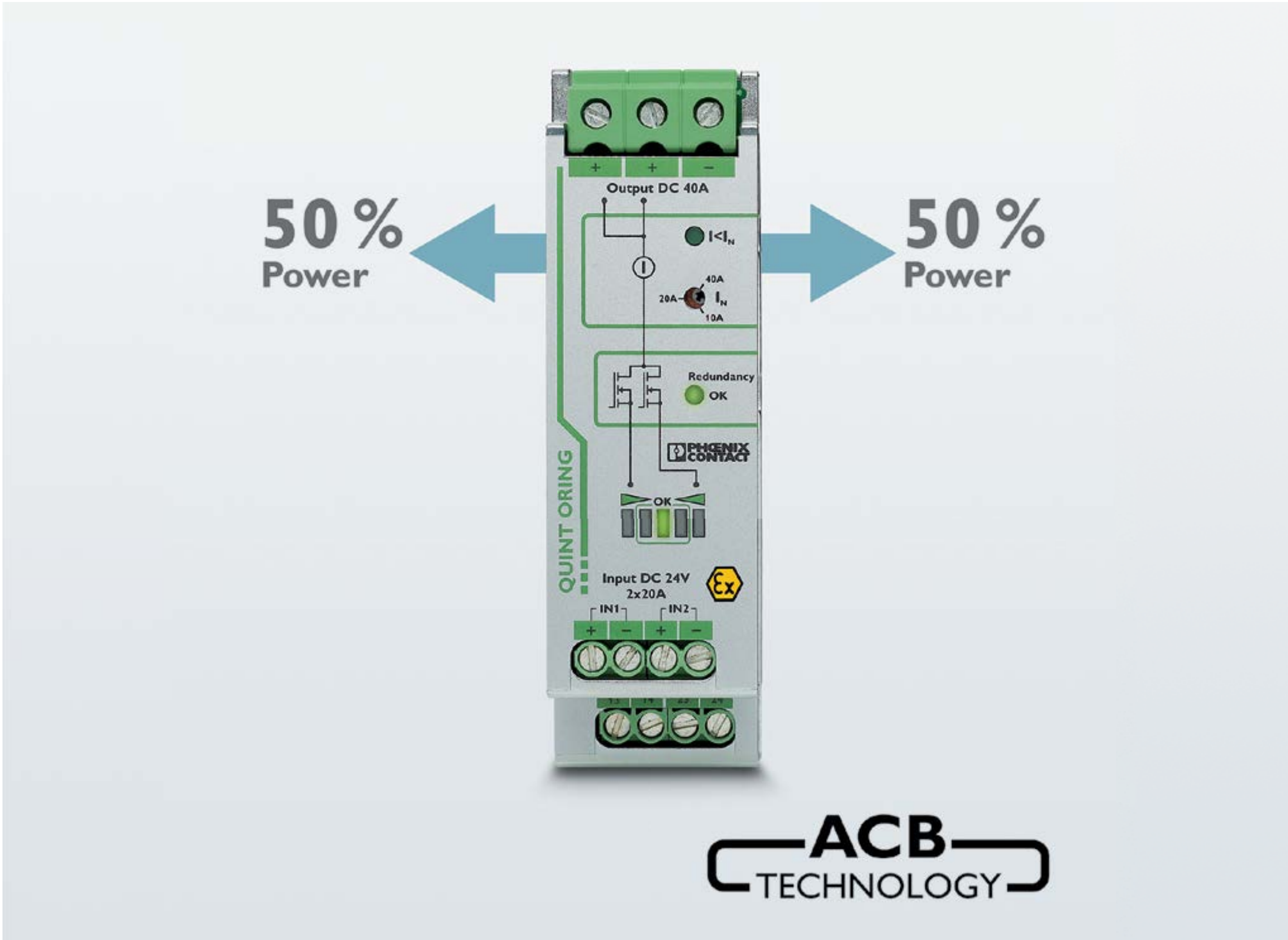
PHOENIX CONTACT
INSPIRING INNOVATIONS



Smart redundancy: Automatic Current Balancing Technology

By Mike Garrick, Product Marketing Manager, Power Solutions, ICE-Power Supplies

Introduction

When a system requires a redundant 24 V DC power system, specific processes or devices must remain powered. There are common problems that jeopardize the reliability and the actual redundancy of the power system. "ORing" technology for redundancy modules takes a new approach to solving these common problems. (Note: ORing is pronounced "OR-ing." The name comes from "OR-ing" technology as a logic function.)

This white paper addresses how this new technology for redundancy modules addresses common redundancy problems and how it differs from common Schottky or silicon diode-based redundancy modules.

