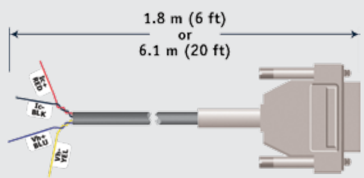
Cryogenic Hall Sensors

Cryogenic Hall sensor features

- Low temperature dependence
- Low resistance, low power dissipation
- Low linearity error: -150 kG to +150 kG
- Axial and transverse configurations available
- Small active area

Attaching Hall sensors to the Model 425, 455, 460, and 475 gaussmeters



The MCBL-6 cable allows discrete Hall sensors to be mated to the Model 425, 455, 460, and 475 gaussmeters. The cable is shipped with a CD-ROM containing the **Hallcal.exe** file to program the cable PROM through the gaussmeter RS-232C port. Because of the many intricacies involved with proper calibration, the user is responsible for the measurement accuracy.

Certain Hall sensor sensitivity constraints are applicable:

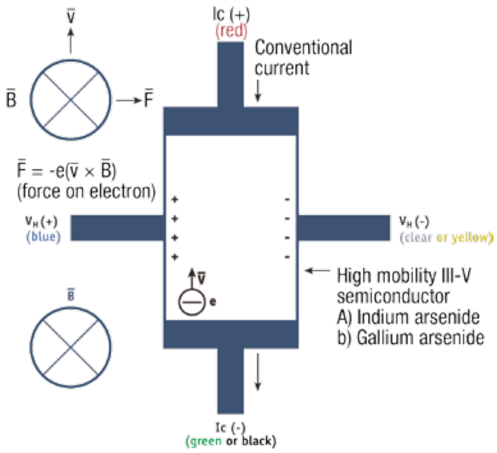
Sensitivities between 5.6 mV/kG and 10.4 mV/kG at 100 mA current.

Sensitivities between 0.56 mV/kG and 1.04 mV/kG at 100 mA current.

System requirements

- Lake Shore gaussmeter connected via RS-232C to the PC
- Hall sensor meeting the sensitivities given above
- Calibration or sensitivity constant and serial number of the Hall sensor

Hall sensor theory



A Hall sensor is a solid state sensor which provides an output voltage proportional to magnetic flux density. As implied by its name, this device relies on the Hall effect principle. The Hall effect principle is the development of a voltage across a sheet of conductor when current is flowing and the conductor is placed in a magnetic field.

Electrons (the majority carrier most often used in practice) "drift" in the conductor when under the influence of an external driving electric field. When exposed to a magnetic field, these moving charged particles experience a force perpendicular to both the velocity and magnetic field vectors. This force causes the charging of the edges of the conductor, one side positive with respect to the other. This edge charging sets up an electric field which exerts a force on the moving electrons equal and opposite to that caused by the magnetic-field-related Lorentz force. The voltage potential across the width of the conductor is called the Hall voltage. This Hall voltage can be utilized in practice by attaching two electrical contacts to the sides of the conductor.

The Hall voltage can be given by the expression: $V_H = \gamma_B B \sin\phi$

where	V_H	=	Hall voltage (mV)
	γ_B	=	Magnetic sensitivity (mV/kG) at a fixed current
	B	=	Magnetic field flux density (kG)
	ϕ	=	Angle between magnetic flux vector and the plane of Hall sensor

As can be seen from the formula above, the Hall voltage varies with the angle of the sensed magnetic field, reaching a maximum when the field is perpendicular to the plane of the Hall sensor.

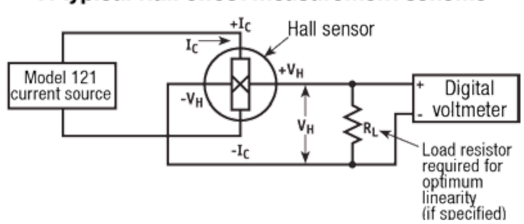
Using a Hall sensor

A Hall sensor is a 4-lead device. The control current (I_c) leads are normally attached to a current source such as the Lake Shore Model 121. The Model 121 provides several fixed current values compatible with various Hall sensors.

The Hall voltage leads may be connected directly to a readout instrument, such as a high impedance voltmeter, or can be attached to electronic circuitry for amplification or conditioning. Device signal levels will be in the range of microvolts to hundreds of millivolts.

