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EDITOR'S NOTE

ENTERING THE THIRD DECADE OF THE 21ST CENTURY

One of the things to remember about 2021 is that it is the first year of the third decade of this century. It is, in some ways, reassuring to know that time is marching on, and these uncertain times will eventually be behind us. One only needs to look at the disruption caused in supply chains, retail networks, and service businesses caused by COVID-19 alone to recognize we are in historic times.

A year spent in isolation, relying on the sophistication of our technology to keep the threads of civilization together, has destroyed some old paradigms while creating new ones. Tele-everything, from tele-working to tele-shopping to tele-tourism, once considered novel and niche application spaces, have been thrust into the limelight as core societal infrastructures.

Beyond the now

What that means for the test and evaluation industry, and the engineers and technologists working within it, is a shift from thinking of electronic systems test as a task, to thinking of test as an ongoing awareness. Some of the greatest advancements in product development and creation is the ability to capture and apply data at every step, in a continuous process.

This constant development in real time is a significant force multiplier and boon to the business of creating, producing, and selling products. This is becoming especially apparent in the growth of in-field monitoring of product performance, from smart vehicles having their software updated over the air to factory systems that call for maintenance when they predict failure.

System awareness

The life cycle of a modern product is a complex one. The days of breadboarding trail circuits is rapidly becoming history, with only hobbyists and tinkerers using benchtop development for core system creation. Today most designs start in a software development environment, where the designer can tweak and test ideas on-the-fly in real time. The resulting design is not only functional, it probably seamlessly integrates advanced subsystems available from a myriad of suppliers.

The trip to the assembly line is another place where advanced test and evaluation solutions have revolutionized the way things get done. Smart facilities and Industry 4.0 processes have made product production an environment of testing, evaluation, and big data as well. In order to achieve six-sigma performance it is necessary to create and monitor an intelligent factory environment.

Once off the assembly line, many products get tested prior to being sent out into the world, and advanced automated test systems enable such oversight on the scale needed. Things like burn-in and power test have always been important, but now things like operating systems, device interfaces, and security must be tested, evaluated, certified, and enabled before the product hits the street.

This paradigm continues into the real world, as user systems not only track device performance for functionality, maintenance, and fault prediction, such systems are also at the core of user fulfillment and activity monitoring. We are rapidly moving to a point where every powered product that performs a task will have intelligent monitoring and management, usually through the Cloud.

Continuous Test and Evaluation

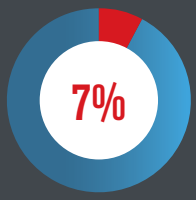
What this means for the test, measurement, and evaluation industry is that the tools, processes, and skills needed to address problems in design and development are ever more in demand. It also means that there is an educational mission out there to bring the benefits of advanced test and evaluation processes to the entire industry, to every application that can benefit from these advanced tools and solutions. EE

Alix Paultre,
Editor

BY THE NUMBERS

39.4 BILLION $

Semiconductor sales in November 2020

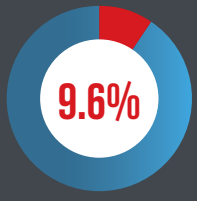


Revenue increase over November 2019

Source: ABI Research

20.89 BILLION $

Predicted global electronic design automation software industry by 2027

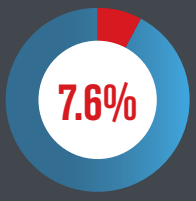


Predicted growth rate 2020-2027

Source: Allied Market Research

2.68 BILLION $

North American semiconductor equipment billings in December 2020



Revenue increase over December 2019

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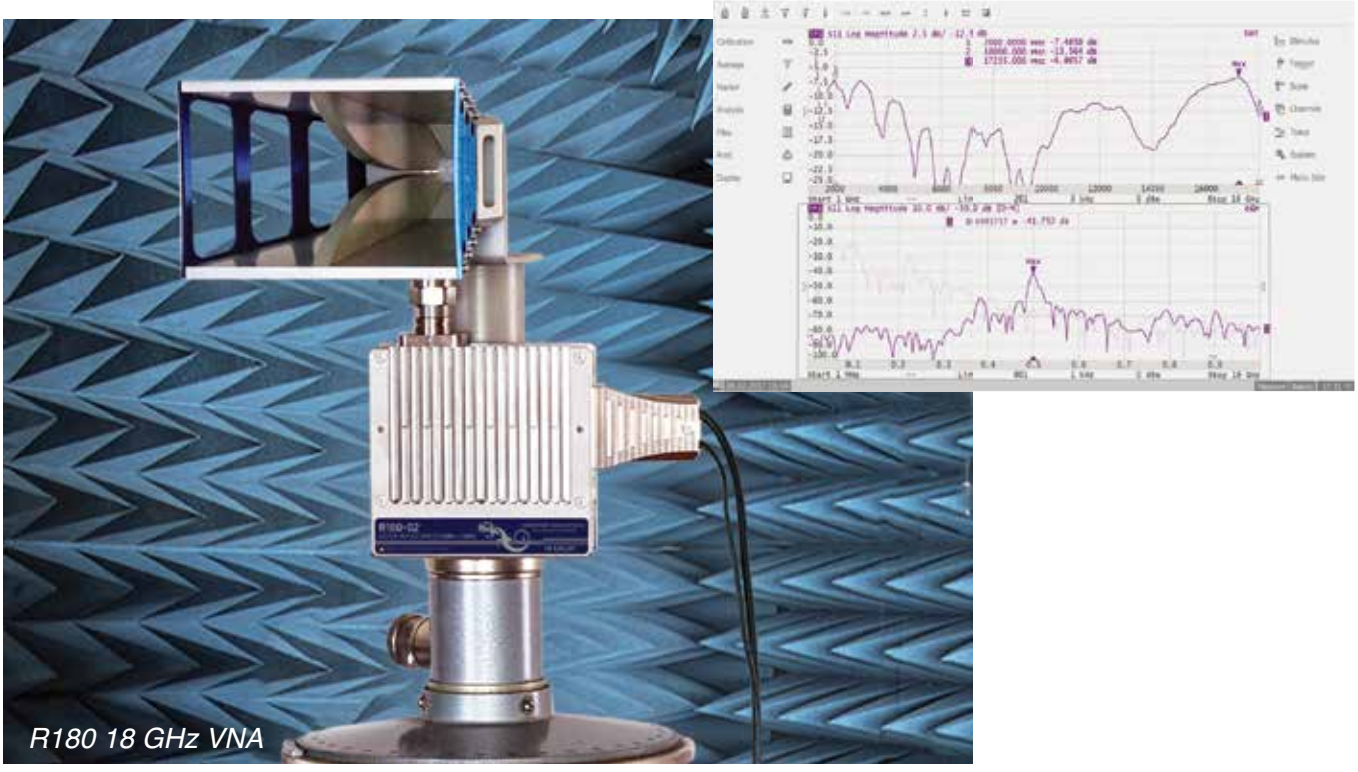

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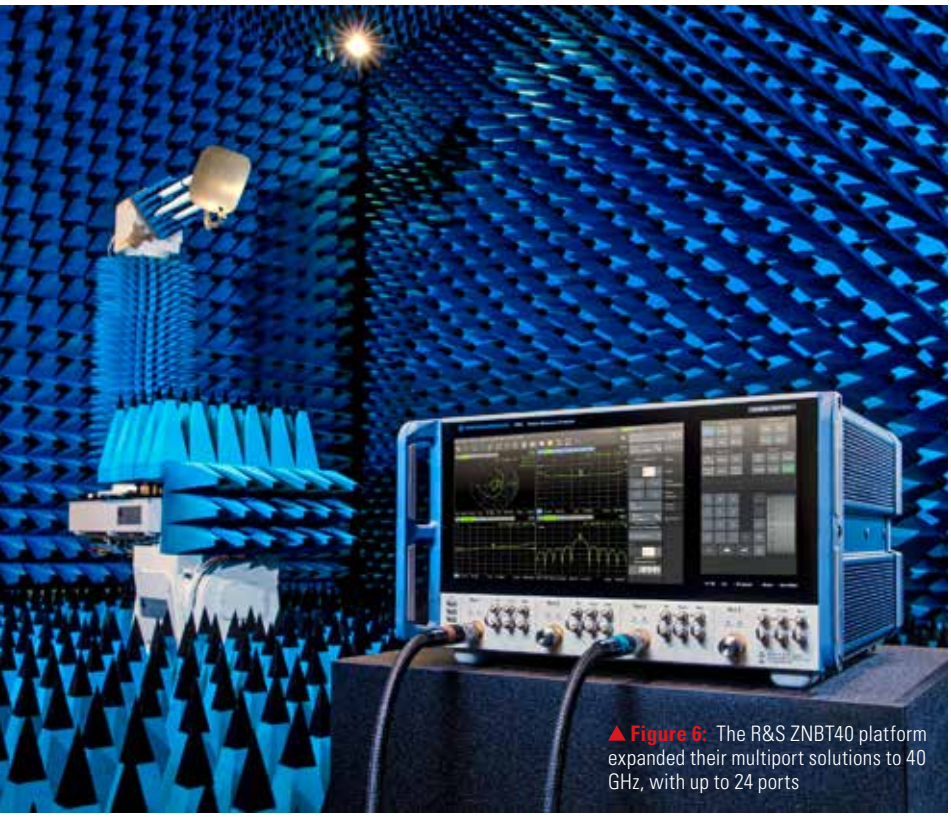


▲ **Figure 6:** The R&S ZNBT40 platform expanded their multiport solutions to 40 GHz, with up to 24 ports

SPECIAL REPORT

VECTOR NETWORK ANALYZERS

by **Alix Paultre**, Editor

In the world of test, measurement, and evaluation, vector network analysis (VNA) is among the most important RF and microwave measurement methodologies. Offering a variety of features, from excellent RF characteristics to a wide variety of analysis functions, the latest VNA solutions facilitate the capture and evaluation of important performance parameters.

Advanced architectures

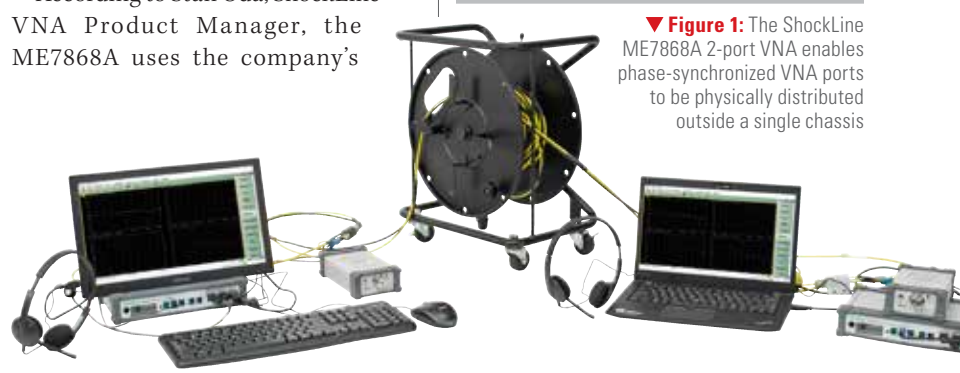
The ShockLine ME7868A 2-port VNA from Anritsu is designed with an advanced architecture that enables phase-synchronized VNA ports to be physically distributed outside a single chassis. This allows the instrumentation to be located at the device under test (DUT) rather than tied to a single location (Figure 1).

According to Stan Oda, ShockLine VNA Product Manager, the ME7868A uses the company's PhaseLync technology to synchronize two ShockLine MS46131A 1-port VNAs. This enables vector insertion loss measurements between the two VNAs. PhaseLync supports synchronization at 100+ meters between 1-port VNAs, improving 2-port S-parameter measurement performance over distances comparable to traditional VNA solutions.

Steve Reyes, Sr. Product Manager, pointed out that the VectorStar ME7838G broadband VNA system provides on-wafer device characterization from 70 kHz to 220 GHz in a single sweep. The system uses Anritsu's Nonlinear Transmission Line (NLTL) modules, which offer excellent performance with industry-best raw directivity, to provide best-in-class calibration performance and measurement stability (Figure 2).

It enables users to go beyond the traditional boundaries in a single sweep without the need to reconstruct the wafer probe station from a 110 GHz to higher waveguide bands. Anritsu has also recently introduced the Universal Fixture Extraction option (UFX) for VectorStar that fulfills the need for high frequency fixture extractions in signal integrity measurements.

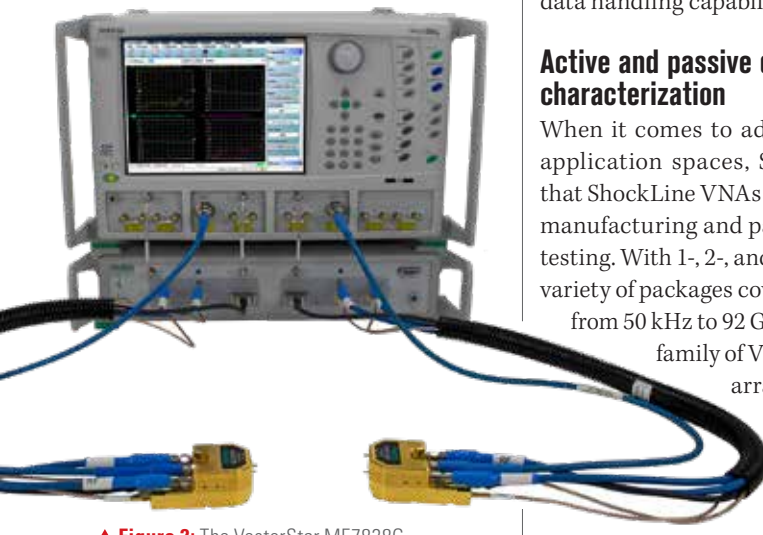
Navneet Kataria, VectorStar VNA Product Manager, added that the VectorStar-based ME7848A Opto-electronic VNA system can characterize Opto-electronic devices. These Optical Network Analyzer (ONA) systems combine a VectorStar VNA, E/O convertor, and a silver-standard NIST traceable reference photodetector to make E/O measurements with NIST traceability up to 70 GHz, on devices such as photodetectors and optical modulators/transmitters.



▼ **Figure 1:** The ShockLine ME7868A 2-port VNA enables phase-synchronized VNA ports to be physically distributed outside a single chassis

Device characterization

Over-the-air (OTA) characterization requirements over longer distances for 5G and large vehicle testing are becoming more of a challenge for traditional VNAs, due to long interconnect cables. The ShockLine ME7868A addresses this requirement by moving the VNA port to the DUT, eliminating the cables and improving measurement stability and dynamic range.



