

A Low Loss Replacement for an ORing Diode

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Introduction

ORing diodes are used to connect multiple supplies together to increase reliability (through supply redundancy) or to increase total power. A diode also allows a supply to disconnect if it has insufficient voltage.

At high power levels a Schottky diode is usually chosen as the ORing diode because of its relatively low forward drop (0.35V to 0.6V). But at higher current levels even a Schottky's forward drop creates significant power loss.

A better alternative is the LT4351 controller, which turns a power N-channel MOSFET into a near ideal diode suitable for high power ORing applications. The low $R_{DS(ON)}$ of the external MOSFET provides for low on resistance when conducting, while the LT4351 maintains a scant 15mV

forward voltage across the MOSFET when lightly loaded.

By way of comparison consider a 10A at 5V (50W) supply. Under these conditions, a Schottky diode with a forward voltage of 0.45 (SBG1025L) dissipates 4.5W of power—a 9% efficiency loss. The LT4351 using a power MOSFET with a 3m Ω on-resistance (Si4838DY) dissipates only 0.3W and creates a 0.03V drop. This is only a 0.6% efficiency loss and the voltage tolerance of the supply also improves. The LT4351 works with inputs down to 1.2V, where efficiency improvements are even greater

My Diode Can't Do That

Figure 1 shows the block diagram of the LT4351. In addition to its basic performance advantages over a diode,

the LT4351 provides, features that a diode cannot. Input comparators serve to detect an undervoltage or overvoltage input supply and disable the MOSFET switch for an out-of-range supply. The comparators also provide a way to manually turn off power from a supply as well. The $\overline{\text{FAULT}}$ output sinks current during undervoltage or overvoltage indicating that the MOSFET is off and an input fault exists.

The LT4351 uses an amplifier to drive the MOSFET gate. This amplifier attempts to maintain approximately 15mV across the MOSFET (input to output). If the $R_{DS(ON)}$ of the MOSFET is too large it applies maximum gate voltage and the forward drop is $I \cdot R_{DS(ON)}$. The gate voltage clamps at 7.5V above the lesser of the input

