

Position and Movement Sensor Solutions

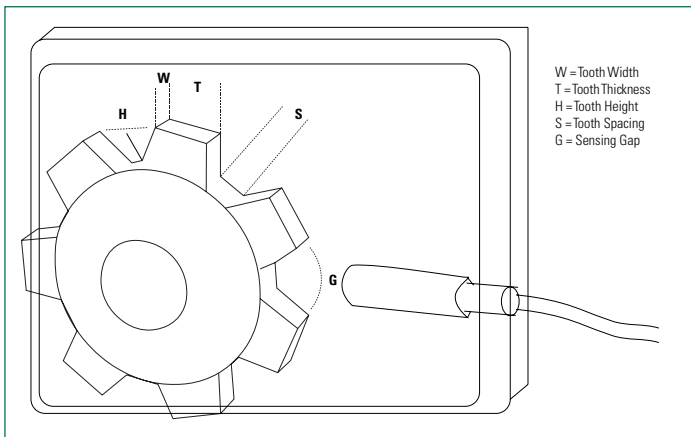
Technical Information

Hall Sensor

Test Geartooth Sensing using 55075 device

The best ferrous targets are made of cold-rolled low carbon steel. Sintered-metal targets are also usable, although care must be taken to ensure uniform material composition and density,

Figure 1. Gear Tooth



The Littelfuse device is a self-adjusting digital output geartooth speed sensor. The sensing distance between the sensor and a geartooth is influenced many factors including the gear teeth dimensions, the grade of ferrous metal of the gear and alignment of sensor to gear. Typically, larger teeth and slots allow a larger sensing air gap. For best performance, the sensor should be located as close as possible to the target. Optimally this gap should be less than 1 mm. The sensor may sense up to 2mm depending on your gear geometry.

General gear guideline should consider the following as an example:

W = 4mm S = 5mm

T = 6mm G = 1.5mm typical

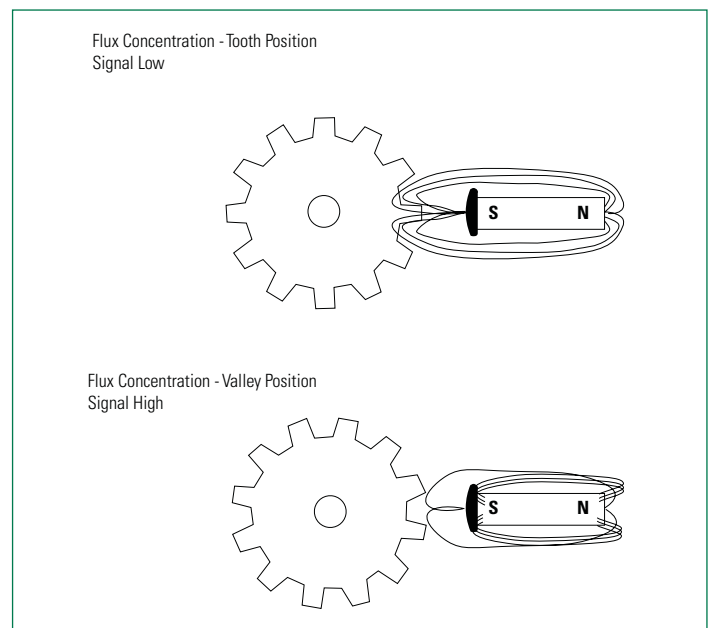
H = 4mm

For gears with smaller tooth dimensions the sensing gap would be typically 0.5 to 1.0mm. It is best to evaluate a sensor against your specific gear prior to final selection.

The teeth or slots of the target should be cut with a slight angle so as to minimise the abruptness of transition from metal to air as the target passes by the sensor. Typical air gaps for Littelfuse geartooth Sensors are between 1-1.5 mm. Littelfuse 55075 includes an internal pull up resistor for the sinking output.