▲ **Figure 2:** The VectorStar ME7838G broadband VNA system provides on-wafer device characterization from 70 kHz to 220 GHz in a single sweep

On-wafer measurements need to span into the upper mmWave frequencies for accurate device characterization. When developing these systems, it is important to characterize the devices over a much broader frequency range, from near-DC to well beyond the operating frequency. For example, amplifiers designed for applications such as 802.11ad should be swept well beyond 60 GHz into the mmWave regions—ideally beyond 180 GHz—to include 3rd harmonic testing.

To satisfy next-generation device bandwidth requirements, technologies are being developed that require the use of extremely high frequencies. One such technology is opto-electronics, which offer enormous bandwidth, low latency, and is commercially viable. The demand for testing these opto-electronic devices precisely is a big challenge today. Anritsu's ONA solution provides accurate and precise measurements with NIST traceability of these opto-electronic devices.

VNAs continue to be used in many varied applications from device characterization to material measurement. The need to perform accurate mmWave measurements well beyond 110 GHz is a key trend. The next-generation 6G cellular network is anticipated to go beyond the 170 GHz D band radio frequencies and enter the 325 GHz regions, to continue to expand data handling capabilities.

Active and passive device characterization

When it comes to addressing specific application spaces, Stan Oda told us that ShockLine VNAs are well suited for manufacturing and passive component testing. With 1-, 2-, and 4-port VNAs in a variety of packages covering frequencies from 50 kHz to 92 GHz, the ShockLine family of VNAs covers a wide array of applications. Navneet Kataria added that VectorStar VNA covers all the major target markets, namely active and passive device characterization.

Opto-electronic device characterization is another target area for Anritsu's VectorStar-based ONA systems. Upgradability, flexibility and NIST traceability in measurement results are some of the unique offerings that help our customers. Material measurements capabilities for various material types covering frequencies up to 1.1 THz is another application for VectorStar.

ShockLine VNAs use Anritsu's patented NLTL technology to achieve cost and space-efficient high-frequency VNA capability. In the future, Anritsu expects to continue using this proven technology to increase test capabilities in the ShockLine family. VectorStar also uses NLTL sampler technology for accurate, high-frequency VNA analysis up to 70 GHz baseband and 110, 125, 145, and 220 GHz broadband. The next step in the line of broadband analysis is the ability to perform differential measurements up to 220 GHz for optimum differential analysis.

Anritsu's position is that VNA will continue to play a key role in 5G, automotive, and general OTA characterization of all devices, from small UE to large vehicles. As frequencies continue to rise and consolidate on-wafer, the need to perform accurate calibrations in-situ as well as the ability to accurately de-embed test fixtures and on-wafer transmission paths will continue to increase.

Non-Invasive Stability Measurement

When we contacted Charles Hymowitz, the VP of Sales & Marketing at Picotest, he brought up their Non-Invasive Stability Measurement, based on a proprietary piece of software using a math algorithm created by Steve Sandler. However, the company has ported it to many VNAs, at no charge, and are trying to have it added to as many as possible. NISM enables the user to get the phase margin from an output impedance measurement.

Many power supply ICs are fixed, and don't have their control loops available for Bode plots, and many regulators have multiple internal loops. In some cases, regulators have become so small that breaking the loop has become impractical. Apart from step load testing, which really doesn't provide a phase margin number, there aren't other ways to get the control-loop stability of such a regulator except by using NISM.

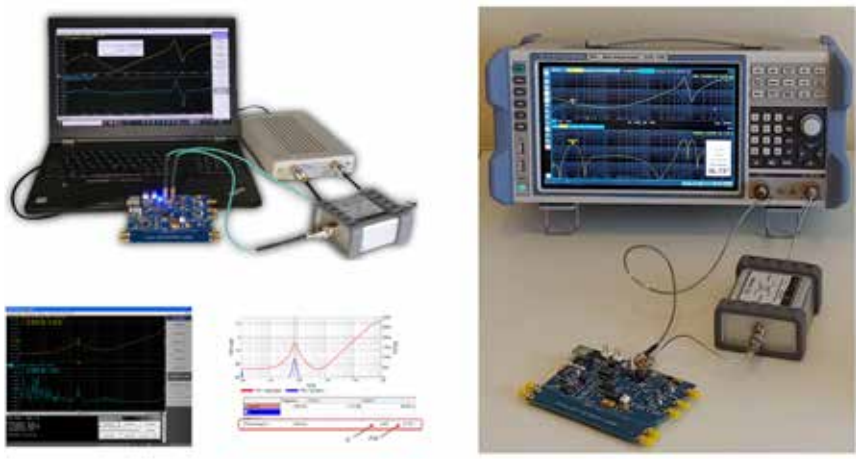
For example, NISM is included with the OMICRON Lab Bode 100 (Figure 3), as a software add-on for the Keysight E5061B/E5071C, as well as the Rohde ZNL/ZNLE, and the line of Copper Mountain CMT VNAs. Other ports are in the works.

All of Picotest's Probes and Signal Injectors can be used with any VNA, allowing DUTs to be connected to the VNA for various measurements. Most of these injectors (besides the Bode plot related items) are proprietary, and not available from other VNA manufacturers. The various Line injectors, such as the J2102B, offer PDN Cable and support PSRR and 2-port impedance measurement. The J2161A active splitter is unique and can turn an oscilloscope into a VNA.

Many new oscilloscopes can be used as VNAs. Picotest's J2161A 2-way Wideband

▲ **Figure 3:** Devices such as the OMICRON Lab Bode 100 include Picotest's Non-Invasive Stability Measurement technology

▼ **Figure 4:** All of Picotest's Probes and Signal Injectors can be used with any VNA



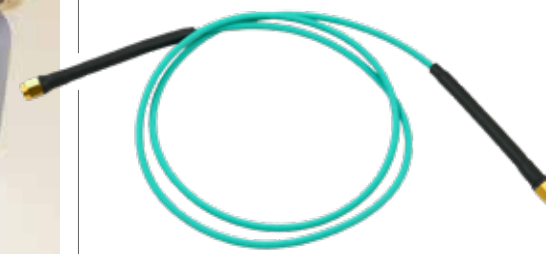
Active Splitter, along with their J2102B Common Mode Transformer, can be used to turn many newer scopes into VNAs with the same or greater bandwidth and sensitivity as dedicated VNAs.

Challenges

Two-port impedance measurement is currently the gold standard for low-impedance measurement, with power integrity and PDN (power distribution network) impedance a huge design and performance concern. Apart from simulation, measurement is essential to understanding, bounding, and designing good PDNs.

In order to measure low and ultra-low impedances, Picotest has created a number of accessories essential to accurate measurement including the J2102B/J2113A ground loop breakers (essential for removing the inherent group loop error in the measurement) and low shield loss, ultra-thin, flexible PDN Cable (Figure 5).

It is critical when measuring milli- and micro-ohm PDN impedance that the sources of measurement error be tamed, and these products do that. In addition, Picotest will be introducing a replacement to its current 2-port probe that will be a true 4-port hand-held BROWSER probe capable of measuring milli-ohm power plane impedance. Connection to the DUT, especially on dense PCBs is a challenging aspect of PDN impedance measurement and the new Picotest P2102A 2-port probe is going to greatly ease this barrier.



▲ **Figure 5:** Low shield loss, ultra-thin, flexible PDN Cable enables accurate measurements

Trends

The trend for oscilloscopes to incorporate VNA capabilities is significant, and one that may dramatically impact sales of traditional VNA instruments, especially as scope vendors incorporate more and better interfaces. One of the most important areas currently for VNAs is power integrity/PDN impedance measurements.

Traditionally, power rail probes were used to measure time domain noise, but this is unacceptable, as it does not bound the possible voltage excursions that can occur on the rail.

Impedance can define the state of the power rail and possible performance issues. In addition, the frequency band of interest is from low frequency (10s of Hz) out to many GHz, making the measurement both challenging and the domain of the VNA. The company also plans to introduce a series of 1- and 2-port probes that will help VNA users connect to their DUTs.

Powerful and flexible tools

The explosion of Cloud-enabled systems and the RF-based infrastructures has put tremendous pressure on engineers

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ENDEAVOR BUSINESS MEDIA

serving the wireless space. We reached out to Rich Pieciak, product manager for vector network analyzers at Rohde & Schwarz USA, and asked what the company is fielding to address these issues. He told us the most recent vector network analyzer platforms from Rohde & Schwarz are the R&S ZNA family, and the R&S ZNBT40 platform, which expanded our multiport solutions to 40 GHz, with up to 24 ports.

The R&S ZNA family of high-performance vector network analyzers address evolving application areas with their sophisticated and flexible hardware architecture. The R&S ZNA family's RF characteristics are highlighted by sensitivity, power sweep range, and linearity, augmented by a novel hardware architecture with four internal phase-coherent sources, two internal local oscillators, and eight receivers for a high level of measurement versatility.

High-speed digital applications have also been expanded in these two instrument families, (likewise the R&S ZNB and R&S ZND families), with the introduction of new de-embedding solutions giving customers the ability to more easily evaluate and utilize industry-accepted solutions to characterize high-speed digital design structures that support ever-increasing frequency ranges.

Keeping ahead of the application

Technology advances in wireless and aerospace & defense applications continue to address integrated assemblies that contain high port counts, due to advanced functions such as beamforming, integrated antenna architectures, and ever-higher digital data transmission rates. All these integration efforts are forcing new approaches to performance validations.

Test instrument architecture needs to evolve to provide the necessary device-under-test performance insight. The R&S ZNA architecture, for example, can now measure nearfield characteristics of an antenna assembly with an integrated LO due to its multiple internal synthesizers and dual local oscillators, coupled with its dual digital receiver architecture.

6G and other research into applications in the mmWave space are putting increased emphasis on extending traditional VNA measurements into frequency areas up to 300 GHz and beyond. Versatile VNA architecture is paramount for proper characterization of the component or corresponding channel environment.

Addressing applications

High-speed digital designs continue taking on importance and especially in the areas of signal integrity. The proliferation of differing standards and corresponding board layouts are necessitating new ways of probing and analyzing signals in both frequency and time domains. Rohde & Schwarz has recently introduced tools to better evaluate the performance of designs and isolate their performance from external sources such as connectors, cables, probes, etc.

New options addressing de-embedding techniques based on the P370 Standard, Smart Fixture De-embedding from Packet Micro, as well as In Situ De-Embedding from AtaiTec are now supported as options in the R&S ZNA, R&S ZNB, R&S ZNBT, and R&S ZND families to allow customers to evaluate the most appropriate techniques to use for their individual applications.

An option addressing Delta-L PCB characterization is now also available. Frequency-converting measurements are another core measurement area extremely well suited to the R&S ZNA, due to its multiple synthesizer architecture and measurement techniques such as those targeted for subassemblies with embedded local oscillators.

The DDS synthesizers in the R&S ZNA are the basis for four-phase coherent and phase-repeatable sources. The user can define amplitude and phase difference between four signals for applications like beamforming or target simulation. mmWave applications and continued advances in integrated assemblies necessitate continued advancement in test strategy. Test platforms need to evolve accordingly in both architecture and corresponding measurement science.

A changing landscape

Network analyzers characterize electronic components in almost every industry. While their versatility has grown, the core architecture of network analyzers has remained largely unchanged for the last few decades. Modern technologies with higher frequencies and wider bandwidths, like 5G, push the limits of current network analyzers and create new challenges for engineers as they measure multichannel devices.

Matt Campbell, Product Marketing Engineer at Keysight Technologies, pointed out that network analyzer sources traditionally didn't have to be highly accurate, as discontinuities could just be ratioed out of the measurements. However, source performance can have a more significant impact on today's complex wideband and nonlinear measurements.

Addressing this, Keysight enabled their PNA and PNA-X network analyzers with the same signal source as their high-end signal generators. Presented as having the lowest phase-noise available, engineers can quickly perform measurements like EVM, converter measurements with phase, and nonlinear network analysis with confidence in the results (Figure 7).

To help with 5G manufacturing test, Keysight introduced their vector component analyzer, presented as the first

Figure 7: Keysight's N5245B PNA-X Microwave Network Analyzer

▲ **Figure 8:** Pasternack's VNA test cables address a wide range of demanding lab and test applications

modular multiport instrument that can perform both network analysis and modulated signal measurements. This enables designers to perform network analyzer measurements like S-parameters and gain simultaneously with EVM and ACP.

Matt pointed out that when customers look for network analyzers, applications like pulsed-RF measurements, spectrum analysis, and time domain analysis are often as important to them as S-parameters. People are thinking of network analyzers as general RF tools, not just S-parameter machines, and Keysight's network analyzers offer features such as guided calibration with an ECal module and wizards that walk through advanced measurements.

Keysight's network analyzers cover every application, from R&D to manufacturing, to field test with form factors tailored to each respective application. Convenient and capable USB VNAs, multiport VNAs with up to 50 ports, and the rugged handheld FieldFox, bring performance wherever it's needed. Nearly every industry is seeing frequencies go up and devices become more integrated, so Keysight provides frequency coverage into millimeter frequencies as well as flexible measurement applications for every form factor.

Connections are important

A link of any kind is only as good as its connectors and cable, and test is no exception. According to Steve Ellis, Product Line Manager at Pasternack, their latest line of highly-flexible VNA test cables addresses a wide range of demanding lab and test applications. Features include a phase stability of +/- 6° at 50 GHz, and +/- 8° at 70 GHz with flexure, as well as VSWR of 1.3:1 at 50 GHz and 1.4:1 at 70 GHz.

These 50 GHz assemblies are terminated with 2.4mm connectors, while the 70 GHz assemblies utilize 1.85mm connectors. The braided, stainless steel armoring surrounding the coax provides a rugged yet flexible cable with a flex life exceeding 100,000 cycles, and the cables are terminated with rugged, stainless-steel connectors that provide up to 5,000 mating cycles when attached with proper care. Both 50 GHz and 70 GHz versions are offered with NMD-style connectors, with swept right-angle 2.4mm and 1.85mm connector options. EE

▲ **Figure 1:** The Series PSB 10000 bi-directional power supply combines the functionality of a programmable power supply and an electronic load.

SPECIAL REPORT

POWER SUPPLIES AND LOADS

by **Alix Paultre,** Editor

Power is a fundamental aspect of all electronics, as nothing happens until the current flows. A product's power electronics have a significant impact on all operational elements of the system driven. How efficient, quiet, safe, and reliable a product's power storage and/or supply methodology is impacts performance aspects, from RF range to battery lifetime.

In order to properly evaluate, certify, and optimize the power infrastructure of devices, programmable power supplies and loads are vital tools in testing products, from low-power IoT devices and consumer appliances, to electric vehicles and smart-grid infrastructures. Here are some of the latest solutions in the space.

