AC Adapter Input Detection for High-Current and High-Voltage Load Switches

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ABSTRACT

High-current load switches such as the TPS2590 or TPS25910 have active-low enable pins that requires additional circuitry for detecting whether the input voltage is in a valid range. Discreet circuit implementations can result in a brief false start-up that may be undesirable in the application. This application report shows how the TPS3700 can both serve as a precision voltage-detection circuit, as well as provide a power good (PG) function to enable downstream dc-dc converters.

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1 Introduction

The TPS25910 is the latest in the family of high-voltage and high-current load switches from Texas Instruments. The device can be programmed to limit the load current from 0.82 A to 6.5 A, and also has the ability to control the slew rate of the output voltage. This feature is critical in applications where it must be ensured that the attached load does not cause a system-wide failure. The block diagram is shown in Figure 1.

Figure 1. TPS25910 Block Diagram
As shown in Figure 1, the TPS25910 has an internal pass FET that is used to both minimize the inrush current into the load and protect the system in the event of a short circuit. The constant power engine also minimizes inrush. This circuit controls the linear current amplifier (LCA) to limit the maximum power dissipated by the pass FET. Therefore, when first enabled, the voltage across the FET ($V_{DS}$) is from $V_{IN}$ to GND (that is, before you enable the TPS25910, the voltage at the IN pins is $V_{IN}$ and the voltage on the OUT pins should be GND because the device has not been enabled). As current ramps through the FET, the capacitance at $V_{OUT}$ is charged. As $V_{DS}$ decreases, the current in the FET ($I_{DS}$) is allowed to increase to maintain a constant power dissipation across the FET.

The FET gate pin is brought outside of the device so that a capacitor can be added to further control the current slewing into the load. This slew rate control is essential for applications where several loads may attempt to power on simultaneously. If the outrush to the load is too severe, it may result in $V_{IN}$ falling or creating a brownout.

The TPS3700 is a window comparator with independent undervoltage and overvoltage thresholds and outputs. This device can operate with VDD ranging from 1.8 V to 18 V. If the voltage at the INB– pin rises above the 400-mV threshold, the OUTB pin is pulled low. Correspondingly, if the INA+ pin falls below the 400-mV threshold, the OUTA pin is pulled low. Because this device is designed as a window comparator, the OUTA and OUTB pins are open-drain outputs and can either be tied together or used independently. See the block diagram shown in Figure 2.

![Figure 2. TPS3700 Block Diagram](image)

The intended operation of the TPS3700 is to validate that $V_{IN}$ is in a proper range before enabling the system. For example, when the window is set to $4.75 \, V < V_{IN} < 5.25 \, V$ and within this window both outputs are high impedance, if $V_{IN}$ falls below 4.75 V, then OUTA is pulled low. Correspondingly, if $V_{IN}$ rises above 5.25 V, then OUTB is pulled low.
2 AC Adapter Detection

Typically, systems require that the input voltage is correct prior to enabling the system power path. A simple comparator with reference effectively achieves this requirement. However, the TPS3700 both detects that the input voltage rail is valid, and sets a PG threshold for the load voltage. R5 and R6 (see Figure 3) set the AC adapter detection threshold as shown in Equation 1:

\[
V_{\text{IN}} = V_{\text{REF}} \cdot \left( \frac{R5 + R6}{R6} \right) = 10.95 \, \text{V}
\]  

(1)

For a 12-V adapter assuming ±5% tolerance, the result in Equation 1 should be enough. If 10% or wider tolerance is required, R6 can be reduced accordingly to accommodate the wider tolerance. When \(V_{\text{IN}}\) rises above this threshold, OUTB is pulled low. This action is used to enable the TPS25910. Once enabled, the TPS25910 starts to slew current into the load.

3 Power Good Indication

Because the effective resistance between the drain and source of the internal MOSFET in the TPS25910 (\(R_{\text{DS(ON)}}\)) is typically less than 30 mΩ with a maximum nominal load current of 5 A, there is only a 210 mV drop across the TPS25910. Therefore, it is possible to use the same threshold for PG detection. This reason is why the same values are chosen for R3 and R4 to detect \(V_{\text{OUT}}\). Of course, if more margin is required, this threshold can be lowered. After the voltage threshold is met, the OUTA pin stops pulling down the PG rail and allows R7 to pull up the PG rail. This threshold can be used to enable either a dc-dc converter or just alert the system that the power is ready.

Figure 3. AC-Adapter and Power-Good Schematic
4 Optional Delay

To avoid accidental startup with a power line glitch or to better debounce an input rail, some applications prefer to delay the startup and PG. If this feature is required, it is as easy as adding one or two additional capacitors to Figure 3, as shown in Figure 4.

Combining the TPS3700 along with the TPS25910 provides a means of providing an application with precision ac adapter insert detection and robust inrush current management and protection. Taking advantage of the second output of the TPS3700 for a PG signal adds a reliable means to enable either dc-dc converters or simply let an MCU know that the input power rail is valid and stable.

5 References

1. TPS25910 Datasheet, SLUSAR6, Texas Instruments
2. TPS3700 Datasheet, SBVS187, Texas Instruments
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