Application Report

Achieving Longer Hold-Up Time Using the TPS62130 in Enterprise SSD Applications

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Buck DC/DC Switching Regulators

ABSTRACT

This application report introduces an application method for longer hold-up time using the TPS62130 device which is an easy-to-use synchronous step-down 3-A DC/DC converter. Longer hold-up time is a special requirement for enterprise SSD, and this requirement ensures enterprise SSD obtains enough time to backup after a loss of 12-V system power rail. By applying the proposed method, it achieves longer hold-up time at a reasonable cost by working down to a lower input voltage for the TPS62130, and this report shows how well the initial design tests met to increase hold-up time using the TPS62130.

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1 Introduction

Most enterprise SSDs, including server and data-center SSDs, rely on power failure functions that monitor the system power rail (12 V) from the host and generate an early warning signal to the SSD controller if the system voltage drops below a predetermined threshold. Additionally, a hold-up circuit is implemented to protect against loss of data upon power failures. The hold-up time is the amount of time that the system can continue to run without resetting or rebooting during a power interruption, and a high-capacity super capacitor or a bank of discrete capacitors can be used for the proper hold-up time function.

Figure 1-1 shows the typical application circuit of the TPS62130 to get 3.3-V output from 5-V input. The recommended input voltage range of the TPS62130 is from 3 V to 17 V, and the device will stop switching if the input voltage of the TPS62130 goes down to below 3.0 V. By adding a few external components, this application report shows how the buck converter with the TPS62130 is working even though the 5-V input voltage goes down to below 3 V, and this increases the hold-up time eventually regulating 3.3-V output properly.

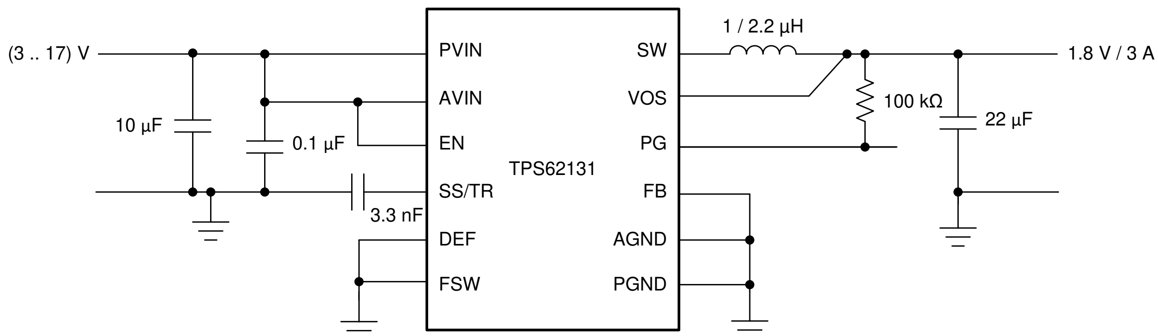

Figure 1-1. Typical TPS62130 Application Circuit

2 Proposed Application Method for Longer Hold-Up Time

Figure 2-1 shows the proposed application method using the TPS62130 for longer hold-up time. The 5-V input for the TPS62130 comes from the output of another DC/DC converter with 12-V input. By adding L2, D1, and M1, it works as a boost pre-regulator to supply higher voltage to the input of the TPS62130. As Figure 2-1 shows, the advantage of this method is that any additional device to control the boost pre-regulator is not needed, and the gate signal of M1 comes from SW node directly having the same duty ratio in this case. Therefore, no independent PWM control is required for the boost pre-regulator, and this makes the solution more attractive in terms of the total solution cost.