Efficiency and flexibility

When we reached out to Elektro-Automatik's (https://elektroautomatik.com/en/) Global Marketing Manager, Craig Frahm, he touted the efficiency, power density, and flexibility of their latest programmable power supply and load products. Among the examples given was their Series PSI 10000, which can supply up to 2,000 V at a power output of up to 30 kW. The 19-in., 4U rack-mount supplies are more than 95% efficient, enabling a high-power density. The supplies are autoranging, allowing them to supply a wider range of currents and voltages than legacy power supplies.

Their Series PSB 10000 bidirectional power supply combines the functionality of a programmable power supply and an electronic load in a single unit (Figure 1). Like the Series PSI 10000, it can supply up to up to 2000 V at a power output of up to 30 kW in a single 4U enclosure with an autoranging output. The Series PSB 10000 can sink up to 30 kW while recovering up to 95.5% of the input power, returning that power to the grid. This functionality helps users to lower energy costs and eliminates the need for expensive cooling systems. The Series ELR 10000 electronic loads also provide this same functionality.

Key features of the PSI 10000, PSB 10000, and ELR 10000 Series include a TFT touch screen, so users can set up and monitor power supply and electronic load functions, and an integrated function/arbitrary waveform generator. This allows users to apply standard functions such as sine, triangle, and square waves, or even arbitrary values, to a power supply output.

The family's Anybus slot is a feature that allows a user to easily configure a unit's digital interface with plug-ins. Modules compatible with this slot offer RS-232, CAN, CANopen, ModBus, TCP, Profibus, Profinet, and EtherCAT interfaces. Additional features include

a galvanically-isolated analog interface and built-in test functions such as battery test, fuel cell test, and photovoltaic array simulation, conforming to both EN50530 and Sandia standards.

There is also a water-cooling option.

Key challenges

Frahm pointed out that battery testing and electric vehicle testing is becoming more and more important. Not only is there a push to electrify consumer vehicles, but commercial and industrial machinery as well. This is leading to the need for power supplies capable of supplying higher voltages and higher power. To meet these needs, Elektro-Automatik is working on more efficient power supplies, increasing power density. For example, the company can supply a system capable of delivering 240 kW in a single rack and up to 2 MW in a multirack system (Figure 2).

Other challenges include electrical costs and environmental concerns. For those concerned about these issues, the company offers high-efficiency power supplies and electronic loads that recover up to 95.5% of the input power and return that power to the grid. The automotive and heavy machinery industries are going with higher voltages and higher power. This includes EVs, buses, and construction and farm equipment.

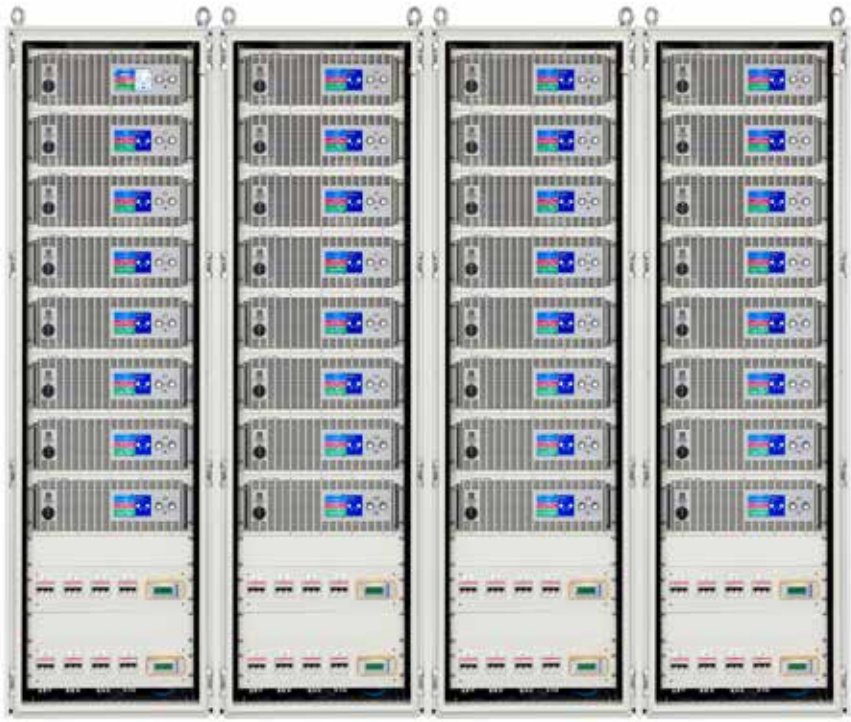
Leading trends

One major trend is the requirement for faster transient response. This faster response is needed for simulating different drive conditions and for fuel cell testing. A fuel cell perturbation test, for example, requires that an electronic load switch from drawing high current to low current in microseconds. In battery testing, Frahm said Elektro-Automatik sees a trend toward bidirectional capability, the ability to both source and sink power, which gives users the flexibility they need to test batteries with a single unit.

Frahm said that E-mobility, including battery testing, automotive, and heavy machinery, is perhaps Elektro-Automatik's biggest market currently, which their product line addresses. For example, their Series PSB 10000 can both charge and discharge batteries with a built-in battery test functionality. There is also an optional software package that allows the simulation of standard lead-acid (AGM) and lithium-ion batteries, in series or parallel. Another application area that is important is the semiconductor industry, where the company's power supplies are used mostly for process control.

He also pointed out that their 10000 Series products all use silicon carbide (SiC) power semiconductors for faster switching speeds and higher efficiencies than traditional MOSFET technology. He also feels that there is going to be more demand for bidirectional products in the future, such as their Series PSB 10000 power supplies. As far as output voltages go, 2,000 V is good for now, but in the future, the industry will migrate toward higher output voltages.

▼ **Figure 2:** This system is capable of delivering 240 kW in a single rack and up to 2 MW in a multirack system.



Current-doubling tech

When we got in touch with Casey Kuzara, Senior Engineering Manager at AMETEK (https://www.ametek.com/), he brought up the company's latest solution, the Asterion Series. The California Instruments Asterion AC Series provides programmable AC, DC & AC+DC power, in models delivering from 500 VA to 36,000 VA, with 200/400-V AC outputs and 250/500-V DC outputs in single- and three-phase configurations. All Asterion Series maximize space with leading power density in 1U, 2U, 4U and 14U high form-factors.

All Asterion sources employ AMETEK's latest current-enhancing technology, which enables output current to increase linearly up to two times the full voltage current, as the voltage decreases from range maximum to one-half of range voltage. iX2 technology results in a source that delivers full power over the widest voltage ranges, eliminating the need to buy overpowered sources just to reach low line current requirements.

The Asterion AC Series is DSP controlled, and can be operated from the intuitive front-panel color touchscreen or available Ethernet LXI, USB and RS232 standard control interfaces, as well as an optional GPIB control interface. Their Virtual Panels GUI allows remote control of the Asterion AC power source, as well as programming communication and monitoring for the Asterion ATE

model without a front-panel display. The Asterion AC Series also features multilanguage capability for global operation, auto paralleling for higher power, arbitrary and harmonic waveform generation, sequencing and measurement analysis, as well as complete IEC and avionics standards test suites.

The newest addition to the Asterion platform of power testing solutions, the Sorensen Asterion DC Series, is available in both fixed- and autoranging versions. The fixed-range supplies are economical, traditional rectangular wave output power supplies with all the enhanced operation advantages standard with the Asterion platform. The autoranging supplies feature expanded current and voltage range at the full output power level, enabling the ability to satisfy a wider testing need without needing additional models.

The fixed-range models come in 40- to 400-V models with output current ratings from 4.3 A to 125 A. The 1,700 kW, 3,400 kW and 5 kW models 1U high. The company also has 10 kW models in 40 V to 400 V with output current ratings from 25 A to 250 A in a 2U high package. AMETEK also offers 15 auto ranging models within this series, featuring expanded current and voltage range at the full output power level, to satisfy a wider testing need without requiring the purchase of additional models.

The Asterion DC Series, just like the Asterion AC Series, has several operating advantages such as easy auto-paralleling, complete remote programming and control via the Virtual Panels GUI, and intuitive front panel color touch-screen operation. Additionally, the instrument can be controlled via standard LXI Ethernet, USB, and RS232 control interfaces, as well as through optional GPIB and EtherCAT control interfaces.

Serving global needs

Kuzara explained that AMETEK's customers are global, and want options on AC input-power compatibility, as they have operations around the world with different electrical mains, grid voltage and frequency ratings. The Asterion DC Series offers a universal input covering single- and three-phase power with an operational range from 90 V to 264 V, plus another three-phase option with an operational range from 342 V to 528 V, covering most electrical mains found around the world.

Figure 3: The 600 W EL34243A dual channel can independently test two sources up to 150 V and 60 A each.

Physical space in the test stand or equipment rack places power density at a premium, with ever-increasing test requirements dictating increased test asset usage. Asterion AC and DC Series were developed to maximize power density to minimize rack space use. AMETEK Programmable Power products are deployed in multiple applications, including semiconductor fabrication and burn-in, automotive and hybrid electric vehicles, telecommunications, avionics, industrial controls, high-power lasers, water purification, and photo-voltaic inverter testing.

The Asterion AC/DC power sources utilize the latest generation of power and control technology, with the output power stage using a novel switched-mode, direct-coupled converter topology to optimize output voltage and current characteristics. An interleaved, dual, full-bridge converter configuration per output phase enables the converters to be configured in series or parallel. Full programming resolution is maintained from 0 to 400 VAC and 0 to 200 VAC, or 0 to 500 VDC and 0 to 250 Casey VDC.

Features include two separate ranges for double the output current rating in the low range compared to the high range, with iX2TM current capability providing up to an additional 2X increase over the full-scale current of a range at reduced voltages. A high-current crest-factor capability of 5:1 reduces output voltage waveform distortion when running demanding loads that draw nonlinear current with a high peak value.

AMETEK's system controller utilizes the latest DSP-based digitally implemented controls that allow generation of pure AC sine waves, DC, or arbitrary waveforms, as well as making accurate and precise measurements with 24-bit analog-to-digital conversion. Firmware-implemented algorithms for the feedback control loops precisely regulate the output voltage or current and are configurable for the mode of operation as to which parameter is regulated.

The controller has extensive command capability, including multiple digital interfaces that run software programs of SCPI commands to set output parameter values, or arbitrary waveforms derived from settings of amplitude and phase of harmonics or data points of instantaneous waveform values. A full complement of real-time programming and readback of analog signals is available, as

well as a color touch-panel display, and a Virtual Panels GUI that can run remotely through a web browser.

Creating test insights

Bill Griffith, Power Products Marketing Engineer at Keysight Technologies, emphasized the built-in data logging capability of the company's EL30000 Series bench electronic loads, which can provide insights that have not been previously available. For example, battery capacity tests can run for hours; seeing the test in progress ensures that the test is going as planned. It also helps avoid typical avoidable mistakes like reverse polarity, starting with a low battery voltage, or setting a drain current that is too high or low.

After the test, it is easy to transfer voltage, current, and power measurements keeping the PC free during the capacity test. The 350 W single-channel EL34143A can test up to 150 V and 60 A, while the 600 W EL34243A dual channel can independently test two sources up to 150 V and 60 A each (Figure 3). Paralleling the outputs allows testing up to 120 A and 600 W.

Recently, Keysight introduced two series of high voltage, high power supplies, the RP7971A and RP7973A. The 20 kW regenerative power supplies are ideal for testing EVs as they move to higher voltages and power levels (Figure 4). Keysight also introduced the PV8921A and PV8922A 20 kW photovoltaic array simulator. The PV8900 Series offers up to 2000 V and the ability to test up to 12 MPPT inverters. When working with energy storage and bidirectional converters common in EVs, the RP7900 Series is regeneration eliminates excessive heat by returning energy to the grid.

While each market has a unique set of challenges, a common need is for more intuitive solutions, combining hardware, software, or additional built-in measurements.

Markets of interest

The two highest market growth areas for the company are designing high-voltage/high-power systems, and driving portable electronics. While each market has a unique set of challenges, a common need is for more intuitive solutions, combining hardware, software, or additional built-in measurements.

For high-power applications, they see customers requiring higher voltage solutions, and expect the need for high-voltage and high-power supplies to continue. The continued improvement in battery technology allows more and more products, of all sizes, to be battery powered. Keysight has introduced several new power supplies, electronic loads, and software applications to characterize energy usage and help provide the greatest run time possible.

Quiet and compact, with large displays for the bench, offering single- and dual-channel power, these supplies and electronic loads are capable of 400 W and 600 W in a compact design. Customers want instruments that are flexible, and the company offers bench supplies and loads using several technologies, allowing the test of both low- and higher-power devices accurately.

Size and flexibility

Griffith compared older Keysight power supplies to the company's latest solutions, mentioning their significant differences, such as size and weight. Their latest 600 W bench electronic load is lightweight and portable, and they recently introduced a 3U-high 20 kW bidirectional power supply using regeneration technology.

He also explained how the company's power supplies offer greater flexibility with an autoranging output, ideal for testing DC-DC converters, and higher output bandwidths can better represent the power available from batteries, as well as fluctuations in DC power systems. More accurate built-in measurements are possible by using additional ranges to test large and small devices, and the ability to measure voltage and current simultaneously.

On the data side, you can log data without a PC, using application software to help characterize or emulate power devices. For example, Keysight's DG9100 Series software can control multiple photovoltaic simulators, and test inverters with up to 12 independent MPPT inputs.

Serving applications

Griffith described Keysight's line of programmable power supplies available in 35 W to 200 kW systems, in over 300 power supply models. He said it's best to divide the solutions into three categories: Bench power supplies with large displays, front terminals, quiet operation, and a compact design. Compact automated test equipment (ATE) occupies little rack space, while modular power supplies provide flexibility in adding additional channels or different voltage-current combinations.

Their high-power supplies are available as single quadrant or bidirectional, depending on the test, and DC power solutions combine software and hardware to test devices from IoT to satellites. Bill pointed out that lately, power supplies and loads often need to provide higher voltages, as it is typically not possible to connect electronic loads in series to achieve a higher voltage input. To address

▼ **Figure 4:** The RP7973A 20 KW regenerative power supply is ideal for testing EVs as they move to higher voltages and power levels

the need for higher voltage, Keysight's latest bench electronic load handles a 150-V input.

Modern power supplies provide greater flexibility to test a variety of devices, with features like autoranging for more voltage-current combinations, as well as auto-parallel and auto-series to provide higher voltage or higher current. Bench power supplies use internal relays to combine outputs, while system power supplies use a digital link. Features like more measurement ranges allow accurate measurements for small and large devices, while digital filtering allows you to trade off between higher bandwidth and stability.