INSIDE:

U002194A.10.19

PHOENIX CONTACT • P.O. BOX 4100 • HARRISBURG, PA 17111-0100
Phone: 800-888-7388 • 717-944-1300 • Technical Service: 800-322-3225 • Fax: 717-944-1625
E-mail: info@phoenixcon.com • Website: www.phoenixcontact.com

Load current sharing

The first application issue is "load-sharing." When the application requires a redundant power system, the user can wire each power supply in parallel so that it provides 50 percent of the load current. This will improve system reliability. For example, if the load requires 24 V DC/10 amps, each 10-amp power supply shall provide five amps each for the most reliable power system possible.

Most industrial-grade power supplies have the ability to load-share evenly when they are installed with very careful consideration to the adjusted output voltage. The key is to have the DC output voltage adjusted to within a certain difference of each other and use the same length/wire gauge connecting the DC outputs to the DC power distribution.

The voltage difference to allow proper load-sharing depends on the power supply itself. A typical range would be 50 to 150 mV difference. If this difference is not considered and the "out of the box" settings are not within the expected range, the power supplies will not load-share evenly. The resistance in the power distribution wiring, resulting in voltage drop, can cause the same effect as power supplies not adjusted correctly. To determine if the voltage adjustment has been precise enough to allow symmetrical load-sharing, the user should take a current measurement from each path.

When power supplies are not load-sharing evenly, one power supply will supply the lion's share of the current. This causes the dominant power supply to run at a temperature 10°C higher than it would if power supplies share the load evenly. Running at a temperature of 10°C higher will reduce the expected lifetime of the redundant power system by 50 percent.

Load-sharing is not only an installation concern. Even if the redundant power supplies are load-sharing correctly when first installed, over time other influences like "temperature drift," internal component tolerance changes and even interference can cause the redundant power system to load-share unevenly.

Redundancy modules with "Automatic Current Balancing" (ACB) technology solve this problem. ACB technology monitors the voltage difference between the redundant power supplies. When the voltage difference is less than 100 mV, the user can be confident that the power supplies are load-sharing perfectly without measuring the current. In this case, the load-sharing display will display the green light in the center, as shown in Figure 1.

Figure 1: ORing load-sharing display

If the voltage difference goes beyond 100 mV, then the yellow load-sharing light will display just to the left or right of center, depending on which power supply has the higher voltage. This yellow indication is only a warning. The ACB technology will continue to balance the load.

If the difference between the redundant power supplies reaches greater than 300 mV, a red load-sharing light will display to the far left or right of center, once again indicating which power supply has the higher voltage. At this point, the "ACB OK" diagnostic contact will activate. This alarm indicates that the ACB technology is approaching its limits. While the voltage difference is between 300 and 500 mV, the ACB technology will continue to balance the load current. At any point, from a yellow warning to a red alarm, the user can manually readjust the power supplies to bring the voltage difference to less than 100 mV. The visual indication will become green. Please note that even if the ACB alarm reaches the red level, the redundant system is still intact.

Load current > One power supply can provide

The second concern is when the load draws more current than a single power supply can provide in a redundant power system. Using an example of a 24 V/10-amp system, this includes:

1. Two 10-amp power supplies
2. Redundancy module to decouple the supplies from each other
3. 10 amp load

PHOENIX CONTACT • P.O. BOX 4100 • HARRISBURG, PA 17111-0100
Phone: 800-888-7388 • 717-944-1300 • Technical Service: 800-322-3225 • Fax: 717-944-1625
E-mail: info@phoenixcon.com • Website: www.phoenixcontact.com

When the load is drawing 10 amps or less, each power supply should be supplying half of the load current in a balanced system. If one of the redundant power supplies fails, then the other is able to supply the entire 10 amps.

If the load is drawing 16 amps, due to an unforeseen problem like worn motor bearings, each power supply in the redundant system will provide 8 amps. To the application, both power supplies appear to be working fine. The real concern is that if one of the redundant power supplies fails, then the other will not be able to provide the entire 16 amps. At this point, the redundancy is essentially defeated even though the system appears to be fine. An additional set point current monitor can be added to the system to monitor the load current to compensate for this potential problem.

A solution is to select a redundancy module that allows you to set the specific amperage of the power supplies connected to it. For example, if the system is a 10-amp redundant power system, use the rotary switch to select the 10-amp setting. If the load current exceeds 10 amps, the “Redundancy OK” and “I<In” (the load current is greater than the nominal current for one power supply) LEDs will start blinking. The Redundancy OK alarm also activates to notify the control system that the redundancy is no longer intact.

Diode-based versus MOSFET-based redundancy modules

All redundancy modules provide the most basic functionality, which is decoupling the power supply DC outputs from one another. This prevents an internal power supply short to ground from bringing the second power supply to a 0 V/ DC ground potential. Also, redundancy modules typically are designed with reverse polarity protection.

Redundancy modules with MOSFET-based technology have all of the following attributes:

- Ability to detect a missing or low input voltage
- LED indication for a missing or low input voltage
- Alarm contact for missing or low input voltage
- Redundant output wiring terminals (for redundant wiring to the load)

Diode-based modules may or may not have these attributes.

