Magnetic Sensors
Introduction

- A magnetic position sensor responds to the presence or the interruption of a magnetic field by producing a proportional output.
- Types of magnetic position sensors include:
  - Hall-effect sensors are constructed from a thin sheet of conductive material with output connections perpendicular to the direction of the current flow.
  - Magnetoresistive digital sensors have a built-in magnetoresistive bridge integrated on silicon and are encapsulated in a plastic package. The integrated circuit (IC) responds to low fields at large distances.
  - Hall-effect vane sensors consist of a magnet and a Hall-effect sensor inside a rugged plastic housing; different package styles provide mounting flexibility.
  - Gear tooth sensors use a magnetically biased Hall-effect IC to sense movement of ferrous metal targets. The specially-designed IC is sealed in a durable plastic probe-type package.
  - Hall-effect basic switches and magnets
  - Digital and analog Hall-effect position sensors
Potential Applications

- Appliances
  - Door lock detection, washer arm RPM, current sensing
- Commercial
  - Vending, automated teller machine, medical
- Consumer
  - RPM measurement in fitness equipment
- HVAC
  - Valve positioning (Variable Air Volume), fan control
- Instrumentation
  - Flux meters, current sensing, remote metering, liquid level
- Infotech
  - Tape drives, copiers, cooling fans, cash registers, uninterruptible power supplies
- Motion control
  - Piston detection in pneumatic or hydraulic cylinders, brushless DC motor commutation, RPM measurement, magnetic encoder, variable speed drives
Magnetic Sensor Technology

\[ V_{\text{hall}} \propto I_c \times H \]

- \( V_{\text{hall}} \) = Output Hall-effect voltage
- \( H \) = Magnetic Flux created by magnet or current-carrying conductor
- \( I_c \) = Constant supply current
Magnetic Sensor Technology

**Hall-effect Sensing Mechanism**

- The current source is applied through a thin sheet of semiconductor material.

![Hall-effect diagram](image)

- A magnetic field applied **perpendicular** to the element creates a voltage change $V_{\text{hall}}$. Its output is **bipolar**.

**Magnetoresistive Sensing Mechanism**

- A magnetic field applied **parallel** to the element changes its resistance and creates a current.

![Magnetoresistive diagram](image)

- MR is **omnipolar**—either pole will operate the sensor.
Design Factors – Magnetic Types

- **Unipolar**: Only a south pole will operate the sensor. The sensor turns on with the south pole(+) and off when the south pole is removed.

- **Bipolar**: Sensor output is pole-dependent. A south pole (+) is designed to activate the sensor; a north pole(-) is designed to deactivate. It’s possible that the sensor could turn off and still be within a positive Gauss level.

- **Latching**: Specifications are tighter on latching. Sometimes it is designed to make certain that when the south pole(+) is removed from the sensor, it will stay on until it sees the opposite pole(-).

- **Omnipolar**: The sensor is designed to operate with either magnetic pole(+ or -).

- **Ratiometric linear**: Output is proportional to magnetic field strength. Output sensitivity range is 2.5 – 3.75 mV per unit of Gauss.

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SS411A Bipolar Hall-Effect Digital Position Sensor
SS461A Series Latching Hall-Effect Digital Position Sensor
2SS52M Series Omnipolar Magnetoresistive Sensor
SS495A Series Standard Miniature Ratiometric Linear Hall-effect Sensor
SS441A Series Unipolar Hall-Effect Digital Position Sensor
Design Factors – Basic Magnetic Characteristics

• When selecting a magnetic sensor, one must consider how much magnetic field the sensor needs before it turns on or off.
• Gauss levels to operate the sensor:
  – 25 Gauss for omnipolar through 400 Gauss for unipolar, and everywhere in between
  • As these sensors are temperature-sensitive, these ranges are at room temperature.

SS490 Series Miniature Ratiometric Linear Hall-effect sensors have a ratiometric output voltage set by the supply voltage that varies in proportion to the strength the magnetic field. The magnetic range of this sensor is -670 Gauss to +670 Gauss.
Design Factors – Electrical Characteristics

• Supply voltage
  – 3.8 to 30 Vdc

• Supply current
  – 10 mA to 30 mA

• Output current
  – 1.5 through 20 mA

• Output voltage
  – .40 volts max.

