Solid state magnetic switches . . .

The Hall Effect

what it is and how it works

Ever heard of the Hall Effect? You haven't?!! Well read on. Hall Effect devices are now available at quite a moderate cost, making it possible for the electronics enthusiast to experiment with these fascinating devices. Imagine being able to measure the flux intensity of a permanent magnet, or use magnets in all sorts of control applications.

by GERALD COHN

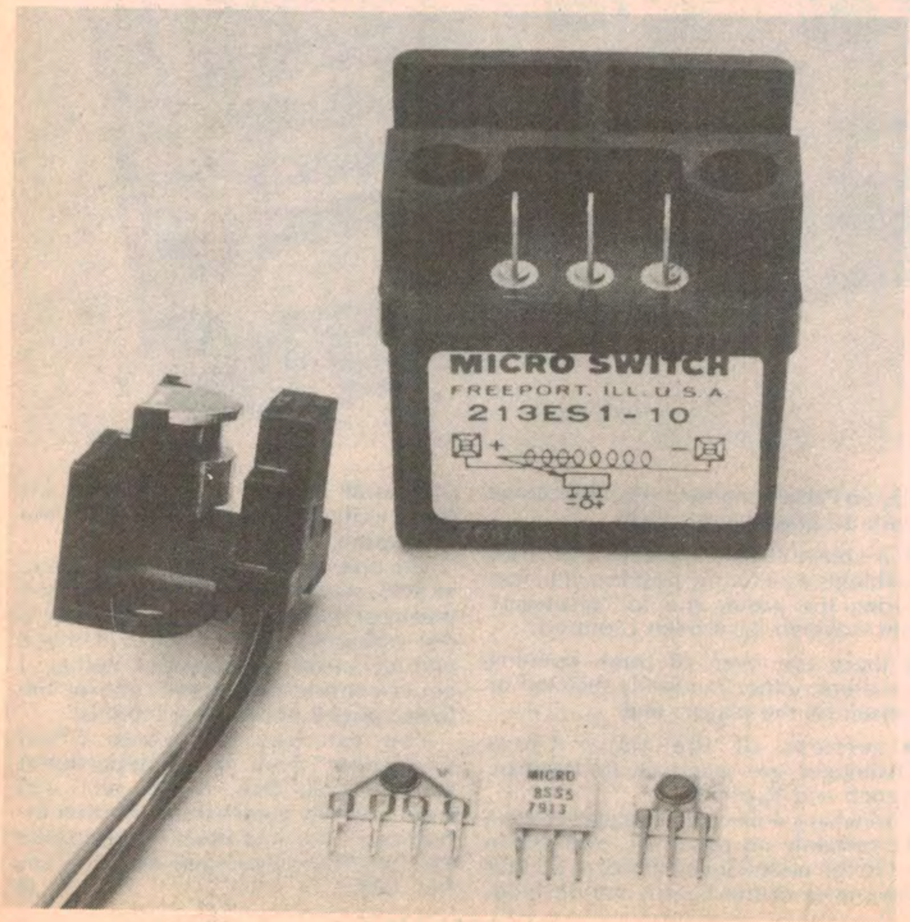
The Hall effect was discovered in 1879 by Edward H. Hall, at the John Hopkins University. Mr Hall found that when a magnet was placed in a position where its field was perpendicular to one face of a thin rectangle of gold through which current was flowing, a difference in potential appeared at the opposite edges. He found that this voltage was in turn proportional to the current flowing in the conductor and the flux density or magnetic induction perpendicular to the conductor.

Today, semiconductors are used rather than gold for the Hall element. The Hall voltages obtained are much higher using semiconductors.

Fig. 1 illustrates the Hall principle. Shown is a thin strip of semiconductor material (Hall generator) through which a constant control current is passed. When a magnet is brought near, such that its field is directed at right angles to the face of the semiconductor, a small voltage appears at the contacts placed across the narrow dimension of the strip. As the magnet is removed the voltage drops to zero.

The Hall voltage is dependent on the presence of the magnetic field and on the current flowing in the element. If either input is zero, the Hall voltage is zero. If the current flow through the Hall element is held constant, the Hall voltage is proportional to the magnetic field, and conversely, if the magnetic field is held constant, Hall voltage is proportional to the control current.

In typical Hall effect devices the control current is held essentially constant and the flux density is changed by the



Left: Typical Hall effect sensors. Shown are a vane sensor, a current sensor and three general purpose devices.

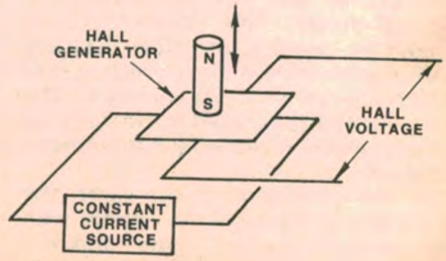


FIG. 1: HALL EFFECT PRINCIPLE

movement of a permanent magnet.

