TEXAS INSTRUMENTS

Application Report
SLVA534–August 2012

Using the TPS3839/1 as an Adjustable Supply Voltage Supervisor

Darwin Fernandez *Portable Linear Solution/Supervisors*

ABSTRACT

The TPS3839 is a family of ultra-low quiescent current supply voltage supervisors (SVS) that monitor a single voltage rail.

Because this device is a fixed-voltage monitor, designers must implement different voltage versions of the TPS3839 for specific voltage rails in their system. However, its low quiescent current of 150 nA makes it suitable for use as an adjustable SVS. This application report describes a simple solution and design considerations for using the TPS3839 as an adjustable SVS for monitoring different voltage rails and implements a design example using the TPS3839A09.

Contents

1 Introduction 2
2 TPS3839 Adjustable Solution 3
2.1 Design Calculations 3
3 Design Considerations 4
3.1 Trigger Threshold Time Delay 4
3.2 Threshold Accuracy 5
4 Design Example 6
5 Conclusion 7

List of Figures

1 TPS3839G12 Typical Circuit for Monitoring a 1.2-V Rail 2
2 TPS3839 as an Adjustable SVS 3
3 $\overline{\text{RESET}}$ Delay Time After the Rail Voltage Reaches its Trigger Voltage 4
4 Effects of Trigger Voltage Accuracy with Various Divider Currents 5
5 TPS3839A09 $\overline{\text{RESET}}$ Profile for a Resistor Divider Current 100x I_{DD} 6
6 TPS3839A09 $\overline{\text{RESET}}$ Profile for a Resistor Divider Current 10x I_{DD} 7

1 Introduction

The TPS3831 is a family of ultra-low current supply voltage supervisors (SVS) that monitor a single voltage rail. Because this device is a fixed-voltage monitor, it is typically configured as shown in Figure 1. The TPS3839 asserts a $\overline{\text{RESET}}$ signal, letting the host know that some system voltage is too low and action must be taken, whenever the V_{DD} supply voltage drops below the threshold voltage V_{th}. In each case, all of the voltages monitored are critical to ensure the proper operation of the entire system. Sometimes the fixed V_{th}, at which the SVS triggers, does not meet an application's specific needs; therefore, designers must rely on an adjustable SVS to trigger at a different V_{th}. This application report describes a simple solution to use a fixed SVS, such as the TPS3839, as an adjustable SVS that can trigger at a different rail voltage.

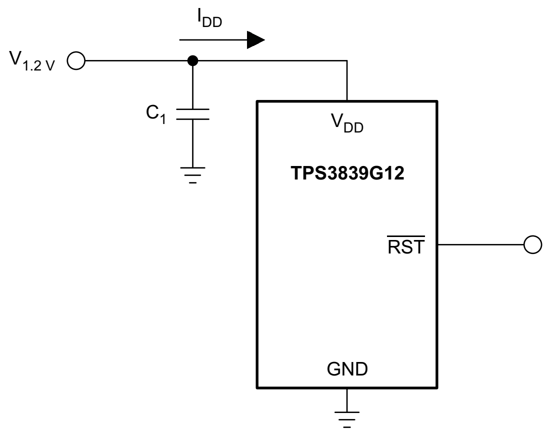

Figure 1. TPS3839G12 Typical Circuit for Monitoring a 1.2-V Rail

2 TPS3839 Adjustable Solution

Figure 2 shows a simple solution for making an adjustable SVS by adding a resistor divider at the V_{DD} input of the TPS3839. By setting the resistor divider, the voltage at which to trigger $V_{Trigger}$ can be varied for different voltage rails. In addition, this allows for higher voltage rails to be sensed without exceeding the absolute maximum ratings of the IC.