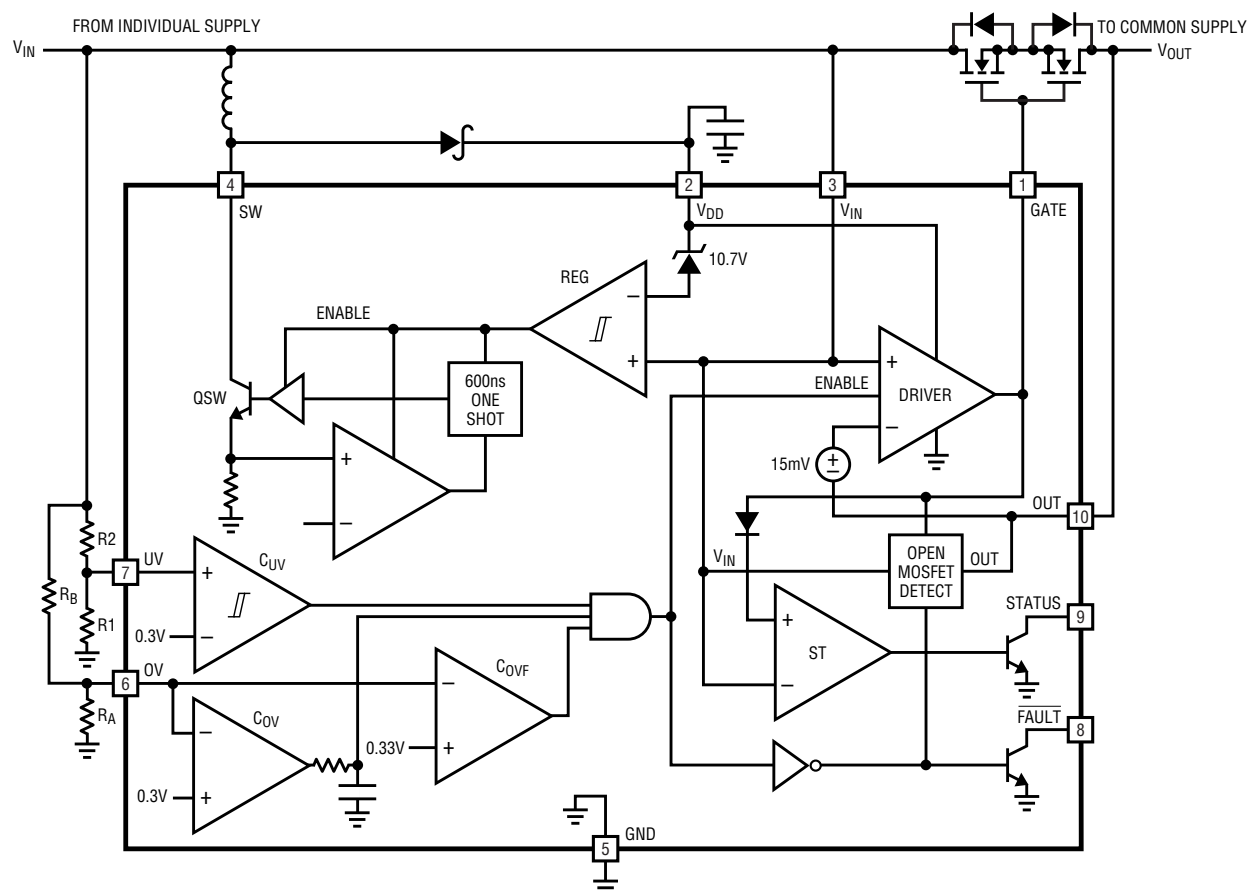


Figure 1. LT4351 block diagram

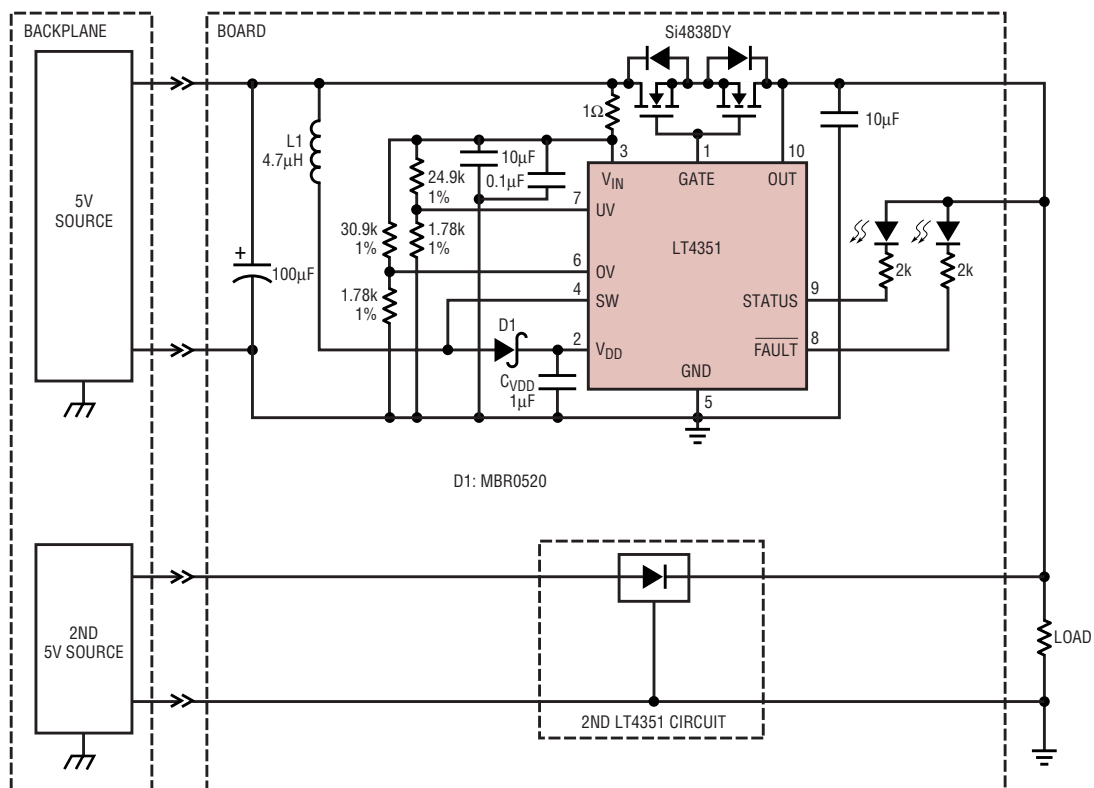


Figure 2. Dual LT4351 5V ORed supply

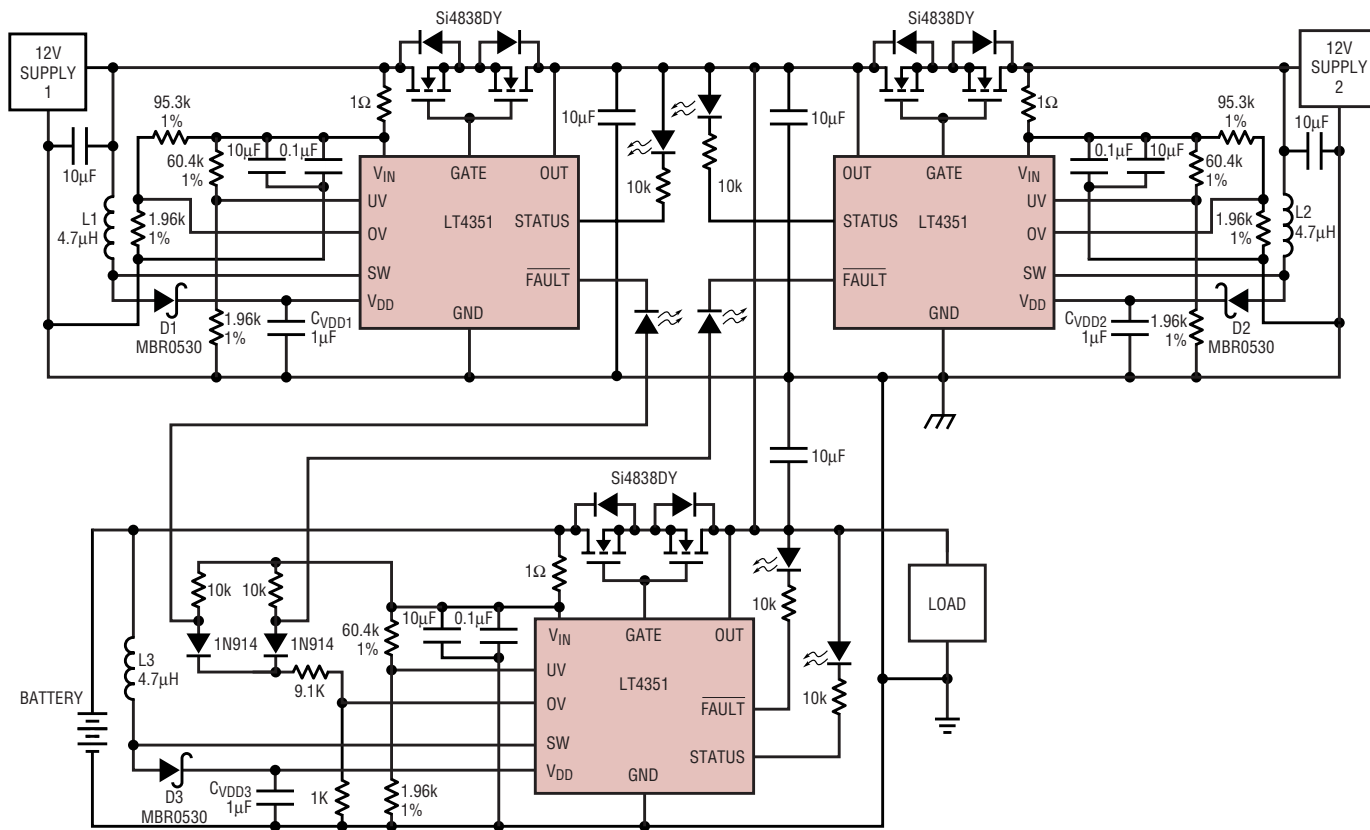


Figure 3. ORed redundant supplies with battery backup

or output to help prevent against gate oxide breakdown in the MOSFET. The strong gate drive amplifier can turn off the MOSFET in under $1\mu\text{s}$ so that minimal reverse current flows in the event of an input short. This strong amp also provides quick recovery from supply glitches.

