How Redundant Power Supplies Prevent System Downtime

When designing systems or products that must have a minimum downtime, the system's power source must be carefully selected. When and how to consider using a redundant and fault-tolerant power system is explored, plus the economics of scalable power and the features required of the power supplies to construct a redundant power system are explained.

This white paper is intended for electronics engineers and designers working with a redundant and fault-tolerant power system.

References

www.uk.tdk-lambda.com/hfe

www.uk.tdk-lambda.com/sws-l

How Redundant Power Supplies Prevent System Downtime

When designing systems or products that must have a minimum downtime, the system's power source must be carefully selected. As a general rule, the longer the power supply's design life, the longer the power supply and the end product or system is likely to operate without a failure.

Power supplies include large electrolytic capacitors that over time can dry out and eventually fail. High-quality industrial-grade power supplies use higher-grade and more expensive electrolytic capacitors that resist drying out and therefore ensure the longest power-supply life possible.

Also, many medium- to high-power supplies use fans to keep them at the correct operating temperature. Since fans are electro-mechanical devices, they often have the shortest lifespan of any component in a power supply and will eventually fail.

In cases where an OEM product or an end user's system cannot tolerate any downtime, a redundant power-supply configuration should be considered. Figure 1 shows a schematic for a redundant power system with three power supplies connected in parallel via internal isolation (ORing) diodes to the system load.

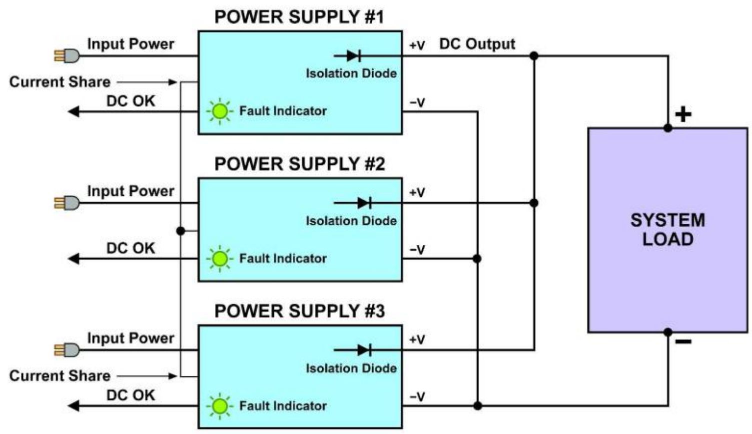

Fig 1: In this typical redundant power system, three power supplies interface in parallel to the system load via internal ORing diodes.

The isolation diodes' function is to become back-biased (as an open-switch) if one of the power supplies fails. In this situation should occur, the failed supply is isolated from the load, its fault indicator turns from green to red, and the system load continues to receive full power from the remaining two redundant power supplies.

The failed supply is designed to be replaced, or "hot-swapped," while the system input and output power remains on. Therefore, it can be replaced at the user's convenience without impeding the operation of the system.

Redundant Reasoning

One of the main reasons for using redundant power supplies that are connected in parallel with isolation diodes is to construct a fault-tolerant power system (Fig. 2). This means that even if one of the paralleled supplies should fail, the system will continue to provide full power to its power bus - this is sometimes referred to as 100% power availability.

In redundant power systems, each supply must include a circuit that automatically disconnects its output from the others should it malfunction. Typically this automatic disconnect is accomplished by having isolation diodes or MOSFETs placed in series with the output of each paralleled supply.

If one of the supplies develops a short circuit on its output (a worst-case scenario) or shuts down for any reason, the isolation diodes would become back-biased or the isolation-MOSFET switch would be turned off (high impedance state). This would prevent the output current from the other supplies from flowing into the shorted or defective output of the failed supply.

In addition to having this automatic output disconnect feature, each supply must include a signal and visual indicator that can be used to alert the user or the monitoring external system that a specific redundant power supply has failed, so it can be replaced and repaired in the future.

