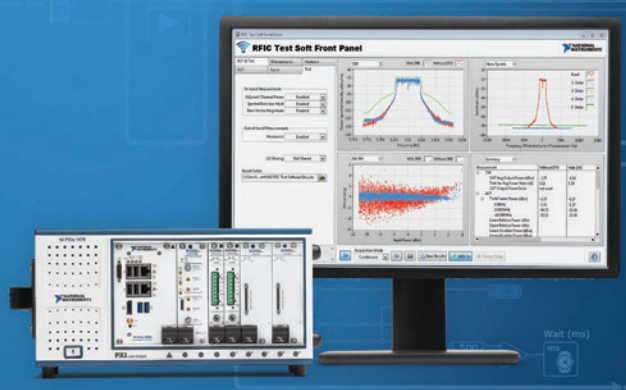

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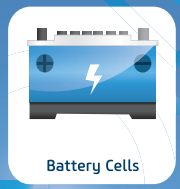
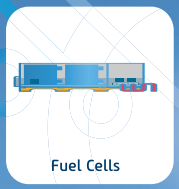

Battery Cells


Fuel Cells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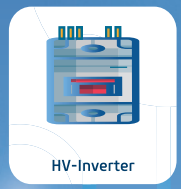
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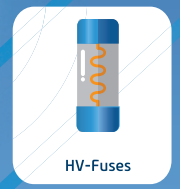
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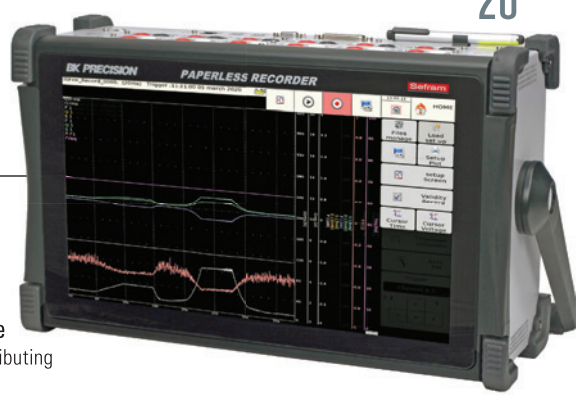

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EDITOR'S NOTE

HOW EXACT ARE THE LINES ON YOUR RULER?

Let me start by saying how pleased and proud I am to be joining the team here at Endeavor Business Media as the Editor of *Evaluation Engineering*. In one sense, you can call me the features editor, as I will be primarily responsible for obtaining and editing the contributions to this great publication. Rick Nelson will continue to handle our Special Reports as contributing technical editor, and managing editor Ken Cormier will still handle *EE*'s press releases.

Evaluation Engineering is not just the name of our publication, but also a way to describe the industry space we serve. In one sense, evaluation is the most critical of all engineering disciplines, as one cannot address an application space without examining it first. One cannot create a design without knowing the physical, mechanical, and electrical parameters of the system being served, and the solution you wish to create.

There is no precision without feedback. In every endeavor, regardless of the nature of the task at hand, accuracy is paramount. Even the basic act of eating cannot be performed if you miss your mouth with the fork. There are some who claim "eyeballing" is an accurate means of calibrating something, not recognizing their trained experience in determining a situation is a validation of the philosophy involved.

Once you establish that measuring things is important, the focus then shifts to the accuracy of the measurement. Information is useless unless it is placed in the proper context, and can be trusted in its stated precision. You may only have lines every foot on your ruler, but if they are exactly placed, that ruler is more useful than one that may have more regular, but less accurate, markings. Unless you can trust the precision of your measurement, it is almost useless.

This applies to all aspects of design. One of the new paradigms is the convergent nature of technology today. There is almost no solution in existence today that doesn't integrate multiple core technologies. with mechanical, electrical, and electronic systems being used in concert. Every aspect of a design is critical today, with no wiggle room in any aspect. Efficiency, power density, form factor, and solution footprint are all important factors today.

What this means to the engineering community is that all parameters are important, and that means all parameters must be measured. This is one of the greatest pressures on the engineer, in that whatever measurement technology and methodology you use, it has to be better than the system(s) you are testing. In order to measure the accuracy of anything, you have to have a greater resolution than the device being measured. The lines on your ruler have to be closer together and more precisely placed than the lines on the ruler you are validating. This means the test community has to stay at least one step ahead of the design engineer.

In the real world, that means you have to have tighter tolerances, faster capture, larger samples, and more memory than anything you expect to encounter in your endeavors. Lasers, mechanical and electronic probes, and other measurement systems must operate and perform at optimum to stay ahead of the rapidly-developing technologies that are creating the creative disruptive design environment we face today.

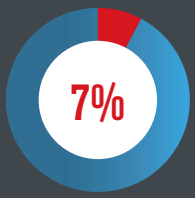
Looking forward, I am very much looking forward to continuing to serve the engineering community as part of the team here at *Evaluation Engineering*. We welcome your input, contributions, and ideas, and extend a warm welcome to anyone who wants to participate in our community. We will continue to serve you to the best of our ability, and I take pleasure and pride in my role in helping achieve that goal. EE

Alix Paultre,
Editor

BY THE NUMBERS

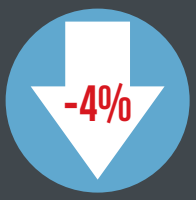
59.8 BILLION

Global semiconductor equipment sales in 2019

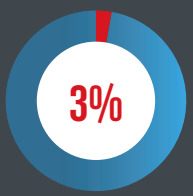


Decrease in semiconductor equipment sales over 2018

Source: SEMI



Forecast for global IC market growth for 2020

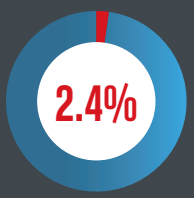


Decline for total IC unit shipments this year

Source: IC Insights

35.4 BILLION

Worldwide sales of semiconductors in February 2020



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

Source: SIA

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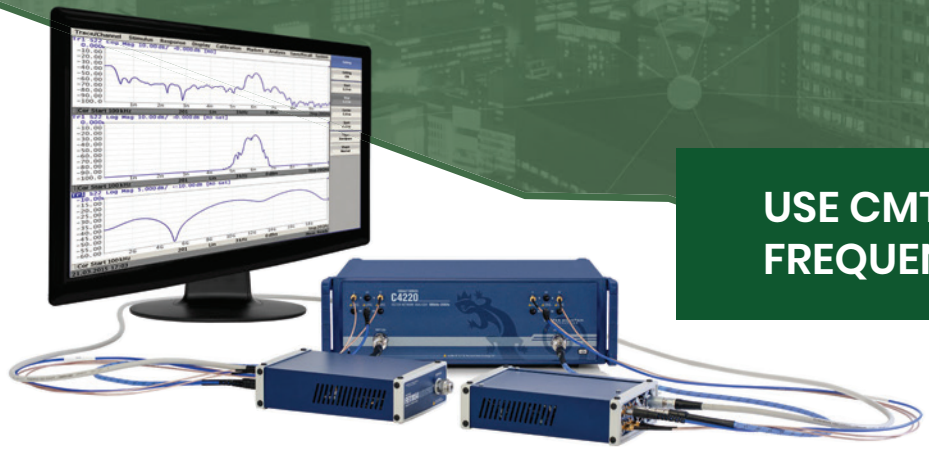

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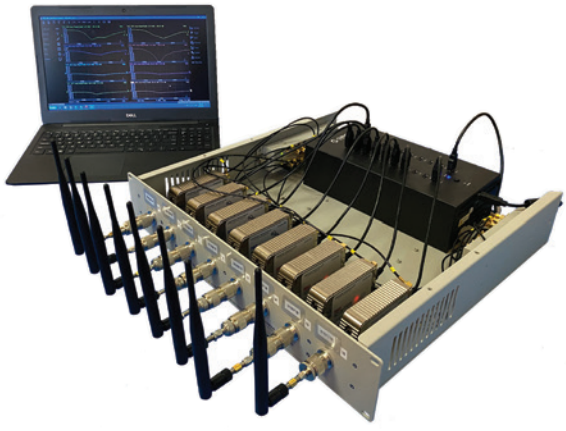

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INDUSTRY

REPORT

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Measuring COVID-19's impact on the world's supply chains

While COVID-19 pummels the world's supply chains, groups like the Institute of Supply Management (ISM) are trying to wrap their arms around the short- and long-term impacts.

ISM looked specifically at the business and supply chain impacts and found that nearly 75% of companies are already reporting disruptions in some capacity due to coronavirus-related transportation restrictions.

More than 80% believe their organizations will experience some impact because of COVID-19 disruptions. Of those companies, ISM says that one in six (16%) report adjusting revenue targets downward an average of 5.6% due to the coronavirus.

"The story the data tells is that companies are faced with a lengthy recovery to normal operations in the wake of the virus outbreak," said ISM CEO Thomas W. Derry in a press release.

"For a majority of U.S. businesses," Derry continued, "lead times have doubled, and that shortage is compounded by the shortage of air and ocean freight options to move product to the United States—even if they can get orders filled."

Tracking Key Procurement Trends

Breaking down the results of its survey, ISM says these key trends emerged:

- 57% of firms noted longer lead times for Tier 1, China-sourced components, with average lead times more than doubling compared to the end of 2019.
- Manufacturers in China report operating at 50% capacity and with 56% of their normal staff numbers.
- Over 44% of respondents *do not* have a plan in place to address supply disruption from China.
- Of those, 23% of companies report current disruptions.
- Of the companies expecting supply chain impacts, the severity anticipated increases after the first quarter of 2020.
- Six in 10 (62%) respondents are experiencing delays in receiving orders from China.
- More than half (53%) are having difficulty getting supply chain information from China.
- Nearly one-half of companies surveyed are experiencing delays moving goods within China (48%).
- Almost one-half (46%) report delays loading goods at Chinese ports.

Stay Tuned for More

Conducted between Feb. 22 and March 5, ISM's survey was based on 628 respondents largely representing U.S. manufacturing (52%) and non-manufacturing (48%) organizations, 81% of which have revenues of less than $10 billion (USD). Respondent roles range from emerging practitioner (4%), to chief procurement officer (6%), with 73% being experienced practitioners, managers and directors in a supply chain management role.

Texas Instruments Plans to Build Up Inventory as Uncertainty Looms

Texas Instruments in April reported sales and profits on the high end of its quarterly forecasts, buoyed by customers building up inventory to protect against delays in supply stemming from the coronavirus outbreak.

Rich Templeton, Texas Instruments' chief executive officer, said on a conference call that it plans to maintain production at about the same level as the beginning of the year even as customers become more cautious. He said its spending on research and development would remain unchanged. The company also plans to push ahead with billions of dollars of investment in a new analog production plant under construction in Richardson, Texas.

Templeton said it has mostly been business as usual for Texas Instruments despite some unforeseen disruptions to its production and supply lines. He said the company has been rolling out parts to customers with short, stable lead times. Texas Instruments is taking advantage of its vast manufacturing operations to package and test its final components in-house instead of sending them out to contractors in China, Europe, or Southeast Asia.

Texas Instruments said sales slipped 7% to $3.33 billion in the first quarter of 2020, on the high end of its guidance of $3.12 billion to $3.38 billion. Profits dipped slightly from $1.22 billion or $1.26 per share a year ago to $1.17 billion or $1.24 a share. Texas Instruments' core analog semiconductor business slipped by only around 2% over the last year, while chips sold to customers in embedded plunged 18% from a year ago, the company said.

Texas Instruments, which tends to report results ahead of other chip manufacturers, said that it widened the range of its revenue forecast to reflect the worsening uncertainty and deepening panic in the population. Profits are projected to be between $0.64 and $1.04 a share in the second quarter of 2020, down from $1.36 a share a year ago. It also predicts revenue in the range of $2.61 billion to $3.19 billion, dipping from $3.67 billion a year ago.

Ball Aerospace Completes CDR for Space Force's Weather Satellite

By concluding its critical design review (CDR) of the U.S. Space Force's Weather System Follow-on (WSF) satellite, Ball Aerospace is now entering into the full production phase of producing the advanced satellite system. The firm is building the satellite for the U.S. Space Force Space and Missile Systems Center (SMC). The next-generation operational environmental satellite system will provide environmental intelligence to military operations as needed.

