Redundant Power Systems

TDK·Lambda

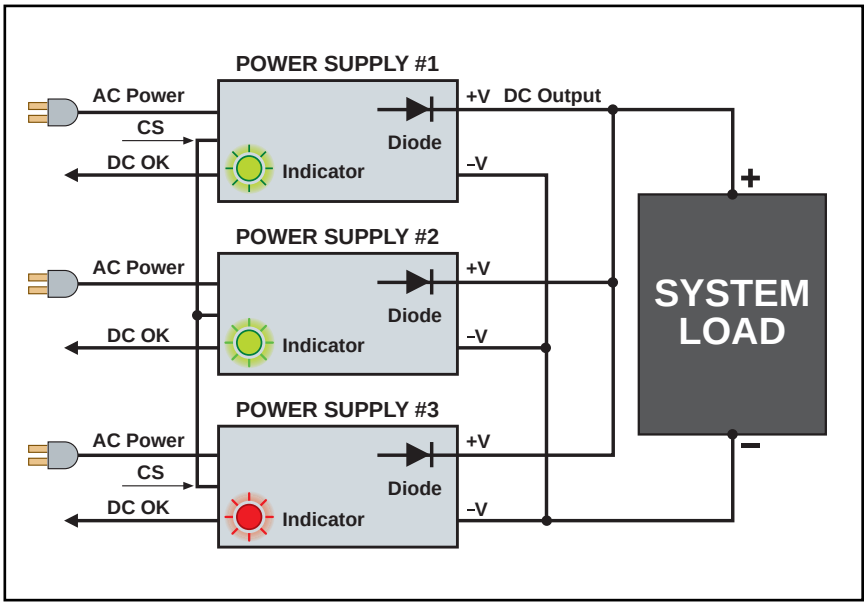
Professor Jim

Hi, my name is Jim Mankowski, Senior Application Engineer at TDK Lambda. What we're going to do today is to demonstrate some of the Lambda power supplies in a system environment.

Lambda's Redundant Power Systems

Power System Diagram

Here is a schematic of a Redundant Power System. You'll notice we have three power supplies connected via ORing diodes to the output bus circuit. The ORing diodes function is to become a back bias switch, so that if a power supply fails, the circuit will be isolated, therefore you can replace the supply without impeding the operation of the bus. The indicators are green, indicating the power supplies are functional. If one of them turns red the power supply is indicated as a failure, it then can be replaced without shutting off the system because the diodes will isolate that leg.



System Demonstration

Here we're going to demonstrate a system to explain what redundancy is all about in hot swapping. As you can see, we have a total of 30 Amps of current flow at 24 Volts. That means that each of these power supplies is going to proportionately share 10 Amps each. If a malfunction occurs, one of the power supplies will go down. Its ORing diodes will shut off that leg, causing the other two power supplies to ramp up from 10 Amps to 15 Amps each, still maintaining 30 Amps total of bus current. The red light will come on the power supply, indicating which one is a failure. Simply remove that power supply. You'll notice the current has not changed, so that we're still applying the same amount of power with just the two power supplies. The fresh power supply would then be installed. The power supply will ramp up, making it 10 Amps again. The other supplies will each reduce down to 10 Amps each. A total system bus current of 30 Amps again exists.

You can get a full text version of this at "Lambda University" on our website. If you have any other questions you can contact us at 1-800-LAMBDA-4 for support. You can also go to our website at www.lambdapower.com and connect to our tech support box, and we can provide you with any information you might need. Thank you.

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Or visit us on the web at www.lambdapower.com

Additional Information about Redundant Power Systems

What is a Fault-Tolerant Power System?

As the name implies, one of the main reasons for using redundant power supplies, connected in parallel with ORing diodes, is to construct a "fault-tolerant" system. This means that even if one of the paralleled supplies should fail, the system will continue to provide full power to its bus. This is sometimes referred to as "power availability." In these systems each supply must include a circuit that automatically disconnects the power supply's output from the others should it malfunction. Typically this automatic disconnect is accomplished by having Isolation (ORing) Diodes or MOSFETs placed in series with the output of each paralleled supply. In the event one of the supplies develops a short circuit on its output (a worst case scenario) or shuts down for any reason, the isolation (ORing) diodes would become back-biased or the isolation-MOSFET switches would be turned off, thus preventing 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 which can be used to alert the user or the monitoring system that a specific redundant power supply has failed, so it can replaced and repaired in the future.

What are N+1 Power Systems?

There are a number of ways to construct Redundant or Fault-Tolerant power systems. 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 of the exact same ratings is provided as a "back-up" in the event one of the two supplies fails. This forms a basic N+1 Redundant and Fault-Tolerant power system (1+1 system). "N" equals the number of supplies required to fully power the system and "+1" equals one back-up or redundant supply that will take over for a failed supply. "N" could consist of two power supplies, each providing 50% of the total load power with "+1" supply having the same power rating as the others. One advantage of this type of power system (2+1) is that under normal operating conditions each of the 3-paralleled supplies are only providing 33.3% of the total system power, thus reducing the thermal stress on each supply, and improving the Mean-Time-To-Repair (MTTR) of the power system.

What about N+2?

In some very critical applications, there may be a need for an N+2 redundant power system. As previously mentioned, the N is the number of supplies needed to support the system's load. But, in mission critical applications, like air control or life support systems, having 2 back-up supplies provides much better fault tolerance than if one is provided. However, there is an added expense to achieve to this improved degree of power availability and fault-tolerance.

What is meant by "Hot-Swap"?

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 is called "Hot-Swap" and is an important feature to have. In this way, a maintenance person can replace the faulty power supply without interrupting the system's operation.

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Paralleling Supplies for Expansion & Cost Savings

Beside redundancy, another advantage of rack mounted power systems is the ease in which power supplies can be connected in parallel. Paralleling consists of connecting two or more power supply outputs together at the load. This allows the user to provide more power to the load than can be supplied by only one supply. For example, if your load requires 24V at 80A, which requires almost 2,000W of power, you can parallel connect two 1,000W power supplies and each will provide 24V at 40A. Besides achieving higher output power ratings, another reason for paralleling power supplies is to accommodate future power needs or to provide different power requirements. A common term for this capability is "System Scalability". For example, a basic system may require 2000-watts of power, which per the example mentioned previously would require two power supplies. Other systems may require only 1000-watts (one power supply) or as much as 3000-watts (three power supplies). In this way the OEM can ship their system with only the required power, thus saving costs, yet still have a means to increase the system's power in the field by inserting one or two supplies into the existing rack-mounted enclosure.

What is Active Current Share?

To properly parallel two or more power supplies, the supplies must 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 and three supplies would each provide 33% of the total current, etc. These current-share connections must be made between all the paralleled supplies. If active current share was not employed, one of the paralleled supply's outputs would drift higher than the others and would then 'hog' most of the load current, which is dangerous and can lead to premature failure of the power supply. Please note that just Paralleling of supplies does not require a means of fault-isolation should one of the supplies fail. However, this feature IS required for fault-tolerant, N+1 power systems as mentioned above.

Must I Use a Rack Mount Enclosure?

No. A rack mount enclosure provides a convenient means for paralleling supplies for expansion, 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, by adding external ORing diodes many Lambda power 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, etc.

In Summary

We have discussed how you can provide increased output power by connecting two or more power supplies in parallel. We have also covered how to construct an N+1 Redundant and Fault-Tolerant Power System and the features required of the supplies in order to accomplish this with the greatest amount of reliability and ease of system maintenance.

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