Geartooth Sensors 55075

Figure 2. Flux Concentration



The need to sense speed and position of ferrous gears occurs in many industries. The ability to convert the repetitive passing teeth to an electrical impulse has been sought for many decades. Purely mechanical systems have been used with the attendant issue of wear and failure limiting its use to low speed and low duty cycle applications. Hall effect geartooth sensing makes use of the Hall element to sense the variation in flux found in the air gap between a magnet and passing ferrous geartooth. By digitally processing the Hall signal, several advantages are obtained. Peak detection, peak hold, and level comparison are all done digitally. The maximum and minimum Hall signal that corresponds to the last geartooth and valley is then remembered indefinitely without the drift associated with analog techniques. The level comparison then adapts to the last peak. This creates true zero speed adaptive speed sensor. It is immune to orientation requirements and can follow the gear speed down to the cessation of motion. It will detect the first edge of the next tooth immediately after power on. The digital signal processing does introduce an uncertainty from quantization that is greater at larger speeds. Extremely demanding timing requirements like those found in crank position sensors may suffer from the loss of accuracy at high speeds.

In order to detect the passing gear teeth with a Hall effect sensor, it is necessary to provide a source of magnetic energy. One simple way to do this is to arrange a permanent magnet such that the axis of magnetization is pointing toward the surface of the gear teeth. As a tooth moves across the surface of the magnet the flux will become attracted to the lower reluctance path provided by the ferrous steel structure.

When this occurs the flux density measured by the Hall element between the face of the sensor and the gear tooth increases. Many schemes have been developed and some patented that use the various attributes of the vector flux field and its changing nature to create zero speed Hall effect gear tooth sensors. Gear tooth Specifications:

Table 1. Recommended Operating Conditions, 55075 Geartooth

Symbol	Parameter	Min	Max	Unit	Comment
V_{DD}	Supply Voltage	4.75	25.2	V	if TJ-MAX is not exceeded
V_o	Output Voltage	0	25.2	V	-
T_s	Storage Temperature	-65	105	°C	-
T_s	Operating Temperature	-40	100	°C	if TJ-MAX is not exceeded

Table 2. Electrical Characteristics, 55075 Geartooth Over $T_A = -40$ to 100°C , $V_{OD} = 4.75$ to 25.2V unless otherwise specified.

Symbol	Parameter	Min	Typ	Max	Unit	Comment
I_{DD}	Supply Current	1.0	-	10.5	mA	$V_{DD} = 4.75$ to 25.2V
I_o	Continuous Output on Current	-	-	20	mA	Operating
V_{OH}	Output High Voltage	$V_{DD} - 2.0$	-	V_{DD}	V	$I_{OUT} = 0.1\text{mA}$
V_{OL}	Output Low Voltage	0	-	600	mV	$V_{DD} = 12\text{V}$, $I_{OUT} = 20\text{mA}$
f_o	Operating Frequency	0	-	15	kHz	Output Frequency

3-Wire Hall Sensors: 55100, 55140

These sensors utilize CMOS technology and consist of a Hall plate, active stabilization circuitry, a comparator, and an open-drain output.

Outputs are active low sinking- an external pull-up resistor is needed for most applications. The supply voltage and pull-up voltage need not be the same voltage. Any pull-up voltage from 0V to 24V nominal may be used. The pull-up resistor value is limited only by the maximum output leakage current over temperature of 10uA and the maximum recommended output current of 20mA.

The polarity of the magnet is very important for Hall sensors. "Switch Type" Hall sensors are activated by the South Pole. The proper magnet pole should be presented to the activation face of the sensor (see the sensor Datasheet for Activation Detail).

This family of sensors utilizes chopper stabilization. This feature provides nearly constant magnetic characteristics over variations in supply voltage, temperature, and mechanical stress. In order to implement this technology, an internal oscillator switches amplifier circuitry between sampling a reference and sampling the active magnetic sensor. The period of the oscillation is called TOSC and is a few microseconds (see specification). The sensor's digital output may be delayed by up to this amount. This very small delay is inconsequential in most applications and is far outweighed by the stability provided by the chopper circuitry.

