Application Note

Common Applications of Wide V_{IN} Overvoltage and Undervoltage Supervisors

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1 What are Wide V_{IN} Supervisors?

To increase the potential fault coverage of a system, voltage supervisors can be used to monitor a power rail and assert a reset signal when the monitored voltage rises above or falls below a desired threshold. Voltage supervisors are normally used to control protection circuitry for sensitive components and provide consistent behavior in the event of power faults. Wide V_{IN} supervisors are supervisors which are designed to support a wide input voltage range, typically greater than 18 V, on both the VDD supply pin and independent sense input pin. This allows for a wide range of possible configurations such as monitoring a high sense voltage with a high supply voltage, a high sense voltage with a low supply voltage, a low sense voltage with a high supply voltage, and a low sense voltage with a low supply voltage. An undervoltage (UV) supervisor detects only a voltage falling below the input threshold. An overvoltage (OV) supervisor detects only a voltage rising above the input threshold. A window supervisor provides both overvoltage and undervoltage monitoring, and is single device solution for cases where both types of monitoring are required. Wide V_{IN} supervisors are typically used to directly monitor a battery that can experience large voltage transients or monitor other common high voltage system rails without the need for extra components to perform level shifting.

1.1 Applications

Automotive applications

- Automotive controllers
- Automotive BMS
- Telematics control unit
- Emergency call system
- Audio amplifier
- Head unit and cluster
- Sensor fusion and cameras
- Body control module

Industrial applications

- Factory automation
- Industrial controllers
- Motor drives
- Analog input module
- CPU (PLC controller)
- Servo drive control module
- Servo drive power stage module
- Servo drive functional safety module
- HVAL valve and actuator control
- Server power supplies

1.2 Benefits of Wide V_{IN} Supervisors Compared to Low Voltage Solutions

- Wide V_{IN} supervisors are capable of directly monitoring 12 V, 24 V and 48 V rails common in industrial and automotive applications with low current consumption.
- Transients up to 65 V from a 12 V battery fall within the input voltage range of TI's wide V_{IN} supervisors. This allows for direct connection to a 12 V battery.
- Wide V_{IN} supervisors can draw power directly from a high voltage rail and monitor SENSE independently from VDD.
- Wide V_{IN} supervisors require few external components allowing for rapid response time, reduced Iq, and a smaller solution size compared to discrete voltage monitoring solutions.

2 Key Features

TI's TPS37, TPS38, and TPS3760 supervisor families support an input voltage range of 2.7 - 65 V, and have a rich feature set including:

- **OV, UV, and Window monitoring options:** Flexible options for monitoring undervoltage (UV) faults, overvoltage faults (OV) or both at the same time (window monitoring).
- **Fixed or adjustable voltage threshold options:** Voltage thresholds can be set using an external resistor divider, or with an internal divider built into the supervisor to limit solution size and Iq.
- **Threshold Hysteresis:** Voltage thresholds have built in hysteresis to help provide power supply stability. A variety of fixed hysteresis options are available for all of TI's wide V_{IN} supervisors, and some topologies allow hysteresis to be adjusted with external resistors.
- **Push pull and open drain output topologies:** A wide range of output topology options allow TI's wide V_{IN} supervisors to integrate seamlessly into the logic of any design.
- **Adjustable sense delay:** The sense delay determines how long the supervisor waits to assert a reset signal after a voltage fault is detected. This allows the supervisor to ignore glitches and known transients on the monitored rail and provides noise immunity. This time delay can be programmed with an external capacitor, allowing it to be tailored to meet specific power supply requirements.
- **Adjustable reset delay:** The reset delay determines how long the supervisor waits to deassert a reset signal after the monitored power rail returns to its acceptable range. This gives the rail time to stabilize after starting up or recovering from a fault. This time delay can be programmed with an external capacitor, allowing it to be tailored to meet specific power supply requirements.
- **Ultra low quiescent current (Iq):** TI's family of wide V_{IN} supervisors have an extremely low quiescent current (~1µA), which means very little power is used when idle. This makes them an excellent choice to power sensitive or battery powered applications.
- **Automotive qualified (-Q1) variants:** All of TI's wide V_{IN} supervisors are available in AEC-Q100 qualified variants designed for automotive end equipment

2.1 Product Comparison

Table 2-1.

