Adding Hysteresis to Supply Voltage Supervisor

Sureena Gupta | *PMP - Linear Power Applications*

ABSTRACT

Some applications require supply voltage hysteresis to keep a supply voltage supervisor (SVS) from falsely resetting the system due to voltage dips and glitches. This application report presents one solution for adding hysteresis to an SVS. The solution schematic is given along with component selection criteria and equations, such that readers can appropriately scale the solution to their own requirements. The document also includes a sample design implementation along with captured waveforms.

Contents

List of Figures

1 Introduction

As the input voltage to a system dips below the minimum required voltage for operation, the supply voltage supervisor (SVS) asserts a reset signal to turn off the system. When the system is turned off, current flow stops, and the voltage to the SVS may rise due to the decreased IR drop. The SVS then falsely turns the system back on. This erroneous reset lasts as long as the input voltage spikes exceed the threshold voltage, or the voltage dips fall below the threshold voltage. This condition can be undesirable for various applications. In order to avoid this undesirable condition due to erratic change in input voltage caused by a discharging battery or perhaps a noisy power supply, hysteresis can be added to the SVS circuitry. The addition of hysteresis implies that the SVS is turned off when the input voltage falls below the threshold voltage, but it is not turned back on until the input voltage rises above another predetermined threshold voltage. For instance, it can be equivalent to the voltage supplied by a newly replaced battery for a battery-supplied input voltage source.

For example, the TPS3808 inherently has some internal sensing voltage hysteresis, but the amount of hysteresis provided is not adequate to avoid the aforementioned erratic condition and needs external components to further add the required hysteresis. This application report presents the design procedures to be followed to add hysteresis to a SVS circuitry.

2 Design Solution

The internal hysteresis voltage of a TPS3808 is 6 mV on the sense pin (the hysteresis calculation is shown in Section 4), and it may not be adequate to meet the customer requirements. Hence, additional input voltage hysteresis can be added to the SVS.

The required additional input voltage hysteresis can be obtained by adding a feedback/hysteresis resistor at the sensing voltage node as shown in the solution schematic, Figure 1.

The hysteresis resistor (Rh) helps increase the hysteresis of input voltage by increasing the threshold voltage when the input voltage is increasing and helps decrease the threshold voltage when the input voltage is decreasing. This phenomenon is explained with simplified circuits in the next section.

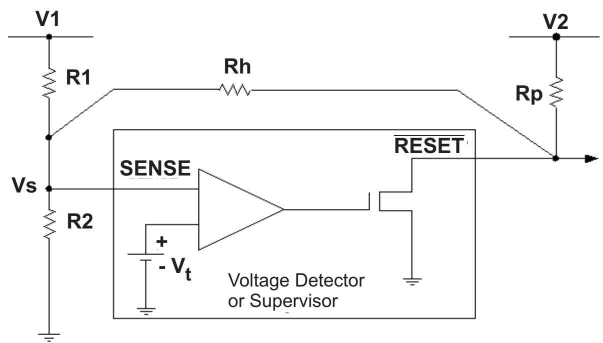

Figure 1. General Schematic for a Supervisor With Increased Hysteresis

Where:

V1 is the input supply voltage;
V2 is the voltage used that the output is pulled up to;
Vs is the voltage at the sense pin;
Vt is the threshold voltage or reference voltage;
Rp is used as a pullup on the $\overline{\text{RESET}}$ output;
Rh is a resistor used to increase the hysteresis.

3 Circuit Analysis

The circuit operates in two conditions. The first condition is when the supplied input voltage (V1) is increasing, and the second condition is when the supplied input voltage is decreasing. Let the '+' sign indicate increasing voltage case and the '–' sign indicate decreasing voltage case.

3.1 CASE 1 – Input Voltage Increasing

The supplied input voltage increases during power up and is denoted by V1+. In this case, the supervisor begins with an active low $\overline{\text{RESET}}$ signal, so the voltage at the $\overline{\text{RESET}}$ pin is close to zero volt. For this case, assume it is zero volt, so the entire sensing schematic simplifies as shown in Figure 2.

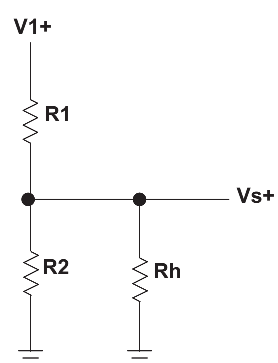

Figure 2. Simplified Sensing Schematic With $\overline{\text{RESET}}$ Pin Voltage Set to Zero

When Vs+ increases beyond Vt+ (internal reference or threshold voltage), the supervisor lets $\overline{RESET}$ float. The equation for the point at which the supervisor stops driving $\overline{RESET}$ low is:

$$\frac{V_{1+} - V_{s+}}{R1} = \frac{V_{s+}}{R2} + \frac{V_{s+}}{Rh} \qquad (1)$$

3.2 CASE 2 –Input Supply Voltage decreasing

The supplied input voltage decreases when the battery is discharging or due to a droop in supplied voltage and is denoted by V1–. In this case, the supervisor is not asserting an active low $\overline{RESET}$ signal, so the voltage at the $\overline{RESET}$ pin is pulled up to V2 via Rp, and the sensing schematic simplifies as shown in Figure 3.

