[Ideas For Design]

Precise Current-Transmitter/Source-Sink Calibrator Has Wide Compliance Range

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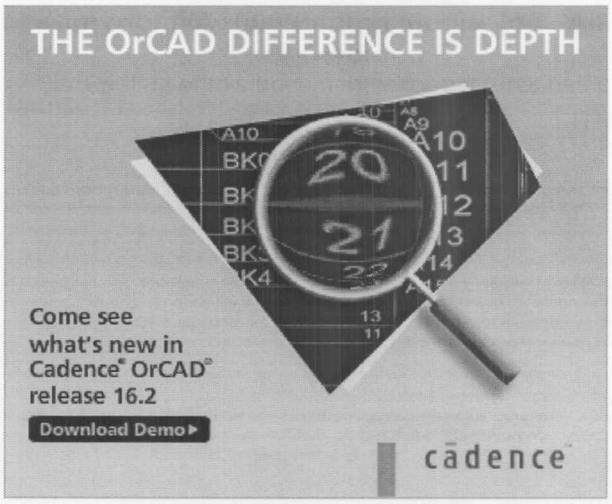


Many industrial and control applications use analog current loops as the physical link for measurements and actuator control. Although several ranges are used, the most popular is still the 4- to 20-mA standard.

Loop accuracy depends on the transmitter's ability to transform the sensor signal to a current. It also depends on the stability of the current-transfer function (measured at the receiver) with respect to temperature, physical length of the loop, stability of the loopsupply voltage, and other uncertainties that appear as the hardware deteriorates with age.

Besides linearity and stability of its current-transfer function, the transmitter output must provide a large dynamic impedance to minimize the influence of loop voltage (at the transmitter terminals) on output current.

The maximum voltage tolerated at the terminals is also important. The higher the better because the electromagnetic environment in industrial plants isn't always benign. At the same time, the minimum-allowed transmitter-terminal voltage, which determines the maximum loop length for a given wire gauge (or the minimum wire cross-section needed for a given loop run), should be minimized.

The transmitter circuit in the figure meets these criteria. It features a very high output impedance (10^8 Ω to 10^9) and a wide compliance range (4 V to 90 V). The lower limit is set by the amplifier's minimum operating voltage, and the upper limit by the power dissipation allowed in the output device (an n-channel depletion MOSFET) at the high end of the current range (20 mA). For brief periods of 20 ms or so, the maximum voltage can go as high as 200 V.

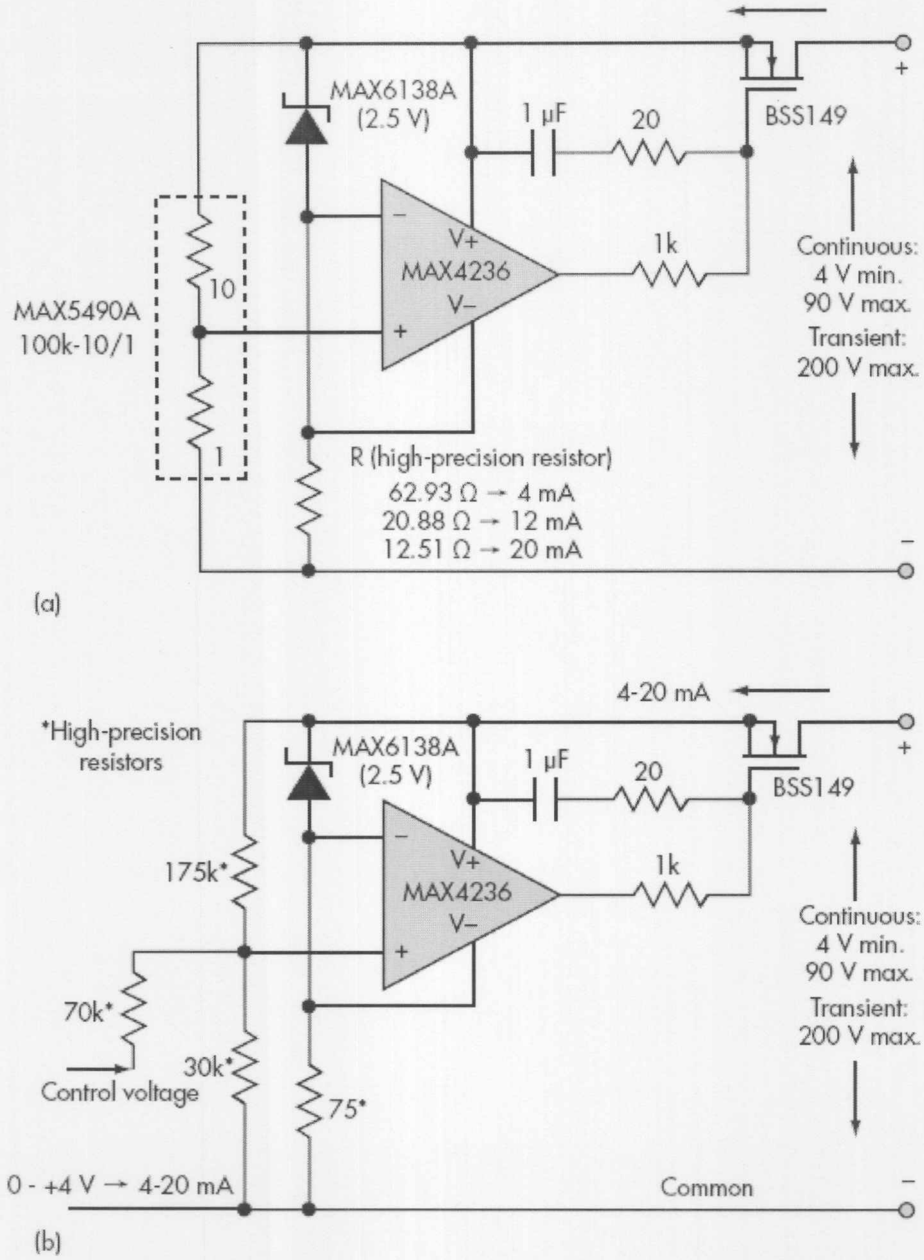
The basic circuit is configured as a loop calibrator (*see the figure, a*). With the components shown, its accuracy from 0°C to 85°C is 10 bits, plus the added uncertainty of resistor R. Having only two terminals, it can operate as either a sinking or a sourcing calibrator.

The loop calibrator can be modified for use as an interface to an open-loop current sensor with a 0- to 4-V output range (see the figure, b). The accuracy of the transfer function in this case depends on the reference (MAX6138) and the precision of the resistors in the interface network. Because the reference equipotential (ground) is shared by the instrument and the transmitter, you should exercise care not to create ground loops in the circuit implementation.

The MAX4236 op amp's input characteristics (20- V maximum offset and 2- V/°C offset temperature drift), its high gain (110 dB), and its ability to operate with inputs down to the negative rail make the influence of all other components negligible. To achieve higher accuracy, therefore, you must use standard trimming techniques that employ either mechanical or IC adjustment potentiometers.

In particular, the amp's ability to operate with input voltages down to the negative rail is essential for circuit accuracy. That's because it allows the amplifier's operating current to be forced through the output current-sense resistor, where it becomes a part of the output current under circuit control.

fig 1



With a few simple modifications, a basic loop-powered, high-compliance, precision current sink (or source) (a) can be used to create a 4- to 20-mA sink transmitter (b).