"Measuring and understanding the physical environment is critical to military operations, from determining tropical cyclone intensity for asset protection and maneuver operations to how wind and sea state play into assured access and aircraft carrier operations," said Mark Healy, vice president and general manager for National Defense at Ball Aerospace.

The WSF is meant to provide the U.S. Department of Defense with environment intelligence it may not be receiving from Space-Based Environmental Monitoring (SBEM) sources, including ocean surface vector winds and low-earth-orbit (LEO) charged energy particles. The WSF will also help to monitor sea ice characterization, soil moisture and snow depth. Ball Aerospace is the prime contractor for the program and is responsible for developing instrumentation, spacecraft and system software, and the algorithms for the data products and delivering them to the SMC.

This AEHF-6 military communications satellite was launched at Cape Canaveral Air Force Station to join the collection of spacecrafts, including the Weather System Follow-on WSF satellite.

United Launch Alliance

FCC Opens 6-GHz Band to Wi-FiTop of Form

The Federal Communications Commission (FCC) has adopted rules that make 1200 MHz of spectrum in the 6-GHz band (5.925–7.125 GHz) available for unlicensed use. These new rules will usher in Wi-Fi 6, the next generation of Wi-Fi, and play a major role in the growth of the Internet of Things. Wi-Fi 6 will be over 2.5X faster than the current standard and deliver improved performance. Opening the 6-GHz band for unlicensed use will also increase the amount of spectrum available for Wi-Fi by nearly a factor of five and help improve rural connectivity.

The 6 GHz band is currently populated by, among others, microwave services that are used to support utilities, public safety, and wireless backhaul. Unlicensed devices will share this spectrum with incumbent licensed services

The Report and Order authorizes indoor low-power operations over the full 1200 MHz and standard-power devices in 850 MHz of the 6 GHz band. An automated frequency coordination system will prevent standard power access points from operating where they could cause interference to incumbent services.

The Further Notice of Proposed Rulemaking seeks comment on a proposal to permit very low-power devices to operate across the 6-GHz band to support high data-rate applications including high-performance, wearable, augmented-reality, and virtual-reality devices. The notice also seeks comment on increasing the power at which low-power indoor access points may operate. EE

Giga-tronics AXIe system for a radar application.

SPECIAL REPORT

LEVERAGING MODULARITY

FROM MEASUREMENT HARDWARE TO DFT SOFTWARE

By Rick Nelson, Contributing Technical Editor

The term "modular" in the context of electronics test and measurement suggests industry-standard architectures like AXIe, PXI, or VXI, which define physical and electrical specifications for modular instruments and chassis. LXI relaxes the physical constraints but lets you interconnect your choice of electrically compatible instruments and compute resources. Similarly, USB configurations allow you to take a modular approach to selecting interconnectable measurement units and computers.

Many manufacturers are continuing to innovate on these platforms, yet others are pursuing proprietary modular approaches. The concept of modularity can extend from instrumentation all the way to design-for-test software, where a hierarchical approach creates retargetable test functionality.

Giga-tronics supports AXIe with its Advanced Signal Generation and Analysis Platform, according to John Regazzi, CEO, and Dan Kirby, vice president of business development. "Modular platforms are primarily advantageous in applications requiring multiple stimulus and measurement channels," they said. "For example, simulating the many radar and EW signals experienced in a modern battlespace usually requires many signal generators. Stacking separate benchtop units not only takes up valuable rack space, but coordinating their behavior to generate multiple emitters often requires additional hardware to phase-lock their signals together."

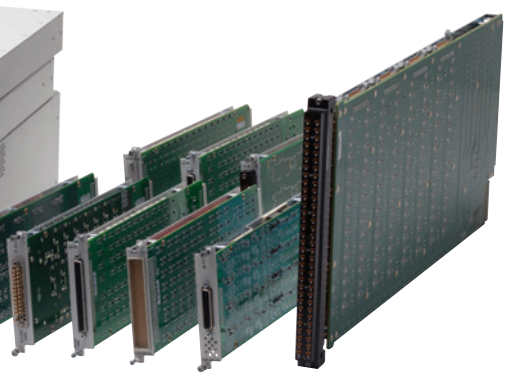
They noted that with the Giga-tronics AXIe platform, each signal generator is a blade that slides into a chassis that includes the infrastructure to share reference and control signals, thereby simplifying the job of simulating many emitters. "One nice thing about the AXIe platform is that the standard has a provision for a customizable section of the backplane, which allows a supplier to add specific capability for enhancing their offering's functionality," they added.

AMETEK VTI Instruments EX1200 modular test family.

Chris Gibson, senior product manager, VTI Instruments, a product line in AMETEK's Programmable Power business unit, defined "modular test" as the capability to integrate source, measure, and switching instrumentation modules through a backplane into a single mainframe. "Modular systems offer more flexibility and interchangeability to select a wide range of instrumentation in a much more compact footprint than a system of conventional stand-alone instruments," he said. "Direct connection of modules to a common backplane enhances synchronization and communication speeds between modules compared with systems configured with independent instruments."

Gibson elaborated on the three different modular test instrument platforms that VTI offers. "The VXI platform provides large-sized modules for high-performance, high-density testing, typically in mission-critical, military/aerospace applications," he said, adding that VTI's VXI modules are individually shielded to maintain signal quality.

Gibson said the LXI platform provides a way to interface to external controllers and workstations through the LAN interface. Because the platform does not have dimensional requirements, the platform can be more cost-efficient while offering high-density and flexibility for switching modules, he explained. "VTI LXI mainframes have an analog backplane for direct, internal connection of multiplexed signals to a measurement instrument, such as a 6½-digit digital multimeter," he said. "The analog backplane maximizes signal integrity through the system and eliminates external wiring between switching modules and a DMM."



Gibson said that with the PXIe platform, modules can communicate with the backplane at up to 2 GB/s, explaining that PXIe is suited for medium- to high-density automated test and data-acquisition systems.

"Modular test generally defines a capability in which measurement, stimulus and switching functions specific to a test application requirement can be plugged into the backplane of a chassis or mainframe," said Bob Stasonis, technical product specialist at Pickering Interfaces. "Modular also implies that these plug-ins are easily accessible by the end user (easy to insert, easy to remove) to allow for simple and fast maintenance."

Stasonis said modular test platforms have been around for more than 30 years. Some are proprietary, where only one supplier's modules can fit into the chassis. In contrast, open standards such as PXI allow vendor interoperability, meaning any vendor's PXI modules can plug into any vendor's PXI chassis.

Proprietary modular platforms give the supplier more flexibility to tailor mechanical and performance characteristics that are specific to their offering, whereas open platforms such as PXI offer a broader range of instrumentation, giving the end user more flexibility in creating a modular test system, Stasonis said.

Craig Hughes, senior manager, instruments, Astronics Test Systems (ATS), defined a modular test architecture as an adaptable design that can add or remove functions by hardware and/or software methods, allowing designers to configure a system to their needs. "When the architecture is based on COTS components and standardized interfaces such as LXI, PXI, USB, and VXI, the designer is afforded additional choices, increased availability, and lower obsolescence risks," he said. "Furthermore, ATS utilizes a synthetic instrumentation (SI) architecture wherever possible."

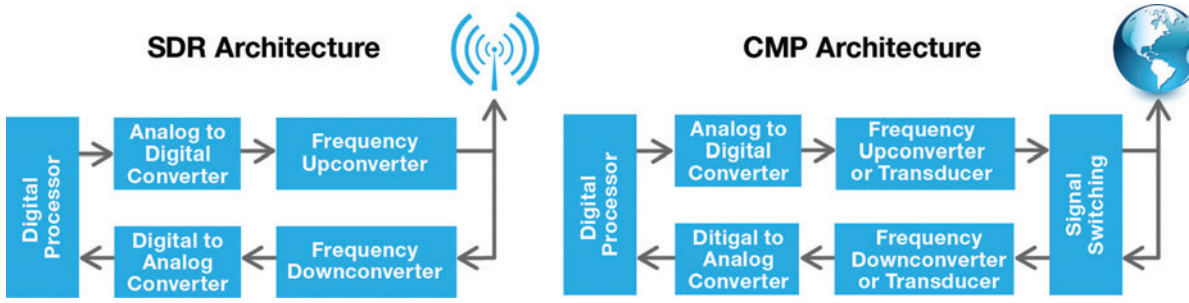
"Modular test typically refers to a class of switching and instrument solutions that require an external chassis to function; the chassis provides power, a high-speed backplane for communications and timing, and a controller," said Jon Semancik, director of marketing at Marvin Test Solutions (MTS). "Rack-and-stack instruments, on the other hand, integrate the desired functionality in a standalone enclosure that typically only requires line power and a communications interface."

Semancik said MTS designs and manufactures PXI-based instrumentation and switching cards, in both 3U and 6U form factors, with products offered with PXI and PXIe interfaces. "PXI is the most widely adopted modular test architecture in the industry, scalable from smaller benchtop applications to large multibay test systems," he said. "The ability to mix and match 3U and 6U devices in a single combination chassis is also a major advantage.

"We define modular tests as a combination of a wide choice of different hardware components on common buses and a universal software API to access these," said Oliver Rovini, technical director at SPECTRUM Instrumentation. "SPECTRUM supports the PCIe, PXIe, and LXI platform."

Each has its own advantages, according to Rovini. "PCIe is common and can be found in nearly every PC system; therefore, it's easy scalable from small low-cost systems to high-end server systems with massive GPU processing," he said. "PXIe

▼ Astronics Test Systems ATS-3100 PXI integration platform.



VIAVI Solutions CMP architecture compared with an SDR architecture.

offers a mechanical, stable industry platform but has a higher system cost. LXI instruments are easiest to integrate as they are based on Ethernet connection and can be operated in any network, remotely or directly from a laptop."

Mark Pickard, product management director at VIAVI Solutions, said, "Modular test is a paradigm that offers hardware and software components that can be configured into customized solutions to meet specific customer test needs. These modular solutions can be modified and scaled to evolve along with the customer's test requirements."

VIAVI Solutions offers the Configurable Modular Platform (CMP), which includes modular products based on AXIe. "Similar to other modular standards, such as PXI, AXIe consolidates common infrastructure components into a card-slot chassis," said Pickard. "The chassis provides common infrastructure needed for each module, including power, cooling, data transport, and triggering....AXIe is well suited for high-performance applications, providing more physical real estate, higher power handling, and higher data bandwidth compared to other modular standards, such as PXI. These enhancements make AXIe the perfect platform for applications such as high-performance RF and high-bandwidth signal generation and acquisition."

Subbaiah Pemmaiah, application engineer, Copper Mountain Technologies (CMT), commented that increased test complexity is driving the need for flexible test instruments for lab, production, and field test environments. "These instruments need to be easily maintainable, have fewer potential points of failure, have adequate memory storage space, be inexpensive, and yet produce fast, accurate, and reliable measurements," he said.

To meet these requirements, CMT introduced USB vector network analyzers for which the measurement module is separated from the processing module. "USB VNAs bring the measurement data to any external Windows or Linux PC using the VNA software," Pemmaiah explained. "All data manipulation (except for digitization) and control occurs on the external PC."

"For Keithley, modular architecture is all about flexibility in both the testing an engineer is able to perform with our products and in the ways they can perform those tests," said Brad Odhner, technical marketing manager. "Many customers come to us knowing they want to eventually expand manufacturing capabilities or R&D functionality. These customers want the ability to purchase part of a system now and expand it later."

Keithley offers several interface options. "Our modern instruments support all the basics—USB, LAN, GPIB, etc.—and most support LXI control with their own webpages for simple remote capabilities," Odhner said. "However, our go-to architecture is Keithley's Test Script Processor (TSP). TSP is an aspect of our instruments' firmware that allows the execution of code written by the user, similar to how one might program an Arduino." TSP includes an extensible communication bus called TSP-Link, which allows Keithley's instruments to send commands and share data. "In this way, our customers can create 'mainframe-less networks' of instruments that can be seamlessly expanded," he said.

"Newark offers two main types of modular test products: software-based and hardware-based modular architectures," said Maureen Lipps, product manager. "Many modular test architectures are a combination of both hardware and software."

Lipps said software-based modular architectures usually consist of one piece of test equipment with all the features built into the hardware. "A customer can add or later purchase a software package or bundle which activates each of the extra features that they need," she said. "The advantages of software modules are that initial costs are minimal, the system can be designed for specific needs, and it can be upgraded immediately with a key code or download." However, she said, future upgrades are limited by initial hardware setup.

