Circuit Breaker Handles Voltages to 32V

A current-sense amplifier, external CMOS switch and several external transistors can be used to create a circuit breaker function.

The simplicity of low-side current monitoring can mask the advantages of a high-side approach. You can monitor load currents in a power supply, a motor driver, or another power circuit on either the high or the low side (ground). However, don't let the ease of low-side monitoring cause you to overlook its dangers or the advantages of a high-side approach. Various fault conditions can bypass the low-side monitor, thereby subjecting the load to dangerous and undetected stresses. On the other hand, a high-side monitor connected directly to the power source can detect any downstream failure and trigger the appropriate corrective action. Traditionally, such monitors required a precision op amp, a boost power supply to accommodate the op amp's limited common-mode range, and a handful of precision resistors. Now, the MAX4172 IC can sense high-side currents in the presence of common-mode voltages as high as 32V (**Figure 1**). IC_1 provides a ground-referenced current-source output proportional to the high-side current of interest. This output current, equal to the voltage across an external sense resistor divided by 100, produces a voltage output across a load resistor.

IC_1 and a few external parts form a low-cost circuit breaker. R_{SENSE} senses load currents, and Q_1 controls the currents. The design accepts inputs of 10 to 32V; you can easily modify it to operate from voltages as low as 6.5V. The initial application of V_{IN} and V_{CC} places the breaker in its trip state. Pressing S_1 resets the breaker and connects power to the load, thereby activating Q_1 , Q_3 , and Q_{4B} . Q_3 powers IC_1 , and Q_{4B} establishes the overcurrent threshold, $V_{THRESH} = V_{CC} - V_{BE(4B)}$. Because V_{CC} (2.7 to 5.5V typical) equals 5V and the base-emitter voltage of Q_{4B} is approximately 0.7V, V_{THRESH} is typically 4.4V. The circuit trips at a nominal load current of 1A. The values for R_{SENSE} , R_{THRESH} , and R_{OUT} are functions of the system's accuracy and power-dissipation requirements. First, select R_{SENSE} =50 mΩ and R_{THRESH} =10 kΩ. Then, calculate $R_{OUT} = V_{CC} / I_{LOAD} R_{SENSE} G_m$, where I_{LOAD} is the trip point (1A) and G_m (IC_1 's typical transconductance) equals 0.01A/v. Thus, R_{OUT} =10 kΩ.

Applying power to Q_3 and Q_{4B} causes Q_{4B} to conduct, which establishes V_{THRESH} and activates Q_3 to power IC_1 . A fraction of the load current through R_{SENSE} mirrors to the IC_1 output and appears as a voltage, V_{OUT} , across R_{OUT} . Q_{4B} turns off when V_{OUT} increases above (V_{THRESH} + $V_{BE(4BA)}$), turning off Q_3 and causing a drop in V^+ (IC_1 , pin 8). When V^+ reaches 2.67V (typical), $\overline{PG}$ goes high, thereby tripping the breaker by turning off Q_1 . Q_2 adds feedback to ensure a clean turn-off at the trip level. Current draw in the tripped state is minuscule and equals the V_{CC} load current, 0.5 mA typical. Press S_1 to reset the breaker. The design is intended for low-cost applications in which the absolute accuracy of the trip current is not critical. The accuracy, which depends on variations in V_{CC} and the base-emitter voltages of Q_{4A} and Q_{4B} and on the error current through R_4 , is approximately ±15% at a trip current of 1A. (DI #2532)

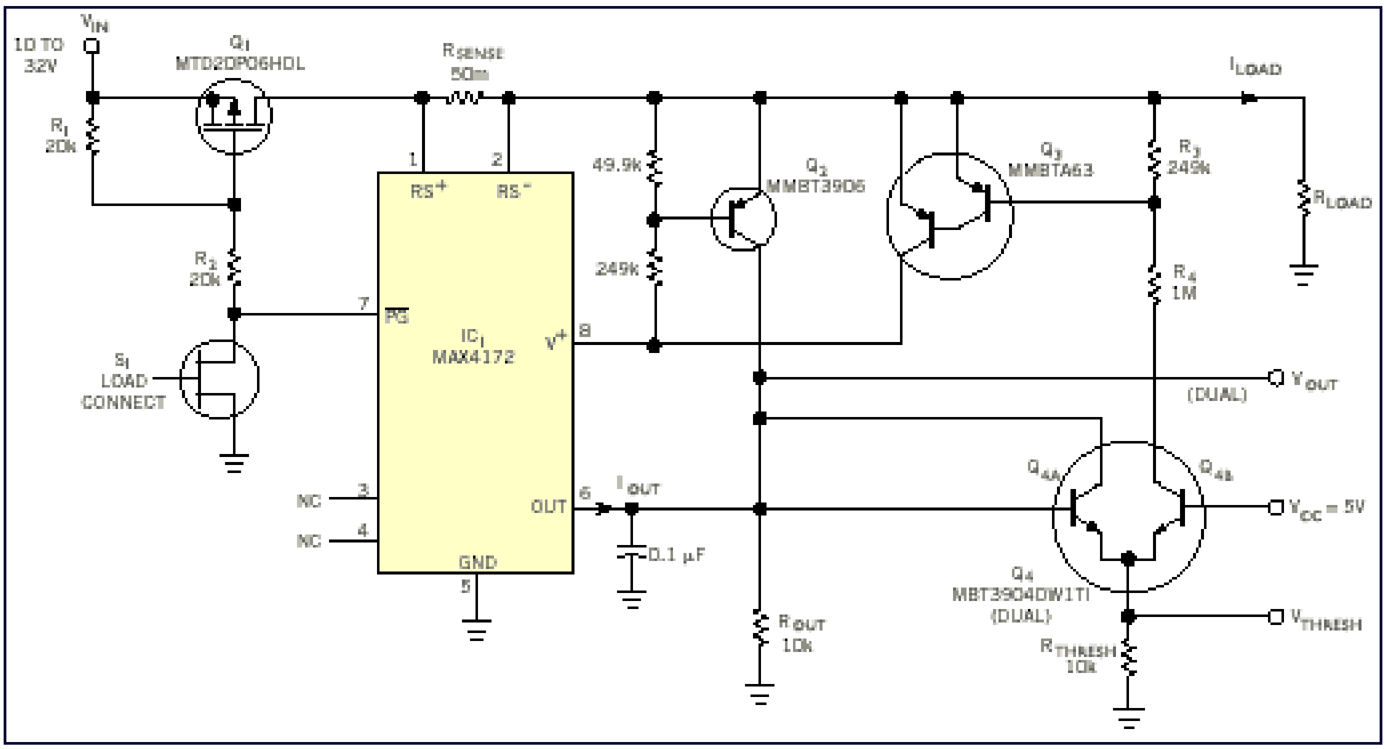

Figure 1. A current sense amplifier and a few transistors form a low-cost circuit breaker.

More Information

MAX4172: QuickView -- Full (PDF) Data Sheet -- Free Samples