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Modular Power Supplies Save Cost, Speed Product Development For Medical Applications

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When specifying power for new designs, "make versus buy" is a constant dilemma—especially for medical power. While optimized for the application, fully customized solutions take time to design, prototype, manufacture and are subject to extensive and time-consuming certification tests before they can be deployed. Custom approaches also carry an inherent level of risk versus standard solutions.

However, choosing standard, off-the-shelf supplies can require compromises in performance, size and thermal management. This is why medical manufacturers are increasingly looking at a "third way"—high-efficiency modular power supplies that can be configured to exactly match application requirements while being fully safety certified and ready for immediate use.

Here we consider the challenges facing designers of medical equipment, introduce the benefits of a modular approach to creating power schemes and look at how the latest advanced features and on-board intelligence in configurable, modular power supplies help to meet performance and control requirements while reducing time-to-market.

Among the application requirements discussed, we consider the environmental and safety requirements specific to medical applications, outlining some of the key safety requirements set forth in IEC 60601, which also covers EMC. The need to limit use of fan-based cooling is addressed as well. After reviewing some of the factors in the make vs. buy decision, we look closely at the modular power supply architecture and its benefits, using the Excelsys CoolX family to illustrate the capabilities offered by modular power supplies.

Medical Applications And Power

There is no simple formula to define a "standard" power solution for medical applications and, while it is true that powering processors and logic is fairly standard, use of medical-specific devices such as exotic sensors can introduce the need for unusual voltages.

When considering power requirements for medical applications, all of the usual parameters such as overall power, number of outputs, and voltages on input and output(s) must be considered. However, other parameters, which may be of less interest in non-medical applications, rise in importance. For example, leakage current is a particular requirement where a patient or operator may come into contact with the equipment and EMI/EMC performance matters more due to the other sensitive or high-energy equipment that may be operating in the vicinity.

Acoustic noise is another consideration in medical applications, not least when it comes to cooling. Not only is the noise from a fan undesirable, it is a moving part, thereby affecting the overall system reliability (Fig. 1). Fans also allow the ingress of dirt and germs into the system, potentially causing damage to the internal components (and the fans themselves), once again impacting system reliability. We'll discuss fans further below. But first let's consider the safety requirements that are unique to medical power supplies.

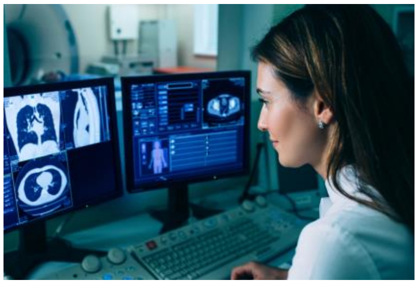

Fig. 1. Advanced medical technologies require reliable power solutions.

Medical Safety Standards For Power

Healthcare is heavily regulated by standards and requirements for product testing to ensure the safety of patients and medical professionals. The primary standard for power solutions is IEC 60601, which was originally published some four decades ago, although regular reviews and updates ensure that it keeps pace with the needs of the industry.

The main safety requirement in medical power supplies is isolation between the mains voltage and the patient and equipment operator. Various different methods can be used (or combined) to achieve this isolation and ensure patient and operator protection, even in the event of a significant fault. Known as means of protection (MOP), these methods can include safety insulation, creepage distances, air gaps (clearances), protective earths and other techniques.

Requirements for operators and patients are slightly different and are known as means of patient protection (MOPP) and means of operator protection (MOOP), with MOPPs being slightly more stringent. The IEC-60601 standard defines these in terms of isolation voltage, creepage distance and insulation level. Table 1 lists the requirements set forth in the standard's current, third edition, which was published in 2005.

Table 1. IEC 60601 defines various methods of protection.

3rd Edition Requirements by Classification			
Classifications	**Isolation**	**Creepage**	**Insulation**
One MOOP	1500 V ac	2.5 mm	Basic
Two MOOP	3000 V ac	5 mm	Double
One MOPP	1500 V ac	4 mm	Basic
Two MOPP	4000 V ac	8 mm	Double

In the past few years, the healthcare sector has changed significantly, not least thanks to an increase in remote monitoring in patient homes and workplaces. This means that the standards can no longer assume that a mains power supply is as "clean" as it would be in a hospital. Also, modern technologies present in home and work environments, such as Wi-Fi and Bluetooth, can present EMC challenges. In its 4th edition, which was published in 2014, IEC 60601 has evolved to recognize these challenges by implementing more stringent noise-related requirements.

Thermal Challenges

Another important issue with power supply design is that of thermal management. Despite the use of the latest highly efficient semiconductors and advanced topologies, power supplies will never be 100% efficient and even in the best designs, as much as 10% of the energy consumed might be released as heat. In many cases, removing this heat involves creating an airflow through the power supply, typically through the use of one or more fans. As moving electromechanical devices, fans are almost always the least reliable component in a power supply. At best, they require regular maintenance and replacement, and at worst they can shorten the life of the power supply and equipment.