3 Wire Specifications

Absolute Maximum Ratings, 55100 3-wire, 55140 3-wire.

Table 3. Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit	Comment
V_{DD}	Supply Voltage	-15	28	V	if TJ-MAX is not exceeded
V_o	Output Voltage	-0.3	26.4	V	-
I_o	Continuous Output on Current	-	50	mA	-
T_s	Operating Temperature	-65	105	°C	if TJ-MAX is not exceeded

Electrical Characteristics, 55100 3-wire, 55140 3-wire (Note 2) Over $T_A = -40$ to 90°C , $V_{DD} = 3.8$ to 24.0V unless otherwise specified

Table 4. Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit	Comment
V_{DD}	Supply Voltage	3.8	24	V	if TJ-MAX is not exceeded
V_o	Output Voltage	0	24	V	-
I_o	Continuous Output on Current	0	20	mA	Note 2
T_o	Operating Temperature	-40	100	°C	if TJ-MAX is not exceeded

Note 1: Conditions beyond the Absolute Maximum Ratings may cause permanent damage to the sensor. Functional operation beyond those shown in Recommended Operating Conditions is not implied. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

Table 5. Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Comment
I_{DD}	Supply Current	2.3	3	4.2	mA	$T_A=20^\circ\text{C}$, Note 2
I_{DD}	Supply Current over Temp.	1.6	3	5.2	mA	Note 2
V_{DDZ}	Supply Overvoltage Protection	-	28.5	32	V	$I_{DD}=20\text{ mA}$, $t=20\text{ ms}$ (used with external resistor), Note 2
V_{OL}	Output Low Voltage	-	0.13	0.28	V	$I_{OL}=20\text{ mA}$, $T_A=20^\circ\text{C}$, Note 2
V_{OL}	Output Low Voltage over Temp	-	0.13	0.40	V	$I_{OL}=20\text{ mA}$, Note 2
I_{OH}	Output Leakage Current	-	0.06	0.1	μA	$T_A=20^\circ\text{C}$, Output off, Note 2
I_{OH}	Output Leakage Current over Temp	-	-	10	μA	$V_{OH}=3.8\text{-}24\text{ V}$, Note 2
T_{osc}	Internal Chopper Oscillator Period	-	16	-	μA	-

Note 1: Conditions beyond the Absolute Maximum Ratings may cause permanent damage to the sensor. Functional operation beyond those shown in Recommended Operating Conditions is not implied. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

Analog Hall Sensor: 55100-AP, 55140-AP

Analog Hall sensors are semiconductor devices that use the Hall effect to measure magnetic fields. They are often implemented using CMOS technology, which allows for programmability and customization of various sensor parameters. Some key features and characteristics of these sensors are as follows:

- 1. Customer Preset:** Analog Hall sensors can be preset to a specific output voltage corresponding to a particular magnetic field strength (measured in gauss). This allows the sensor to be tailored to the specific requirements of the application.
- 2. Programmability:** The sensor electronics are programmable, enabling customization of different parameters, such as magnetic field range, sensitivity, output voltage range, and temperature coefficients. This flexibility makes the sensors suitable for a wide range of applications.
- 3. Ratiometric Output:** The output voltage of the sensor is referenced to the supply voltage. This means that the output value is proportional to the magnetic field strength relative to the supply voltage. Ratiometric outputs provide a stable and accurate measurement even when the supply voltage fluctuates.
- 4. Fault Tolerance:** The sensor is designed to handle different fault conditions, such as power supply open-circuit, ground open-circuit, or power supply over/undervoltage to ground or supply voltage. This ensures reliable operation even in challenging scenarios.
- 5. Total Error:** The sensor's total error, which includes all sources of inaccuracies, is specified to be less than 2% over the entire operating voltage and temperature range. This level of accuracy makes the sensor suitable for precise measurement applications.

