

# ***Voltage Supervisors (Reset ICs): Frequently Asked Questions (FAQs)***

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## **ABSTRACT**

This Application Note answers the most commonly asked questions for Voltage Supervisors/Reset ICs, Voltage Detectors, Watchdog Timers, and all related monitoring devices.

- [Difference Between Voltage Detector and Voltage Supervisor?](#)
- [How to Add Programmable Delay to Voltage Detectors?](#)
- [How to Create a Fault Detector Using Any Type of Sensor?](#)
- [How to Adjust the Trigger Voltage on Fixed Threshold Devices?](#)
- [How to Extend the Input Voltage Range of a Voltage Supervisor?](#)
- [How to Calculate the Total System Quiescent Current \(I<sub>q</sub>\) for Various Types of Voltage Supervisors/Detectors?](#)
- [What is the Function of a Watchdog?](#)
- [Difference Between "Standard" and "Window" Watchdog?](#)
- [How to Utilize a Voltage Supervisor to Enable/Disable a Buck Converter?](#)
- [What is Device Accuracy? Device Tolerance? How to Calculate Worst-Case Detection?](#)
- [Mitigating the Indeterminate Output of a Voltage Supervisor \(Reset IC\) During Power-Up/Down?](#)
- [What is the Minimum Pulse Width to Cause a Reset?](#)
- [How to Latch a Voltage Supervisor? How to Latch a Watchdog Timer?](#)
- [How to Calculate Pull-Up Resistor Value for Active-Low, Open-Drain Devices?](#)
- [How to Add Hysteresis to a Voltage Supervisor Detection Threshold?](#)
- [What are Back-Up Battery Voltage Supervisors and Why are they Needed?](#)

Summary

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## 1 Difference Between Voltage Detector and Voltage Supervisor?

The main difference between voltage detectors and voltage supervisors is rising output timing, specifically called the reset delay. When the voltage detector goes from an undervoltage to a normal voltage condition, the fault is released immediately with a propagation delay typically in the range of microseconds. Voltage supervisors, on the other hand, have a longer delay in releasing a fault event, typically in the range of milliseconds.

To be more specific, both voltage detectors and voltage supervisors detect an undervoltage condition and trigger a fault immediately as shown by  $t_{pd(HL)}$  in the figure below. However, the only difference is that voltage detectors do not have a long delay in releasing that fault event as shown by  $t_{d(RST)}$  being longer than  $t_{pd(LH)}$ .

Voltage supervisors come in both fixed and programmable delays. This delay can be useful to prevent a false trigger as the output can remain in the fault state until the normal voltage condition has been detected for a certain period of time.

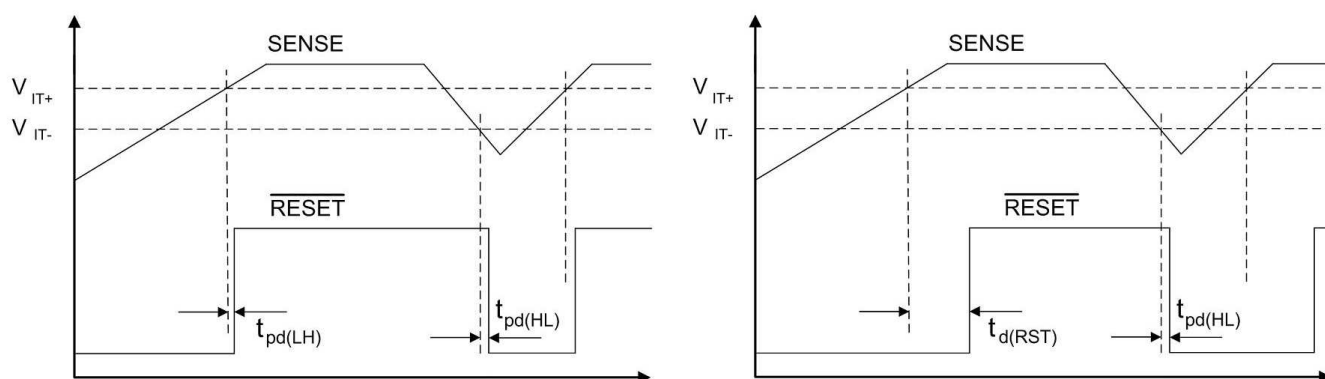


Figure 1. Voltage Detector (Left) vs Voltage Supervisor (Right)

## 2 How to Add Programmable Delay to Voltage Detectors?

Voltage detectors usually do not have a reset delay other than the inherent propagation delay. In this case, a delay capacitor can be added to the output of the open-drain voltage detector to increase the time it will take for the fault event to release after the device goes from an undervoltage to a normal voltage condition. Adding a buffer after the capacitor will clean up the output signal, producing a sharp digital output. The delay capacitor and buffer are shown in the red dotted line in Figure 2.

