Designing Power Supplies For Portable Devices

Medical Design
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Medical professionals expect high performance from portable medical electronic systems in everything from diagnostic tools, such as ultrasound devices, to life support systems, such as infusion pumps. But while function grabs the spotlight, less glamorous design factors demand equal attention. Electronic equipment that's rolled or carried around a hospital or clinic must be sturdy, compact, washable, reliable, and above all, safe.

How well the internal power circuits are designed will have a big impact on all of the above. Specifically, portable devices that operate on battery power, and plug into the wall to recharge, require a dc/dc converter to provide power and regulated voltage to electronic components and subsystems.

It is possible to find commercial off-the-shelf dc/dc converters that are medically approved, fit the space, and meet every electrical requirement. It's much more likely, though, that you will have to design the converter, or commission a custom design. Most converters for portable medical devices end up with a unique set of requirements for input (battery) voltage, output voltages, size, power, and form factor.

Wide open ranges

Batteries as the main power source present a number of challenges to the power-converter designer. The first is accommodating a wide range of input voltages. An alkaline battery, for example, may start at 1.6 V and wear down to 0.8 V before it is replaced. This 50% voltage difference means that large capacitors must handle the high voltage of a new battery and the low level (with high ripple current) of a depleted battery. You will have to balance component choices against size and weight constraints.

The design must handle a wide load range on the output as well. Portable instruments typically go into sleep mode when not actively in use. This extends battery life but also results in a large power surge when the equipment kicks back to active mode. The power supply must provide a well-regulated voltage over the entire load.

High power-supply efficiency is important, but it is not easy to design a converter for high efficiency over wide input voltage and load ranges. You will have to compromise on efficiency over a good portion of the range. It can help to understand how the equipment is most likely to be used. For example, if it will spend most of its time in sleep mode with occasional short power draws, use that information to maximize efficiency for the most common load.

Designing for high temperatures is essential for portables, even in a clinical or hospital setting. Why? Because these electronics are typically fully enclosed so the equipment can be washed down and disinfected. The full output power load is often dissipated into a small, closed box. Thus, even if the power supply is efficient, the internal temperatures will rise significantly versus the ambient.

Power-converter circuits contain key components, such as electrolytic capacitors, that experience sharply accelerated failure rates with increasing operating temperature. Careful placement of these components can increase power-supply lifetime and reliability despite the high operating temperatures. Even when placing components close together for a compact design, you can avoid creating hot spots near heat-sensitive components.

Also, choose quality components with high-temperature ratings. Increased product reliability is well worth the additional cost for medical applications.

Next, consider protection against shock and vibration. One technique is to avoid using tall components. Consider using a conformal coating or gluing components to the board. Potting the entire power-supply unit provides the best protection, but also adds significant weight. This may be acceptable if the instrument is on rollers.

Choosing a high-switching frequency, typically 1 MHz or more, is a good technique for making a power supply small and light. A high-switching frequency allows using smaller capacitors and inductors, because the higher pulse rate means less energy per pulse to deliver the same power. Switching losses are proportional to voltage, so losses are not a concern for low voltage systems.

Some battery-powered systems are protected from reverse battery damage by making it physically impossible to install the battery pack backwards. However, if this protection is lacking or discrete batteries are used, then you must provide internal protection. The simplest solution puts a diode in series with the supply. Unfortunately, this can have an unacceptable impact on efficiency. A 3 V supply, for example, could have a 0.5 V drop across the diode, essentially throwing away 16%. In battery-powered instruments, Mosfets are usually better solutions.

Most electronic equipment includes some protection against damage from electrostatic discharge (ESD) both while operating and powering down. Battery-powered devices should also consider the problem of ESD protection while the batteries are being replaced. Opening the battery case exposes the heart of the electronics. Further, because the unit is not plugged in, there is no ground connection to bleed off charge. The device needs input protection such as a filter capacitor at the input before the microprocessor.

Low limits on noise and leakage

Medical equipment may also have low electrical-noise limits, especially monitoring and diagnostic systems that work by measuring small voltage changes in a patient's body. Portable sensors often make extensive use of analog and RF circuitry, which tends to be sensitive to noise in any case. The problem is exaggerated by the need to make systems small, putting the power supply close to sensitive analog circuitry.

Finally, some medical devices are powered by ac current with battery back-up. Units used while plugged in to the wall outlet will need a converter with low leakage current. Three classes of medical equipment (B, BF, and CF) each have a different allowable leakage current. The class is determined by where and how the product is to be used. For example, the leakage-current limit is lower for equipment that comes in contact with a patient's heart than for equipment that is simply used near a patient.

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