The Hall sensor input is not isolated from its output. In fact, impedance levels on the order of the input resistance are all that generally exist between the two ports. To prevent erroneous current paths which can cause large error voltages the current supply must be isolated from the output display or the downstream electronics.

A typical Hall effect measurement scheme



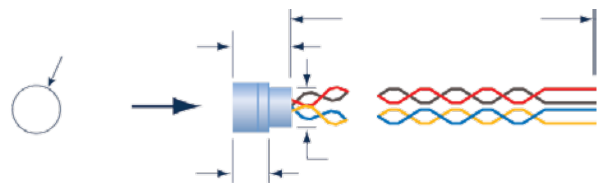
Configurations

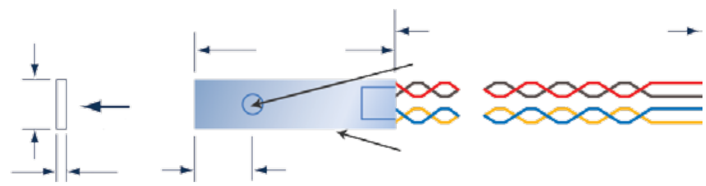
Hall sensors come in two main configurations, axial and transverse. **Transverse** devices are generally thin and rectangular in shape. They are applied successfully in magnetic circuit gaps, surface measurements, and general open field measurements. **Axial** sensors are mostly cylindrical in shape. Their applications include ring magnet center bore measurements, solenoids, surface field detection, and general field sensing.

Active area

The Hall sensor assembly contains the sheet of semiconductor material to which the four contacts are made. This is normally called a “Hall plate.” The Hall plate is, in its simplest form, a rectangular shape of fixed length, width, and thickness. Due to the shorting effect of the current supply contacts, most of the sensitivity to magnetic fields is contained in an area approximated by a circle, centered in the Hall plate, with a diameter equal to the plate width. Thus, when the active area is given, the circle as described above is the common estimation.

Specifications	**HGCA-3020**	**HGCI-3020**
Description	Cryogenic axial; phenolic package	Cryogenic transverse; ceramic package
Active area (approximate)	0.030 in (0.762 mm) diameter	0.040 in (1.016 mm) diameter
Input resistance (approximate)	1 Ω	1 Ω
Output resistance (approximate)	1 Ω	1 Ω
Nominal control current (I_{CN})	100 mA	100 mA
Maximum continuous current (non-heat sunk)	300 mA	300 mA
Magnetic sensitivity at I_{CN}	0.55 mV/kG to 1.05 mV/kG	0.55 mV/kG to 1.05 mV/kG
Magnetic sensitivity change with temperature	+0.7% at 200 K; +0.8% at 100 K; +1.0% at 3.8 K	+0.7% at 200 K; +0.8% at 100 K; +1.0% at 3.8 K
Maximum linearity error (sensitivity versus field)	±1.0% RDG (–30 kG to +30 kG) ±2.0% RDG (–150 kG to +150 kG)	±1.0% RDG (–30 kG to +30 kG) ±2.0% RDG (–150 kG to +150 kG)
Zero field offset voltage (maximum)(I_C = nominal control current)	±200 µV	±200 µV
Operating temperature range	1.5 K to 375 K	1.5 K to 375 K
Mean temperature coefficient of magnetic sensitivity (approximate)	±0.01%/K	±0.01%/K
Mean temperature coefficient of offset (maximum) (I_C = nominal control current)	±0.4 µV/K	±0.4 µV/K
Mean temperature coefficient of resistance (maximum)	±0.6%/K	±0.6%/K
Leads	34 AWG copper with Teflon® insulation	34 AWG copper with Teflon® insulation
Data	Room temp; 30 kG data supplied	Room temp; 30 kG data supplied





Gaussmeters

Lake Shore gaussmeters offer a straightforward and cost effective solution to measure magnetic fields. Hall sensors or factory calibrated probes connect to the gaussmeter rear panel and the sensor data is automatically uploaded into the instrument. Lake Shore gaussmeters offer easy-to-make flux density measurements with high accuracy, resolution, and stability, and are available with RS-232C and IEEE interfaces, analog outputs, relays, and alarms.