Overall, analog Hall sensors utilizing CMOS technology offer a versatile and reliable solution for measuring magnetic fields across various industries and applications, including automotive, industrial, and consumer electronics.

The standard programming of the AP series Analog Hall Sensor has a preset voltage output of 2.5 Vdc and declines to approximately 0 Vdc as the magnetic field strength increases (magnet pole approaches the sensor face). Customization is accomplished using a Programming Interface and Dedicated Programming Software.

3-Wire TMR Sensors 54100, 54140

These TMR (Tunneling MagnetoResistance) sensors utilize CMOS technology which consist of a TMR sensing element, band gap regulator, a comparator and a Push/Pull output.

Outputs are active low sinking and active high sourcing. The maximum recommended output current is 6 mA.

The Omnipolar sensors require either a North or a South magnetic pole to operate. The sensor is activated (output sinking to ground) by the either pole once the BOP threshold is exceeded and deactivated (output sourcing to Vcc) when the BRP threshold is crossed. The magnet pole should be presented to the side of the sensor opposite the wired side. See Product Datasheet for application detail.

3-Wire TMR Sensors Specifications

Table 6. Absolute Maximum Ratings 54100, 54140 (Note 2) (@ $T_A = +25^\circ\text{C}$, unless otherwise specified.)

Symbol	Characteristics	Values	Unit
V_{CC}	Supply Voltage	7.0	V
V_{RCC}	Reverse Supply Voltage	0.3	V
$I_{OUTSINK}$	Output Current	9.0	mA
B	Magnetic Flux Density	4000	Gauss
V_{ESD}	ESD Level (HBM)	2	kV
T_A	Operating Temperature	-40 ~ 125	$^\circ\text{C}$
T_{stg}	Storage Temperature	-50 ~ 150	$^\circ\text{C}$

Note 2: Stresses greater than the 'Absolute Maximum Ratings' specified above may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Table 7. Electrical Characteristics 54100, 54140 (@ $T_A = +25^\circ\text{C}$, $V_{CC} = 3.0\text{V}$)

Symbol	Parameter	Min	Typ	Max	Unit	Conditions
V_{CC}	Supply Voltage	1.8	3.0	5.5	V	Operating
V_{OH}	Output High Voltage	$V_{CC}-0.3$	-	V_{CC}	V	-
V_{OL}	Output Low Voltage	0	-	0.2	V	-
I_{CC}	Supply Current	0.5	1.5	2.0	μA	Output Open
Freq	Response Freq	-	1.0	-	kHz	-

Table 8. Magnetic Characteristics 54100, 54140 (@ $T_A = +25^\circ\text{C}$, $V_{CC} = 3.0\text{V}$)

Symbol	Parameter	Min	Typ	Max	Unit
B_{OPS}	Operation Point	10	17	25	Gauss
B_{OPN}		-25	-17	-10	Gauss
B_{RPS}	Release Point	5	10	20	Gauss
B_{RPN}		-20	-10	-5	Gauss
B_H	Hysteresis	-	7	-	Gauss

Custom Design Sensors

Littelfuse specializes in meeting our customers specific requirements. Littelfuse offers full service Engineering capability in-house. Please contact our local Sales Representative or the Littelfuse factory for any relative

EMC and ESD

For applications with disturbances on the supply line or radiated disturbances, a series resistor and a capacitor are recommended. The series resistor and the capacitor should be placed as closely as possible to the sensor. Applications with this arrangement passed the EMC tests according to the product standards DIN 40839.

