



Selecting the Right
Programmable Power Solution

Get the Most Out of Your Application



Choosing the right power system is critical to getting the most out of your application or test system.



You can only enable higher system performance and efficiency, easier product validation and regulatory compliance, and faster go-to-market timelines by making the right power selection. That is why power selection will be one of the most defining choices you make regarding the success of your products.

With such a heavy value placed on power, it is essential to know that power systems and power supplies are not a “one-size-fits-all” solution. You cannot expect a standard power supply to fit your system’s unique requirements, just like you cannot take a typical automotive engine and expect it to work in a new fighter jet.

Before looking at a potential power supply, you must first define the specific power requirements of your application, ensuring that your selection meets your operational needs. Failing to select a suitable power supply can lead to:

- **Performance losses**
- **Cost inefficiencies**
- **Delayed production/development timelines**
- **Unoptimized or non-compliant designs**

However, a thorough approach to power selection can avoid all the above issues. This handbook will detail modern advancements in power supplies, the importance of power systems and how to get the right solution based on your specific application.



TURNKEY POWER SOLUTIONS

The Need for Advanced Power Supplies

As technology advances, so must the power supplies that fuel that change. Whether you are directly powering a new product or powering the test systems used to validate the design, advanced power supplies allow engineers to bring innovative products to life.

In this way, power supplies and the systems they power mutually build off one another. A product is only as good as the power supply behind it. Advanced power supplies that do not fit the needs of new products or systems essentially have no practical purpose. That is why more recent power supply designs are directly influenced and led by the evolving needs of modern industry.

Here are some of today's leading trends that are helping create the programmable power supplies of tomorrow:

Compact Designs/Miniaturization with Even Greater Power Output

Miniaturization is a significant advancement in power supply design. Smaller and more compact power supplies can provide greater power output in a smaller footprint, allowing engineers to reduce the size and weight of the overall design of their product or system configuration. Alternatively, engineers can also drastically increase power output without increasing the power supply volume. Evolving research on gallium nitride (GaN) field-effect transistors (FETS) and silicon carbide transistors is helping to fuel the miniaturization movement, which is excellent for power efficiency.

Precision Power

Many demanding applications require a specific amount of power to function correctly. This increased accuracy and precision is essential for a wide range of applications, such as medical device testing and research. Another example: if you are building a laser or high-energy weapon/tool, your power supply must provide enough power for the device to operate without overshooting the mark. Get the voltage too high, and you will destroy the laser sources. Not only will that render the device inoperable, but it can also be hazardous, depending on the device you are working with.

Precision power is all about finding the optimum amount of power – enough to power the device or system without any loss in performance, but not so much that you start experiencing inefficiencies or destroying your equipment.



Programmable Power and Modularity

We said that there is not a “one-size-fits-all” solution when it comes to power supplies. However, that is not entirely true. While no single power output can meet the requirements of every device, you can program a power supply to have different power outputs, thus creating a solution that can be used across multiple products and testing environments. This also allows you to change and modify your power output as your products evolve without specifying an entirely new power supply.

Programmable power allows you to tweak electrical characteristics such as voltage, current, and frequency as you see fit. Flexible and adaptable, AC and DC programmable power supplies can handle demanding power transitions while allowing you to control and adjust fundamental electrical properties during operation. Modular programmable power designs are exceptionally flexible, as they can more easily fit into various new or existing power systems.

Regenerative Power Supplies

Unlike power supplies of the past, regenerative power supplies can both supply and accept power. This duality makes regenerative power supplies crucial for applications where energy storage and overall efficiency are vital metrics.

Regenerative power supplies can help maintain consistent sources of power while cutting down on energy waste, all leading to more renewable power systems. Regenerative power supplies are also set apart by their ability to return operational heat energy to the grid safely. This saves on energy that can then be stored for later while eliminating any additional costs that come with the heat management of typical unidirectional power supplies.



