Reliable system availability in case of short-circuit

Efficient redundancy for power supplies

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Redundancy modules guarantee reliable system availability, even if a power supply fails. However, the decoupling diodes in the module lead to high power losses in form of heat and a large voltage drop.

Therefore, PULS is replacing the diodes with efficient MOSFETs. The redundancy modules also receive further useful features.

In a redundant system, two or more power supplies are switched in parallel and decoupled by one or more redundancy modules. The module prevents short-circuiting of the bus voltage if a short-circuit occurs in the output side of a power supply.

To achieve this, a diode or equivalent component is used for decoupling. One is sufficient for each power supply. The disadvantage of this method: diode decoupling causes significant power losses in form of heat.

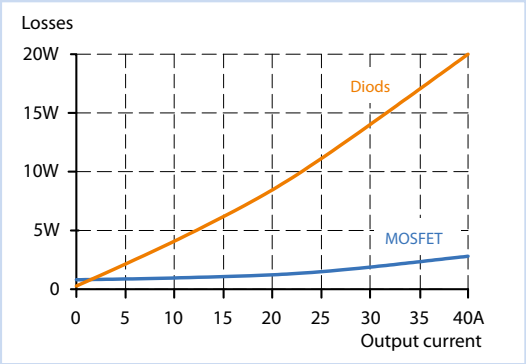

Image 1:
A comparison of no-load losses of diode and Mosfet redundancy module (YR80.241)

A load current of 40A creates approx. 20W of power losses (*image 1*). This means heavy thermally induced stress for the electronics, which can only be reduced by means of large heat sinks.

PULS engineers were not willing to accept this compromise. They carried out research to find out what users require specifically in a redundancy system.

Ten criteria have emerged for optimal redundancy:

1. Highest safety and availability
2. Minimal power losses
3. Ease of use
4. Load-side return voltage immunity
5. Short-circuit protection
6. Parallel function: Power distribution between power supplies
7. Signal in case a power supply fails
8. Inverse-polarity protected input
9. Signal in case of error condition
10. Hot swapping: Swapping without voltage interruptions.

When analysing the results, it quickly became clear to the development team that standard epitaxial or Schottky diodes could not fulfil the need for minimal no-load losses. Therefore, a decoupling solution with MOSFETs was developed instead.

This technology reduces power losses. For instance, when using a MOSFET module, a load current of 40A will only produce power losses amounting up to 3W instead of 20W.
However, points five and eight were a major challenge for the development team when designing the new MOSFET solution. This is because short-circuits or inverse polarity in the power supplies could destroy the MOSFETs.

Circuit design actuates MOSFET in case of short-circuit

If a short-circuit occurs in the load or cabling, the power supply voltage fails and almost no useable voltage is present at the redundancy module input. However, the MOSFETs in the redundancy module must remain continuously actuated for the short-circuit current to flow with low power losses. Otherwise, this current is absorbed by the body diodes in the components. This increases power losses by 15 times and could eventually destroy the MOSFETs. This weak point of the components is overcome by a new circuit that even in the case of a short-circuit, it takes advantage of the minimal residual voltage to actuate the MOSFETs properly (*image 2*).

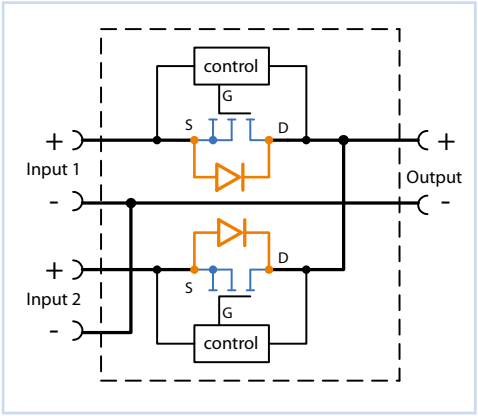

Image 2:
Circuit design with Mosfet technology

The circuit can be bypassed even in other critical situations, such as when the power supplies are connected to an existing short-circuit or if the input voltage has been reverse-poled.

A voltage drop of just 50 mV

With MOSFETs as a decoupling element, even voltage drops can be minimised. Diodes in standard redundancy modules cause a voltage drop of 500mV between the input and output. Thanks to the MOSFET redundancy modules, this situation could be improved drastically. For instance, in the redundancy module YR80.241, the voltage drop at 40A output current is lower than 50mV between the input and output.

Uniform power distribution via parallel function

After implementing MOSFETs, even the parallel-use mode achieves better thermal balance, thus leading to an extended lifetime. In this process, the load current is divided equally between the individual power supplies.

There are two ways of integrating the parallel function in the system. It can be either integrated directly into the power supplies or into the redundancy module. In the integration of power supplies, the output voltage is regulated in such way that it is around 4% higher at no load than it is at nominal load. This results in an automatic current distribution between devices, as long as their no-load voltage is identical. If a power supply takes up more current, its voltage decreases automatically and a current symmetry is restored. This property ensures that there are no power losses in the current distribution. In the integration of the parallel function in the redundancy module, the MOSFETs are used in linear

mode. They generate a well dosed voltage drop in the channel with the higher voltage so that a current symmetry is achieved between the two channels, i.e. the power supplies. This method also enables power supplies without integrated parallel-use mode to be used in parallel.

PULS developers deal intensively with the optimisation of both approaches. It is crucial for the parallel-use mode to always support the safety, availability and efficiency of the redundant system – both for classic 1+1 redundancy systems and for N+1 systems.

Hot swapping – replacement without voltage interruptions

An additional technical innovation was implemented in the design of the redundancy module YR40.245. Hot swapping is therefore also available in this module for the first time. With „hot swapping" one understands the replacement of a power supply or a redundancy module while the system is running. To enable this, the critical connections have plug connectors with short-circuit protection. If the predetermined sequence is observed when replacing the defective device, it can be replaced without voltage interruptions. Redundancy is restored immediately after replacement. This is indispensable for systems, whereby even a temporary failure could mean significant security risks or serious economic losses.

YR40.245

About PULS

PULS is the only company worldwide focused entirely on the development and production of DIN rail power supplies. We concentrate our engineering knowledge, resources and energy on one goal: To be the best in this technology. As a result of this focus, our product families DIMENSION, PIANO and MiniLine set standards in terms of efficiency, size and service lifetime.

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