Application Report
SLUA855–November 2017

UCC2888x Diode Selection When Configured as a High-Side Buck

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ABSTRACT

The UCC28880 and UCC28881 devices integrate the controller and a power MOSFET into one monolithic device. Due to the integration, additional design considerations are required to stay within the safe operating area of the devices, such as the diode reverse recovery time and reverse recovery charge. These parameters, if not dictated properly, can damage the device and lead to catastrophic failure. This application note reviews the diode reverse recovery time and charge and compares diodes, displaying the effects of inadequate component selection.

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1 Introduction

In an increasingly more electronic world, more devices are becoming "smart" and require electricity to power their intelligence. Many of these devices require less than 1-W of power and do not require electrical isolation from the input, since the circuit is inaccessible to users. Offline switchers, like the UCC28880 and UCC28881, can be configured as a buck to generate this bias power in the simplest and most cost-effective manner. While designing a buck converter with these devices is relatively simple, some design considerations must be taken into consideration to prevent catastrophic failure. One that is often overlooked is the diode.

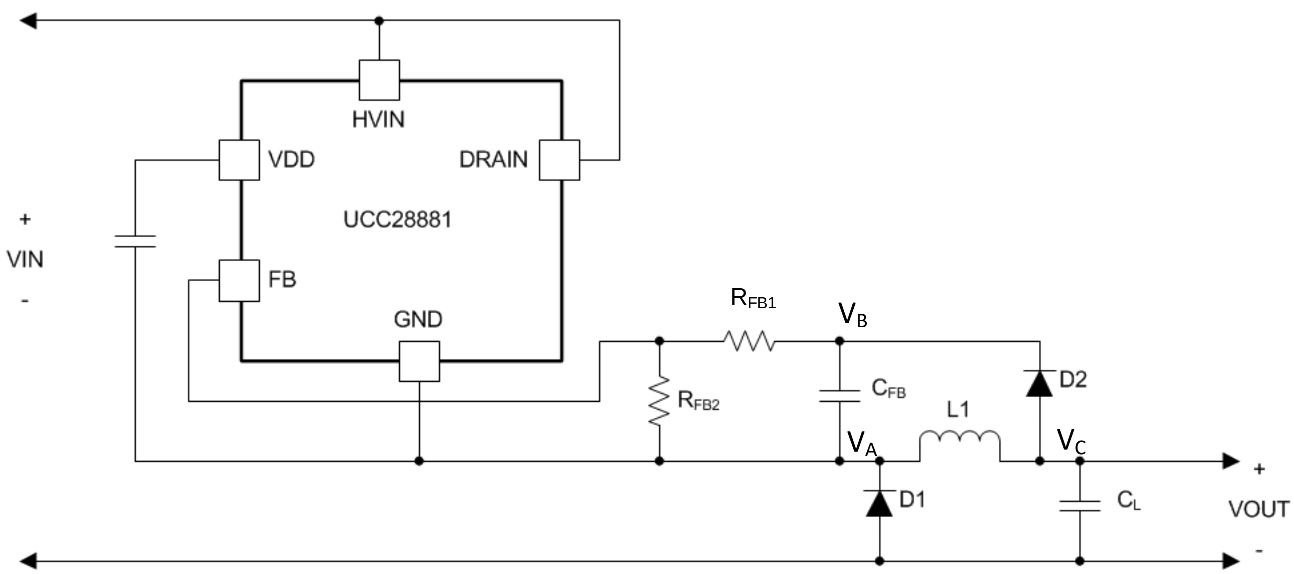

Figure 1. UCC2888x High-Side Buck Converter Configuration

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2 Diode Parameters

Diode selection involves more than just the blocking voltage and current rating. Consideration of the reverse recovery time (t_{rr}) and the reverse recovery charge (Q_{rr}) is just as important. When a diode is conducting in its forward bias state and is quickly reverse biased, time is required to clear the depletion region of charge carriers such that the diode can block the reverse voltage again. Reverse recovery time is how long it takes to remove the accumulated charge distribution in the diode junction before becoming a non-conducting diode. Data sheets specify under what conditions the reverse recovery time is measured. This is important because in different environments, this parameter changes. For example, reverse current increases greatly with temperature because higher temperature generates more electron-hole pairs increasing conductivity, thereby increasing Q_{rr}. Increased forward current increases the amount of charge on the depletion layer, again increasing t_{rr}.

3 Limitations of Internal Power MOSFET

The UCC2888x devices have a current-limit sensor between the internal 700-V power MOSFET source and the IC return (pin GND). When the current through the MOSFET reaches the current limit, I_{LIMIT}, the internal current limit signal goes high, turning off the MOSFET. This limit value is sensitive to temperature changes, and can increase in colder temperature environments and decrease in hotter ones.

4 Effect of Diode Recovery on the Power MOSFET

The UCC2888x high-side buck converter uses two diodes: the diode in the power path of the buck converter (freewheeling diode, D1) and the feedback diode (D2). During the on to off conduction transition of D1, the high dv/dt of the switch node causes the diodes to undergo reverse recovery. Since the voltage across the capacitors cannot change during commutation, when diode D1 experiences a high dv/dt, so does diode D2, because the voltage across D2 is $V_{D2} = V_A + V_B – V_C$. This causes the internal power MOSFET to have to carry the reverse recovery current (I_{rr}) of both D1 and D2. If the diodes do not recover fast enough and have a large amount of reverse recovery current, then the power MOSFET sees a large current spike during this switching transition. If this total current is larger than the limitation of the power MOSFET, then the device can be damaged.