"Hardware-defined modular test products consist of a mainframe or chassis base unit which usually consists of a power supply, bus communication, and a reference clock along with slots for hardware modules for various test operations," Lipps continued. Hardware modules are usually plug-and-play and are flexible. "As with software architectures, the initial costs can be minimal and can be configured for specific needs," she said.

According to Christian Fischer, senior director, product management, T&M systems and projects at Rohde & Schwarz, a modular test platform allows the configuration of a tester by different hardware modules to meet a specific application. "This configuration and exchange of modules is very easy and can be performed also by the end-user," he said. "This means one tester can be configured for different applications without the need to change to a different tester. Functionality which is not needed can be removed"—thereby achieving minimum cost and footprint.

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Nicholas Piotrowski, product manager at Ikonix USA, defined "modular test" as a test setup that allows the user to add test points to the system to expand production and/or capability. He cited several modular architectures the company supports, including the OMNIA II 8204/54 Series electrical safety compliance analyzer from the company's Associated Research Division in combination with the 620L LineCHEK II leakage tester. "The OMNIA II 8204/54 allows for ground-bond, AC/DC-hipot, and insulation-resistance testing," he said. "The addition of the 620L expands the electrical safety testing capability to include LCT (leakage current testing) to test leakage current in product insulation while the device is operating."

▲ Ikonix Associated Research OMNIA II Series electrical safety compliance analyzer.

Piotrowski also described the company's SC6540 scanning matrix as "completely modular," offering eight to 16 channels for multipoint ground bond and/or hipot testing. "A master module can be linked with up to four slave modules to get up to 80 channels," he said. "Any number of masters can be added to the system for an infinite number of test points if need be."

Vitrek applies the concept of modularity to its power analyzers, such as the Model PA900. "Many applications require the use of multiple PAs to accomplish the task at hand," said Chad Clark, Vitrek's VP of sales and marketing. "For example, testing the efficiency of a power-conversion system along with studying parameters like input power factor and output harmonics would require two analyzers—one for the input and one for the output. As another example, fully characterizing a double-conversion UPS requires three PAs—one for the input, one for the battery charge/discharge section, and one for the output. While nearly all PAs provide versions that can handle either single-phase or multiple-phase inputs, Vitrek's modular approach integrates separate PAs into a single instrument. Vitrek calls this approach VPA. The VPA (for "Virtual Power Analyzer") turns each channel in the instrument into an individual PA channel. Channels can be combined, enabling a single device in some applications to perform the work of multiple instruments."

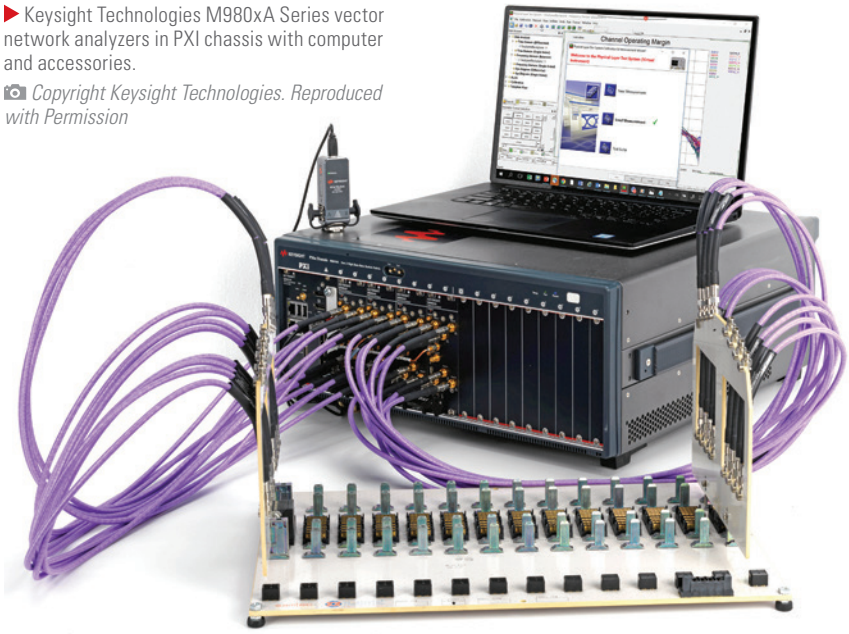
◀ Vitrek Model PA900 power analyzers.

Design for test

Jay Jahangiri, product manager, Tessent ATPG and compression products for Mentor, a Siemens Business, addressed modularity with respect to the company's Tessent family of semiconductor design-for test software products. "In the context of DFT used by chip designers, modular test refers to the approach of segmenting the design into smaller modules for DFT," he said. "Similar to the divide-and-conquer approach of tester instruments, the chip design is broken down to allow performing DFT tasks such as test logic insertion and pattern generation on smaller portions of the design."

Jahangiri said that historically modular test referred to performing DFT at lower design levels (or cores), but often work was done from the chip level, which still required the entire chip design to be loaded into the tools. "Today's 'modular test' is better described as 'hierarchical test,' which is the practice of inserting test logic and creating retargetable test at lower design levels and being able to verify and sign off all DFT work early in the design flow," he said, adding that the approach allows for DFT work to be performed on cores concurrently and much earlier than when the full chip-level design becomes available.

"In addition to improvements in implementation, hierarchical DFT provides significant reduction in pattern count and test time, diagnosis costs, machine resources, and more," Jahangiri said. "Furthermore, an optimal hierarchical DFT flow takes DFT out of the critical path and is able to easily handle late-stage design changes (ECOs)."



Keysight Technologies M980xA Series vector network analyzers in PXI chassis with computer and accessories.

Modular hardware

Specific modular products include Keysight Technologies' E5080B, P50xxA, and M980xA Series vector network analyzers, which come in benchtop, USB, and PXI formfactors, respectively. These analyzers combine built-in pulse generators and modulators and perform spectrum analysis and time-domain analysis in a single instrument to fully characterize modern devices without the need for additional test hardware. Offering frequency ranges from 9 kHz to 4.5/6.5/9/14/20 GHz and 100 kHz to 26.5/32/44/53 GHz, the instruments simplify and reduce the number of parts in a test setup, accelerate test times and improve throughput with automated setup, and enhance accuracy by eliminating loss from extra connectors and external switches. In addition, customers can adapt their hardware to meet future test requirements. Application software supports automatic fixture removal, time-domain and spectrum analysis, basic pulsed-RF measurements, and gain-compression measurements.

Gibson at VTI described several of the company's modular products. The EX1200-3604 and EX1200-3608 LXI modules are 4- and 8-channel isolated DACs with 200-VDC and 200-VAC peak isolation; the EX1200-7416 LXI comparator module enables the capture of signals as narrow as 1 μs for detection of glitches; the EX1200-7008 LXI RTD simulator simulates up to eight RTD sensors for testing and calibrating an RTD-based temperature monitoring system; the EX1200-7600 LXI programmable load module presents resistances from 0.5 Ω to 1.5 MΩ, which can be used both to test power sources and to calibrate test sources; the EX1214-ICA LXI mainframe (with an integrated test adaptor) eliminates cabling between the DUT and the test modules; and the EX1200 LXI switch modules enable users to define switch-closure configurations that cannot be enabled to avoid creating switch paths that can cause damage to the system or to the DUT.

"VTI's goal is to maximize the life of its modular products for all customers," Gibson said. "VTI supports all modular instrument standards for interoperability, and software drivers provide the flexibility to work with any test software on any operating system."

Stasonis said Pickering Interfaces is known for its selection of switching and simulation products in the PXI formfactor. "To address newer market demands, we have created a line of modular chassis that are controlled by either LXI/Ethernet or USB and can accept virtually any of Pickering's range of PXI switching and simulation modules," he said. "This chassis range goes from two slots to 17 slots." These chassis serve applications that need a few extra slots of switching as well as remote switching-only applications, they simplify interfacing with a PC controller, and they can isolate electrically noisy switching from instrumentation, he added.

"We have also created switching systems based on LXI/Ethernet and USB control with a proprietary modular design that has certain advantages over PXI in specific applications," Stasonis continued. "The advantages include larger PCB real estate for very dense switching, internal backplane buses for easy expansion of a matrix, and higher DC power to control more relays simultaneously."

Hughes at Astronics Test Systems said the company offers chassis, instruments, switching subsystems, and integrated systems using modular architectures such as AXIe, LXI, PXI, and VXI. "In addition, we provide configurable and modular test system solutions," he said. Specific

Pickering Interfaces modular chassis family.

products include the ATS-3100 PXI integration platform for system development, the PXIe-6943 32-channel pattern-based digital stimulus/response instrument, the PXIe-2461 2-channel, universal 235-MHz frequency and time interval/counter, the PXIe-1803 130/180-MS/s dual channel PXI Express digitizer, the PXIe-3352 PXI rubidium standard (which combines a rubidium oscillator with a GPS receiver), the PXIe-1209 fully programmable dual pulse generator, and the PXIe-1802 2-channel AWG.

In addition, Hugues said, the company offers an RF and digital switching product line, including ASCOR switching products, CTS-6000 Series communications testers, and the ATS-6100 wire fault tester. Astronics also sells the Tabor product line, including the new Proteus arbitrary waveform transceivers, he added.

According to Semancik at Marvin Test Solutions, the company offers an array of 3U and 6U switching and instrumentation cards as well as chassis and controllers. He described several of these, saying that the GX6xxx Series includes a range of 3U PXI switch cards; the GX5960 Series digital subsystem addresses both legacy and next-generation digital test needs, offering a 125-MHz vector rate with timing per pin; the GX3700e user configurable FPGA-based 3U PXI Express card offers 160 digital I/O signals and employs an Altera Stratix III FPGA; the GX3104 PXI source-measure unit (SMU) forces and senses both voltage and current over a range of ±20 V; the GX2065 DMM features 6½ digit resolution and up to 3,500 reading per second; and the GTX22x0 PXI universal time interval counters offer many of the functions of high-end stand-alone frequency counters.

Semancik also said that the GX7016 GENASYS switching subsystem features a compact footprint and the option to support both switching and instrumentation resources within a single PXI chassis. An integrated MAC Panel SCOUT receiver provides a "cable-less" receiver interface, eliminating thousands of wires.

Hartmann Electronic supports PXI and PXIe, focusing on high-speed backplane technology and offering chassis for modular test systems, according to Frank Godulla, CEO. "Our new LMH000792 PXIe chassis offers six slots in a horizontal arrangement by occupying only 1U rack space. With four of the six slots being configured as hybrid PXI/PXIe, the chassis can be used for both PXI as well as PXIe instruments," he said, adding that the chassis is capable of 40 W/slot and can operate in an ambient temperature range of -25°C to 70°C. He also said the company provides an installation package for the PXIe chassis to allow automatic detection by the National Instruments Measurement and Automation Explorer.

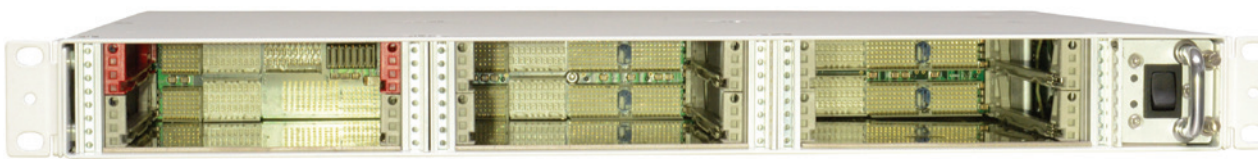
▲ Marvin Test Solutions GX7016 GENASYS switching subsystem with integrated MAC Panel SCOUT receiver.

▼ Rohde & Schwarz R&S CompactTSVP Test System Versatile Platform.

According to Fischer, "Rohde & Schwarz offers the modular platform R&S CompactTSVP, which is based on PXI, but with a lot of additional features not covered by the standard PXI." It includes modules for analog test, digital test, and in-circuit test, with switching modules from 1 A up to 50 A. "All measurement modules are floating," he said, adding that third-party PXI modules can be integrated into the R&S CompactTSVP by means of an additional 6-slot 1U chassis extension. "A specific mass interconnect interface from Virginia Panel allows direct connection of the receiver to the R&S CompactTSVP modules without any additional cabling," he added.