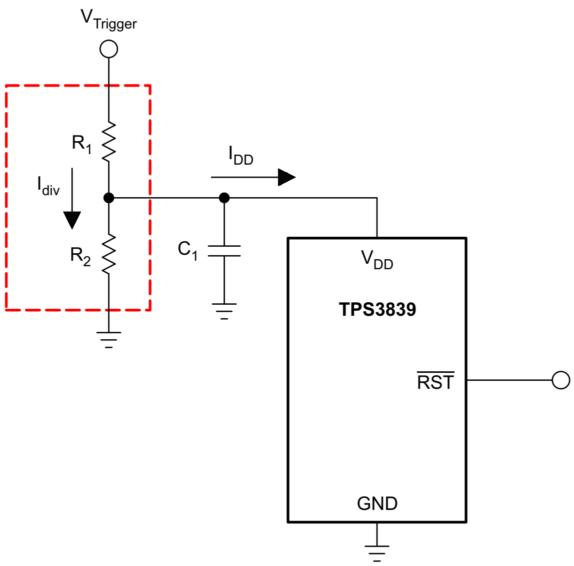

Figure 2. TPS3839 as an Adjustable SVS

2.1 Design Calculations

In order to keep an accurate trigger voltage, a practical guideline is that the current through the resistor divider I_{div} should be 100 times the current into the device I_{DD}. That is,

$$I_{div} \geq 100 \times I_{DD}\ (Max) \tag{1}$$

$$\frac{V_{Trigger}}{R_1 + R_2} \geq 100 \times I_{DD}(Max) \tag{2}$$

The voltage, $V_{Trigger}$, at which to trigger a reset, $\overline{\text{RESET}}$, is calculated using Equation 3 where V_{th} is the negative-going threshold voltage specified in the datasheet.

$$V_{th} = \frac{V_{Trigger}}{R_1 + R_2} \times R_2 \tag{3}$$

Combining Equation 2 and Equation 3 yields Equation 4, or the maximum bottom resistance R2 must be to meet the minimum divider current requirement. Equation 5 is the resulting top resistance R1 that sets $V_{Trigger}$.

$$R_2 \leq \frac{V_{th}}{100 \times I_{DD}(Max)} \tag{4}$$

and

$$R_1 = \left(\frac{V_{Trigger}}{V_{th}} - 1\right) \times R_2 \tag{5}$$

3 Design Considerations

3.1 Trigger Threshold Time Delay

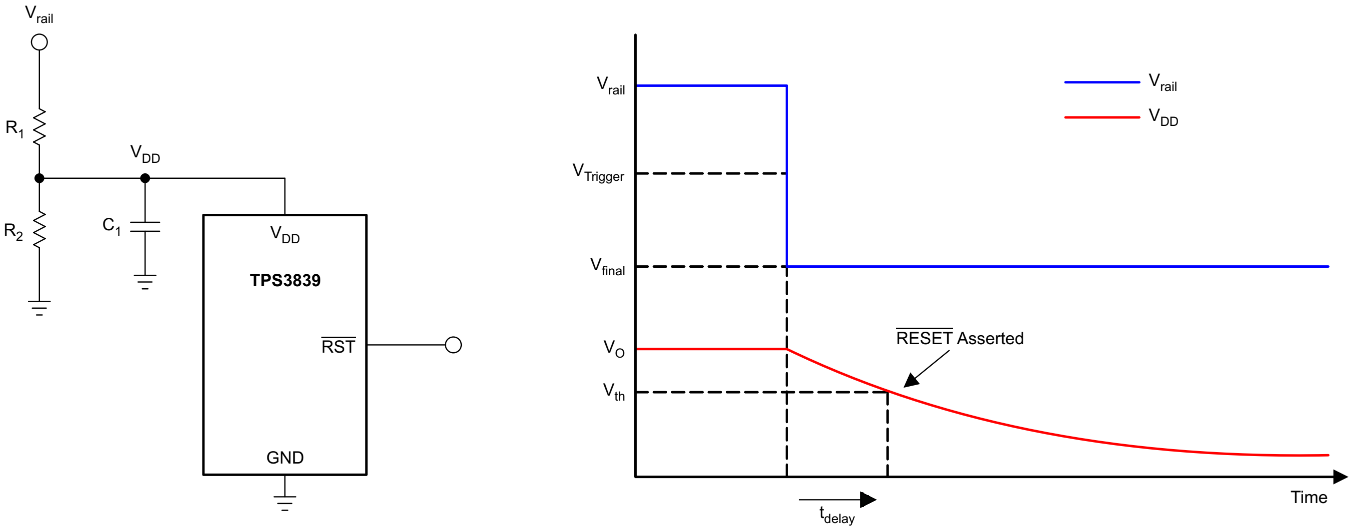

Figure 3. $\overline{\text{RESET}}$ Delay Time After the Rail Voltage Reaches its Trigger Voltage

