Switchmode power supplies meet EMC demands and more

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When designing electronic equipment, a consideration for safety takes precedence over all others. This concern is just as important in industrial equipment as it is in medical applications. It might be tempting to think that power supplies which have been safe in industrial applications would be equally suitable for use in medical equipment. This is not always the case because the risks are different.

Furthermore, much of the electronic equipment used in hospitals, such as patient monitors, operate with low-level signals making them more sensitive to electromagnetic interference than industrial versions. Consequently, electromagnetic compatibility, EMC, becomes a key concern in medical applications.

The first and most basic requirement is for effective and reliable **isolation** between a power supply's input and its output, because any isolation shortcoming would result in a higher risk of electric shock. Several factors contribute to effective isolation, including spacing between conductive parts. Although IEC 60601 standards lay down minimum spacing distances, it is important to note that these are greater than spacing distances prescribed by relevant standards for industrial and general-purpose power supplies.

In addition to adequate conductor spacing, effective isolation also depends on reliable **insulation.** Most modern power supplies use double insulation or reinforced insulation, whose effectiveness is verified by dielectric-strength testing. This involves subjecting the insulation to a much higher voltage than it operates at, and ensuring there are no failures.

Once again, medical requirements differ from those for standard power supplies. Reinforced or double insulation in supplies which, for example, operate from a 240Vac main, must withstand a dielectric test at 4kVac for medical applications, whereas the corresponding figure for industrial use is just 3kVac. This difference must be taken into account when choosing a power supply. Those approved to less than 4kVac may be used in medical applications as part of a reinforced barrier, assuming the insulation provided by the power supply is regarded as a lesser 'basic' or 'supplementary' barrier. This case requires additional isolation to meet requirements of a reinforced barrier between the main supply and user.

The leakage current requirements laid down by IEC 60601 are difficult to meet. The maximum permissible earth leakage is 300µA for worldwide approvals, but this figure applies to the end-product as a whole, not just the power supply. To allow for additional leakage in other components it's a good idea to have an even lower leakage current from the power supply.

This leads to an interesting conundrum. As noted, EMC performance is an issue for medical power supplies. All modern power supplies are switch-mode designs because they are small, efficient, and cost effective. Switch-mode supplies, however, generate electromagnetic interference and require filters to limit the effect.

Capacitors in the filters allow a small amount of leakage current to flow. The more effective the filter at suppressing the interference, the more leakage it is likely to produce. Hence, there's a trade-off between

Leakage currents might have no effect on healthy people, but in a hospital where health is compromised, even small leakage currents can be problematic.

EMC performance and leakage current for conventional switchmode supplies. EMC performance can be improved by methods other than simply providing more filtering. A better approach is to minimize the amount of interference the power supply generates in the first place. To explain how this is done it's necessary to understand a little about how switchmode power supplies work.

Essentially, switchmode power supplies first convert ac power from the mains into dc. This dc is then converted or switched on and off to provide pulsed-dc, but at a much higher frequency than the mains supply. The current can then be applied to a lightweight compact transformer to produce the required output voltages. This dc to pulsed-dc conversion is carried out by a switching circuit, and hence the name, switchmode supplies.

Outputs from the transformer are converted back to dc and fed to regulators which ensure the output voltages remain stable when current from the supply varies. Current limiters, to protect against overloads, are also usually incorporated. From the EMC perspective, however, the switching circuit is of most interest.

The switches are transistors (or FETs) and are usually arranged to switch as quickly as possible to minimize losses in the power supply. Unfortunately, the faster the transistors switch, the more interference the switching circuit generates.

Some of the best modern power-supply designs, therefore, deliberately slow the switching rate using special zero-voltage switching or 'ZVS' circuits. These still let the transistors switch relatively fast while gaining voltage transitions (rise and fall times) that are much slower. The transitions in a ZVS circuit may be of the order of 100ns compared to 20ns in a conventional power supply.

The zero-voltage switching circuitry, gives power-supply designers slower switching without compromising the supply's efficiency. The amount of electromagnetic interference generated is greatly reduced and only a small filter lets these supplies meet even the most demanding EMC requirements. With only a modest amount of filtering, leakage currents can also be kept low, satisfying another important requirement.

A further benefit is that the circuitry eliminates the need for an interwinding shield within the transformer, a traditional measure for improving EMC performance. Eliminating the shield allows using a physically smaller transformer, thereby reducing the overall size of the power supply, and also increases the efficiency.

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