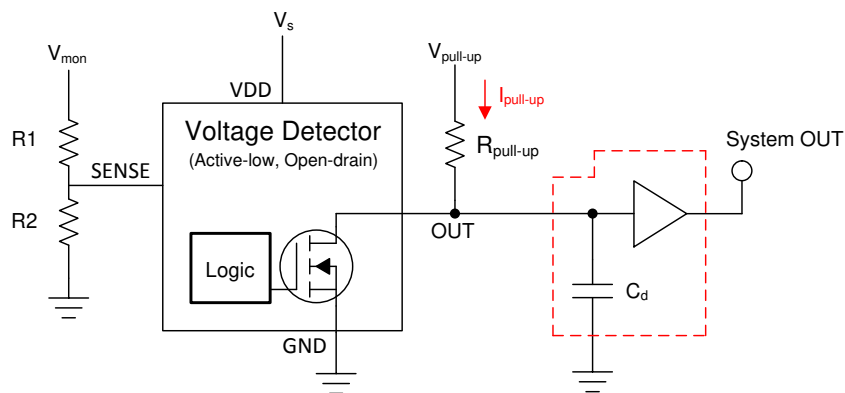
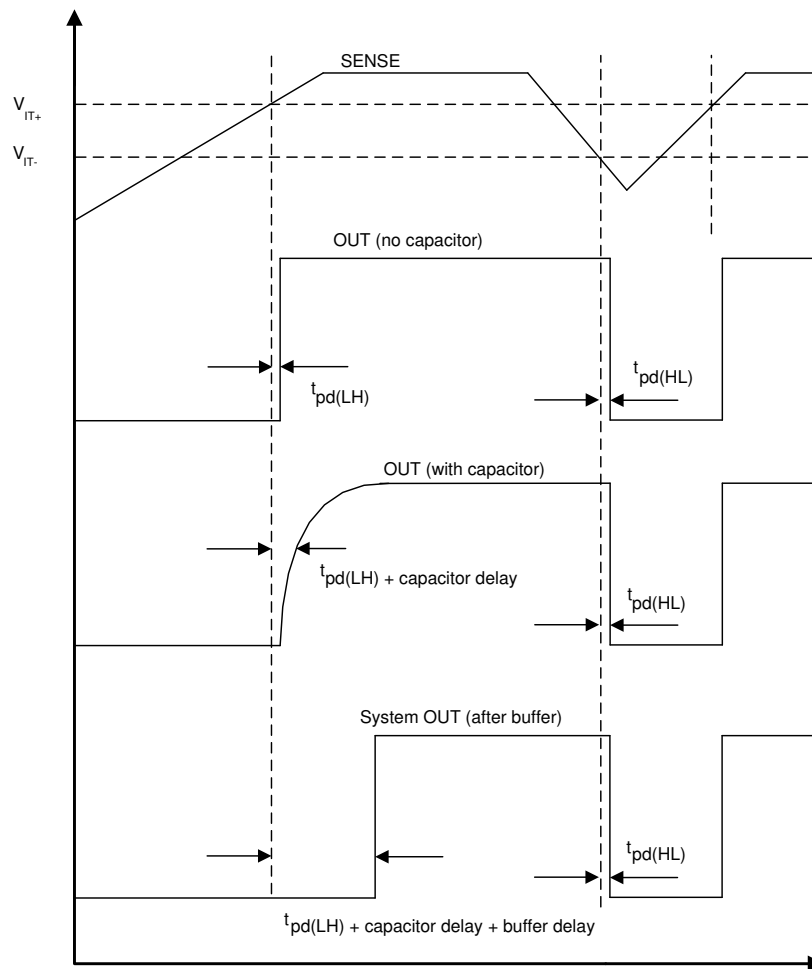


Figure 2. Adding Programmable Reset Delay to Voltage Detectors Circuit Schematic

The effect of the capacitor and buffer can be compared to the standard configuration without the delay circuitry shown in [Figure 3](#).