For most SVSs, a capacitance, C1, on V_{DD} is required. When a resistor divider is added to the V_{DD} input of the SVS, there is a time delay between the rail voltage reaching $V_{Trigger}$ and the TPS3839 asserting a $\overline{\text{RESET}}$. Figure 3 shows this for a rail step from V_{rail} to a final voltage, V_{final}, that passes through $V_{trigger}$. Therefore, selecting lower resistor divider values triggers a faster time delay when triggering a $\overline{\text{RESET}}$. Equation 6 shows this relationship. V_{th} (actual) is calculated in the next section.

$$\text{Delay Time } T_{Delay} = -\frac{R_1 R_2 C_1}{K_1} \times \ln\left[\frac{K_1 V_{th(actual)} - K_2}{K_1 V_o - K_2}\right] \tag{6}$$

Where:

$K_1 = R_1 + R_2$

$K_2 = R_2 V_{final} - I_{DD} R_1 R_2$

$$\text{Initial Voltage on } V_{DD}\ V_0 = \frac{V_{rail} R_2}{R_1 + R_2}$$

3.2 Threshold Accuracy

As stated in the previous section, the divider current should be at least be 100 times the current through input of TPS3839 to prevent a trigger voltage offset due to the supply current into the device. This is shown in Figure 4 and is explained in detail in the application report, *Optimizing Resistor Dividers at a Comparator* (SLVA450). Lower resistor divider values (higher I_{div}) have a more accurate trigger threshold and yield shorter time delay. The drawback is that the circuit consumes more current and can be a significant drain on battery life and run time. However, a given application may allow that the resistor divider can be increased (less I_{div}) if less accuracy and a longer time delay meets system requirements. V_{th} (actual) is calculated in Equation 7.

$$V_{th(actual)} = R_2 \frac{\left(V_{Trigger} - I_{DD} R_1\right)}{\left(R_1 + R_2\right)} \quad (7)$$

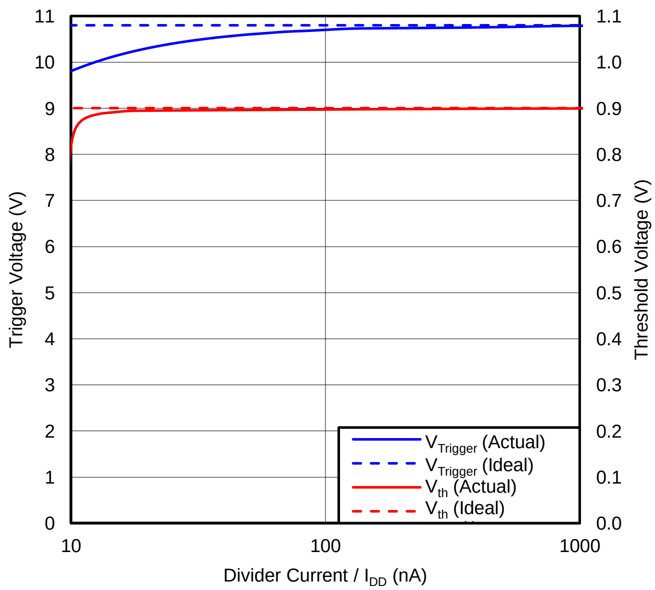

Figure 4. Effects of Trigger Voltage Accuracy with Various Divider Currents

Adding a resistor divider to the SVS system means the tolerance of the resistors ($\%Tol_R$) must be taken into account for the overall accuracy of the SVS ($\%Tol_{SVS}$). A common misconception is that using two resistors of a particular tolerance in the divider corresponds to an error of $\pm 2\%Tol_R$. In fact, this is usually not the case. Application note (SLVA450) describes this in detail. In summary, the added tolerance with the resistor divider is shown in Equation 8.The error is actually inversely proportional to the divider ratio and decreases linearly as the trigger voltage approaches the threshold voltage.

$$\pm\%Tol_R(\text{Actual}) = 2 \times \left(1 - \frac{V_{th}}{V_{Trigger}}\right) \times \%Tol_R(\text{Specified}) \quad (8)$$

