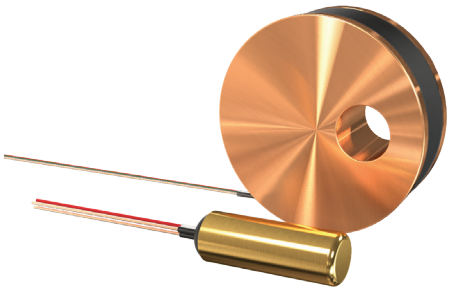
# Germanium RTDs

## Germanium features

- Recognized as a “Secondary Standard Thermometer”
- High sensitivity provides submillikelvin control at 4.2 K and below
- Excellent reproducibility better than ±0.5 mK at 4.2 K
- Various models for use from 0.05 K to 100 K
- Excellent resistance to ionizing radiation

Lake Shore germanium resistance temperature sensors are recognized as “Secondary Standard Thermometers” and have been employed in the measurement of temperature from 0.05 K to 30 K for more than 40 years.

Germanium sensors have a useful temperature range of about two orders of magnitude. The exact range depends upon the doping of the germanium element. Sensors with ranges from below 0.05 K to 100 K are available. Between 100 K and 300 K, dR/dT changes sign and dR/dT above 100 K is very small for all models. Sensor resistance varies from several ohms at its upper useful temperature to several tens of kilohms at its lower temperature. Because device sensitivity increases rapidly with decreasing temperature, a high degree of resolution is achieved at lower temperatures, making these resistors very useful for submillikelvin control at 4.2 K and below.

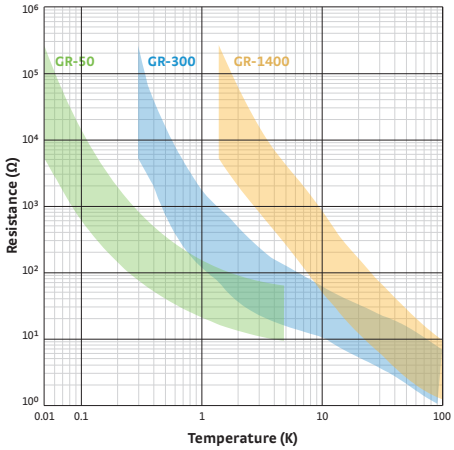


The sensors offer excellent stability, and ±0.5 mK reproducibility at 4.2 K. The germanium resistor is usually the best choice for high-accuracy work below 30 K. Use in a magnetic field is not recommended.

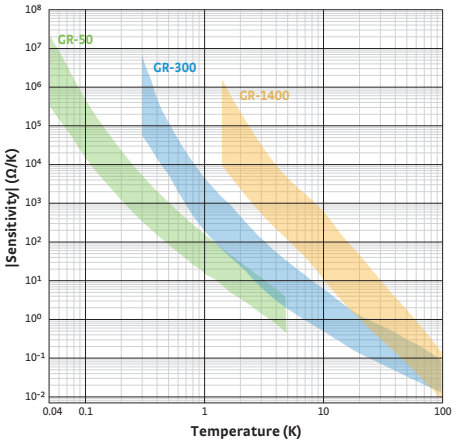
## Packaging options

**AA,CD**

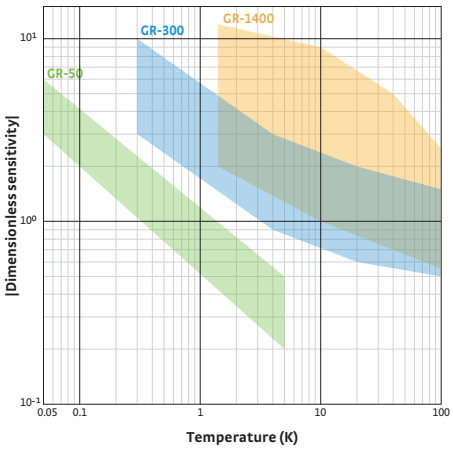
## Typical germanium resistance




## Typical germanium sensitivity




## Typical germanium dimensionless sensitivity



## Specifications

**Standard curve** Not applicable

**Recommended excitation**[1] 20 µV (0.05 K to 0.1 K); 63 µV (0.1 K to 1 K); 10 mV or less for T > 1 K

**Dissipation at recommended excitation** $10^{-13}$ W at 0.05 K, $10^{-7}$ W at 4.2 K (temperature and model dependent)

**Thermal response time** 200 ms at 4.2 K, 3 s at 77 K

**Use in radiation** Recommended for use in ionizing radiation environments—see Appendix B

**Use in magnetic field** Because of their strong magnetoresistance and associated orientation effect, germanium sensors are of very limited use in magnetic fields—see Appendix B

**Soldering standard** J-STD-001 Class 2

## Reproducibility

| | Short term[2] | Long term[3] |
|---|---|---|
| 4.2 K | ±0.5 mK | ±1 mK/yr |
| 77 K | — | ±10 mK/yr |

