TEKTRONIX®

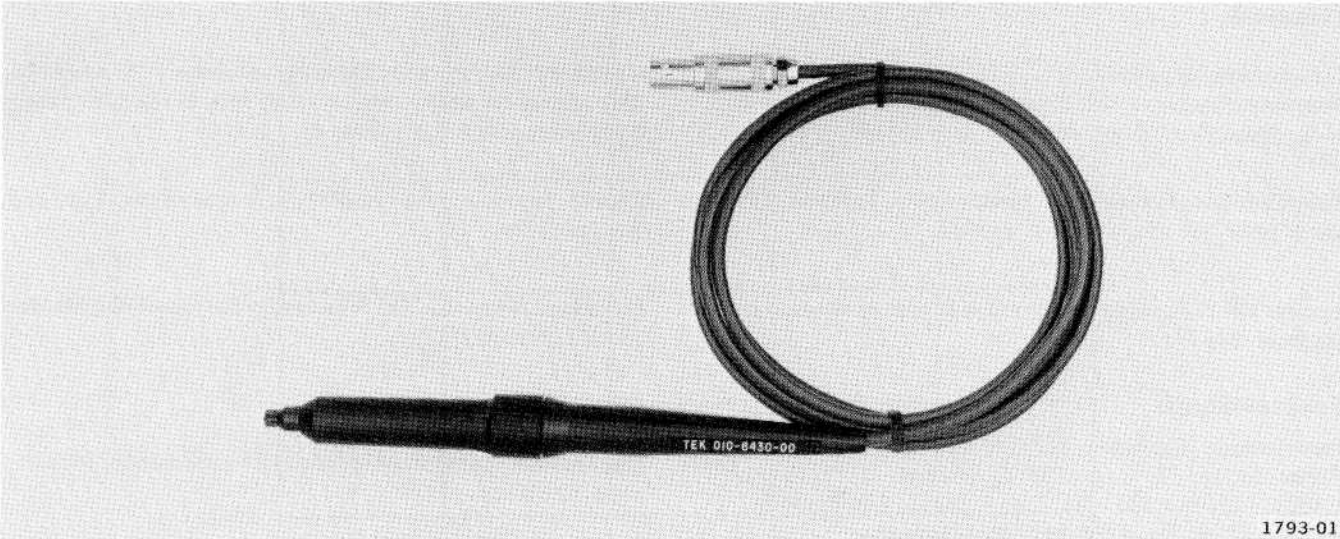
P6430

TEMPERATURE PROBE

INSTRUCTION MANUAL

DM 502 B032298 is [used] with this P6430 probe. For use with other DM 502s see Pages 1-8 in DM 502 manual for performance specifications.

P6430 TEMPERATURE PROBE



The P6430 probe provides temperature measurement when used with Tektronix Digital Multimeters. Temperature is measured by touching the sensor tip to the device being measured. The plug-in feature of the nose tip sensor transistor allows easy replacement. The small diameter probe body design lends itself to use in compact circuitry. Power is supplied to the transistor and signal is connected to the associated digital multimeter through a two-conductor cable and special two-pin plug. Ground for the base of the sensor transistor is applied through the shell of the probe plug.

SPECIFICATIONS

Electrical

Temperature (Equilibrium)[1]**:** −55°C to +150°C. Accuracy determined by Digital Multimeter and conditions described under Measuring Temperature.

Maximum Safe Voltage on Measurement Surface: 100 V (dc + peak ac) above chassis ground.

Typical RF Frequency and Voltage Limits on Measurement Surface: See Fig. 1.

Environmental

Temperature: Storage—−55°C to +105°C. Operating—(Probe Body) −55°C to +105°C. (Cable) −15°C to +105°C. (Sensor tip) −55°C to +150°C. See Replaceable Parts List, Fig. 6 for part identification.

Altitude: Storage—To 50,000 feet. Operating—To 15,000 feet.

[1] **Temperature measurement specifications apply to standard measurement sensor tip supplied with the probe.**

Humidity: Storage and Operating—5 cycles (120 hours) to 95% relative humidity referenced to MIL-E-16400F (para. 4.5.9 through 4.5.9.5.1, class 4).

Shock: Nonoperating—To 400 g's, ½ sine, ½ ms, 1 ms, and 2 ms duration.

Maximum Allowable Tip Pressure on Surface Being Measured: 20 pounds.

Physical

Dimensions: Length—64 inches (164 centimeters) including probe body.

Net Weight: Probe only—Approximately 3 ounces (84 grams).

Shipping Weight: Probe and Manual—Approximately 10 ounces (280 grams).