Advanced Testing

Testing goes hand in hand with power. You need to simulate a power source to validate a design accurately. Highly accurate measuring equipment allows you to monitor your electrical environments during testing closely, ensuring your designs’ dependability. Repeatable and consistent testing is required, as any significant testing variation means risk.

Automatic and flexible test equipment adds additional usability, allowing you to adapt to different testing requirements quickly. The more adaptable, automated, and modular your test equipment is, the easier it will be to validate your equipment.

A Note on Power Supply Design

When looking for a power supply, the first thing that you must do is determine what outputs you need. Do you require a DC output, an AC output, or both? It would be best to balance properties such as output voltage, current, and power factor to find the right solution for your requirements.

Additional considerations include:

- **Performance losses**
- **Cost inefficiencies**
- **Delayed production/development timelines**
- **Unoptimized or non-compliant designs**

This handbook will not get into the fine details of power supply design, instead focusing on overall power systems, applications and total power solutions. For more detailed considerations, specifically on power supply design, look at [AMETEK Programmable Power’s Buyer’s Guide](https://www.programmablepower.com/buyers-guide).

APPLICATION NOTE

Research Institute Chooses Solar Array Simulator to Test Ultrafast PV Energy Storage

This application note highlights a European non-university research institute's initiative to develop an efficient, ultrafast short-term energy-storage scheme for solar power systems. The goal is to address the challenges of power fluctuations caused by cloud movements and other factors affecting solar-array irradiance, ultimately providing a steady flow of grid-quality renewable power. The institute required a test system with a programmable DC power supply to simulate the characteristic curve of PV modules' outputs to achieve this.

The institute chose AMETEK Programmable Power's TerraSAS for the task. TerraSAS is designed to emulate the dynamic electrical behavior of a terrestrial PV solar array and offers low output capacitance and high closed-loop bandwidth to keep up with advanced maximum power point tracking (MPPT) algorithms. With TerraSAS, the institute successfully concluded a multi-year laboratory development phase and is now preparing to demonstrate its ultracapacitor system under real-world conditions.



Testing renewable energy equipment like the ultracapacitor system demands high performance and flexibility from programmable-power systems. AMETEK Programmable Power provides a range of catalog and custom-engineered products to meet renewable energy testing needs, and their team can collaborate with customers to provide optimal programmable power equipment for various renewable energy applications.

Solar energy is experiencing significant growth worldwide, and efforts to convert fundamental research into practical applications are driving its success. Research institutes and companies like AMETEK Programmable Power contribute to the advancement and efficiency of solar power systems, paving the way for a sustainable and renewable energy future by addressing challenges related to power fluctuations and energy storage.

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Power Supplies: Just One Part of the Bigger Power Solution

Power supplies are important but are only a single piece of the puzzle. Several parts of power performance are related to other parts of the system or the system as a whole – not just the power supply. That is why you must take a system-level approach to power to optimize your designs.

Taking only a power supply-focused approach to system power means that you could be missing out on other key design elements. This is likely to lead to performance and efficiency issues and testing problems, as your products could fail for the wrong reason.

Think of your power supply as akin to the engine of a car. No matter how good of a machine you design or what horsepower and fuel efficiency you achieve in the lab, that engine is only as good as the other elements of the car. That engine will only go somewhere with the right wheels and braking system.

Instead of only focusing on the power supply component, you must focus on the integrated system. For instance, some applications may require a large capacitor bank to handle power-factor correction that a power supply alone could not. AMETEK Programmable Power engineers often see this with newer, more energy-efficient engines with variable valve timings. In these engines, the solenoids immediately take a lot of current to energize. If you just tried using a power supply, no matter how well it was designed, it would need to be able to open the valves faster.

Since you always want to avoid overloading your system, many power supplies have short circuit or overload protection. This often comes in the form of circuit breakers. Circuit breakers are included in some of our products, and they are externally resettable. Circuit breakers reach the same goal by heating, bending, and triggering a spring that shuts the circuit down until you are ready to reset the breaker and restore the power.