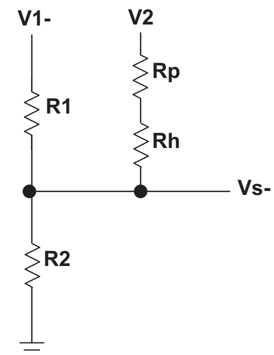

Figure 3. Simplified Sensing Schematic With $\overline{RESET}$ Pin Voltage Pulled Up to V2 via Rp

The equation for the trip point in this case is:

$$\frac{V_{1-} - V_{s-}}{R1} + \frac{V_2 - V_{s-}}{Rh + Rp} = \frac{V_{s-}}{R2} \qquad (2)$$

4 Design Example

The aforementioned cases and equations can be illustrated using the TPS3808 as an example. This device has some inherent hysteresis; the are two different threshold voltages depend on whether the supplied input voltage is increasing or decreasing. When the input voltage is increasing, the internal sensing threshold voltage is denoted by Vs+ and when the input voltage is decreasing, the internal sensing threshold voltage is denoted by Vs–.

These threshold voltage values are listed in the data sheet (SBVS103). The data sheet indicates that the internal reference voltage Vt is set to 0.4 V, and the typical hysteresis is set at 1.5% Vt. Hence, the values can be deduced as:

Vs– = 0.4 V
Vs+ = 0.406 V

The amount of inherent hysteresis provided can be calculated as (Vs+) – (Vs–). For the TPS3808, the inherent internal hysteresis is approximately 6 mV. The amount of hysteresis (from the battery perspective) is (V1+) – (V1–), which is simply (Vs+) – (Vs–) gained up through the resistor divider formed by R1 and R2. This equates to 27 mV of hysteresis on a 1.8-V battery voltage (V1–).

Assume that a system powered by two AA batteries needs to be reset when the battery voltage falls below 1.8 V. Also, assume that the system must not come out of reset until the battery voltage is above 2 V. This condition requires 200 mV of hysteresis, which is much greater than the 27-mV hysteresis provided by the TPS3808 device. Hence, additional hysteresis is required. The remaining section demonstrates the procedure to be followed to implement the required additional hysteresis.

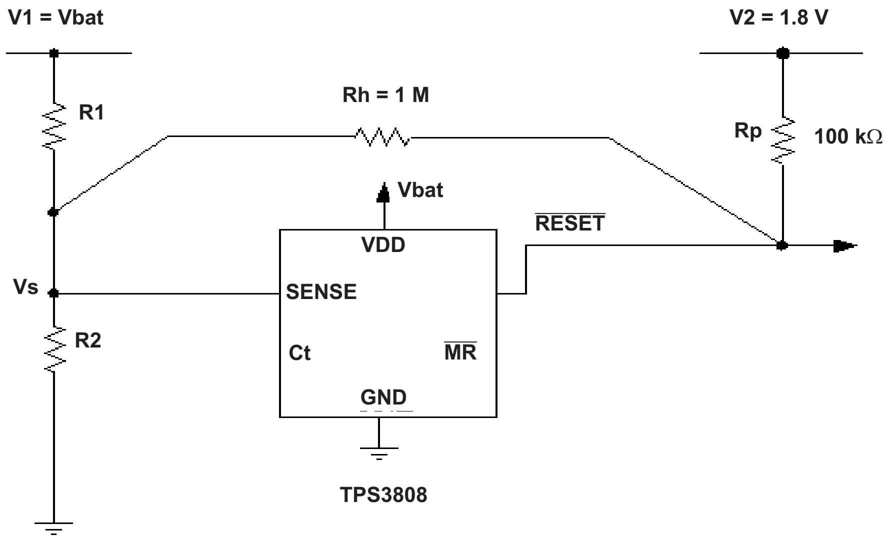

Figure 4. Schematic of Supervisor TPS3808 With External Hysteresis Resistor

Using the SVS TPS3808, the circuit was connected as shown in Figure 4. The values for different components were selected as per the requirements and are listed as follows:

V1+ = 2 V
V1– = 1.8 V
V2 = 1.8 V

To solve the design problem, consider the seven variables and two equations. Five of the seven variables were selected in order to solve the two equations.