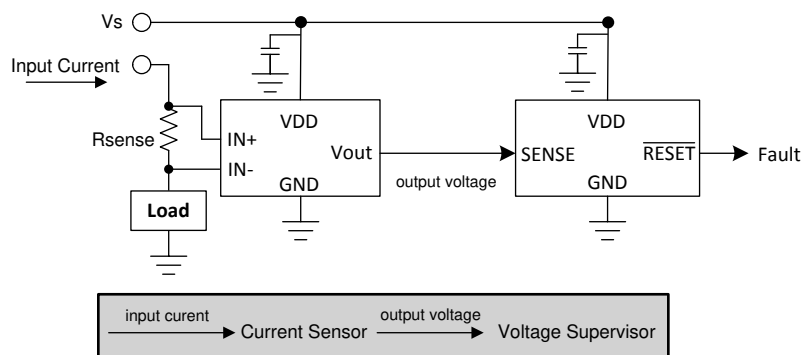
**Figure 3. Adding Programmable Reset Delay to Voltage Detectors Timing Diagram**

This can be useful for voltage detectors that have a unique wide voltage input (VIN) specification making them a very suitable device for applications that only have high voltage rails in the range of 7V or more. These wide VIN voltage detectors can accept up to 36V at VDD. There may be applications that require a wide VIN voltage detector but also require a certain reset delay that voltage detectors don't normally provide.

Please see [Adding Programmable Reset Time Delay to Detectors](#) Application Report for more information.

### 3 How to Create a Fault Detector Using Any Type of Sensor?

Did you know that voltage supervisors can act as fault detectors for any sensor? By having a sensor that converts the input measurement to an output voltage, the voltage supervisor or voltage detector can then be attached to monitor the sensor's output voltage. A fault can then be triggered by the supervisor when the sensor reaches a certain threshold. This is useful for detecting over or under fault conditions, as long as the output voltage range of the sensor and the detect voltage threshold are correctly chosen. An example of a current monitoring solution is shown in [Figure 4](#).



**Figure 4. Using a Voltage Supervisor for Current Sense Fault Protection**

The above solution example can be applied to any sensor with a voltage output allowing users to monitor any sensor and set the fault trigger threshold to any value within the operating range of the voltage supervisor.

### 4 How to Adjust the Trigger Voltage on Fixed Threshold Devices?

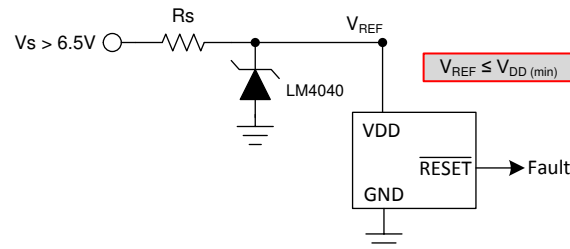
The TPS3839 is a family of ultra-low quiescent current supply voltage supervisors (SVS) that monitor a single voltage rail. Because this device is a fixed-voltage monitor, designers must implement different voltage versions of the TPS3839 for specific voltage rails in their system. However, its low quiescent current of 150nA makes it suitable for use as an adjustable SVS.

A simple solution for making an adjustable SVS is by adding a resistor divider at the VDD input of the TPS3839. By setting the resistor divider, the voltage at which to 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.

Please see [Using the TPS3839/1 as an Adjustable Supply Voltage Supervisor](#) TechNote for more detailed information:

## 5 How to Extend the Input Voltage Range of a Voltage Supervisor?

To increase the input voltage range allowed to power a voltage supervisor without damaging the device, a Shunt Voltage Reference or Zener Diode can be added to the input pin to protect the input pin from going above the recommend operating input voltage. This solution, shown in the [Figure 5](#), allows a voltage supervisor to be used at a higher input voltage than the device's recommended operating range. The shunt voltage reference variant and the resistor value need to be chosen such that the voltage at V<sub>DD</sub> remains within the recommended operation conditions of the voltage supervisor/detector.



