High-Power Programmable AC Sources Leverage New Technologies to Meet Evolving Industry Requirements

The market for high-power programmable AC and AC + DC sources is evolving as power technology advances, and many industry verticals increasingly require flexible, reliable programmable instruments.

Technology advances include wide-bandgap semiconductor devices that enable better performance and reliability compared to silicon-only MOSFETs. Other technological advancements relate to user interface and control options, like rugged full-color touchscreen displays enabling efficient front-panel control. Many AC sources come standard for remote control with the latest generations of Ethernet and USB. Keep in mind, however, that if you are adding a new source to a legacy system, you may need a GPIB or RS-232 interface, which you should be able to select as an option.

With the move toward digital transformation, companies are implementing digital-twin strategies and power hardware-in-the-loop (PHIL) simulation.[1] Common applications involve simulation of power plants, electric vehicles (EVs), hybrid-electric vehicles (HEVs), and renewable energy systems. Also evolving are how programmable AC sources are finding use.

Demand for programmable AC sources is growing for a wide range of products, including power-conditioning equipment, consumer electronics and appliances, avionics and shipboard electronics, automotive subsystems, manufacturing testers, and renewable-energy equipment.

Each of these product categories has unique requirements. Still, common to all is the need to test them over a wide range of input conditions to evaluate whether they shut down gracefully (or seamlessly transfer to a backup power supply) during a power outage and to see whether they resume normal operation on the restoration of power. The ability to simulate adverse grid conditions is becoming essential to test how products respond to a grid that may become unstable.

Beware High Crest Factors

Across these categories, the characteristics of the loads the products present are changing. With the proliferation of switching power supplies in products ranging from appliances to avionics subsystems, products present high crest factors—the ratio of peak current to RMS current—which you must consider when choosing an AC source.

In Figure 1, both current waveforms have an RMS value of 5 A. But whereas the blue sinusoidal waveform has a peak value of 7.07 V, and therefore a crest factor of 1.414, the red waveform has a peak value of 21.21 A, leading to a crest factor of 4.24. Choose a programmable AC source with low output impedance to drive high-crest-factor loads. A source's data sheet should state the allowable crest factor.

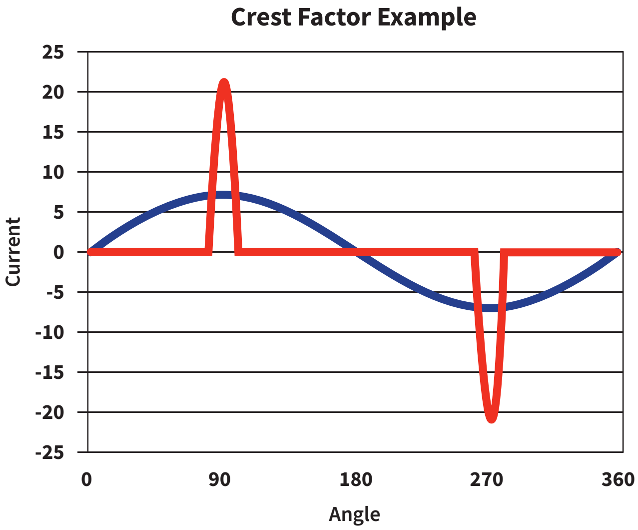

***Figure 1.** The blue waveform has a crest factor of 1.414, whereas the red waveform has a crest factor of 4.24.*

Also, consider software. For a source in a system with one or more other instruments, you may plan to write test programs in a high-level language to control the instruments and process measurement data. If you do not intend to do that, or even if you do, you can also benefit from easy-to-use software provided by your instrument vendor. Look for an intuitive GUI that you can run on your host computer to set output parameters, read back measurements, and program multiple steps and sequences. In addition, look for a vendor who provides software for specific application areas. For example, for avionics test applications, look for software options for aircraft power-quality standards such as MIL-STD 704 and RTCA DO-160. For shipboard power equipment, look for software support for MIL-STD 1399. Such options will enable a programmable AC source to emulate aircraft or shipboard power buses to help quickly pre-validate product compliance, saving you the time of creating test cases.

AC-Source Applications

Specific applications range from renewable energy to production end-of-line tests. The combination of the utility grid with distributed green-energy generation is accelerating, with the green-energy sources that can export power to the grid requiring extensive tests. A four-quadrant programmable AC source can act as an ideal grid that can sink current from PV inverters, wind turbines, and other renewable energy sources during tests. Seamless switchover between source and sink modes allows the source to emulate various test conditions mandated by international standards such as IEC 61727, which describes the characteristics of the interface between a PV system and the utility grid.

Power-conditioning equipment, including UPSs, are in demand as increasing electrical-power consumption makes maintaining power quality challenging. But before connecting to the grid, the equipment requires thorough testing for performance and reliability. Such tests generally require an AC source that offers the flexibility to configure a single solution that supports a variety of roles in your test setup, including AC/DC programmable power source, AC/DC grid simulator, and AC/DC resistive or complex electronic load. In addition, the source should allow you to change parameters during test, and it should provide the ability to synchronize with external waveforms.

Still other applications for high-power programmable AC sources include EV testing. The expansion of EV infrastructure requires extensive testing to ensure compatibility among various vendors' equipment. The tests need an AC source that can emulate multiple grid conditions, and a four-quadrant source can enable bidirectional vehicle-to-grid (V2G) tests.