	Vin Range	Iq	# of Rails Monitored	Separate VDD/Sense Pins	Adjustable Sense Delay	Adjustable Reset Delay	Sense Configuration	Voltage Threshold
TPS37	2.7 - 65 V	1 µA	2	✓	✓	✓	OV and UV (Window)	Fixed or Adjustable
TPS38	2.7 - 65 V	1 µA	2	✓	✓	✓	2x OV or 2x UV	Fixed or Adjustable
TPS3760	2.7 - 65 V	1 µA	1	✓	✓	✓	OV or UV	Fixed or Adjustable

Selection Guide

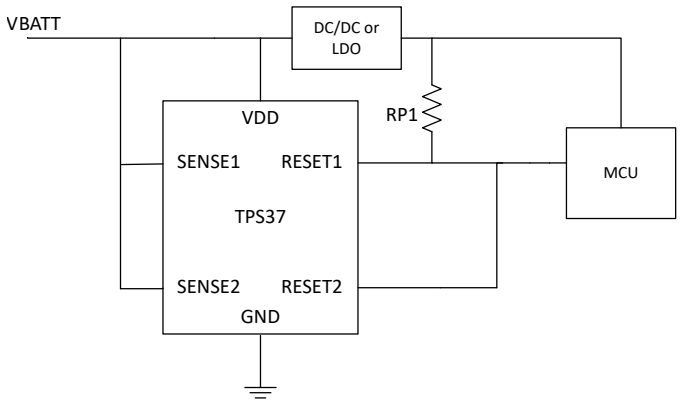
Application	Recommended Device
Single channel OV or single channel UV monitoring	TPS3760 or automotive AEC-Q100 qualified TPS3760-Q1
Single channel window monitoring or independent OV and UV monitoring	TPS37 or automotive AEC-Q100 qualified TPS37-Q1
Multichannel OV or multichannel UV monitoring	TPS38 or automotive AEC-Q100 qualified TPS38-Q1

3 Common Applications and Use Cases

This section describes common applications for wide V_{IN} supervisors. Each use case details the type of supervisor being used, how to implement, device recommendations, and application-based documents to consider.

Direct Battery Monitoring

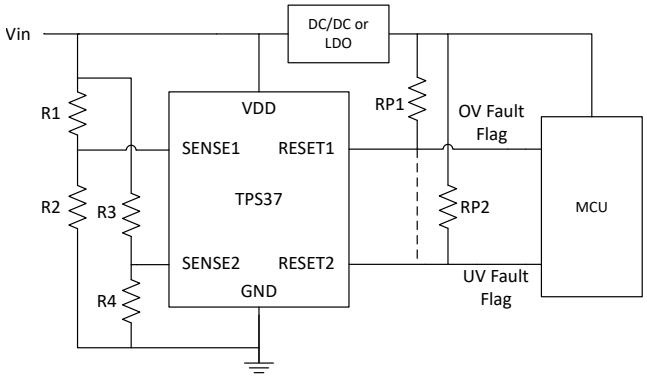
Due to the large capacitive delays present in most power supply designs, monitoring the source power rail directly can provide an earlier fault warning than monitoring a downstream rail. This presents a challenge for battery powered applications, as a supervisor directly connected to the battery constantly draws power. A low Iq supervisor with fixed thresholds minimizes total power draw. The TPS37 handles battery voltage transients up 65 V. The pullup resistor RP1 can be set to a standard value of 10 kΩ.



Device shown: TPS37-Q1 fixed threshold variants

Adjustable Window Monitoring

TPS37 is capable of monitoring a power rail for both OV and UV faults simultaneously. Reset signals for OV and UV faults can be tied together on an open drain bus as shown by the dashed line, or connected to the rest of the system independently. The voltage thresholds of the TPS37A010122DSKR are set with resistive voltage dividers R1, R2 and R3, R4. The linked online calculator below can be used to calculate the sense input resistors or refer to section 10.1 in the data sheet linked below for more information. Pullup resistors RP1 and RP2 can be set to a standard value of 10 kΩ.



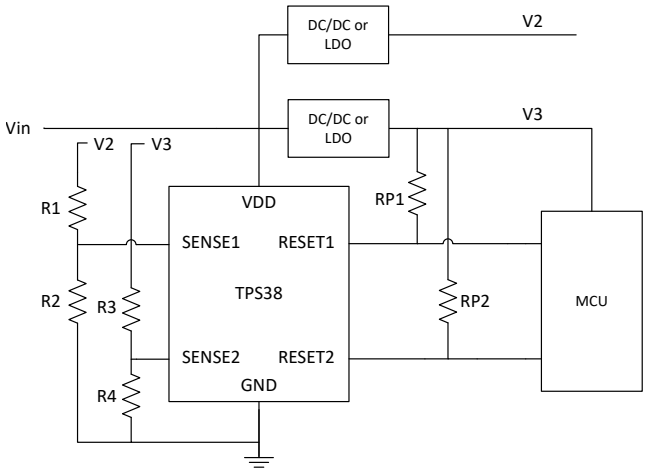
Device shown: TPS37A010122DSKR adjustable threshold variant