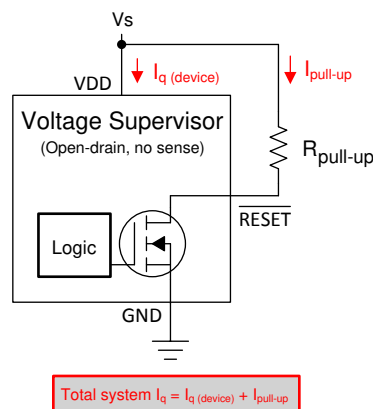
**Figure 5. Adding a Shunt Voltage Reference to Increase the Input Voltage Range**

The Zener diode and shunt voltage reference only sink current when the supply voltage is above the breakdown voltage or voltage threshold of those devices. Therefore, when the voltage supply drops below that breakdown voltage or voltage threshold, the voltage supervisor will operate normally as if there were no Zener diode or shunt voltage reference in the system.

Please see [Using Voltage Supervisors in High Voltage Applications](#)

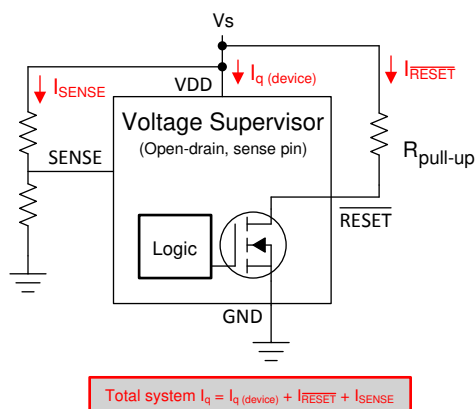
## 6 How to Calculate the Total System Quiescent Current (I<sub>q</sub>) for Various Types of Voltage Supervisors/Detectors?

There are two kinds of output topologies, open-drain and push-pull, that must be considered when accounting for total system current consumption. In an open-drain topology, the supervisor's I<sub>q</sub>, or quiescent current, does not include the current through the pull-up resistor. If the pull-up voltage is pulled from the supply, the total system quiescent will increase as supply current will also go through the pull-up resistor as shown in [Figure 6](#).



**Figure 6. Open-Drain, No Sense Pin, Voltage Supervisor**

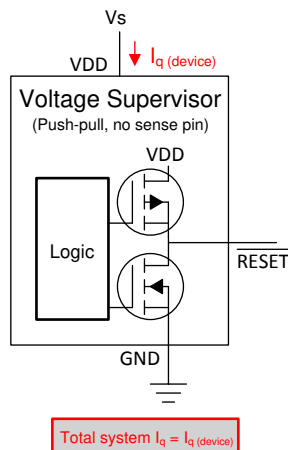
If the pull-up voltage is connected to another source, the system  $I_q$  will equal the supervisor  $I_q$  from the datasheet in addition to the supply current from the second power source. Also, if the voltage supervisor has a SENSE pin that is connected to VDD directly or through a resistor divider, the current through the resistor divider must also be accounted for when calculating total system  $I_q$  as shown in Figure 7.



**Figure 7. Open-Drain, Sense Pin, Voltage Supervisor**

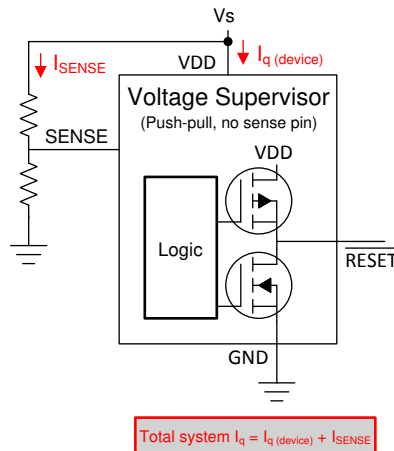
Since the pull-up voltage can be connected to different supplies, the  $I_q$  spec of the supervisor does not account for the additional output current required from the pull-up resistor of the open-drain output topology.

In a push-pull topology, the total system  $I_q$  calculation is slightly different to that of the open-drain. Since there is no external pull-up resistor is required, the output will not consume additional current as shown in Figure 8.