Rovini at SPECTRUM said the company has focused on fast and high-resolution digitizers and AWGs. "Their sampling speed ranges from 1 MS/s to 5 GS/s," he said. Key products include PCIe cards with one to eight channels, which could be combined to build extended systems with more than 100 synchronous channels. Growing in popularity are the company's standalone Ethernet/LXI-boxes. "The mobile versions, which contain up to two of our PCIe cards, are a key product

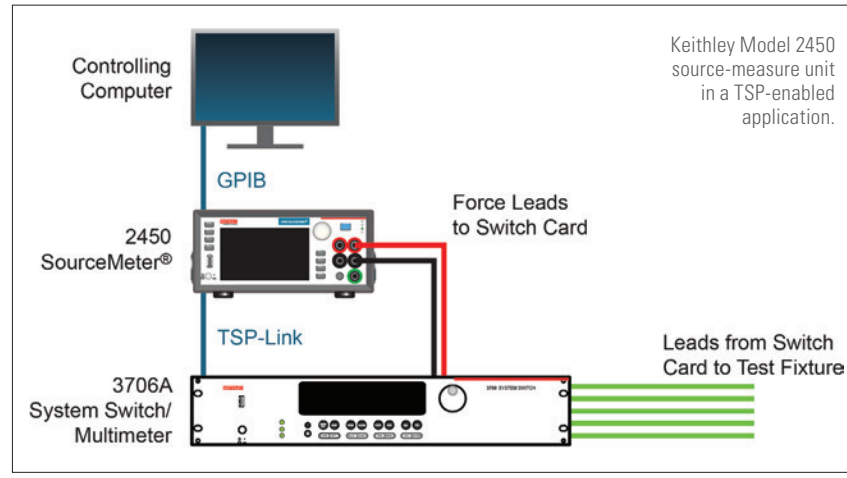
▼ Hartmann Electronic 1U 6-slot PXIe chassis.



line now," he said. "The rack versions with up to six PCIe cards and up to 48 channels are chosen for situations where multiple signals—for example, from arrays of sensors, transducers, or antennas—need to be acquired and analyzed in an uncomplicated way."

Lipps at Newark described several modular products the company offers. "The Keysight U2781A USB modular instrument chassis is a high-performance 4U chassis that comes with a 200-W universal AC power supply and a built-in protection circuit," she said. "This portable chassis can house up to six Keysight USB modular products. This chassis supports Keysight USB modular data acquisition (DAQ) and USB modular instruments (digital multimeter, arbitrary waveform generator, oscilloscope and source measure unit)."

Newark also offers the Keithley Integra 2750 DMM/data-acquisition/datalogging system with GPIB and RS-232 interfaces, she said, adding, "The Keithley 2750 combines the functions of a DMM, switch system and datalogger with five slots for modular plug-ins. Users have a choice of 12 switch/control modules including RF modules and multiplexers."



Keithley Model 2450 source-measure unit in a TSP-enabled application.

In addition, Newark offers the B&K Precision MDL001 modular DC electronic load. "The MDL001 is a multichannel modular electronic-load system which provides four slots for various DC loads," she said. "B&K and Newark offer a choice of seven different modules of programmable DC loads ranging in power from 200 W to 600 W, providing users the flexibility to test a wide range of power sources."

She added that Newark offers software-upgradeable instruments, including the Tektronix MDO3000 Series oscilloscope (which offers software modules/upgrades to add an arbitrary function generator, logic analyzer, and serial protocol trigger and analysis capability) and Rhode & Schwarz FPC1500 spectrum analyzer (for which key-code options can unlock up to 3-GHz performance).

According to Odhner at Keithley, "We currently lean towards the discrete instrument side of modularity. We often find that chassis-based systems are confusing and cumbersome to the large portion of engineers that don't operate their equipment exclusively over a remote interface." He added that for Keithley instruments that support TSP, such as the Model 2450 source-measure unit, customers get the benefits of a single-box instrument plus the speed and synchronization of a modular system.

"That said, we do offer several instruments that take qualities from chassis-based instruments," he continued. "The Keithley 4200A-SCS, for example, is a parameter analyzer with nine customizable instrument slots for current-voltage (I-V), capacitance-voltage (C-V), and ultra-fast pulsed I-V instruments."

Jim Shaw, Diversified Technical Systems' director of sales and marketing, said, "DTS manufactures the smallest, most rugged, modular data-acquisition systems on the planet. DTS DAQ can be positioned on or in small test articles without altering test dynamics. User-configurable SLICE data recorders are designed to be embedded close to the point of interest, reducing complex and costly sensor wiring and improving measurement quality." He added that DTS modular instrumentation offers dynamic measurement capabilities including acceleration, shock, vibration, and angular rate. Shaw added that DTS miniature SLICE DAQ can be integrated with other modular architectures via an API or run out of the box using DTS software.

Pemmaiah at Copper Mountain Technologies said all his company's VNAs are USB-based metrology-grade instruments. "Our 2-port Compact Series and 1-Port Series network analyzers deliver lab-grade performance despite being very compact in size. The patented 1-Port VNA can even be directly connected to an antenna or other DUT without the need of a test cable," he said.

AXIe products

Addressing AXIe, Giga-tronics offers an upconverter and downconverter for building test solutions used in the evaluation of radar and EW systems. "These converters cover 100 MHz to 20 GHz with 1 GHz of instantaneous bandwidth; they switch frequencies phase coherently in under 1 ms and offer low phase noise, harmonics, and spurs," said Regazzi and Kirby. "The company also offers two AXIe-compliant chassis—a 4U size handling two channels and a 7U version that can house up to four separate converter blades. It's possible to mix and match up- and downconverters within the same chassis."

They continued, "To assist in the coordination and phase stability between channels, Giga-tronics produced a separate frequency reference module that supplies reference signals to each converter blade and allows tying multiple chassis together for larger systems. This reference module takes advantage of AXIe's Zone3 provision within the standard and shares its reference signals across the backplane eliminating a patchwork of cables on the front panel."

Regazzi and Kirby emphasized Giga-tronics' converter approach to signal generation and analysis. "For example, rather than creating a traditional signal generator and post modulating the output, the company chose to build a converter that allows modulation at the IF," they said. "This means the modulator needs only operate at one frequency and simplifies optimizing performance over a wide instantaneous bandwidth. And because of advances in ADC and DAC technology, the digital portion of the solution can now be directly provided at the IF from digital cards plugged into open PCIe slots within a standard PC workstation." The cost-effective COTS approach, they added, allows customers to upgrade as technology improves, permits customers to add their own IP and other third-party hardware, and makes for easier servicing of the resulting test system. "Delivering the RF blades in a modular format is the best approach for the target market due to the need for multiple channels of stimulus and measurement," they concluded.

According to Pickard at VIAVI Solutions, "The CMP provides a highly scalable computing, signal-processing, and automation framework. Its modular hardware and component-based software support rapidly tailored solutions that are easily upgradeable and reconfigurable. Utilizing the Software Communications Architecture (SCA) and modern 'real-time' CORBA, it scales from embedded single-processor systems up through fully distributed heterogeneous systems of various CPU, FPGA, GPU, and DSP assets running multiple operating systems and communicating over multiple bus-interface architectures."

Pickard said VIAVI's CMP is architected similarly to a software-defined radio (SDR). "Like SDR, the CMP is implemented using generic hardware modules and component-based, software-defined functionality," he said. VIAVI's AXIe products include a mass data-storage module with up to 12.8 TB of waveform storage, a 6-GHz vector signal transceiver with 30-GHz Downconverter module, a single or dual i7 embedded computer module, 5- and 2-slot AXIe chassis, the Ranger vector signal analyzer and generator system, and the Raptor integrated development and test platform.

"The new Raptor versions of our CMP are configurable for use as a development platform as well as a test system and can provide both functions simultaneously," said Pickard. "Due to the platform's modularity, we can even implement solutions that integrate the combined functionality of our Raptor systems and our Ranger signal-generation, analysis, record, and playback platforms."

From DFT to maintenance software

Jahangiri at Mentor elaborated on the company's Tessent family of DFT products, which include automation software that analyzes the design, creates and inserts the necessary hardware instruments for test, generates and re-targets patterns, and performs silicon

diagnosis and yield analysis. Specific Tessent products include MemoryBIST, LogicBIST, TestKompress (for compression and ATPG), MissionMode (for on-chip mission mode control), and ScanPro (for inserting scan, test points, OCC, and wrapper chains). In addition, Tessent Diagnosis supports scan diagnosis, Tessent IJTAG supports universal access based on IEEE 1687 standard, and Tessent Connect supports optimal implementation flow and automation.

"Tessent's DFT flow is the industry's only production-proven hierarchical solution that enables the customer to fully automate their core-level DFT tasks, as well as all top-level logic and core interactions," Jahangiri added.

Several companies outlined their software support for their modular hardware. Piotrowski at Ikonix said, "We have our proprietary Autoware 3 software for test and instrument control, test creation, and data collection. It allows the user to connect and control our instruments and SC6549 scanners for a completely automated test system."

Semancik at MTS said, "ATEasy is a comprehensive test executive and a rapid application development framework for functional test, ATE, data acquisition, process control, and instrumentation systems with exceptional cybersecurity protection and controls. ATEasy provides all the necessary tools to develop, deploy, and maintain software components—including instrument drivers, test programs, and user interfaces—as well as a complete and customizable test executive." He added, "For OEM suppliers of test systems, ATEasy-Lite offers a cost-effective, full-featured test executive and test development software suite that can be bundled with the suppliers' ATE systems."

Shaw at DTS commented, "DTS offers standalone test setup, control, and data logging software that is purpose-built for dynamic, embedded applications that require rugged modular data acquisition. Our software is designed to work out of the box with modular DTS data-acquisition hardware. For applications that require integration with other modular architectures, we provide an API that can be called from most popular languages used in test such as C/C++/C#, LabVIEW, and Matlab."

"VTI includes a full suite of industry standard IVI drivers for use in the most common application development environments, such as LABVIEW, LabWindows/CVI, C++, and Visual Basic," said Gibson. "In addition, the operating system-independent drivers will operate in both the Windows environment and the Linux environment." He added that both the LXI and PXIe platforms have an embedded web browser and graphical user interface (GUI), and The LXI platform has a turnkey test package called EXLab, which allows engineers to design a mixed-signal, distributed measurement system without any coding. EE

B&K Precision DAS1700 high-speed data-acquisition system.

SPECIAL REPORT

DAQ VENDORS COMBINE FAST SAMPLING, WIDE INPUT RANGES, EASE OF USE

By Rick Nelson, Contributing Technical Editor

Vendors of data-acquisition systems are addressing increasingly complex customer applications by introducing systems that offer fast acquisition rates as well as wide input ranges across multiple channels. In addition, they are offering a choice of resolution, data-analysis, and storage options. Applications extend from low-voltage IoT and IIoT sensors to SIGINT and electronic warfare.

Specific products extend from portable data recorders and loggers to open-architecture COTS FPGA board-level products. Many companies are augmenting their DAQ systems with ease-of-use features such as touchscreens and intuitive software.

Products/features

"As customer applications become increasingly complex, DAQ systems must keep up," said Jamie Pederson, product marketing manager at B&K Precision. "This means faster sampling rates to capture transients, lower voltage ranges for small sensor signals, and higher voltages for measuring higher power systems."

But the variety of manufacturers in the market, each offering multiple solutions, can present challenges. "It can be confusing for customers when trying to determine which product meets their needs," Pederson said. "B&K has addressed this by clearly defining each product and providing tools that help the end user select the best recorder for their application."

Pederson identified a trend in the data-acquisition industry toward touch displays, wider input voltage ranges, and increased integration of measurements, calculation, and analysis. "All of our instruments feature an easy-to-use touch interface for menu navigation and on-screen data analysis," he said. "We've also included the ability to write custom functions with an intuitive script editor for creating math functions applicable to multiple channels. Our wide range of input voltage ranges, combined with fast sampling rate and deep memory, help capture events that are often missed by other recorders."

Pederson said B&K Precision offers a full line of data-acquisition recorders and loggers with large touch displays and batteries for portability and power-loss backup. "Our DAS220-BAT and DAS240-BAT both feature a 1-ms sampling interval, 16-bit resolution, 100-V maximum input, and up to 15 hours of battery life," he said. "The DAS220-BAT has 10 built-in channels for maximum portability, whereas the DAS240-BAT is expandable from 20 to 200 channels."

