# DESIGN NOTES

Ideal Diode Controller Eliminates Energy Wasting Diodes in Power OR-ing Applications – Design Note 386

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Introduction

Many modern electronic devices need a means to automatically switch between power sources when prompted by the insertion or removal of any source. The LTC®4412 simplifies PowerPath™ management and control by providing a low loss, near ideal diode controller function. Any circuit that could otherwise use a diode OR to switch between power sources can benefit from the LTC4412. The forward voltage drop of an LTC4412 ideal diode is far less than that of a conventional diode, and the reverse current leakage can be smaller for the ideal diode as well (see Figure 1). The tiny forward voltage drop reduces power losses and self-heating, resulting in extended battery life. Features include:

- Voltage drop across the controlled external MOSFET of only 20mV (typical)

- Low component count helps keep overall system cost low

- 6-pin ThinSOT™ package permits a compact design solution
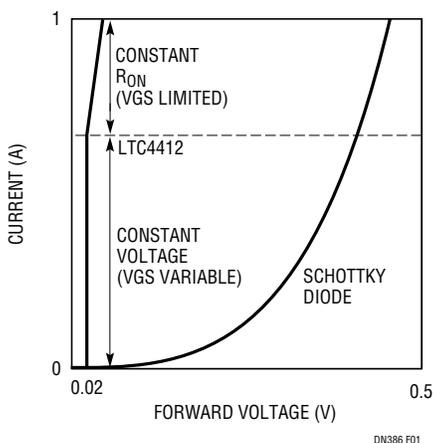
Figure 1. LTC4412 Ideal Diode Controller vs Schottky Diode Characteristics

- Wide supply operating range of 2.5V to 28V (36V absolute maximum)

- Protection of MOSFET from excessive gate-to-source voltage with VGS limiter

- Low quiescent current of 11µA with a 3.6V supply, independent of the load current

- A status pin that can be used to enable an auxiliary MOSFET power switch or to indicate to a microcontroller that an auxiliary supply, such as a wall adapter, is present

- A control input pin for external control, such as from a microcontroller

Applications include anything that takes power from two or more inputs:

- Cellular phones

- Portable computers

- PDAs

- MP3 players and electronic video and still cameras

- USB peripherals

- Wire-ORed multipowered equipment

- Uninterruptible power supplies for alarm and emergency systems

- Systems with standby capabilities

- Systems that use load sharing between two or more batteries

- Multibattery charging from a single charger
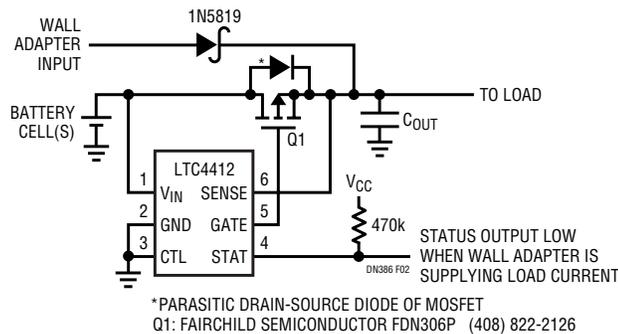
- Logic controlled power switches

Automatic Power Switching Between Two Power Sources

Figure 2 illustrates an application circuit for the automatic switchover of load between two power sources, in this example a wall adapter and a battery. While the wall adapter is absent, the LTC4412 controls the gate of Q1 to regulate the voltage drop across the MOSFET to 20mV, thus wasting negligible battery power. The STAT pin is an open circuit while the battery provides power. When a wall adapter or other supply connected to the auxiliary input is applied, the SENSE pin voltage rises. As the SENSE pin voltage rises above $V_{IN} - 20mV$, the LTC4412 pulls the GATE voltage up to turn off the P-channel MOSFET. When the voltage on SENSE exceeds $V_{IN} + 20mV$, the STAT pin sinks 10µA of current to indicate that an AC wall adapter is present. The system is now in the reverse turn-off mode, where power to the load is delivered through the external diode and no current is drawn from the battery. The external diode is used to protect the battery against some auxiliary input faults such as a short to ground. Note that the external MOSFET is wired so that the drain to source diode will reverse bias and not deliver current to the battery when a wall adapter input is applied.

Load Sharing

Figure 3 shows a dual battery load sharing application with automatic switchover of power between the batteries and a wall adapter. In this example, the battery with the higher voltage supplies all of the power until it has discharged to the voltage of the other battery. Once both batteries have the same voltage, they share the load with the battery with the higher capacity providing proportionally higher current to the load. In this way, the batteries discharge at a relatively equal rate, maximizing battery run time.

When a wall adapter input is applied, both MOSFETs turn off and no load current is drawn from the batteries. The LTC4412's STAT pins provide information as to which input is supplying the load current. The ganging of the LTC4412s can be applied to as many power inputs as are needed.

Conclusion

The LTC4412 provides a simple means to implement a low loss ideal diode controller that extends battery life and reduces self heating. The low external parts count results in low implementation cost and with its ThinSOT 6-pin package, a compact design as well. Its versatility is useful in a variety of applications (see the LTC4412 data sheet for additional applications).

Figure 2. Automatic Power Switching Between a Battery and a Wall Adapter
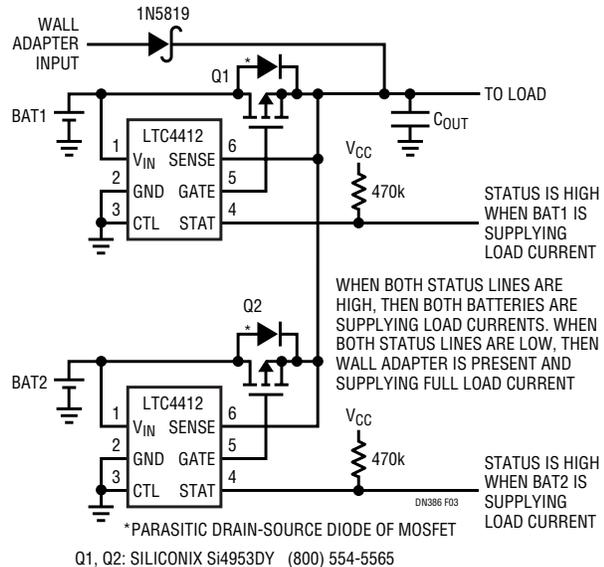
Figure 3. Dual Battery Load Sharing with Automatic Switchover of Power from Batteries to Wall Adapter