4 Design Example

The following design example uses the TPS3839A09 under the following conditions for monitoring an 11-V rail and triggers a reset when the rail drops 50% of its nominal voltage (5.5 V):

- V_{rail} = 11 V
- $V_{Trigger}$ = 5.5
- I_{DD} (Max) = 500 nA
- V_{th} = 0.9 V (TPS3839A09)

Using Equation 4 and Equation 5, R_1 and R_2 was chosen to be

R_1 = 70 kΩ
R_2 = 13.5 kΩ

Figure 5 shows the resulting waveform for a sudden drop to 5 V (V_{final}) in the 11-V rail. The time delay can be measured as 2.57 ms. In this configuration the current through the resistor divider is approximately 50 µA (or 100x I_{DD}). Using Equation 6, the calculated delay time is 2.6ms.

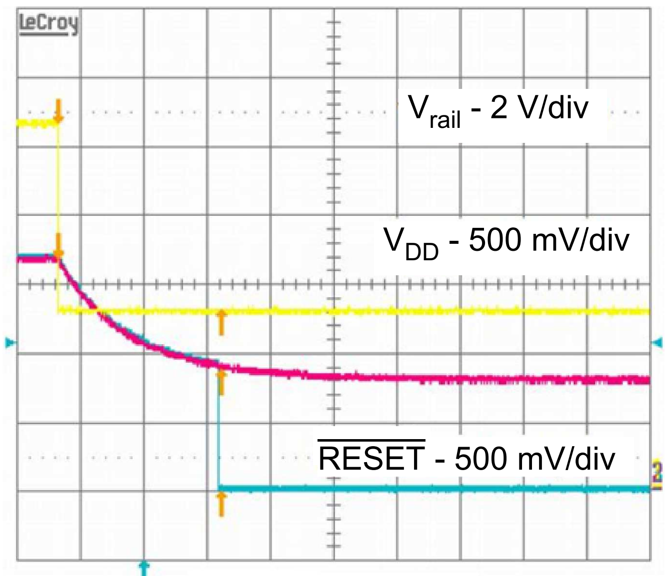

Figure 5. TPS3839A09 $\overline{\text{RESET}}$ Profile for a Resistor Divider Current 100x I_{DD}

To reduce the current through the resistor divider, thus prolonging battery life, the resistor divider can be increased. Figure 6 shows the resulting waveform for the divider current 10 times the supply current. Where R_1 is 700 kΩ and R_2 is 135 kΩ. Because the resistance has increased, the time delay has increased to approximately 22.1 ms. Using Equation 6, the calculated time is 21.6 ms.

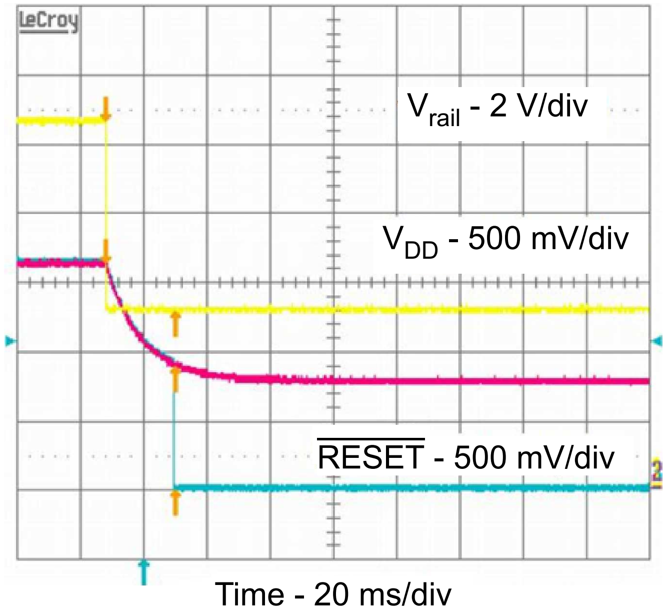

Figure 6. TPS3839A09 $\overline{\text{RESET}}$ Profile for a Resistor Divider Current 10x I_{DD}

5 Conclusion

This application report has demonstrated a simple circuit and design considerations for using the TPS3839 as an adjustable SVS. The addition of a resistor divider at the input of the SVS creates a user programmable voltage threshold that can go as low the fixed threshold version V_{th}.