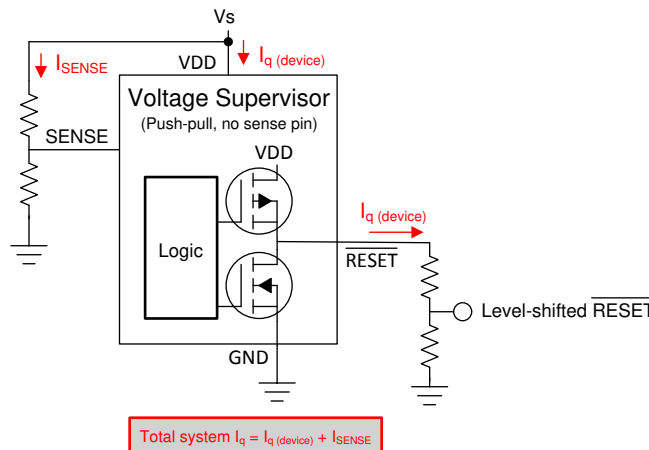
**Figure 8. Push-Pull, No Sense Pin, Voltage Supervisor**

However, similar to that of the open-drain, if a resistor divider is used at the SENSE pin, the total system current consumption will increase as shown in [Figure 9](#)



**Figure 9. Push-Pull, Sense Pin, Voltage Supervisor**

Lastly, [Figure 10](#) shows there is no additional  $I_q$  when using a level-shifting resistor divider at the output of a push-pull voltage supervisor.



**Figure 10. Push-Pull, Sense Pin, Level-Shifted Output, Voltage Supervisor**

## 7 What is the Function of a Watchdog?

Coupling a voltage supervisor with a watchdog timer allows for both supply voltage monitoring and internal fault detection of the microprocessor. The watchdog timer adds critical redundancy to systems where a processor may freeze or hang. Watchdog timers are used for safety-critical applications or for processor monitoring that requires a reset if the microprocessor is not active for a certain duration. This feature prevents the system from continuing to run if the microprocessor is not functioning properly.

Voltage detectors and supervisors/reset ICs with watchdog timers wait for signal activity on the watchdog input (WDI) pin. A reset triggers if the supervisor does not detect a signal within the watchdog window. You can program this window using an external capacitor, making the watchdog window more flexible.

TI also offers standalone watchdog timers if voltage monitoring is not required: [TPS3430/TPS3431](#)



## 8 Difference Between "Standard" and "Window" Watchdog?

The difference between "standard" and "window" watchdogs is the lower boundary specification. In standard watchdogs, a pulse must arrive before the watchdog timeout otherwise a fault occurs. Looking at the right of Figure 11, notice that the standard watchdog only alerts the system on late faults. In window watchdogs, a pulse must arrive before the watchdog timeout and after the lower boundary window otherwise a fault occurs. Taking a look at the left of Figure 11, notice how the window watchdog alerts the system on *both* early and late faults.

