SPECIAL REPORT

POWER MEASUREMENTS SPAN IOT TO GRID SIMULATION

By Rick Nelson, Contributing Technical Editorr

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

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

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

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

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

Turner cited other products as well, including the PSB 9000 and 10000 Series of bidirectional (2-quadrant) DC power supplies. "2-quad is the ability to both source and sink power with zero crossover deadtime," he explained. "Hardware like EV/PHEV chargers, batteries, and HV inverters are just a few examples that require the ability to source and sink power. While in sink mode (load mode) the PSB returns up to 95% of the energy back to the localized AC grid, which greatly reduces operational costs. Using a high-efficiency power stage allows EA to pack up to 30 kW in a single-rackmount 4U chassis."

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

Turner added, "High-power systems (30 kW+) are generally a multichassis solution that requires integration and system build into 19-in. racks. Customers need to maintain focus on their product development and not worry about designing and sourcing material to build up the system. EA Elektro-Automatik helps customers by offering turnkey, off-the-shelf solutions up to 2 MW and 2,000 VDC with no NRE design costs."

Kai Li, product manager at Mean Well, identified several

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Power instrumentation

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

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

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

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

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

He added, "Keysight's BT2100 Series self-discharge measurement solutions provide a revolutionary reduction in the time to measure and characterize the self-discharge performance of Li-ion cells. These lithium-ion self-discharge measurement solutions determine a cell's self-discharge by directly measuring its self-discharge current."

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

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

According to Philipp Weigell, director, product management, power products, at Rohde & Schwarz, the company's newest additions are the 2-quadrant R&S NGL200 and R&S NGM200 power supplies, which are optimized for testing battery-powered devices and battery-management systems. "As soon as the externally applied voltage exceeds the set nominal voltage, the power supply automatically switches from supply mode to load mode; current flows into the power supply," he said.

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

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

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

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

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

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

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

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

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

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

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

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

▲ Vitrek DL Series digital programmable DC load.

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

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

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

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

B&K Precision offers power supplies and electronic loads for general electronic test applications, according to David Holt, senior director of product management and sales. "We also provide power supplies addressing specific applications, such as our PVS Series with a built-in SAS (Solar Array Simulation) function and the 9115-AT model, which is capable of generating automotive power test waveforms compliant to DIN 40839 and ISO 16750-2 standards to simulate common test conditions for electrical and electronic devices installed in automobiles," he said. "All of our programmable AC sources can simulate grid faults, voltage dips, and other power-line disturbances."

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

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

PXI and rackmount

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

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

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

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

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

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

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

Goodman noted that the GENESYS+ products offer a variety of features: multifunctional front-panel display with embedded user menus, an arbitrary waveform generator with auto-trigger capability, a constant-power limit mode (autoranging), internal resistance simulation, programmable slew-rate control (up/down for voltage/current), wide-range 400 VAC/480 VAC inputs, built-in communication interfaces (LAN, USB, RS-232/RS-485, and isolated analog), protection functions (including CV or CC foldback and OCL), an enable/disable function with polarity selection, an internal pre-load ON/OFF control, a blank front panel option, and an air-filter kit accessory.

From modules to systems

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

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

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

Chips, IP, and software

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

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

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

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

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

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

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

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

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

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

REFERENCE

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