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Even with the above, system developers do not have everything they need to specify their power and test systems fully. Power supplies only handle the “input” of the system. It would be best if you also had the following:

- **Electronic loads and load simulation**
- **Measurement and diagnostic systems**
- **Environment-simulating devices and external stimulus systems**

Capacitor banks, heat sinks, circuit breakers, electronic loads – all of these components are utilized along with power supplies to achieve a complete power solution. That is why it is essential to partner with a power and test expert that goes beyond simply providing a power supply. Having the knowledge and experience to know when you only need a power supply versus when you need a system-level approach to power can mean the difference between delayed development timelines and a successful product launch.

The Importance of Trust

With all that goes into specifying a power system, trusting your supplier is key. The right power and test partner will have a good track record of quality power and testing products and the ingenuity to design a unique power system for your application’s specific needs. You should not need to become a power system design expert yourself. When a good supplier understands your application, you can trust them to “own the design” of your power solution. That way, you can keep your engineers, and system developers focused on your products rather than worrying about power supplies and test systems.



APPLICATION NOTE

Oil-field Services Company Chooses New AC Programmable Sources to Upgrade Legacy Equipment

Oil-field services companies operate in a dynamic and unpredictable market influenced by geopolitical events, technological advancements, and fluctuating demand and prices. The Permian basin in Texas and New Mexico exemplifies the volatility of the oil industry. Oil production in the region declined when prices dropped below profitability thresholds. However, a renewed focus has been on increasing production in the Permian basin, prompting the need for equipment upgrades.

One oil-field services company turned to AMETEK Programmable Power to replace their aging AC sources used in downhole tooling for drilling operations. AMETEK Programmable Power worked closely with the company's engineering team over several years to plan a seamless transition to newer models. The sales team highlighted the advantages of the Asterion AC programmable sources, such as higher power density, improved interfaces, and enhanced software flexibility.

The company chose the Asterion AC models, specifically the AST 1501 and AST 3003, which offer superior performance compared to the legacy sources. The new models feature a touchscreen and encoder interfaces, providing easy access to programming parameters, control interfaces, and measurement results. The Asterion AC Virtual Panels graphical user interface allows remote control of the sources from a host computer. The models also incorporate AMETEK Programmable Power's iX2 current-doubling constant-power technology, ensuring a consistent output-power characteristic across various operating conditions.

The company plans to upgrade approximately 500 systems in various locations for its production expansion. AMETEK Programmable Power offers support and reliable, high-performance solutions to meet the evolving needs of the oil services industry. As market conditions change, AMETEK Programmable Power remains committed to helping companies expand their production capacity and upgrade their equipment to ensure the reliability and performance of their systems.



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Types of Power Applications

While countless operations and systems require power, most applications can be broken down into one of three main types: **emulation**, **stimulus** and **process applications**. Each type has its own typical needs and power requirements.

Power Emulation

Emulation applications involve simulating a power source or load to test a product. Here, power supplies or electronic loads mimic a solar panel or a battery in a testing environment. That way, engineers can validate their product and system, given the properties of these emulated sources.

One example of a device used in emulation applications is a solar array simulator (SAS). These power supplies simulate the power you would get from a solar array. Solar array simulators allow for more efficient and cost-effective ground-based testing when testing out the power environment of a spacecraft or another solar-powered piece of equipment.



Spacecraft solar arrays, in particular, face large temperature excursions, varying isolation as the amount of sunlight hitting the array changes and mechanical changes that go along with aging. An excellent solar array simulator can reproduce all possible outputs based on the different input conditions an array faces, including orbital rotation, spin, axis alignment, and eclipse events, as well as beginning-of-life versus end-of-life operations. System developers can comprehensively verify design margins and quickly test spacecraft power systems and any associated electronics by accurately and precisely simulating a solar panel under various space conditions.