Either single MOSFETs or back-to-back MOSFETs can be used. Back-to-back MOSFETs are used to block reverse conduction through the MOSFET body diode. A LT4351 with back-to-back MOSFETs disconnects the output from an input overvoltage condition, something a normal diode cannot do.

The UV and OV pins use hysteresis to reduce the probability of

triggering a false undervoltage or overvoltage condition. The UV pin uses current hysteresis. When the UV pin drops below the UV threshold (an undervoltage fault), $10\mu\text{A}$ of current is drawn from the external resistive divider. This allows the user to set the desired hysteresis level by choosing the appropriate resistor values in the divider. The OV pin has an internal filter that reduces the response to small pulses.

The LT4351 STATUS pin provides indication of the MOSFET state. When the input is greater than the output and the gate to source/drain voltage is greater than 0.7V , STATUS sinks current indicating that the MOSFET

should be on. If the input to output voltage exceeds 210mV and the GATE voltage is at its maximum (clamped), **FAULT** turns on indicating a possible non-functioning MOSFET.

The LT4351 also contains a boost regulator that generates the V_{DD} supply to power the MOSFET gate driver. The boost regulator output current strength allows for quick charging of the V_{DD} supply and supports higher gate drive currents. Thus, the MOSFETs can be turned on quickly during start up and can be quickly turned on and off during normal operation. The regulator only requires a small $4.7\mu\text{H}$ to $10\mu\text{H}$ inductor, Schottky diode and capacitor.