Fig. 2 illustrates the concept behind a practical Hall device. The output voltage of the Hall element, as a function of magnetic flux, is linear and therefore the device cannot be considered as a switch. Rather, the function of the element is to sense the presence of a magnetic field and provide an electrical output which is proportional to the flux density.

Fig. 3 shows the linear relationship between the magnetic flux density and a typical Hall element's output voltage is millivolts. As the magnetic field is increased, the output voltage increases in a predictable fashion. For example, if the output of the Hall element is 9.5mV on a meter, then we would know that the magnet was producing 150 gauss. Moving the magnet closer to the element increases the output reading on the voltmeter. When the meter reads 28.5mV, the magnetic field would be 750 gauss (or .075 Tesla).

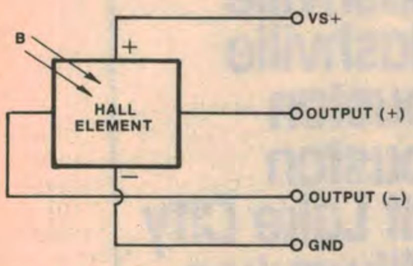


FIG. 2: SIMPLIFIED HALL ELEMENT SCHEMATIC

Another important feature of the Hall element is the differential output. In other words, as the voltage at out output rises, the voltage at the other output falls. This only occurs when the element is subjected to a magnetic field. Another important feature of the Hall element is its ability to determine the magnetic polarity of the applied field. This is a particularly useful feature if the poles of a magnet are unmarked, and need to be identified.

Specially calibrated elements are available that have a known output voltage for given quantity of applied magnetic flux. These devices are primarily intended for the measurement of magnetic field strengths and for other instrumentation purposes where a known characteristic is of prime importance. As would be expected, these devices are considerably more expensive than standard production types which are designed to operate between known limits.

Linear output Hall effect devices are somewhat limited in application, however. For this reason, digital output devices have been developed, and these find a much greater range of application due to the ease with which they can be interfaced with digital circuitry.