Pederson described the company's DAS30/50/60 as high-speed multifunction recorders with a sample interval of 1 µs in memory mode, an input rage of ±5 mv to ±500 V, 64 GB of solid-state memory, and 9.5 hours of battery life. "Users can

choose from two, four, or six input channels and a thermal printer as an option," he said. "These instruments are capable of measuring signals from small sensors to large electrical systems and analyzing single- or three-phase power networks."

In addition, B&K Precision recently released its DAS1700 high-speed data-acquisition system. "This instrument features four types of measurement boards that can be installed in the base unit in any combination of up to three boards or up to six boards with an optional expansion," said Pederson. "These boards include a universal input with a maximum voltage of up to 500 V and six channels, a high-voltage board for up to 1,000 V and six channels, a strain-gauge board with six channels, and a multiplexed board with 12 channels. The sampling rate is 1 µs in all memory modes, with a 14-bit resolution for universal and high-voltage boards or 16-bit resolution for multiplexed and strain-gauge boards." He added that options include CAN and LIN inputs and a 2-TB SSD.

Pederson added that B&K Precision offers software tools for remote setup and control as well as post-acquisition analysis. "Data can be displayed in real-time and displayed in a numerical or graphical format," he said.

Keysight offers data-acquisition products including the 3-slot, mid-range DAQ970 Series, which comes with flexible interfaces and a range of plug-in modules, according to Bernard Ang, product marketing. "The DAQ970 Series now comes with a new solid-state switching multiplexer to scan up to 450 channels per second and a new four-channel simultaneous digitizer module that allows sample signals up to 800 kS/s per channel," he said.

Ang added that Keysight's larger-scale, 8-slot 34980A data-acquisition system provides a scan rate of up to 1,000 channels per second and a choice of mix-and-match plug-in modules. "This standalone mainframe offers fast time to insight, measuring multiple signal types and sensors," he said. "You can easily configure and run, with no programming."

Keysight also offers PXI and USB products. The industry-standard modular M9000 PXI Series provides the flexibility, compatibility, and performance required for demanding applications, Ang said, while the U2000 USB Series offers the flexibility to be used as standalone products, or modules can be plugged into a chassis to make synchronized measurements.

▲ Keysight Technologies DAQ970A and DAQ973A-modules.
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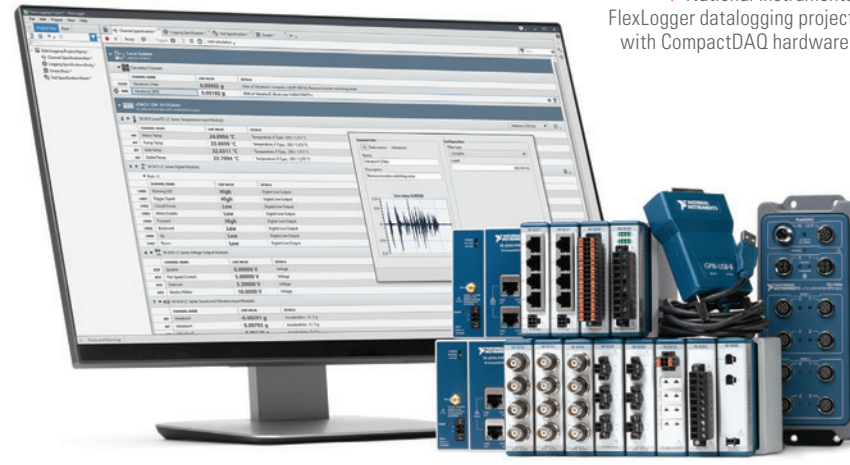
Ang also commented on software. "Keysight's Pathwave BenchVue data-acquisition software helps to control our DAQ970 Series, U2000 USB Series, and 34980A data acquisition systems remotely," he said. "This software runs on a PC and can, therefore, take advantage of the resources of a PC. It can configure and control multiple DAQ systems and other types of instruments together, synchronize data capture, stream data into PC storage as the DAQ system captures data, and provide test automation, without the need for programming. Everything can be completed through a point-and-click graphical user interface. It can display trend charts, time-domain charts, frequency domain charts, bar charts, histograms, and more, for data analysis work."

According to Kristoffer Iversen, senior product marketing manager, data-acquisition lead; Derek Burrows, product marketing manager, data acquisition; and Rebecca Bassett, product marketing manager, systems and data management, all at National Instruments, "DAQ systems are composed of two elements, namely software and hardware. FlexLogger application software supports CompactDAQ, FieldDAQ, and PXI DAQ boards so users can take advantage of our modular data-acquisition products to set up tests and start logging data in minutes without any programming required."

Iversen, Burrows, and Bassett said that NI also provides application and test operations software to accelerate data search, access, and normalization for root-cause analysis. "DIAdem is a robust application software designed for engineering data inspection and analysis," they said. "It's purpose-built for test, and ships with commonly used engineering analysis functions and visualization tools



▼ National Instruments FlexLogger datalogging project with CompactDAQ hardware.

out of the box. Additionally, through our DataPlugin technology, engineers can normalize data in over 1,200 formats, removing barriers that closed solutions introduce to the engineering workflow."

RADX LibertyGT modular COTS system.

RADX offers DAQ products that build on National Instruments' technology. "RADX has developed the LibertyGT suite of COTS, modular, real-time, software-defined turnkey DAQ solutions that employ the National Instruments FlexRIO PXIe-57xx (and PCIe-57xx) family of FPGA-enabled, high-speed serial DAQ products," said Ross Smith, RADX co-founder and CEO. "The NI PXIe-57xx family includes digitizers, signal generators, and transceivers that include Xilinx Kintex Ultra FPGAs and DDR3. NI FlexRIO PXIe-57xx DAQ modules, combined with RADX Measurement Science Firmware and Software (MSFS), enable users to quickly and efficiently deploy PXIe-57xx-based DAQ solutions, without having to develop their own applications."

Smith said RADX COTS DAQ solutions are available either as an integrated, turnkey system that is ready "out-of-the-box" or as an "integration kit" that includes RADX MSFS apps and accessories including a 22-in. touchscreen interface that customer can add to their existing systems. "In addition, RADX has developed USB-Controlled Signal Conditioning Modules (SCM3) that provide amplification and attenuation for both RX and TX applications for the FlexRIO products that enable users to easily integrate the FlexRIO modules into their applications," Smith said.

Measurement Computing Corp. (MCC) offers a range of data-acquisition and datalogger devices, such as the MCC 152 voltage-output and DIO HAT (Hardware Attached on Top) add-on board for Raspberry Pi-based systems. "We focus on ensuring that MCC systems are easy to use, easy to integrate, and easy to support," said Peter Anderson, general manager. "MCC has seen a huge increase of interest in implementing DAQ and data-logging solutions around low-cost Linux minicomputers like the Raspberry Pi. When paired with a DAQ device, these units provide a perfect platform for edge computing, industrial IOT, agile development, and product prototyping."

▲ Measurement Computing Corp. MCC 152 voltage-output and DIO HAT (Hardware Attached on Top) add-on board for Raspberry Pi-based systems.

Anderson said, "MCC offers a powerful and attractive, yet simple application—DAQami—for data visualization and collection from any USB or Ethernet-based MCC data-acquisition device," Anderson said. "For customized applications MCC offers DASYLab, an icon-based application development environment for data collection, reduction, and analysis. Both these environments are easy to learn and use—reducing development time and cost."

Pico Technology offers PC-based data loggers for measurement of voltage, current, temperature, and numerous user-defined parameters, according to Trevor Smith, business development manager. "The loggers are compact devices that connectare to a host computer and powered over a USB or Ethernet interface," he said. "They are supplied with PicoLog 6 data-acquisition software that enables easy configuration of one or more loggers to capture, display, store and analyze data."

Smith elaborated on the software. "PicoLog 6 is our main tool for data collection and results presentation," he said. "It has additional tools such as Alarms, Math Functions and Waveform Annotations. The file system can store huge datasets, limited only by the size of the hard disk or SSD on your computer."

Smith continued, "At the heart of PicoLog 6 is a robust file system that is resistant to data loss and corruption. If the computer is shut down and rebooted, PicoLog resumes capturing without losing the previously stored data. Data is stored automatically without the need to provide a file name and location—but if you wish to save data to a file, you can, even in mid-capture. This makes it easy to share data with fellow PicoLog users."

VTI Instruments, a product line in AMETEK's Programmable Power business unit, offers data-acquisition instrumentation on each of two platforms, PXI Express and LXI, according to Chris Gibson, senior product manager. "The PXIe systems are designed for interoperability with the LXI interface to enable tight integration into hybrid test systems that offer the advantages of both platforms," he said. The PXIe line includes the EMX-425x and EMX-43xx digitizers with up to four 24-bit, 625 kS/s channels, the EMX-2500 Gigabit Ethernet remote controller with an LXI interface and IEEE-1588 synchronization lines, and the CMX09 and the CMX18 enclosures with up to 18 PXIe slots and 8-GB/s backplane bandwidth.

The LXI product line includes EX1200 Series mainframes as well as switch, sensor-simulator, resistor-ladder, and comparator/event-detector modules. Gibson added that the EX1200 multifunction

B&K PRECISION

Introducing
Data Acquisition Recorders

B&K Precision offers a full range of data acquisition recorders and loggers from powerful portable instruments to full-featured configurable systems. Features like high speed recording, large channel count, deep memory, remote connectivity, long battery life make these instruments ideal for many applications ranging from small sensor signal logging to electrical power analysis.

www.bkprecision.com

counter, DAQ, and digital I/O Module offers eight frequency channels, 16 isolated digital I/O ports, and two isolated DAQ channels; it can measure revolutions/minute from a tooth wheel and position and speed from a quadrature encoder signal.

"VTI products also include a set of independent, Gigabit Ethernet, ruggedized, LXI instruments for testing in a wide range of environmental conditions," Gibson said, including the RX0124 24-channel bridge and strain-gauge measurement, RX0224 24-channel charge-vibration-measurement, RX0424 24-channel IEPE-accelerometer instruments, and the RX1032 32-channel thermocouple measurement system. "These instruments are rated for operation over an extremely wide temperature range of -20°C to +60°C and are capable of withstanding harsh environments such as jet engine test cells," he added.

Additional independent, LXI data-acquisition instruments employ power-over-Ethernet (PoE) for portable acquisition applications and include the EX1401 16-channel isolated thermocouple and voltage measurement instrument with built-in cold-junction compensation, open thermocouple detection, and 13th-order polynomial linearization for thermocouple voltages in real time; and the EX1403 16-channel bridge and strain gauge measurement instrument with built-in shunt calibration and TEDS support, Gibson said.

Gibson also commented on software. "Customers with sophisticated data-acquisition applications need to write their own software," he said. "To serve these customers, VTI products provide industry-standard IVI-COM, IVI-C, and LabVIEW drivers. In addition, these products enable customers to work in either the Windows operating system or the Linux operating system, depending on the customer's preference."

All LXI modules have built-in web browsers for web-based access using any web-enabled device located anywhere in the world. All modules allow monitoring and control to save significant time during test setup and troubleshooting.

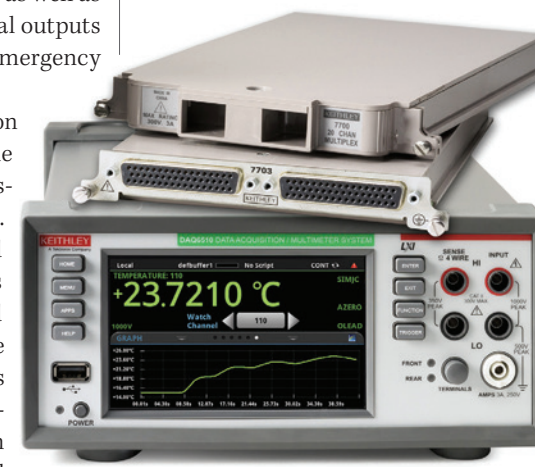
He added, "VTI ExLab, a data-acquisition software package with icon-based setup/control and a spreadsheet-style format, is available for less extensive data acquisition applications. ExLab has a client/server architecture with multiple displays, real-time graphical analysis, and numerous post-acquisition analysis methods."

