Basic introduction to the use of the ZNI1000 Nickel Temperature Sensor

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This application note describes the ZNI1000 temperature sensor, which uses a nickel element connected between 2 pins of a SOT23 package to measure temperature accurately. Nickel has a very precisely known resistance versus temperature characteristic and this is expressed as a polynomial. The element is designed to be 1000Ω at 0°C. By measuring the resistance, temperature can be measured to within ± 2°C down to -55°C and to within ± 1.5°C up to +150°C.

The element is connected between pins 1 and 2 of a standard SOT23 package. Pin 3 is not connected electrically, but has very good thermal contact with the element. This means it can be soldered to the object whose temperature is being measured, thus following changing temperatures quickly and accurately.

The resistance can be expressed as follows:

$$R_T = R_0 * (1 + A*T + B*T^2 + C*T^4 + D*T^6)$$

where R_T is the resistance at temperature T

R_0 is the resistance at 0°C (1000Ω)

$A = 5.485 * 10^{-3}$

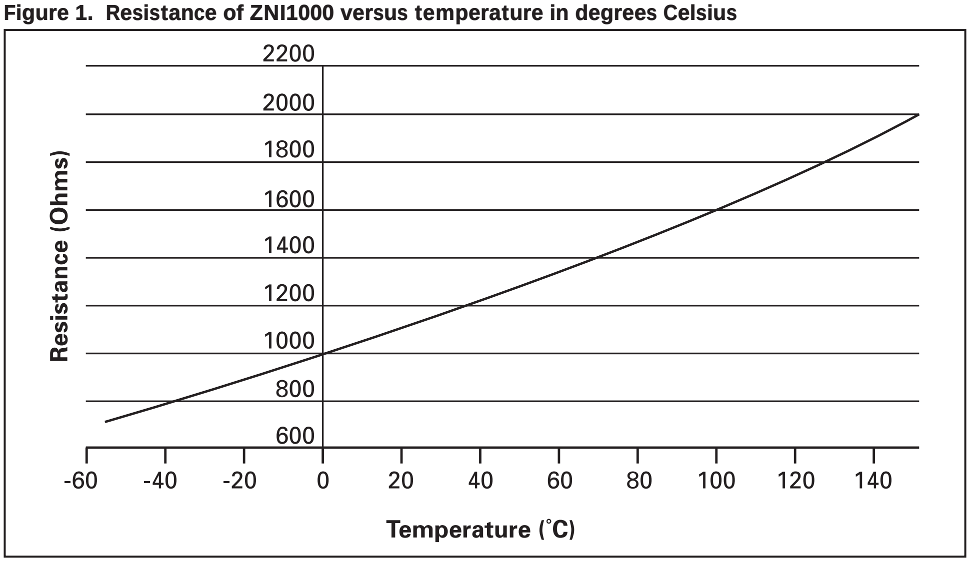
$B = 6.650 * 10^{-6}$

$C = 2.805 * 10^{-11}$

$D = -2.000 * 10^{-17}$

Clearly, for most applications, the sixth order term can be omitted. For example, even at +150°C, it only decreases the resistance, which is almost 2000Ω at that temperature, by 0.2Ω. The curve of resistance versus temperature is shown in Figure 1.

Figure 1. Resistance of ZNI1000 versus temperature in degrees Celsius



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In addition to the polynomial, there is a specification of the deviation in degrees.

For temperatures from -55°C to 0°C, the deviation in °C is:

Error ° = ± (0.4 + (0.028 * |T|) °C.

Note the modulus signs around the T, so that the two error terms still ADD despite T being negative - they do NOT cancel.

For temperatures from 0°C to +150°C, the deviation in °C is:

Error ° = ± (0.4 + (0.007 * T) °C Again the two error terms ADD.