N+1 and N+2 Redundancy

There are several ways to construct a redundant or fault-tolerant power system. The most common method is to have at least one supply with sufficient output power to fully satisfy the system's power requirements. Then, a second power supply with the exact same ratings is provided as a backup in case one of the two supplies fails.

This forms a basic N+1 redundant and fault-tolerant power system (1+1 system) where N equals the number of supplies required to fully power the system and +1 equals one backup or redundant supply that will take over for a failed supply. Alternatively, N could consist of two power supplies, each providing 50% of the total load power with the +1 supply having the same power rating as the others.

One advantage of the 2+1 power system is that under normal operating conditions each of the three paralleled supplies only provides 33.3% of the total system power, reducing the thermal stress on each supply and improving its mean-time-to-repair (MTTR).

Some mission-critical applications may need an N+2 redundant power system. For applications like air control, data backup, or life support systems, two backup supplies provide much better fault tolerance than one. However, there is the added expense to achieve this improved degree of power availability and fault-tolerance.

What is Hot Swapping?

It is best if all the redundant and fault-tolerant supplies have the type of interface circuits and input/output connectors that allow the supplies to be replaced while the system's ac input and dc output power is still in the on state. The ability to do this, called hot-swapping, is an important feature to have. Maintenance personnel then can replace the faulty power supply without interrupting the system's operation.

What Is Active Current Sharing?

To properly parallel two or more power supplies, the supplies should include an active-current-share or master/slave feature. This function forces each of the paralleled supplies to contribute its share of current to the load. For example, two paralleled supplies would each provide 50% of the total load current, three supplies would each provide 33.3% of the total current, and so on.

These current share connections must be made between all the paralleled supplies. Without active current share, one of the paralleled supply's outputs could drift higher than the others and draw most of the load current, which can be dangerous and can lead to the premature failure of the power supply, especially in high-power applications.

Fig. 2: This HFE1600 series 19-in. rack-mount redundant power system houses five 1.6-kW hot-swap power supplies. If fewer supplies are required, blanking plates can be installed in the unused slots.

Fig. 3: This unit, a SWS1000L series power supply, delivers up to 1 kW of output power and features alarm signals and active current sharing. Two or more can be connected in parallel with external isolation diodes to form a redundant and fault tolerant power system.

What is Scalable Power?

Economic savings can be achieved where a system requires a specific power level when it is originally built and shipped to the end user, but can be upgraded in the field to add more power as the system grows. For example, for data centre servers the original power requirements for the system may require two or more power supplies in parallel. But as more data-handling capacity is added, more power will be required.

The ability to add or reduce the total power provided to a system is known as scalable power. With a rack-mounted redundant power system, the original configuration can consist of some number of power supplies with blanking plates covering the unused slots. As the system needs more power, one or more blanking plates then can be removed and additional hot-swap power supplies can be added to supply additional power.

Is a Rack-Mount Enclosure Necessary?

No. A rack-mount enclosure provides a convenient means for paralleling supplies for expansion (scalability) and/or to form a redundant, hot-swap configuration. However, many power supplies have the necessary features for being connected in parallel with active current sharing and failure alarm signals (Fig. 3). By adding external isolation diodes, these supplies can be configured to form a redundant power system.

Always check your power supply's instruction manual to be sure that your supplies can be connected in parallel. The only feature that paralleling individual supplies will lack compared to the rack-mounted systems, previously described, is the special mechanical aspects that allow them to be hot-swapped while the input and output power is active. So, in non-hot-swap applications, a scheduled maintenance shut-down period is required to allow time for replacing the faulty power supply.

Summary

We have discussed when and how to consider using a redundant and fault-tolerant power system plus the economics of scalable power and the features required of the power supplies to construct a redundant power system with the greatest amount of reliability and ease of system maintenance. Now all you have to do is choose your supplies wisely.

For more information about the HFE and SWS-L power supplies, please visit:
www.uk.tdk-lambda.com/hfe
www.uk.tdk-lambda.com/sws-l

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Ref: 03/12 LA9589