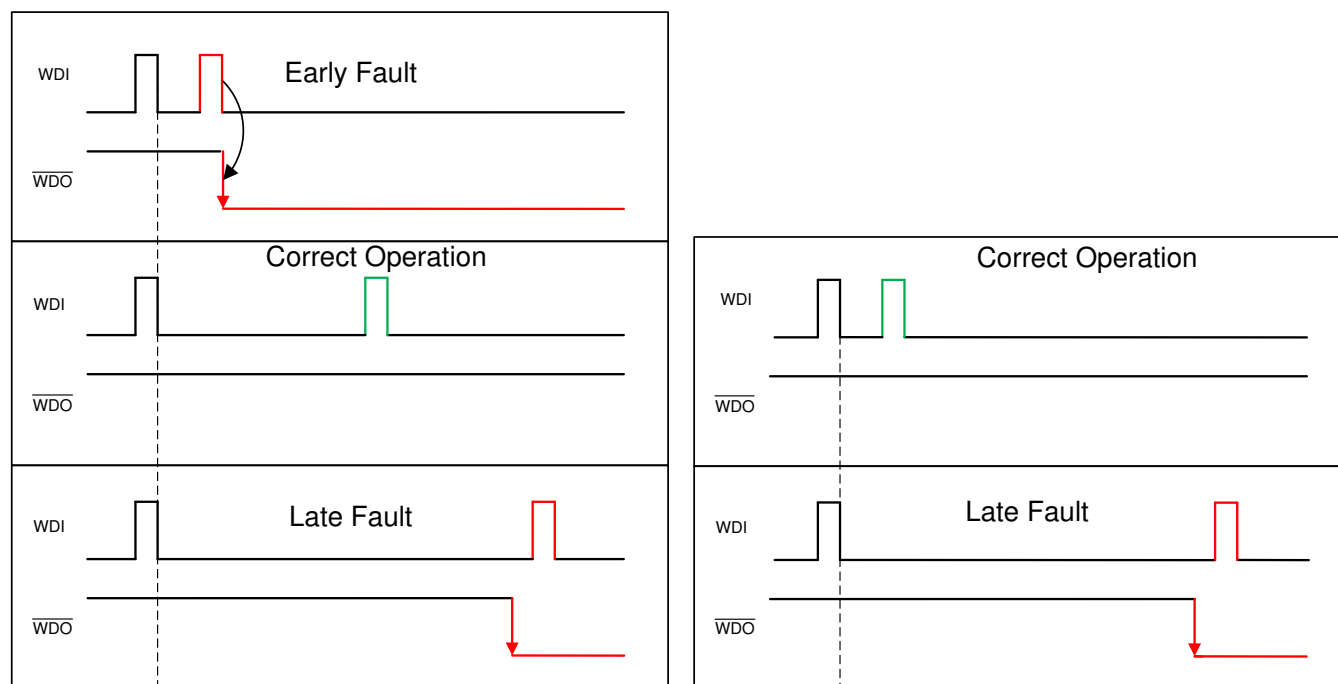


Figure 11. Window (Left) vs Standard (Right) Watchdog Timers

## 9 How to Utilize a Voltage Supervisor to Enable/Disable a Buck Converter?

In most applications, the MCU, ADC, or other signal processing device cannot work off an unregulated supply. Therefore, designers typically use voltage supervisors or detectors to enable or disable the point of load power management devices. Take the [TIDUCR4A](#), a TI Design for automotive camera's, as an example. As shown in Figure 12 the TPS3808 reset output is connected to the PDB pin of the serializer. It will then monitor the 1.8V rails, as shown in the figure below. The TPS3808 holds the PDB pin of the serializer in the low state, preventing the serializer from turning on, until the 1.8-V supply voltage rail reaches a threshold voltage of 1.67 V in this case. Once this threshold voltage is reached, there is a hard 20-ms delay until the supervisor releases the serializer from reset.

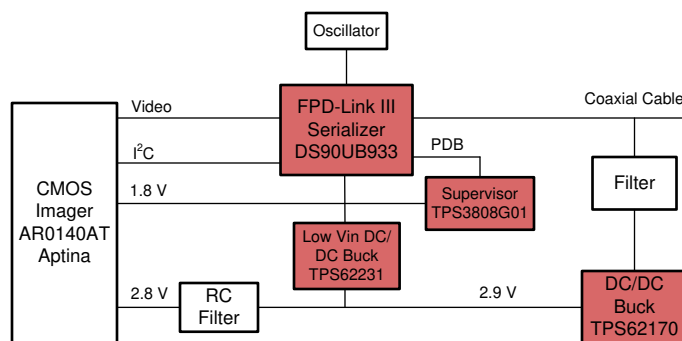


Figure 12. Camera Block Diagram with Voltage Supervisor Protection

## 10 What is Device Accuracy? Device Tolerance? How to Calculate Worst-Case Detection?

Device accuracy is sometimes confused with device tolerance but these specs are not the same.

Device accuracy refers to the minimum and maximum limits on the voltage threshold. This spec includes all device variation across all temperature and operating conditions. Sometimes the minimum and maximum values are written as a number that can be used to calculate the accuracy, as shown in the chart below.

The calculations for minimum and maximum accuracy are given in [Equation 1](#) and [Equation 2](#):

$$Accuracy_{min} = \left(1 - \frac{VIT_{min}}{VIT_{typ}}\right) \times 100 \quad (1)$$

$$Accuracy_{max} = \left(1 - \frac{VIT_{typ}}{VIT_{max}}\right) \times 100 \quad (2)$$

Note: the voltage threshold (VIT) can be displayed in the device datasheet as a voltage value or as a percent from the nominal VIT.

On the other hand, device tolerance refers to the percentage away from the nominal voltage rail to trigger a reset and is shown in [Equation 3](#).

$$tolerance = \left(1 - \frac{VIT_{typ}}{V_{rail\_nom}}\right) \times 100 \quad (3)$$

For example, a 3.3V device (TPS389033) will trigger a reset at 3.17V not 3.3V since 3.3V is considered a normal operating condition. This means the device tolerance for TPS389033 is ~4%.