VPG offers two brands of instrumentation, according to Anton Chittey, Europe product and sales manager with Micro-Measurements, and Patrick Rule, senior sales manager with Pacific Instruments. "Micro-Measurements instruments including our StrainSmart systems offer turnkey solutions enabling setup in minutes for rapidly changing test requirements, from 1 to 1,024 channels. This makes them ideal for small-to-medium test laboratories performing anything from material property tests, PCBA production qualification, automotive, aerospace, and education," they said. "Pacific Instruments (PI) offers high speed (up to 10 Ms/s) and high channel counts (>8,000). In addition, PI [products] have compatibility with third-party control systems and data streams as well as in-rack analog, DSP, and digital outputs for low-latency control and emergency shutdown conditions."

With regard to data collection and analysis, Chittey and Rule said data is sent to a Windows-based PC over USB or Ethernet. "An optional embedded hard drive inside the DAQ allows for redundant recording and is often desired in destructive testing applications where tests can only be run once," they explained. "Data is recorded in raw A/D counts and exported after recording to any post analysis package format for data analysis. Data reduction is available by decimation either during export or during recording which effectively allows the user to change their sample rate on the fly."

They added, "Export features also allow for the user to export all or certain channels or specific time slices of data. Playback mode allows for recorded data to be replayed and viewed in desired time increments and in many different types of displays. Calculated channels are also easily defined pre- or post-recording and easily displayed and exported along analog data."

Keithley Instruments focuses on precision data acquisition when accuracy and reliability are a priority, according to Brad Odhner, technical marketing manager. "Our two main offerings are the DAQ6510 6-1/2-digit data-acquisition and logging multimeter and the 3706A systems switch/multimeter," he said. "The DAQ6510 features a touchscreen user interface that greatly simplifies test setup without the need to navigate complex menus or use an external computer. It also allows simple real-time monitoring of tests via the front panel, allowing users to check their tests at a glance. The 3706A offers a 7-1/2-digit multimeter for enhanced precision and six customizable card slots, allowing test flexibility and up to 576 2-wire channels. Both instruments also offer built-in scripting support with Keithley Test Script Processor (TSP), allowing custom programs and calculations to be run on the DAQs themselves."



▲ Keithley DAQ6510 6-1/2-digit data-acquisition and logging multimeter.

Odhner added that Keithley Test Script Processor (TSP) technology helps to enhance scan speeds and achieve the faster scan rates. "This embedded scripting also allows our DAQs to operate on their own without waiting for a controlling computer to command the next step in a sequence or calculate a result," he said. "TSP is commonly used so a Keithley DAQ can control a part handler or environmental chamber."

William Wadkins, FPGA product manager at Digilent, outlined his company's DAQ products. "We recently released several new products as part of our Eclypse platform: the Eclypse Z7 development board, Zmod ADC, and Zmod DAC," he said. "The Zmod ADC and DAC can acquire and generate, respectively, signals at up to 100 MS/s with 14 bits of resolution. The Eclypse Z7 also comes with Petalinux supported out of the box, and pre-built Linux images are accompanied by the API for bulk data transfer. This system allows users to plug in their Zmods of choice and get started prototyping new high-speed measurement systems without directly interfacing with the FPGA until desired."

The Eclypse Z7 with Zmod converters is designed for high-speed instrumentation, control, and measurement. "The best-in-class for performance-per-watt Zynq-7000 SoC also makes this development board suitable for edge-computing," Wadkins said.

Newark offers DAQ products from a variety of manufacturers. "One of Newark's best-selling DAQ products is the Keithley DAQ6510," said Maureen Lipps, product manager, Test & Tools. "This precision data-acquisition/data-logging system features the measurements, functions and traceability of a 6.5-digit DMM plus 80 channels of instrument-grade switching. A large 5-in. multitouch display guides users through set-up, data visualization, and analysis, removing the necessity of a PC and custom software for many applications." She added that the system is commonly applied to device characterization, where a DUT resides in an environmental chamber and is being stressed under varying environmental conditions. For users who prefer a PC, IVI and LabVIEW drivers are available.

"The B&K Precision DAS220-BAT, another key product in Newark's DAQ portfolio, measures and records parameters commonly found in process applications including voltage, temperature, current, resistance, frequency, and pulse," Lipps said. "It includes 10 universal integrated analog channels with convenient screw input terminals. For maximum ease of use, measurement results are viewed graphically and numerically on a 10-inch color touchscreen and saved either to internal memory or external USB memory. The user experience is further simplified and improved through icon-driven menus which make the instrument easy to navigate. The free DasLab Windows PC software allows users to remotely control and configure the recorder, transfer logging results and configuration files, and view live data in graphical or numerical format on the PC."

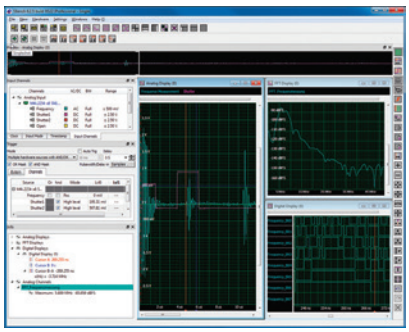
Lipps continued, "Pico Technology's TC-08 is one of Newark's most popular DAQ products. The TC-08 is an 8-channel thermocouple datalogger designed to measure an effective temperature range of -270 to +1,820°C. The TC-08 is also capable of measuring other sensors using

the 70-mV range," adding that the thermocouple datalogger comes with Picolog 6 software.

"Newark's broad product portfolio and holistic support services ensure engineers at every level are supported, whether that be to set up simple or advanced acquisitions, or to record, view and analyze data, products such as the TC-08 ensure engineers can do so quickly and easily," Lipps said.

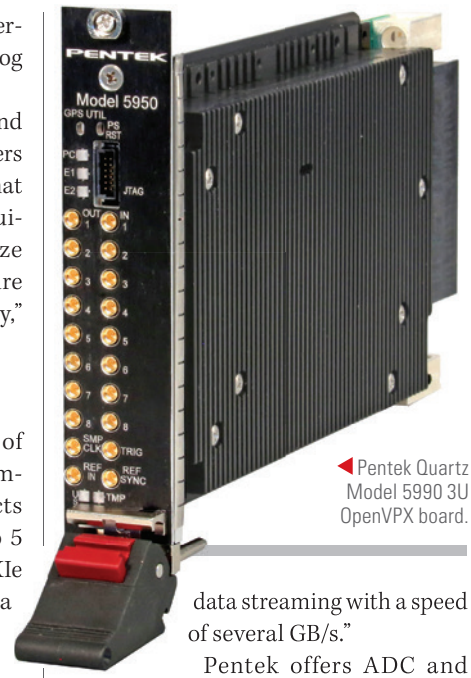
To 5 GB/s and beyond

According to Oliver Rovini, CTO of Spectrum Instrumentation, the company offers 130 different DAQ products with speeds ranging from 1 kS/s to 5 GS/s. "They are available as PCIe and PXIe cards with one to eight channels on a single card or one to 128 channels in a PC-system," he said. "For customers wanting a fast setup and a mobile solution, we offer stand-alone units with LXI/Ethernet connection to any PC, laptop, or LAN. They cover the same wide speed range with two to 48 channels per box." In addition, he said the company offers a five-year warranty plus support directly from the company's design engineers.



▲ Spectrum Instrumentation SBench 6 software for data collection, storage, analysis, and reporting.

Rovini also said the company offers easy-to-use and out-of-the-box SBench 6 software for data collection, storage, analysis, and reporting. "The software is designed by Spectrum and focuses on our own product range and supports all hardware features," he said. "Key benefits are the fast start with first measurement results within minutes and the possibility to do high-speed data streaming with a speed of several GB/s."



◀ Pentek Quartz Model 5990 3U OpenVPX board.

Pentek offers ADC and DAC open-architecture COTS FPGA board-level products for VPX, PCIe, XMC, cPCI, and AMC, with sampling rates ranging from 200 MS/s to 6.4 GS/s with resolutions of 12 to 16 bits, according to Rodger Hosking, vice president and cofounder. "They are highly programmable across wide operating limits using software board support packages and drivers for Windows and Linux," he said. "We also provide graphically oriented FPGA development tools with source code and development libraries for custom applications."

Pentek also offers its Navigator development tools for software and FPGA development, including acquisition and waveform generation engines for triggered operation suitable for radar range gates and beamforming. "We include hardware and FPGA-based decimation and interpolation filters to cover bandwidths from a few kHz to 2.5 GHz," he said. "Our Navigator Signal Viewer displays time and frequency display of live signals acquired during runtime to speed development of new applications."

▼ Per Vices Cyan platform rear view showing QSFP+ ports

"Per Vices offers the highest bandwidth DAQ products available," said Brandon Malatest, COO. "Our Cyan platform is the latest and highest performance COTS platform available with up to 16 GHz of instantaneous RF bandwidth and 4x40-Gb/s QSFP+ ports for data transfer to host systems."

Malatest said the company's focus is on two parts: data acquisition and data processing. With respect to the former, he said, "Our platforms are very high-performance and application-agnostic, which allow them to meet the needs of many markets. These systems are designed for flexibility for the customer to use as needed." As for data processing, he said, "Cyan has a Stratix 10 FPGA SoC on board which enables customers to take advantage of very high DSP capabilities on the same platform as the raw data acquisition. These DSP capabilities are either offered to the customer to implement their own solution, or we can use and modify our existing IP to offer a complete solution."

Targeting niches for DAQ technology

While many DAQ providers address a variety of industries and signal types, others focus on a specific niche. TotalTemp, for example, applies data-acquisition technology to the thermal test of devices such as power semiconductors.[1] "TotalTemp uses the award-winning Synergy Nano temperature controller, which not only can log thermal and process information, but includes logging of external analog and digital signals as well as alarms that can stop testing or notify the test operator of events via text or email," said John Booher, CTO. The low-cost logging capability built into the controller, he said, supports automated cloud storage for data protection, on-screen logging, and the ability to automatically print results to a PDF file or network printer. It also facilitates the export of results to Excel.

"Lawson Labs has been making high-resolution data-acquisition systems since 1981," said Thomas Lawson, founder and president. "Distinguishing features

▲ TotalTemp Synergy Nano temperature controller.

include 24-bit resolution, optical isolation, true differential protected inputs, signed USB drivers, and free software with free updates."

Continued Lawson, "We serve the most demanding lower speed applications. Those include electrochemistry, chromatography, precision temperature measurement, instrumentation, and mechanical testing. DC accuracy, stability, flexibility, reliability, and low cost make our products attractive for both research and OEM applications."

When asked about tools for data analysis, Lawson said, "A data-acquisition system based on Excel already has first-rate analysis and presentation tools that the customer already knows how to use. We have templates for various applications, and the customer can write their own, if they prefer. Control rules can be as simple or complex as desired, and exceptions or variations or calibrations can be inserted by nonprogrammers."

Lawson continued, "If you look at DAQ2GO you will see a company that sells user-friendly spreadsheet templates for many different applications. Their software, with our hardware, makes a first-rate GC instrument, or a viscometer, or an autosampler, or a mechanical testing system."

▼ Ikonix Associated Research HypotULTRA electrical safety compliance analyzer.

Ikonix offers data-acquisition products serving the field of electrical safety test. "The reality is that electrical safety testing is required for compliance," said Nick Piotrowski, Ikonix USA Product Manager. "Records need to be strictly stored and monitored for analysis and audit purposes, and our solutions meet that customer expectation. Our DAQ solutions cover every customer application. Whether the customer is running a handful of benchtop tests for R&D or compliance purposes all the way up to thousands of safety tests per day—our instruments and software will record and store all data."

Piotrowski cited several specific products for data acquisition and analysis. "Our Hypot and HypotULTRA Series have onboard data storage as well as a USB port for direct connection to a USB thumb drive," he said. "The user can program the

instrument to record all data to the onboard memory or directly to the drive." The company also offers a software solution called Autoware 3. "With the software, users program the system to save all testing data as well as provide print reports."

Piotrowski said that in mid-2020, Ikonix USA will release a new SaaS. "This will allow for complete cloud storage of instrument information, test sequences, and test data," he said, adding that data can be recorded anytime, anywhere without the risk of losing any information. "Ikonix will be the first electrical safety testing manufacturer to offer a SaaS platform for customer data and analytics," he said.

Software toolboxes for DAQ

MathWorks addresses data acquisition with its software tools. "MATLAB is our platform for data acquisition and analysis," said Eric Wetjen, senior product marketing manager, test and measurement solutions. "With MATLAB and add-on toolboxes like Data Acquisition Toolbox, Signal Processing Toolbox, and Statistics and Machine Learning Toolbox, our customers can collect and analyze all their data from the same environment." He said the company offers additional toolboxes for acquiring data from webcams and frame grabbers for computer-vision applications and from software defined radios (SDR) for wireless and RF algorithm development.

