Application Note

Making Temperature Measurements With The DMM916

The Tektronix DMM916 Digital Multimeter provides direct temperature measurements with readouts in °C and °F.

The past decade has seen DMMs evolve from simple volt/ohm/current meters into indispensable tools that provide direct readout of true RMS voltage, AC or DC current, decibels (dB), frequency (Hz), capacitance (farads), diode forward voltage test, continuity check, and now temperature (°C or °F). The Tektronix DMM916 Digital Multimeter provides direct temperature measurements from –50° C to +980° C (–58° F to +1,796° F).

Direct Temperature Readout

With direct readout in °C or °F and internal calibration routines, the DMM916 can present temperature measurements in units the user expects to see. There are no specialized adapters that need careful calibration every time the instrument is used. There are no adapter batteries that can affect measurements when voltage levels are low. The DMM916 offers a level of convenience that's also cost-effective – eliminating the need for a separate temperature meter or digital thermometer.

Typical DMM Temperature Measurement Applications

As electronic designs continue to shrink and circuit components get ever smaller and faster, heat dissipation becomes a major concern for digital designers. The DMM916 can be used to evaluate prototype designs and measure operating temperatures of ICs and processors. With a built-in Δ (Delta) measurement feature, it can measure the temperature of an IC with respect to ambient, or with respect to nearby components. It can also be used to characterize environmental performance and identify worst case scenarios during "burn-in."

The DMM916 can also be used to monitor air and fluid temperatures in HVAC and process control applications. Its temperature sensor can be mounted in heating and cooling ducts to verify proper operating temperatures or identify and troubleshoot leaks in the system. In process control applications, it can be used to monitor fluid temperatures.

How DMMs Measure Temperature

The block diagram in Figure 1 illustrates how DMMs make temperature measurements. A thermocouple consists of a junction of two dissimilar metals. A small voltage is generated by the junction (known as the Seebeck effect) based on its temperature and the work function of the metals used. A similar junction is located within the connector at the other end of the cable and is connected in series with, but opposite in polarity to, the measurement junction. This is termed the reference junction. When both reference and measurement junctions are at the same temperature, the voltages produced by the two junctions will cancel, due to the series connection, and no voltage is present at the connector pins. Changing the temperature of the measurement junction causes a difference in voltage between the two junctions, which appears on the connector pins. This voltage is on the order of 40 microvolts per degree Celsius (or Centigrade) for the commonly used type K thermocouple (see Figure 2).

A thermistor located within the DMM is used to establish the ambient temperature, which is assumed to be similar to that of the reference junction in the connector. This provides a measurement point for the DMM's microprocessor to periodically compute the temperature of the external measurement junction.

Tips for Measuring Temperature with Maximum Accuracy

Selecting The Appropriate Thermocouple Form Factor. Thermocouples are available from several suppliers in many materials and styles. It's important to use only thermocouples of the type for which the measurement instrument is specified. In the case of the DMM916, the common type K (Chromel-Alumel) is specified. Other thermocouples, such as type E, J, R, etc., have different voltage vs. temperature characteristics and thus will not yield calibrated readings with an instrument calibrated for type K.

The most common and least expensive thermocouple is the "bead" style. It consists merely of a welded bead junction formed at the end of two wires. The bead is applied to the surface being measured with tape, adhesive, or a thermally conductive compound, or suspended in air for ambient measurements. Other thermocouple styles include air probes, immersion probes, surface probes, and piercing probes. All employ bead probes permanently mounted within stainless steel tubes with insulated handles.

Allow Settling Time. Because the internal reference junction of the DMM plays a critical role in determining temperature, care should be taken to stabilize the internal temperature before measurements are made. When moving the DMM from cold to warm environments (or vice versa), allow at least 30 minutes for the internal temperature to stabilize before making measurements. The rapid temperature change occurring inside the DMM can seriously degrade measurement accuracy if not allowed to stabilize.

Avoid handling the adaptor and the connector housing the reference junction. Even brief touching of the metal connector blades can cause an offset error of a few degrees that will take several minutes to stabilize.

Inaccuracies vs. Offsets. Listed "Best Accuracies" for DMM temperature measurements are typically an order of magnitude or two larger than those for voltage, current and resistance measurements. While these inaccuracies may seem unacceptably large, in actuality, they chiefly reflect the need to account for calibration offsets from a zero reference point. Once calibrated, temperature measurements made with DMMs are quite accurate and repeatable.

It should be remembered, however, that the listed accuracy for a DMM does not take into account the accuracy of the thermocouple itself.

Conclusion

With direct temperature readout, the DMM916 is a convenient yet rugged handheld solution to a wide range of measurement requirements – from IC packaging, to HVAC applications, to everyday troubleshooting. It eliminates the need for a separate temperature meter or digital thermometer.

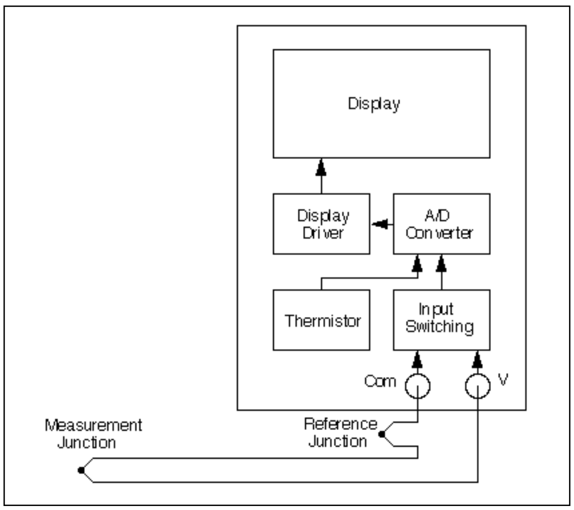

Figure 1. How DMMs measure temperature.

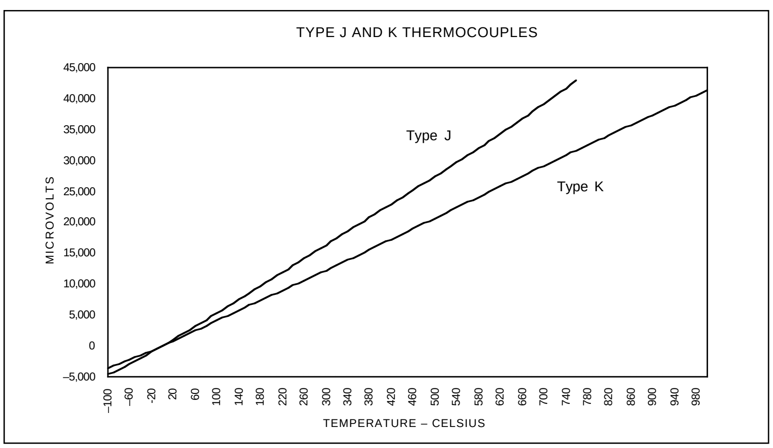

Figure 2. Temperature response of common thermocouple probes.

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ISO 9001

2/97 TD/XBS 40W–11341–0

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