AND9038/D

Efficiency Improvements Using DSN2 Schottky Diodes

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APPLICATION NOTE

ABSTRACT

This application note describes the advantages of using Low Forward Voltage (V_f) Schottky diodes in a variety of applications. The lower voltage drop results in a significant increase in efficiency.

Lower Forward Voltage Drop

Figure 1 shows the relative improvement in forward voltage drop, V_f, with the DSN2 Schottky diodes technology. The comparison is made to industry SOD−323 EP Schottky diodes.

It is clear that such a significant improvement can have major impact on the efficiency of many circuit applications.

The forward voltage drop of the DSN2 Schottky diodes is shown in Table 1. The data are taken from the typical data charts on the data sheet at 25°C at the devices rated specifications. A comparison can be made between a 20 V device and a 30 or 40 V device. Four surface mount footprints are shown, 0201, 0402, 0502 and 0603. The forward voltage drop is presented at rated currents.

All Schottky diodes have a negative temperature coefficient of approximately 1 mV/°C. The forward voltage drop can be as much as 0.100 V lower at 125°C when compared to the voltage drop at 25°C.

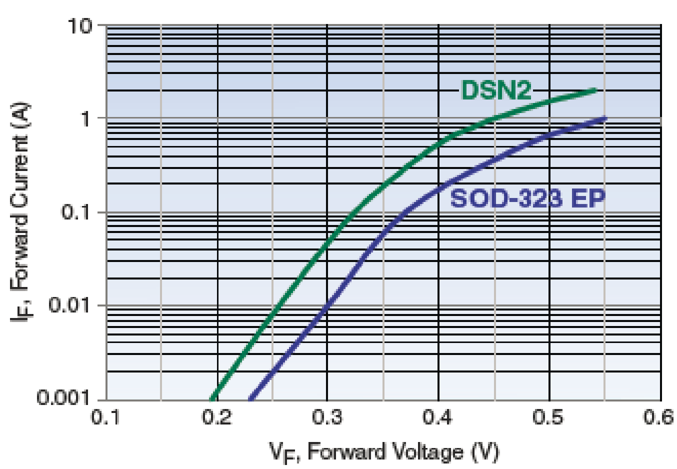

Figure 1. Low Forward Voltage Comparison

Table 1. FORWARD VOLTAGE FOR DSN2 SCHOTTKY DIODES AS A FUNCTION OF FORWARD CURRENT, ALL VALUES ARE AT 25°C

	NSR01F30NX	NSR02F30NX	NSR05F20NX	NSR05F30NX	NSR05F40NX	NSR10F20NX	NSR10F30NX	NSR10F40NX	NSR20F20NX	NSR20F30NX
I_F	0.1 A	0.2 A	0.5 A	0.5 A	0.5 A	1.0 A	1.0 A	1.0 A	2.0 A	2.0 A
V_R	30 V	30 V	20 V	30 V	40 V	20 V	30 V	40 V	20 V	30 V
DSN2 Package	0201	0201	0402	0402	0402	0502	0502	0502	0603	0603
V_F @ Rated I_F	500 mV	550 mV	390 mV	400 mV	420 mV	430 mV	450 mV	445 mV	450 mV	445 mV

OR'ing Diode Applications

In the application shown in Figure 2, a low forward voltage drop part is desired. In this example, it is more cost effective to use a single Schottky diode than to use a rectifier. This can be useful where multiple power supplies are needed for redundancy to improve the mean−time−between−failure (MTBF) for a power supply system.

The current rating of the OR'ing device is often much higher than the current flowing through the device used. As an example, a NSR10F20NXT might be used for applications where only 1.0 A of load current is needed for the load. This is used only to keep the energy loss to a minimum. The forward voltage drop is approximately 0.43 V for the NSR10F20NXT at room temperature, as shown by Table 1 above.

If one of the power supplies is a battery, the forward voltage drop is important. The lower the forward voltage drop, the greater the amount of energy available for use as a standby power supply.

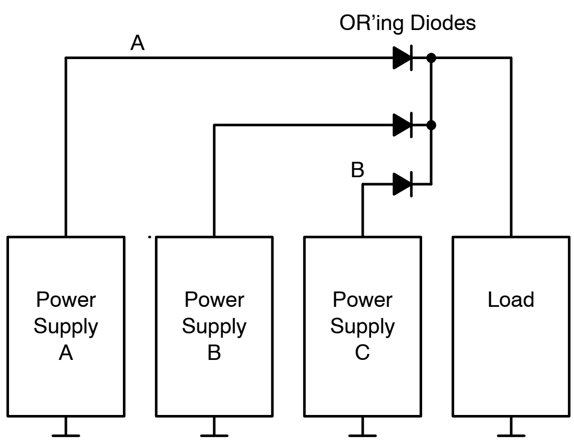

Figure 2. OR'ing Diode Application

Diodes for Reverse Battery Protection

Another application where a low V_F Schottky diode is often desired is in the reverse battery protection. This is shown in Figure 4.