Regeneration returns energy to the grid, not only being a greener solution, but also avoids generating excessive heat when dissipating power. Regeneration is a game changer for high power systems; it is very unpleasant to be near a system that converts tens of kilowatts to heat. This is important in high-power markets, like EVs, energy, and energy storage. Customers want higher voltages and more power to meet their testing needs. Keysight is seeing an increased use of regenerative power supplies, which provide many advantages when testing high-power bidirectional inverters and batteries.

Power supplies with lower ranges and higher bandwidths can accurately source and measure power to determine the drain on a battery. Using the data, engineers can tune their hardware and software to reduce the use of energy. Keysight offers several software and hardware solutions to capture the dynamic current, plus solutions like the Keysight X8712A IoT Device Battery Life Optimization Solution, can relate RF events to the current drain.

Accuracy with fast recovery

Dr. Philipp Weigell, Director of Product Management and Planning Power Products, Meters, Sources, and Audio Analyzers at Rohde & Schwarz told us about the company's latest R&S NGU source measure units (SMU). He pointed out that the high accuracy and fast load recovery time of the R&S NGU source measure unit addresses challenging applications.

▲ **Figure 5:** The Rohde & Schwarz DC power supply portfolio has tailored offerings for mobile handset applications and IoT

◀ **Figure 6:** One can simulate battery stacks, from a single cell up to 250 V, using the R&S NGM200 series.

Weigell said that "Batterification" is a key topic for them these days, as everything is getting a battery, from eBikes and IoT sensors, to smartwatches and other portable electronics. The company's R&S NGL, R&S NGM specialty power supplies, and their newly introduced R&S NGU include battery simulation features, fast load-recovery, and low ripple and noise. In combination, these instruments address developing and testing battery management systems.

He pointed out that in order to address complex applications, like simulating a battery, you need a user interface that matches the requirements. The user experience has improved a great deal with the advent of capacitive touchscreens for power supplies, allowing the setup of realistic battery models and complex arbitrary voltage and current sequences. The Rohde & Schwarz DC power supply portfolio (Figure 5) focuses on applications where the emphasis is on test and measurement, with tailored offerings for mobile handset applications and IoT.

Rohde & Schwarz' latest addition, the R&S NGU401, extends their portfolio for wireless devices while also addressing new applications such as advanced material research. Another application is the trend toward 48 V technologies for electric cars. For example, one can simulate battery stacks, from a single cell up to 250 V, using the R&S NGM200 series (Figure 6). In addition, the R&S HMP4040 and R&S NGP800 series address high-speed digital design and the high-power demand on many input lanes of modern FPGAs.

Low-noise power

The submission from Shah Hassan, Business Manager at Keithley, a Tektronix company, started with their Keithley Series 2280S supplies, which deliver up to 192W of low-noise power with superior load-current measurement sensitivity.

They offer built-in plotting functions to allow monitoring trends such as drift, offering up to 6½-digit resolution for characterizing small changes in load currents with confidence. Four load current measurement ranges support measuring a device's full load current, standby mode current, and small sleep mode currents with DMM-quality accuracy.

Hassan added that the Keithley Series 2230G power supplies can provide up to 375 W of power in a compact 2 U high, half-rack wide enclosure. The 2230G-30-6 offers up to 6 A from two channels; the 2230G-60-3 offers up to 60 V from two channels. Adjustable, independent, and isolated channels can test two single-voltage devices, or a multiple voltage device, with one power supply. You can combine 30 V channels in series to increase voltage up to 60 V, or connect two or three channels in parallel to output as much as 15 A using the 2230G-30-6.

The Keithley Series 2380 programmable DC Electronic Loads are single output, standalone loads with 200W, 250W and 750W models. Multiple operation modes, with up to 25 kHz of dynamic cycling, superior voltage/current resolution and readback accuracy together with multiple interface choices, make the Series 2380 useful for testing a power source in your bench.

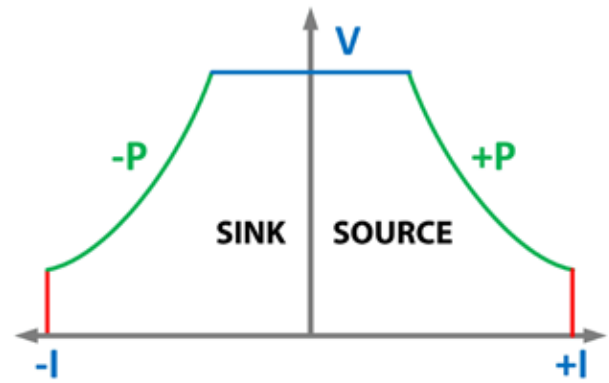
Multiple, isolated outputs

Hassan explained that certain customer test cases require multiple, isolated outputs from a power supply. Thus, all the channels on the power supply need to be independent and electrically isolated. This challenge is addressed by offering this feature in our 2230G line of power supplies. The power supplies have 3 channels and the outputs are isolated. Other customers are looking for higher accuracy readback currents for their testing, as good as those found in DMMs from their power supplies. He said that the company offers this in the Keithley 2280S Series of power supplies, which have 6½-digit resolution.

On the subject of trends, he said customers are looking for high accuracy and low noise outputs in their power supplies. The tolerance specs on the devices they are testing are getting tighter and tighter, necessitating the use of higher performance testing equipment. The Keithley 2280S series of power supplies targets the wireless device testing market, and their 2230G series of power supplies targets the medical market, due to the need for electrical isolation in medical applications. The Keithley 2380 series of electronic loads is used for power management applications to test DC-to-DC converters.

▲ **Figure 7:** AZX Series bi-directional AC & DC sources offer Four-Quadrant operation and can recycle energy from the load back to the utility grid

▼ **Figure 8:** The DCB Series of 30kW Regenerative Bidirectional DC power supplies address advanced fast-charging applications



Regenerative power

Herman vanEijkelenburg, Director of Marketing at Pacific Power Source, highlighted the availability of their latest advanced regenerative programmable AC & DC Power Sources. Available at power levels from 30 kVA to 200 kVA, these AZX Series bidirectional AC & DC sources offer Four-Quadrant operation with the ability to recycle energy from the load back to the utility grid for energy efficient operation (Figure 7).

These power sources can be operated using their front-panel color LCD touch screen, or a standard remote-control interface like LXI-compliant LAN, GPIB, and USB. The built-in web server allows control from any network-connected PC or Wi-Fi tablet. Key features include dual constant power mode voltage ranges up to 360 V AC Line to Neutral or 624 V AC Line to Line in three-phase mode and an output frequency range from 15 Hz to 1000 Hz. In DC mode, output voltage ranges are ± 255 V DC and ±510 V DC, with no power derating.

vanEijkelenburg pointed out that many of their customers face the need for cost containment in military avionics and weapons support systems, and the need to stretch ATE system life cycles to longer and longer periods. This requires support for legacy products by the T&M manufacturer, and Pacific Power has a history of supporting its products for decades. Another challenge is the increasing need to test at higher voltage for DC applications relating to the EV Charging infrastructure.

With increasing EV battery pack capacities aimed at extending driving range, reducing the fast-charging time becomes a key challenge, requiring ever-higher DC voltage to manage current levels. PPST solutions offer both regenerative DC power supplies and DC loads, with Adaptive Power Systems up to 2000 V DC to address this growing market need. One example can be found in the DCB Series of 30 kW regenerative bidirectional DC power supplies (Figure 8).

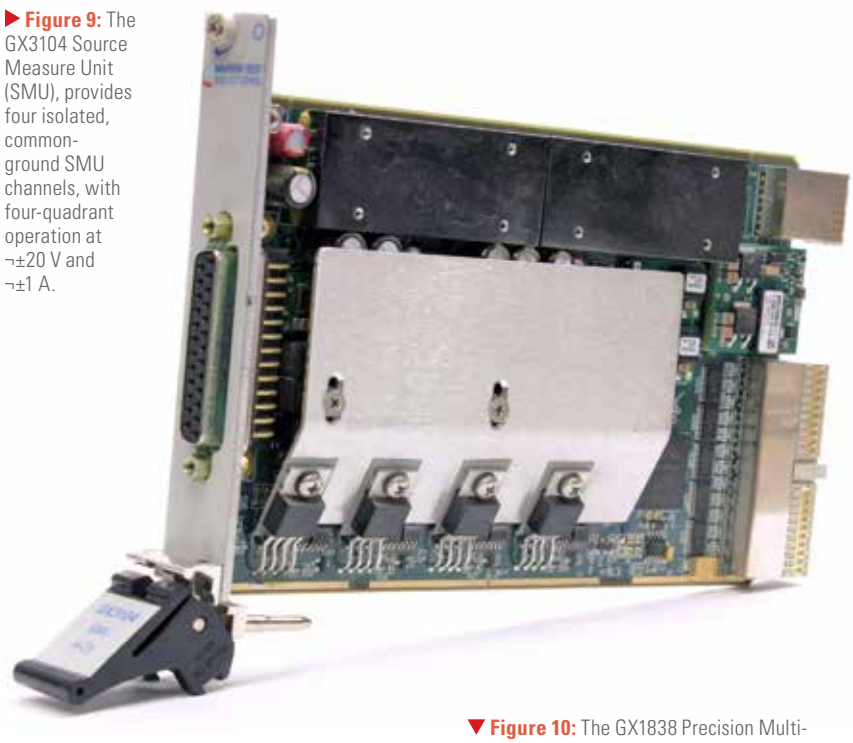
Wide-bandgap semiconductors

vanEijkelenburg explained that advances in wide-bandgap power devices are enabling new levels of power density and power efficiency in a wide range of power conversion products. For example, Pacific Power Source's new AZX Series regenerative AC power source uses SiC power devices in all power conversion stages for high power density. It offers standard output voltages to 360 VAC, with Line-to-Neutral and optional extensions up to 624 Vac Line-to-Line.

Applications and industries supported by the Pacific Power Source catalog include PV inverter and EV Charger test applications (Regenerative AC sources), Battery development and test (Battery Test Systems, regenerative DC Loads and DC power supplies), UPS testing (Regenerative AC loads), as well as traditional Avionics and Defense applications requiring 400Hz AC power or 360 to 800 Hz wild frequency power.

vanEijkelenburg emphasized that the company's programmable power test products offer full regenerative modes, as well as special built-in application-specific test functions beyond simply programming settings. For example, their latest AC & DC load models include test modes for UPS testing, Solar Inverter MPPT testing, and battery discharge testing. Pacific Power Source multifunction products can be configured as either AC and DC source or AC and DC load as needed.

When asked about the look forward, vanEijkelenburg said they expect to see growing demand for higher-power test solutions requiring both higher voltage ranges, higher current, and higher power density for both AC and DC applications.



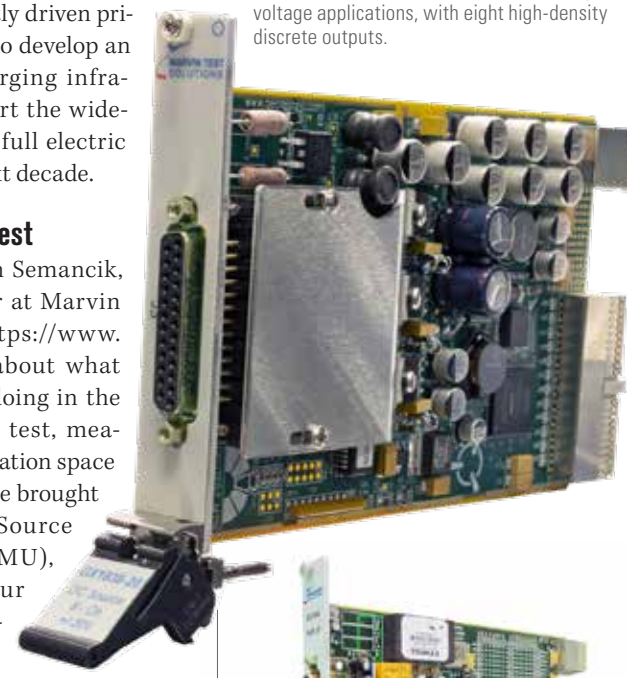
▶ **Figure 9:** The GX3104 Source Measure Unit (SMU), provides four isolated, common-ground SMU channels, with four-quadrant operation at ¬±20 V and ¬±1 A.

This trend is presently driven primarily by the need to develop an acceptable EC charging infrastructure, to support the widespread adoption of full electric vehicles over the next decade.

Serving Mil/Aero test

When we asked Jon Semancik, Marketing Director at Marvin Test Solutions (https://www.marvintest.com), about what the company was doing in the military/aerospace test, measurement, and evaluation space (no pun intended), he brought up their GX3104 Source Measure Unit (SMU), which provides four isolated, common-ground SMU channels, with four-quadrant operation at ±20 V and ±1 A. PXI hybrid-slot compatible, it provides 24-bit ADC's and 18-bit DAC's, and offers seven current ranges, at ±2.5 µA to ±1 A full scale, and up to 1A capability on one channel.

The company's GX1838 Precision Multi-channel DC Source serves avionics and high-voltage applications, with



▼ **Figure 10:** The GX1838 Precision Multi-channel DC Source serves avionics and high-voltage applications, with eight high-density discrete outputs.

▲ **Figure 11:** The GX7404 Power Interface has +3.3 V, +5 V, +12 V, and -12 V voltage outputs, with software-controlled on/off switching.

eight high-density discrete outputs and three programmable voltage rails, with 14-bit resolution. PXI hybrid slot compatible, it offers two output configurations: -10 V to +32 V (GX1838) or -20 V to +20 V (GX1838-20), with a 500-mA maximum current output.

Semancik also highlighted Marvin Test Solutions' GX7404 Power Interface, which offers +3.3 V, +5 V, +12 V, and -12 V voltage outputs with software-controlled on/off switching. The PXI hybrid-slot compatible solution can monitor voltage and current remotely, with an external power-inhibit line and an on-board prototyping area.

When asked about the challenges their customers are facing, Semancik responded that test system size and footprint are always a concern, which is why Marvin Test Solutions implements solutions on the PXI platform for size reduction and performance. Configuration flexibility is also valued, and PXI provides the ability to expand capabilities with minimal impact to overall system layout.

Semancik said that applications vary for programmable power products, but the most common areas for them include testing of LRU/SRU avionics, automotive ECU, semiconductor component test and characterization and general ATE. Their GX3104 employs 18-bit DACs for the sourcing of voltage and current, and since multiple current ranges are critical, the GX3104 incorporates 7 current ranges, from ±2.5 μA FS to ±1 A FS.

