Application Brief
Using Voltage Supervisors in High Voltage Applications

TEXAS INSTRUMENTS

Introduction

Voltage supervisors come in many form factors with a variety of functions to help designers increase the robustness of their system. Voltage supervisors are typically used to monitor power rails. One of the advantages of using voltage supervisors in almost every design, industrial or automobile applications, is that supervisors help processors to prevent brownouts conditions to occur. Monitoring the power rails going into a MCU with a supervisor will help to reset the MCU from the unwanted voltage rail faults such as sudden voltage drops, spikes and transient.

Another popular purpose of a voltage supervisor is its ability to act as a comparator for battery or system power rail monitoring. Whenever an overvoltage or undervoltage event occurs, the supervisor can sense and react to this event. TI has very wide portfolio that can provide supervisors with different thresholds, accuracies, hysteresis so that low voltage power rails as well as high voltage power rails can be monitored.

Designers can choose between utilizing a properly rated high voltage supervisor or a low voltage supervisor with extra circuitry that allows the supervisor to operate beyond its recommended operating conditions. This application note covers several design solutions to monitoring high voltage power rails with both high and low voltage supervisors.

High Voltage Supervisors

Figure 1 shows the TPS37's low-complexity solution to monitoring both undervoltage and overvoltage conditions on a standard 24V rail. As the TPS37 is designed to handle up to 65V, the device can easily monitor a direct connection to a 24V power supply.

Similarly Figure 2 shows the TPS38 being used to monitor two separate voltage rails directly and Figure 3 shows the TPS3760 monitoring an undervoltage condition on a standard 12V rail.
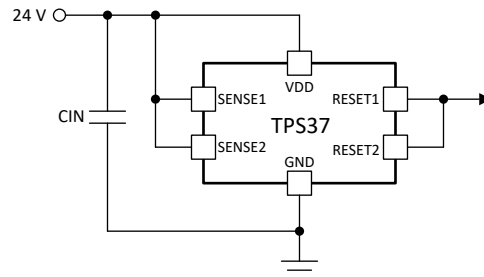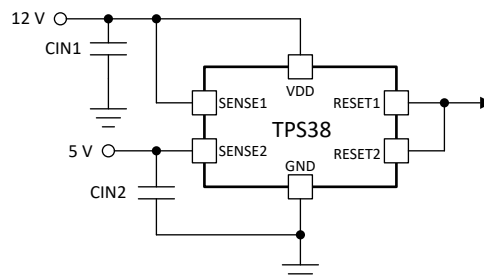

Figure 1. TPS37 Circuit
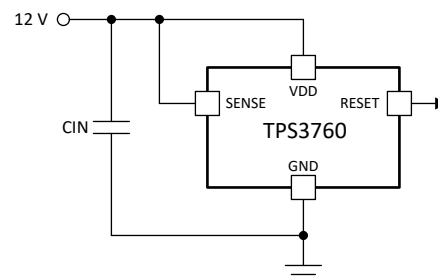

Figure 2. TPS38 Circuit

Figure 3. TPS3760 Circuit

Table 1. High Voltage Supervisor Comparisons

Features	TPS37	TPS38	TPS3760	TPS3762
Number of Channel	Dual	Dual	Single	Single
Window Supervisor	✓	—	—	✓
Output Reset Latch	—	—	—	✓
FuSa Capable / Compliant	Capable	Capable	Capable	Compliant

Programmable sense and reset time delay feature, low quiescent current, manual reset feature and having different output topologies options are some of the common features for TPS37, TPS38, and TPS3760. Please refer to application note Common Applications of Wide VIN Overvoltage and Undervoltage Supervisors for more details about key features of TPS3760, TPS37, and TPS38.

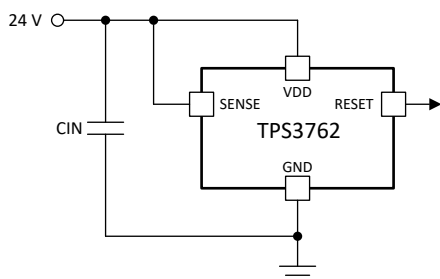**Figure 4. TPS3762 Circuit**

As shown in Figure 4, TPS3762 is another 65V window supervisor with low supply current that can also monitor directly to 12V / 24V. It also has output reset latching feature that can help bring the system to safe state, and built-in self-test feature that runs diagnostics internally in the device. One of the advantages of TPS3762 is that, thanks to the bist functionalty, SIL-3 Functional Safety-compliant level is targeted for TPS3762 for industrial applications, and ASIL-D Functional Safety-Compliant is targeted for TPS3762 -Q1 for automotive applications, which will help a designer to meet their functional safety requirements as shown in Table 1.

