The Hall Effect Transistor.

The little transistor that's not an amplifier.

By Jules Perrin VK3JFP

In 1879 Edwin Hall, an American physicist, explored the interaction between magnetism and electric current for his doctoral degree. His findings identified what is now known as the "Hall Effect". This phenomenon is widely used today in many industries and applications.

Photo 1 shows a small selection of Honeywell packaged sensors for many industry applications. The sensors intention and output states are not al linear. There are self-latching, unipolar, bipolar and speed sensing to list a few.

Photo 1 Various packages used by industry.

Hall Effect

Electric current is an orderly movement of electrons though a conductor from the negative terminal to the positive terminal. See Figure 1. Hall's experiments found that exposing the electron flow to a magnetic field caused the electrons to deviate into a curved path as they move through the material. See Figure 2.

Moving the electrons to one side makes that side microscopically negative and a very small potential difference can be detected either side of the conductor. See Figure 3.

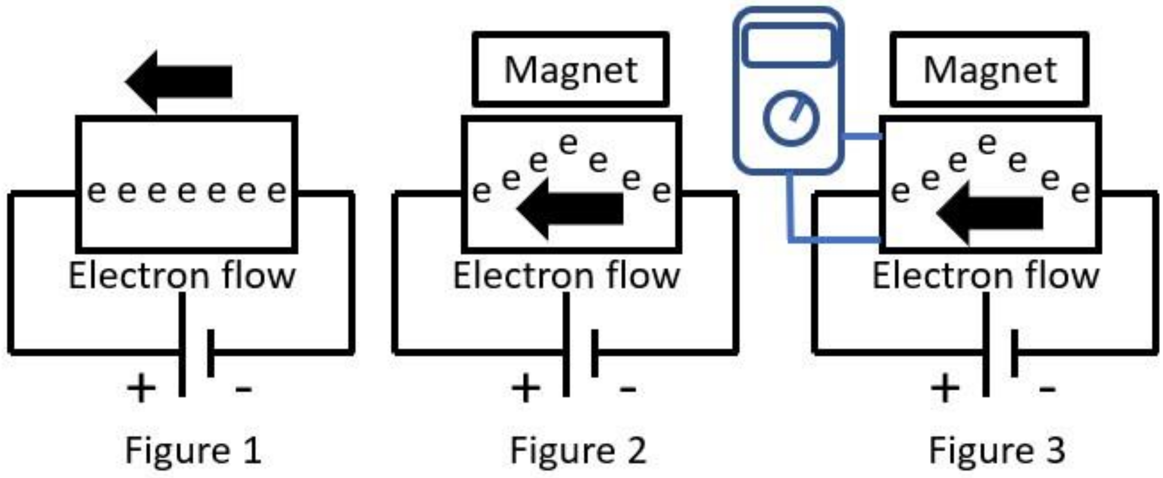

Fig 1 Electron flow. Fig 2 Magnetic effect. Fig 3 Potential difference.

Magnets

Quick rehash on magnets. A magnet is an object with an invisible field that can attract ferromagnetic materials. The strength of the magnet's field is called the "flux density". A magnet has two poles, North and South, and the field flows from North to South. See Figure 4. The output voltage is directly proportional to the magnet's flux density when near the conductor.

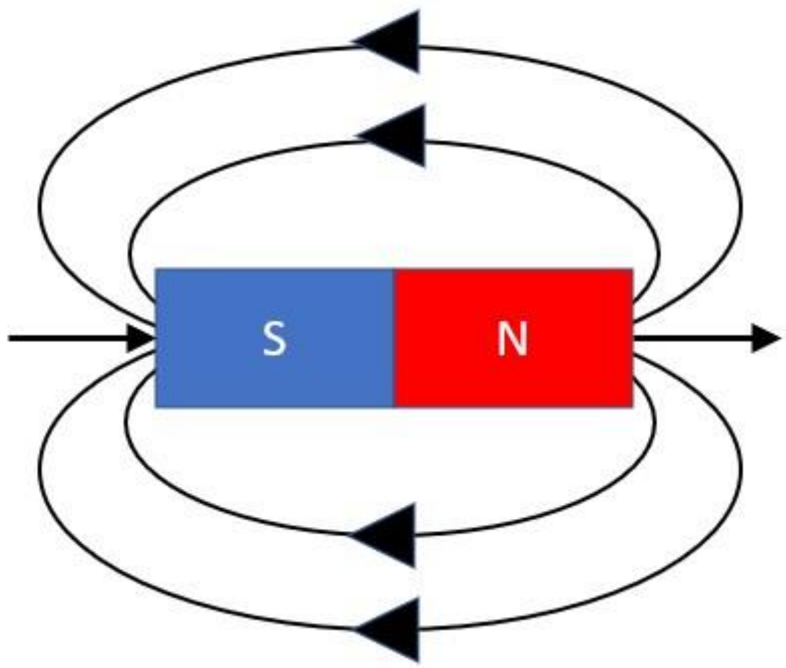

Fig 4 Magnet with poles and field.

If magnets, one with South towards the conductor and the other with North towards the conductor, are rotated around the conductor, the electrons will be moved from side to side. See Figure 5. The potential across the conductor will vary from positive to negative potential.