Measurement accuracy is also essential, and this is accomplished with 24-bit ADCs leveraging programmable resolution from 18 to 24 bits. Each output channel includes SMU output connections, Kelvin (sense) connections, and a driven guard connection for low level current measurements.

Power performance

When we reached out to the people at KIKUSUI AMERICA about their latest programmable power supply and load products, they brought up their PCR-WE2 series of high-capacity AC power supply, a PWM type solution with specifications approaching a linear-type power supply (Figure 12). This and their PLZ-5WH2 series high-capacity high voltage DC electronic load support high-power industry applications.

The company mentioned that they are seeing customers with applications that demand increasingly larger power requirements, forcing them to purchase larger equipment or multiple units to keep up. KIKUSUI AMERICA continues to focus on increasing the power capacity of their models while keeping the size compact. The company also allows the mix and match of units so customers can build systems that appropriately fit their needs.

Figure 12: The PCR-WE2 series of high-capacity AC power supplies offers specifications approaching a linear-type power supply.

They have also noticed a move toward the ethernet in their customers test systems, so now have LAN and other common communication interfaces as standard on their products. The company's LAN offerings are also LXI compliant, so customers can leverage benefits specific to test instrumentation.

When asked about application areas, they brought up their focus on high-power applications, supporting customers in the EV, Heavy Machinery, Aerospace/Defense, and similar industries. The latest products in these areas are their PCR-WE2 AC/DC power supply and PLZ-5WH2 DC electronic load.

The PLZ-5WH2 was designed specifically to support large-voltage DUT such as the batteries used in EVs, and can serve other battery applications such as in heavy machinery. The 100 kW capacity and 1000 V range of the PLZ-5WH2 addresses these applications, with built-in functions for power supply testing. Users can record integrated data until a programmable cutoff to easily measure the Ah or Wh capacity. The sine function superimposes a current ripple on the DUT and was designed to measure the impedance characteristics of power supplies.

On the power side of things, their PCR-WE2 AC/DC power supply has been a reliable solution for traction motor applications. Using PWM technology, they have increased efficiency while still maintaining the reliability and response traditionally associated with linear power supplies. Because the PCR-WE2 can output AC and DC in single- or multiple-phase at up to 5kHz, it can emulate multiple components in the EV space. With a max capacity of 144 kVA, the PCR-WE2 can address higher-power applications as well.

When asked about their plans for the future, KIKUSUI said they have always been very focused on reliability and precise control, working to improve digital control technology. They also touted the reliability that comes from the company's thermal design research, enabling their customers to meet specifications for demanding environments, in efficient and compact designs.

Their closing words are suitable for this entire piece: "Our customers' applications are what inspire us to push our products forward. Even in these unprecedented times, advancements in EV, space exploration, renewable energy, IoT and 5G are happening every day and are improving humans' lives. It is an exciting time to be an engineer and definitely an exciting time to be a part of the power supply and electronic load industry." EE

ELECTRONICS COUNTERFEITING: RISKS AND REMEDIES

by **Alix Paultre,** Editor

When most people hear the word "counterfeiting" they think about money. That's because money is a great target for the activity, as it takes a relatively small effort (printing on paper) to get a significantly higher payout (the face value of the money). Counterfeiting in electronics is done for the same reasons, as a chip that you made/stole/obtained can sell for quite a price.

The nature of counterfeiting in electronics is multilayered, as what is considered counterfeit may not be a copy, it may be "gray" goods, or recycled parts presented as new. In the software space, this could extend to trojan programs intended to not only waste your money, but steal your data. Cybercriminal groups targeting semiconductor companies can use such counterfeit products to attack target organizations.

A good anti-counterfeiting process starts with microscopy and material analysis.

Hardware issues

To get an idea of the complexity of the issue and some ways the industry is addressing them, we reached out to Astute Electronics (https://www.astute.global/), a supply-chain infrastructure support company that has to address counterfeit products in its operations. We spoke to Geoff Hill, their Managing Director, about some of the issues involved and solutions available to the industry.

EE: Geoff, when we talk about counterfeiting, especially when it comes to hardware, there are levels, right? You can get a part that's quote-unquote 'counterfeit.' but it could be a real part, right?

Hill: Yes, absolutely. It comes in many different forms, like a device that's just been pulled off of a board, cleaned up, legs straightened, and then resold as original or new.

EE: That's the first thing that came to mind when the topic of counterfeit products came up. One can just picture somebody heating up a board over a hot fire somewhere, prying chips off with a screwdriver, and throwing it into a box that somebody later cleans up and sells as new.

Hill: A lot of that has come from the waste that was sent over to Asia to be disposed of, and basically that hardware waste or equipment then was harvested, originally in China, but then they became a little bit further down the food chain. Now it's harvested in Africa, around Nigeria. Then they send it off to China, who basically counterfeit it in one form or another.

Counterfeits in that form, which is your basic form, really, of getting a part that's used. So it could have been programmed, it could be used, and therefore its integrity has been compromised. You can also get parts that are just empty packages, so you've just got the packaging with no die inside, and they're sold as new.

But again, with the equipment that's available, nobody really should fall for that anymore. A lot of the other stuff is where you can get a bad product that has been intercepted from the factories, and for whatever reason, being destroyed, and they were intercepted and then sold back into the market as used, even though the product has obviously failed tests. So you get a whole range of different parts, and then also you get parts which are the same package, maybe the same family. This is where the real problem comes.

Good bad fakes

Hill: The counterfeiters now, in fact, have original manufacturers' equipment and they can silkscreen and really make the parts look to be very, very much the part that you require and in some respects, can actually go past first initial tests, electrical tests, or they could actually meet some of the characteristics that would indicate that it's the same family. So it's quite complex, and over the years, of course, the counterfeiters have become incredibly clever at what they do. They've invested fortunes because they're making so much, so it's not as basic as it used to be 10, 15 years ago. It's a really clever business.

Hill: If you're getting a part, and it should be $20 and you're only paying a dollar, the likelihood is there's something wrong with it.

EE: Which is always the case. Then there you go, because I would say at the microcontroller level, good fake parts are less of an issue. But I would imagine that when it comes to passives and magnetics, that's got to be rife.

Hill: It is rife. If you look in China, certainly outside in some of the country areas, a $600-a-year salary is a big salary and they can get that selling a real multilayer ceramic, especially when you've got tantalum that has historically been in short supply, and multilayers. So, yes, the attitude years ago was, "Oh, well, the counterfeits only want to sell your FPGA business because that's the high end, nice and expensive. No. No, no. They actually want to hit the low end because they don't think anyone's looking carefully in that direction.

EE: That's right. That's an excellent point, and who knows, maybe the capacitor will test out right.

Hill: The problem is that, depending on the printed circuit board, the capacitors of course are littered all over the board. It comes to two different events, really. One is an economic standpoint, where the recall of the boards for damage to reputation, your whole standing in the marketplace is compromised. That could have knock-on effects to your customers, to your product, to everything to do with the economy.

But when you really talk about safety-critical applications, some of these parts, they won't fail at the front end, but they'll fail at mission-critical status, especially if there's a temperature that's going to be affected, and things like that. Then you're talking about life and death. You're talking about a whole different topic of where it's not an economic thing, it could threaten thousands of lives.

So the whole thing has become, in some respects, the level of testing that you do on something that's nontraceable. Of course, nontraceability is driven by obsolescence. With mergers and acquisitions as strong as they are, that's very prevalent. So it becomes application-centric. If you're

making a coffee machine, you could argue, what's the damage that can be done? Not a lot. But if you're talking about some sort of decoy device for a fighter jet, it's fatal.

So it really becomes an education scenario, and we have to invest more and more in good behaviors, good tests. Where you can, you buy from authorized sources where you've got the provenance of the part, and that's the only way to beat it. When you've got behaviors that are driving costs down all the time, and there's no policing of your behaviors, the reality is, then you're going to drive people to make very bad choices.

Obtaining secured product from authorized sources ensures full traceability

EE: Geoff, you were saying coffee machines, but there is a lot of growth in smart and advanced devices. My coffee machine, if it broke on me, I'd be quite upset, because it cost me a healthy penny. It grinds the beans, it checks the temperature. You're talking about three to five hundred bucks worth of coffee machine, depending on whose brands you buy, for a modern top end. But then you could apply that to anything. A new web-enabled refrigerator, or a toaster that now gives me internet updates, and could print pictures on the toast or something. All of these devices are now smart, and there's more opportunities for bad chips.

Hill: There is. It comes down to, again, how you treat your washing machine or your toaster. If it goes wrong, generally people throw them away and they buy a new one. If you're selling something that is airborne and it's safety-critical, then you need to... basically the cost to investigate, to put corrective actions, look up the origin of the problem, could cost hundreds of thousands, if not millions.

We don't have to go very far. Looking at the 737 Max scenario, I know that was a software issue with Boeing, but it only takes one issue to ruin years and years of a reputation. That's where it comes down to, really, it's how people are going to react to an issue. Then, of course, it comes down to negligence. If there's culpable negligence, then of course, then you're talking to legalities and lawsuits. It can be quite a big issue, if it's not managed with a certain amount of responsibility.

EE: Excellent point. Now, having laid out all of the dangers, let's talk a little bit about mitigation. What can you do to address this issue?

Hill: Obviously, you need to review your buying techniques, your behaviors, you've got to buy from authorized sources, so you get full traceability, full manufacturer's warranty. That's your first point of call. Now, as I mentioned before, with mergers and acquisitions, there are so many companies now that are on this aggressive acquisition trail, especially in the semiconductor business. Because even if you look at what's happening, Intel with Arrow, Xilinx now with AMD, Nvidia on Arm, it's huge, Maxim and Analog Devices. What happens is, obviously, they make a lot of parts end-of-life straight away, and just because the investment in getting ahead of the curve on new technologies is such a great return for them.

Then they go into last-time-buy scenarios, and we offer that, nitrogen cabinets and that sort of thing. You store the die, you can make them forever more, but that is really reliant upon you having good forecasting. My experience with my customers is they really haven't got a clue. So, often they get it wrong. The numbers are always going to be wrong. It's going to be too high, too low, whatever else. Actually, a lot of the manufacturers or the OEM equipment, there's always requirements and demand for many, many years, following their expectation of when they could say goodbye to it.

So what happens is they have to go to the gray market, and the gray market is not always a bad market because a lot of that product could be excess. It's where the manufacturer, they've got too much product because they overbought on a last-time buy and they want some dollars back for their investment. So it goes back into the market, but this is where the issue comes. When you're buying products without any warranty or traceability, you have to test. There's an AS6081 spec that we use mainly for semiconductors and for components generally. It ranges a whole range of equipment that we've been doing for many, many years.

Our process starts off with visual microscopy, at 20x magnification. Then it goes into spectrometry and material analysis for material elements that might be different. So the amount of gold in there, amount of silver, that sort of thing, which could throw up an anomaly. You've also got marks and permanency. So, obviously, if the marking of the device suddenly comes off, even with basic things like your-

EE: Soap and water.

Hill: Yeah, yeah, pretty much. Then you've got a problem, but actually they're very, very complicated now. Then we also do heated solvent testing using Dynasolve, and the disruptive test on that marking, that highlights any ghost markings. So you can see what originally was marked underneath. We also do scrape tests for blacktopping, which was one of the initial things they did. Obviously blacktopping is a giveaway, although some manufacturers do blacktop, if they do a special run.

So it's not always 100% assured, and we've had many manufacturers that have done blacktopping. Then you've got real-time X-ray. Obviously, you're

looking for the consistency of bond wire that surrounds the die, and making sure that's 100% consistent within the batch. Then you do a decapsulation, and then topography. You're looking really at the recognition of the actual die. Then going back to verify that that die or whatever, its second source is absolutely as per the manufacturer. You do that with high-powered microscopy.

Scanning electron microscopy and energy disbursement goes back and uncovers the original coatings, coating upon coating upon coating. That really gives it away, that that top surface has, in some respects, been changed or altered, and there's some stuff on there that shouldn't be there. That's really good because it draws you a very good diagram of what it should look like, with the carbon and everything else that should be there, and that's not there.

Then after that, you do the solderability, you might have an issue with water ingress. It might affect the solderability. You check whether the parts are programmed. Then we also do electrical tests using diagnosis. So we're actually putting some parametric and functionality tests through electrical capability. All of that, these are fairly advanced, and expensive, and long-winded ways of basically reverifying your device.

What happens nowadays, you can buy products off the gray market and use things like escrow, so it gives you time to test the product without any money being transferred. But in the early days, they used to say, "Oh, well, we'll do 50/50, give us 50% upfront and 50% when you've tested them," knowing full well they're going to fail, but they've already got your 50% money and done a runner. It took a long, long while for people to get familiar with behaviors, and understanding the con that was in place.

So what happens now is, you tell people you're going to test, and that you do it yourself. That often is a barrier, because all of a sudden they'll turn around and say, "Oh no, we've sold them. No, we haven't got them any more," just so that it puts you off the scent, really, because they know that they're trying to have you over, so to speak. So it's a fairly dynamic business, because their abilities to counterfeit are improving all the time.

The money they're making seems to be increasing as well. That's a cultural thing, as well as anything else. You would have actually thought, if they actually put that amount of money and effort into something legit, that they would make as much if not more money, but I think it's a cultural thing. They get a kick out of it.

EE: Some people look short-term.

Hill: People always look short-term, that's the problem. The only way to overcome it is to have robust testing and good education, and the communications of what the market is and how we overcome it, and to look for those signs. That's the only way you can stop it.

EE: Agreed. Are there any other things that Astute provides to help address the issue?

Hill: We're probably looking at some other forms of equipment to invest in, and probably enhance a bit more of the electrical testing capability. We have 17 nitrogen cabinets, so we stock a lot of die for customers, just to help them. Because if they stock die, then they're not basically taking on the whole cost of that last-time buy. They've got that security to turn, to package it, as and when the need is there.

So we support them in that, and in any sort of long-term and end-of-life buy that goes over several years, but generally what it comes down to is the experience and your data library. Because there are more and more parts... you'll find you're doing the same parts time and time again, so you've got to create a history, a lot of knowledge, and that communication is very valuable because you're really going from a position of strength, saying, "Well, I've seen this before. I know about this device. I know about that."

Also, enhancing your relationship with the component manufacturers is crucial, because they need to understand that you're not there to take food off their table, you're there to protect their reputation. Because a lot of times, they would say, "it's not my problem, it is your problem", because if you haven't helped to identify a potential problem before it gets into a safety-critical application, then hang on to your hat. It is literally life and death. I think the main thing that we're doing more and more is education. If you don't need to take a risk, don't take a risk. That's the message.