"Data Acquisition Toolbox lets users bring data directly into MATLAB from USB, PCI, PCI Express, PXI, and PXI Express DAQ devices from National Instruments and other vendors," Wetjen said. "For less demanding applications, we have hardware support packages that let user collect data from Arduino and Raspberry Pi directly into MATLAB. MATLAB users can then leverage built-in apps to configure and run a data acquisition session without writing MATLAB code. To later set up automated procedures, users can automatically generate MATLAB code from these built-in apps. Using apps and command-line functions, users can easily control the analog input, analog output, counter/timer, and digital I/O subsystems of their DAQ devices."

He explained that once the data is in MATLAB, customers can use MATLAB and analysis add-on toolboxes to analyze and visualize data for a variety of signal-processing and AI applications. "For example, our customers often use Signal Processing Toolbox functions and its Signal Analyzer app to explore and preprocess signals. This app can be used to apply low-pass, high-pass, bandpass, or band-stop filters to a signal, and it can remove trends and compute signal envelopes. With the functions and apps provided by Statistics and Machine Learning Toolbox and Deep Learning Toolbox, our customers build and train predictive models for AI and predictive-maintenance applications. These toolboxes provide algorithms for feature extraction, classification and regression algorithms for supervised machine learning, and clustering algorithms for unsupervised machine learning."

Applications, challenges, and trends

The topics covered in this article span the gamut of DAQ products: simulation and data-analysis software, rugged and portable data recorders, modular instruments, and high-channel-count systems. Vendors will continue to leverage advances in data-converter and communications technologies to meet the challenges of future DAQ applications.

Several contributors to this report elaborated on applications, trends, and challenges in the DAQ marketplace. For example, Pederson at B&K Precision said, "Our data-acquisition solutions feature fast sampling rates of up to 1 MS/s, wide input voltages from a few millivolts to 1,000 V, up to 16 bits of resolution, and battery life up to 15 hrs. This makes our instruments suitable for a wide range of applications from small sensor signal logging to large electrical power analysis in both portable and benchtop environments."

Pederson added, "The biggest challenge is staying on the leading edge of DAQ technology by providing more channels, better accuracy, and a lower price. We've met this challenge head-on with new platforms and by adapting our user interface to keep up with an ever-evolving market and changing customer requirements.

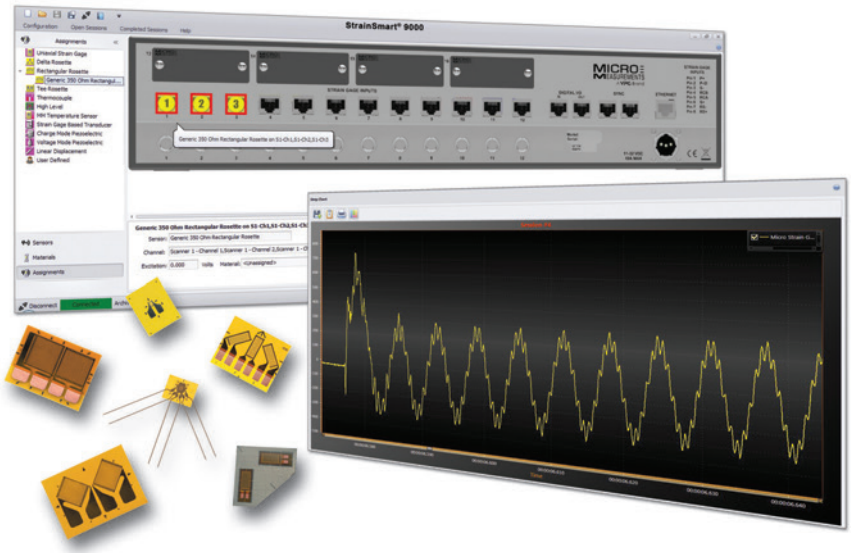
He cited the DAS30/50/60 Series input voltage up to 500 V, fast sampling rate to 1 MS/s, resolution of 16 bits, and the integrated power analysis feature. He also cited the DAS1700's interchangeable measurement boards, which let customers configure the recorder to meet their requirements. "These boards allow for up to 72 input channels, a maximum input voltage of 1000 V, and the 1 MS/s on up to six channels simultaneously," he said. "For applications that require a higher number of input channels, our DAS240-BAT can be configured with up to 200 analog inputs."

Applications

Ang at Keysight said the company's DAQ systems are used across multiple industries for product characterization and validation, product manufacturing testing, and process monitoring. Until recently, he said, Keysight standalone DAQ systems were used as data-logging systems capturing static data. However, he added, Keysight's recently introduced DAQM909A four-channel simultaneous digitizer module for use in the DAQ970 Series enables new dynamic data acquisition applications such as mechanical vibration analysis, acoustic analysis, and dynamic AC/DC power analysis.

When asked about trends, Ang said, "With the proliferation of IoT solutions across all industries, we have seen requirements for new solution form factors, improved connectivity to the cloud for data storage and analysis, improved battery-analysis tools, and lower cost RF measurement solutions." He also cited a trend toward including data acquisition into simulation models to improve model performance.

Iversen, Burrows, and Bassett said NI's DAQ portfolio addresses applications ranging from low-channel-count systems for quick measurements to high-density, distributed, and custom systems. "Because our hardware is modular, users can tailor their setup to meet their needs across different applications," they said. "FlexLogger software provides the sensor configuration, logging options, and event



▲ VPG Micro-Measurements strain gage patterns and StrainSmart System 9000 screens.
▶ VPG Pacific Instruments 1,000 Channel Series 6000 signal conditioning and data acquisition system.

response needed for typical measurements, while LabVIEW can provide lower-level control over an application when custom functionality is necessary. Our NI-DAQmx driver also provides support for third-party languages such as C#.NET, Python, and MathWorks MATLAB software, with its Data Acquisition Toolbox."

Iversen, Burrows, and Bassett also identified trends that align with connected devices and the IIoT. "There is a need for Ethernet devices that can be distributed and synchronized with minimal efforts, like our time sensitive networking (TSN) CompactDAQ chassis and FieldDAQs," they said. "Users are also looking for ease-of-use so they can connect their hardware, test their sensor input, configure their measurements, and log and analyze data. FlexLogger application software delivers on that experience and provides the ability to perform engineering analysis with just a few clicks."

Ross Smith at RADX elaborated on his company's product offering. "RADX LibertyGT DAQ Solutions uniquely employ COTS hardware and RADX MSFS, with a focus on advanced, wideband, multichannel, synchronized DAQ applications for customers that desire to use their instrumentation as opposed to develop applications for it," he said. "RADX LibertyGT DAQ solutions are uniquely scalable, high-performance, and low-cost and support precision synchronization that is essential for advanced sensor-based systems."

Trevor Smith at Pico Technology said the company's dataloggers are widely used in laboratories and in field applications. "They address diverse engineering, scientific, and industrial applications," he said. "Up to 20 loggers of any type can be configured and controlled with PicoLog 6 to collect up to 160 channels of data. One or more loggers can be reconfigured in just a few minutes to address the specific measurements that are needed at each stage of a project, or to build ad hoc configurations as the need arises."

IoT devices are presenting designers with challenges related to conserving power and prolonging battery life, Smith said. "Engineers need more insight about the power consumption behavior of their devices over time and operational life cycles," he explained. "The Pico ADC-20 / ADC-24 precision voltage loggers provide 20- and 24-bit resolution respectively. Matched with a user-configurable terminal board and precision shunt resistors, the loggers can make differential or single-ended measurements at the µV or µA level with better than 0.1% accuracy."

In addition, he said, engineers working on embedded systems have to pay special attention to power consumption and thermal performance of their designs to maintain semiconductors and other devices within their specified temperature ranges. "Thermocouple based loggers, such as the Pico TC-08, provide precise multipoint measurements of package temperatures as well as monitoring heat sink, inlet and outlet temperatures, etc. Prototype devices can be equipped with multiple thermocouples to measure all the critical points of a design. Thermocouple loggers are particularly well suited for making multichannel measurements in an environmental chamber during burn-in or accelerated life cycle testing."

Smith said scientists and engineers need to make diverse measurements in applications ranging from life sciences through industrial processes. "No one data-acquisition equipment manufacturer can address all of those needs with 'out of the box' solutions," he said. EE

REFERENCE

1. Nelson, Rick, "Effective test and measurement drives wide-bandgap device applications," EE-Evaluation Engineering, March 2020, p. 16.

▶ **For more modular test equipment** content, see the full story in the Special Reports section at evaluationengineering.com/21137069.

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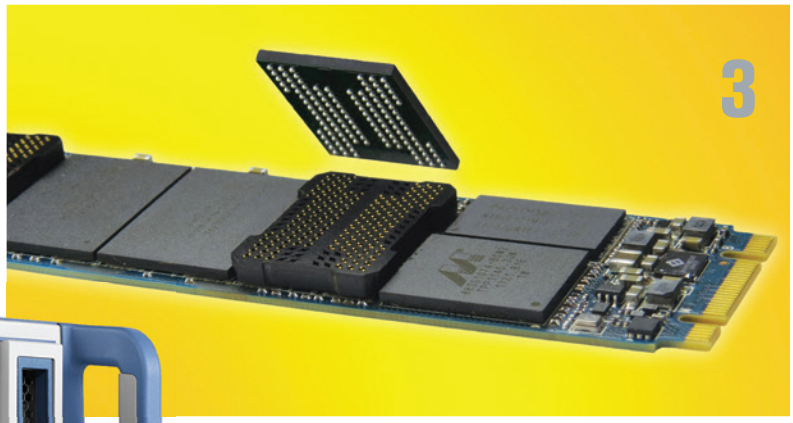
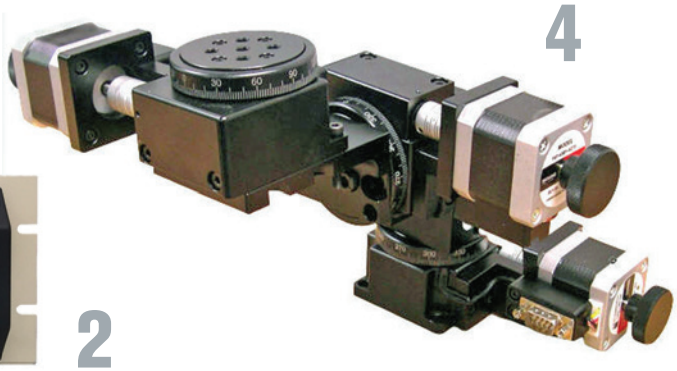
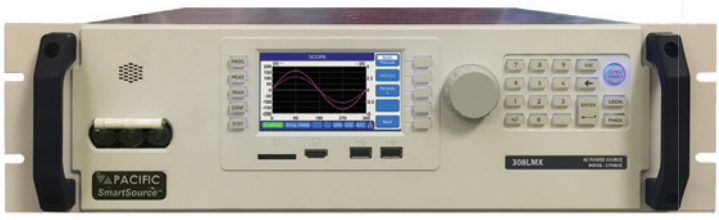






1. Wideband I/Q data recorder

The R&S IQW100 brings signals from the real world into the laboratory to simulate real-world test environments, used in combination with selected midrange R&S signal analyzers and generators. The R&S IQW100 supports recording and replaying signals with bandwidths up to 200 MHz and sampling rates up to 250 MS/s. Typical applications for the R&S IQW100 are signals for cellular communication, EME, GNSS, or radio or TV broadcast. Users can record signals acquired with the analyzer in any chosen environment, then replay the recorded signals using the generator.

Rohde & Schwarz

2. Programmable linear AC power sources

Pacific Power Source has introduced a new range of precision programmable linear AC power sources for a wide range of AC power test applications. This new LMX Series consists of over 20 different models ranging in power from 500VA to 30,000VA. Compared to more commonplace PWM switching AC power sources, the LMX Series uses linear technology to offer high performance with respect to output noise, voltage distortion, output impedance and peak current capability. The LMX Series also offers a 15Hz to 5,000Hz output frequency range which is higher than most switch mode AC power sources.