## 11 Mitigating the Indeterminate Output of a Voltage Supervisor (Reset IC) During Power Up/Down?

Voltage supervisors require a minimum voltage called the Power-on Reset Voltage (Vpor) on the supply pin before the supervisor is operational. The output voltage of the supervisor is in an indeterminate state when the voltage supply is below Vpor. By simply connecting a JFET at the output, this indeterminate voltage can be eliminated.

Please see [Mitigating the Indeterminate Output of a Voltage Supervisor \(Reset IC\) During Power-Up/Down](#) TechNote for a detailed explanation.

## 12 What is the Minimum Pulse Width to Cause a Reset?

There are typically three ways to trigger a reset on a voltage supervisor/detector:

- VDD or SENSE (voltage fault)
- Manual Reset
- Watchdog

For VDD, the minimum pulse width to cause a reset is specified as "Pulse duration at VDD" and refers to the minimum pulse width on VDD for the voltage value to be recognized by the device. For devices with the SENSE pin, the minimum pulse width to cause a reset is specified as "SENSE pin glitch immunity". For a reset caused by the Manual Reset pin, the minimum pulse width is specified as " $\overline{MR}$  pin glitch immunity". For a reset caused by the watchdog, the pulse width is specified as "Minimum WDI pulse duration". All of these pulse widths are specified as typical values only with the exception of VDD which is most often specified as a minimum value.

## 13 How to Latch a Voltage Supervisor? How to Latch a Watchdog Timer?

Some applications require a latching output whenever a fault occurs that requires user intervention before the system can resume normal operation. In this case, latching circuitry can be added to Voltage Supervisors to either latch the  $\overline{RESET}$ , the WDO, or both. Please refer to [Latching a Voltage Supervisor \(Reset IC\)](#) and [Latching a Watchdog Timer](#) TechNotes for a detailed explanation.

## 14 How to Calculate Pull-up Resistor Value for Active-Low, Open-Drain Devices?

To calculate the value of the pull-up resistor for active-low, open-drain devices three specifications need to be considered. These are the pull-up voltage, the recommended maximum current through the **RESET** pin, and  $V_{OL}$ . To calculate the resistor, simply use Ohm's law of  $V=IR$ , where  $V$  is the difference of  $V_{pull-up}$  and  $V_{OL}$  and  $I$  is the current through the pull-up resistor, specifically chosen to satisfy the maximum current limit of the **RESET** pin and minimum current required by the load. Please refer to [Figure 13](#)

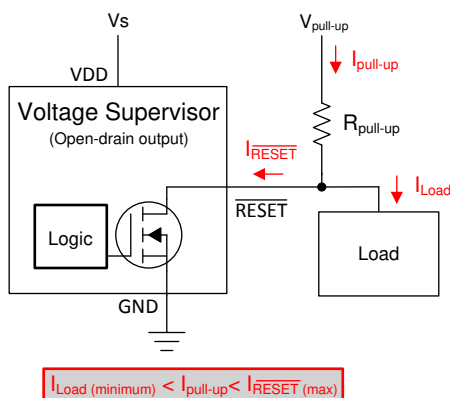


Figure 13. Calculating Pull-Up Resistor for Open-Drain Outputs

## 15 How to Add Hysteresis to a Voltage Supervisor Detection Threshold?

Some applications require supply voltage hysteresis, a voltage difference between rising and falling trigger thresholds, to keep a voltage supervisor from falsely resetting the system due to dips and glitches in the voltage supply. The TPS3808, for example, inherently has internal sensing voltage hysteresis of 6mV. That means the rising threshold is 6mV higher than the falling threshold and that amount of hysteresis may not be enough in some applications to avoid false resets. As shown in [Figure 14](#), without enough hysteresis, a voltage supply with ripple at the fault trigger threshold can cause the output to continuously trigger which is undesired.

