White Paper

How to Choose Power FETs for ORing MOSFET Controllers

Introduction

Many power applications use multiple supplies with fault tolerance to share the load current, or to have redundancy in the power system for high reliability.

In these power distribution systems, paralleled power supplies contribute equally to the load current through some type of output sharing scheme. A common design practice is to include discrete ORing power diodes to protect against reverse current flow in the event that one of the power supplies suffers a catastrophic output short-to-ground. Reverse current also can occur if the current sharing scheme fails and an individual power supply voltage falls significantly below the other power supplies.

Although the discrete ORing diode solution is common and inexpensive to implement, it has some drawbacks. The primary downside is the increased power dissipation loss in the ORing diodes. Another disadvantage is that it can be difficult to detect a shorted or open ORing diode. These drawbacks can jeopardize power system reliability.

This article examines how using ORing MOSFET controllers and power FETs in place of ORing power diodes can reduce power consumption in high-current power distribution systems. Presented are the key selection steps for choosing power FETs, along with proven design tips to ensure engineers meet their target specifications when developing a redundant power distribution system.

Figure 1 shows the disadvantage of using ORing diodes in a high current supply system: in this system, each diode is dissipating 10W (20A with a diode drop of 0.5V). Both would need their own heat sink, as the diodes alone consume 20W in this system.

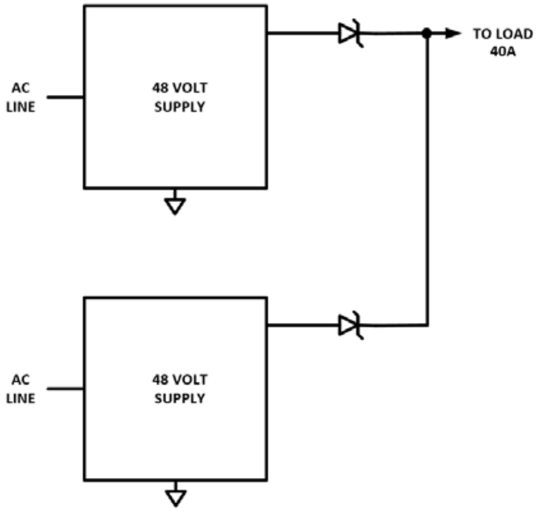

Figure 1. High current redundant power supply using ORing diodes

In high load current applications, power consumption can be reduced if the ORing diodes are replaced with MOSFETs managed by a high voltage MOSFET ORing controller, such as Intersil's ISL6144. Figure 2 shows the ISL6144, which includes an on-chip charge pump for driving a power FET. The controller also includes features that allow it to shut down its output if the input supply fails. This helps prevent transients when another redundant system controller sources its output load-current. Using an ORing MOSFET controller reduces power loss and enhances reliability.

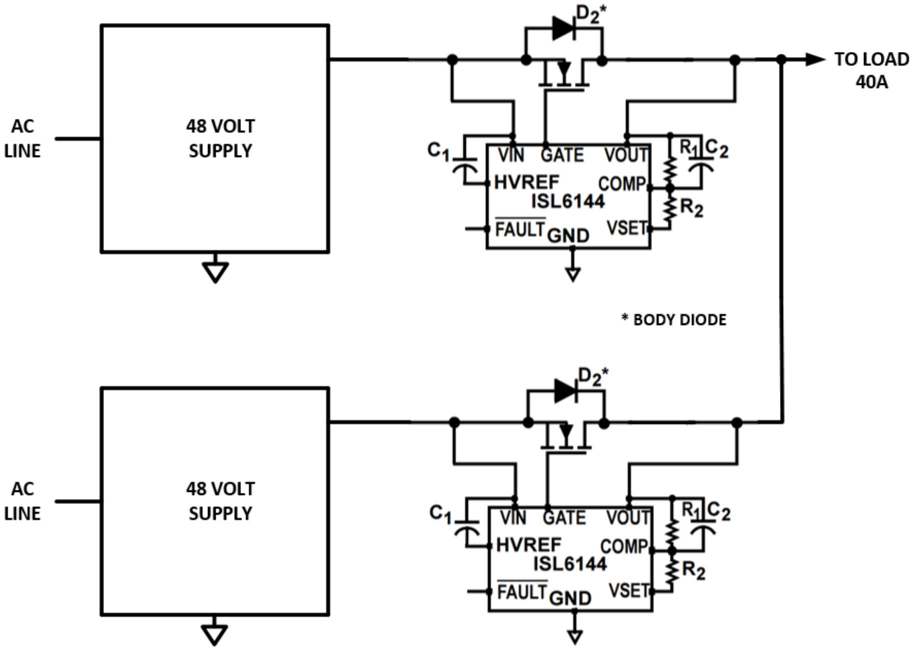

Figure 2. High current redundant power supply using ORing MOSFET controllers

Selecting Power FETs

Selecting the right power FET is necessary to help the ORing MOSFET controller perform its job. You can select a suitable FET by following these steps:

1) Use an N-channel FET that has a drain-source voltage (Vds) breakdown that is greater than the bus voltage. For example, if the bus voltage is 48V, you will want to use a FET with 60V breakdown voltage.

