

# 9V to 80V Ideal Diode Reduces Heat Dissipation by Order of Magnitude over Schottky

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## Introduction

High availability systems often employ parallel-connected power supplies or battery feeds to achieve redundancy and enhance system reliability. Schottky ORing diodes have long been used to connect these supplies at the point of load. Unfortunately, the forward voltage drop of these diodes reduces the available supply voltage and dissipates significant power at high currents. Costly heat sinks and elaborate layouts are needed to keep the Schottky diode cool.

A better solution is to replace the Schottky diode with a MOSFET-based ideal diode. This reduces the voltage drop and power dissipation, thereby reducing the complexity, size and cost of the thermal layout and increasing system efficiency. The LTC4357 is an ideal diode controller that drives an N-channel MOSFET and operates over a voltage range of 9V to 80V.

## How It Works

The LTC4357's basic operation is straightforward. The external MOSFET source is connected to the input supply and acts like the anode of a diode, while the drain is the cathode. When power is first applied, the load current initially flows through the body diode of the MOSFET. The LTC4357 senses the voltage drop and drives the MOSFET on. The LTC4357's internal amplifier and charge pump try to maintain a 25mV drop across the MOSFET. If the load current causes more than 25mV

of voltage drop, the MOSFET is driven fully on, and the forward drop becomes equal to  $R_{DS(ON)} \cdot I_{LOAD}$ . If the load current reverses, as may occur during an input short, the LTC4357 responds by quickly pulling the MOSFET gate low in less than 0.5 $\mu$ s.

## Load Sharing Redundant Supplies

Figure 1 shows a 48V/10A ideal diode-OR application. An MBR10100 Schottky diode would dissipate 6W under these operating conditions. In contrast, the FDB3632 MOSFET dissipates only  $7.5m\Omega \cdot (10A)^2 = 0.75W$ . The reduced power loss increases efficiency and saves space required for heat sinking. If the power supply voltages are nearly equal, the

load current is shared between the two supplies. Otherwise, the supply with the highest output voltage provides the load current.

Load sharing is accomplished using a simple technique known as droop sharing. Load current is first taken from the highest supply output. As this output falls or droops with increased loading, the lower supply begins to contribute. Regulating the forward voltage drop to 25mV ensures smooth load sharing between outputs without oscillation. The degree of sharing is a function of MOSFET  $R_{ds(on)}$ , the output impedance of the supplies and their initial output voltages. Backfeeding of one supply into the other is precluded by the diode action of the LTC4357.

## Solar Power Application

In solar power systems, Schottky diodes are used to prevent discharge of the battery during hours of darkness. Unfortunately, the voltage drop and power dissipation of a Schottky diode can be quite large when used with high wattage solar panels, thus reducing the amount of power available to charge the battery. Figure 2 uses the

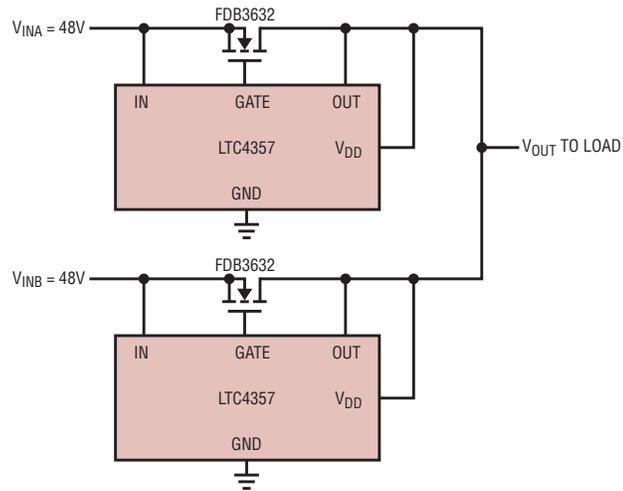


Figure 1. Two load-sharing, redundant, 48V/10A power supplies using an ideal diode

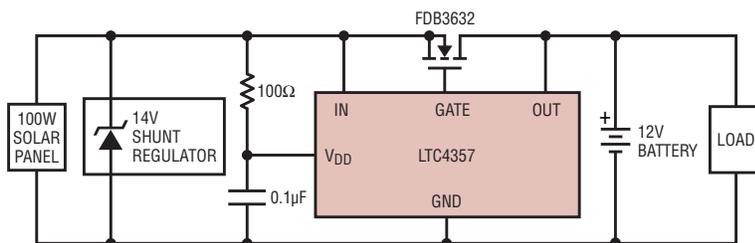


Figure 2. Solar panel charging 12V battery through ideal diode to prevent back feeding

LTC4357 with a FDB3632 MOSFET to replace the Schottky diode.

