Circuit senses high-side current from negative supply

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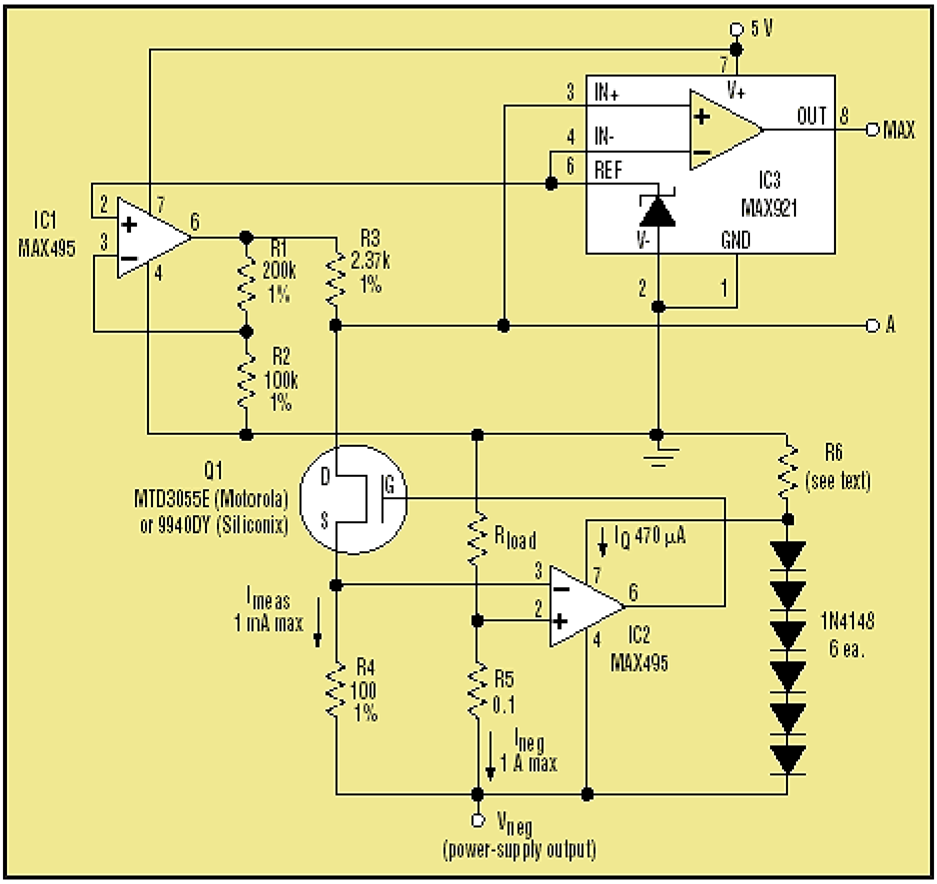
The circuit shown monitors the flow of load current into a negative voltage source (Fig. 1). This requirement often arises in private branch exchanges, in ISDN power supplies, when monitoring supply currents in the central-office supply of a telecom system, or when monitoring current from the negative supply rail of an audio amplifier.



1. This circuit monitors high-side load current into a negative supply, generating a digital alarm (MAX) when the current reaches its maximum.

Ground-side current sensing is relatively easy, but most of these cases feature supply-side sensing and its associated design problems. Small current-sense voltages near the negative rail are difficult to measure; few op amps can handle the high voltages involved (approximately −48 V to −72 V).

Fewer still offer the required rail-to-rail operation and the resulting current measurement signal must be transferred and level-shifted for suitable interfacing with a microcontroller. The current-sense resistor (R5) is on the "hot side" of the load with a value that allows maximum load currents of 1 A. Its tolerance should be 1% for acceptable accuracy. You can easily set other maximum load currents (INEGmax) by adjusting the resistor's value:

$R5 = 100\ mV/I_{NEGmax}$

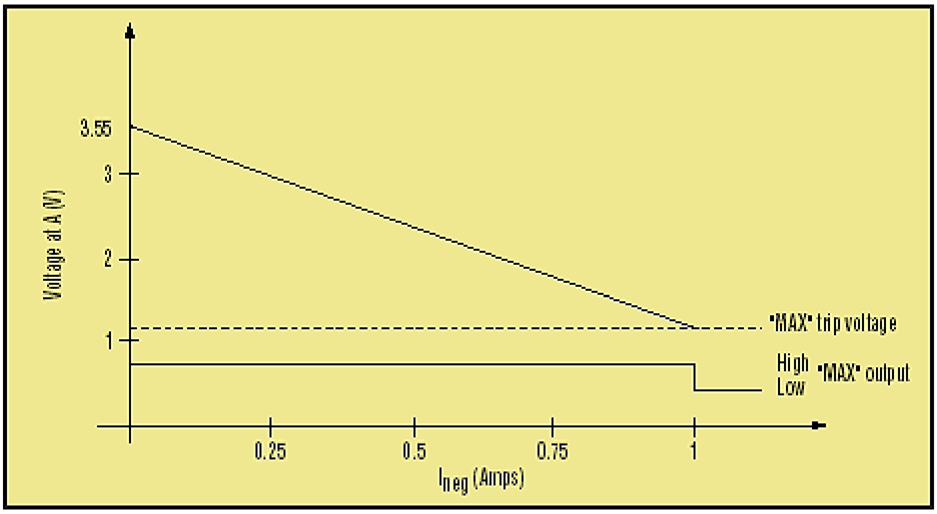
The rail-to-rail operation of opamp IC2 enables it to recognize the small positive voltage produced at its noninverting input by the load current through R5. IC2's gate drive to the MOSFET then causes an identical voltage to appear across R4. R4's value (100 Ω) is of similar tolerance but 1000 times that of R5, so its current is 0.001 that of R5. This R4 current flows through the MOSFET and R3. IC2's low offset value (500 mV maximum) has little effect on the accuracy of current through R3.

IC2's low quiescent current (170 µA maximum) and low operating voltage allow operation with a simple power supply. Six 1N4148 diodes in series produce sufficient voltage (4 V) to operate the op amp and provide adequate gate drive to the MOSFET. This arrangement also allows use of a single-supply op amp. For a given value of V_{NEG}, R6 should bias the diodes at about 500 µA:

$R6 = (4V - V_{NEG})/500\ \mu A$

(you also can use a 3.5V-to-6V Zener diode in place of the 1N4148s.)

Op-amp IC1 amplifies the 1.182-V reference in IC3 by a factor of three, producing an output of 3.55 V. Thus, as the load current (I_{NEG}) ranges from 0 to 1 A, the current in R3 ranges from 0 to 1 mA, producing a signal voltage (A) that ranges from 3.55 V down to 1.182V (Fig. 2). This range ensures that "A" remains positive for maximum load currents.



2. The signal voltage "A" in Figure 1 varies with load current as shown, producing the digital warning signal (MAX) at the specified maximum. Polarity of this signal can be easily changed.

Signal voltage "A" also connects to IC3, so the comparator output changes from high to low when the load current reaches its 1-A maximum. The polarity of this digital output can be changed by swapping the comparator's input connections.