Generally speaking, using fans in medical equipment is not ideal as drawing in air will inevitably draw in dust and dirt that can eventually impede airflow and/or lead to shorts that cause intermittent or complete failure. Fans also produce a level of audible noise that is undesirable and they require holes to allow airflow, which means that extreme care has to be exercised when cleaning with liquids that could enter the unit.

While other thermal management techniques exist, the simplest way to manage heat in any design is to not generate it in the first place. Simply put, the higher the efficiency of the power supply, the less thermal management that is required. This also impacts reliability as running at a lower temperature will increase the lifetime of all components—especially if the efficiency is high enough that a fan is not required.

Make Vs. Buy For Medical Power?

Many factors play into the make versus buy decision, not the least of which are the cost (and risk) of development, the manufacturing volume and the price sensitivity of the end product. In high-volume consumer electronics (e.g. tablets, smartphones and laptops) the decision is almost always made due to the price sensitivity, the need for small size and the high volumes that can drive component prices down.

But the medical world is very different; volumes tend to be much lower, especially in large capital equipment such as MRI machines and scanners, and standards requirements make designs more challenging and riskier. This can tend to lead towards a decision of "buy," allowing products to get to market quickly and with minimal risk. In fact, when it comes to healthcare technology, time-to-market can be a life-or-death decision—especially, as we have seen recently, during a global pandemic.

However, in order for buy to be a valid decision, the necessary solution has to be available for purchase on the open market, ideally from more than one manufacturer to ensure security of supply. Unfortunately, given the varied nature of medical power requirements, there is a relatively high degree of probability that the ideal solution does not exist for purchase.

Modular Power Supplies

Although there are many different topologies available and in use, fundamentally all power supplies consist of a front end that rectifies the ac mains and provides power factor correction (PFC) and safety isolation. The output from this stage is often a semi-regulated dc rail of around 400 V or so.

This is followed by a secondary stage that, at its simplest level, converts the dc rail to the voltage(s) required by the load(s). In most cases each voltage will have a separate circuit and voltages may be replicated so that noisy digital circuit elements remain separate from noise-sensitive analog circuitry.

A modular power supply uses this concept of a primary and secondary split and pairs a front-end PFC stage with a range of modular output stages. The result is a solution that sits somewhere between make and buy, which is an ideal solution for the needs of the healthcare industry.

In a typical modular design, the housing contains the front end and this front end can be selected or configured with the appropriate power rating and features required by the target application. Importantly, this will include the primary safety isolation that, for a medical power supply, must meet the requirements of IEC 60601. The front end will terminate in a backplane and connectors that will accept secondary power modules.

A range of secondary modules will be available that will offer a variety of output voltages, some of which may be adjustable to meet more obscure requirements. Most modules will feature output protection (OVP, OCP, short-circuit, etc.) and some, or all, may have other features such as remote sensing or parallel operation.

Benefits Of The Modular Approach

While there may be some lower-power applications where they are not an option, for designs requiring powers of 300 W and above, modular power supplies represent a useful alternative to full-custom solutions. In these cases the modular approach provides a flexible platform with multiple different output options, pre-approval to safety standards and known/quantified EMI performance. This is exactly what is needed in medical applications such as imaging—including MRI, CT and ultrasound; electrosurgery and medical lasers; and life science equipment such as analyzers.

Once the power needs of a system are known, design time with a modular solution is negligible. It is simply a matter of selecting a chassis with sufficient capacity in terms of power delivery and output slots and then choosing the required output modules.

Often, the modular solution can be used earlier in the design cycle before the design is fully stable as, if any requirement changes occur, swapping out a module takes seconds and requires nothing more than a screwdriver. Furthermore, the complete flexibility of the modular approach means that the same platform can be used across multiple different products allowing familiarity and experience to be gained as well as delivering economies of scale in purchasing.

As modular systems are pre-approved to relevant safety and EMI standards, designers can have confidence that the end system will be compliant—provided all guidelines have been followed. This removes a significant risk from the design process as well as saving significant time and cost.

And the benefits of the modular approach continue into the in-service and maintenance phase. In the unlikely event of a failure of an output module, only that module needs to be replaced. This is a simple task in the field. Similarly, should additional features be required, additional modules can be added at a later date, provided the chassis has remaining capacity.

Integrating Intelligence

Monitoring and control, such as that provided by I^2C or PMBus allows faster reaction to load changes and real-time acquisition of information. This permits designers to monitor and control the system during the design phase and rapidly identifies design margins that may require attention.

Once the power supply has been deployed, parameters including voltage, current and temperature can be reported and monitored, providing a window into the health of the system. This can help with preventative, rather than reactive, maintenance, which, in turn, contributes to greater system uptime. Using a standard protocol such as PMBus also allows the use of GUIs and ensures simplified, open access to all relevant data.

This approach to integrated intelligence has been taken by Advanced Energy in developing its Excelsys CoolX modular power supplies. The CoolX family includes the CoolX1000 series, the world's only fanless 1000-W modular power supply and the fanless CoolX600. Using a combination of 200-W/300-W dc output modules, these power supplies can deliver up to 1000 W of ac-dc power across multiple outputs.