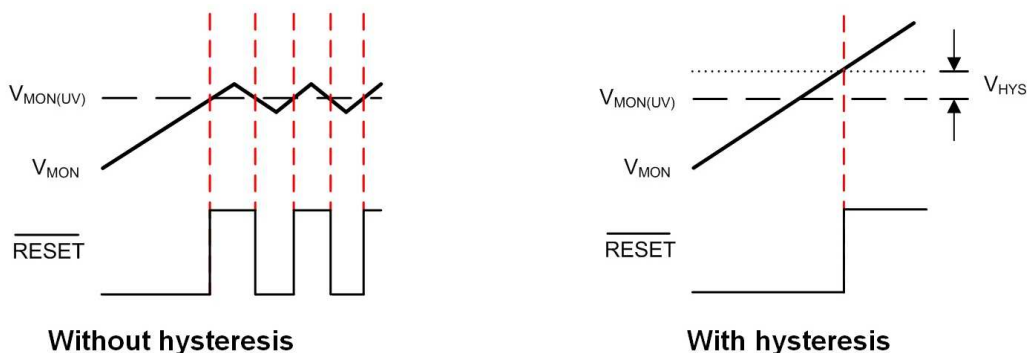
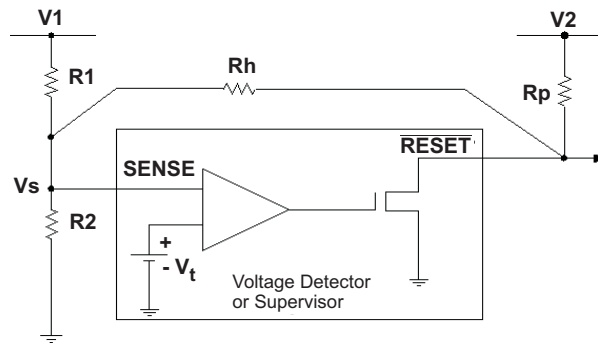


Figure 14. Voltage Monitoring Without Hysteresis (Left) and With Hysteresis (Right)

The solution to fix this issue is to add hysteresis so that the sense input must rise or fall by a larger voltage to release or trigger a fault. This is accomplished by adding a hysteresis resistor,  $R_h$ , as shown in [Figure 16](#).



**Figure 15. Adding Hysteresis Circuit**

This effectively prevents AC ripple or voltage glitches on the supply rail to falsely trigger resets.

Please see [Adding Hysteresis to Supply Voltage Supervisor](#).

## 16 What are Back-Up Battery Voltage Supervisors and Why are they Needed?

Battery back-up voltage supervisors are used in applications that require data retention of CMOS RAM during fault conditions. When the voltage at Vdd drops below a preset threshold, the reset output asserts AND Vout switches from Vdd to Vbat so that the battery can directly supply power instead of the falling voltage on Vdd. Battery back-up voltage supervisors are important in applications where brownout conditions cannot be tolerated as the back-up battery will provide the system with power and prevent any system malfunction or loss of data.

Please see [Using the TPS3619 with MSP430 Microcontroller Can Reduce the System Power Consumption with Charge Pumps](#) for more information on other back-up battery voltage supervisor applications.

## 17 Programmable Push-Button, Pulse Detection, and Pulse Generator Solutions

Voltage supervisors offer solution flexibility by providing programmable reset delay, enable and manual reset features, and various output logic and topologies. Voltage supervisors can be configured as programmable push-button devices such that the output only reponds after a push-button input has been pressed or released for a certian duration of time. With multiple voltage supervisors, programmable pulse detector and pulse generators can be created. See [Programmable Push-Button, Pulse Detector, and Pulse Generator Solutions](#) for more details.

## 18 Summary

For questions not addressed in this document, please visit [e2e.ti.com/support/power-management](http://e2e.ti.com/support/power-management) to post a question. These questions will be answered by a voltage supervisor expert, and may be featured in our next revision of this FAQ document.

## 19 References

These resources provide additional information and related documentation for Voltage Supervisors:

- To learn more about voltage supervisor basics, watch [Voltage Supervisor Basics Video Series](#)
- To understand voltage supervisor features in more detail, read [Selecting Voltage Detectors, Supervisors, and Reset ICs for System Safety: Part 1](#) and [Selecting Voltage Detectors, Supervisors, and Reset ICs for System Safety: Part 2](#)
- To see the voltage supervisor options available, see [Supervisors and Reset ICs Quick Reference Guide](#)
- Visit the TI Voltage Supervisors homepage: [Overview for Supervisors and Reset ICs](#)

## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Original (October 2018) to A Revision</b>	<b>Page</b>
• renamed <a href="#">Figure 11</a> title to reflect window watchdog on left, standard watchdog on right .....	<a href="#">9</a>
• Added <a href="#">Section 17</a> Programmable Push-Button, Pulse Detection, And Pulse Generator Solutions .....	<a href="#">12</a>

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