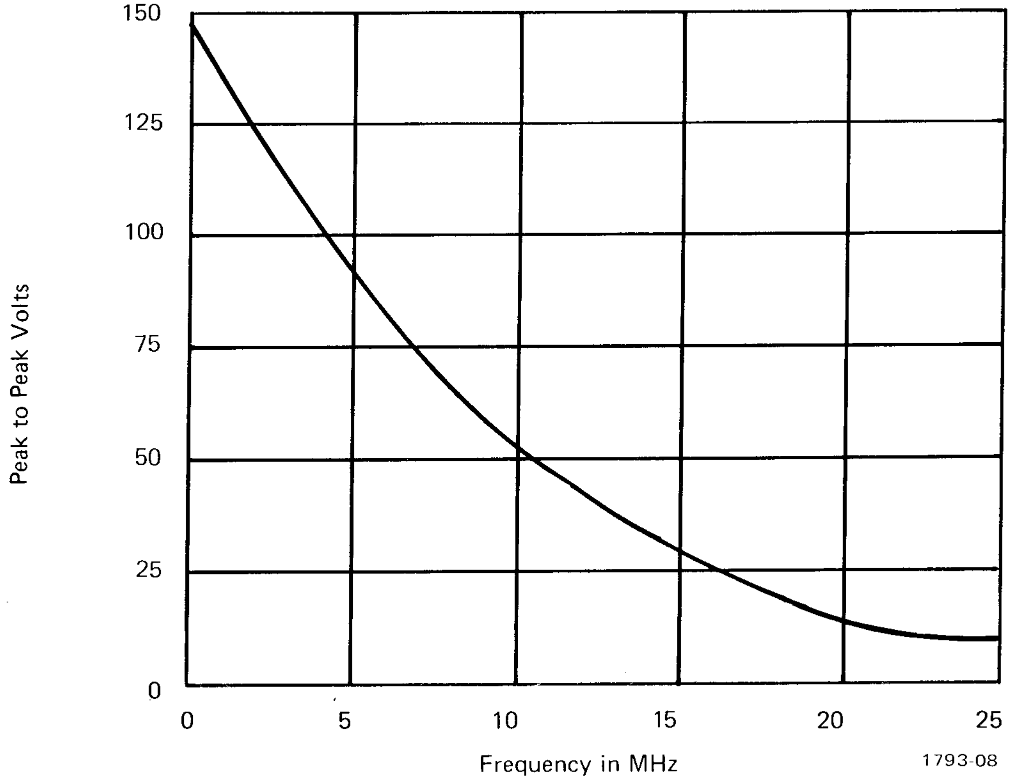


Fig. 1. Typical allowable rf signal limits at the probe tip.

OPERATION

Theory of Operation

Temperature measurement is accomplished through the use of a NPN silicon transistor located at the tip of the voltage probe. Associated circuitry is located in the digital multimeter.

The emitter-base voltage of the transistor is the parameter which is measured to indicate temperature. With zero collector-base voltage and sufficient emitter-base voltage, the collector current of a transistor can be expressed as an exponential function of the base-emitter voltage[2]:

$$I_c = I_o \exp(qVbe/kT)$$

When the associated digital multimeter circuitry switches the collector current between two levels, the difference between the two levels of emitter-base voltage will be a linear function of temperature:

$$\Delta Vbe = \frac{kT}{q} 1n(I_{c2}/I_{c1})$$

Where I_{c2} and I_{c1} are the two levels of collector current, k is Boltzmann's constant, q is the charge on the electron, and T is absolute temperature. The factors limiting the linear range of operation are the decrease in beta at low temperatures and leakage currents at high temperature. The sensor transistor is connected in the feedback loop of the operational amplifier with the collector at the input, emitter connected to the output, and the base grounded. For a given current input, the output of the operational amplifier forward biases the emitter-base junction of the transistor to the level necessary to maintain the input collector current. (Input current to the operational amplifier is negligible and, thus, the input current essentially is the collector current of the transistor.)

Connecting the Probe to the Digital Multimeter

CAUTION

If the Probe connector and the Digital Multimeter jack are not correctly aligned, the terminals can be damaged by forcing the connector and jack together.

Measuring Temperature

CAUTION

The P6430 is not intended to be used for liquid temperature measurements except as a part of the calibration procedure. The probe body should not be immersed in any liquid past the sealed portion of the probe tip. (See Fig.2). Avoid contact with acids and strong salt solutions.

The surface of the device to be measured should be coated with silicone grease, and the probe sensor tip applied to mate the flat surfaces of the tip and the device, (see Fig. 2) to assure optimum temperature transfer. Surface temperature reading is affected by the angle of contact between probe tip and the surface being measured. When taking a reading, this angle should be varied slightly until the maximum reading is obtained on the associated digital multimeter.