The ability to operate without a fan or conduction cooling has been made possible by high operating efficiencies of up to 93%. Not only does this improve reliability, supporting an MTBF of >2,900,000 hours and allowing Advanced Energy to offer a five-year warranty, it also eliminates vibration and acoustic noise.

The CoolX1000 accepts up to six CoolMod modules, allowing for a maximum of 12 isolated dc outputs ranging from 2.5 V to 58 V (see Table 2). The medical version (CX10M) offers 2x MOPP and dual fusing and carries the IEC60601-1 (3rd edition) and IEC60601-1-2 (4th edition, EMC) approvals (Fig. 2). Analog and digital communications and control are facilitated via the PMBus.

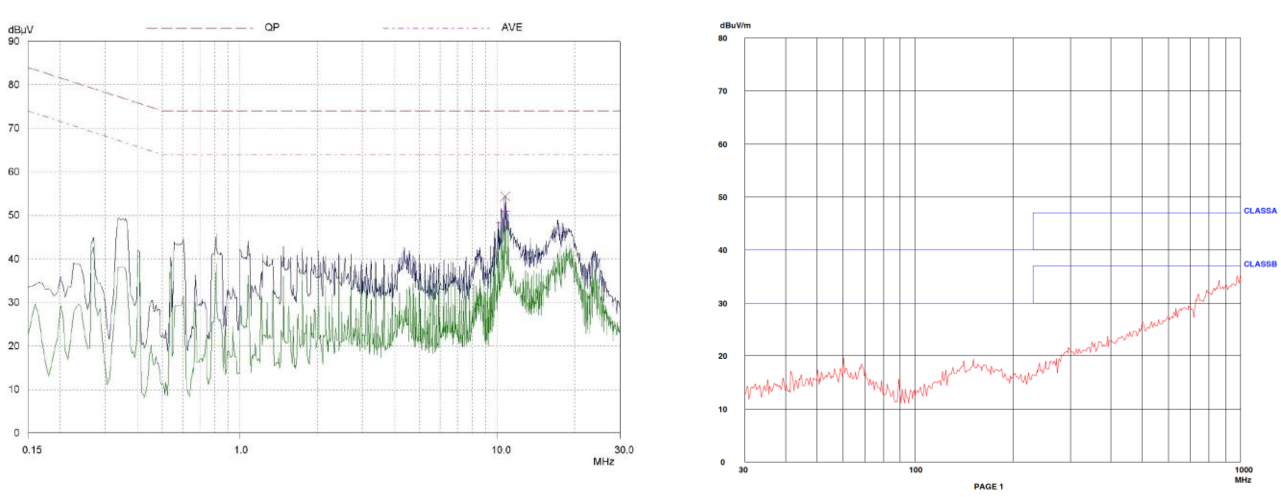

Fig. 2. Conducted (left) and radiated emissions (right) of a CoolX power supply versus the EN55011/CISPR 11 limits.

A range of 12 different CoolMod modules are available, each occupying just one slot and offering single and dual outputs as well as high-power and wide-trim options. Single-output modules have screw terminals while those with dual outputs include a convenient connector. All modules include a remote sensing capability. Units can be mounted in any orientation and can be supplied with a DIN rail mounting option to ensure complete installation flexibility.

Table 2. Advanced Energy's CoolX power supply series offers a wide range of solutions specifically for medical applications.

Model	CoolX1800 series 	CoolX1000 series 	CoolX600 series 
Maximum power	1800 W	1000 W	600 W
Isolated outputs	Up to 12	Up to 12	Up to 8
Cooling methods	Variable fan-speed control	Natural, convection-cooled	Natural, convection-cooled
Dimensions (mm)	262 x 127 x 41	165.1 x 254 x 39.1	215.9 x 114.3 x 39.1

Finally, at the higher power end of the spectrum, Advanced Energy also offers modular, configurable 1800-W and 3000-W power supplies for medical applications. These operate at 91% efficiency and are, again, fully certified against all relevant standards. While they use fan-based cooling, variable-speed fan control provides optimized thermal management. All units feature on-board intelligence that includes temperature monitoring and detection of fan speed to enhance reliability in medical applications.

For users seeking even higher power levels, the CoolX family can be connected in parallel to meet higher system-power demands.

Reference

[AC/DC Low Voltage Power Supplies](#)

About The Author

Dermot Flynn is the director of strategic marketing, high voltage and low voltage at Advanced Energy. In his 20 years in the power supply industry, Dermot has held a number of senior roles in product development, product & technical marketing, and sales. Dermot holds a BAI in electronic and electrical engineering and a BA in mathematics from Trinity College, Dublin, as well as a higher diploma in management & marketing from University College, Cork, and H-Dip in education from Trinity College, Dublin.

For further reading on design and selection of medical power supplies, see the How2Power Design Guide, locate the Application category and select "Medical". Also, see How2Power.com's section on Industrial Power Supplies.