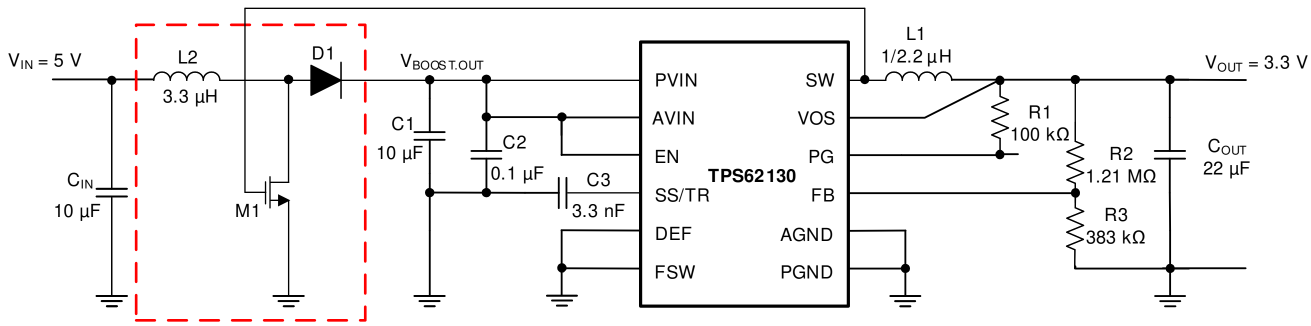

Figure 2-1. Proposed Application Circuit Using Boost Pre-Regulator

Once startup is achieved with the proposed application method, V_{IN} can go down to a couple of volts from 3.3 V while maintaining the output at 3.3 V. Since the output voltage is 3.3 V, V_{IN} never goes below 3.3 V in the typical application of the TPS62130 as Figure 1-1 shows, and it is obviously beneficial to have a longer hold-up time with the proposed method because V_{IN} can go down to around 1 V.

The relationship between the input and the output for the boost converter is:

$$V_{BOOST.OUT} = \frac{V_{IN}}{1 - D_{ON.BOOST}} \tag{1}$$

The on-duty ratio of the boost pre-regulator is calculated as follows:

$$D_{ON.BOOST} = \frac{V_{BOOST.OUT} - V_{IN}}{V_{BOOST.OUT}} \tag{2}$$

The relationship between the input and the output for the buck converter can be expressed as follows:

$$V_{OUT} = V_{BOOST.OUT} \times D_{ON.BUCK} \tag{3}$$

The output of the boost forms the input to the buck. Calculate the on-duty ratio of the buck converter with the TPS62130 using:

$$D_{ON.BUCK} = \frac{V_{OUT}}{V_{BOOST.OUT}} \tag{4}$$

Since the gate signal of M1 comes from the SW node directly having the same duty ratio, $D_{ON.BOOST}$ should be the same with $D_{ON.BUCK}$.

$$\frac{V_{BOOST.OUT} - V_{IN}}{V_{BOOST.OUT}} = \frac{V_{OUT}}{V_{BOOST.OUT}} \tag{5}$$

Therefore, the output voltage of the Boost pre-regulator is determined by:

$$V_{BOOST.OUT} = V_{IN} + V_{OUT} \quad (6)$$

As Equation 6 shows, this is an interesting result that the output voltage of the boost pre-regulator is being automatically regulated regardless the output load conditions if V_{IN} and V_{OUT} are not changed. Because the input voltage and the output voltage are 5 V and 3.3 V respectively, $V_{BOOST.OUT}$ is regulated to 8.8 V in steady state.

Figure 2-2 shows another application example using a load switch for higher efficiency eliminating the switching loss of the boost pre-regulator. In normal operation, the load switch is turned off to eliminate the switching loss while it is turned on during power fault detection in the system.

The load switch is controlled by the eFuse device, and this eFuse device is designed to protect systems such as enterprise SSDs against sudden power loss event. The eFuse device signals the TPS62130 depending on the system status. The power fault signal remains asserted turning on the load switch until the fault condition is removed, and the load switch is turned off for the normal operation eliminating the switching loss of the boost pre-regulator.

