Low-dropout linear regulators double as voltage-supervisor circuits

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Many low-dropout voltage regulators include an enable-input pin that can also serve as an inexpensive alternative to a voltage-supervisor IC. Although the enable pin normally serves as a means of shutting down the regulator's output to save power, a few discrete components ensure that the regulator's output will turn on and off at appropriate input voltages. Thus, you can use the circuit as a voltage supervisor or as a controlled-characteristic linear-voltage regulator.

A typical low-dropout regulator's internal enable circuit comprises a voltage comparator that determines whether the voltage at the enable pin is either larger or smaller than an internal reference voltage, V_{REF}. Although you can create a low-dropout voltage supervisor by directly connecting the enable pin to the unregulated input voltage, this circuit's turn-on and turn-off voltages equal the reference voltage, which typically falls below the minimum operating voltage that most ICs powered by the regulator's output require.

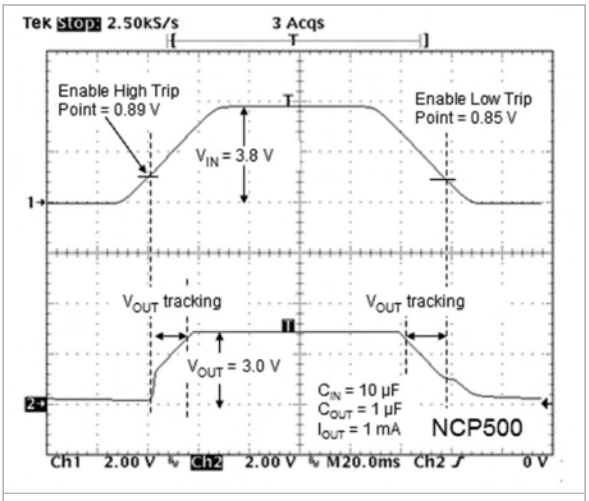

Figure 1 Connecting a low-dropout regulator's enable pin directly to the unregulated voltage input forces the output voltage to track the input voltage during the regulator's turn-on and turn-off intervals.

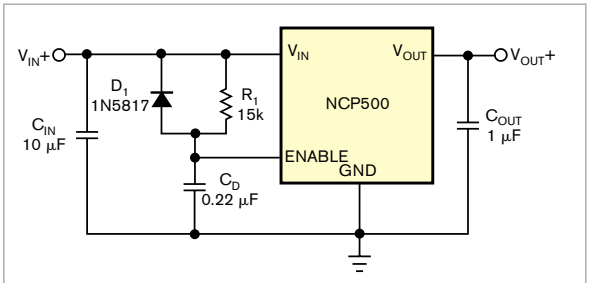

Figure 2 An alternative to directly connecting the regulator's input and enable pins, this "conventional" modification uses a resistor and a capacitor to delay the regulator's turn-on time. The diode eliminates the power-down delay interval.

In addition, directly connecting the enable pin to the unregulated input doesn't provide a turn-on delay to ensure that the input voltage has reached a value higher than the low-dropout regulator's dropout voltage. The directly connected circuit has unsatisfactory power-up and power-down characteristics (**Figure 1**). As a first-order improvement, you can enhance the circuit's performance by adding R_1, C_{IN}, and D_1 to provide a start-up delay for the voltage regulator's enable pin (**Figure 2**). Unfortunately, the external delay network improves the output's rising-edge characteristic, but its falling edge continues to track the input voltage (**Figure 3**).

You can solve the circuit's shutdown problem by replacing the single resistor with a voltage-divider network (**Figure 4**). Resistor R_2 raises the switching threshold of the regulator's enable pin and "tricks" the enable comparator into turning on at a higher voltage. The regulator's output then exhibits an adequate start-up delay and

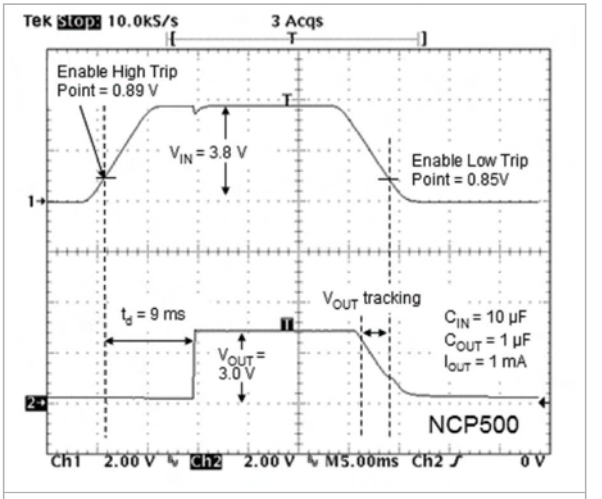

Figure 3 The added components in Figure 2 eliminate the problem of rising-edge output-voltage tracking. However, the falling-edge output voltage still tracks the input voltage.

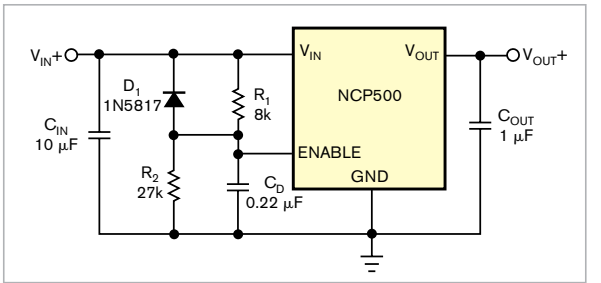

Figure 4 Resistor R_2 increases the enable pin's switching threshold voltage.

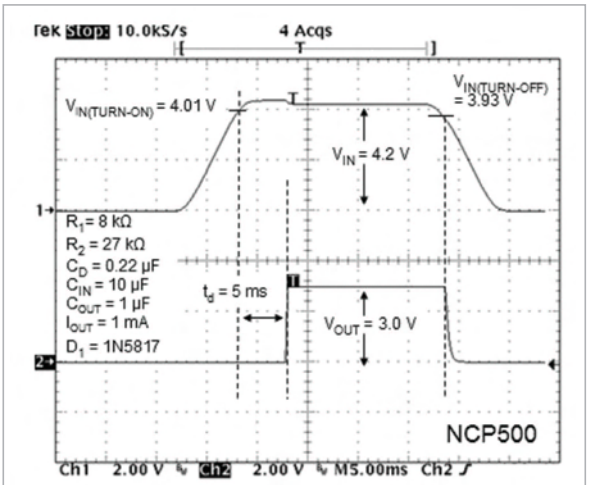

Figure 5 The addition of R_2 in Figure 3 solves the falling-edge problem, and shutdown occurs immediately after the input voltage drops too low. The regulator's output switches on only after sufficient voltage is present at its input.