MOSFET enhances low-current measurements using moving-coil meter

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A previous Design Idea describes an interesting and useful method for using a moving-coil analog meter to measure currents in the less-than-1A range (**Reference 1**). The design offers considerable flexibility in the choice of meter-movement sensitivity and measurement range and simplifies selection of shunt resistors. Although the design uses a bipolar meter-driver transistor, under some circumstances, a MOSFET transistor represents a better choice. The original circuit comprises a voltage-controller current sink that measures the bipolar transistor's emitter current, but the transistor's collector current drives the analog meter. A bipolar transistor's emitter and collector currents, I_E and I_C, respectively, are not identical because base current, I_B, adds to the emitter current.

You can express these current components as $I_E=I_C+I_B$ and then as $I_C=I_E-I_B$. Whether base current adversely affects the measurement accuracy depends on the magnitude of I_B and the magnitude of the common-emitter current gain, β, because base current $I_B=I_C/β$. When β is greater than 100, the base current's contribution to emitter current is generally negligible. However, β is sometimes smaller. For example, the general-purpose BC182, an NPN silicon transistor, has a low-current β of only 40 at room temperature. If you were to use a 15-mA-full-scale meter in the transistor's collector, full-scale base current I_B at minimum β would amount to 0.375 mA. Subtracting base current from collector current introduces a 2.5% error.

But if you use a moving-coil meter that requires 150 μA for full-scale deflection, the measurement error increases considerably because β decreases as collector current decreases. For the BC182, reducing collector current from a few milliamps to 200 μA, current gain decreases β by a factor of 0.6 and adversely affects the meter reading's accuracy.

To solve the problem and improve the circuit's accuracy, you can replace the

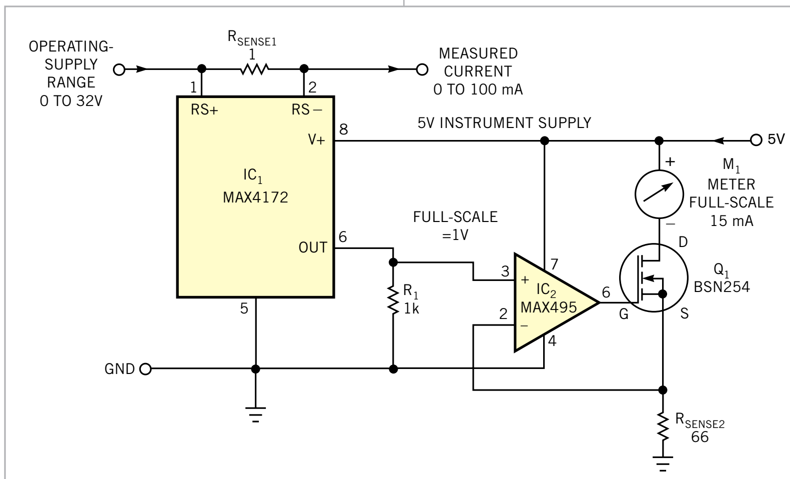

Figure 1 This updated version of an earlier Design Idea uses a MOSFET to drive an analog meter display, offering great flexibility in power-supply-current measurement.

BC182 with an N-channel MOSFET, such as the BSN254 (**Figure 1**). Because a MOSFET draws no gate current, its drain current, I_D, equals its source current, I_S. When you select a MOSFET for the circuit, note that the device's gate-source threshold voltage should be as low as possible. For example, the BSN254 has a room-temperature gate-source threshold-voltage range of 0.8 to 2V. The remainder of the circuit design proceeds as in the original Design Idea; that is, for a maximum voltage drop of 1V across R_1, you calculate R_{SENSE2} as follows: $R_{SENSE2}=(1V/I_{METER})$, where R_{SENSE} is in ohms, 1V represents the voltage drop across R_1, and I_{METER} is the full-scale meter reading in amps. Note that a 1-kΩ resistor at R_1 develops 10V/1A output across sense resistor R_{SENSE1}. In this application, 100 mA produces 0.1V across R_{SENSE1}, and the voltage across R_1 thus corresponds to 1V for full-scale deflection of the meter.EDN

REFERENCE

1 Bilke, Kevin, "Moving-coil meter measures low-level currents," *EDN*, March 3, 2005, pg 72, www.edn.com/article/CA505070.