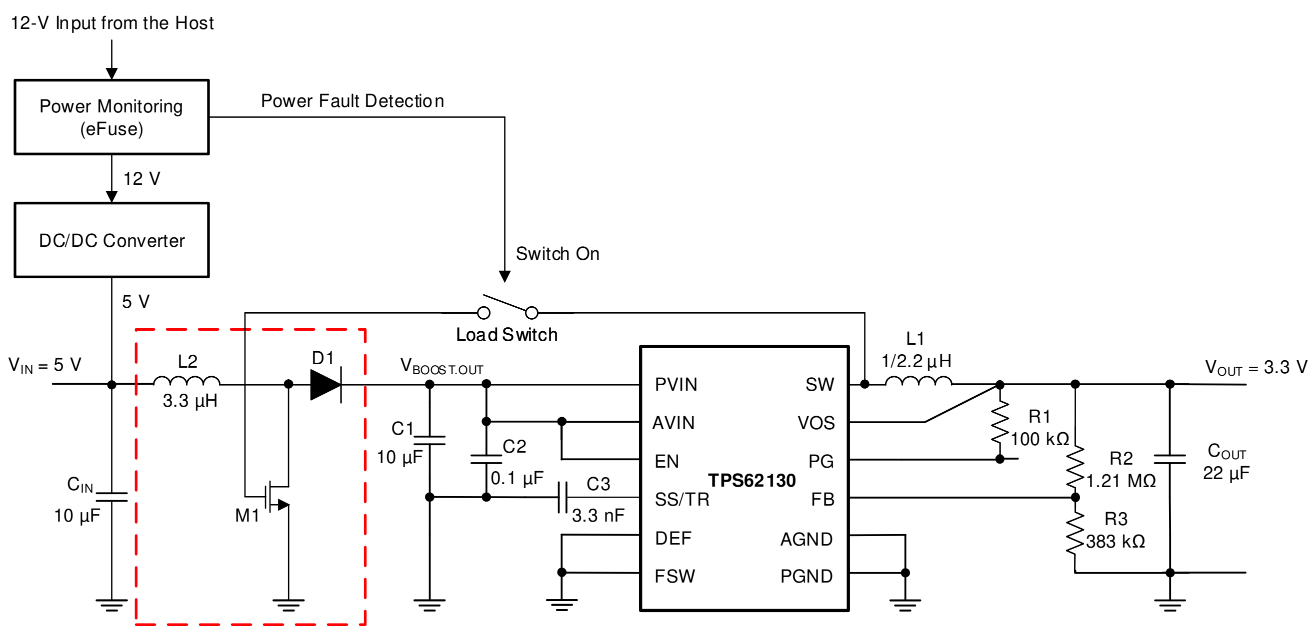

Figure 2-2. Application Example With Load Switch

3 Simulation and Experimental Results

Figure 3-1 and Figure 3-2 show PSpice simulation results with the critical waveforms to verify the operation and performance of the proposed application method. The input and output voltages are 5 V and 3.3 V respectively, and the output current is 1 A for the simulation.

As Figure 3-1 shows, the output voltage of the boost converter is regulated even though there is no independent PWM controller. As $V_{BOOST.OUT}$ is determined by Equation 4, 8.3 V is calculated in this case. Since $V_{BOOST.OUT}$ is the input of the TPS62130, it is important to note that the input voltage of the TPS62130 goes up to a certain voltage level based on V_{IN} and V_{OUT} conditions.