Heat and efficiency are other areas where the diode-based redundancy modules might create concern. When looking at the most basic Schottky or silicon diode-based redundancy module design, it’s easy to understand why the housing for these kinds of devices is, in reality, a heat sink. Figure 2 shows input 1 (IN1) and input 2 (IN2) connected to the internal decoupling diodes D1 and D2. D1 and D2 will drop approximately 0.6 V. Assuming that this diode-based redundancy module is connected to two 24 V, 10-amp power supplies, the calculation for dissipated wattage is 10 amps x 0.6 V = 6 watts. There are 6 watts of power dissipation for each path through the redundancy modules. This adds up to 12 watts of total power dissipation.

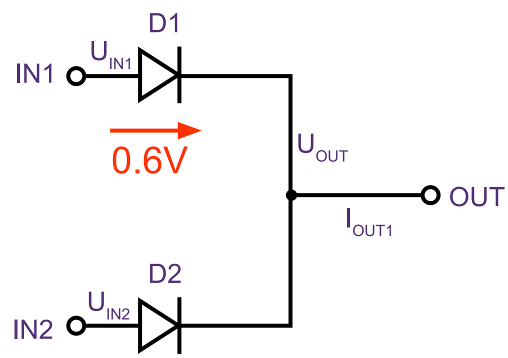


Figure 2: Simplified Schottky or silicon diode-based redundancy module

Figure 3 shows a MOSFET-based design with input 1 (IN1) and input 2 (IN2) connected to the internal decoupling MOSFETs T1 and T2. T1 and T2 will drop approximately 0.1 V. In addition to the voltage drop for the MOSFET, there is also an internal resistance to consider. Assuming that the MOSFET-based redundancy module is connected to two 24 V, 10-amp power supplies, the voltage drop for the internal resistance will be 0.05 V. Adding 0.1 V to the 0.05 V, the total voltage drop for each path is 0.15 V. The calculation for dissipated wattage is 10 amps x 0.15 V = 1.5 watts. There are 1.5 watts of power dissipation for each path through the redundancy modules, for a total of 3 watts of total power dissipation.

PHOENIX CONTACT • P.O. BOX 4100 • HARRISBURG, PA 17111-0100
Phone: 800-888-7388 • 717-944-1300 • Technical Service: 800-322-3225 • Fax: 717-944-1625
E-mail: info@phoenixcon.com • Website: www.phoenixcontact.com

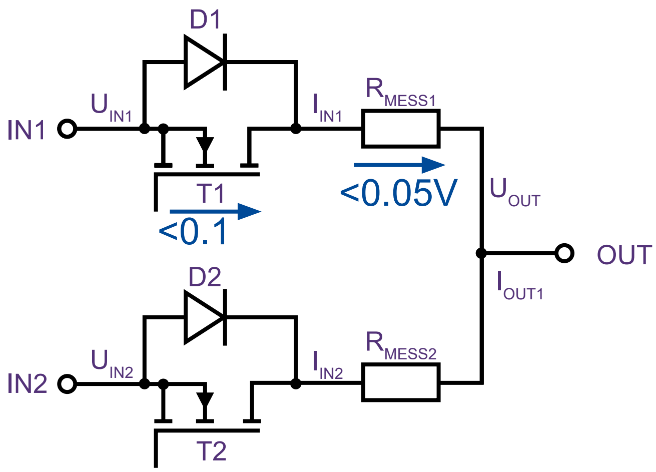


Figure 3: Simplified MOSFET-based redundancy module design

Note: The orientation of the MOSFET and internal diode is such that if there is a failure of the internal electronics of the ORing module that affects the MOSFET (driver, power, etc.), the specific channel(s) of the ORing module will become a standard silicon diode redundancy module using D1 and D2. With this event, a Redundancy OK signal is given to the control system, and the Redundancy OK LED will blink.

Summary

There are no stand-alone diode-based redundancy modules on the market today that can automatically balance the current between redundant power supplies or understand if the load is drawing more current than a single power supply in the redundant system can provide.

Phoenix Contact's QUINT ORing redundancy modules combine Automatic Current Balancing (ACB) technology with a MOSFET-based design to improve the reliability and efficiency of a redundant power system. The QUINT ORing redundancy module design will conservatively save 70 percent of the energy used when compared to a Schottky or silicon-based diode redundancy module. This design also allows for the QUINT ORing module to provide an alarm to the control system if its own internal redundancy is defeated.

For critical 24 V DC redundant power applications, using a "smart" redundancy module will provide the highest level of system reliability, efficiency and security.

PHOENIX CONTACT • P.O. BOX 4100 • HARRISBURG, PA 17111-0100
Phone: 800-888-7388 • 717-944-1300 • Technical Service: 800-322-3225 • Fax: 717-944-1625
E-mail: info@phoenixcon.com • Website: www.phoenixcontact.com