Additional resources: TPS37 data sheet section 10.1

TPS37 online design calculator

Monitoring Downstream Power Rails

Many types of end equipment power several downstream power rails using a source high voltage rail. For maximum fault tolerance, a supervisor monitoring the downstream rails must be powered by the source high voltage supply, so that the supervisor continues to function even if downstream power supplies fail. The linked online calculator below can be used to calculate the sense input resistors or refer to section 8.3.7 in the data sheet linked below for more information. Pullup resistors RP1 and RP2 can be set to a standard value of 10 kΩ.



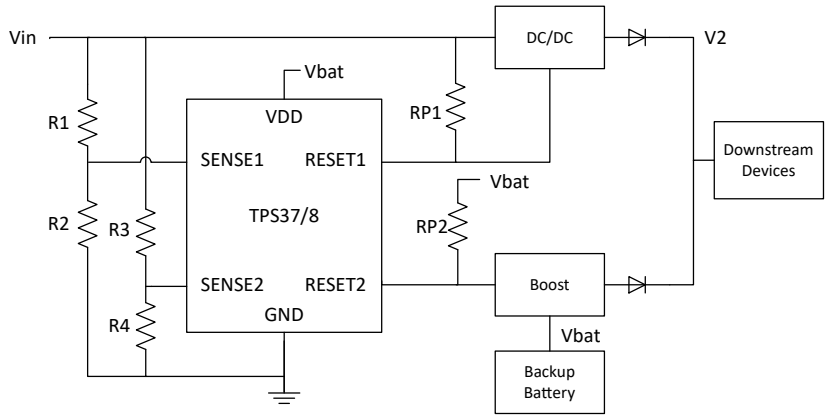
Device shown: TPS38A010122DSKRQ1 adjustable threshold variant

Additional resources: TPS38 data sheet section 8.3.7

TPS38 online design calculator

Battery Backup Management

A supervisor is used to start up a battery backup system when the primary voltage input falls below an operating threshold. The supervisor draws power directly from the battery backup, making sure that the supervisor is always on and monitoring the primary power rail. The linked online calculator below can be used to calculate the sense input resistors or refer to section 10.1 in the data sheet linked below for more information. Pullup resistors RP1 and RP2 can be set to a standard value of 10 kΩ.



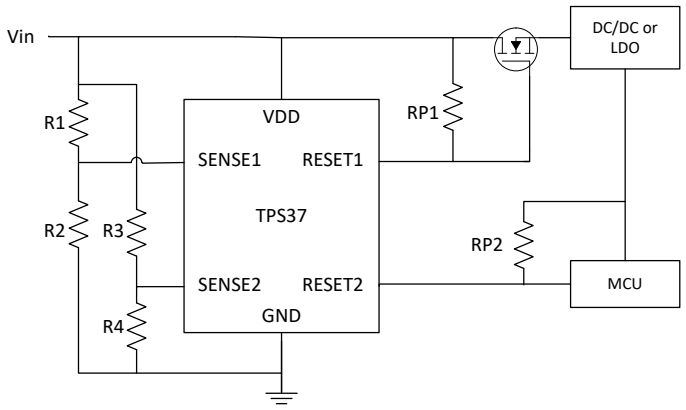
Device shown: TPS37A010122DSKR adjustable threshold variant

Additional resources: TPS37 data sheet section 10.1

TPS37 online design calculator

Low Current Load Switch Controller

Large OV transients can cause damage to downstream devices. An OV supervisor can be used to detect these transients and shut off a MOS device or load switch to disconnect downstream devices, protecting them from damage. The linked online calculator below can be used to calculate the sense input resistors or refer to section 10.1 in the data sheet linked below for more information. Pullup resistors RP1 and RP2 can be set to a standard value of 10 kΩ.