[1] Recommended excitation for T < 1 K based on Lake Shore calibration procedures using an AC resistance bridge—for more information refer to Appendix D and Appendix E

[2] Short-term reproducibility data is obtained by subjecting sensor to repeated thermal shocks from 305 K to 4.2 K

[3] Long-term stability data is obtained by subjecting sensor to 200 thermal shocks from 305 K to 77 K

## Range of use

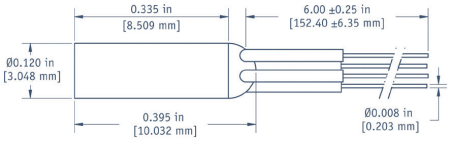
| | Minimum limit | Maximum limit |
|---|---|---|
| GR-50-AA | <0.05 K | 5 K |
| GR-300-AA | 0.3 K | 100 K |
| GR-1400-AA | 1.4 K | 100 K |

## Calibrated accuracy[4]

| | Typical sensor accuracy[4] | | |
|---|---|---|---|
| | GR-50 | GR-300 | GR-1400 |
| 0.05 K | ±5 mK | — | — |
| 0.3 K | ±5 mK | ±4 mK | — |
| 0.5 K | ±5 mK | ±4 mK | — |
| 1.4 K | ±6 mK | ±4 mK | ±4 mK |
| 4.2 K | ±6 mK | ±4 mK | ±4 mK |
| 77 K | — | ±25 mK | ±15 mK |
| 100 K | — | ±32 mK | ±18 mK |

[4] [(Calibration uncertainty)2 + (reproducibility)2]0.5 for more information see Appendices B, D, and E

## AA package




General tolerance of ±0.005 in [±0.127 mm] unless otherwise noted

## Typical magnetic field-dependent temperature errors[5] ΔT/T (%) at B (magnetic induction)

| | Germanium | | |
|---|---|---|---|
| | 2.5 T | 8 T | 14 T |
| 2.0 K | -8 | -60 | — |
| 4.2 K | -5 to -20 | -30 to -55 | -60 to -75 |
| 10 K | -4 to -15 | -25 to -60 | -60 to -75 |
| 20 K | -3 to -20 | -15 to -35 | -50 to -80 |

[5] Long axis of thermometer parallel to applied field

## Typical resistance values

| GR-AA | Typical resistance at 4.2 K | Typical resistance range at 4.2 K |
|---|---|---|
| 50 | 30 Ω | 9 Ω to 65 Ω |
| 300 | 95 Ω | 15 Ω to 155 Ω |
| 1400 | 1750 Ω | 350 Ω to 6500 Ω |

## Temperature response data table (typical)—see Appendix G for expanded response table

| | GR-50-AA | | | GR-300-AA | | | GR-1400-AA | | |
|---|---|---|---|---|---|---|---|---|---|
| | R[8] (Ω) | dR/dT (Ω/K) | (T/R)·(dR/dT) | R[8] (Ω) | dR/dT (Ω/K) | (T/R)·(dR/dT) | R[8] (Ω) | dR/dT (Ω/K) | (T/R)·(dR/dT) |
| 0.05 K | 35000 | -3642000 | -5.2 | — | — | — | — | — | — |
| 0.1 K | 2320 | -71860 | -3.1 | — | — | — | — | — | — |
| 0.2 K | 364.6 | -4043 | -2.2 | — | — | — | — | — | — |
| 0.3 K | 164.0 | -964.0 | -1.8 | 35180 | -512200 | -4.4 | — | — | — |
| 0.5 K | 73.75 | -202.9 | -1.4 | 5443 | -34800 | -3.2 | — | — | — |
| 1.0 K | 33.55 | -31.33 | -0.93 | 875.7 | -1901 | -2.2 | — | — | — |
| 1.4 K | 24.73 | -13.15 | -0.74 | 448.6 | -581.3 | -1.8 | 35890 | -94790 | -3.7 |
| 2.0 K | 19.32 | -6.167 | -0.64 | 248.8 | -187.4 | -1.5 | 11040 | -16670 | -3.0 |
| 4.2 K | 13.66 | -1.036 | -0.32 | 94.46 | -26.56 | -1.2 | 1689 | -861.9 | -2.1 |
| 10 K | — | — | — | 33.20 | -3.97 | -1.2 | 252.8 | -61.95 | -2.5 |
| 40 K | — | — | — | 7.79 | -0.235 | -1.2 | 9.57 | -0.449 | -1.9 |
| 77.4 K | — | — | — | 3.50 | -0.050 | -1.1 | 3.55 | -0.050 | -1.1 |
| 100 K | — | — | — | 2.72 | -0.024 | -0.88 | 2.80 | -0.021 | -0.74 |

## Proper selection of germanium sensors for use below 1 K

Germanium resistance thermometers are often classified according to their 4.2 K resistance value. However, for devices to be used below 1 K, there is no close correlation between the 4.2 K resistance and the suitability of the device as a thermometer. As a result, the Lake Shore low resistance germanium sensors (GR-50-AA and GR-300-AA) are classified according to their lowest useful temperatures, not their 4.2 K resistance values.

