

DESIGN NOTES

Convert Temperature to Current at High Linearity with LT3092 Current Source – Design Note 484

Todd Owen

Electronics 101

One of the first lessons in a basic electronics course covers the symbols for resistors, capacitors, inductors, voltage sources and current sources. Although each symbol represents a functional component of a real-world circuit, only some of the symbols have direct physical counterparts. For instance, the three discrete passive devices—resistors, capacitors, inductors—can be picked off a shelf and placed on a real board much as their symbolic analogs appear in a basic schematic. Likewise, while voltage sources have no direct 2-terminal analog, a voltage source can be easily built with an off-the-shelf linear regulator.

The black sheep of basic electronics symbols has long been the 2-terminal current source. The symbol shows up in every basic electronics course, but Electronics 101 instructors must take time to explain away the lack of a real-world equivalent. The symbol presents a simple electronics concept, but building a current source has, until now, been a complex undertaking.

A Real 2-Terminal Current Source

With the introduction of the LT[®]3092, it is now as easy to produce a 2-terminal current source as it is to create a voltage source. Figure 1 shows how the LT3092 uses an internal current source and error amplifier, together with the ratio of two external resistors, to program a constant output current at any level between 0.5mA and 200mA.

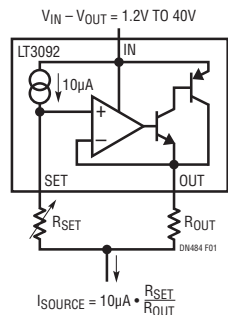


Figure 1. 2-Terminal Current Source Requires Only Two Resistors to Program

The flat temperature coefficient of the internal reference current (highlighted in Figure 2) is as good as many voltage references. Low TC resistors do not need to be used; the temperature coefficients of the external resistors need only match one another for optimum results.

No frequency compensation or supply bypass capacitors are needed. Frequency compensation is internal and the internal reference circuitry is buffered to protect it from line changes.

No input-to-output capacitors are required. While extensive testing has been done to ensure stable operation under the widest possible set of conditions, complex load impedance conditions could provoke instability. As such, testing in situ with final component values is highly recommended. If stability issues occur, they can be resolved with small capacitors or series RC combinations placed on the input, output, or from input to output.

The LT3092 offers all the protection features expected from a high performance product: thermal shutdown, overcurrent protection, reverse-voltage and reverse-current protection. Because a simple resistor ratio sets the current, a wide variety of techniques can be utilized to adjust the current on the fly. The LT3092 can also be configured as a linear regulator without output capacitors for use in intrinsic safety environments.

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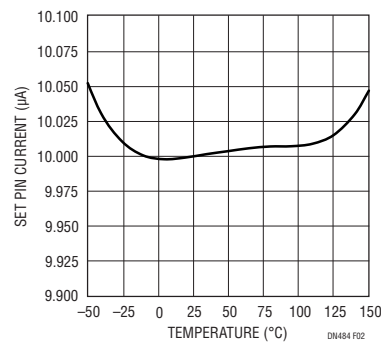


Figure 2. SET Pin Current vs Temperature

The LT3092 as a T-to-I Converter

Omega's 44200 series linear thermistor kits* include thermistors and resistors that together create a linear response to temperature when appropriately configured. These kits generate either a voltage or resistance proportional to temperature with high accuracy; the #44201 kit is listed for the 0°C to 100°C temperature range with 0.15°C accuracy.

Obviously, these kits easily satisfy the needs of a wide variety of applications, but problems arise when the thermistor must be placed at the end of a long wire—application information from Omega suggests no more than 100 feet of #22 wire for thermistor kit #44201. Wire impedance interferes with the thermistor resistance and defeats the accuracy inherent in the kit.

By adding the LT3092 to the thermistor kit along with three 0.1% accuracy resistors and one final trim, a very accurate 2-terminal temperature-to-current converter can be built. This circuit measures 700µA operating current at 0°C, dropping by 2µA every degree until 100°C, at which point the current measures 500µA. The obvious advantage to this T-to-I converter over a T-to-V converter is that current remains constant regardless of the wire length—as long as there is sufficient voltage to meet the compliance of the LT3092 circuit while not exceeding its absolute maximum. Electronics 101: Kirchoff's laws dictate conservation of current in the wire runs as long as there are no nodes for current to leak along the run.

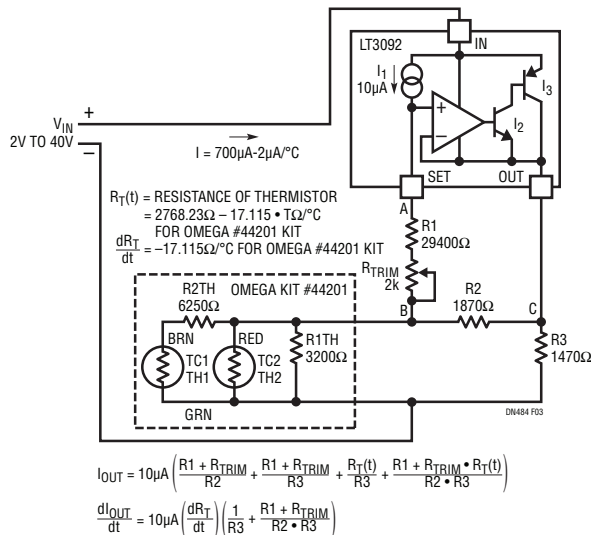


Figure 3. 2-Terminal Temperature-to-Current Thermometer Suitable for Use at the End of Long Wire Runs

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Figure 3 shows the schematic for linear thermistor kit #44201 from Omega with the LT3092 and the additional resistor values. The formulas under the figure allow for substitution of other thermistor kit values and determination of appropriate complementary resistors to fit the application.

Once the initial circuit is built, any initial tolerance, variations, and offsets are easily trimmed out by connecting a voltmeter from node A to node B and trimming the potentiometer to measure 302mV (for this design). This voltage remains constant regardless of temperature.

Now, one wire runs out and back for temperature sensing at significant distances. By providing input voltage above the compliance level of the LT3092 (less than 2V for this circuit and resistor combination) and sensing the resultant current (use a 1k resistor and DVM) one can measure temperature. Figure 4 shows the current output from the circuit across temperature and the difference between measured and calculated response.

Conclusion

The LT3092 requires only two external resistors to produce a 2-terminal current source that references to input or ground, or sits in series with signal lines.

A 2-terminal current source enables a number of applications, especially those involving long wire runs, as Kirchoff's laws dictate the conservation of current over long wire distances—distances where a voltage signal would be corrupted. The example presented here uses the LT3092 and a linear thermistor to convert temperature to current, creating a 2-terminal current output thermometer. Placing this in series with long distances of wire maintains accuracy despite the distance of wire used.

*Available from www.omega.com

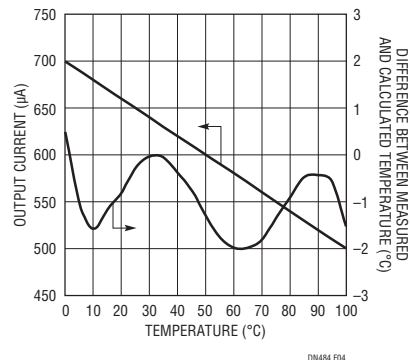


Figure 4. Calculated vs Measured Performance of the Thermometer in Figure 3.

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