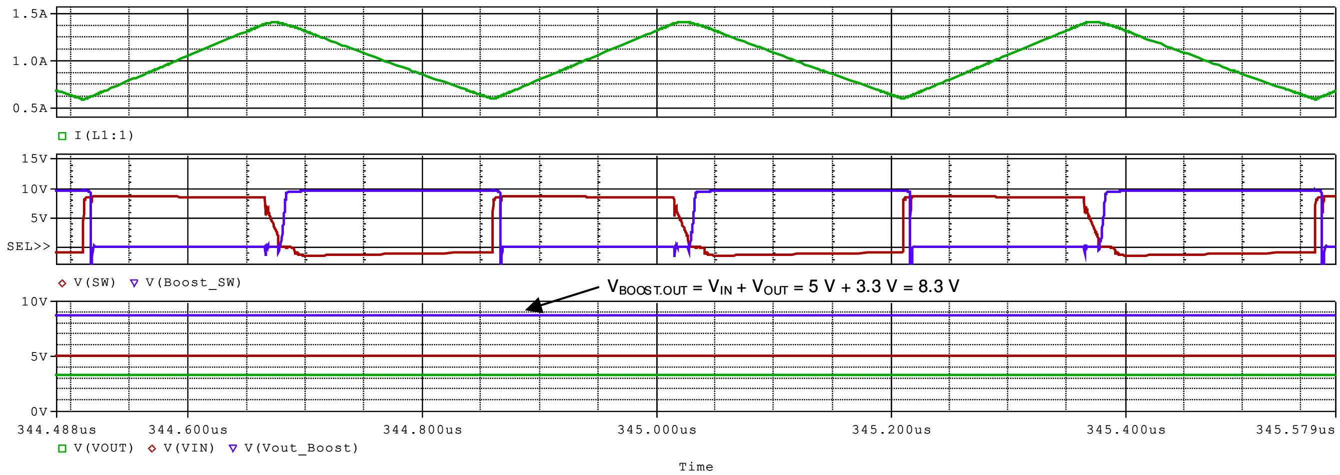

Figure 3-1. PSpice Simulation Results in Steady State

Figure 3-2 shows V_{IN}, $V_{BOOST.OUT}$ and V_{OUT}. Though V_{IN} is falling below 3.3 V, $V_{BOOST.OUT}$ is still high enough to regulate V_{OUT} increasing hold-up time, and V_{OUT} is being regulated until $V_{BOOST.OUT}$ reaches around 3.3 V, as shown in Figure 3-2.

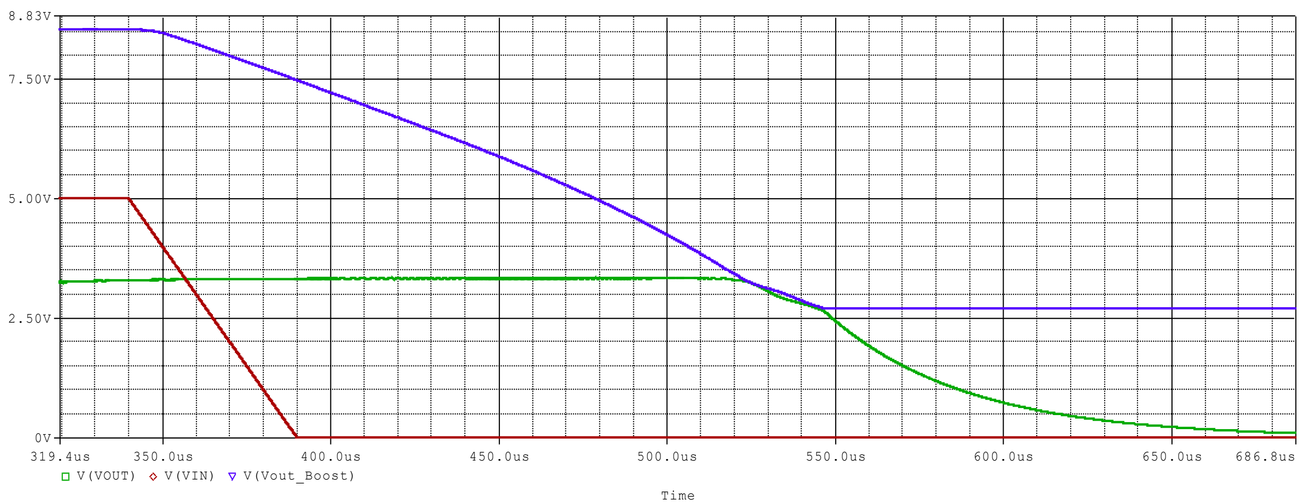

Figure 3-2. PSpice Simulation Results (V_{IN}, $V_{BOOST.OUT}$, V_{OUT})