When talking about simulating solar arrays and other alternative energy sources, key characteristics to consider for your power simulation system include:

- Peak power tracking accuracy
- Peak power tracking speed
- PV array modeling
- Automated test support

APPLICATION NOTE

Programmable Sources and Loads Boost Manufacturer's Micro Inverter, Electric Vehicle Projects

This application note discusses the use of programmable sources and loads in boosting the development of microinverters and electric vehicle (EV) projects in the context of renewable energy. The global market for microinverters is expected to reach \$13.5 billion by 2030, while the solar EV charging market is forecasted to reach \$330.9 million by 2031. Testing PV inverters presents challenges, as their characteristics require specialized equipment. A programmable DC power supply is needed to simulate the output characteristics of solar cells accurately, and a solar-array simulator must exercise the inverter's maximum power point tracking (MPPT) capability. Additionally, an inverter test system requires a regenerative programmable AC power source to act as a grid simulator.



One renewable energy provider partnered with AMETEK Programmable Power for pre-compliance testing of a solar microinverter and battery-storage infrastructure and establishing a functional and production test facility for microinverters. AMETEK's products, such as the TerraSAS PV simulators, the MX Series, and Sequoia regenerative programmable sources, were chosen for their capabilities and support. The Sequoia source offered benefits like higher output voltage ratings, resistive, inductive, capacitive (RLC) load emulation, and external drive features. AMETEK Programmable Power's solutions met the company's needs and helped it transition from legacy equipment.

Furthermore, the company aimed to enter the electric vehicle service equipment (EVSE) market and required flexible test equipment to address the components and subsystems of the EVSE energy ecosystem. AMETEK's Sequoia sources were chosen for their ability to serve as EV emulators and grid simulators, offering flexibility as testing requirements evolve.

With its product quality and application expertise, AMETEK Programmable Power is well-suited to support renewable energy products. The company offers a range of standard products and customized solutions to meet specific power supply needs.

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Another example of a power supply used in an emulation application is the battery string simulator (BSS). These power supplies provide safe and reliable battery power for spacecraft testing and other demanding applications. Battery string simulators typically operate in one of two modes: static and dynamic. In the static mode, the BSS can instantly produce the terminal voltage corresponding to that state of charge. When in the dynamic mode, the battery string simulator can charge and discharge energies being impressed on the supply, modifying the terminal voltage accordingly. With these two modes, the BSS can easily vary the voltage to simulate a charged or discharged battery, eliminating hours of testing time.

Engineers and developers looking to simulate batteries and other types of energy storage will primarily be concerned with:

- **Constant voltage, power, current and resistance modes**
- **Ultra-low-voltage operations**
- **Sequence simulation**
- **Continuous, pulsed, and toggled transient simulation**
- **Programmable slew rate simulation**

Stimulus Power

In basic terms, a stimulus application is where you attempt to stimulate a load to do something in response to the input from a power supply. This is typically done in testing environments. Stimulus applications deal with a wide range of precision AC and DC power sources and eLoads. Used across virtually all power and test operations, stimulus applications are vital to the following industries:



Automotive and Transportation

Every new vehicle that hopes to hit the road relies on power supplies for countless product tests during manufacturing. Tier One automotive suppliers, in particular, require fast production speed without compromising quality. Automotive research and development labs use power supplies for electronic integration and margin testing. Researchers require power supplies with high precision, flexibility and programmability.



Commercial/Industrial

During the development cycle, commercial and industrial R&D labs utilize power supplies for margin and integration testing of materials, electronics and electrical devices. Power supplies are also used to power factory end-of-line tests to increase throughput.



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Energy and Power Generation

Programmable power supplies need to be ready to provide flexible standard or engineered solutions to serve the testing needs of emerging renewable-energy power-generation applications while continuing to support conventional power-generation systems.



