

## Overvoltage Protector for High-Voltage Loads

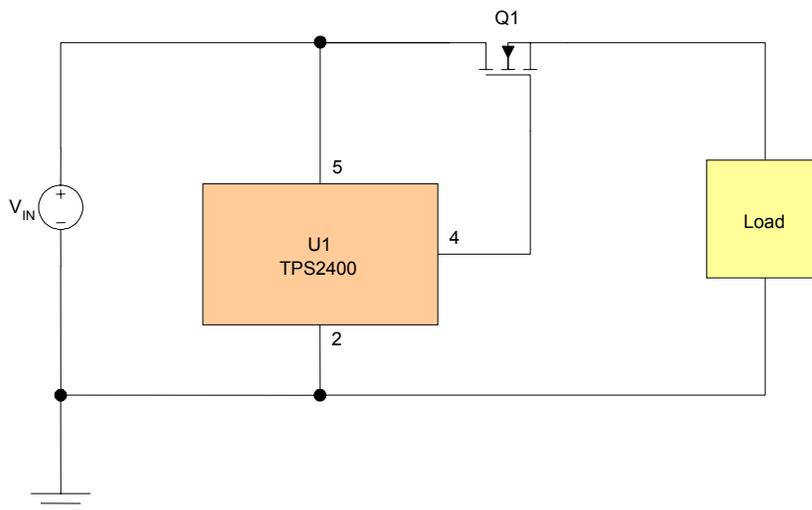
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### ABSTRACT

The TPS2400 has fixed turnon and turnoff thresholds of 3 V and 6.9 V, respectively, making it an ideal overvoltage protector for 3.3-V and 5-V loads that are 6.9-V tolerant. However, many loads have an operating voltage that is greater than 6.9 V. To be compatible with these loads, the overvoltage threshold of the protector circuit can be raised above 6.9 V using the scheme presented in this application report.

### A Basic Overvoltage Protector

Figure 1 shows a basic TPS2400 circuit that connects the load to the power supply if  $V_{IN}$  is between 3 V and 6.9 V and disconnects the load from the power supply if  $V_{IN}$  is outside this range. The operating voltage of the load must be less than 6.9 V (e.g., 74HC CMOS logic systems); otherwise, the circuit does not apply power to the load.



**Figure 1. A Basic TPS2400 Circuit That Can Drive a 6.9-V Load**

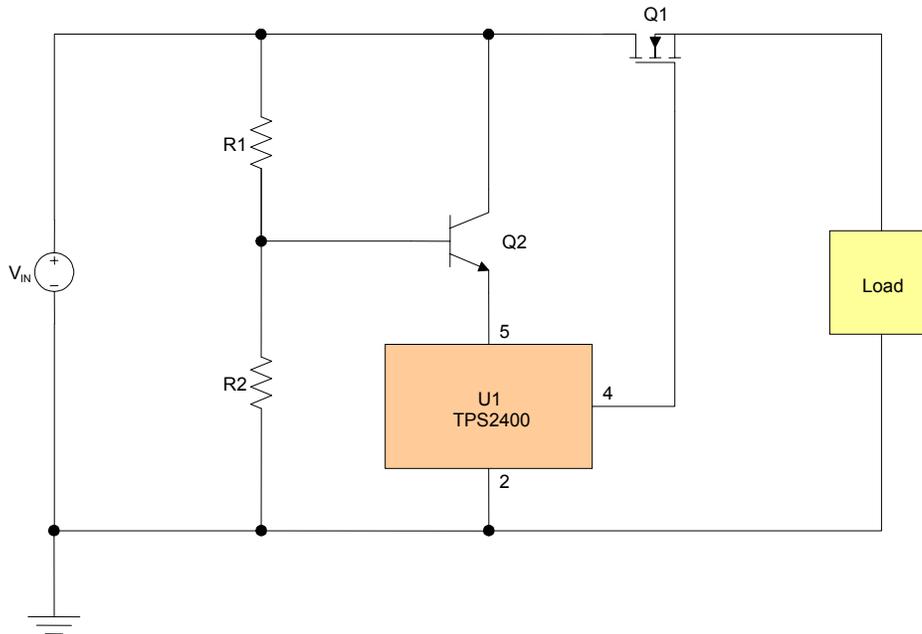
### Driving a High-Voltage Load

The circuit in Figure 2 has higher threshold and hysteresis levels than the circuit in Figure 1. These threshold and hysteresis levels are defined by Equations 1 and 2, respectively. A higher overvoltage threshold allows the circuit in Figure 2 to drive a load with more than 6.9 V without shutting down.

$$V'_t = \left(1 + \frac{R1}{R2}\right) \times (V_t + 0.5) \quad (1)$$

$$V'_{hyst} = \left(1 + \frac{R1}{R2}\right) \times V_{hyst} \quad (2)$$

The parameter  $V_t$  represents the TPS2400 undervoltage lockout or overvoltage protection threshold and the parameter  $V_{hyst}$  is the corresponding hysteresis.



