# NASA TECH BRIEF

*Langley Research Center*

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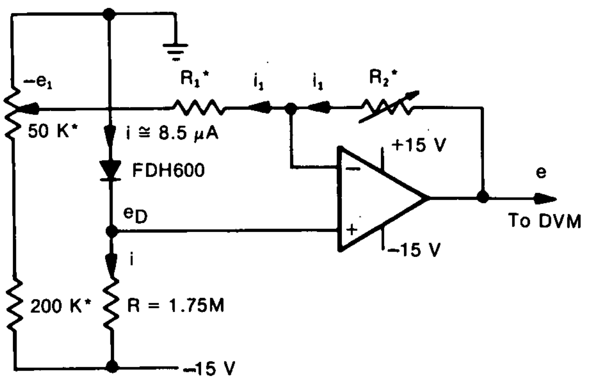
## Simple Temperature Sensor With Direct Readout

A new temperature sensor is easy to construct, requires only one operational amplifier, and has very fast response. It provides direct readout of temperature on a digital voltmeter (a scale factor of precisely 100 K per volt for example). Parameters can be changed to give different scale factors (e.g., 10° C or 10° F per volt). The system is capable of accuracy to ±0.1° C, if calibrated over the range of 0° to 40° C.

This sensor could be applied in any instance requiring fast response and a direct temperature indication. This could be in a temperature-controlled oven or any other place where a small diode could be placed in contact with an object to determine its temperature.

A silicon diode (Fairchild FDH600) can be used as the temperature sensor because the forward voltage across the diode is a nearly linear function of temperature, from cryogenic temperatures (e.g., 77 K) to above 300 K, provided that the forward current in the diode is constant. Data from tests of a diode operating at 8.5 μA current reveal that the voltage is linear with temperature to about ±0.1° over a range of 0° to 40° C (i.e., 273 to 313 K). Linearity is poorer when the range is extended further, about ±1.0° over the range of 77 to 313 K.

The schematic diagram is of a circuit for supplying approximately constant current to the diode and includes an operational amplifier that performs a simple analog operation on the diode voltage, such that the output of the amplifier is a voltage that is directly proportional to the diode temperature in degrees Kelvin. Resistance values may be chosen to select a suitable scale factor for 100 K per volt, the temperature is 100 times the indicated output voltage). A digital voltmeter (DVM) is used as an indicator, and a ±15-V regulated supply is used for the operational amplifier, the DVM, and the Diode bias.




Note: All Resistances Are in Ohms.

$$i \cong \frac{15}{R} \cong 8.5\ \mu A$$

$$i_1 = \frac{e_D + e_1}{R_1} = \frac{e - e_D}{R_2}$$

$$\therefore\ e = e_D \left(1 + \frac{R_2}{R_1}\right) + \frac{R_2}{R_1} e_1$$

* — Low Tempco

Diode Circuit for Temperature Sensor

Test data also show that the voltage drop across the diode is not too sensitive to current changes. Typically, a 1-percent change in diode current produces only a 0.4-mV change in voltage. For this reason the simple circuit shown is adequate for ±0.1 K accuracy over the range of 273 to 313 K. A greater temperature range is obtained by adding an additional operational amplifier to form a constant-current regulator, thereby holding diode current strictly constant over the whole temperature range. A slight nonlinearity in the diode characteristic will degrade accuracy as the temperature range is increased.

(continued overleaf)

**Note:**

Requests for further information may be directed to:

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