Capacitance Temperature Sensors*

Capacitance features

- Virtually no magnetic field-induced errors
- Capable of mK control stability in the presence of strong magnetic fields
- Monotonic in C versus T to nearly room temperature

* *Patent #3,649,891, exclusively assigned to Lake Shore Cryotronics, Inc.*

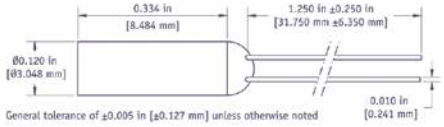
Temperature reproducibility

Over a period of days, thermal cycling of capacitance sensors can provide variations in their capacitance/temperature values equivalent to several tenths of a degree at 4.2 K, 77 K, and room temperature. Over longer periods of time, variations can reach one degree or more. However, any reduced capacitance, C(T)/C(4.2 K), is generally stable to within ±0.5 K. These variations, or shifts, in the temperature response curve have no effect on the sensor's stability when operating at a given temperature and, therefore, do not impair the sensor's primary function as a control element.

Capacitance sensors (CS) are ideally suited for use as temperature control sensors in strong magnetic fields because they exhibit virtually no magnetic field dependence. Displacement current is not affected by magnetic fields. Consequently, temperature control fluctuations are kept to a minimum when sweeping magnetic field or when changing field values under constant temperature operation.

Because small variations in the capacitance/temperature curves occur upon thermal cycling, calibrations must be transferred to the capacitor from another sensor after cooling for the best accuracy. It is recommended that temperature in zero field be measured with another temperature sensor and that the capacitance sensor be employed as a control element only.

CS-501GR



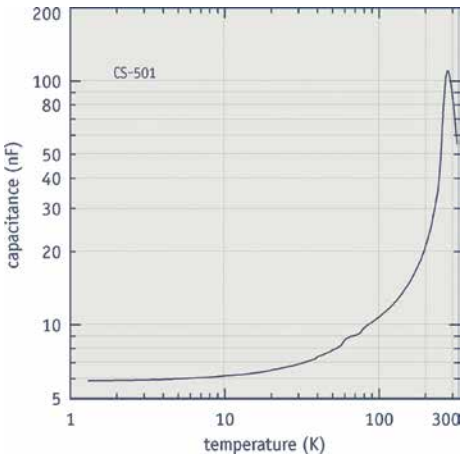
Temperature stability/ temperature transfer accuracy

Capacitance sensors will provide very stable control conditions for long periods of time at operating temperature, but because an operational "aging" phenomenon exists, care must be taken to account for this occurrence in their use.

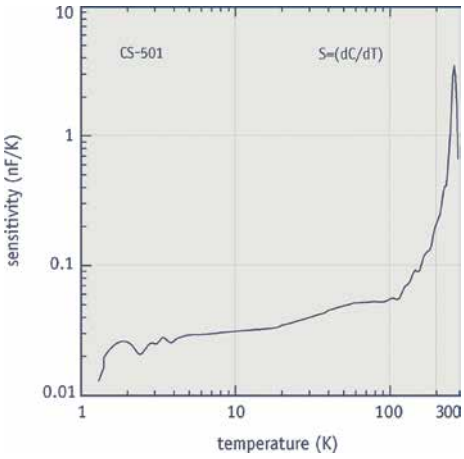
The variation in capacitance/temperature characteristics is likely the result of the time dependence of the dielectric constant and the dielectric loss, or "aging", that all ferroelectric dielectrics exhibit. This time dependence, which occurs as a short term drift (minutes to hours) in capacitance/temperature value, is initiated by disturbing the sensor thermally or by changing the voltage or frequency of excitation. To compensate for this, the sensor should be stabilized for one hour after initial cool-down to desired operating temperature and whenever significant adjustments in control temperature are made.

After the one hour stabilization, this short-term drift is on the order of a few tenths of a millikelvin per minute at 4.2 K, and several millikelvin per minute at 305 K. The drift is always in the direction of decreasing capacitance; consequently, it corresponds to decreasing temperature below 290 K.

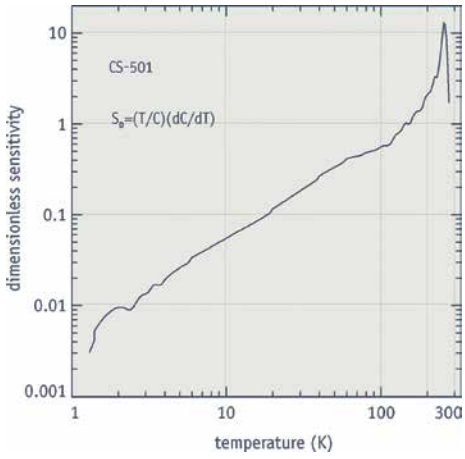
Typical CS capacitance



Typical CS sensitivity



Typical CS dimensionless sensitivity



Specifications

Standard curve Not applicable

Nominal capacitance 6.1 nF

Nominal sensitivity 26 pF/K

Accuracy (interchangeability) Not applicable

Accuracy (calibrated) Calibration should be performed in situ

Recommended excitation 1 to 5 kHz, 0 to 7 V peak to peak or any other acceptable capacitance measuring method

Dissipation at recommended excitation Not applicable

Expected long-term stability ±1.0 K/yr

Thermal response time Minutes, dominated by electronic setting time

Radiation effects Not available

Magnetic fields See table on right

Reproducibility See shaded box on previous page for detailed discussion

Soldering standard J-STD-001 Class 2

Range of use

	Minimum limit	Maximum limit
CS-501GR	1.4 K	290 K

Typical magnetic field-dependent temperature errors[1] ΔT/T (%) at B (magnetic induction)

Package parallel to field B	
	18.7 T
4.2 K	-0.15
77 K	<0.05

[1] *Recommended for control purposes; monotonic in C vs T to nearly room temperature; frequency dependent*

Physical specifications

	Size	Mass	Lead Type	Internal atmosphere
CS-501GR	3.0 mm × 8.5 mm long	260 mg	2 phosphor bronze with heavy build polyimide attached with epoxy strain relief at sensor	Air

Packaging options

For more information on sensor packages and mounting adapters, see page 21.

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

Capacitance sensor	Uncalibrated sensor Specify part number CS-501GR
Part number	Uncal
CS-501GR	■

Accessories suggested for installation—see Accessories section for full descriptions
Stycast® epoxy
Apiezon® grease
90% Pb, 10% Sn solder
Indium solder
VGE-7031 varnish
Phosphor bronze wire
Manganin wire
CryoCable™