Software issues

The role of software in the electronics industry continues to grow, and that sector also has its issues with counterfeiting. We talked to one of our industry experts in the space, Alan Grau, VP of IoT and Embedded Solutions at Sectigo (https://sectigo.com), to talk about the state of that part of the industry.

EE: Now, with hardware counterfeiting, it's easy to sit at face value and just say, "Yeah, well, it's a fake product," but with software it goes deeper than that. Doesn't it?

Alan Grau: Well, there's lots of different levels in hardware. It can be everything from a knockoff product, a fake product, companies that are using a manufacturing facility that's like a contract manufacturer that's not trusted where they'll do overruns. Or components that are fake or from an untrusted manufacturer, whether it's chips or boards or other elements of the solution, or the software piece. So there's multiple different ways to look at it.

EE: The overrun aspect is a very threatening aspect on the counterfeit side for the manufacturer. At least it's less of a problem for the end user because they're still getting a good product. It's not kosher as it were, but at least they're not getting something that was pried off of a board over a fire and dusted off, wiped up and repackaged and sold to you.

Grau: Yeah. They may not get the same support, but at least the product is real. That's true. I actually was talking to a major manufacturer who everybody would recognize, this had been several years ago, and they were talking about a support issue where a customer that kept complaining about the device that they bought not working right.

They couldn't figure out what was wrong with it until they finally sent somebody out there and opened it up, and realized that it looked really good on the outside, but when they got inside, it was not their product. It was packaged well,

it looked great, but yeah, exactly. It didn't work properly.

EE: You could say mislabeled consumer product is also counterfeit, because I've seen people buy, say, for example, it says a 1-terabyte drive for 5 cents, and of course they don't think about the fact that how can you have a 1-terabyte drive for 5 cents? They order it, they plug it in, it runs. And then they realize that it's a 256K USB drive hot glued into an empty box.

Grau: That's pretty bad. But yeah, there are all sorts of scams out there. As you said, some more obvious and blatant and some more problematic than others, but in all cases it's costing people revenue, it's causing frustration for the end-user.

EE: It's all flavors of the same bad recipe, multiple issues and multiple facets to the problem. Are there multiple solutions? Or are there solutions to protect against multiple counterfeiting vectors?

Grau: There's definitely not one silver bullet that's going to solve this problem. On the software side, which is where I live, there are certainly well-known techniques to help mitigate against this risk. The main one of course is code-signing techniques so that you can validate the code being installed on the device, or the code being downloaded, and depending upon the system, is the code that was produced by the OEM, the manufacturer, or the software vendor.

This is really, with the recent SolarWinds hack, which was a multiple-level attack, right? There were some very patient attackers who were able to get into SolarWinds' system, and I heard different theories on how they got in. And I haven't actually read up on that lately to see if anyone's confirmed where that originated, how they initially breached SolarWinds. But once they got in, they were able to insert malicious firmware into the build system of the SolarWinds, one of their products.

This became a cybersecurity issue. So then people were updating this trusted cybersecurity product on their network, with code from SolarWinds, and even though it was code signed, it still had malicious content in the update package. And the reason for that is hackers were able to insert their malicious code into the build process.

The way code signing works, once you trust what the manufacturer built, SolarWinds could sign it and say, "Okay, this is our trusted, good software," it would be downloaded to thousands of organizations. Those organizations would check and say, "Oh yeah." Or, well, the update process would validate that it had been signed by SolarWinds and it hadn't been changed. It was bit-for-bit the same software produced by SolarWinds.

So everybody installed it and ran it, and there was this malicious code in there, and that was because that malicious code had been inserted upstream of the signing process. So you're trusting the signature, which is the right thing to do, but what was signed was bad. So that really shows there's a step missing in that process, and once somebody had breached their build process, they really were able to do tremendous damage and a very, very broad attack. I mean, it has affected thousands of organizations.

But code signing fundamentally is still a great technology. So things like secure boot and secure code updates that use code signing and are still critical technologies. You can verify that what you are installing was in fact from a trusted party, and it's just that you're trusting they weren't breached. In SolarWinds' case, they were. But on the software and firmware side, code signing is a critical technology and helps ensure what you're receiving ... Again, they actually were installing what was the authentic code from SolarWinds, it's just that it had been tampered with prior to that signature process.

EE: Got it. Now, as far as protections, there are obviously things you can do before the product leaves the building, and then there are things you can do once the product leaves the building. But again, are we concerned about counterfeit parts within the product? Are we concerned about counterfeit software being downloaded to those products? Or are we worried more about counterfeit software being sold to the users of those products once they've left your control?

Grau: Yeah. So we can talk about each of those individually because they are all different. If it's an IoT or an embedded product, typically the update process is an integral part of the device, right? So if I'm updating my software on my home router, typically the home router will go retrieve the software. It knows where to retrieve it from. Ideally that's an authenticated process where each end is using a certificate to verify that it's connecting to the OEM to get new software, so that it can validate, "Yes, I'm going to the OEM."

Then it uses another signed code package, certificate-based signing to say, yes, the software is actually valid as well. But, another case where I've seen an attack is someone hacked into the update server for an OEM and put malicious firmware on the download site. And this was before code signing was widely used. So if you validate, again, using a validation of the server you're connecting to, and then validating the software that's being downloaded, it's a pretty robust mechanism.

The human factor

Grau: The next one though, that you're talking about is a human's involved. So for users going to update the firmware, how do you or how does the user know he's pointing to the right site or getting software from the right place? Again, you can use the same techniques, right? If you're using signed code and doing all that, again, you've got a strong level of protection.

So if we shift out of the embedded world into, say, the Windows or Mac world, where you're downloading software, we're seeing much more software that's code signed, and then the installation process when you go to update it, on a Windows PC, for example, it will pop up a window and you can verify who had signed the code. The system will look at the signature, will look at the certificate used to sign the code and say, "Oh, you're installing code from Alan Grau software, do you trust this supplier?"

Again, that's a pretty robust mechanism, right? Because the user should be able to know who they're getting the software from. But humans are more prone to error, so there's always a risk there that someone will click, "Yes, I trust this source," when they shouldn't. But one of the defenses against that with code signing is

the certificate used to sign the code, if it's discovered that that person or that entity shouldn't be trusted, they're doing malicious things, the certificate can be revoked.

So security companies come to us and say, "Hey, we see that the code signing cert that was issued to Alan Grau Software is doing malicious things. It should be revoked." The CA will revoke that certificate, and then the next time somebody tries to install software that was signed by that certificate, the operating system will check and say, "Hey, this is not trusted software, the certificate's been revoked." So it will then either not allow the software to be installed, or display a much stronger warning message. In general, if the certificates revoked it probably shouldn't install it at all. But again, that's handled specifically by the OS.

EE: In the context of the aspect of counterfeiting, are IP blocks considered hardware or software? For example in certain microcontrollers, they'll purchase an IP block from a vendor for X, Y, Z functionality on their device. And now, obviously they're going to usually just buy direct from the vendor there. You don't really walk up and pull that kind of stuff off a shelf. But is there a danger that you could wind up getting bad intellectual property products from someone?

Grau: That's a great question. I'm sure that there is. So I guess it depends a little bit whether or not those IP blocks are capabilities that are baked into the hardware, that can be simply enabled through purchase. In which case, if it's already in the hardware, it's unlikely that it would be tampered with, unless it was tampered with earlier in the cycle.

If something's built into the hardware where when you buy the hardware, it's got additional capabilities in the hardware that you just enable and disable, and there's lower risk there. It would have to have done an attack earlier in the supply chain to tamper with that. If it's essentially firmware, microcode, or software that's running from when it's downloaded over the air, then there's the same risks as there would be otherwise. But, again, if it's something baked in, then you're pretty safe unless it was tampered with prior to manufacturing.

But if we switch over and start talking about hardware attacks, again, there's several flavors there. The first one, or one of them, is how you handle overruns, and how you ensure that if your manufacturer isn't fully under your control, how do you guarantee that there are no overruns? And there's multiple ways that you can address that. Some of them are as simple as physical security where you've got cameras and things like that.

But what we're starting to see are people that are actually building product-based solutions to have better control over the manufacturing. So there's actually a company that is out of the UK, called Secure Thingz, actually owned by a company called IAR, that has developed a solution that they can deploy into manufacturing facilities, where basically they're encrypting the firmware in the device provisioning solution.

Each time they program that solution or the package, the firmware package is programmed into a device. It gets decrypted for that individual device in a manner that has traceability. So you have to have something on the device that can be encrypted, and you can track then, "Okay. We've just hit 10,000 units, turn it off now." Or if it keeps going, at least you've got an auditable report that says, "Hey, the manufacturer produced 11,000 units." And so you've got accountability.

EE: "We've got 15,000 clients in the field."

Grau: Yeah, exactly. Well, you can go back to the manufacturer and say, "Hey, you were authorized to produce 10,000 units. The report says you produced 11,000 or 15,000. Where are my other units?" And if they shipped those out the back door to somebody else, then you can deal with the problem right away. So, there are companies that are developing solutions very specifically targeted for exactly that problem. Some of the other things that can be done that don't require quite that... That's a fairly comprehensive solution that has to control the whole and be involved in the whole manufacturing process.

A lighter-weight solution that's still pretty effective is just a matter of issuing device identity search to the devices as they roll off of the manufacturing line. It depends a little bit on the functionality of the device. So if you're producing a device that's going to connect back to a cloud service and it's only useful if it connects to that cloud service, say you've got a monitoring system that collects some data and sends it back to a cloud service where you can analyze it and use that information, you can require that the device have a certificate issue to connect back to the cloud service.

That way you can monitor how many certificates are issued, if you've got the right system to control how certificates are issued. And then you've got an audit on that. So if somebody produces additional devices, either you would know that they had issued additional certificates, or if they create them without certificates or with certificates from a different source, and they try to connect back to the cloud service it would fail. That doesn't work if it's a completely standalone device that doesn't require that outside connectivity. So it depends a little bit upon the type of device you're building.

Then the other place where it can become problematic is people producing counterfeit components. And there, again, it can come back to the same capability, if you can issue a certificate onto the components. So if you've got a processor chip or an SoC and you're using the products, if the manufacturer of the SOC can insert a certificate into the SoC, then when you're doing manufacturing, or when you're first doing your system test on the device, you can retrieve the validation of the certificate to make sure that the SoC is authentic. So you can do things like that to protect the supply chain.

EE: Can the same secure block used for crypto be used for verification?

Grau: Yeah. You just need the data, a certificate in there that was issued by a known, trusted CA that you've got control over, so that you can control it against that. So you can somehow know that, oh, this wasn't produced by a TI, or Microchip. It's a knockoff version. So you need that other piece in there so that you've got something to inspect, to validate the components. EE

ADDRESSING PRODUCT QUALITY AND PERFORMANCE WITH EFFECTIVE TEST METHODS

by Alix Paultre, Editor

When it comes to ensuring that a product meets the standards established for performance, reliability, and safety, how well that compliance testing is performed directly impacts the product's eventual success or failure in the field. Production test is an aspect of the true value-add, and where the real mission to create a good product occurs. To talk about designing, developing, making, and fielding a product, we reached out to Daniel Knighten of Audio Precision, who does a lot of testing of consumer and commercial acoustic devices.

EE: Okay, now, I have an idea, I'm designing it. I've got to test it during design. There are issues involved at that stage. I've got to make sure that it gets manufactured properly. First, the design, depending on how you look at it, it's either one or two stages. In a modern world, I'm designing in a design simulation software and then I'm building a hardware prototype, making two stages of design. I'm doing my software simulation, and then I'm doing my hardware prototyping and then I'm manufacturing. Each of those has separate requirements.

Daniel Knighten: It starts at the very beginning. There's a very real issue for everybody designing a device today, regardless of what kind of devices they are. There are companies whose fundamental selling proposition is, "Hey, do you want to build a smart speaker? Have we got a chipset for you? Buy our chipset. Follow our design guide. Here, we're going to give you schematics, and gerbers and such, and you can just do this."


Knighten

It's the same model as Blue Apron and whoever else that's saying, "Hey, do you want to cook, but you don't know how to cook? We'll send you a box of ingredients, and instructions and, in theory, at the end of it you'll have a beautiful meal." So, the reality is, the very first place where most of our customers start with using our gear, is they get those building blocks. They get evaluation modules with different ICs. They get sample speakers, and microphones and they test them to see if they actually have the characteristics that they need for their product.

At a paranoid level, they might even test them and see if they actually meet their own published specifications, but even more practically, one of the things you may have noticed, if you cruise around data sheets, is there are no two companies that publish specifications the same way. At the very earliest parts of a design stage for a product, where a customer is qualifying the components they're going to go with, they're using supplied products and they're testing samples of those components and verifying that they'll work for them.

The next thing they do, is actually, in the world of audio, and I'll divide it between the electronics portion and the acoustic portion. The electronic portion is pretty well modeled. It's still not perfectly modeled, so there are second- and third-order effects. There are things like crosstalk and just stuff that never gets modeled perfectly, so there are a fair enough number of people who will design a circuit board, they've modeled it all up,

◀ Speaker Test - APx517B analyzer with GRAS 46AE measurement microphone

and they just fab it up and it's good to go, but they're still going to test it.

But, as soon as you move into the acoustic realm, into speakers and microphones, no, there's no good models of even first order. By first order effects, what I mean is you have a model of a speaker driver and therefore you want to predict the frequency response. There are software packages that will do that, but they're going to be pretty far from whatever the actual frequency response is. So what you'll get in there and what you'll see customers doing is, they're going to totally mock up their design.

They will 3D-print what they think their physical form factor is, and there will be an iterative design process for the acoustic side of the product, both the speakers and the microphones, and that iterative process itself. If you're trying to sell a product for $25, you're not going to spend a lot of time on that process, but you're probably still going to iterate several times. For a high-end product, you might see thousands. It's kind of scary. You see these guys, there are graveyards of mechanical prototypes.

EE: At that point, Daniel, one of the things I'm fond of saying, as mentioned, I've been in the audio business myself, is you could give two sets of engineers a stack of wood, the exact same drivers, the exact same capacitors, and passives, and tell them to make two speakers and those speakers will look differently and sound differently, even though they're from the same components.

Knighten: Absolutely, so there our equipment gets used very intensively. Not only do you want to on-access frequency response, you want the off-access frequency response. You probably want to do it at multiple angles. Again, it all depends on what your ultimate goal is with this product, but for, let's call it a mass-market smart speaker from a Tier 1 company, this process is going to take months to years and it will involve... If you actually counted it, it would involve tens of millions of measurements, and they'll go through that process and, "Okay, we finally arrive at our first prototype."

