

## System Monitor with Instrumentation-Grade Accuracy Used to Measure Relative Humidity

Design Note 510

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Because much can be deduced about a physical system by measuring temperature, it is by far the most electronically measured physical parameter. Selecting a temperature sensor involves balancing accuracy requirements, durability, cost and compatibility with the measured medium. For instance, because of its low cost, a small-signal transistor such as the MMBT3904 is an attractive choice for high volume or disposable sensing applications. Although such sensors are relatively simple, accurate temperature measurement requires sophisticated circuitry to cancel such effects as series resistance.

The **LTC2991** system monitor has this sophisticated circuitry built in—it can turn a small-signal transistor into an accurate temperature sensor. It not only measures remote diode temperature to  $\pm 1^\circ\text{C}$  accuracy, but it also measures its own supply voltage, single-ended voltages (0 to  $V_{CC}$ ) and differential voltages ( $\pm 325\text{mV}$ ).

While ostensibly designed for system monitor applications, the top shelf performance of the LTC2991 makes it suitable for instrumentation applications as well, such as the accurate psychrometer described here.

### A Psychrometer: Not Nearly as Ominous as It Sounds

A psychrometer is a type of hygrometer, a device that measures relative humidity. A hygrometer uses two thermometers, one dry (dry bulb) and one covered in a fabric saturated with distilled water (wet bulb). Air is passed over both thermometers, either by a fan or by swinging the instrument, as in a sling psychrometer. A psychrometric chart can then be used to calculate humidity by using the dry and wet bulb temperatures. Alternatively, a number of equations exist for this purpose. The following equations are used in testing this circuit.

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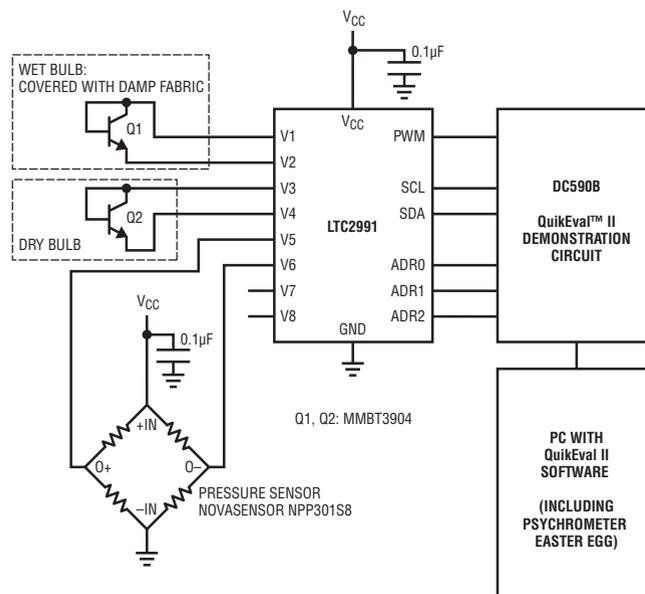


Figure 1. Simple Psychrometer Using the LTC2991

$$A = 6.6 \cdot 10^{-4} \cdot (1 + 1.115 \cdot 10^{-3} \cdot \text{WET})$$

$$\text{ESWB} = e^{\left( \frac{16.78 \cdot \text{DRY} - 116.9}{\text{WET} + 273.3} \right)}$$

Where:

$$\text{ED} = \text{ESWB} - A \cdot P \cdot (\text{DRY} - \text{WET})$$

$$\text{HUMIDITY} = \frac{\text{ED}}{\text{EDSB}}$$

WET = wet bulb temperature in Celsius

DRY = dry bulb temperature in Celsius

P = pressure in kPa

Figure 1 shows a [LTC2991](#)-based psychrometer. The two transistors provide the wet bulb and dry bulb temperature readings when connected to the appropriate inputs of the LTC2991.

The equations include atmospheric pressure as a variable, which is determined here via a Novasensor NPP301-100 barometric pressure sensor measured by channels 5 to 6 configured for differential inputs. Full-scale output is 20mV per volt of excitation voltage, at 100kPa barometric pressure (pressure at sea level is approximately 101.325kPa).

The LTC2991 can also measure its own supply voltage, which in our circuit is the same supply rail used to excite the pressure sensor. Thus, it is easy to calculate a ratiometric result from the pressure sensor, removing the error contribution of the excitation voltage.

### Error Budget

The LTC2991 remote temperature measurements are guaranteed to be accurate to  $\pm 1^\circ\text{C}$ . Figure 2 shows the error in indicated humidity that results from a  $0.7^\circ\text{C}$  error in the worst-case direction, and the error in indicated humidity resulting from a  $0.7^\circ\text{C}$  error in the worst-case direction combined with worst-case error from the pressure sensor.

### Try It Out!

A psychrometer readout is implemented as an Easter egg in the LTC2991 ([DC1785A](#)) demonstration software, available as part of the Linear Technology QuikEval software suite.

The demo board should be set up as shown in Figure 1. To access the readout, simply add a file named tester.txt in the install directory of your DC1785A software. The contents of this file do not matter. On software start-up, the message "Test mode enabled" should be shown in the status bar, and a Humidity option will appear in the Tools menu. Relative humidity readings can then be compared to sensors of similar accuracy grade, such as resistive and capacitive film.

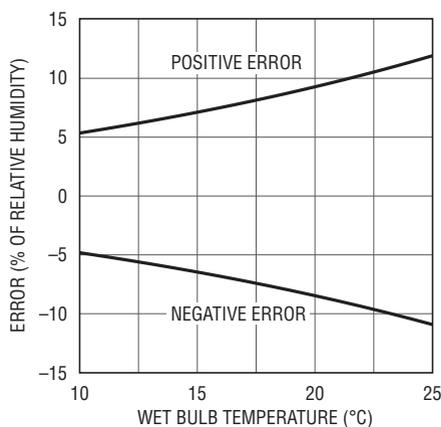


Figure 2. Worst-Case Error

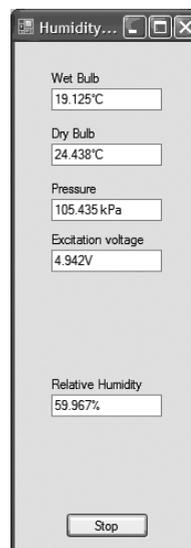


Figure 3. A Psychrometer Readout Is Implemented as an Easter Egg in the LTC2991 (DC1785A) Demonstration Software, Available as Part of Linear's QuikEval Software Suite

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