Hall Effect Sensors

Introduction

Hall effect sensors are used in applications that require a magnetic field to be measured (linear sensors) or just detected (digital sensors). An example of the former is in the measurement of current, in which the magnetic field strength, as measured by the Hall effect sensor is proportional to the current being measured. An example of the latter is in the measurement of rotational speed, in which a Hall effect sensor detects the presence of a permanent magnet attached to the rotating member every time it passes the sensor. In this situation, the magnitude of the magnetic field is irrelevant.

The SS495A Hall effect sensor is a linear sensor, giving an output voltage of around 30 mV/mT when supplied with 5V dc. The principle of operation, some useful data, and information on practical usage of the SS495A follows.

Principle of operation

Referring to Fig. 1, when the voltage V is applied to the slab of semiconductor, charge is caused to flow with drift velocity **v**. In the presence of the magnetic flux density **B**, a force acts on the moving charges given by:

$$\mathbf{F}=e(\mathbf{v}\times\mathbf{B}) \tag{1}$$

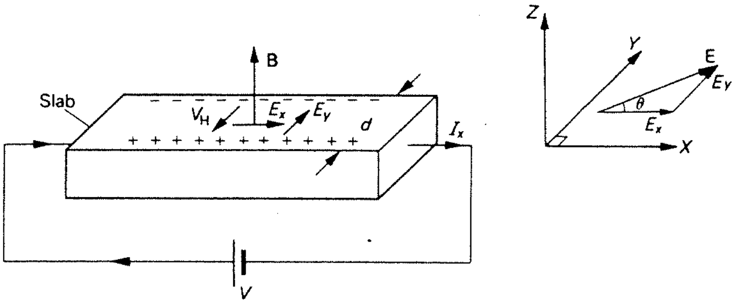

Fig. 1

in which e is the electronic charge in Coulombs. If the current and flux density are orthogonal, as shown in Fig. 1, then the force of equation 1 acts in the positive *y* direction for positive charges, and in the negative *y* direction for negative charges. Hence, charges accumulate as shown in Fig. 1, producing an electric field **E**. The moving charges experience an additional force due to this electric field, giving the total force as:

$$\mathbf{F}=e(\mathbf{E}+\mathbf{v}\times\mathbf{B}) \tag{2}$$

Charges accumulate until equilibrium is established, for which the total force must be zero. Equation 2 shows that for this to occur:

$$\mathbf{E}=-\,\mathbf{v}\times\mathbf{B} \tag{3}$$

The electric field **E** is associated with a voltage known as the Hall voltage, V_H. The Hall voltage and the electric field are related by:

$$\mathbf{E} = -V_H/d \qquad (4)$$

Since the drift velocity of the charges is proportional to the applied voltage V, and combining equations 3 and 4 shows that:

$$V_H \propto V\ B \qquad (5)$$

in which it is assumed that the charge drift velocity and the magnetic field are orthogonal. Therefore, the resulting Hall voltage, V_H, is proportional to the applied voltage, V, and the magnetic flux density, B. For a fixed applied voltage e.g. 5 V, the Hall voltage is simply proportional to B, as required.

Practical Use

For the Hall voltage to be maximized for a given supply voltage and magnetic field, the current must be perpendicular to the magnetic field. In the SS495A sensor, the sensing element is oriented such that the chip must have the printed face parallel to the magnetic tape which it is to detect. Figure 2 shows the pins of the chip as viewed such that the printed side faces you, and figure 3 shows the internal configuration of the device. The + and – inputs are for 5 V and 0V respectively, and the pin marked 'o' is the output. In order to design a circuit for detecting the presence of the magnetic strip, it is suggested that you construct a simple circuit in which you connect a 5 V power supply to the sensor. Then, measure the voltage at the sensor output as a function of distance from the magnetic strip. Using this information you should be able to decide how to implement the magnetic strip detection circuit.

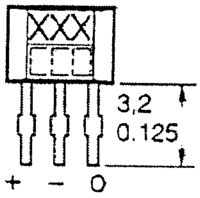

Fig. 2

SS495A

SS490 Series Standard Miniature Ratiometric Linear Sensors, Radial Lead I.C.

BLOCK DIAGRAM CURRENT SINKING OR SOURCING OUTPUT

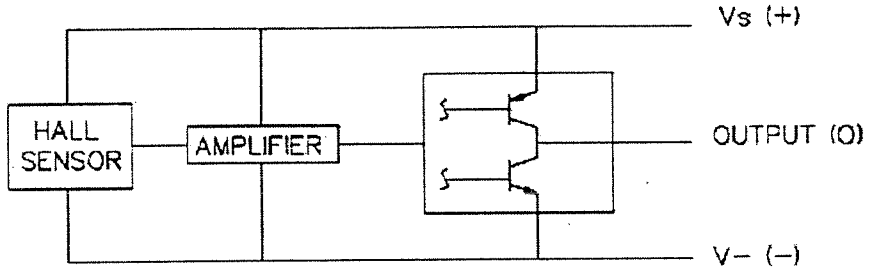

Fig. 3

Useful Data

Over the page is some relevant data photocopied from the manufacturer's specification for the SS495A

T J Flack Michaelmas 2001

SS495A

SS490 Series Standard Miniature Ratiometric Linear Sensors, Radial Lead I.C.

Product Specifications	
Product Type	Hall Effect Linear Position Sensor
Package Quantity/Type	Available in 1,000/Bag
Package Style	Radial Lead I.C.
Supply Voltage	4.5 Vdc to 10.5 Vdc
Supply Current max., (mA) @ 25 °C	8.7 @ 5 Vdc
Output Type	Sink/Source
Magnetic Actuation Type	Ratiometric
Sensitivity @ 25 °C	3.125 mV ± 0.125 mV/gauss
Operating Temperature Range	-40 °C to 150 °C [-40 °F to 302 °F]
Output Voltage	0.2 to (Vs-0.2) typical/0.4 to (Vs-0.4) min.
Output Voltage Swing (Negative Gauss)	0.4 V
Output Voltage Swing (Positive Gauss)	Vs-0.4 V
Linearity (% of Span)	-1.0 % typical/-1.5 % max.
Temperature Error (@ 25 °C) Null Shift (%/°C)	-0.06 % min., +0.06 % max.
Temperature Error (@ 25 °C) Sensitivity (%/°C)	-0.01 % min., +0.05 % max.
Output current (mA)Typical Source Vs > 4.5 Vdc	1.5
Output Current (mA) Minimum Source Vs > 4.5 V	1
Output Current (mA) Minimum Sink Vs > 4.5 V	0.6
Output Current (mA) Minimum Sink Vs > 5.0 V	1
Magnetic Range (Typical)	-670 Gauss to + 670 Gauss [-67 mT to +67 mT]
Magnetic Range min.	-600 Gauss to + 600 Gauss [-60 mT to +60 mT]
Output Voltage Span (Typical)	0.2 to (Vs -0.2)
Output Voltage Span (min.)	0.4 to (Vs-0.4)
Null (Output @ 0 Gauss, V)	2.50 ± 0.075
Response Time (µs)	3 µs
Availability	Global
Series Name	SS490 Series