Again, there are scales at every different level and products, but let's say you're a Tier 1 company, you're making a mass-market product. In a mass-market product, we often lose sight of the scale, but when you make a mass-market product, you're going to sell tens of millions of these things, maybe hundreds of millions of these things. It blows your mind the first time you go visit a factory in China that's making a true mass-market product.

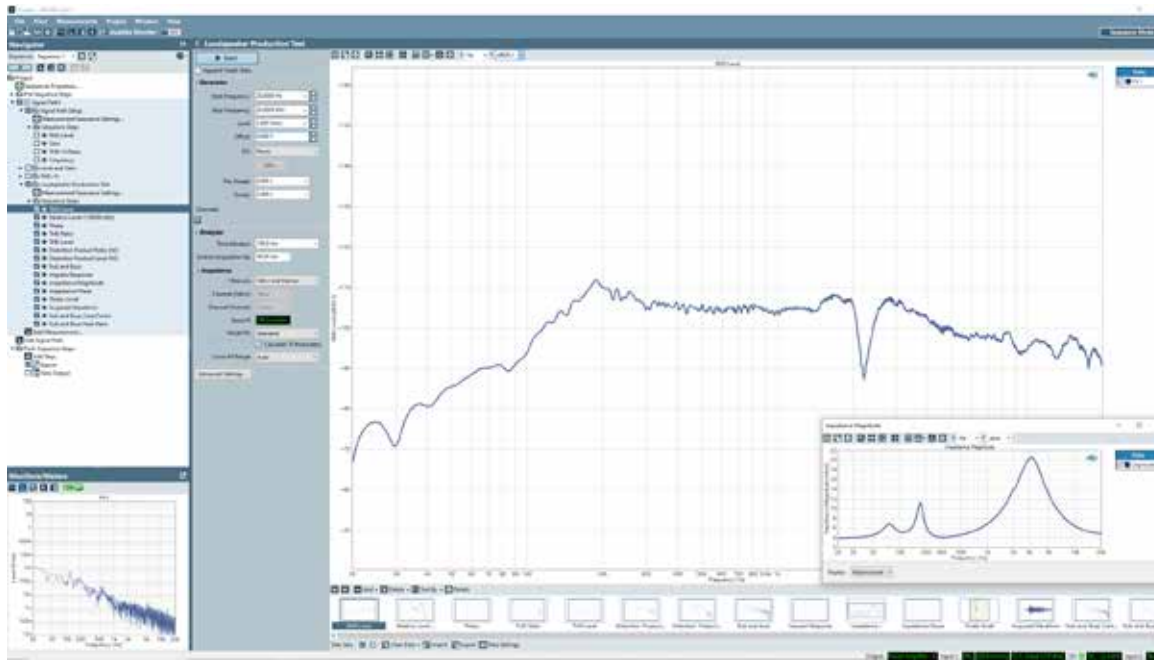
So, one of the things that can be stunning is, let's say you're a little boutique speaker manufacturer. Prototypes might be single digits. The R&D engineer who's designing it may, in fact, be the person who hand-assembles the prototype. But, if you're a mass-market company, your prototype runs may look like other companies' lifetime production runs.

One company that we work with, their prototype runs are 10,000 units. Lots of the ideas you have around, well, what does a prototype run look like, really don't apply. Here, a prototype looks like a full-scale-production run, but what remains true, especially about prototype runs, is you do a lot more measurements than you plan to do when you're in regular production.

EE: But, you still have to do QC when you're in regular production. You can't just stop testing once you've gotten a good product.

Knighten: There is, especially for audio products... What I like to point out is, speaker drivers are the last moving part in a consumer electronics product these days. Everything else is solid-state electronics, very well understood, very reliable. ICs, these days, it's very, very rare for somebody to get a defective IC, but a speaker is paper. We forget that, but it's made out of paper, maybe coated with something so it's not obvious that it's paper, but it's paper, and it's a spring, and it's a magnet and some type of compliant material.

From a manufacturing perspective, it is an incredible variable component. Speakers do not have the repeatability of any solid-state components and they're really, incredibly complicated. It's a mechanical device, it's an electronic device, it absorbs and exhausts humidity, and human beings listen to them and human



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beings are kind of terrible at making objective assessments, but especially when human beings experience something all the time, they become extremely good at picking up small variations.

This is one of the challenges that remains in the world, is that a completely untrained human being could pick up a phone and if the speaker is caught in the gap they will detect any issue ... They may not be able to say what it is,-

EE: Can't put their finger on it.

Knighten: ... but they'll pick up that phone, they'll listen to their aunt talking and they'll say, "This phone is crap," and return it.

EE: Well, Dan, to add to what you were just saying, what about some of these newer piezoelectric glass-shaker technologies that some of these television companies are implementing. They still have to be tested as well, just because they are solid-state doesn't make them magically acoustically good.

Knighten: I'm curious to see how that technology goes. They're solid-state but they're still a moving part. Actually, they're still many moving parts.

EE: At that point, would you consider vibration... Obviously, a speaker vibrates, but that's pistonic motion. But, I mean in the case of a piezo electrically-stimulated display, you're vibrating 80 diagonal inches of engineered plastic, I was going to say glass, but you know what I'm saying? At what level do you consider a vibrational surface a moving part? Does it make a difference to your test equipment how that sound is generated?

Knighten: Ultimately, we're measuring air pressure and the question is, how is that air pressure being modulated? I would say that the MEMS-actuated vibrating surface transducers, and there's a few different technologies for doing that, those are a moving part, and I'll give you a very simple reason why. One of the most common ways in which speakers go bad or since they go bad, are bad, is the adhesive isn't applied correctly, or the adhesive cures incorrectly or something goes wrong with the ingredients used in the adhesive. And, that's not less of a problem when you're vibrating the screen, that's more of a problem.

EE: Excellent point.

Knighten: And, the screen is now a giant diaphragm. Is the screen a uniform thickness? What is your repeatability in the manufacturing of that diaphragm? The problems aren't less, the problems are different. For that particular kind of thing, the problems are actually more challenging.

EE: Well, then they would need you more, actually. You know what I'm saying? These newer technologies are actually going to need more acoustics tests to ensure that these Blue Sky, advanced ways of emitting sound actually do something.

Knighten: Just very, very broadly speaking, at a couple miles off the ground, when you introduce a new technology, test requirements increase, and they increase until people have a grip on that technology and figure out how to make the technology repeatable. The goal of anybody who runs a manufacturing line is to figure out how to do the exact same thing over and over again. And, what happens with new technologies is, you haven't figured out how to do that yet.

EE: Why don't you put some of your product solutions in context with... I want to go back to what you were saying about highly reproducible, which goes back to manufacturing tests. We can talk more about the exotic aspects of it, but at the end of the day, I'm trying to manufacture. I want to be consistent in my tests. Why don't you give us an example of one of your solutions in context, in the production line, to help me get my product out the door properly?

Knighten: Right, so a very good analogy you made earlier was, test equipment has to be better, along whatever access you want to imagine in the device under tests. If you want to measure the noise

floor of a power amplifier, the thing that has to measure that noise floor has to have a lower noise floor and if you want to measure the frequency response of something, you have to have a flatter frequency response that what you want to measure.

In manufacturing, if your basic goal of manufacturing is to do the same thing over and over again, then your test equipment has to be reliable and repeatable. And, I would say that is maybe not the number one thing AP is known for. People generally think of Audio Precision for the performance of our test equipment, but, certainly, part of the performance of our test equipment is that it will measure the same thing over and over again in a relatively harsh environment for decades.

EE: An industrial floor can be a harsh environment.

Knighten: An industrial floor can be a very harsh environment, because it turns out that when people build factories and think about manufacturing costs, they might decide that air conditioning is not something they actually need, so the temperature inside the factory could vary 20, 30 degrees C or Fahrenheit during the day. The humidity could suck. It could be a dusty, dirty environment. All of those things are very true. Particularly for our customers using our equipment in production tests, that's really the No. 1 thing, is that our equipment can be relied upon to be exceptionally repeatable and reliable in an adverse environment.

Typically, we're in that realm where, actually, our customers take it for granted. They just assume, "Yep, I can buy this piece of equipment, put it in this environment and never think about it again." That's something where, with our partners, it's true of their equipment. That's, actually, one of the things that distinguishes, I'll say, a measurement microphone from a non-measurement microphone, as a measurement microphone uses a stainless steel diaphragm instead of, say, a Mylar diaphragm, and it is quite robust and stable.

EE: It goes far beyond just putting an extra gasket on it and some plastic.

Knighten: Oh, yeah. It's generally, again, the stability and repeatability that will exhibit over time, temperature, humidity and dust, is orders of magnitude better than what you would see from any other kind of microphone.

The thing is, is that in terms of what we're doing these days, the key for us and our customers is, No. 1, we have a lot of different products targeted at some different segments, but they all run the same software, so somebody who starts out using, say, the APx555 in an RNT environment, they can recommend an APx517 or 515 for the manufacturing environment and they can assume that the measurements are going to be the same, the measurements are being made with the same algorithms, they can compare the measurements and they can assume that, after that product, after the analyzer has been on the assembly line for two years, that those measurements are still correct.

That, I would say, is the most fundamental thing that we're offering today, is that within this sub-segment of... You take a consumer electronics product and you're entirely right—it's amazing, all the different things that a smartphone has to do these days—but if you take the audio subsystem, and the speakers, and the microphone, and the codex, and amplifiers and all of that stuff, we're offering a solution to our customers from the design stage through the production, and we do a fair amount of stuff with return centers.

Our analyzer will actually sit at a warehouse that's collecting stuff returned by consumers and they will test it to see, "Well, is the consumer just returning it, and we can repackage it and resell it or is this actually defective?"

EE: That's a very interesting test aspect, successfully reclaiming useful return stock, that's another nice, cost-effective way to rationalize the equipment if you are on the fence about getting it.

Knighten: The thing is that speaking to stuff at the higher end, when you start talking about a smartphone that might have a value of something approaching $1,000, all those companies have gotten, in the early days, that stuff would just get binned. But, I think I can say, authoritatively, that at this point, all the major smartphone companies have a process to reclaim smartphones and they will, in fact, do a repair. So when you return your trade-in smartphone, they will, actually, test it, make some assessment and quite possibly, depending on the component, repair it before reselling it, rather than just binning it.

EE: Why don't you give us a final thought for the audience, to make them think about acoustic tests in a way that they may not be?

Knighten: This is the quote I use, which is not original, by my part, this goes back a lot, but audio often gets not enough credit, in that most people... Think about the advertisement you see for smartphones. When was the last time that somebody touted the great audio of a smartphone?

The analogy I use is movies. Nobody would ever go back to silent movies. Audio is interesting, in that it doesn't get, I think, very much credit in the general populace, exactly. Every smartphone I see, they tout the screen. "Oh, it's got a fantastic screen. It's got so many pixels by so many pixels. It's this size." They never talk about, "Oh, and by the way, the built-in speakers have this frequency response and this sound pressure level," right?

Nobody ever says that, but on the other hand the screens, the manufacturing of screens has gotten really good. You don't have issues like dead pixels anymore. Smartphones are not, generally, being returned by consumers because of a screen defect. Smartphones are being returned because a consumer picks the phone up, gets on a phone call and it doesn't sound right.

Audio test is important and often underappreciated. It's a very large cause of returns on consumer products. Consumer products and cars, that's another one we're dealing with, but the car companies actually do a lot of audio tests, because when a car gets-

EE: Well, audio and cars have evolved together.

Knighten: Audio and cars have evolved together, and the cost of a consumer returning their car is grotesque. EE

EVALUATION ENGINEERING'S

FEATURED TECH

1

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3

4

1. Edge AI Starter Kit

Lanner Electronics collaborated with Intel to launch the Edge AI Starter Kit for industrial automation. Combining Lanner's Edge AI Appliance with Intel Edge Insights for Industrial, the kit aims to deliver an all-in-one platform composed of a high-speed camera, Intel CPU- and VPU-accelerated computing hardware, and application-tailored software to accelerate time-to-market AI deployment at the industrial edge, such as vision inspection, predictive maintenance and operator monitoring. Lanner Edge AI Starter Kit for industrial is powered by the edge compute platform LEC-2290, integrated with 8th Gen Intel Core i7 CPU (codenamed "Coffee Lake-S").

Lanner Electronics

2. Anritsu Launches Portable 400G Network Tester

Anritsu released its battery-powered Network Master Pro MT1040A for 400G networks, with directly-mounted QFSP-DD optical modules. The tester also has a simultaneously-installable 10M-to-100G interface for access, metro, mobile fronthaul/backhaul, and data-center transmission quality tests, Features include a GUI, a remote-control-over-network option, and auto-test functions. The MT1040A is presented as the smallest B5-size 400G Ethernet tester available, and offers added functions for efficient testing, installation, and maintenance of faster networks up to 400G speeds.

Anritsu

3. 100 MHz oscilloscope

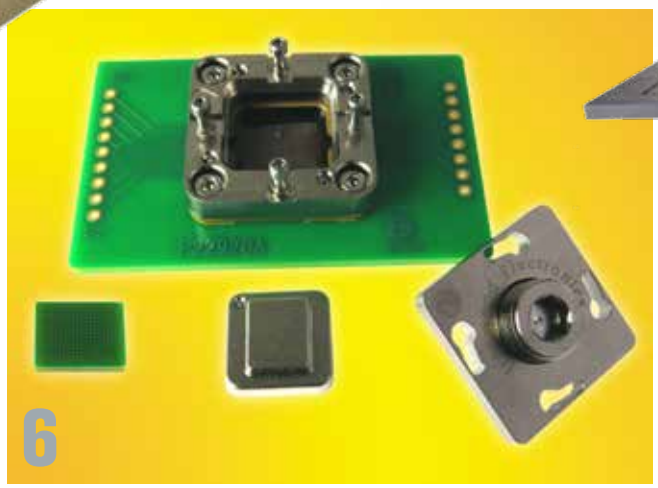
Saelig Company's SDS1104X-U 4-channel 100MHz oscilloscope is a lower priced, economy version of the SDS1104X-E. Many features have been retained, including the large 7" TFT-LCD display and ergonomic front panel design, while economies have been made by removing the optional MSO and function generator upgrade capabilities, a reduced time-base resolution and vertical resolution, eliminating web page and WiFi control, and using one 1GSa/s ADC not two 1GSa/s ADCs. The SDS1104X-U uses the latest generation of Siglent's Super-Phosphor technology, yielding waveform capture rates up to 100,000wfm/s (400,000wfm/s in sequence mode).