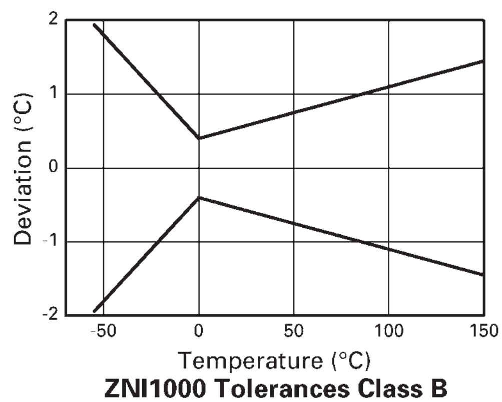
This produces a Deviation graph as shown in Figure 2.

At first sight enabling a readout of temperature versus resistance measured appears to require a look-up table, but a technique can be used which "linearises" the output and makes readout much simpler.

If the element is put into a bridge circuit which is driven by a constant current then, as the bridge resistance increases, the applied bridge voltage increases and this applies a non-linear term to the Vout versus Resistance equation which causes the higher order terms to be partially canceled out.

The bridge circuit is shown in Figure 3.

Figure 2. ZNI1000 Error in Degrees Celsius versus Operating Temperature

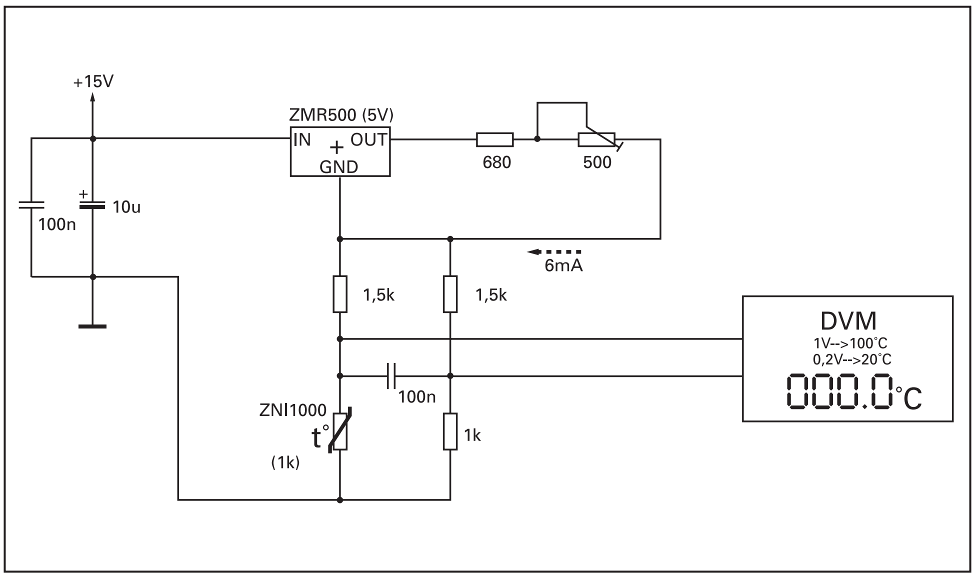


The constant current chosen is shown as 6mA in the circuit, but is strictly 6.0623mA to give exactly 1 volt output at +100°C. The 500Ω trimpot is adjusted so that the output is exactly 1 volt at +100°C and the DVM will then read with ± 2°C over the range -55°C to +150°C.

The error introduced by this circuit by assuming that Vout is linearly proportional to temperature is only -0.8°C at -55°C and only +0.2°C at +150°C, obviously being zero by definition at 0°C and zero by calibration at +100°C. The worst case error between 0°C and +100°C is 0.033°C in addition to the error due to the deviation formula above, which gives 1.1°C at 100°C, so within the 0°C to +100°C range all the errors only add up to ± 1.2°C.

It should be noted from the spec that the maximum continuous current is specified as 4mA. This is because it is necessary to make the nickel element very thin to obtain 1000Ω resistance as nickel has a very low resistivity. In practice the user should keep the current as low as possible because of the thermal resistance of a SOT23 package. This will not be appreciable if the unit is soldered down to a metal tab, as this will always ensure that the nickel element is at the correct temperature. However, if the unit is used in free air, the thermal resistance will be about 200°C/Watt, so the current should really be kept down to 2mA to keep the errors due to self-heating to below 1°C.

Figure 3. ZnI1000 and ZMR500 used with a DVM as a Thermometer



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