Aerospace and Defense

Power supplies are the go-to choice for simulating the unique power conditions found in space. Power systems and components must perform flawlessly, even when exposed to electromagnetic fields. And, electrical testing is crucial to military environments. To keep military electronics working, power supplies are part of the automatic test equipment used for electronics repair in military depots. No matter the industry or specific operation, system developers looking for AC/DC power simulation in stimulus and measurement applications are typically concerned with:

- Brown-outs and black-outs
- Transients
- Phase loss
- Frequency variations
- Regenerative sink capabilities

On the electronic load side of stimulus power and testing, system developers will often need to consider:

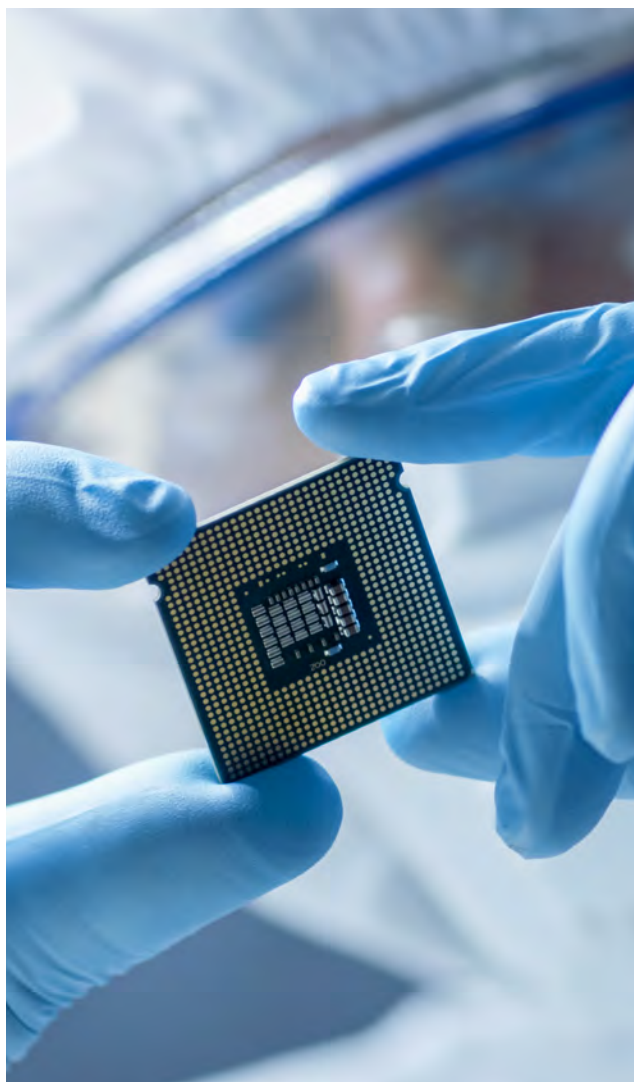
- Non-linear loads
- Short circuits
- High crest and variable power factor simulation
- High peak current and low power factor simulation
- Ultra-low-voltage operations
- Constant voltage, power, current and resistance modes
- Sequence simulation
- Continuous, pulsed, and toggled transient simulation
- Programmable slew rate simulation





Process Power

Process applications utilize power to transform a product. These applications require ultimate control of the power system, determining exactly where and how power is used. Due to the nature of process power applications, system developers must also more heavily consider external simulation. You are not so much simulating a device as you are loading it down and stressing the system to eliminate infant mortality or early electronic failure.



For semiconductor processes to consistently produce reliable and high-quality devices/circuits, all processes must be tightly controlled. Semiconductor process monitoring is one of the major process power applications. Process monitoring allows system developers to detect problems early on when they are easier to handle and rectify. Many demanding process applications require real time control and adjustments. Isolated and/or non-isolated analog inputs control the power output for hardware-in-the-loop (HiL) applications. Power solutions that enable this process monitoring must be extremely accurate and precise. Other process power applications include:

- **Precision reactor heating**
- **Oil exploration/recovery**
- **Accelerator magnets**
- **Power safety systems**

One system that is critical to process power is the energy absorber test system. This integrated system includes multiple DC power supplies operating in a Leader/Follower configuration. In addition to the power supplies, the system also offers:

- **An AC distribution and interlock system**
- **A regenerative energy absorber chassis**
- **An absorber load resistor chassis**

The current monitoring of the power supplies indicates their output current. This ensures that the system's current readback is available separately and free of additional error sources. No regenerative current is conducted through the power supplies due to a blocking diode in the energy absorber chassis.