The SS495A Series Standard Miniature Ratiometric Linear Hall-effect Sensor has a supply voltage of 4.5 to 10.5 V and an output current of 1.5 mA.
Design Factors – Output Type

- Ratiometric linear sinking or sourcing
- Digital sinking or digital sourcing

4AV Series Second Level Hall-effect Sensors are digital sinking sensors. They operate via a low-cost, easy-to-fabricate ferrous vane and can be used as limit switches by operating with a single large vane; as tachometer sensors by using multiple vanes; or as synchronizing elements by using cams or sectors.

103SR Series Second Level Hall-effect Sensors are ratiometric sinking/sourcing sensors. These sensors detect the proximity of an external magnet and are available with a current sourcing or and sinking output. They come in a rugged sealed, threaded aluminum housing.
Design Factors – Package Style

• Standard (plastic radial) lead
  – Leads are longer so they can be inserted into a circuit board. If the lead needs to be adjusted, it can be bent which provides flexibility when putting it on a circuit board.

• Plastic surface mount (SOT-89 package)
  – This very low profile package is designed for high speed pick-and-place assembly operations. The sensor is placed on top of the circuit board and wave soldered.

SS441A Series Unipolar Hall-effect Digital Position Sensor

SS541A Series Unipolar Hall-effect Sensor; SOT-89B surface mount package
Design Factors – Packaging Styles

- **Reduced lead length**
  - Leads are cut short to allow them to be inserted into the circuit board

- **Ceramic SIP (single inline package), ceramic with solder bumps**
  - Package style allows for increased temperature stability because they’re ceramic based, not plastic
    - Ceramic packages with laser trimmed, thin and thick film resistors minimize sensitivity variations and compensate for temperature variations
  - Magnetic ranges ±100 Gauss to ± 2500 Gauss
  - Also available linearly (output proportional to magnetic field)

SS441A-R Series Unipolar Hall-effect Reduced Lead Length Digital Position Sensor

SS941A Series General Purpose Ratiometric Linear Sensor; Vdc supply voltage
Design Factors – Packaging Options

• Tape and reel
  – Often ideal for end customers with pick-and-place manufacturing. Customers can order a surface mount version packaged for shipment on tape and reel so the reel can be put on an automated assembly machine.

*Tape and reel packaging for SS500 Series Temperature Compensated Hall-effect Sensors. Any SOT-89 package sensor is available in this tape and reel package.*
Design Factors – Packaging Options

- Bulk pack
  - The sensors are ordered, manufactured and put into a bag for shipping

- Ammopack
  - Parts are mounted on a fan fold that folds back and forth so it can be fed out of a box

Ammopack for SS400 Series Temperature Compensated Hall-effect Sensors.
Design Factors – Operating Temperature Range

• An important design characteristic because a wide operating temperature range often offers the end user the ability to design into more applications

• Typical operating temperature range: -40 °C to 150 °C
Summary

- Magnetic sensors are designed to provide:
  - Digital and analog Hall-effect position, magnetoresistive, Hall-effect vane, gear tooth, and Hall-effect basic switches and magnets
  - Unipolar, bipolar, bipolar latch, omnipolar, and linear magnetics
  - Digital sourcing, digital sinking (open collector), digital sinking and sourcing, and ratiometric sinking or sourcing
  - Plastic surface mount (SOT-89 style), ceramic SIP, ceramic with solder bumps, plastic radial lead IC, aluminum threaded barrel, plastic probe, plastic dual tower wire exit, plastic dual tower with connector, plastic mechanical switch
  - Wide continuous operating temperature range
Engineered Excellence

• Part Innovation
  – A global leader in cost-effective, problem-solving sensors and switches

• Part Engineering
  – Over 50,000 products ranging from humidity, position, speed, pressure, torque and airflow sensors to snap action, limit, toggle, pushbutton and pressure switches

• Total Solutions
  – 75 years of developing solutions to meet millions of customers’ needs
Warranty and Remedies
Warranties and Remedies

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DO NOT USE these products as safety or emergency stop devices or in any other application where failure of the product could result in personal injury.
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