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

SPECIAL REPORT

RF/MICROWAVE SWITCHING ADDS FLEXIBILITY TO DIVERSE APPLICATIONS

by Rick Nelson, Contributing Technical Editor

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

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

"One of our more interesting products is our MS2010A DC to 18-GHz switch matrix (NxM) that is available in sizes from 4x4 to 12x12 and can be further expanded to 33x33 with multiple units," Alderson said. "The signal path is completely passive. It provides 1:1 connectivity in a full matrix array with exceptional channel isolation and low loss, which is one of the most desired features in a wideband test matrix."

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

The company also offers its modular UC1 for test applications. "This is a flexible 1RU product that can be reconfigured in the field as test needs change (which they always do)," Alderson said. "Currently it only has 1xN (Nx1) and signal-transfer (A:1/B:2) type configurations offered, but new configurations are in the development pipeline." He explained that the UC1 can accommodate up to two "PUC" plug-in elements that can be removed from the chassis assembly and remotely located. "Each PUC element can be remoted up to 400 feet away," he said. "The UC1 includes front-panel controls, a 1-Gb/s Ethernet LXI-compliant interface, a multiserial interface, and redundant power supplies."

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

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

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

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

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

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

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

▶ Marvin Test Solutions
GX7016 GENASYS switching subsystem.

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

He continued, "GENASYS switching supports multiple topologies with a scalable matrix providing connections to systems resources, multiplexed pins with support for over 4,000 interface test points, and a hybrid pin architecture supporting digital or analog test capability to each test system interface pin."

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

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

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

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

Stasonis said Pickering's products come with software drivers for virtually all major OSs and application development environments. "While we supply IVI drivers as mandated for LXI instruments, we do offer a common API that interfaces with all products, regardless of the communications link to the host PC," he added. Consequently, customers can choose the platform best suited to meet a specific application requirement without needing to incorporate a new software interface. "Our drivers include soft front panels (SFP) that provide the ability to manually control the on/off state of each relay," Stasonis said. "We have recently introduced a shared memory architecture that allows users to monitor the states of the relays on the SFP during program execution which facilitates integration debug efforts."

Stasonis commented that microwave switch systems can be complex networks of interconnected relays, passive components, and wiring. "We have learned over the years that the integration effort can become a time-consuming task for software engineers who need to define the states of all relays required to establish a path between a test instrument and the article under test," he said. "To help accelerate integration, our products are supported by our Switch Path Manager utility (SPM), which enables an entire switching subsystem, including all relays and external interconnects, to be virtually defined using a graphical interface. Once a switch architecture has been defined in Switch Path Manager, software engineers can simply write function calls that connect the desired input to output without needing to manage individual switch states."

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

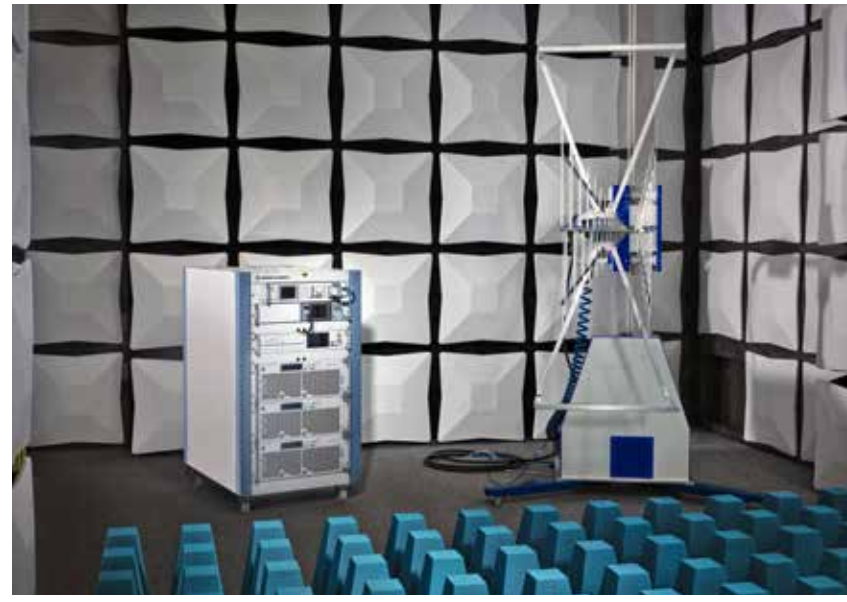
▲ Pickering Interfaces Model 60-801-008 50-Ω 6-channel LXI microwave multiplexer.