TESTED EXPERIENCE

Advanced Precision Programmable Power Systems

AMETEK Programmable Power offers a full suite of power supplies, electronic loads, and other power and test components. Power supplies and test systems come standard or custom for full design flexibility. All products focus on modularity and precision programmable power for optimized power systems. AMETEK Programmable Power's industry-leading products include:

Asterion AC Series



The California Instruments Asterion AC power sources cover a diverse range of applications, with a product line spanning from 500VA to 36kVA, catering to compliance test systems, rack-mounted industrial power subsystems, and beyond. As leaders in the design and manufacture of AC power sources, AMETEK Programmable Power's products are extensively used in research and development, test and measurement, avionics testing, inverter testing, arbitrary waveform generation, bulk power, and power conditioning applications. These AC power sources are widely used across various industrial segments due to their precision, programmability, and reliability.

Asterion DC Series



Catering to a wide range of industrial segments, the Sorensen Asterion DC Series is a product line that includes modular power supplies and rack-mounted industrial power subsystems. The DC power supply range offers a power output ranging from 1700W to 10kW, and is suitable for a wide range of applications, including R&D, test and measurement, process control, power bus simulation, and power conditioning. The Asterion DC power supply line provides a wide range of voltage, current, and power options with precise control to meet specific needs. Its advanced digital monitoring and control features, combined with industry-leading density and reliability, make Asterion the go-to choice for DC power supplies.

Sequoia and Tahoe Series



The California Instruments Sequoia Series offers an advanced high-power Grid Simulator in a compact, floor-standing chassis. With a state-of-the-art silicon carbide (SiC) power switching architecture, the Sequoia Series covers a wide range of single- and multi-phase AC or single- and multi-channel DC applications at an affordable cost. Additionally, an electronic, programmable, regenerative load option can be added to support advanced renewable energy simulation and testing requirements.

The California Instruments Tahoe Series is a robust two-quadrant AC, DC, and AC+DC power platform with a wide range of test application routines for military and commercial avionics, shipboard power, and EMC compliance testing. Like the Sequoia Series, Tahoe is designed with SiC power semiconductors, combining efficient, reliable performance with a low cost of ownership for an ideal solution for power test applications.



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Sorensen SGX Series



Engineered for exceptional load transient response, low noise and the highest power density in the industry, the Sorensen SGX series is designed to deliver outstanding performance as a high power programmable DC power supply. The SGX is a 3U package that can provide a full 15 kW down to 20 V output, and its power density is unmatched in the industry. The front air intake design enhances the power density, enabling users to stack supplies without requiring any clearance between the units.

At the core of the SGX series is a 5 kW power module. Depending on the output voltage, one to six modules can be integrated into a single chassis to provide 5 kW to 30 kW of power. Furthermore, users can easily parallel combinations of these chassis to achieve power levels up to 150 kW. The paralleled units function like a single supply and offer a total system current to support a variety of industrial applications.

Elgar Solar Array Simulator



The performance of a spacecraft solar array is influenced by various factors such as temperature fluctuations, changing insolation, mechanical stress, and aging, both in the short and long term. In order to ensure the spacecraft's power system functions properly, it is necessary to test the solar array under various simulated conditions, which can be accomplished through the use of a solar array simulator.

The Elgar SAS system offers a cost-effective solution for ground-based testing by reproducing all possible solar array outputs based on the array's operating conditions, including factors such as orbital rotation, spin, axis alignment, eclipse events, beginning-of-life, and end-of-life operation. The SAS also provides complete programmable control over all parameters that shape the solar cell I/V output curve.

By accurately simulating solar panels under various space conditions with complete control, the SAS enables system developers to comprehensively verify design margins and quickly test spacecraft power systems and associated electronics during production. This ensures that the spacecraft's power system can operate effectively and efficiently under various conditions, ultimately enhancing its overall performance and longevity.