Device shown: TPS37A010122DSKR adjustable threshold variant

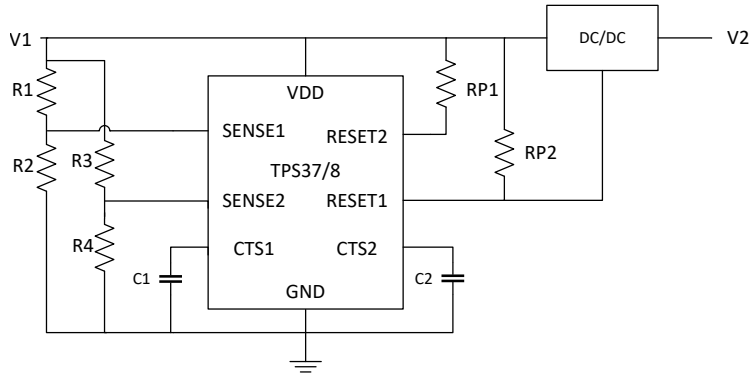
Additional resources: Monitoring 12V automotive battery systems technical article

TPS37 data sheet section 10.1

TPS37 online design calculator

Monitoring Rails With Known Transients

Adjusting the sense and reset delays on a supervisor allows for known transients to be accounted for by the design. If there are transients on a monitored rail which will cause unwanted behavior in downstream devices, then the sense delay can be set to make sure that reset is not asserted when these transients are encountered. The linked online calculator below can be used to calculate the delay capacitors or refer to sections 8.3.4 and 8.3.5 in the data sheet linked below for more information. Pullup resistors RP1 and RP2 can be set to a standard value of 10 kΩ.



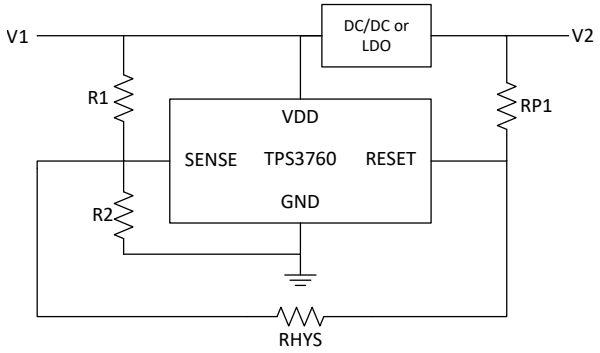
Device shown: TPS37A010122DSKR adjustable threshold variant or TPS38A010122DSKRQ1 adjustable threshold variant

Additional resources: TPS37 data sheet section 8.3.4

TPS37 online design calculator

Adjustable Hysteresis

For applications which require large hysteresis values, or different values of hysteresis for each channel, the hysteresis of the supervisor can be adjusted using external resistors as shown in the diagram below. Adjustable hysteresis requires an open drain active low output topology for UV channels and an open drain active high output high output topology for OV channels. The linked online calculator below can be used to calculate both RHYS and the sense input resistors. Pullup resistor RP1 can be set to a standard value of 10 kΩ.

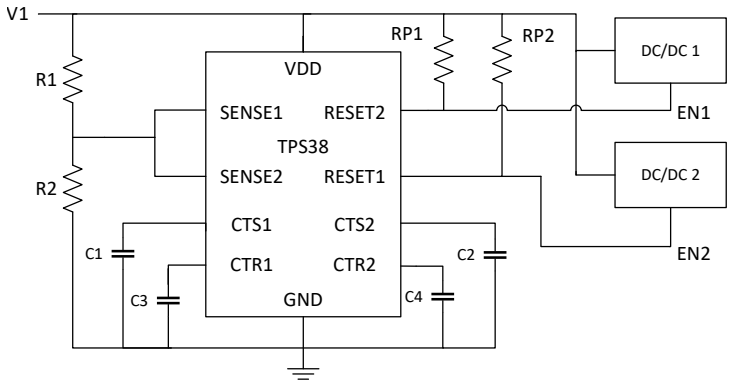


Device shown: TPS3760A012DYYR adjustable threshold variant

Additional resources: TPS3760 online design calculator

Power Sequencing

One or more supervisors can be used to enable/disable downstream LDOs or DC/DC converters in a desired order. The sense and reset delays of the supervisor/s can be used to set the timing of the sequence and make sure that successive power rails are not brought up until the previous rail has stabilized. R1 and R2 set the enable voltage of the sequence. C1 and C2 set the power down sequence. C3 and C4 set the power up sequence. The linked online calculator below can be used to calculate the delay capacitors or refer to sections 8.3.4 and 8.3.5 in the data sheet linked below for more information. Pullup resistors RP1 and RP2 can be set to a standard value of 10 kΩ.