Figure 3-3 and Figure 3-4 show the related experimental waveforms (V_{IN}: Ch1 in light blue with 1 V/div, V_{OUT}: Ch2 in blue with 1 V/div) to see actual hold-up time with 1-A load condition, and the switching frequency is 1.25 MHz for this test. The TPS62130 evaluation module (TPS62130EVM-505) was used for this measurement, and the hold-up time is 2.2 ms in this typical application case.

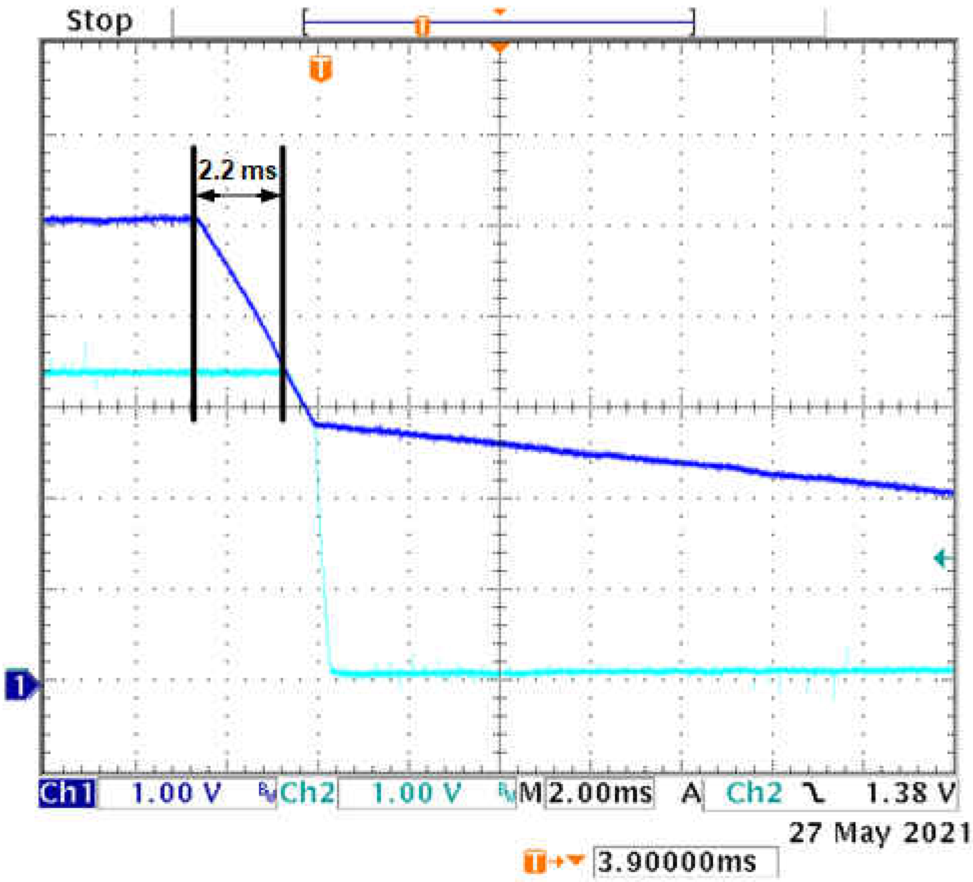

Figure 3-3. Test Waveform With the Typical Application TPS62130 Method

A prototype schematic shown in Figure 2-2 was built and tested to verify the operation, and Figure 3-4 shows V_{IN} and V_{OUT} with the same 1-A load condition. As shown in Figure 3-4, the proposed application method has 7.2 ms hold-up time which is 5 ms longer compared to the typical application case of the TPS62130. Also, V_{OUT} is still regulated to achieve a steady 3.3 V even though V_{IN} goes down to around 1 V.