Saelig

4. Three-phase AC Power Source and Alternator Simulator

Highland Technology introduced the P900 3-phase AC power source and alternator simulator. It can simulate aircraft power buses, and PMA permanent-magnet alternators and drive FADEC shunt regulators. Each phase can output 0 to 160 VRMS at 200 VA and 120 Hz to 4 kHz, including applications requiring a 400 Hz or APU/wild power source. Outputs can be programmed as low-impedance voltage busses or alternators with controlled source impedances. Features include output measurements, waveform monitors, and fault simulation. Control interfaces are USB and Ethernet.

Highland Technology



5. Non-Commutated Linear Actuator

Moticont has added another non-commutated linear actuator to its DDLM series of low-cost actuators. The DDLM-019-070-01 Linear Actuator can develop 10.1 oz (2.8 N) of continuous force and 32.1 oz (8.9 N) of peak force at 10% duty cycle. Having a stroke of 0.960 in. (24.4 mm), this clean, fully enclosed linear actuator, also referred to as an electric cylinder, is useful for use in critical medical applications. Measuring just 0.750 in. (19.1 mm) in. diameter and 2.750 in. (44.5 mm) long, this zero cogging, bidirectional actuator is easily integrated into new and existing applications.

Moticont

6. 75 GHz Bandwidth RF Socket for 1280 I/O 0.25 pitch device

Ironwood Electronics' 0.25 pitch socket uses a high-performance elastomer capable of 75 GHz operation at a low inductance for wide-temperature applications. The 1280 WLCSP socket is designed for a 10 x 8 mm package size and operates at bandwidths up to 75 GHz, with less than 1dB of insertion loss and a contact resistance of ~20 milliohms per pin. This socket uses a bolt-on lid with an integrated compression mechanism. This socket can be used for hand test and temperature cycling as well as debugging application in development and device characterization.

Ironwood Electronics

7. Oscilloscopes

As part of its "Full Bench. High Value." program, Rohde & Schwarz' offers oscilloscopes, spectrum-, cable & antenna- and vector network analyzers as well as DC power supplies, power meters, signal generators, and power analyzers. The entry-level line of oscilloscopes comes equipped with a logic analyzer, protocol analyzer, waveform and pattern generator, and voltmeter in the same instrument. Featuring the power of 10, the R&S RTB2000, R&S RTM3000 and the R&S RTA4000 include a class exclusive 10-bit analog-to-digital converter (A/D converter), quality memory depth and a 10.1-inch touchscreen.

Rohde & Schwarz

8. 30 MM Motorized Vertical Lift Stages

OES (Optimal Engineering Systems) has added 3 high-precision vertical lift stages capable of elevating heavy loads by 30 mm (1.18 in.) in an ultra-low profile design. The rigid box construction of the moving component of the elevator stage travels on six slide rails, ensuring smooth vertical travel and parallelism of the table and mounting surface at all times. Powered by a two-phase stepper motor the vertical lift stage features: 3.315 microns (full-Step) resolution, 5 microns repeatability, and 15-micron positional accuracy. Motor options include two-phase stepper motor, single phase DC servo motor, and a 3-phase brushless servo.

OES

SECURING NETWORKS THROUGH SOFTWARE-DEFINED RADIO

by Simon Ndiritu

Software-defined radio (SDR) technology enables implementation of a variety of radio systems using a common platform architecture.

One of the fields that has been significantly impacted by this technology is networking. The flexibility and performance of SDR technology makes it suitable for building dynamic, efficient and highly secure network components.

SDR technology allows implementation of network devices that can be upgraded without modifying existing hardware. In addition, its flexibility enables network devices to operate seamlessly on different communication protocols and frequencies.

SDR platforms can be broadly categorized into two classes: enthusiast grade and commercial grade SDRs. Enthusiast grade platforms are optimized to allow users to explore both the hardware and firmware aspects of radio systems.

Commercial-grade SDR platforms are specially engineered to meet the evolving needs of today's industries. The flexibility and programmability of these platforms allow industries to update or upgrade their systems without replacing existing hardware. Other features that make this technology an attractive option include impressive reliability, reusability of components and low cost of production and maintenance.

Network setup (hardware perspective)

The SDR paradigm enables implementation of software-based modules that are flexible and easy to upgrade. The programmability of SDRs makes them ideal for the rapidly evolving network ecosystem.

SDR technology has the potential to enhance resource allocation and access, interoperability and upgradeability in both wireless and wired networks. Examples of network functionalities that can be implemented using the SDR paradigm include routers, firewalls and load balancers.

The flexibility and reconfigurability of SDRs allows implementation of interoperable radio devices. These devices can serve as radio bridges and are suitable for joining two or more heterogeneous networks.

When properly utilized, techniques such as frequency hopping can help to boost the tolerance of networks against attacks. SDRs are versatile and can be programmed to broadcast below the noise floor. Employing this technique can help to further boost the resilience of software-based radio bridges against traditional attack mechanisms.

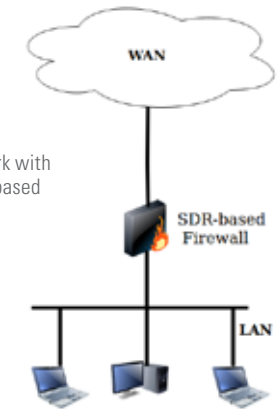
Overview of a typical network (from a security standpoint)

The network layer is responsible for controlling and routing of data traffic within a network and is prone to a variety of threats. IP address spoofing is one of the major threats to the network layer. Network layer security is enhanced by employing anti-spoofing filters and firewalls.

The application layer is the topmost layer in the OSI's 7 layer model and is highly exposed to security threats. When this layer is compromised, the attacker can access the other layers with minimum difficulty. When properly secured, this layer is capable of detecting malicious activity and handling sensitive information. Using authentication processes and high-level firewalls helps to enhance application layer security.

Software-based solutions that are traditionally used to secure network infrastructure are no longer good enough. One promising solution to this performance gap is a reconfigurable hardware implementation whose architecture is based on the SDR paradigm.

An SDR-based defense system blends the parallelism of hardware and flexibility of software to provide a versatile and high performance network security solution. This security layer solution overcomes the inherent limitations of traditional security solutions and enables real-time implementation of complex defense functions.



A network with an SDR-based firewall

The flexibility and high performance of FPGAs make them suitable for implementing a broad array of security solutions including packet classification systems, protocol wrappers and intrusion detection systems. For such security applications, it is necessary to select an SDR platform that has sufficient hardware resources to accommodate future updates and additional functions.

The future of network security

Security solutions that are based on reconfigurable hardware are increasingly replacing traditional solutions. The infrastructure of future networks requires building blocks that are both flexible and reconfigurable. The versatility and impressive performance of the SDR technology makes it an ideal choice for the implementation of future network encryption mechanisms and security protocols.

With the SDR paradigm, it is possible to implement advanced hardware-based network layer and application layer security functions. Since FPGA-based security solutions are highly versatile, using this approach creates a window for future algorithm or architectural innovations. EE

TECH FOCUS

HIGH-SPEED DIGITAL TEST

Traveling at ever increasing speeds over digital interfaces, signal-integrity challenges, such as measuring jitter and evaluating complex modulation schemes, create challenges for front-line electronics designers. These latest devices represent related testing challenges and component solutions.

Programmable Linear Power Sources

Pacific Power Source has introduced a range of precision programmable linear AC power sources for a wide range of AC power test applications. The LMX Series consists of over 20 different models ranging in power from 500VA to 30,000VA. Compared to legacy PWM switching AC power sources, the LMX Series uses linear technology to offer superior 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. This allows the LMX to support gyro and other navigational avionics equipment applications that require AC frequencies well above 1,000Hz.

Housed in a 19" rack mount chassis, the LMX Series can be used on an engineering bench as well as easily integrated in an automated test station. LAN with LXI, USB, GPIB and RS232 Remote control interfaces are all standard and with the available PPSC Manager Windows 10® software, compliance testing to a wide range of avionics and commercial power standards is available without the need to write custom programs. This includes DO160, Mil-Std 704, Airbus ABD0100.1.8, ABD0100.1.8.1, AMD24D and Boeing B787, as well as IEC 61000-4 Grid.

Pacific Power Source

Integrated motion controllers and driver

Optimal Engineering Systems, Inc. (OES) has introduced their ICAD Series of integrated motion controllers and drivers for 2-phase stepper motors. Available as 1, 2, 3, and 4 axes modules (pictured), they are ideal for handling NEMA 8 to NEMA 42 stepper motors. These compact 6.000 in. x 8.000 in. plug-and-play, integrated controllers incorporate high-resolution micro-stepping drivers for precise positioning. Other features include home and limit switches on each axis, joystick interface, TTL/CMOS inputs and outputs, quadrature encoder feedback, with USB and optional Ethernet interfaces to permit each module to be customized for specific applications.

The ICAD series is powered from a single power supply up to +48 VDC. The high-voltage power supply allows for high-speed operation. Additional features of these ICAD Series modules include: Low power consumption, auto current reduction, high torque and high-speed capabilities, serially or manually controllable, or host controlled. Modes of motion include: Point-to-point positioning, jogging, and coordinated motion. OES

Broadband Microwave RF Conical Inductor Line

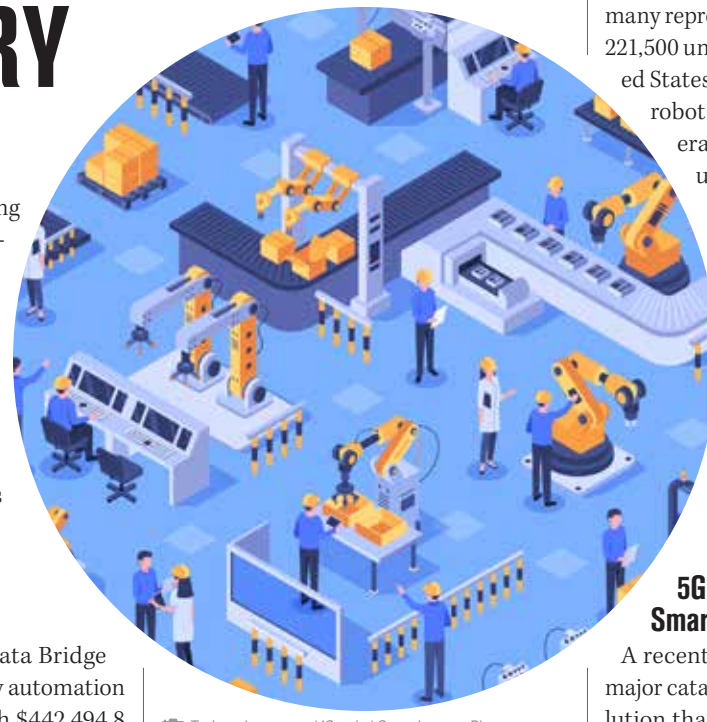
Gowanda Electronics introduced additional broadband microwave RF conical inductors—C070—now available in SMT (C070SM) and Flying-Lead (C070FL) configurations for system flexibility, especially for communication applications. Features include an inductance from 0.165 µH to 1.050 µH, DCR ohms from 0.08 to 1.50 and current rating mA DC from 150 to 625. These conicals have been outgassing-tested per ASTM E595, and meet the TML requirement of 1.0% max. The C070FL coil measures 0.07 inches in length; the C070SM version is slightly longer overall due to its SMT design. These broadband conicals address a range of industries including aerospace, defense, space, medical, transportation and commercial sectors.

Gowanda

INDUSTRY 4.0 – NOT LIKE GRANDAD'S FACTORY

By Ken Cormier, Managing Editor

Manufacturing is evolving into what was considered science fiction in the not-too-recent past. Automation is infiltrated by robotics, AI, sensors, and more—a far cry from the notorious sweatshops early in the Industrial Revolution. Here are a few recent news headlines on the subject:



Tetiana Lazunova / iStock / Getty Images Plus

Factory Automation Market Growth

According to a report by Data Bridge Market Research, the factory automation market is projected to reach $442,494.8 million by 2027, with the market growth rate at 9.60 % during the forecast period 2020-2027.

The Factory Automation Market is expected to reach USD 442,494.8 million by 2027 witnessing market growth at a rate of 9.60% in the forecast period of 2020 to 2027. The report provides analysis and insights regarding the various factors expected to be prevalent throughout the forecast period while providing their impacts on the market's growth.[1]

Robots Don't Have To Social Distance

Robotics will continue to be a major source of interest in 2021 for manufacturers trying to compete in the marketplace, according to a recent article base on a survey by *Industry Week*. The article cites a report by ABI Research in stating that COVID-19 will not be a significant disrupter to the robotics market, allowing for a significant rebound as the worldwide crisis dissipates. According to Michael Perry, vice president of business development at Boston Dynamics, the pandemic created a significant opportunity for robots in work environments. "Industries that did not previously pose a health and safety risk to workers now do. Employers are looking to technology to help protect their workers from infection, and the pandemic has accelerated the need for humans and robots to work together in new ways to respond to crises," he said.[2]

2.7 Million Industrial Robots in 2019

In 2019, more industrial robots operated in factories around the world than ever before, according to the World Robotics 2020 Industrial Robots report from the International Federation of Robotics (IFR), which says that the 2.7 million robots in use represents a 12% increase over 2018. Asia continues to be the strongest market for industrial robots. Operational stock in China rose by 21%, for a total of around 783,000 units in 2019. Japan came in second with a 12% increase to about 355,000 units. Industrial robot deployment in India increased 15%, for an approximate total of 26,300 units. Europe's operational stock reached around 580,000 units in 2019, an increase of 7%, with Germany representing the main user at about 221,500 units. In North America, the United States remains the largest industrial robot user, with a 7% increase in operational stock to about 293,200 units. Mexico ranked second with 40,300 units, an increase of 11%, with Canada in third place with approximately 28,600 units, representing a 2% increase. Collaborative robot installation increased 11% worldwide, with cobot sales representing 4.8% of market share of the 373,000 industrial robots installed in 2019.[3]

5G is Benefactor to Smart Factories

A recent CNBC article names 5G as a major catalyst for the new industrial revolution that is launching smart factories worldwide. Also described as Industry 4.0, smart factories depend on data and artificial intelligence at high speeds, which puts connectivity as an essential tool. Offering its quick speeds and expanded bandwidths, 5G is expected to make manufacturing more flexible than its hard-wired predecessors. According to a report by the Capgemini Research Institute, a new breed of smart manufacturing plants could add between $1.5 trillion to $2.2 trillion to the global economy annually.[4] EE

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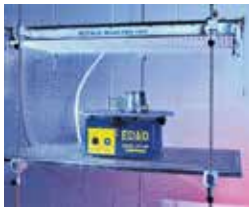

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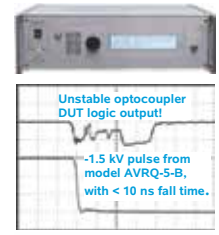

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