Pacific Power Source

3. SSD NAND and 3D XPoint zero-footprint test sockets

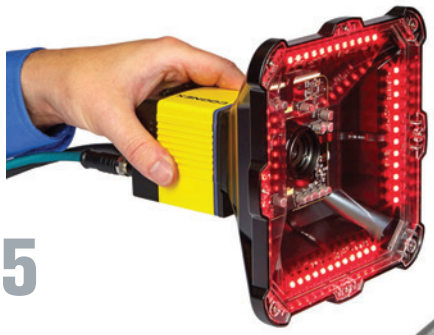
Ironwood Electronics has a complete line of NAND, controller, and buffer sockets used in solid state drives, cards and modules. The zero footprint (Grypper) sockets are available for the NAND and open NAND flash interface (ONFi) Standard and also sockets for the new 3D XPoint devices. The socket is surface mounted, using standard soldering methods to the same location on the PCB. The Grypper requires no lid—the device simply snaps into the socket. Because the Grypper contacts are only 1.5 to 2.2 mm long, the electrical performance is S21 @ -1bd to 40 GHz.

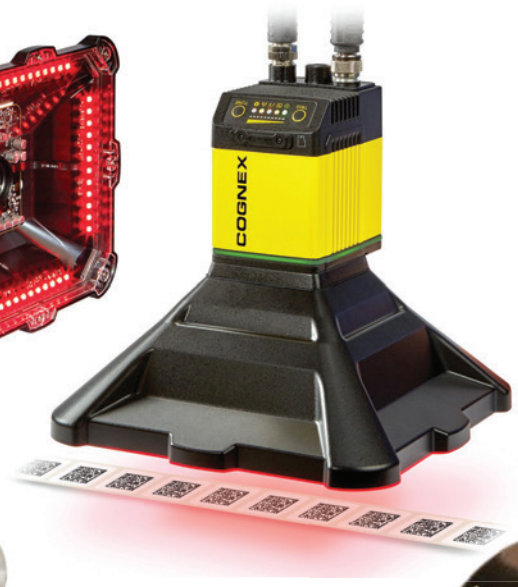
Ironwood Electronics

4. Three-axis miniature gimbal mounts

OES' new three-axis miniature gimbal mounts have heights less than 170 mm (6.693 inch). These compact, motorized, high accuracy yaw, pitch, and roll stages are suitable for: Prototype development, reverse engineering, for use with a CMM, laser scanning, and in robotic or manual assembly when exposure to multiple surfaces is required. The YPR60-60-60-01 (stepper motor driven - pictured), the YPR60-60-60-02 (brushless servo motor driven) and the YPR60-60-60-03 (DC servo motor driven) are stacked precision rotary stages with positional accuracies of 0.05 degrees, repeatability of +/- 0.01 degrees.

Optimal Engineering Systems, Inc.





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5. Inline barcode verifier

Cognex Corporation has launched its DataMan 475 Inline Barcode Verifier (475V). This ISO-compliant, high-speed system delivers reliable code verification and quality reporting for 1D, 2D, and direct part mark (DPM) codes. The DataMan 475V features precision optics, powerful lighting, robust grading algorithms, and a high-resolution camera. The system uses DataMan's high-speed, multicore processing engine. Combined with advanced data delivery capabilities, the DataMan 475V ensures informative, repeatable results for industries including automotive, medical device, consumer products, pharmaceutical, and logistics.

Cognex

6. Millimeter-wave waveguide antennas

Pasternack, an Infinite Electronics brand and a provider of RF, microwave and millimeter wave products, has expanded its offering of mmWave waveguide antennas to address the growing number of 5G and other high-frequency applications. Pasternack's line of millimeter-wave, waveguide antennas has added 54 new models and now covers broad operating frequency ranges from 1.7 to 220 GHz, provides nominal gain ranging from 0 dBi to 40 dBi, and features a variety of different waveguide sizes. In addition to introducing four entirely new categories of waveguide antennas, Pasternack has also added 19 models to their existing categories of scalar feed horn and omnidirectional waveguide antennas.

Pasternack

7. DIN rail mount DC-DC converters

TDK Corporation introduces the TDK-Lambda brand DIN rail mount DDA DC-DC converters. The series uses step-down nonisolated power modules that operate from an input range of 9 up to 53Vdc, with a wide adjustable output voltage range of 3.3 up to 24V. The DDA is suited for generating additional low cost, high current outputs from an existing 24V bus in industrial, semi fabrication and test and measurement equipment. Three models are available in the DDA series: a single nominal output +12V 20A, a dual output +12V 20A / +5V 20A and a dual output +12V 14A / -12V 8A.

TDK Corporation

8. Voice coil actuators

H2W Technologies manufactures voice coils that have been custom designed for the medical industry. Voice coil actuators in quantities of 100 to 200 are available in 4 weeks and OEM (Original Equipment Manufacturers) quantities can be available in 6 to 8 weeks from receipt of order. Voice coils have been desirable for applications such as ventilators because of their compact design and high-speed capabilities coupled with their sliding contact bearing system, which allows for high lifetime, high cycle, and a desirable MTBF in the system.

H2W Technologies

TECH FOCUS

HANDHELD INSTRUMENTS

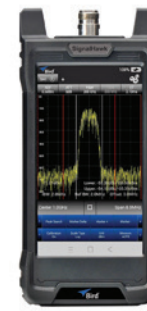
Portable electronic test instrumentation usage has surged for test engineers over the past couple of decades, although benchtop solutions still rule the roost when it comes to general use, because they comprise more features compared to their portable counterparts. Handheld instruments now contain nearly as many test features as their benchtop cousins, due to natural evolution to smaller form factors. Here are some lighter-weight contenders out there, but they are no lightweights when it comes to the testing arena.

Rohde & Schwarz adds new handheld microwave spectrum analyzers to its R&S Spectrum Rider FPH family

Rohde & Schwarz has added three base models to the R&S Spectrum Rider FPH family with three new base models providing frequency ranges from 5 kHz to 6 GHz, 13.6 GHz and 26.5 GHz. Since upgrades require neither downtime nor recalibration, users can easily upgrade their base models, e.g. from 26.5 GHz to 31 GHz. New higher-frequency models enable the rugged R&S Spectrum Rider FPH to perform a large range of measurement tasks in the field and lab. In combination with other options, the R&S Spectrum Rider FPH verifies signal transmission over 5G, broadcast, radar and satellite communications links. The instrument supports everyday measurement tasks in aerospace and defense, mobile network testing and broadcasting, as well as tasks for regulatory authorities and in education. Weighing just 2.5 kg, the R&S Spectrum Rider FPH is ideal for mobile use. Its battery lasts more than six hours, making the instrument capable of working a full day without recharging. The analyzer can be remotely controlled via USB or LAN. The R&S MobileView app for iOS and Android provides wireless remote control of the R&S Spectrum Rider FPH from a mobile device.

Rohde & Schwarz

Handheld spectrum analyzers



SH-60S-TC

SH-60S-AOA

RF provider Bird expands its SignalHawk family of rugged, handheld spectrum analyzer products with the addition of the SH-60S-AOA Angle of Arrival spectrum analyzer and the SH-60S-TC, offering a frequency range of 6 GHz. The new SignalHawk SH-60S-TC and SH-60S-AOA provide test coverage for all major wireless systems. The SH-60S-TC, RF Analyzer can view RF signals between 9 kHz and 6 GHz and offers intuitive menus and predefined measurements. Higher frequency coverage and spectrogram (waterfall) display. Additional built-in functions include: FM demodulation, GNSS Signal Quality Test, Field Strength and Spectrum masking. The SH-60S-AOA, RF Analyzer enables the SH-60S-TC to triangulate the location of an interferer on a map for signals between 9 kHz and 6 GHz. Triangulation allows the user to locate the source within 3 measurements, forming a triangle in the area of the emitter with a built-in map to find the exact location of the problem. Bird

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INNOVATIONS DRIVE WEARABLES MARKET

By Ken Cormier, Managing Editor

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Wearable electronics worn by consumers often include health and fitness tracking devices, but also watches, jewelry, clothing, implantable devices and head-mounted displays. The medical world is no lightweight in this area, employing smart patches, smart pills, and other wearables for the treatment of chronic diseases and remote telemedicine.

Here are some news updates on developments in wearables.

Report: Wearables market $61.4 billion by 2025

The global market for wearable electronics is predicted to hit $61.4 billion by 2025, according to a report by ReportLinker. Expected driving forces will be "inexpensive sensors, miniaturized yet powerful microchips and processors, low-power, lighter electric components, and the expansion of applications addressed by wearable products and services," the report says. The greatest impact on industry growth will be in medical electronic wearables, which will enhance digital medical telehealth, according to the report.[1]

Fish scales could make wearable electronics more sustainable

New research in the American Chemical Society's *ACS Nano* describes a method to create electronic displays such as a glowing tattoo or a digital readout on human skin—using fish scales. Up to now, electricity-conducting and light-emitting components have been layered onto transparent plastic film, to make them flexible enough to stay on skin or other soft surfaces. The ACS Nano article describes how to make such displays, which would likely be disposable after one use. Researchers Hai-Dong Yu, Juaing Liu, Wei Huang and colleages settled on a gelatin derived from collagen found in fish scales, which was fashioned into a film. An attractive aspect of the film is that it is unlikely to linger in landfills after use, as it dissolves within seconds when immersed in hot water. When buried in soil, it degrades within 24 days. The researchers built a working AC electronluminescent device that continued to glow, even after being bent and relaxed 1,000 times.[2]

Ford tests buzzing wristbands for social distancing

Maybe the production lines aren't churning out vehicles at Ford Motor Company, but the auto giant is getting ready for renewed activity on wheeled products when the COVID-19 threat diminishes.

At a Ford factory in Plymouth, MI, a dozen workers are testing watch-like wearables that vibrate when workers come within 6 feet of each other. The object is to keep workers outside the distance recommended by health experts to avoid spreading the coronavirus.

The social-distancing gizmo could be part of new Ford safety protocols, developed in cooperation with the UAW, when it resumes production as soon as next month, following a six-week shutdown. Also under consideration is thermal imaging scanning to detect fevers.

The smartwatches, manufactured by Samsung Electronics Co., and using software from Austin-based Radiant RFID, use Bluetooth short-wave and low-power technology.[3]

Stretchable supercapacitors

A novel supercapacitor that remains functional even when stretched to eight times its original size has been developed by researchers at Duke University and Michigan State University. It reportedly doesn't exhibit ill effects from repeated stretching, and maintains all but a few percentage points of energy performance after 10,000 cycles of charging and discharging. The researchers anticipate the supercapacitors being used as part of a power-independent, stretchable, flexible electronic system that could be used in wearables and biomedical devices.

To create the supercapacitors, the team grew a carbon nanotube "forest" on top of a silicon wafer, and coated a thin layer of gold nanofilm on top of it. A coat of gold nanofilm was applied to the forest, which was then transferred to a prestretched elastomer substrate. The gel-filled electrode was allowed to relax, which crumpled the gold layer and condensed the forest. When the resulting dense forest was filled with a gel electrolyte, it was able to trap electrons on the surface of the nanotubes. When two of these final electrodes were sandwiched close together, voltage could be loaded onto one side with electrons while the other was drained.[4] EE

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3. Bloomberg, "Ford Tests Buzzing Wristbands to Keep Workers at Safe Distances," April 15, 2020
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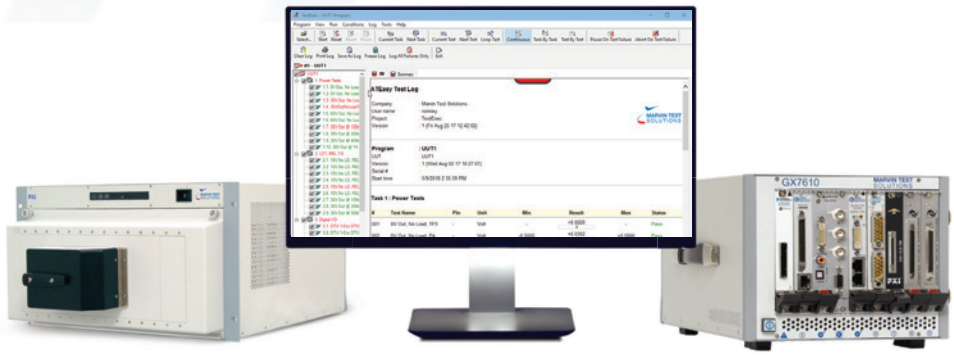

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