Essentially, the digital output device uses the linear element as a detector,

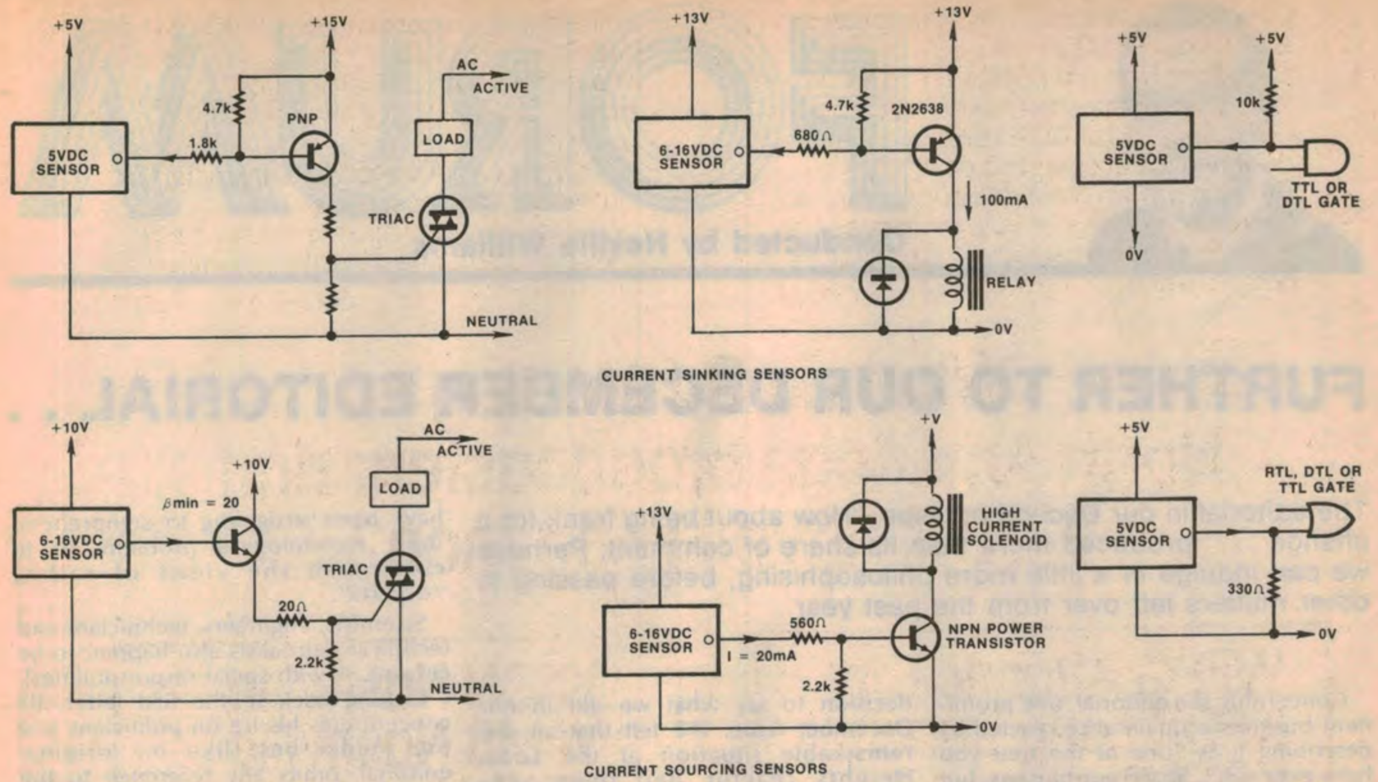


FIG. 4: DIGITAL/HALL EFFECT INTERFACE

the output of which is then amplified and fed to a trigger circuit. This, in turn, drives an output transistor to provide the digital output.

The digital devices are available with two types of outputs: current sinking and current sourcing. The current sinking output consists of an open collector that is capable of sinking in the region of 10mA. The emitter of the transistor is internally connected to the ground rail of the chip. The current sourcing type has an open emitter output, capable of sourcing 10mA. The collector of this transistor is internally connected to the supply line of the Hall element.

The digital devices can be interfaced to external circuitry in quite a number of different ways, some examples of which are shown in Fig. 4.

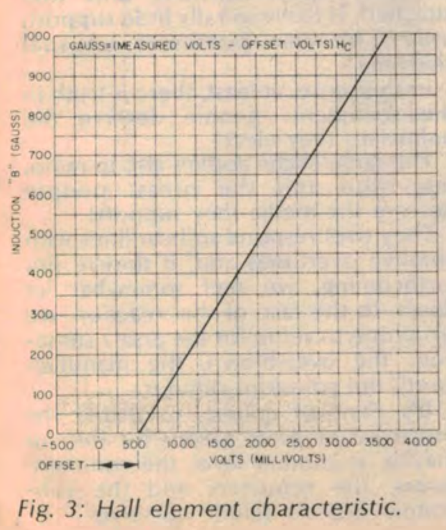


Fig. 3: Hall element characteristic.

Hall effect devices have several big advantages over their electro-mechanical counterparts. These include longer life, greater reliability, and the elimination of contact bounce (since there is no mechanical switching action). This latter advantage has been exploited by such companies as Honeywell and IBM (to name just two) for a range of computer and typewriter keyboards.

The basic scheme is quite simple. Small magnets are attached to the various keys, and activate Hall effect devices whenever the keys are depressed. By eliminating the contact bounce problem of mechanical keyswitches, the interfacing circuitry to the keyboard is considerably simplified.

Another commercial application for Hall effect devices, and one that is increasing in popularity, is in auto ignition systems. Here a cup-shaped vane, with as many teeth as there are engine cylinders, rotates through a Hall effect vane sensor mounted in the engine distributor. The resultant logic pulses are used to trigger an electronic ignition system without the use of points.

Hall effect devices can also be used in flow meters and computer peripherals, and as current and position sensors in a wide range of industrial machinery and home appliances. They can, for example, be used to control the commutation of field current in brushless DC motors, to sense tone arm position in record players, and to control conveyor belts on production lines.

Electronic sewing machines, coin operated machines, office machines, telephone systems, electronic keyboards on musical instruments, and utility meters with remote reading capabilities can all make use of Hall effect devices.

Typical applications in which the hobbyist could use Hall effect devices include burglar alarm installations (instead of reed switches, for example), or as detectors in model railway layouts. The Hall device could be mounted in the middle of the railway track, at the point where it is desired to detect the presence of a train, and activated by a magnet fastened to the underside of the locomotive or one of the carriages. The output of the device could be used to switch points or signals, or even provide signals to a computer that is controlling the layout.

Well, that's at least a basic introduction to the Hall effect and the way in which it can be applied. It's now up to you to find your own applications for these interesting devices.

This article has been prepared from information supplied by Micro Switch, division of Honeywell Pty Ltd. Micro Switch manufactures a wide range of Hall effect devices and sensor packages, including vane sensors, proximity sensors, current sensors and plunger operated sensors. Further information on these may be obtained from Honeywell Pty Ltd, 863-871 Bourke St, Waterloo, NSW 2017. Telephone (02) 699 0155.