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5 Diode Recovery Comparison

Figure 2 and Figure 3 demonstrate the difference of the recovery time on diode D1 (from Figure 1) with a fast diode compared to a slower diode. If the power MOSFET of the UCC2888x is operating at full load, and experiences these commutation spikes every switching cycle, there is a possibility that these current spikes force the power MOSFET outside its safe operating area and damage the device.

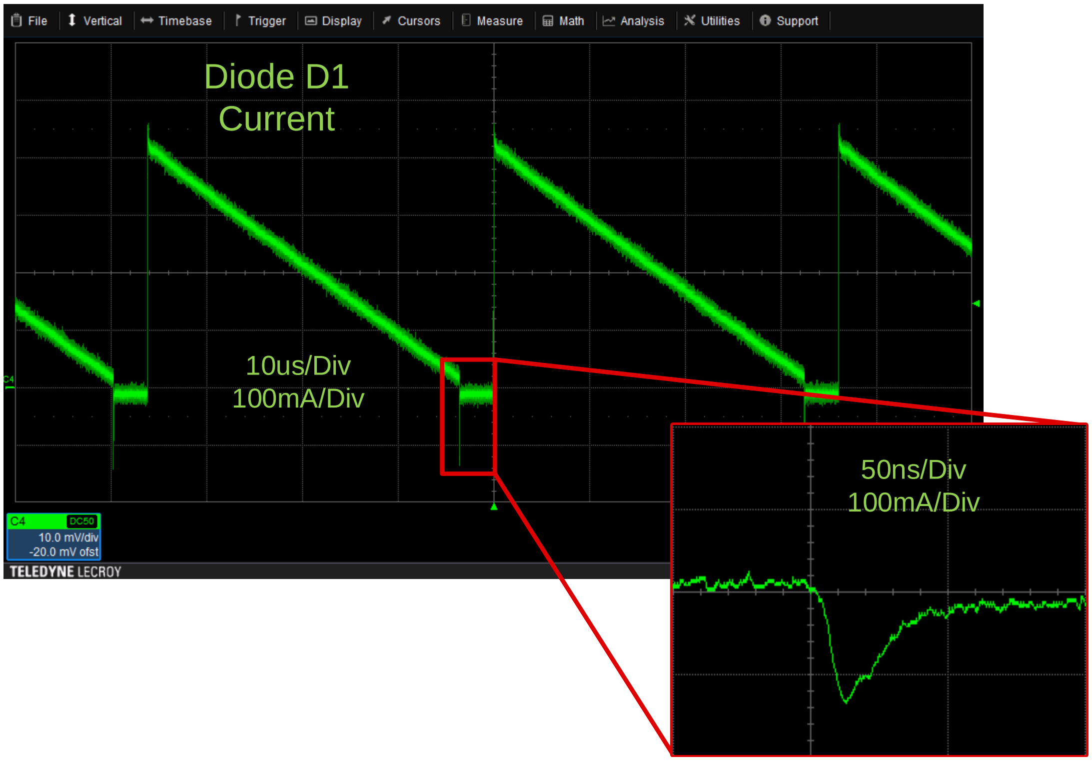
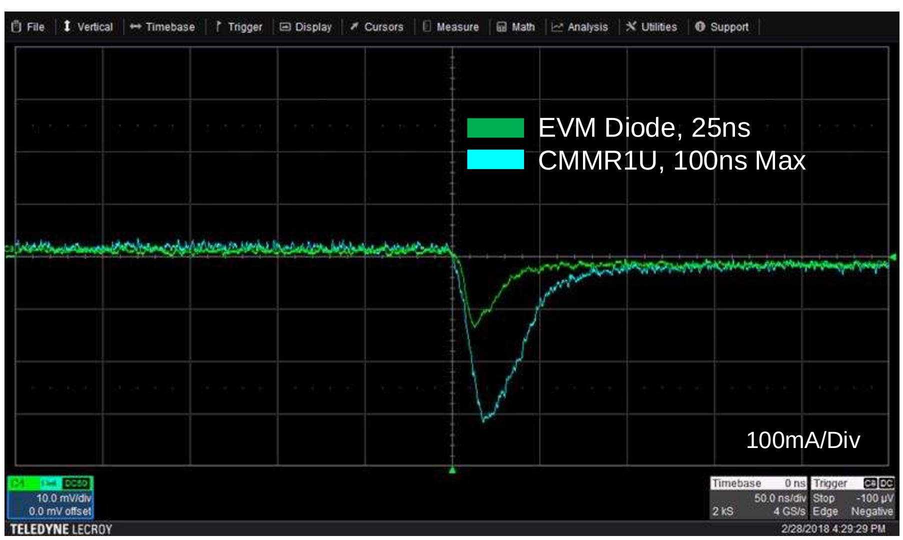


Figure 2. Diode Overshoot (Reverse Recovery) Occurs in Zoomed in Portion



Doubling the recovery time of the EVM diode increased the reverse recovery current three-fold. The CMMR1U diode, rated at 100-ns maximum t_{rr}, takes only 50 ns to recover, as it is being placed under a different environment from initial tests.

Figure 3. Comparison of Reverse Recovery Time of the EVM Diode and a Slower Diode

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6 General Design Recommendations

The data sheets for UCC28880 and UCC28881 specify diode maximum reverse recovery time that will not cause failure. In continuous mode operation, the diode reverse recovery time should be less than 35 ns (such as the STTH1R06A, which provides a 25-ns t_{rr}). If the device is being operated in discontinuous current mode, a slower diode with a reverse recovery time of 75 ns, or less, can be used. Generally, using faster reverse recovery diodes, those that have a t_{rr} < 20 ns over the entire temperature range, is recommended since doing so provides additional design margin and reduces this loss mechanism.

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