

Reduced Interference with an Additional Schottky Diode

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In the field of point-of-load (POL) step-down, or buck, converters, synchronous variants in which the high-side switch and the low-side switch are both active have become established. Figure 1 shows this type of circuit with ideal switches. These switching regulators have several advantages over variants in which a passive Schottky diode is used as the low-side switch. The main advantage is the higher efficiency of voltage conversion due to the lower voltage drop occurring when the low-side switch is carrying a current than is the case with passive diodes.

However, in comparison with nonsynchronous switching regulators, synchronous step-down converters can cause stronger interference. If both ideal switches in Figure 1 are turned on simultaneously, even for a brief moment, a short circuit from the input voltage to the ground will occur. This can destroy the switches. It must be ensured that the two switches are never turned on at the same time. Hence, for safety reasons, a certain time during which both switches are turned off is required. This time is called the dead time in switching regulators. However, there is a current-carrying inductor (L1) wired from the switch node to the output voltage. The flow of current through an inductor can never be changed instantaneously. The current flow can increase and decrease continuously, but it can never jump. Thus, problems arise during the dead time. All current paths are interrupted on the switch node side. With ideal switches as shown in Figure 1, a voltage of minus infinity is yielded at the switch node during the dead time. In real switches, the voltage would become more and more negative until one of the two switches experienced shoot-through and allowed current to flow through it.

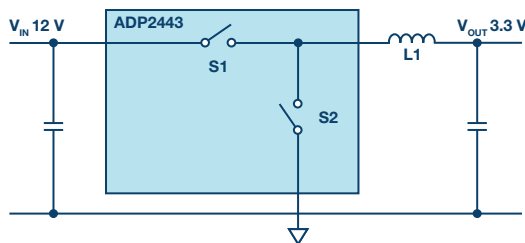


Figure 1. Synchronous switching regulator for step-down conversion with ideal switches.

Most switching regulators use n-channel MOSFETs as active switches. These switches possess a very advantageous property with respect to the situation described above. Besides having its own switching function, a MOSFET has a so-called body diode. There is a P-N junction between the source and the drain in the semiconductor. In Figure 2, MOSFETs with the corresponding P-N junctions are inserted. Through this, the switch node will not drop to a voltage of minus infinity, even during the dead time, but instead the P-N junction in the low-side MOSFET (shown in red) will carry the current until the dead time has elapsed and the low-side MOSFET is turned on.

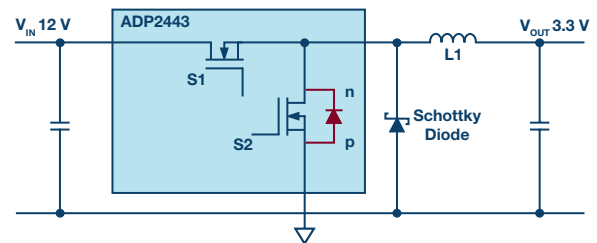


Figure 2. Synchronous switching regulator for step-down conversion with n-channel MOSFETs and an additional Schottky diode for minimizing interference.

The body diodes in the corresponding MOSFETs have a major disadvantage. Due to the reverse recovery phenomenon, they have a very low switching speed. During the reverse recovery time, the voltage at the switch node drops to several volts below ground because of the inductor (L1). These steep negative voltage peaks at the switch node result in interference, which can be capacitively coupled to other circuit segments. This interference can be minimized through insertion of an additional Schottky diode, as shown in Figure 2. Unlike the body diode in the low-side MOSFET, it doesn't exhibit a reverse recovery time and takes up the current flow very rapidly when the dead time begins. This results in a much less steep drop in voltage at the switch node. Less interference is generated and distributed through the circuit via coupling effects.

The Schottky diode can be designed very compactly because it only carries current for short periods during the dead time. Thus, it isn't heated up that much and can be placed in small, low cost housing.

About the Author

Frederik Dostal studied microelectronics at the University of Erlangen-Nuremberg, Germany. Starting work in the power management business in 2001, he has been active in various applications positions, including four years in Phoenix, Arizona, working on switch mode power supplies. He joined Analog Devices in 2009 and works as a power management technical expert for Europe. He can be reached at frederik.dostal@analog.com.

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