APPLICATION NOTE

“New Space” Company Chooses Solar Array Simulator for Satellite Power Test

The emergence of “new space” companies, characterized by their focus on low costs, fast turnaround times, and entrepreneurial approaches, has disrupted the traditional dominance of governments and established aerospace contractors in the space industry. With its experience in serving the “old space” community, AMETEK Programmable Power has adapted to support these new players in the industry.

A new space company recently turned to AMETEK Programmable Power for programmable-power products for various initiatives. One specific requirement was a flexible solution for designing and validating the power distribution network of a spacecraft. The company chose two 20-channel racks of equipment based on the Fast Profiling Current Source (FPCS), a fundamental component of the Elgar Solar Array Simulator (SAS). The FPCS accurately simulates the output characteristics of a satellite’s solar array, allowing for independent programmable control of each channel’s output current-voltage (I-V) profile. The configuration was customized to meet the company’s specific requirements, with an output power of 900 W per channel and an output voltage of 220 V.

AMETEK Programmable Power’s experience in solar and space applications enabled effective communication and understanding of the company’s needs. The company’s lack of experience compared to traditional space players highlights the importance of standards, procedures, and expertise. AMETEK Programmable Power and its partners are well-equipped to guide new space companies in selecting flexible and reliable test systems, whether from their catalog or through custom-engineered solutions, that will meet their requirements for years. AMETEK Programmable Power is committed to supporting new space ventures and providing optimized solutions for their diverse applications.



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AMETEK Programmable Power: Providing a Total Power Solution

Experience the ultimate power solutions tailored precisely to your needs. As a global leader in electronic instruments and power systems, AMETEK Programmable Power specializes in pioneering highly differentiated power and testing equipment for the most groundbreaking products around the globe. In fact, customers from multiple disciplines and hundreds of companies worldwide trust our expertise for projects ranging from a single power supply to meticulously engineered systems. Don't settle for anything less than extraordinary. Elevate your power game with AMETEK Programmable Power and unlock the true potential of innovation.



TURNKEY POWER SOLUTIONS

AMETEK Programmable Power is more than just a supplier. As your trusted power partner, AMETEK Programmable Power offers expert resources to ensure you find the perfect solution.

Our teams of expert engineers and visionary systems designers are deeply engaged and responsive to your needs and committed to high quality standards. We work with our customers for the best possible understanding of an application's characteristics and unique requirements. With this knowledge, we become the architects of power, shaping solutions that align with your needs. Whether it's a cutting-edge power supply, a comprehensive power ecosystem, or something in between, we can leverage the characteristics of each individual element and their synergistic relationships to create that ultimate power solution for your specific needs.



TRUSTED POWER PARTNERS

Your team should not have to worry about the specifics of power selection. By "owning the design" of your power system, AMETEK Programmable Power can fully handle all power integrations, ensuring that all your instruments work together as a unified system. This begins with our focus on modularity, which leads to a solution that overcomes integration challenges. The result is a harmonized, unified system more significant in total than the sum of its parts.

With our turnkey solutions, you can confidently acquire a comprehensive system from the AMETEK Programmable Power experts without worrying about fitting a power supply into your existing system. We handle the complexities while you focus on what matters to you.



TESTED EXPERIENCE

Worldwide locations. Dedicated staff with decades of industry-leading proficiency. Experience in every major industry and application. Our engineers and power system designers have overcome so many challenges, allowing us to quickly arrive at the right solution for your application.

Our unwavering commitment to effective communication, unparalleled responsiveness, and steadfast engagement ensures a seamless collaboration as we diligently work towards delivering precisely what you need. At AMETEK Programmable Power, we are renowned for our ability to adapt and provide tailored solutions that propel your success.

Find industry-leading technology, turnkey solutions, and unparalleled engineering expertise at AMETEK Programmable Power. Count on us as your one-stop shop for all your power and test needs.



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