HALL-EFFECT TRANSDUCERS

The material used in the manufacture of Hall-effect devices is a p-type or an n-type semiconductor. Typical examples are indium arsenide, indium arsenide phosphide, and doped silicon. Figure 5.15 shows a section of a p-doped semiconductor subjected to a magnetic field B_z in the z direction and an electric field E_x in the x direction. A current I_x flows in the x direction.

The holes move in the x direction across the magnetic field and experience an upward magnetic force, which results in the accumulation of holes on the top surface and electrons on the bottom face, as indicated in Fig. 5.15.
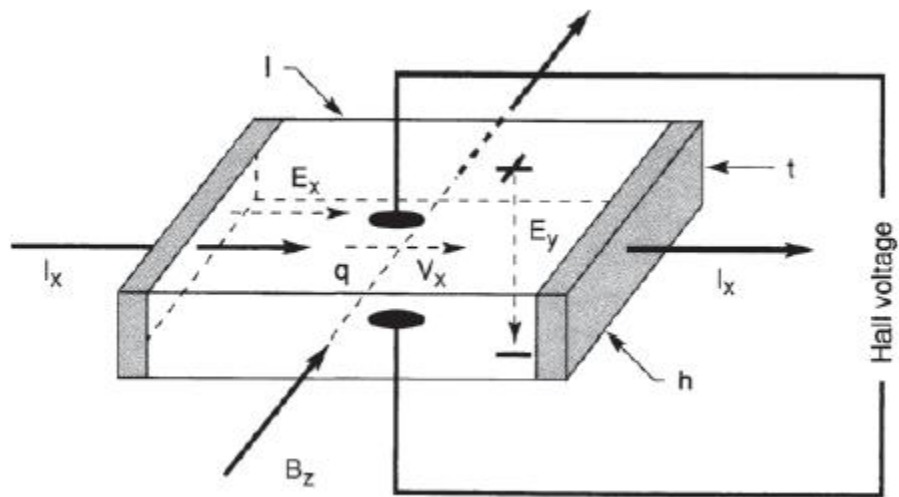

Figure 5.15 Hall-effect device.

An electric field Ey, known as the Hall field, is set up as a consequence, and this is known as the Hall effect. The corresponding Hall voltage VH=Eyt. Since there is no flow of current in the y direction, the magnetic force equilibrates with the electric force that is exerted on the holes, and as a result the Hall voltage can be expressed as

$$V_H = \frac{R_H(I_x B_z)}{h} \tag{5.17}$$

where R_H is the Hall coefficient. R_H is negative for an n-type semiconductor. h is the dimension parallel in B_z. Equation 5.17 represents the transduction mechanism.
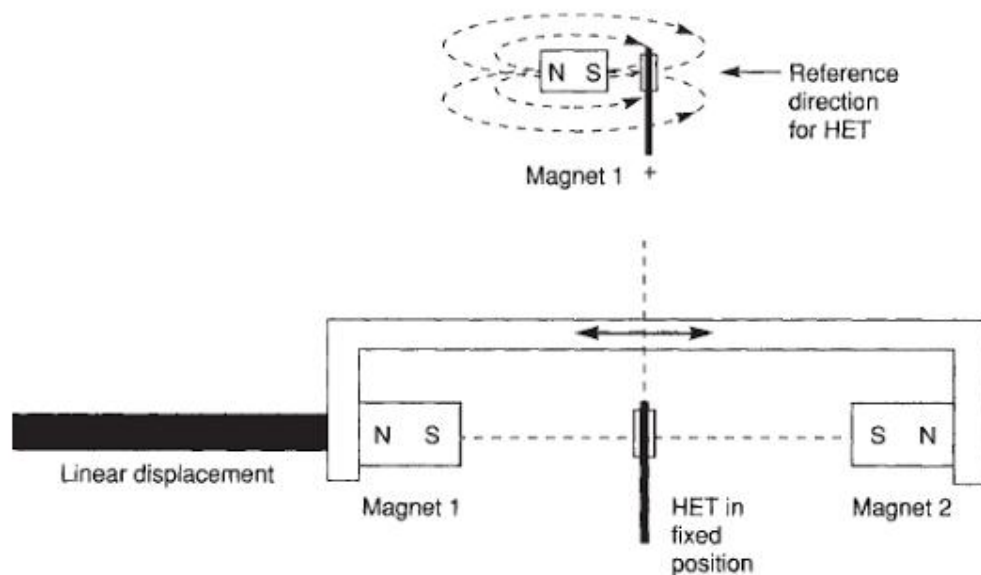

Figure 5.16 Hall-effect displacement transducer.

Figure 5.16 shows the HET being used to measure small displacements. If the displacement brings magnet 1 close to the transducer, the output voltage will be increasingly positive, and it will be incresingly negative if magnet 2 moves closer to the HET.

The magneto resistance effect is closely associated with Hall-effect transducers.33 If the length of the device in Fig. 5.15 is made much shorter than its width h, the Hall voltage can be almost short-circuited. As a consequence, the charge carriers move at the Hall angle to the x direction. The increase in path length causes an increase in resistance of the device, and this is known as the geometrical magneto resistance effect.33 Transducers for measuring angular velocity of ferrous gear wheels have been developed based on this effect.