

# Instructions, Silicon Diode Temperature Sensor Installation, Model DT-421-HR and DT-422-HR



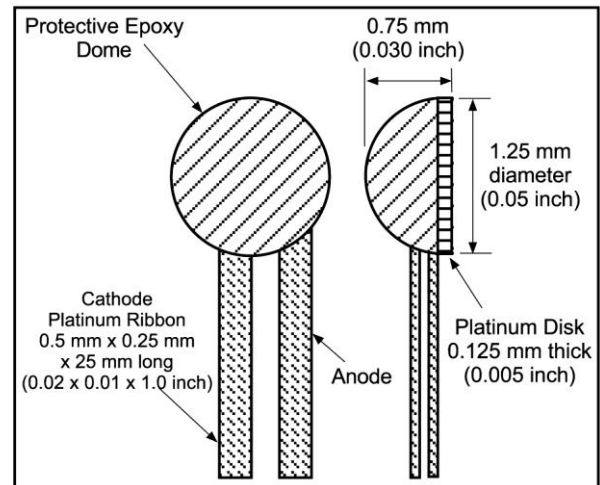
**CAUTION:** This temperature sensor is sensitive to Electrostatic Discharge (ESD). Use ESD precautionary procedures when handling, or making mechanical or electrical connections to this device in order to avoid performance degradation or loss of functionality.

There are three aspects of using a cryogenic temperature sensor which are critical to its optimum performance. The first involves the proper mounting of the sensor package, the second relates the proper joining of sensor lead wires and connecting wires. The final concern is the thermal anchoring of the lead wires. Although the sequence in which these areas should be addressed is not fixed, all elements covered under each aspect should be adhered to for maximum operating capabilities of the sensor.

## SENSOR MOUNTING

The DT-421-HR/DT-422-HR is designed for mounting on a flat surface or in a 1.9 mm (0.075 inch) diameter by 1.3 mm (0.05 inch) deep hole. Primary thermal contact to the sensing chip is made through the platinum base.

**CAUTION:** The platinum disk that forms the package base is connected to one of the electrical leads. For that reason, solder attachment it is not a recommended mounting method. Care must be taken to electrically isolate the package base from the the experiment to prevent grounding of the electrical lead.



1. Mounting area should be prepared and cleaned with a solvent such as Acetone followed by an Isopropyl Alcohol rinse. Allow time for the solvents to evaporate before sensor mounting.
2. The list below provides brief instructions on mounting a sensor using a number of different methods. The constraints of your application should dictate the most appropriate mounting method to follow.

*Apiezon<sup>®</sup> N Grease* – Is best used as a thermal conductor when the sensor is mounted in a hole or recess and when the sensor is intended to be removed. The sensor should be surrounded with thermal grease and placed into the mounting position. When the temperature is lowered the thermal grease will harden, giving good support and thermal contact.

*IMI 7031 Varnish* – Prepare varnish and apply a thin layer on the mounting surface. Press the sensor firmly against the varnish during curing to ensure a thin bond layer and good thermal contact. Varnish will air dry in 5–10 minutes. Sufficient time must be allowed for the solvents in the varnish to evaporate. There is a small probability of ionic shunting across the sensor during the full cure period of the varnish (typically 12–24 hours).

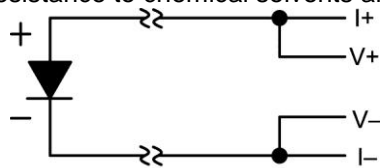
*Stycast<sup>®</sup> 2850FT Epoxy* – Prepare epoxy and apply a thin layer on the mounting surface. Press the sensor firmly into the epoxy during curing to assure a thin bond layer and good thermal contact. Epoxy will cure in 12 hours at 25 °C or in 2 hours at 66 °C.

**CAUTION:** The DT-421-HR uses epoxy in its construction. If epoxy is used to mount the sensor, any future removal using epoxy stripper may permanently damage the sensor.

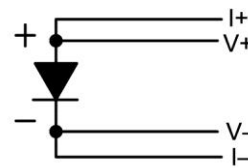
3. Follow manufacturer's instructions for adhesive curing schedule.

## LEAD ATTACHMENT

- Although the DT-421-HR/DT-422-HR sensor package is a two-lead device, measurements should be preferably made using a four-wire configuration to avoid uncertainties associated with lead resistance.  
*Two-lead measurement scheme* – The leads used to measure the voltage are also the current carrying leads. The resultant voltage measured at the instrument is the sum of the temperature sensor voltage and the voltage drop across the two leads. (See Figure 1A.)  
*Four-lead measurement scheme* – The current is confined to one pair of current leads with the sensor voltage measured across the voltage leads. (See Figure 1B.)
- Lead Polarity: When viewed with the base down (the base is the largest flat surface) and the leads towards the observer, the positive lead (anode) is on the right and the negative (cathode) is on the left.
- Strip the insulation from the connecting wires by delicately scraping with a razor blade, fine sand paper, or steel wool. Phosphor-bronze or manganin wire, in sizes 32 or 36 AWG, is commonly used as the connecting lead wire. These wires have low thermal conductivity and high resistivity which help minimize the heat flow through the leads. Typical wire insulation is Polyvinyl Formal (Formvar™) or Polyimide (ML). Formvar™ insulation has better mechanical properties such as abrasion resistance and flexibility. Polyimide insulation has better resistance to chemical solvents and burnout.