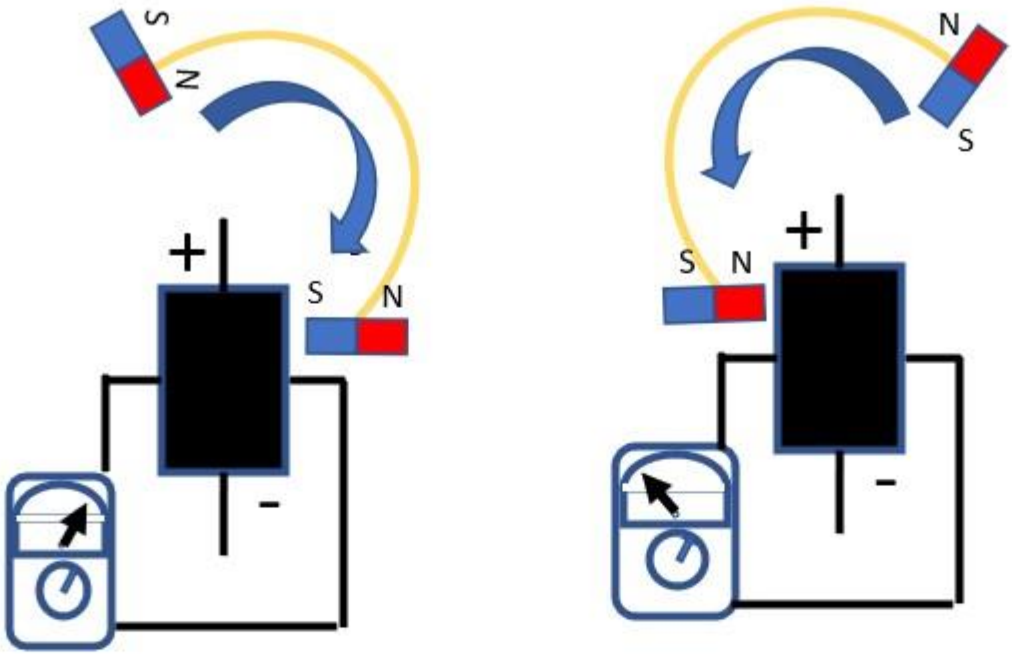

Fig 5 Varying potential caused by the magnets.

Hall Effect Transistor

As mentioned previously, the potential across the conductor is very small so, an amplifier is included in the transistor to increase the output.

V_{CC} (Voltage Common Collector) is the higher voltage with respect to G_{nd} (Ground) and is the power input of a device. V_{CC} may be positive or negative with respect to G_{nd}.

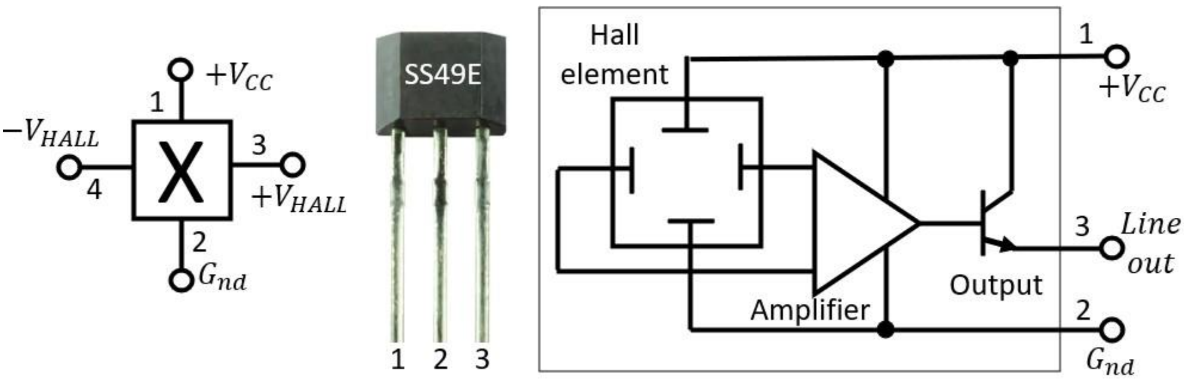

Fig 6 Hall Effect Transistor.

Figure 6 shows the circuit symbol for a Hall effect transistor, the transistor with numbered pins and an overview of the transistor internals. In the symbol for the SS49E, pin four would not be drawn and $-V_{Hall}$ is tied to ground inside the transistor.

There are also four pin devices, such as A1421, A1422 and the A1423.

Orientation

There many magnet orientations for applications using the Hall transistor. The two most common are listed below.

Sideways detection – Here the magnet moves across the face of the sensor in a sideways motion. The output voltage will climb to a peak and then diminish as the magnet moves away.

Head-on detection - The magnetic field is perpendicular to the sensor and the magnet moves towards the sensor. The magnetic field is to the sensor, the greater the output voltage.

Application

I found these transistors when repairing the grandson’s electric scooter. One was used in the throttle where a magnet connected to the throttle, rotated around the transistor. The output was a linear voltage similar to a potentiometer but without the moving parts.

The motors in these scooters, and others, are brushless DC motors. The power to the motors is distributed from a central controller. The transistors in the motor measure the position and phase of the electric motor and coordinate the power from the controller to each of the coils in the motor.

A common Hall Effect transistor for this application is the SS49E, a three-pin device in three package styles. Honeywell’s data sheet describes the SS49E as “High Performance Miniature Ratiometric Linear”.

After some translating this clever wording translates to the following description.

- Fast
- Small
- A magnet’s strength causes the output to change,
- The output is a straight line.

Other applications include tachometers, access security alarms, water level sensing, to name a few.

Have fun and stay safe.