V1+ and V1– were selected to create the desired input supply voltage hysteresis as required by the system.

V2 was selected to pull up the output of the $\overline{\text{RESET}}$ pin to the desired logic voltage levels.

Rp is typically selected in tens of kΩ.

Any other resistor can be selected out of the remaining three. Usually, Rh is a good choice with values in single-digit MΩ. Typically, Rh is a large value.

When designing the resistors Rh and R2, consider that as R2 increases, Rh increases. Typically, Rh is a large-valued resistor (can be more than 1 MΩ). Because resistors larger than 1 MΩ are uncommon and cost more than regularly available resistors, it is a good practice to design Rh as 1 MΩ and then calculate resistor R1 and R2 values by simultaneously solving Equation 1 and Equation 2. On the other hand, selecting R2 with a higher resistance can help further reduce the quiescent current, which improves the device efficiency. However, a higher R2 resistance implies a large-valued resistor Rh (Rh > 1 MΩ). For this example, the following values were selected:

Rp = 100 kΩ.
Rh = 1 MΩ

By solving Equation 1 and Equation 2, deduce the values for R1 and R2.

After solving,

R1 = 102 kΩ
R2 = 26.7 kΩ

The designed components were implemented on a printed-circuit board, and the output waveform was recorded as shown in Figure 5. The input voltage V1 is ramped between 1 V and 3 V, so that the designed operations can be observed. When V1+ = 2 V, (the circuit operation is initialized and after certain predetermined time delay Td (20 ms in this case), the $\overline{\text{RESET}}$ pin voltage rises from 0 V to 1.8 V (V2). When the input voltage is decreasing and V1– falls below 1.8 V, the $\overline{\text{RESET}}$ pin voltage falls back to 0 V.

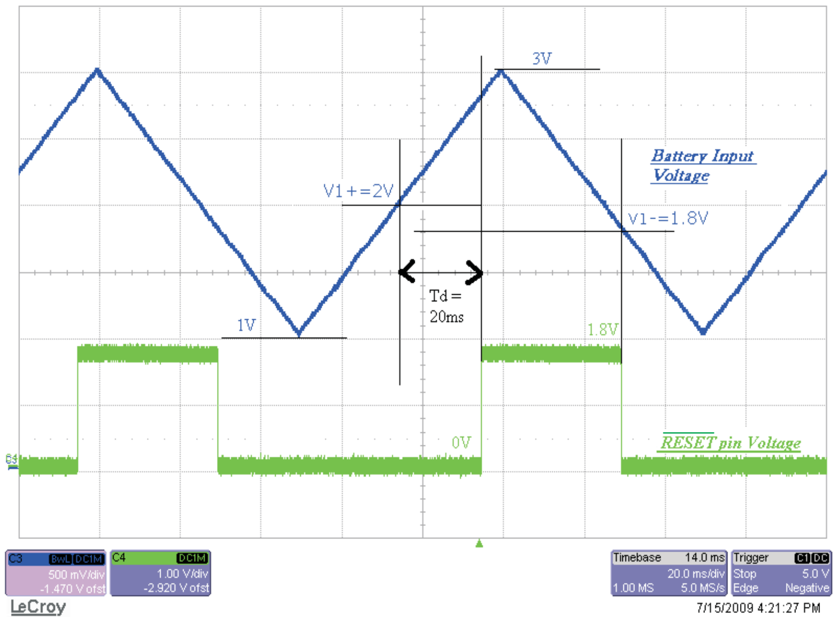

Figure 5. Output Waveform Indicating Input Voltage and $\overline{\text{RESET}}$ Pin Voltage

5 Conclusion

This application report presents a solution schematic for adding external hysteresis to the supply voltage supervisors, along with the circuit analysis to clarify how to configure an SVS for this kind of application. Along with the appropriate equations, the design process can assist designers in tailoring a solution based on the required applications. A sample module using the TPS3808 was designed and implemented to guide the user through the procedure. A screen shot from the oscilloscope displays the required results.

In summary, this application report helps designers add supply voltage hysteresis to the SVS to meet customer application requirements.

6 Reference

TPS3808-EP, Low Quiescent Current, Programmable Delay Supervisory Circuit data sheet (SBVS103)

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DLP® Products	www.dlp.com	Broadband	www.ti.com/broadband
DSP	dsp.ti.com	Digital Control	www.ti.com/digitalcontrol
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Military	www.ti.com/military
Logic	logic.ti.com	Optical Networking	www.ti.com/opticalnetwork
Power Mgmt	power.ti.com	Security	www.ti.com/security
Microcontrollers	microcontroller.ti.com	Telephony	www.ti.com/telephony
RFID	www.ti-rfid.com	Video & Imaging	www.ti.com/video
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265