Redundant Power Supply Concepts

Important Contribution to Uptime

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Executive summary

To ensure business success in the industrial sector, machines and systems around the world require a high degree of reliability. Less downtime results in higher profits, and control cabinets that operate continuously are a key to keeping factories efficient. For this reason, many engineers are implementing redundant power supply concepts combined with redundancy modules.

INSIDE:

Power supplies are configured redundantly anywhere that downtimes would have a negative impact. For example, for a device with a rated current of 20 A, the power supply system would consist of two power supplies, each with 20 A on the output side, connected in parallel. If one of the power supply units develops an internal fault or if the primary power supply fails, the second unit automatically takes over and supplies the load current. This means that the power supplies must be dimensioned so that one power supply unit can cover the complete power demand of the connected devices in all operating states.

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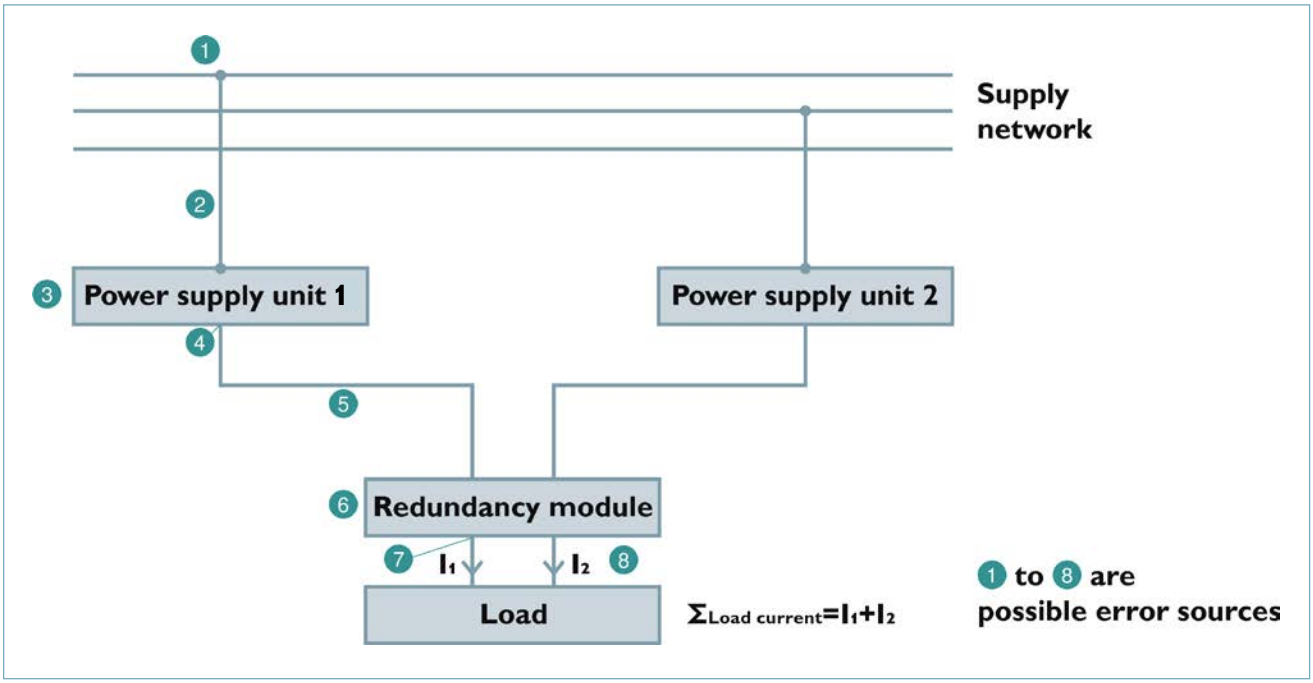

FIGURE 1: Possible causes of faults in a redundant power supply system

Considering all possible fault sources

To minimize the risk of a failure, consider all potential fault sources. Below are some examples of potential failures listed in bold, followed by suitable solutions (see Figure 1):

Fault in one phase of the primary power supply 1
Power supply units connected in parallel are operated on separate phases. This way, if one phase fails or malfunctions, the supply of power is not affected.

Short circuit or break in the cable to the power supply 2 **or failure of one power supply unit** 3
Neither problem will impair the supply of power. The system is redundant, as the second power supply can still satisfy the entire load demand even if the other unit no longer provides an output voltage.

Short circuit between the power supply and the redundancy module 4
In this case, parallel operation of two power supply units is not sufficient. What is needed here is a diode or redundancy module that decouples the two power supplies from each other. In this setup, the second power supply unit continues to supply the required power to the load and does not feed into the short circuit. Without decoupling, the load demand would no longer be satisfied, because the current from the redundant power supply feeds into the short circuit.

Break in the cable between the power supply unit and the redundancy module 5
If the input voltage of the redundancy module is monitored, a fault in the wiring will be detected immediately. After removing it, the power supplies function redundantly again.

Internal defect in the redundancy module 6
A self-monitoring function reports internal faults so that the faulty unit can be replaced without any delay.

Break in the cable between the redundancy module and the load 7
To increase the availability of the connected load, the wiring to the load should also be redundant. If all modules have two or more output terminal blocks, easy and quick installation is ensured.

Excessive load current caused either by a faulty load or subsequent increase through other devices 8
The solution for this scenario is to monitor the load current and issue a warning as soon as a predefined value is exceeded.

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Monitoring the load current

Figure 2 illustrates the advantage of combining load current monitoring with an alert. If a user connects additional loads to a redundant power supply when expanding the system, the system redundancy will be defeated.

