DESIGN NOTES

Replace ORing Diodes with MOSFETs to Reduce Heat and Save Space – Design Note 363

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Introduction

High availability telecom systems employ redundant power supplies or battery feeds to enhance system reliability. Discrete diodes are commonly used to combine these power sources at the point of load. The disadvantage of this approach is the significant forward voltage drop and resulting power dissipation, even with Schottky diodes. This drop also reduces the available supply voltage, which is sometimes critical at the low end of the input operating range. A circuit with "ideal" diode behavior overcomes the dissipation and voltage loss problems by eliminating the forward drop.

The LTC®4354 negative voltage diode-OR controller realizes near-ideal diode behavior. External N-channel MOSFETs, actively driven by the LTC4354, act as pass transistors to replace the diodes. The device maintains a small 30mV forward voltage drop across the MOSFETs at light load; under heavy load the voltage drop becomes a function of $R_{DS(ON)}$. For example, an 18mΩ MOSFET and 5A load current produce a drop of 90mV, representing a more than five fold improvement in drop and power dissipation over a Schottky diode, which exhibits 500mV drop under the same operating conditions. Lower power dissipation conserves board space and saves the cost of heat sinks. At the same time, 410mV of input operating range is added—a critical factor when the system is running on hold-up capacitors with only a few volts of headroom.

Ideal –48V ORing Diode

Figure 1 shows a comparison of power dissipation for a diode and a MOSFET driven by the LTC4354. At 10A, the voltage drop across a 100V Schottky diode (MBR10100) is around 620mV; a heat sink is required to handle resulting 6.2W of power dissipation. Using an LTC4354 driving a 100V N-channel MOSFET (IRFR3710Z), the dissipation is only 1.8W due to the low 18mΩ (max) $R_{DS(ON)}$ of the MOSFET. This is easily dissipated in the circuit board with no additional heat sinking.

The LTC4354 implements two ideal diodes, simultaneously controlling two external N-channel MOSFETs with the source pins tied together, as shown in Figure 2. This common source node is connected to the V_{SS} pin, the negative supply of the device. Its positive supply is derived from –48V_RTN through an external current limiting resistor. The LTC4354 includes an internal shunt to regulate the V_{CC} pin at 11V.

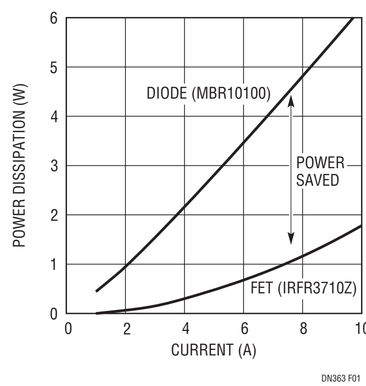

Figure 1

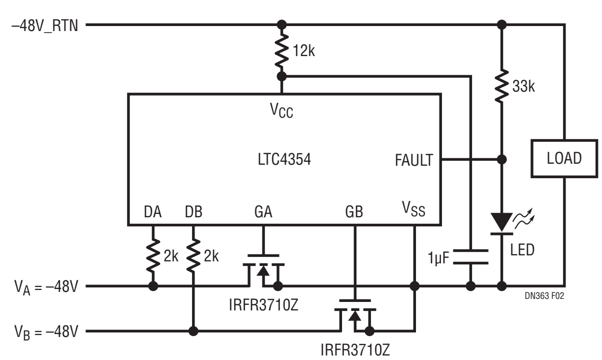

Figure 2

At power-up, the initial load current flows through the body diode of the MOSFET and returns to the supply with the lower (most negative) voltage. The associated gate pin immediately ramps up and turns on the MOSFET. The LTC4354 tries to regulate the voltage drop across the source and drain terminals to 30mV. If the load current causes more than 30mV of drop, the gate is driven higher to further enhance the MOSFET. Eventually the MOSFET is driven fully on and the voltage drop increases as dictated by $R_{DS(ON)} \bullet I_{LOAD}$.

If the power supply voltages are nearly equal, this regulation technique ensures that the load current is smoothly shared between them without oscillation. The current level flowing through each MOSFET depends on the $R_{DS(ON)}$ of the MOSFETs, the output impedance of each supply and distribution resistance.

In the case of supply failure, such as an input supply short to –48V_RTN, a potentially large reverse current could flow from the –48V_RTN through the MOSFET that is on. The LTC4354 detects this condition as soon as it appears and turns off the MOSFET in less than 1µs. This fast turn-off prevents reverse current from reaching a damaging level, exhibiting a behavior not unlike a discrete diode with a recovery time measured in hundreds of nanoseconds.

Fault Output Detects Damaged MOSFETs and Fuses

The LTC4354 monitors each MOSFET and reports any excessive forward voltage that is indicative of an overcurrent fault. When the pass transistor is fully on but the voltage drop across it exceeds the 260mV fault threshold, the open-drain FAULT pin goes high. This allows an LED or optocoupler to turn on and flag the system controller. It is important to recognize excessive voltage drop in the MOSFETs because extra heat is being dissipated. If the condition persists the system controller can take action and shut down the load.

Positive Low Voltage Ideal Diodes

LTC4354 is also suited for positive, low voltage applications, as shown in Figure 3. With this circuit the outputs of multiple high current switching converters can be combined, without concern about back feeding or supply failure shorting out the common bus. One diode "channel" comprises the LTC4354 and six parallel MOSFETs, supplying 100A to a 1.2V load. The circuit is easily adapted to any supply voltage between 0V and 5V, provided there is a path for up to 4mA V_{EE} current to ground at either the input or the output. Most high current switching converters can easily sink 4mA and no preload is necessary. No circuit changes are necessary for different operating voltages.

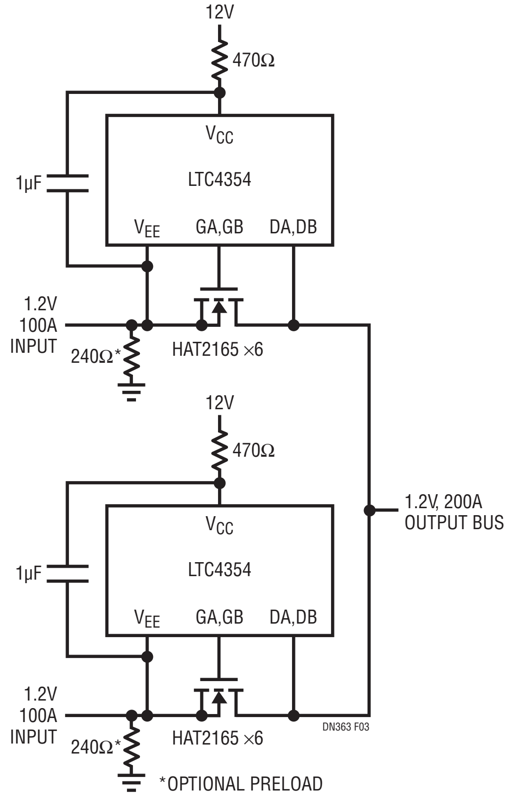

Figure 3. Positive Low Voltage Diode-OR Combines Multiple Switching Converters

Conclusion

The trend in today's telecom infrastructure is toward higher current and smaller module space. Traditional diode ORing is increasingly cumbersome. The LTC4354 provides an improved solution by controlling low $R_{DS(ON)}$ N-channel MOSFETs to reduce power dissipation and save board space and heat sinks, on both sides of the isolation barrier. Furthermore, the LTC4354 monitors and reports fault conditions, information not provided by a traditional diode-OR circuit.

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