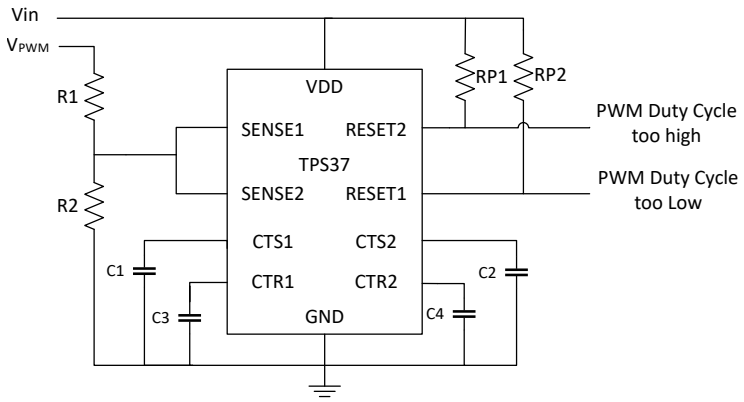
Device shown: TPS38A010122DSKRQ1 adjustable threshold variant

Additional resources: TPS38 data sheet section 8.3.4

TPS38 online design calculator

PWM Duty Cycle Monitoring

The duty cycle of a PWM signal is monitored using the sense pins of a window supervisor along with the sense and reset delays. When the duty cycle of the PWM signal is above threshold, a pulsing output is observed on the OV reset output. When the duty cycle of the PWM signal is below threshold, a pulsing output is observed on the UV reset output. Capacitors C1-C4 set the pulse width. The linked online calculator below can be used to calculate the delay capacitors or refer to sections 8.3.4 and 8.3.5 in the data sheet linked below for more information. Pullup resistors RP1 and RP2 can be set to a standard value of 10 kΩ.



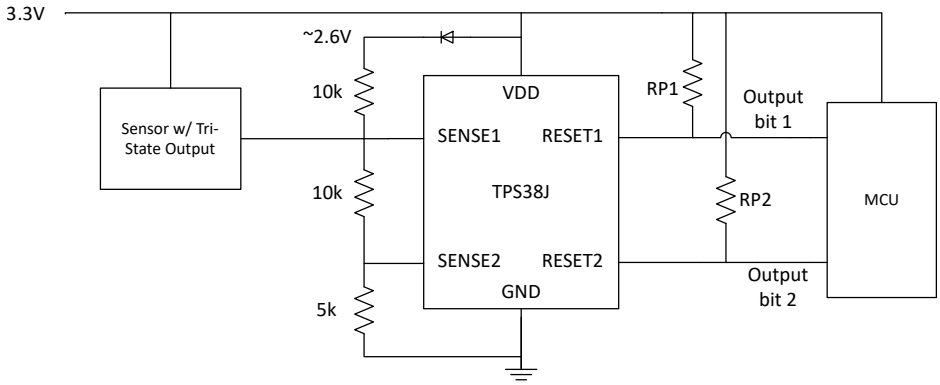
Device shown: TPS37A010122DSKR adjustable threshold variant

Additional resources: TPS37 data sheet section 8.3.4

TPS37 online design calculator

Tri-state Pin Decoding

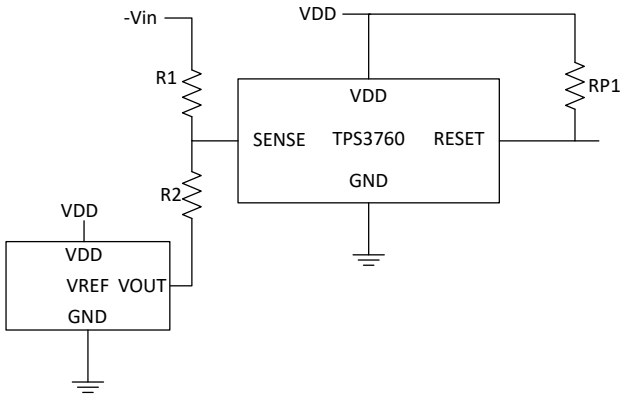
In this application, the voltage sensing pins on a supervisor are used alongside a resistor divider to decode a tri-state sensor input into a 2-bit binary value which can be read using standard digital I/O pins. The SENSE pins on TPS38 are 65 V tolerant, ensuring robustness to transients introduced by a sensor connector. Pullup resistors RP1 and RP2 can be set to a standard value of 10 kΩ.



Device shown: TPS38J010155DSKRQ1 adjustable threshold variant

Negative Voltage Monitoring

With the addition of an external reference and resistor divider, a wide V_{IN} supervisor can be modified to monitor negative voltage rails. The resistor divider values for a specific threshold voltage can be calculated using the equation 0.8V = (R1*V_{ref} + R2*V_{th}) / (R1+R2) More detailed instructions and calculations can be found at the link below. Pullup resistor RP1 can be set to a standard value of 10 kΩ.



Device shown: TPS3760A012DYYR adjustable threshold variant

Additional resources: Voltage Supervisor and Reset ICs: Tips, Tricks and Basics E-book

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