2) Pick a FET with a current rating that can support the bus load. The Figure 2 example shows a redundant system where either 48V supply could fail. If a supply failure occurs, the other power supply will need to send the full 40A load through one ORing FET. Therefore the FET would need to be rated for more than 40A.

3) Pick a FET with an appropriate R_{dson} for what you are trying to achieve. Several factors will affect this choice. You will want to focus on FET power dissipation under worst-case conditions, followed by checking that the FET's worst case R_{dson} allows the power supply voltage to maintain supply voltage regulation with margin.

Be mindful that the amount of power dissipation in the FET dictates how much heat sinking will be required. The value chosen for R_{dson} will directly affect the worst-case power dissipation, which in turn dictates the heat sink requirements. The choice of the R_{dson} value may be an iterative process where you choose the R_{dson} value based upon what heat sink or airflow requirements are needed to make the solution fit your system.

For higher power levels, efficiency may be the biggest concern as lower power dissipation minimizes the heat sinking or air flow requirements. The value of R_{dson} directly affects the heat sink requirements and whether airflow will be required for cooling. It can be more cost-effective to choose an expensive FET for lower R_{dson} (which buys you higher efficiency) as this may save costs on the heat sink and airflow requirements.

During this process, be sure to use the worst case R_{dson}. The ISL6144 ORing MOSFET controller's charge pump enables the gate FET drive to be 10V above its source. Thus, be sure to look at the FET characteristics when it's driven with $V_{gs(on)}$ of 10V. Do not worry about choosing a FET for high frequency switching. In this application, the FETs will slowly turn on-and-off. Therefore, minimizing the gate charge is not required.

FETs vs. Diodes: A Closer Look

To see the true benefit of FETs over diodes in a redundant power distribution application, set a goal of achieving lower power dissipation in the FET under worst-case conditions – set it lower than diodes can achieve. In the original system highlighted earlier, we saw that each diode dissipated 10W under normal operating conditions. If one diode fails, the other diode would need to carry the full 40A. This would push the diode system to a forward voltage of 0.6 volts for a worst-case power dissipation of 24W.

In the FET system, the worst-case power dissipation occurs when the system fails and forces one FET to carry the full 40A load. Your goal should be to use the lowest possible R_{dson} FET so that efficiency is improved and the heat sink and airflow requirements are minimized.

When you reach this point in the design, a good next step is to log on to your favorite component distributor's web site and go to the FET selection section. Many distributors have search tools that allow you to input a variety of FET parameters and get a listing of appropriate devices that meet your parameters. Since R_{dson} is a key parameter for this application, you want to search for the devices with lowest R_{dson} values at a reasonable cost. Since the distributors tools include pricing you can get a good idea what lower R_{dson} will cost.

By using the distributor's search tool, you'll see that a FET with 60V breakdown and 100A can be found with R_{dson} at 125 °C at about 4.3 milliohms – all for a cost of less than $1 at 1K quantities.

If you use this FET, your first task is to check the worst-case power dissipation, which in this case is having one failed input supply. Under this condition, the I^2R power dissipation is: 40A x 40A x 0.0043 = 6.88W. Under normal (non-fault) conditions, each FET carries 20A and operates at a cooler temperature. This results in lower R_{dson} and even lower losses.

Knowing the wattage prepares you to design the cooling system, which will likely depend upon the heat generated by other system components and whether you planned air-cooling for this system. Lastly, you will need to check the voltage regulation from the selected FET. With 40A flowing through the FET R_{dson} of 0.0043 ohms, the voltage drop will be 40 x 0.0043 = 0.172V. Therefore, the 48V output would change by only 0.172/48 = 0.3%.

Conclusion

Moving away from the use of standard ORing power diodes to an ORing controller that drives a power FET can minimize power loss and maintain redundant system reliability. The power FET selection steps and design tips provided will guide you in the design of your next redundant power distribution system. Remember, these FETs lack voltage and overcurrent protection so never chose a FET at its absolute limits. Give yourself plenty of headroom.

Next Steps

- Learn more about the ISL6144
- Download the datasheet
- Order samples

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