Applying the tip of the probe to a device for temperature measurement may cause a slight change in the temperature of the device. This is similar to the voltage change in an electrical circuit caused by probe loading, and in the case of temperature measurement, is due to a combination of heat sinking and a steady-state gradient error associated with heat transfer between bodies. Heat sinking depends on the thermal mass of the device being measured. The amount of heat sinking, in degrees C, versus the initial device temperature above ambient, is illustrated in Fig. 3 for TO-3, TO-5, and TO-18 transistor cases.

In addition to heat sinking effect, there is a "steady state" error when measuring surface temperature which is caused by the "steady state" gradient associated with flow of heat from the device being measured to the main probe body. Thus the temperature of the sensing transistor will differ from the final surface temperature. This steady state error is dependent upon the final surface temperature above ambient and is illustrated in Fig. 4.

In order to approximate the actual surface temperature of the device, that existed before the probe was applied, both the heat sinking and the thermal gradient effects must be considered. Fig. 5 provides a convenient method for approximating the combined heat sinking and the thermal gradient errors for three common transistor cases, the TO-3, TO-5, and TO-18. The initial temperature of the case can also be found to within 8% using the following equations.

TO-3: $T_1 = 1.13\ T_m - 0.13\ T_o$

TO-5: $T_1 = 1.20\ T_m - 0.20\ T_o$

TO-18: $T_1 = 1.24\ T_m - 0.24\ T_o$

T_1 is the initial case temperature, T_m is the temperature read from the associated multimeter, and T_o is the ambient temperature.

Calibration

There are no adjustments in the P6430. Procedures for calibrating the digital multimeter to match the probe are included in the Digital Multimeter instruction manual. The multimeter should be recalibrated if the probe sensor tip is replaced.

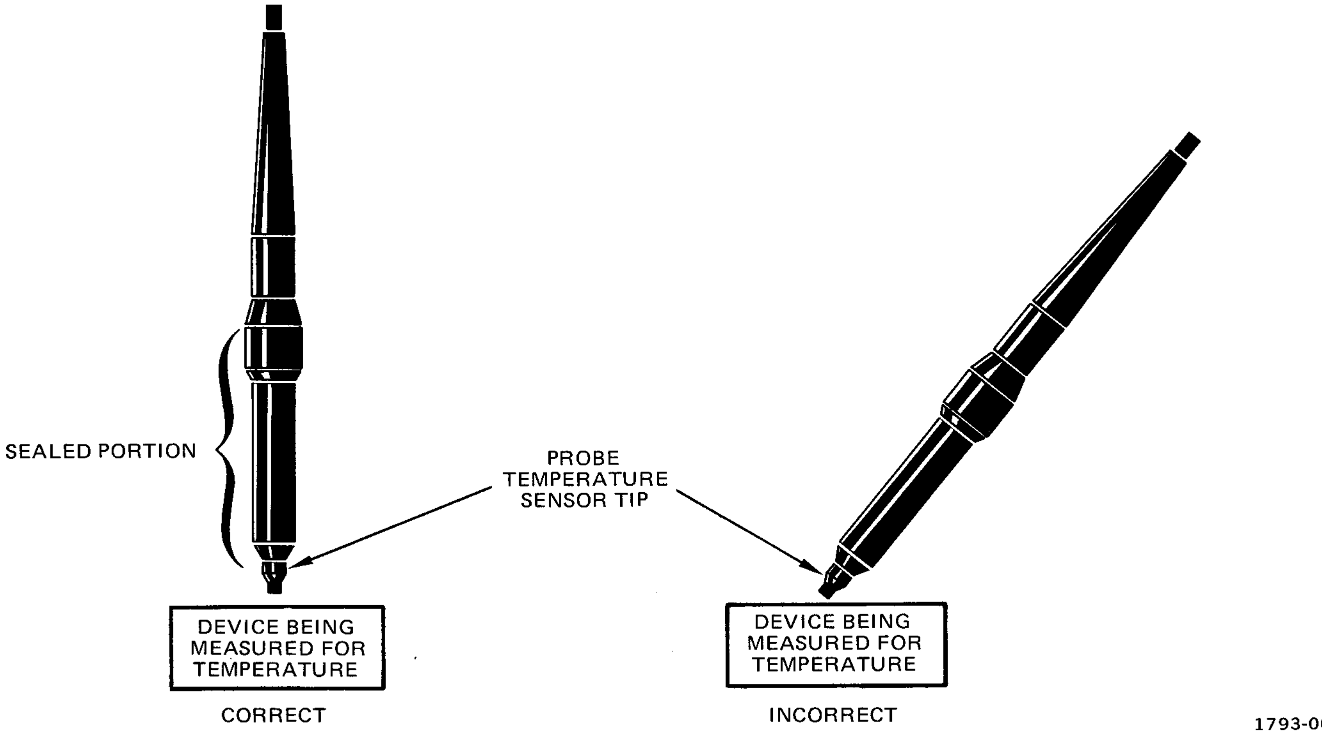


Fig. 2. Correct and incorrect method of applying sensor tip for temperature measurement.