The resistance vs. temperature behavior for these devices is typical of all the germanium sensors. As the temperature is lowered, both the resistance and sensitivity (dR/dT) increase logarithmically. The lowest useful temperature is generally limited by the rapidly increasing resistance and the difficulties encountered in measuring high resistance values.

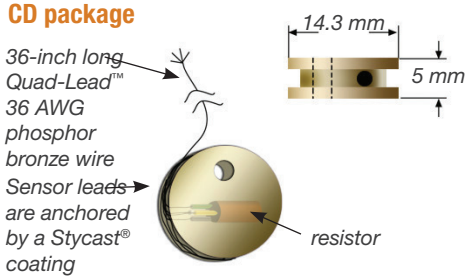
The following recommendations are made concerning the optimum temperature range for using these devices:

| | |
|---|---|
| GR-50-AA | 0.05 K to 1.0 K |
| GR-300-AA | 0.3 K to 100 K |

Increasingly better temperature resolution is achievable at lower temperatures.

In general, it is recommended you do not purchase a device which has a lower temperature limit than required, since some sensitivity (dR/dT) will be sacrificed at the higher temperatures. For example, a GR-300-AA will have more sensitivity at 1 K than a GR-50-AA.

## CD package

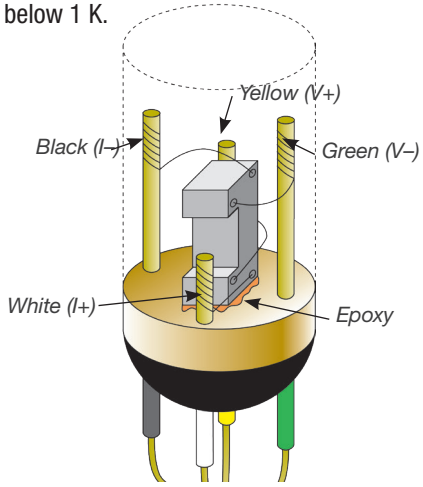



## Physical specifications

| | Mass | Lead type | Internal atmosphere |
|---|---|---|---|
| GR-50-AA<br>GR-300-AA<br>GR-1400-AA | 395 mg | 4 color coded phosphor bronze with heavy build polyimide, attached with epoxy strain relief at sensor | Helium 4 (4He) at ≥500 Ω, air at <500 Ω |

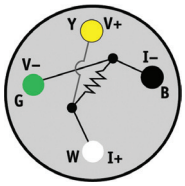
## Germanium series construction detail

The epoxy holding the chip to the header is omitted for germanium devices designed for use below 1 K.



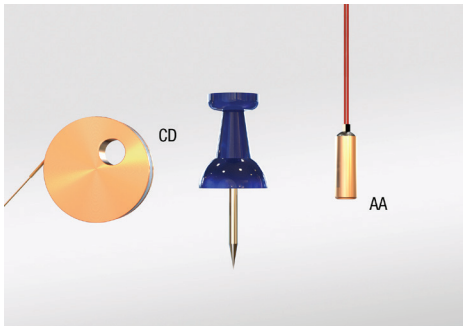

*Looking at the wiring end with leads toward user*

| | Key | Lead Color |
|---|---|---|
| W | I+ | White |
| G | V- | Green |
| Y | V+ | Yellow |
| B | I- | Black |




## Packaging options

**For more information on sensor packages and mounting adapters, see page 20.**




**See the appendices for a detailed description of:**
Installation
Uncalibrated sensors
SoftCal™
Calibrated sensors
CalCurve™
Sensor packages

**To add length to sensor leads, see page 25.**

## Ordering information

**Uncalibrated sensor**—Specify the model number in the left column only, for example GR-50-AA.

**Calibrated sensor**—Add the calibration range suffix code to the end of the model number, for example GR-50-AA-0.05A.

| Germanium RTD | Calibration range suffix codes<br>Numeric figure is the low end of the calibration<br>Letters represent the high end: A=5 K, D=100 K | | | |
|---|---|---|---|---|
| Part number | Uncal | 0.05A | 0.3D | 1.4D |
| GR-50-AA | ■ | ■ | | |
| GR-300-AA | ■ | | ■ | ■ |
| GR-1400-AA | ■ | | | ■ |
| GR-50-CD | ■ | ■ | | |
| GR-300-CD | ■ | | ■ | ■ |
| GR-1400-CD | ■ | | | ■ |

**NOTE: The GR-50-AA calibration is not useful above 5 K*
*Other packaging available through special order—consult Lake Shore*

**Accessories available for sensors**
COC-SEN Certificate of conformance