Keywords: analog, temperature sensors, temperature, 4-20mA, temp sensor, loop

APPLICATION NOTE 1873

Using a 4–20mA Loop-Powered Temperature Sensor

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Abstract: This application note describes a simple circuit that allows a 4–20mA output to power an analog temperature sensor.

A similar version of this article was published in *Electronic Design* on May 6, 2001.

The circuit in **Figure 1** uses an analog temperature sensor, op amp, transistor, and low-dropout linear regulator to provide a 4–20mA output over a 3.75V to 28V compliance range. The low quiescent current of these devices permits them to be powered by the loop with the only consequence being a slight offset error.

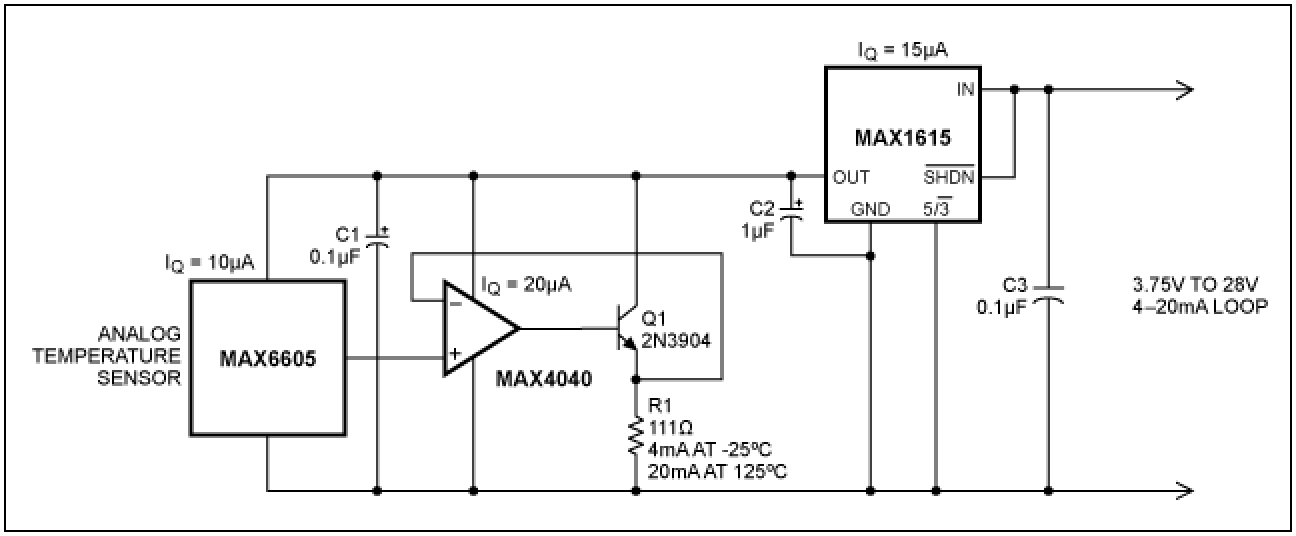

Figure 1. A circuit with an analog temperature sensor (MAX6605), an amplifier (MAX4040), a transistor (Q1), and a low-dropout linear regulator (MAX1615) that provides a 4–20mA current output.

The temperature sensor (MAX6605) feeds the op amp/transistor combination, MAX4040 and Q1, with R1 as the load on the amplifier. The MAX6605's output consists of an offset of 744mV at 0°C and a scale factor of 11.9mV/°C. R1 is selected to provide the best possible fit of the MAX6605's temperature range to the 4–20mA output. In this example, the MAX6605's output at -25°C is 0.4465V, and the 111Ω resistor (R1) provides a 4mA output at -25°C. At 125°C the MAX6605's output is 2.213V, yielding 19.937mA with the 111Ω resistor (R1). This current is reflected at the input of the low-dropout linear regulator (MAX1615).

Besides regulating the voltage to the sensor and op amp circuit, the linear regulator (MAX1615) provides compliance at the voltage input required for connection to the 4–20mA loop. The MAX1615 is pin programmable to provide either 3.3V or 5V output. In this circuit, the device is programmed to provide 3.3V to the temperature sensor (MAX6605) and the op amp (MAX4040). This maximizes the input compliance by allowing input voltages as low as 3.75V (as well as resulting in a slight reduction of the quiescent current of the MAX6605 and the MAX4040 and therefore less error due to quiescent current).

The total quiescent currents of all components are added to the 4mA output, which corresponds to negative full-scale. Consider this 45µA quiescent current in light of the scale factor, which is proportional to:

4–20mA Output Current Scale Factor = (11.9mV/°C)/R1

and yields a current scale factor of 106.66µA/°C. The 45µA quiescent current represents an offset of approximately 0.43°C. Since it is an offset, it is possible to compensate for it elsewhere (such as in the software, if the temperature data becomes digitized).

Related Parts		
MAX1615	High-Voltage, Low-Power Linear Regulators for Notebook Computers	Free Samples
MAX4040	Single/Dual/Quad, Low-Cost, SOT23, Micropower Rail-to-Rail I/O Op Amps	Free Samples
MAX6605	Low-Power Analog Temperature Sensor in SC70 Package	Free Samples