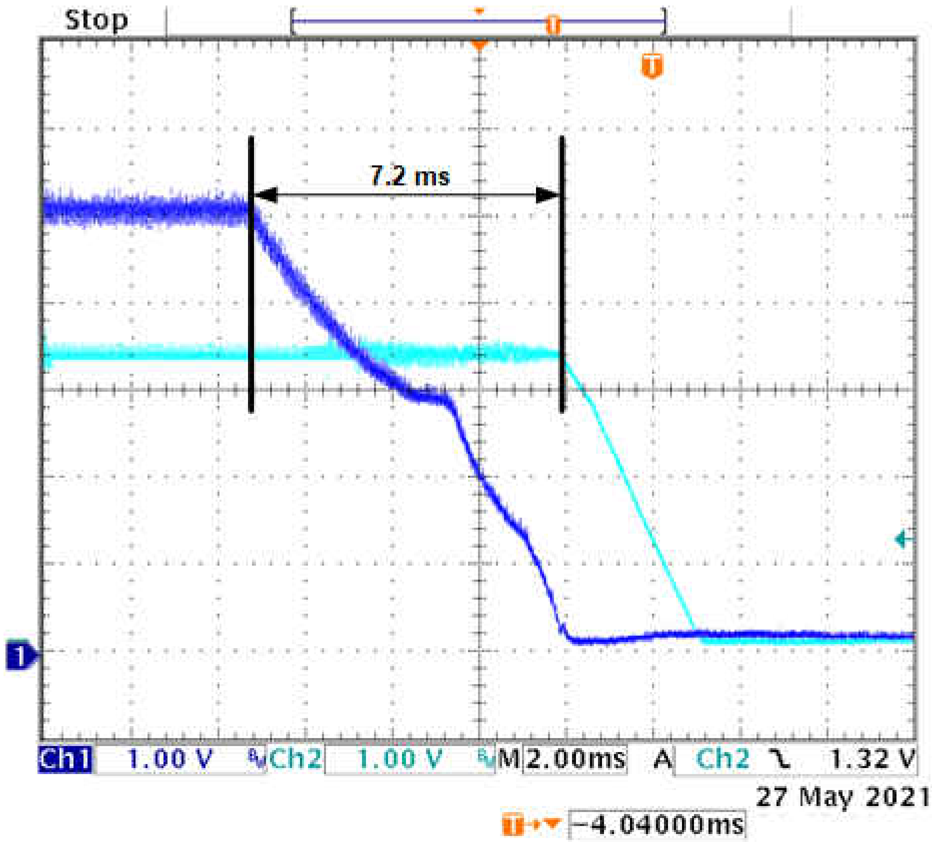

Figure 3-4. Test Waveform With the Proposed Application Method

4 Conclusion

A practical approach to achieve longer hold-up time is proposed in this application report. As it has been confirmed with the actual application case (V_{IN} = 5 V, V_{OUT} = 3.3 V, L1 = 1.0 µH, L2 = 3.3 µH, F_S = 1.25 MHz), the solution operates properly having 5 ms longer hold-up time compared to the typical application case of the TPS62130, and a boost pre-regulator without an independent PWM controller is used for achieving longer hold-up time at a reasonable cost. This makes the solution more attractive in terms of the total solution cost. Since $V_{BOOST.OUT}$ will be the input of the TPS62130, $V_{BOOST.OUT}$ should be carefully reviewed in terms of its voltage level, and PCB layout is also critical to get the desired results.

5 References

- Texas Instruments, *TPS6213x 3-V to17-V, 3-A Step-Down Converter In 3x3 QFN Package* data sheet
- Texas Instruments, *TPS62130EVM-505, TPS62140EVM-505, and TPS62150EVM-505 Evaluation Modules* user's guide