

Meeting Medical System Needs With Configurable Digital Power

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Large-scale, high-power medical devices—such as diagnostic imaging scanners and surgical or cosmetic laser systems—often present complex power design requirements. These challenges are driven by the need to support numerous digital and analog subsystems, as well as arrays of sensors and actuators operating at varying, often non-standard, voltages. Further complexities can emerge from elements like battery chargers and capacitor banks, which provide pulsed energy to lasers and frequently require stable constant-current supplies.

Complexity arises not just from technical specifications, but also from strict safety and isolation requirements, especially limits on leakage current for medical equipment designers. Defined in specifications such as the IEC-60601 safety standards for medical electrical equipment, these encompass means of operator (MOOP) and patient (MOPP) protection for those coming into contact with the equipment (Fig. 1).

Faced with such varied yet exacting requirements, finding an off-the-shelf, medical-approved multi-output ac-dc power supply (PSU) tailored to the requirements of the application at hand is difficult. In the past, multiple off the shelf power supplies were combined or custom power supplies were developed to satisfy such application requirements. This article discusses some of the limitations of those approaches and how configurable, digitally controlled power supplies can overcome those limitations in medical applications.



Fig. 1. In medical environments such as operating rooms, power supply requirements are complex both in terms of electrical specifications for voltages and currents, but also with regard to the approvals needed to ensure the safety of equipment operators and patients.

Custom Power Supplies Or Off-the-Shelf?

One solution is to use individual ac-dc PSUs that collectively meet power needs, installing them separately within the enclosure. However, this requires more space, which can be a drawback.

Despite the large overall physical size of “big iron” equipment such as scanners or surgical systems, there is often little space available to install the PSUs themselves. This can be for a variety of reasons, ranging from the need to integrate as much functionality and performance into the system as possible or the fact that power is often considered late in the project development timeline. Using separate PSUs with individual ac-dc front ends wastes space inside the equipment.

In addition, the use of multiple ac-dc units also imposes multiple sets of transformers (and associated circuit) losses, which leads to reduced efficiency as well as significant power dissipation and thermal management challenges.

The obvious alternative is to take a turnkey route by creating a custom power design tailored to exactly meet application-specific requirements. While such an approach may help to address performance, functionality, efficiency, size and weight tradeoffs, design and development are typically time-consuming and expensive. Additionally, each custom design requires the PSU to undergo full medical product-level testing, which increases development time and cost.

Configurable Digitally Controlled Power

The above tradeoffs were essential in analog-regulated platforms that are fixed for a given conventional power supply design. However, recent years have seen the rise of a third approach that makes use of the significant flexibility that comes from the deployment of digitally controlled power supplies.

Unlike traditional analog regulation techniques, digital control allows parameters such as voltage regulation, current limits and fault protection to be configured through software. These parameters can be monitored in real-time and adapted dynamically if needed. This flexibility enables configurable modular power supplies to reduce the complexities associated with providing multiple different constant-voltage and constant-current supplies, in a space-saving and energy efficient solution compliant with medical-industry safety approvals.

In this methodology, a universal chassis equipped with ac-dc front-end circuitry, including power-factor correction (PFC), offers several standardized slots for the installation of individual power modules. These modules are digitally configured to efficiently and rapidly deliver the specific output requirements of each application (Fig. 2).

Digital power control technologies can be managed over a fieldbus such as MODBUS RTU. Chassis and modules equipped with this connectivity are configurable via digital commands, using standard instructions that enable the programming of parameters including voltage regulation, current limits, power sequencing, and fault response. These systems also support real-time monitoring for system control and diagnostics. Additionally, many of these power supplies include a black box feature to support fault analysis.

In addition, both the implementation of automated fault detection and recovery and real-time setting adjustment can be enabled. The former helps mitigate power failures and prevents damage while the latter more effectively meets the demands of a system in a dynamic operational environment.



Fig. 2. Configurable pre-certified supplies such as the NP08 help optimize medical power designs.

One example of configurable supplies for optimized custom designs is Advanced Energy's NeoPower NP08 ac-dc PSU for output powers of up to 4000 W.

This platform offers eight output power slots, can be programmed to be both a voltage and current source, and has an output current range of 0 to 448 A. Sharing the ac-dc front-end between all modules in the chassis makes for an energy-efficient and space-efficient solution.

Modules can be selected to provide individual outputs up to a maximum voltage or current. Furthermore, because galvanic isolation can be ensured, the supplies can be connected in series to provide a higher voltage or in parallel to deliver higher current (see the reference).

Meeting Medical Standards

As previously mentioned, the configured power supplies must comply with medical standards. These are almost universally based on IEC 60101 and, as a result, power schemes deployed in medical systems will need to implement operator and patient protection and ensure limits on permissible leakage current. The NP08 mentioned above, for example, is fully IEC/EN-60601-1 3.2 compliant and BF-rated—but what does this mean?

For equipment that will come into contact with the patient, creepage and clearance distances need to be designed to ensure input-to-out isolation that meets the MOPP specification. For 250-Vac-powered equipment, input-to-output isolation of at least 4000 Vac is needed to meet the MOPP requirement.

In addition, leakage currents are subject to maximum limits and equipment that will be in contact with the patient must satisfy the type BF (body float) limit or type CF (cardiac float) for dialysis and other equipment that comes into contact with the heart or bloodstream.

For type BF, the leakage to earth must be less than 0.5 mA in normal conditions (NC) and below 1.0 mA in single-fault condition (SFC). Type BF also sets a maximum enclosure leakage current limit (in case of touch) of less than 0.1 mA (NC) and 0.5 mA (SFC).

Pre-testing and certifying the chassis according to general electrical safety standards, such as IEC 62368-1, and medical-specific standards, such as IEC 60601, ensures compliance with relevant regulations once the final power supply configuration is established. If changes to the design are needed later in the product lifetime, engineers can quickly make adaptations by changing one or more modules or reprogramming without needing to re-certify the PSU as a new item of equipment. Provided the designer configures the modules in accordance with manufacturer instructions, the certification remains valid and there is no delay in releasing the end product to market.

This contrasts with the requirement for recertification that typically applies when developing a custom PSU, which can be expensive and time-consuming, potentially delaying any new product release by weeks, if not months.

Conclusion

Digital power technology, especially when paired with configurable and modular approaches, can greatly simplify complex power supply design for medical devices. Certification to IEC 60601-1 medical specifications also allows designs to be modified for future adaptability and scalability without re-certifying.

The benefits of these systems include space savings and efficiency gains over the approach with multiple individual power supplies each having their own independent ac-dc front end. In addition, designers gain extra flexibility to refine and quickly adapt their designs throughout development and in subsequent revisions to the product after launch.

Reference

NeoPower NP08 series [product page](#).

About The Author



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For more on medical power supplies, see How2Power's Industrial Power Supplies [section](#). For more on designing power supplies for medical applications, see the How2Power Design Guide's "[Medical](#)" search results.