High voltage supervisors offer the simplest solution to monitoring high voltage rails. TI's high voltage supervisors are designed to handle voltages up to 65V with low current consumption for both industrial SELV power rails as well as automotive battery system. As these supervisors can be directly connected to high voltage power supplies without extra circuitry (as shown in Figure 5), they offer simple solutions to monitoring high voltage power rails with fast response times.
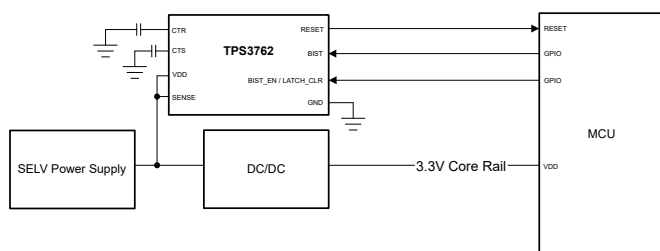

Figure 5. TPS3762 Typical Application

Low Voltage Supervisors

For some designs, there is a benefit to adapting a low voltage supervisor for voltage monitoring applications above the device's rated voltages. For example, some applications require the use of a low voltage supervisor such as the TPS3808E to monitor a standard 12V rail, despite the 6.5V functional limit of the TPS3808E. A solution to this is to add additional circuitry to help the supervisor stay within its recommended operating conditions. To do this there are two common approaches, which can be either adding in a voltage divider or adding in a shunt voltage reference. Table 2 outlines some of the differences between using these low voltage supervisor solutions or a high voltage supervisor like the TPS37.

Voltage Divider Method

One way of doing this is to use a voltage divider connected to the VDD pin of the supervisor to scale the power voltage rail down to a recommended level. For example, if you have a nominal 12V battery voltage rail that has 40V transients but need to power a TPS3840 of the same rail, the supervisor needs to still function when the rail is 40V. A solution to this is to connect the voltage divider to the VDD pin to scale the power to the recommended level on the TPS3840, as shown in Figure 6. One issue is that the voltage divider is always on and therefore will always have a leakage current. The low Iq of the TPS3840 allows the resistor values to be increased to lower the leakage current. The voltage divider method can increase the VDD capabilities of a supervisor as a low solution cost but come at the expense of power. In the case of noisy applications, TI recommends implementing an input capacitor on VDD when using a resistor divider. However, adding a capacitor on VDD can significantly slow down the response time of the device as it creates an RC circuit with CIN and the resistors used for the voltage divider.
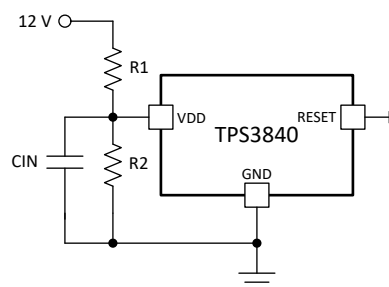

Figure 6. Voltage Divider at VDD

Shunt Voltage Reference

An alternative option is to use a shunt reference to clamp the input voltage, as shown in Figure 7. In this example a LM4040 reference is used to clamp VDD to 6.5V. Shunt references conduct very little current and then shunt the rest of the current above its set shunt voltage. In the situation that the voltage rail is below 6.5V, the current consumption will be low, and the shunt does not limit the voltage at the TPS3808E VDD pin. This means that the TPS3808E can regulate once the power rail is above the minimum input voltage. Implementing a shunt reference in this fashion creates a low-cost buck regulator that is only enabled when the voltage is above 6.5V. Figure 7 shows a typical example of how LM4040 can be implemented with a TPS3808E to monitor a 12V rail.
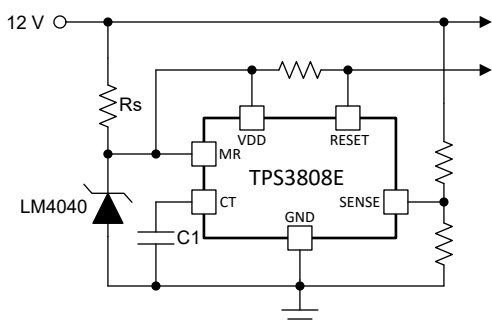
Figure 7. TPS3808E with Shunt Reference

Conclusion

There are a variety of ways to monitor a high voltage rail. TI offers a plethora of devices that can accomplish a wide range of functions that can benefit high voltage rail supervision. In general, TI recommends implementing one of its high voltage supervisors, that offer simple yet effective solutions to monitoring high voltage rails with fast response times and low power consumption. Using a low voltage supervisor with one of the outlined circuitry can be a viable solution for any high voltage need, provided the application does not require low-power consumption or fast response times. Table 2 compares some of the high voltage supervision solutions that TI offers within its portfolio.

Table 2. Design Solution Comparisons

Specs	TPS37	TPS38	TPS3840	TPS3808E + LM4040
Component Count	1 Capacitor	2 Capacitors	2 Resistors, 1 Capacitor	4 Resistors, 1 Capacitor, 1 LM4040
IC I_Q	1.2µA	1.2µA	700nA	0.6µA
Power Dissipation	Low approx. 1.2µA	Low approx. 1.2µA	High[1]	High approx. 65µA

(1) Using higher value resistors can decrease power dissipation, but can come at the cost of overall accuracy.

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