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Build a negative-voltage power-side switch

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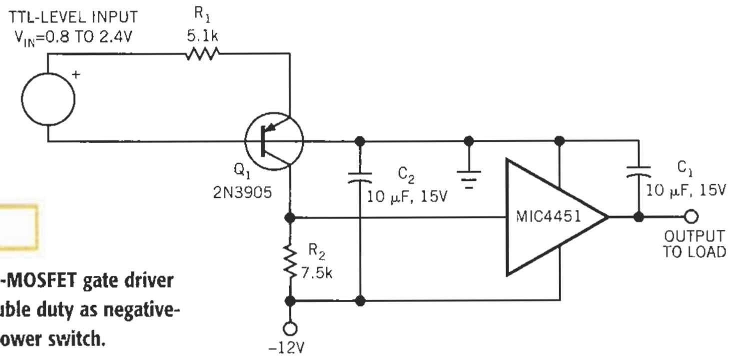
When you need to quickly connect a negative power supply under logic control, the negative power-side switch in **Figure 1** can help. Although originally intended for driving the gates of high-current MOSFETs, the MIC4451 can assume a different role. It provides complementary, low-on-resistance MOSFET switches to connect a system power-supply rail to a negative input voltage or to ground, enabled by a digital signal. The MIC4451 comprises an input buffer with a small amount of hysteresis and several logic inverter/buffers that ultimately drive a high-current output stage. **Figure 2** shows a block diagram of the MIC4451. The on-resistance of the n- and p-channel devices at the output is approximately 1Ω. So, the output can connect a 100-mA load to the negative input voltage with less than 100-mV voltage drop. A noninverting version, the MIC4452, simplifies inversion of logic control as needed. **Figure 1** shows details of the interface of the MIC4451 to TTL levels, using a common-base pnp transistor for level translation. The emitter current of Q_1 is approximately: $I_E=(V_{TTLH}-V_{BE})/R_1\approx(2.4-0.65)/R_1$, where V_{TTLH} is the TTL-high level, 2.4V. I_E should be $\leq$400 µA in accordance with TTL specs, so $I_E=(2.4-0.65)/R_1\leq400$ µA.

Figure 1



A power-MOSFET gate driver does double duty as negative-supply power switch.

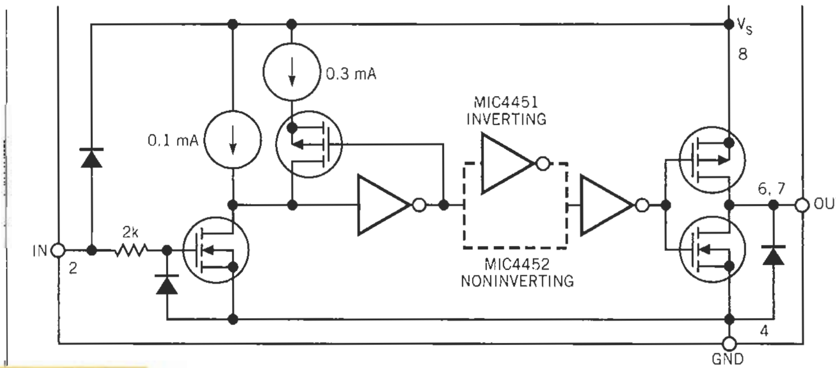
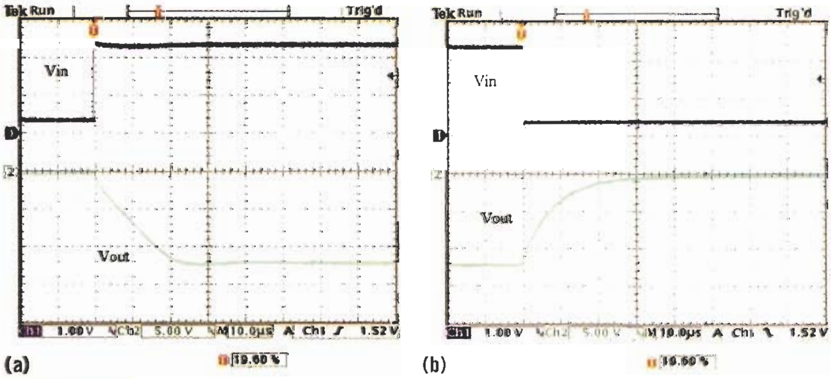


Figure 2 **The MIC445x FET driver includes low-on-resistance complementary FETs.**



(a) (b)

Figure 3 **Turn-on (a) and turn-off (b) characteristics of the circuit in Figure 1 are for a −12V supply.**

Solving for R_1, you obtain $R_1\geq1.8\text{V}/400\ \mu\text{A}=4.5\ \text{k}\Omega$. The V_{IH} (lowest permissible high input) logic-level specification of the MIC4451 is 2.4V. Ignoring base-current errors, $I_C\approx I_E$, so $R_2I_C\geq2.4\text{V}$. Note that the MIC-4451's input voltage, V_{IH}, is specified with respect to the ground pin of the part. To determine R_2:R_2=2.4V/

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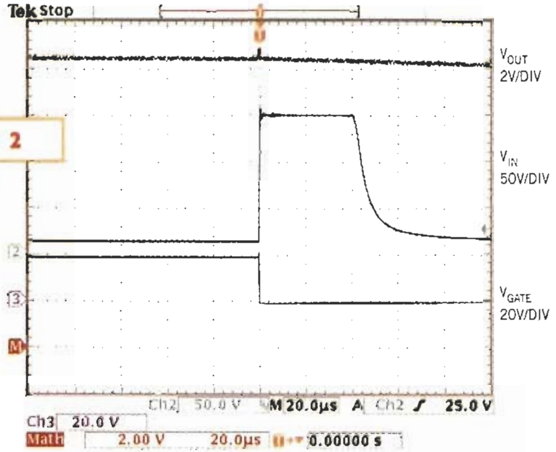
Figure 2



A 150V transient applied to V_{IN} of the Figure 1 circuit has little effect on V_{OUT}.

detector. The power switch and series-connected power rectifier, D_1, protect the load against high-voltage transients and continuous overvoltage as high as ±500V of either polarity.

In the circuit, which powers loads as heavy as 1A from a nominal 12V power line, a high-side-switch driver, IC_1, biases the power switch fully on. You can increase the maximum load current by changing D_1 and Q_1. To guard against low supply voltage, IC_1 includes an undervoltage-lockout feature that allows operation only when the line voltage is greater than 10V. To protect against overvoltage, the circuit includes a three-transistor, no-bias-current, 50-nsec-operation overvoltage detector that triggers when the input voltage reaches approximately 20V. At that time, Q_4 "crowbars" the gate of the power switch to ground, turning it off hard. Rising overvoltage first turns on zener diode D_2, which protects the IC by clamping the voltage across it to approximately 18V. Zener current flows through the 2.2-kΩ resistor, producing a base voltage that turns on Q_2. That action initiates a rapid sequence: Q_3 turns on, which turns on Q_4, which turns off Q_1 by quickly discharging its gate capacitance.

You can demonstrate the circuit's performance by applying a 150V transient to the supply voltage while the circuit output is delivering 1A at 12V (**Figure 2**). The internal impedance of the transient source is 1Ω, and the rise time of the applied voltage is 1 µsec. The circuit draws 20 µA during normal operation, including 3 µA by the undervoltage-lockout, voltage-sensing divider and 17 µA by IC_1. If your design needs high-temperature operation, note that the gate-current output of IC_1 is relatively limited. Your design calculations for high temperature should also pay close attention to leakage currents that the other circuit components contribute.□