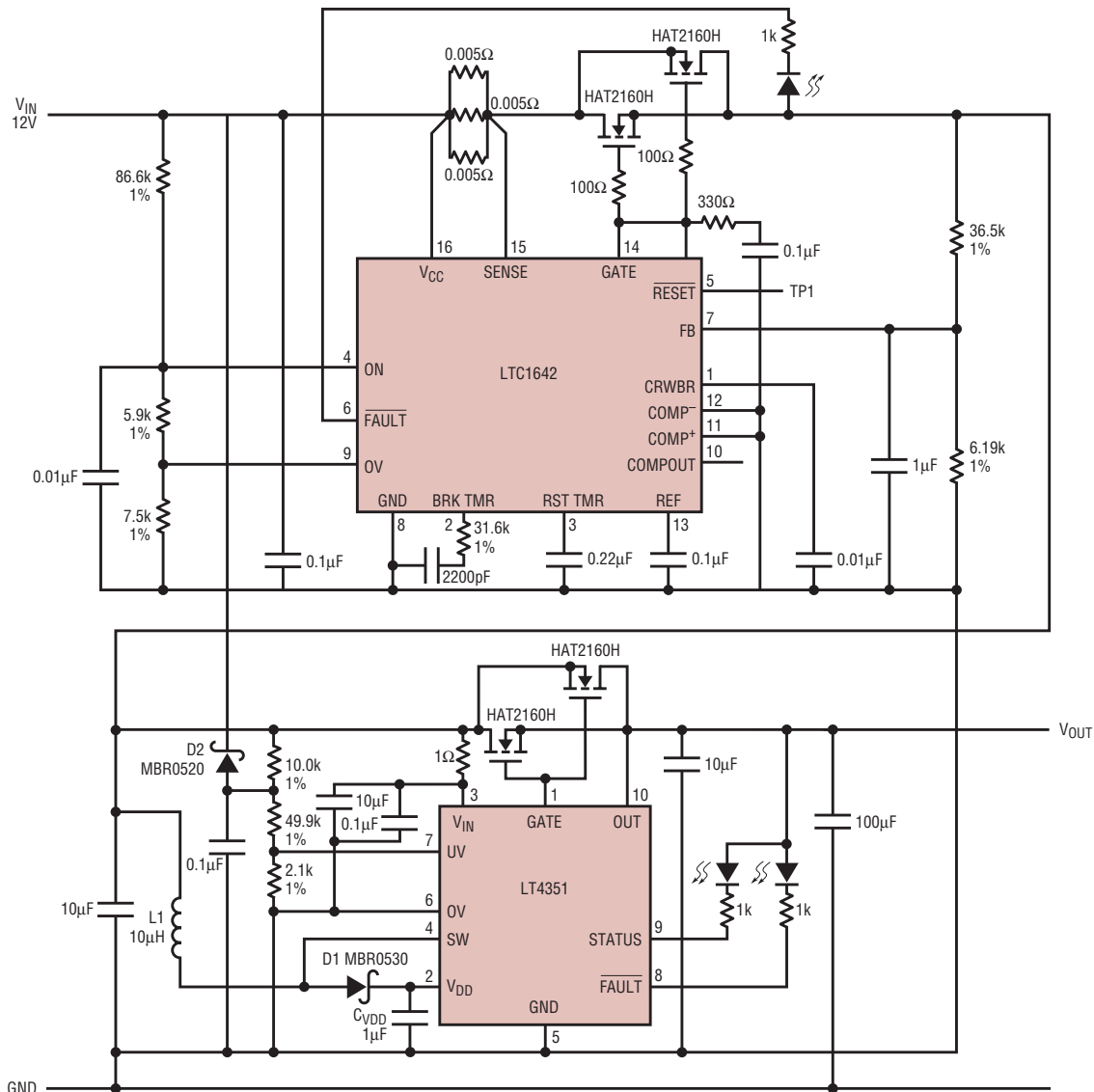


Figure 4. Hot swappable supply with ideal diode

Dual 5V Example

Figure 2 shows an example of a redundant 5V supply. In the event that one supply goes down, the back up supply would take over. In this application, back-to-back MOSFETs are used to prevent the body diode of the MOSFET from conducting in the event that a 5V supply loses regulation and goes into an overvoltage condition.

Resistive dividers from IN to UV and OV set the fault detection thresholds. In this example the UV fault occurs at 4.5V with 0.25V of hysteresis and the OV fault occurs at 5.5V.

L1 and D1 are the boost regulator components. The LT4351 creates a V_{DD} supply of 10.5V above IN. If an external supply that can provide sufficient gate drive is available, that supply can be used instead of the boost regulator.

The MOSFETs are sized based on desired voltage drop with considerations for power dissipation. In this case the Si4838DY has a worst case $4.5m\Omega$ $R_{DS(ON)}$ (at temperature) so the back-to-back pair is $9m\Omega$. These MOSFETs come in SO-8 packages so if power is limited to 1W in each then they can handle 14.9A. The

voltage drop across both MOSFETs at this current is $2 \cdot 4.5m\Omega \cdot 14.9A = 0.134V$. If more current is required, use MOSFETs with lower $R_{DS(ON)}$ and/or better thermal resistance, or add parallel MOSFETs.


The LT4351 is useful in any ORing situation benefiting from low power dissipation—not just redundant supplies. Different types of power sources can also be ORed together, and because the LT4351 diode function is gated, power sequencing of different supplies is relatively easy.

For example, Figure 3 shows a system with two redundant supplies and a battery backup. The two redundant supplies are ORed via the ideal diodes, so power is delivered from the higher of the in-range supplies. Their undervoltage and overvoltage thresholds are set based on the input supply range. The LT4351 circuit for the battery disconnects the battery when power is supplied from either system supply. Its OV pin is above threshold if the \overline{FAULT} is off on either system supply (UV is set above threshold). If both system supplies are disabled (\overline{FAULT} of both systems are

low) then the battery's LT4351 OV pin is pulled below threshold to allow the battery to provide power.

Figure 4 shows an example of combining the LT4351 ideal diode function with a Hot Swap controller. This can be used to create ORed redundant supplies on a plug-in board. The Hot Swap controller provides current limiting, circuit breaker functions and reset timing while the LT4351 provides the ideal diode behavior.

Conclusion

The trend in today's power supplies is toward higher currents, lower voltages, higher efficiency and increased reliability. These needs are forcing designers away from traditional Schottky ORing diodes. The LT4351 provides an improved ORing solution by controlling low $R_{DS(ON)}$ MOSFETs to create a near ideal diode. In addition the LT4351 adds increased functionality with supply monitoring that can disable power path conduction. An LT4351 solution has significantly lower power dissipation than a Schottky diode and offers protection features that a Schottky cannot. 

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for -15V. If desired, an independent positive voltage source between 5V and 15V can be connected to V_{INV} to produce any desired negative voltage between -5 and -15V.

Conclusion

The LTC3450 delivers a highly compact and efficient power supply solution for small LCD displays. Its wide input voltage range makes it easy to drop into a variety of applications. Built-in inrush current limiting, output disconnect and power saving controls simplify the task of implementing power friendly LCD displays. 