Redundant power supply concepts

Important contribution to high levels of availability

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The high degree of availability of machines and systems installed across the world is a key prerequisite for business success in any industrial sector. Only continuously supplied control cabinet components increase the profitability of the application. For this reason, users are increasingly implementing redundant power supply concepts, which are often combined with redundancy modules (lead figure).

Power supplies are configured redundantly everywhere where downtimes would have a highly detrimental effect. For a device with a rated current of 20 A, this means, for example, that two power supplies, each with 20 A on the output side, are 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. This means that the power supply units must be dimensioned so that one power supply unit can cover the complete power demand of the connected devices in all operating states.
Considering all possible fault sources

To minimize the risk of a failure, all potential fault sources have to be considered. For this purpose, potential reasons for failure in a redundant power supply configuration are described below, including suitable solutions (Figure 1):

- **Fault in one phase of the primary power supply (1)**
  Power supply units connected in parallel are operated on separate phases. In 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 plus 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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**Figure 1 | Possible Fault Sources**

![Diagram of possible fault sources in a redundant power supply configuration.](image-url)
Monitoring the load current

The following example illustrates the advantage of combining load current monitoring with an alert (Figure 2). Redundancy can be lost if a user connects additional loads to a redundant power supply when expanding the system.

For example, a controller that requires 5 A is supplied by two redundant power supply units, each with a rated current of 5 A. The user now connects an additional load drawing 3 A. Due to its power reserve, the power supply easily provides 8 A without resulting in any voltage dip. However, the system is no longer redundantly supplied with power. If one of the two power supply units now fails, the second unit can no longer provide the 8 A because its power reserve is no longer sufficient. This is why it is important to monitor the load current. In doing so, the system operator will be immediately aware of the loss of redundancy. To facilitate this, the Phoenix Contact product portfolio for redundancy modules includes Oring devices with a function which informs users of an overload. The function operates with a delay of four minutes to prevent operators from misinterpreting high currents caused, for instance, by starting motors, with a permanent overload situation.

As a result of asymmetries, i.e., when output voltages are configured unevenly, 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 cause the device to wear out more quickly. If both power supply units are operated at half the rated power, their temperature will decrease by around 0°C, which will increase service life significantly. Based on this principle, Phoenix Contact’s proprietary ACB (Auto Current Balancing) technology integrated in the Oring modules doubles the service life of the redundant power supplies, ensuring that both power supply units work under the same load. To this end, the modules use MOSFETs instead of the usual Schottky or silicon diodes. The MOSFETS correct input 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 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. The load utilization of the power supplies is transparently displayed as a bar chart. A single glance is all it takes to identify which input voltage is higher, i.e., which power supply is under a heavier load. Users are thus quickly informed about various states, allowing them to 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 is defective in this path. The display and layout comply with the NAMUR recommendation.

Conclusion

In sensitive applications, a redundant configuration of the automation solution ensures high availability. 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.

Figure 3  I   All the areas shown in green are monitored

QUINT DIODE, STEP DIODE, UNO DIODE
Decoupling with diode + monitoring of the power supply voltages

TRIO DIODE
Decoupling with redundancy module + monitoring of the power supply voltages and the wiring

QUINT ORING
Decoupling with active redundancy module + monitoring of the power supply voltages, the wiring, the decoupling and the load current