AMETEK VTI Instruments offers switching products including the SM7000 Series microwave switch modules, which consist of 13 C-size single and dual-slot VXI modules that range in frequency from DC to 18 GHz, 20 GHz, 26.5 GHz, and 40 GHz, according to Chris Gibson, senior product manager. "Relays are SPDT, SP4T, SP6T, and transfer switches, and the relays can be unterminated or terminated," he said. "Many modules include up to 32 SPST low-frequency control relays for controlling external devices such as electronic RF/microwave attenuators. Two modules are nonblocking 4x4 RF/microwave matrices."

In addition, the SMX Series includes 20 PXI Express modules having either 3.5-GHz or 26.5-GHz bandwidths, Gibson said. Modules have multiple 1x4, 1x6, 1x8, 1x16, and 1x32 multiplexer configurations with a 3.5-GHz bandwidth. The 26.5-GHz bandwidth modules include single and multiple, independent coaxial SPDT, SP4T, and SP6T switches, pass-through adapters, and a transfer switch. "The SMX PXI Express modules have an embedded virtual schematic control application that enables control of all relays for facilitating test setup and debugging," explained Gibson. "This application is independent of the test protocol application software."

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

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



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

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

— Matt Campbell, product marketing engineer, Keysight

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

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

EX7000 systems can be fully customized, Gibson said, adding, "When required, systems can be built with matched phase lines. Also, when semi-rigid or rigid cables are required, cable lengths and bend radii are documented. Thus, systems can be easily duplicated." He said the company's RF/microwave switching systems serve test applications primarily in the military/aerospace and wireless communication infrastructure markets.

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

Heuer said the R&S OSP's modular design enables users to quickly and easily set up test and measurement configurations for applications in production, test labs, and development. Features include an external hardware trigger, a web GUI, an optional touch screen, extension units, different housing configurations (2HU, 3HU), and the ability to install RF modules on front and rear side of the 19-in. unit. The OSP is flexible, he said, and supports higher test speeds for lower test cycle times.

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

Switching architectures

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

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

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

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

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

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

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

And PXI vs. LXI deployments aren't mutually exclusive. Continued Stasonis, "We offer our LXI/USB modular chassis that can support up to six PXI modules and can be controlled via USB or Ethernet, bringing together the advantages of both platforms."

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

Switches

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

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

Alderson at Universal Switching said, "We build many solid-state switching products but, in our experience, most ATE test engineers prefer a relay-based product due to the characteristics provided by a relay such as low loss, zero distortion, and high isolation—all of which affect test measurements of a UUT. In our opinion, the limited availability of MEMs components and their associated cost/performance do not yet make them a viable technology to use in the automated-test-equipment arena."

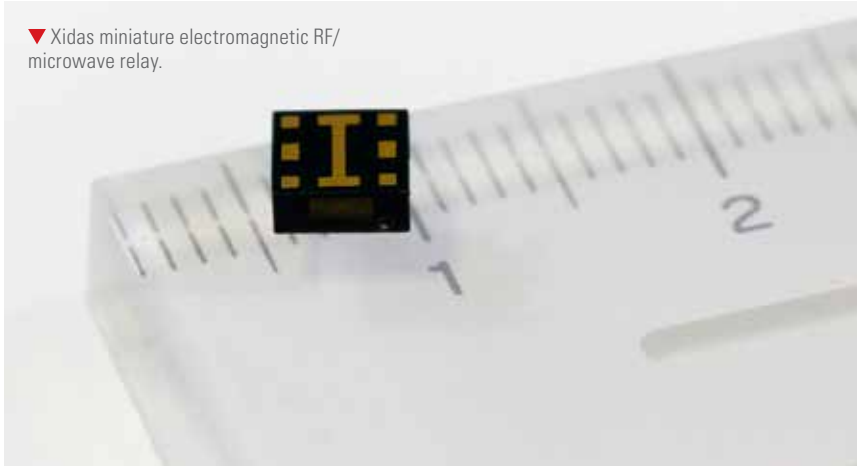
And Campbell at Keysight commented, "As testing moves from connectorized devices to wafers, customers need fast, long-lived switches for automatic test systems. Modern solid-state PIN and FET switches are becoming popular for low-power measurements of RFIC components, handheld power amplifiers, and SAW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

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

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

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

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



▼ Xidas miniature electromagnetic RF/ microwave relay.

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

The relays' RF performance extends to 8 GHz, Dhillon said, and they have been designed to provide seamless transmission throughout the signal path, avoiding transmission losses from the relay to the circuit board, thereby improving overall switching system VSWR. He commented, "Our relays become part of the RF stripline!" He added that the low-power devices are bistable latching relays that don't require power to stay in an on or off state.

From automotive to IoT

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

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