When the solar panel is illuminated by full sunlight, it charges the battery. A shunt regulator absorbs any excess charging current to prevent overcharging. If the forward current is greater than  $25\text{mV}/R_{\text{DS(ON)}}$ , the MOSFET is fully enhanced and the voltage drop rises according to  $R_{\text{DS(ON)}} \cdot (I_{\text{BATTERY}} + I_{\text{LOAD}})$ . In darkness, or in the event of a short circuit across the solar panel or a component failure in the shunt regulator, the output voltage of the solar panel will be less than the battery voltage. In this case, the LTC4357 shuts off the MOSFET, so the battery will not discharge. The current drawn from the battery into the LTC4357's OUT pin is only  $7\mu\text{A}$  at 12V.

### Protecting Against Reverse Inputs

In automotive applications, the LTC4357 inputs can be reversed. An additional component, shown in Figure 3, prevents the MOSFET from turning on and protects the LTC4357.

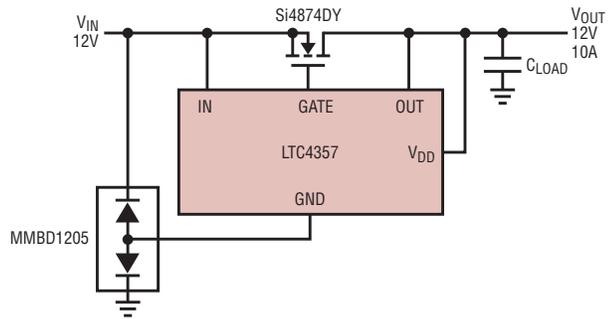


Figure 3. -12V Reverse input protection blocks reverse input voltage to the load

With a reverse input, the diode connected to system ground is reverse biased. The GND pin is pulled by the second diode to within 700mV of the reverse input voltage. Any loading or leakage current tends to hold the output near system ground, biasing the LTC4357 in the blocking condition. If the output is held up at +12V by a backup source or stored charge in the output capacitor, roughly double the input voltage appears across the MOSFET. The MOSFET is off and held in the blocking state.

### Conclusion

The LTC4357 ideal diode controller can replace a Schottky diode in many applications. This simple solution reduces both voltage drop and power dissipation, thereby shrinking the thermal layout and reducing power loss. Its wide 9V to 80V supply operating range and 100V absolute maximum rating accommodate a broad range of input supply voltages and applications, including automotive, telecom and industrial. A dual version, the LTC4355, is available in 4mm x 3mm DFN-14 or SSOP-16 packages.

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boost regulator and monitored by the LTC2931. The LTC3780 is protected from transients by the LT4356DE-1 and is capable of delivering full power to the load with a supply voltage as low as 6V. The LTC2931 is configured to monitor four fixed and two adjustable voltages, including two independent 5V supplies. 1.5% voltage monitoring accuracy is guaranteed over the entire operating temperature range. Additionally, each voltage monitoring channel has its own comparator output that can be used by the microprocessor to identify a fault condition. The comparator outputs are pulled up to the 5V bus that powers both voltage monitoring devices. The LTC2931 has an adjustable watchdog timer, which allows the LTC2931 to report a malfunctioning microprocessor to the rest of the system.

The unregulated battery voltage and power supplies delivered to the in cabin electronics are monitored by the LTC2932. This application monitors

the unregulated battery voltage, and the COMP4 output alerts the system to a low battery condition, allowing the system to enter a standby or power save mode.

The LTC2932 also provides a mechanism to override a reset or fault condition. This is accomplished by pulling the  $\overline{\text{RDIS}}$  pin low. With  $\overline{\text{RDIS}}$  pulled low, the  $\overline{\text{RST}}$  output pulls up to the V2 input voltage. Since V2 is tied to V1, the reset high level is 5V. The  $\overline{\text{RDIS}}$  function allows the system to have flexibility in controlling the power sources without generating system faults. Additionally, the LTC2932 allows real time setting of the voltage monitoring threshold. This could be useful when changes in loading or environment make for predictable supply variances.

### Conclusion

The LTC2930, LTC2931 and LTC2932 can each monitor six supplies, saving valuable board area in space con-

strained applications. The LTC2930 is available in a 3mm x 3mm DFN, while the LTC2931 and LTC2932 are available in 20-pin TSSOP packages.

All include design-time saving features for multi-voltage applications. Voltage thresholds are accurate to  $\pm 1.5\%$ , guaranteed over the entire  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  temperature range. This translates directly to simplified power supply design, as threshold accuracy must be accounted for in the entire power supply tolerance budget.

Comparator glitch immunity eliminates false resets, with no effect on the high accuracy of the monitor. These devices support a variety of voltage combinations, easily set with only a few external components. The reset timeout period is also adjustable with a single capacitor.

Lastly, the features which differentiate the LTC2930, LTC2931 and LTC2932 give users the flexibility to choose one for any application.