**Figure 2. A High-Side Switch Overvoltage Protector That Can Drive a 12-V Load**

For example, if R1 is equal to 2.49 k $\Omega$  and R2 is equal to 5.11 k $\Omega$ , then the undervoltage lockout threshold and corresponding hysteresis are:

$$V'_{UV} = \left(1 + \frac{2.49k\Omega}{5.11k\Omega}\right) \times (3V + 0.5V) = 5.21V \quad (3)$$

$$V'_{hyst(UV)} = \left(1 + \frac{2.49k\Omega}{5.11k\Omega}\right) \times 100mV = 144mV \quad (4)$$

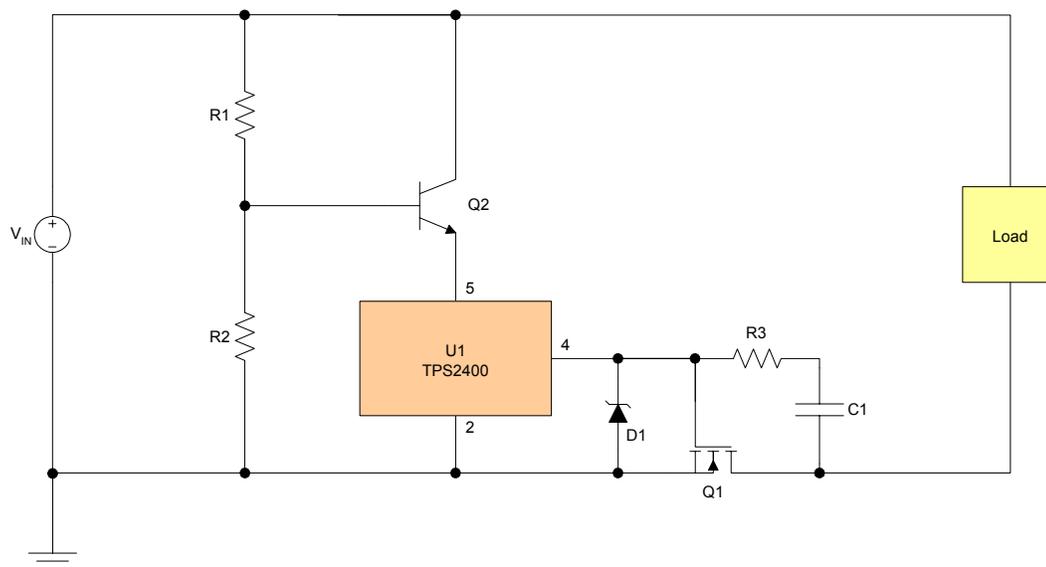
The overvoltage protection threshold and corresponding hysteresis are:

$$V'_{OV} = \left(1 + \frac{2.49k\Omega}{5.11k\Omega}\right) \times (6.9V + 0.5V) = 11V \quad (5)$$

$$V'_{hyst(OV)} = \left(1 + \frac{2.49k\Omega}{5.11k\Omega}\right) \times 150mV = 223mV \quad (6)$$

Because transistor Q1 is wired as a source follower, the 16-V gate drive of the TPS2400 limits the load voltage to no more than 12 V dc (i.e., assuming transistor Q1 is logic level).

Equations 1 and 2 are also valid for the low-side switch overvoltage protector in Figure 3. An advantage of this circuit is the ability to drive a 100-V load.



**Figure 3. A Low-Side Switch Overvoltage Protector That Can Drive a 100-V Load**

Capacitors C1 and  $C_{rss}$  (i.e., gate-to-drain capacitance) of transistor Q1 set the turnon voltage slew rate that is described by Equation 7.

$$\frac{\partial V_L}{\partial t} \approx \frac{5\mu A}{C_1 // C_{rss}} \quad (7)$$

The value of resistor R3 is typically 1 k $\Omega$  – 10 k $\Omega$ . This resistor decouples capacitor C1 from the circuit so that the TPS2400 can rapidly turn off transistor Q1 in response to an overvoltage transient. Zener diode D1 is required only if transistor Q1 has a gate-to-source voltage rating below 20 V.

## Transistor Selection

Transistors Q1 and Q2 are rated at 100 V or higher for  $V_{DSS}$  and  $V_{CEO}$ , respectively, if 100-V transients are present. For a 1-A load, a logic-level threshold device like an International Rectifier's IRLD120 is recommended for transistor Q1 in Figure 2, whereas, a standard threshold device like an IRFD120 is recommended for transistor Q1 in Figure 3. Because transistor Q2 dissipates little power, a general-purpose, high-voltage NPN transistor like a Rohm 2SC4102 works in all applications.

## Summary

In its basic configuration, the TPS2400 provides overvoltage protection to a load with an operating voltage of up to 6.9 V. The simple voltage-divider circuit that is described in this application report allows the TPS2400 to provide overvoltage protection to a load with an operating voltage of up to 100 V.

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