In order to prevent damage to the electronic circuits inside the product caused by reverse polarity or surge event, a series diode is used. This device has a typical forward voltage drop of 0.9 V at 1.0 A. The battery voltages can range between 1.4 V and 1.65 V depending upon the state of charge and current draw. Using a 1.5 V cell, the ratio of 0.9/1.5 indicates that 60% of one cell's voltage is used to overcome the protection diode. In a typical application where there are four cells, the ratio of forward diode voltage to battery voltage is between 13.64 and 16%: (0.9/(4*1.65) = 0.1364 or 13.64%) or (0.9/(4*1.40) = 0.16 or 16%)

Instead of using a standard diode, substitute a 1 A low forward voltage Schottky or a 0.5 A device. The burden voltage of the NSR10F20NXT is only 0.430 V, which is a 52.2% reduction, ((0.9 – 0.430)/0.9 = 0.522) over a standard diode. Using the NSR05F30NXT at 0.400 V, the percentage gain is even higher at 55.6 percent, ((0.9 – 0.40)/0.9 = 0.555) over the industry standard rectifier.

The burden voltage is very critical if the batteries are Lithium ion (Li−Ion) or nickel metal hydride (NiMH). There are many consumer applications where using a low V_F device is key in helping improve the systems efficiency. The use of a NSR10F20NXT can provide protection and not be a major burden on the battery voltage needed for the application.

The forward voltage drop can be reduced further by using the 20 V Schottky, (NSR05F20NXT), which has a forward voltage drop of only 0.390 V at 0.5 A.

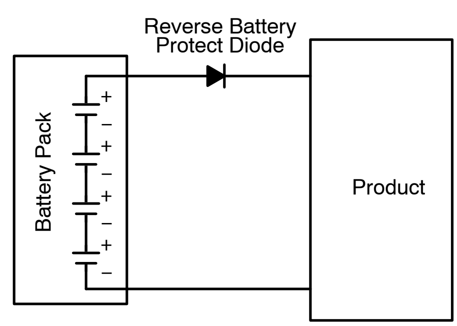

Figure 3. Reverse Battery Protection

DC to DC Converters

Another application where the use of low V_F Schottky diodes improves efficiency is the DC to DC converter circuit. In portable type products where a multiple cell NiCd, NiMH, or lithium ion (Li−Ion) rechargeable battery pack is used as a power source, a buck regulator can produce output voltages such as 1.5 V, 2.2 V, or even 3.3 V. A buck regulator can be very efficient. An alternative method of obtaining 1.8, 2.2 or 3.3 V at the output is to use a linear regulator, but this can be inefficient. When implementing the controller as a buck regulator and using different Schottky rectifiers, it can be shown that the lower the forward voltage drop of the diode, the greater the efficiency of the buck regulator. Such a schematic is shown in Figure 5.

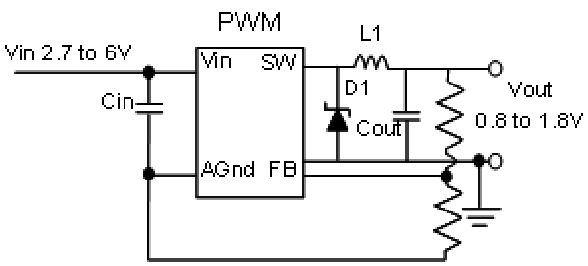

Figure 4. Buck Converter Circuit

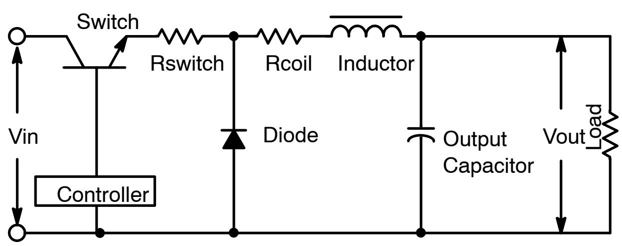

Figure 5. Simple Buck Regulator

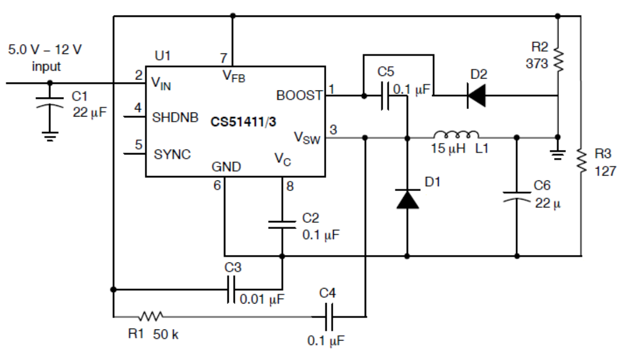

Figure 6. Inverter Converter

Diode Selection

The diode in the buck converter provides the inductor current path when the power switch turns off. The peak reverse voltage is equal to the maximum input voltage. The peak conducting current is clamped by the current limit of the IC. The average current can be calculated from:

$$I_{D(AVG)} = \frac{I_O\left(V_{IN} - V_O\right)}{V_{IN}}$$

The worst case of the diode average current occurs during maximum load current and maximum input voltage. For the diode to survive the short circuit condition, the current rating of the diode should be equal to the Foldback Current Limit.

Conclusion

When selecting a Schottky diode it's important to keep in mind the forward voltage and reverse blocking voltage characteristics. Choosing the proper Schottky diode will help reduce the impact of power losses in various applications. On Semiconductor has a range of Schottky diodes in variation of package from SOT−23 down to the smallest 0201 to suit any application.

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