Finally, high-power programmable AC sources can serve in manufacturing line testers. Choose sources that can scale as power requirements change to protect your investment for such applications. Also, look for ease-of-use features that help semi-skilled operators work safely and efficiently.

Sequoia and Tahoe

AMETEK Programmable Power's next-generation precision programmable AC and DC sources include the California Instruments Sequoia and Tahoe series, which combine intelligence and flexibility with high power. Both use a state-of-the art wide-bandgap silicon-carbide (SiC) power switching architecture, which, compared with silicon MOSFET architectures, improves reliability and minimizes the need for external components such as inductors, helping to cut costs. Sequoia is a full four-quadrant product with an electronic-load option that combines compactness, robustness, and functionality in a floor-standing chassis, no larger than a typical office copying machine. Tahoe offers the same advanced features in a two-quadrant configuration.

***Figure 2.** The Sequoia Series source employs SiC power devices.*

The Sequoia and Tahoe series sources come in three form factors: 15kVA, 22/30/45kVA, and 90kVA, all of which can deliver the same power rating in DC mode. As many as six 22/30/45kVA chassis can be connected in parallel up to a maximum of 270kVA. As many as twelve 90kVA form factors can be connected in parallel for 1.08MVA max. The design is quite flexible, and power ranges above 1.08MVA are also possible.

The Sequoia and Tahoe series offer dual-range 0- to 166-V and 0- to 333-V line-to-neutral direct-coupled outputs, corresponding to 287 VAC and 576

VAC line to line. For applications requiring higher voltages, an optional output transformer provides an additional 0- to 442-V L-N and 0- to 766-V L-L output range for use in AC mode only. Custom versions are also available.

Both the Sequoia and Tahoe products can be operated completely from their menu-driven front-panel controller. The full-color touch display shows menus and setup data and displays read-back measurements. With the programmable arbitrary waveform generator, you can generate application-specific waveforms, obtain time and frequency domain measurements, and capture actual voltage and current waveforms. USB and LAN remote control interfaces and instrument drivers for popular ATE programming environments are available, allowing the sources to be easily integrated into an automated test system.

Both Sequoia and Tahoe come standard with Ethernet, USB and RS-232C interfaces to allow remote programming of all instrument functions from an external computer. You can add the GPIB option if your requirement includes an IEEE-488.2 interface.

If you are writing your own programs, send the appropriate SCPI commands to the instruments. SCPI, a common platform for instrumentation, provides a standard set of commands to simplify the control of one or more instruments from a host computer. Alternatively, AMETEK Programmable Power offers its Virtual Panels GUI, which lets you control the source from a host computer without coding.

Both series tolerate high crest factors to drive difficult nonlinear loads with ease. The Sequoia 30-kVA model, for example, tolerates a crest factor of 4.5 and can deliver up to 300 A of repetitive peak current (in the 150-VAC range) per phase. Sequoia also offers an External Drive feature that allows an external analog signal to control the source while in AC operation, essentially turning the Sequoia into a four-quadrant high-bandwidth amplifier for PHIL applications.

Sequoia and Tahoe serve the full range of application areas for high-power programmable AC and AC + DC sources. For aerospace and marine applications, the sources offer fundamental frequency ranges to 550 Hz with support for 905 Hz optional to simulate all types of power in most aircraft and shipboard electrical systems. In addition, Sequoia can sink power from DC to 500 Hz, making it a good choice for validation of onboard power-conversion packages. You can also use the sources with the Virtual Panels GUI, which includes options to support tests in accordance with aircraft and shipboard power-system standards.

Sequoia offers grid-emulation capabilities and an electronic-load option for testing power-conditioning equipment. Its ability to synchronize with external waveforms provides multiple methods of validation for R&D. For green-energy distributed-power applications, Sequoia can act as an ideal grid and can sink current with 100% power recovery while emulating test conditions mandated by international standards. Tight integration with Virtual Panels software eases the generation of test sequences for safety, compliance, and EMI tests in accordance with various UL, IEC, IEEE, and other standards. An output isolation contactor facilitates anti-islanding tests with minimal external accessories. In addition, a parallel RLC parameter emulation mode helps load tuning as recommended by IEC 62116, which describes the islanding-prevention test procedure for utility-interconnected photovoltaic inverters. Full protection from phase-to-phase, phase-to-neutral, and phase-to-ground faults helps protect your investment, even in the case of UUT failure, during fault simulation.

With 85% of power-recovery efficiency, the sources not only help save electricity, but also minimize heat emissions inside the lab. For EV test, the Sequoia sources can help simulate various grid conditions, and their electronic-load mode can help emulate a car's on-board battery charger. In addition, the DC source mode and AC sink modes facilitate V2G testing.

Finally, for manufacturing line tester applications, Sequoia and Tahoe offer an automatic paralleling option to dynamically scale up and scale-down power capacities. In addition, they provide external interlocks to assure operator safety and to facilitate coordination with other equipment. Other features include 16 instrument-status memory locations, and load-dependent variable-speed fans help reduce the acoustic noise.

Conclusion

Applications across multiple industries require high-power programmable AC and AC + DC sources that offer the ultimate in performance, reliability, and flexibility. With its new Sequoia and Tahoe Series high-power programmable sources, AMETEK Programmable Power is leveraging SiC power devices and the latest in user-interface and remote-control technologies to offer flexible, reliable instruments that can serve in a variety of power test applications.

Reference

1. Van Hoa Nguyen, et al., "Digital twin integrated power-hardware-in-the-loop for the assessment of distributed renewable energy resources," ResearchGate, April 2022.