A. Two-Lead Measurement Scheme



B. Four-Lead Measurement Scheme

**Figure 1. Two-Lead Versus Four-Lead Measurements**

- DT-421-HR/DT-422-HR sensor leads (Pt) can be easily soldered if an acidic flux is used. One suitable flux is “Stay Clean Solder and Tinning Flux” (J.W. Harris Company, Cincinnati, Ohio). Use appropriate solder with respect to temperature (recommend Sn60/Pb40 for up to 400 K).
- The “Stay Clean Solder and Tinning Flux” is acidic. Hence, after soldering, clean off the residual flux with a solvent which is “basic” in nature. (For example, baking soda dissolved in water will also work.)
- Join one sensor lead with two of the connector wires. Apply the soldering iron to the connector wire above the joint area until the solders melt, then remove the iron. Repeat for the other set of connector wires and the other sensor lead. Heat sinking the mounting surface of the sensor with a flat jaw alligator clip is good practice to eliminate heat build up at the sensor element.
- Avoid putting stress on the device leads and leave enough slack to allow for the thermal contractions that occur during cooling which could fracture a solder joint or lead. Some epoxies and shrink tubing can put enough stress on lead wires to break them.

## HEAT SINKING/THERMAL ANCHORING

- Since the area being measured is read through the base of the sensor, heat flow through the connecting leads can create an offset between the sensor chip and the true sample temperature. Thermal anchoring of the connecting wires is necessary to assure that the sensor and the leads are at the same temperature as the sample.
- Connecting wires should be thermally anchored at several temperatures between room temperature and cryogenic temperatures to guarantee that heat is not being conducted through the leads to the sensing element. Two different size copper bobbins are available from Lake Shore for heat sinking connecting leads: P/N 9007-900 and 9007-901.
- If connecting wires have a thin insulation such as Formvar™ or Polyimide, a simple thermal anchor can be made by winding the wires around a copper post, bobbin, or other thermal mass. A minimum of five wraps around the thermal mass should provide sufficient thermal anchoring. However, if space permits, additional wraps are recommended for good measure.

To maintain good electrical isolation over many thermal cycles, it is good practice to first varnish a single layer of cigarette paper to the anchored area then wrap the wire around the paper and bond in place with a thin layer of IMI 7031 Varnish. Formvar wiring insulation has a tendency to craze with the application of IMI varnish. If used, the wires cannot be disturbed until the varnish is fully cured and all solvents have evaporated (typically 12 – 24 hours).

4. A final thermal anchor at the sample itself is good practice to ensure thermal equilibrium between the sample and temperature sensor.

**CRYOGENIC ACCESSORIES** – Recommended for proper installation and use of DT-421-HR/DT-422-HR sensors:

**Stycast® Epoxy 2850FT** (P/N 9003-020, 9003-021): Permanent attachment, excellent low temperature properties, poor electrical conductor, low cure shrinkage.

**Apiezon® N Grease** (P/N 9004-020): Low viscosity, easy to use, solidifies at cryogenic temperatures, excellent lubricant.

**IMI 7031 Varnish** (P/N 9009-002): Nonpermanent attachment, excellent thermal conductor, easy to apply and remove.

**Indium Solder** (P/N 9007-002-05): 99.99% pure, excellent electroplating material, foil form.

**Phosphor-Bronze Wire** (P/N 9001-00X): Available in single, duo, and quad strands, no magnetic attraction, low thermal conduction.

**Manganin Wire** (P/N 9001-00X): Low thermal conductivity, high resistivity, no magnetic attraction.

**Heat Sink Bobbin** (P/N 9007-900 Large, 9007-901 Small): Gold-plated oxygen-free high-conductivity (OFHC) copper bobbins.

**Instruments:** Lake Shore sells a complete line of instrumentation used with the DT-421-HR/DT-422-HR sensors, such as: Current Sources, Cryopump Monitors, Temperature Controllers, Monitors and Thermometers, Temperature Scanners and Transmitters.

For complete product description and detailed specifications on the above accessories and instruments, consult the Lake Shore Temperature Measurement and Control Catalog, call at (614) 891-2243, E-mail at [sales@lakeshore.com](mailto:sales@lakeshore.com), or visit our website at [www.lakeshore.com](http://www.lakeshore.com).