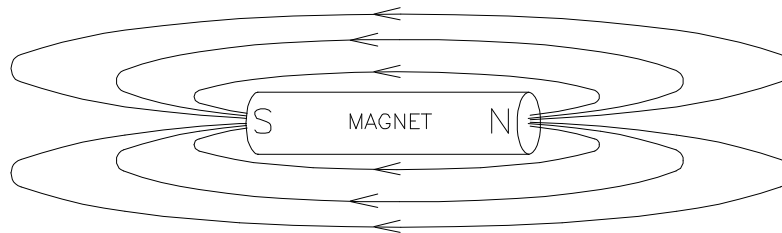




Understanding flux density

Magnetic fields surrounding permanent magnets or electrical conductors can be visualized as a collection of magnetic *flux* lines; lines of force existing in the material that is being subjected to a magnetizing influence. Unlike light, which travels away from its source indefinitely, magnetic flux lines must eventually return to the source. Thus all magnetic sources are said to have two *poles*. Flux lines are said to emanate from the “north” pole and return to the “south” pole, as shown here below



Flux Lines of a Permanent Magnet

One line of flux in the CGS measurement system is called a *maxwell* (M), but the *weber* (W), which is 10^8 lines, is more commonly used.

Flux density, also called magnetic induction, is the number of flux lines passing through a given area. It is commonly assigned the symbol “*B*” in scientific documents. In the CGS system a *gauss* (G) is one line of flux passing through a 1 cm^2 area. The more commonly used term is the *tesla* (T), which is 10,000 lines per cm^2 . Thus

$$1 \text{ tesla} = 10,000 \text{ gauss}$$

$$1 \text{ gauss} = 0.0001 \text{ tesla}$$

Magnetic field strength is a measure of force produced by an electric current or a permanent magnet. It is the ability to induce a magnetic field “*B*”. It is commonly assigned the symbol “*H*” in scientific documents. The unit of “*H*” in the CGS system is an *oersted* (Oe), but the *ampere/meter* (A/m) is more commonly used. The relationship is

$$1 \text{ oersted} = 79.6 \text{ ampere/meter}$$

$$1 \text{ ampere/meter} = 0.01256 \text{ oersted}$$

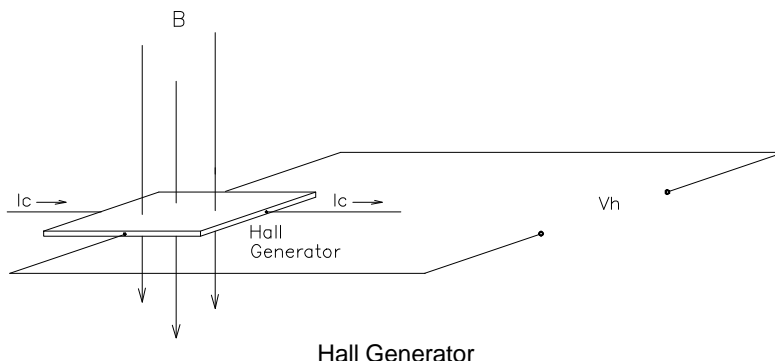
It is important to know that magnetic field strength and magnetic flux density are not the same. Magnetic field strength deals with the physical characteristics of magnetic materials whereas flux density does not. The only time the two are considered equal is in free space (air). Only in free space is the following relationship true:

$$1 \text{ G} = 1 \text{ Oe} = 0.0001 \text{ T} = 79.6 \text{ A/m}$$

Understanding flux density

MEASUREMENT OF FLUX DENSITY

A device commonly used to measure flux density is the *Hall generator*. A Hall generator is a thin slice of a semiconductor material to which four leads are attached at the midpoint of each edge, as shown in figure below.

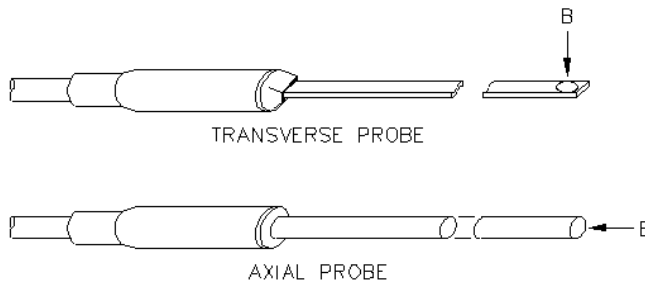


A constant current (I_c) is forced through the material. In a zero magnetic field there is no voltage difference between the other two edges. When flux lines pass through the material the path of the current bends closer to one edge, creating a voltage difference known as the Hall voltage (V_h). In an ideal Hall generator there is a linear relationship between the number of flux lines passing through the material (flux density) and the Hall voltage.

The Hall voltage is also a function of the *direction* in which the flux lines pass through the material, producing a positive voltage in one direction and a negative voltage in the other. If the same number of flux lines pass through the material in either direction, the net result is zero volts. This sensitivity to flux direction makes it possible to measure both static (dc) and alternating (ac) magnetic fields.

The Hall voltage is also a function of the *angle* at which the flux lines pass through the material. The greatest Hall voltage occurs when the flux lines pass perpendicularly through the material. Otherwise the output is related to the cosine of the difference between 90° and the actual angle.

The sensitive area of the Hall generator is generally defined as the largest circular area within the actual slice of the material. This *active area* can range in size from 0.2 mm (0.008") to 19 mm (0.75") in diameter. Often the Hall generator assembly is too fragile to use by itself so it is often mounted in a protective tube and terminated with a flexible cable and a connector. This assembly, known as a *Hall probe*, is generally provided in two configurations:



Hall Probe Configurations

In "transverse" probes the Hall generator is mounted in a thin, flat stem whereas in "axial" probes the Hall generator is mounted in a cylindrical stem. The axis of sensitivity is the primary difference, as shown by "B" in figure above. Generally transverse probes are used to make measurements between two magnetic poles such as those in audio speakers, electric motors and imaging machines. Axial probes are often used to measure the magnetic field along the axis of a coil, solenoid or traveling wave tube. Either probe can be used where there are few physical space limitations, such as in geomagnetic or electromagnetic interference surveys.