Figure 3. 3-Wire Devices

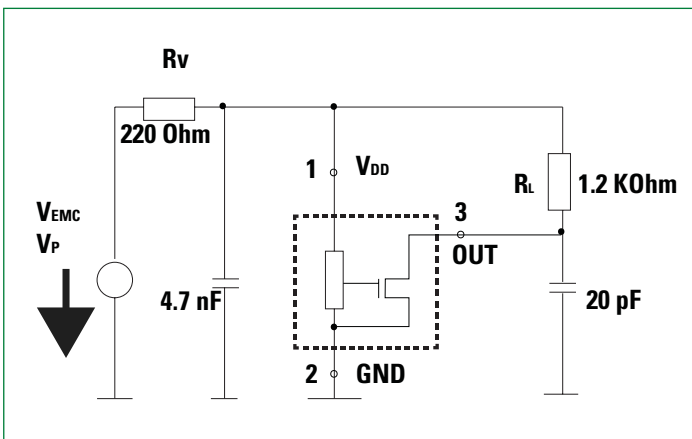
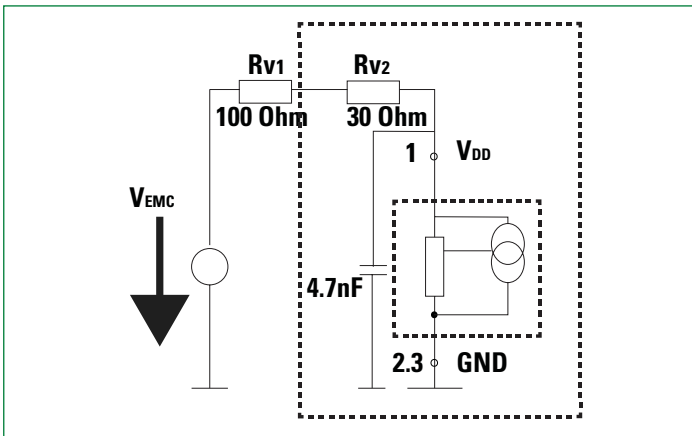


Figure 4. 2-Wire Device



Overvoltage Protection except 55075

Absolute maximum rating for a continuous supply is 24 V. If the supply voltage exceeds the Zener voltage of 28 V, the current consumption of the devices increases. Voltages above the Zener voltage can be tolerated only for short time. In order to protect the Hall sensor against overvoltage, an external series resistor is required. The voltage drop at this series resistor increases with increasing supply current. A Zener diode in combination with a (external) series resistor acts as clamping device, limiting the supply voltage of the device to the Zener voltage.

Reverse Voltage Protection except 55075

The maximum reverse voltage is -15 V. As an example, if the device is used with an automobile 12 V supply, it may be connected incorrectly without damage. As with overvoltage protection, with external components this value can be increased. Please consult Littelfuse for details.

Temperature, Voltage, and Power

Like all solid-state semiconductor devices, Hall and TMR sensors have a maximum operating junction temperature. The operating junction temperature is determined by the power (voltage times current) that the sensor is dissipating, the thermal resistance of the package, any heat-sinking effects resulting from mounting configuration, any air movement, and ambient (air) temperature. Because of the internal power dissipation and self-heating, the maximum operating temperature may need to be reduced at higher supply voltages in order to limit the junction temperature to an acceptable value.

ESD Precautions

Littelfuse semiconductor products are sensitive to Electro Static Discharge (ESD). Always follow ESD control procedures whenever handling our Hall Effect Sensors

FAQs

- Q:** Does Littelfuse manufacture its own Hall elements?
- A:** Littelfuse procures the Hall Effect IC from reputable Hall Effect vendors and places these into our value add sensing products.
- Q:** How large of a sensing gap can I obtain between the magnet and the sensor?
- A:** The relative distance is dependent upon the environment within and around the magnetic circuit. Relative factors are characteristics of the magnet, the presence of ferrous materials and other magnetic fields. Littelfuse shows typical operate values on its Hall sensor and TMR sensor datasheets to be used as a guide. These are based upon using our standard Hall sensor and TMR sensor actuator. Other magnet designs would have their own characteristics. Please feel free to contact Littelfuse technical support for assistance.

- Q:** Does Littelfuse offer more than one sensitivity of Hall and TMR sensors?
- A:** Littelfuse offers high, medium and low sensitivity Hall sensors. Please reference our individual data sheets in Table 1 of the individual specification sheets. We also offer custom variants if our standard selection does not meet the requirements of a specific application.