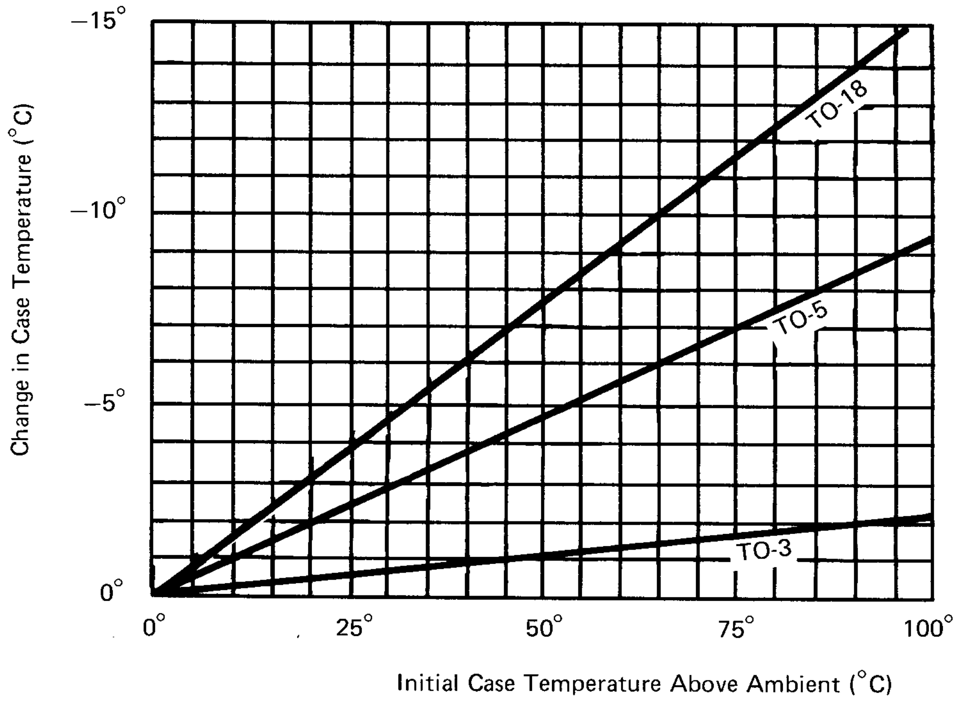


Fig. 3. Typical decrease in device case temperature in °C due to probe heat-sinking effect on various devices (with silicon thermal joint compound applied).