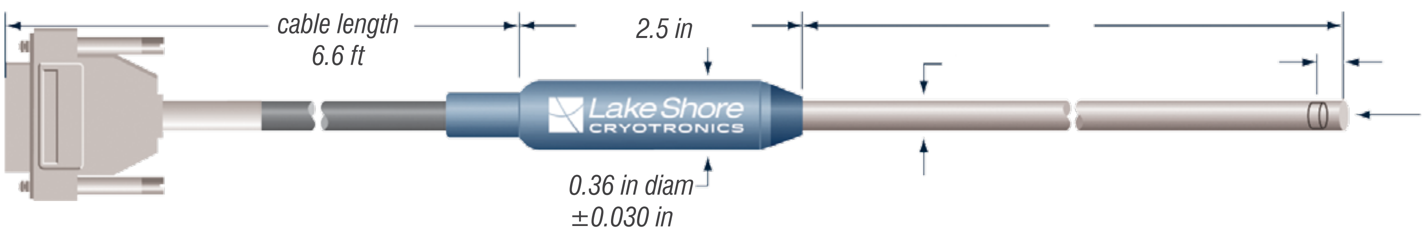
For more information call, or visit www.lakeshore.com.

Cryogenic Hall Probes

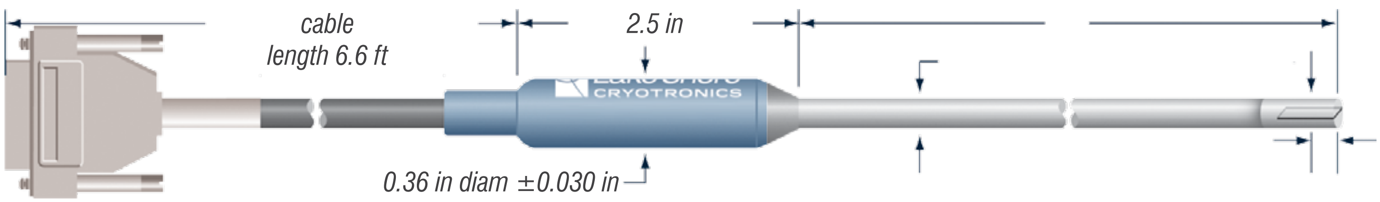
Lake Shore offers cryogenic Hall sensors mounted into gaussmeter probes, which work in a variety of magnetic measurement applications. Our probes are factory calibrated for accuracy and interchangeability. Pre-calibrated probes feature a programmable read-only memory (PROM) in the probe connector so that Hall sensor calibration data can be read automatically by a Lake Shore gaussmeter.

Lake Shore also offers a complete line of axial, transverse, flexible, tangential, gamma, brass stem, and multi-axis Hall probes.
For more information call us, or visit www.lakeshore.com.

Axial



Transverse



	Model	L	D	A	Active area	Stem material	Frequency range	Usable full scale ranges	Corrected Accuracy (% of reading)	Operating temperature range	Temperature coefficient (maximum) zero	Temperature coefficient (maximum) calibration
Axial	MCA-2560-WN	60 in ±0.50 in	0.25 in dia ±0.006 in	0.025 in ±0.005 in	0.030 in dia (approx)	Stainless steel	DC	300 G, 3 kG, 30 kG, 300 kG	±2% to 100 kG	1.5 K to 350 K	±0.13 G/°C	±0.010%/°C
Transverse	MCT-3160-WN	61 in ±1 in	0.25 in dia ±0.010 in	0.210 in ±0.050 in	0.040 in dia (approx)	Stainless steel	DC and 10 Hz to 400 Hz	300 G, 3 kG,30 kG, 300 kG	±2% to 100 kG	1.5 K to 350 K	±0.13 G/°C	±0.010%/°C

Ordering information

Cryogenic Hall sensors and probes

Part number	Description
HGCA-3020	Cryogenic axial Hall sensor
HGCT-3020	Cryogenic transverse Hall sensor
MCA-2560-WN	Cryogenic axial gaussmeter probe
MCT-3160-WN	Cryogenic transverse gaussmeter probe

Room temperature Hall sensors also available—consult Lake Shore