Micropower Thermometer

National Semiconductor
Linear Brief 27

The introduction of a monolithic temperature transducer for the −55°C to +125°C temperature range can considerably simplify the problems encountered in temperature measurement. The three most common sensors—thermistors, resistance sensors, and thermocouples—require a reasonable amount of circuitry for use. Thermistors are highly nonlinear, resistance sensors and thermistors require a stable excitation voltage, and thermocouples have low output. Further, none of these sensors provide an output directly calibrated in a known temperature scale.

The new monolithic temperature transducer provides an output directly proportional to absolute temperature at 10 mV/°K. The chip includes a temperature stable voltage reference and op amp. These allow the output to be offset and scaled to provide any desired temperature scale factor and zero output temperature.

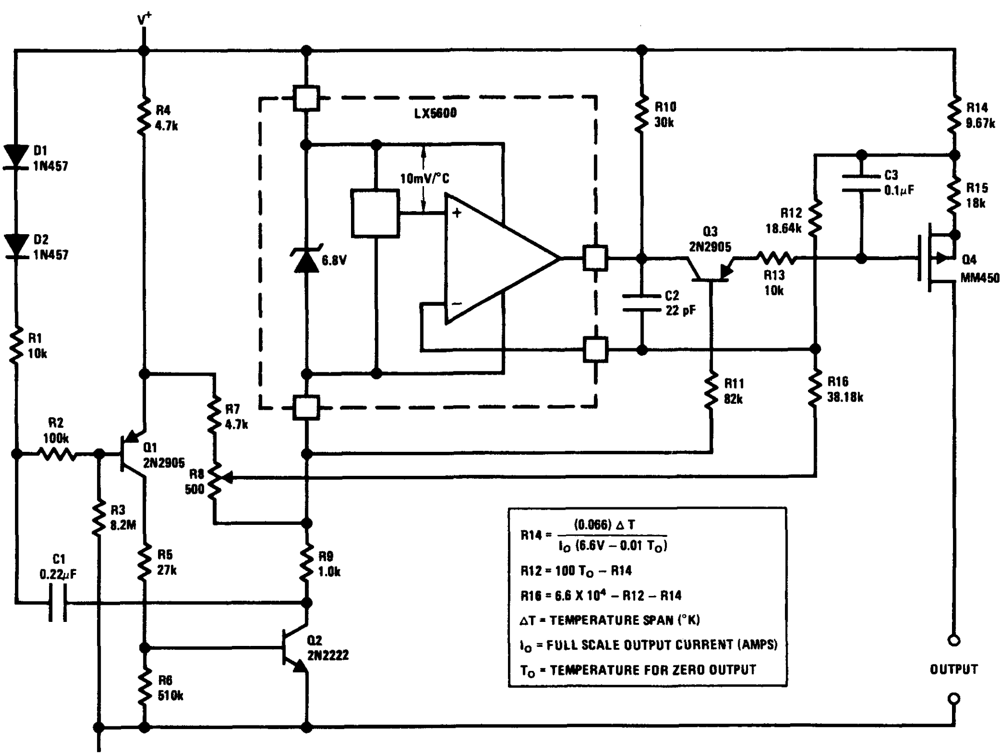
THERMOMETER DESIGN

The circuit shown will provide a temperature sensitive output with both zero and scale factor independently selectable. Since the temperature transducer requires about 1.0 mA for normal operation, the thermometer is pulsed at a low duty cycle to reduce power consumption. A continuous output is obtained between pulses by a sample and hold. Since temperature does not usually change rapidly, the pulsed operation of the thermometer does not detract from its usefulness.

With the components shown, duty cycle is about 0.2% with a one second sample rate. This gives an average current drain of about 25 μA plus the output current. It is designed to operate over a supply voltage of 8.0V to 12V with good results. A small 8.4V mercury battery can give an operational life in excess of one year.

The output of the thermometer is a current proportional to temperature which can be used to drive a meter for a direct readout. Alternatively, a resistor or op amp can be used to obtain a voltage output.

A complementary astable multivibrator, made of Q1 and Q2, drives the LX5600 through R9. The timing is set by several



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Micropower Thermometer Circuit Diagram

components. C1 and R3 control the off-time and C1, R1, R4 and R7 control the on-time. R9 sets the operating current of the transducer to 1.0 mA at the lowest supply voltage.

When the transducer is "on," sample transistor Q3 is also on. The output of the op amp drives the sample capacitor, C3, and MOSFET, Q4. Feedback is obtained from R12, R14 and R16 which set both the zero and scale factor of the thermometer. When the transducer is turned off, a continuous output is provided by C3 and Q4. Resistor R15 decreases the circuit's sensitivity to MOSFET gm, allowing almost any MOSFET to be used. About 2.0V should be dropped across R15 at full scale output. R8 is used to trim the thermometer, correcting for zener tolerance, temperature error in the sensor and resistor tolerance. With the values shown, a 0 to 50 μA output is obtained for a +50°F to +100°F temperature change. Other ranges can be selected by using the formulas shown in the box on the circuit diagram.

The low power consumption makes this thermometer especially attractive for battery operated equipment. Further, the current source output allows long lines to be driven with no loss of accuracy. Finally, the circuit is easy to set up for almost any desired temperature range.