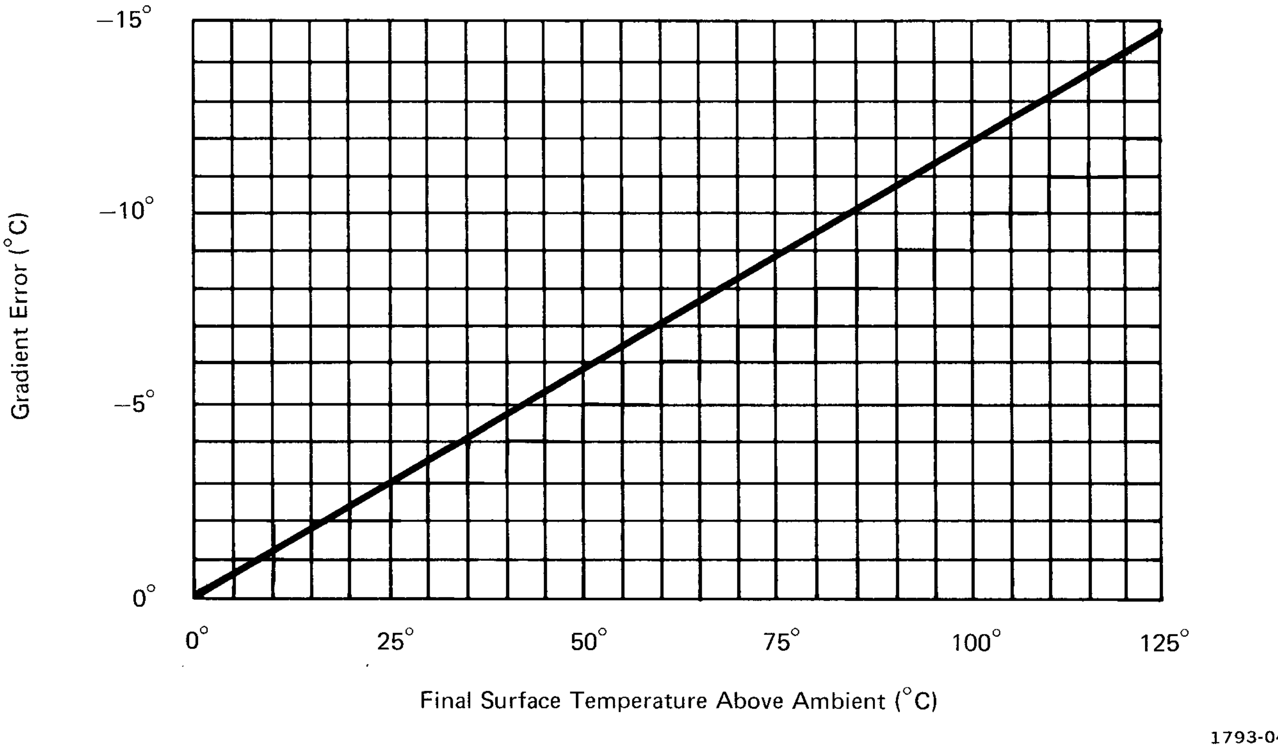


Fig. 4. Thermal gradient effect on temperature measurement.

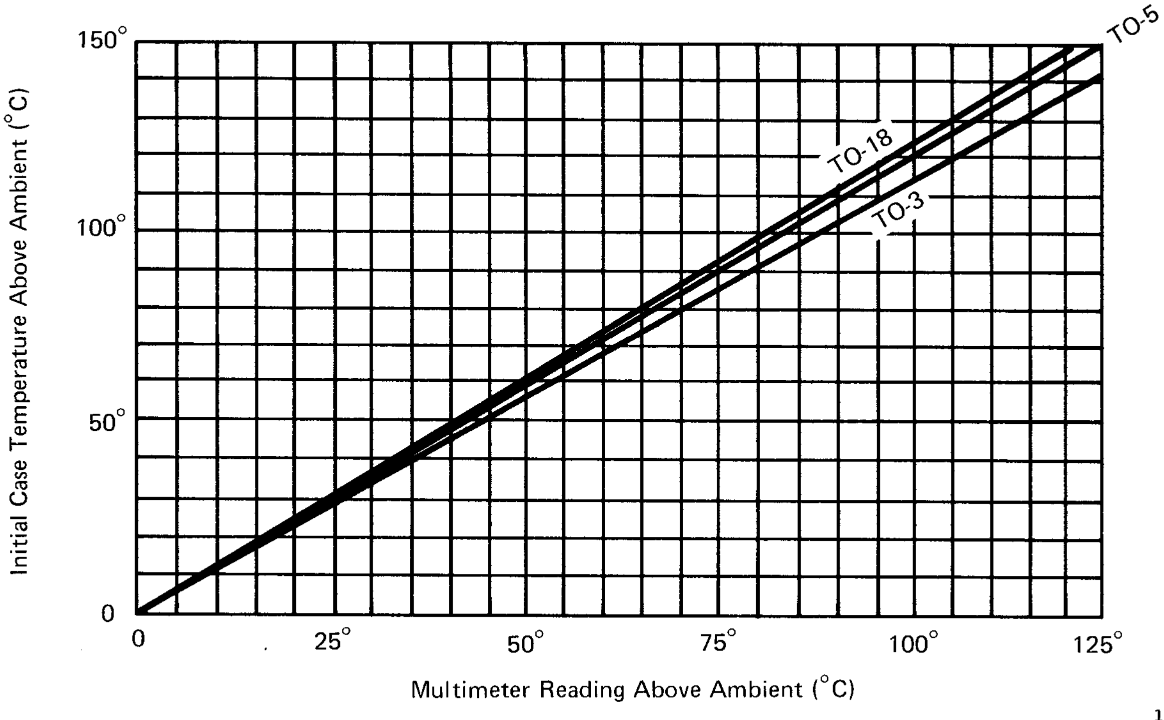


Fig. 5. Typical initial case temperature above ambient vs multimeter reading above ambient. (Subtract ambient temperature from multimeter reading, then use graph to determine actual device case temperature above ambient.)

CABLE AND SENSOR TIP REPLACEMENT