For example, let's say two redundant power supplies, each rated with a current of 5A, are powering a 5 A controller. The user now connects an additional load drawing 3 A. Due to its power reserve, the power supply easily provides 8 A without a dip in voltage. However, the system is no longer redundant. If one of the two power supply units now fails, the second 5 A unit is unable to provide the 8 A because its power reserve is insufficient.

This is why it is important to monitor the load current. This makes the system operator immediately aware of the loss of redundancy. To facilitate this, some of today's redundancy modules have an "ORing" function, which can inform users of a loss of redundancy due to load current draw. The function operates with a four-minute delay. This prevents operators from misinterpreting temporary high currents, such as those caused by starting motors, with a permanent overload situation.

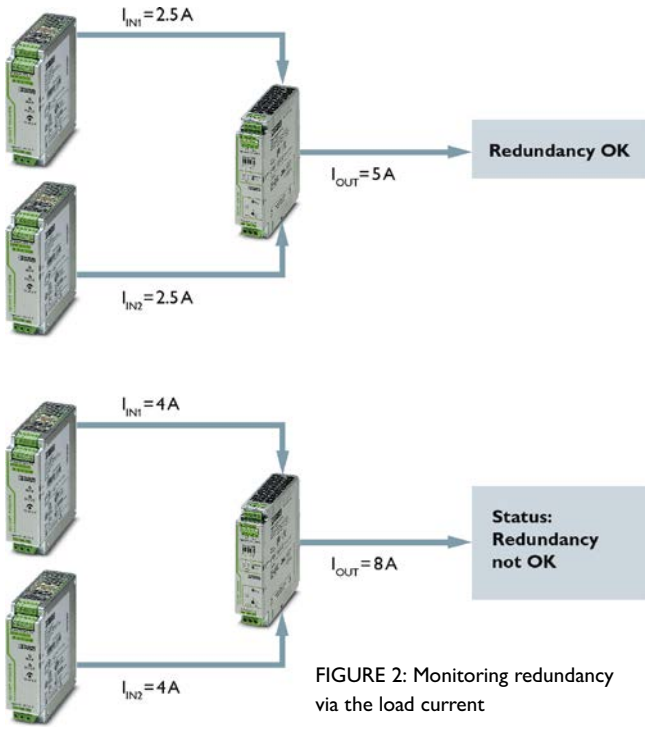

FIGURE 2: Monitoring redundancy via the load current

Service life has been doubled

When output voltages are configured unevenly, this results in asymmetries. Often, only one power supply unit feeds the load while the other device remains idle. This places thermal stress on the power supply, which will reduce its electrical lifetime. If both power supply units are operated at half the rated power, their temperature will decrease by around 10 degrees Celsius, which will significantly increase service life.

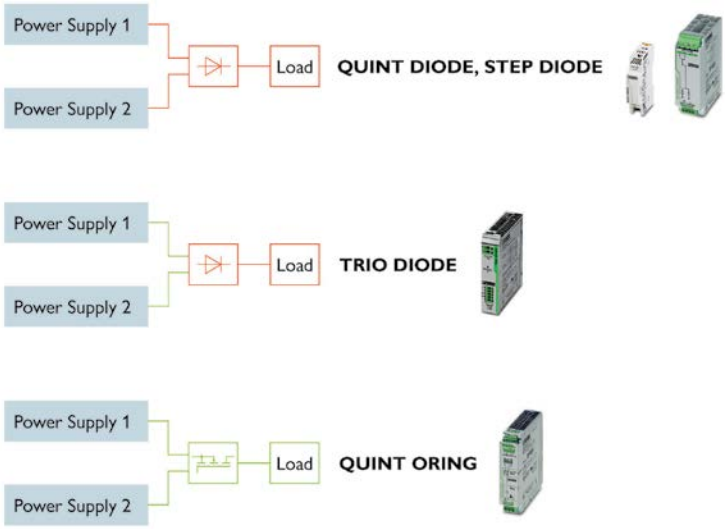

FIGURE 3: Continuous monitoring of redundancy increases availability, monitored sections appear green

Based on this principle, a technology that automatically balances the power supplies can ensure that both power supplies share the load current evenly – doubling the service life of the redundant power supplies. To this end, the power supplies use MOSFETs instead of the usual Schottky or silicon diodes. The MOSFETs correct redundant power supplies' DC voltage differences of up to 300 mV. The load current is automatically distributed fully symmetrically. In addition, this solution is 70 percent more energy efficient than conventional solutions. Also, lower power loss means that all control cabinet components stay cooler.

ORing redundancy modules solely monitor the complete redundant solution – extending from the output voltages of the power supplies through the wiring and the decoupling section up to the load current (Figure 3). The floating "Redundancy OK" and "ACB OK" signal contacts as well as the LED displays are used to monitor the units' proper operation.

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The load utilization of the power supplies is transparently displayed as a bar chart. With a quick glance, the user can identify which input voltage is higher, that is, which power supply is under a heavier load. With this insight about the different states, operators can immediately spot problems and resolve them. For example, a red flashing light indicates that the power supply voltage at one input is more than 300 mV higher than the voltage at the other input. If the red light illuminates continuously, a MOSFET in the path is defective. The display and layout comply with the NAMUR recommendation.

Conclusion

In sensitive applications, a redundant configuration of the automation solution ensures high system reliability. In this context, corresponding power supply concepts are recommended. Depending on the application, operators can choose between solutions without decoupling or with decoupling by means of diodes or a MOSFET.

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