- Q:** What's the maximum operating speed of a Littelfuse Hall and TMR sensor?

A: Hall and TMR sensors can switch much faster than the requirements of many mechanical sensing applications. The Hall sensor will reliably switch up to 10kHz. Geartooth sensors can work at even higher frequencies. Refer to sensor specific data for details.

Q: When I mount a Littelfuse Hall or TMR sensor, do I need to worry about the orientation of the sensor or the magnet?

A: The sensing face of Littelfuse Hall and TMR sensors are on the datasheet. Littelfuse digital products are designed to be operated using the magnetic south pole of the actuating magnet. Of course, the latching Hall uses both poles and the analog Hall can operate with both poles or one pole.

Q: What's the expected operating life of a Littelfuse Hall and TMR sensor in terms of number of operations?

A: A Littelfuse sensor is a solid state device with no moving parts, so its operational life is virtually unlimited if operated within electrical load ratings and its junction temperatures are not exceeded.

Q: How do I know whether a reed switch, Hall or TMR sensor is better suited for a specific application?

A: While they are both magnetic proximity sensors, Hall or TMR sensors and reed sensors have significant differences in the way that they function. A reed sensor is a mechanical switch in which the precious metal contacts are hermetically sealed within a small glass tube. The reed sensor has a digital output and has no analog capability. The reed switch can be magnetically biased to obtain a latching version. A TMR and Hall effect sensor is a solid-state device with no moving parts. The Hall sensors that Littelfuse uses have 3 types of output options: digital, latching, and analog. Each technology has its advantages or disadvantages. Hall and TMR sensors may have advantages over reed sensors if you have the following requirements:

- Unlimited life and fast operation. For example, if you have a spinning magnet application with a cycle rate less than 1000 Hz, a reed will work fine. If the cycle rate is up to 10KHz, a Hall and TMR Sensor will operate well beyond a billion operation cycles. Reed sensors generally have very long life compared to other electro-mechanical devices. For many logic level electrical loads, a reed will operate a billion cycles.
- You need bounce free switching.
- A Hall or TMR sensor is excellent for geartooth speed sensing or rotary position sensing. A reed sensor is very difficult to bias and obtain long term stability when used as a geartooth sensor.

A reed sensor may be preferable to a Hall or TMR sensor if you have the following requirements:

- You need a two-wire device that requires no power.
- You require immunity to ESD and have a low target price.
- Special reed sensors can effectively switch up to 240 Vac at low current. A Hall device is typically limited between 5 to 24Vd and less than 50mA

Q: What sort of material do you recommend I use to operate a Littelfuse vane sensor?

A: Low carbon steel, which is magnetically soft, makes an excellent ferrous material for vane applications that are highly calibrated. Cold roll steel is acceptable but magnetic retentivity is a concern that may result in less than acceptable actuation repeatability for your sensor.

Q: Are there advantages of a Littelfuse vane sensor over an opto-interrupter?

A: There are a few potential advantages, depending upon your application. Opto-interrupters are very sensitive to contamination that will inhibit light detection. Reliability will be an issue within this environment. Hall effect vane sensors are immune to dust, dirt and grease. 2. We also recommend ferrous vane sensors for their stability at high temperatures. Littelfuse offers standard vane sensors with maximum operating temps up to 100°C and higher with special added features.

Interfacing, Signal Conditioning, Interference

Q: I just received a Hall Effect Sensor from Littelfuse, and I can't figure out how to get a signal from it. What should I do?

A: Littelfuse's Hall sensors use sinking outputs, also commonly referred to as "open collector outputs". For sinking outputs, you need to select an appropriate external pull-up resistor, connected between Vdd and Vout. If you have questions about connecting to your sensor, you can obtain assistance by contacting Littelfuse technical support.

Q: Are Littelfuse Hall or TMR sensors ESD sensitive?

A: Littelfuse Hall and TMR sensors are ESD sensitive. Normal ESD precautions should be taken when handling sensors that are not grounded.