Hall Effekt Transducers

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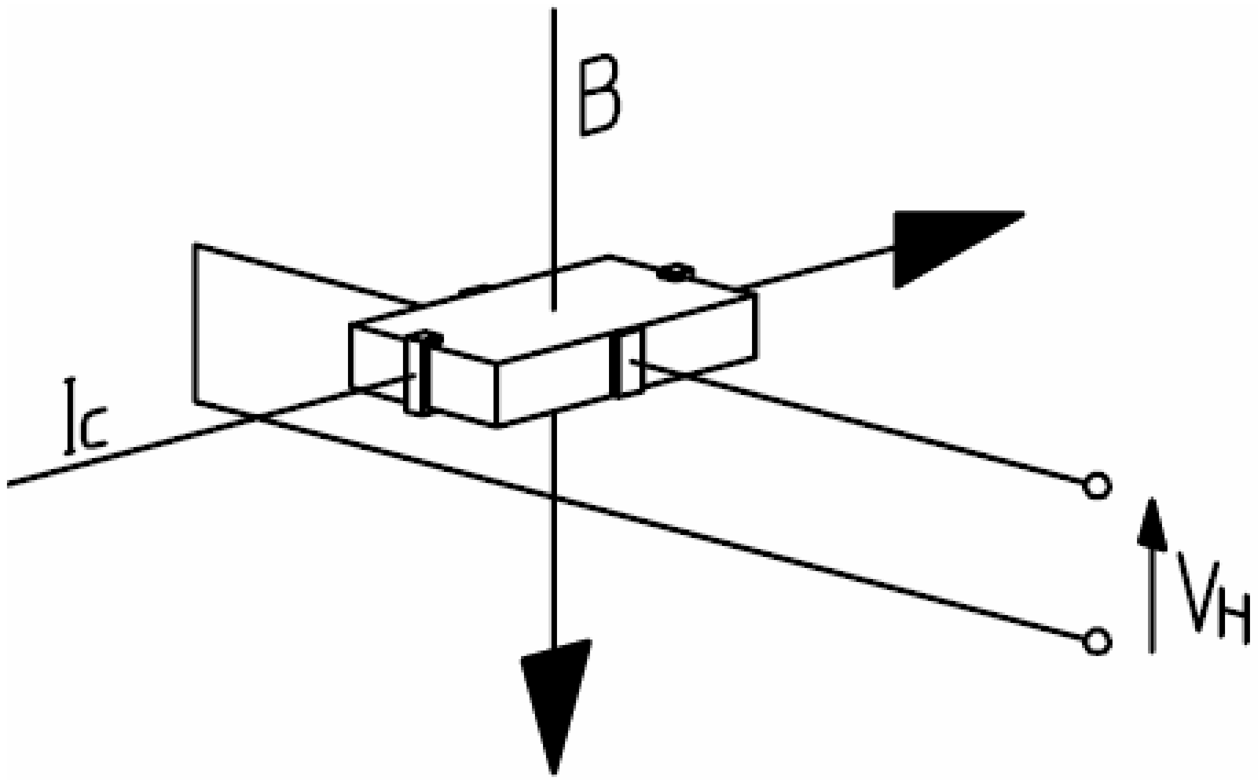
Both the open loop and the closed loop transducers use the Hall effect, which was discovered in 1879 by the American physicist Edwin Herbert Hall, at the John Hopkins University in Baltimore.

The Hall effect is caused by the *Lorentz force*, which acts on the mobile electrical charge carriers in the conductor, when they are exposed to a magnetic field that is perpendicular to the current direction.

A thin sheet of semiconductor material is traversed lengthwise by a control current IC (Fig. 1). The magnetic flux B generates a Lorentz force FL perpendicular to the direction of the mobile charge carriers composing the current. This causes a change of the number of charge carriers at both edges of the sheet, thus creating a potential difference referred to as Hall voltage VH.

Representation of the electrical parameters of the Hall effect



Hall effect generator

For the arrangement, described above (referred to as Hall generator), with a magnetic field perpendicular to the current, we obtain:

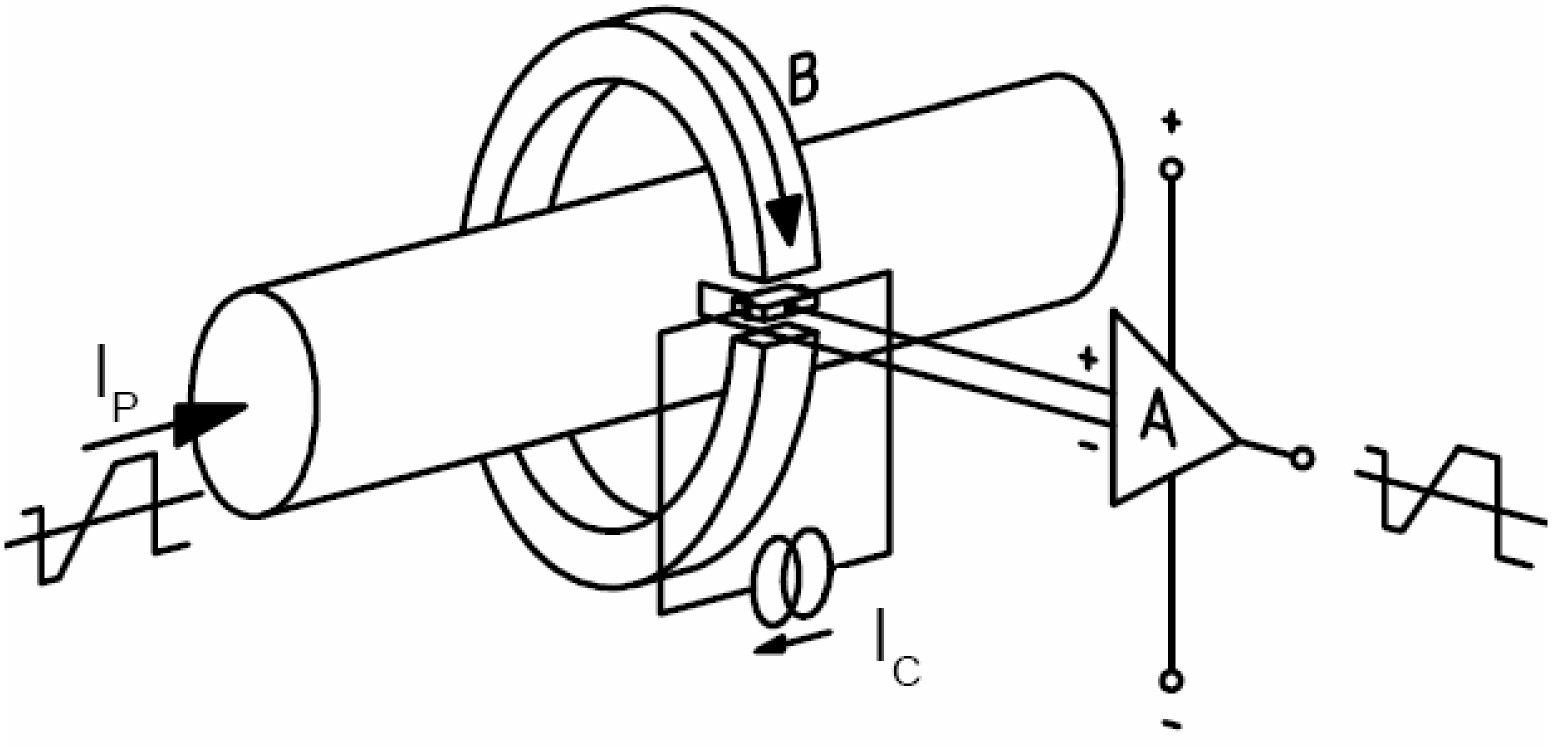
$$VH = (K/d) \bullet IC \bullet B$$

K: is the Hall constant for the material used,
D: the thickness of the thin sheet.

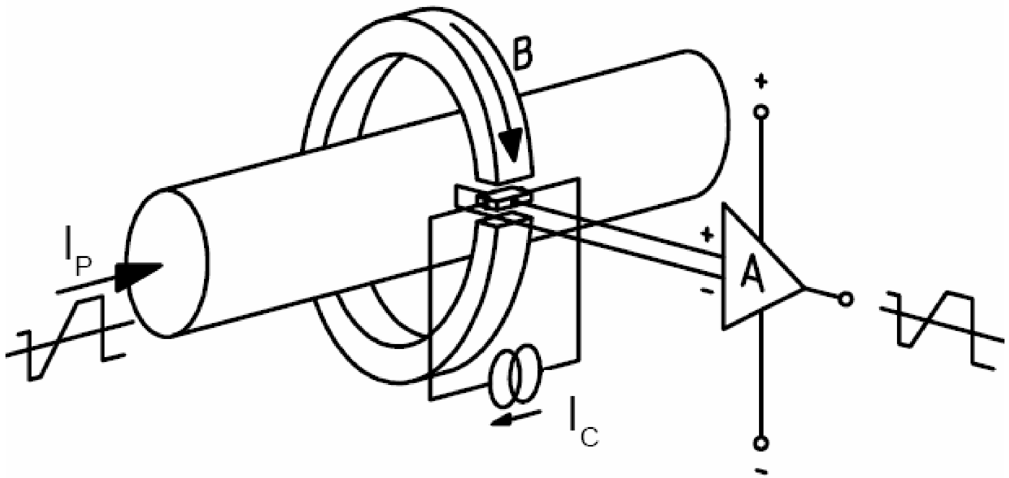
The Hall effect generators show a certain dependence of the Hall sensitivity and the offset voltage VOT on temperature, which can, however, be greatly compensated by the electronic circuit of the current transducer.

Construction and principle of operation

The open loop transducers use the Hall effect. The magnetic induction B, contributing to the rise of the Hall voltage, is generated by the primary current IP to be measured. The control current IC is supplied by a constant current source



Conversion of the primary current into an output voltage



Within the linear region of the hysteresis cycle, B is proportional to IP (Bair gap = constant (a) • IP).

The Hall voltage is thus expressed by:
VH = (K/d) • IC • constant (a) • IP
Except for IP, all terms of this equation are constant.
Therefore: VH = constant (b) • IP

The measurement signal VH is amplified to supply the user output voltage or current.

Current ranges

The LEM transducer range permits measurement of nominal currents IPN reaching from several Amperes to several tens of kA with an overall accuracy of a few percent.

Advantages and limitations

The open loop transducers are capable of measuring DC, AC and complex waveform currents with galvanic isolation. They stand out by their low power consumption and their reduced size, as well as low weight, in particular for the high current range. They involve no insertion losses in the circuit to be measured and they are particularly resistant to current overloads. They are relatively low priced and, in general, well suited to industrial applications.

Characteristics and features

Measurable current range It is defined by the linear region of the magnetisation curve of the magnetic circuit (Fig. 3) Generally, the measurement range varies, according to the type, from 1 to 3 times the nominal current.

Output signal This voltage is directly proportional to the measured current. The available voltage level depends on the supply voltage. Generally the output voltage Vout is 4 V at the nominal current IPN. Current output versions are also available.

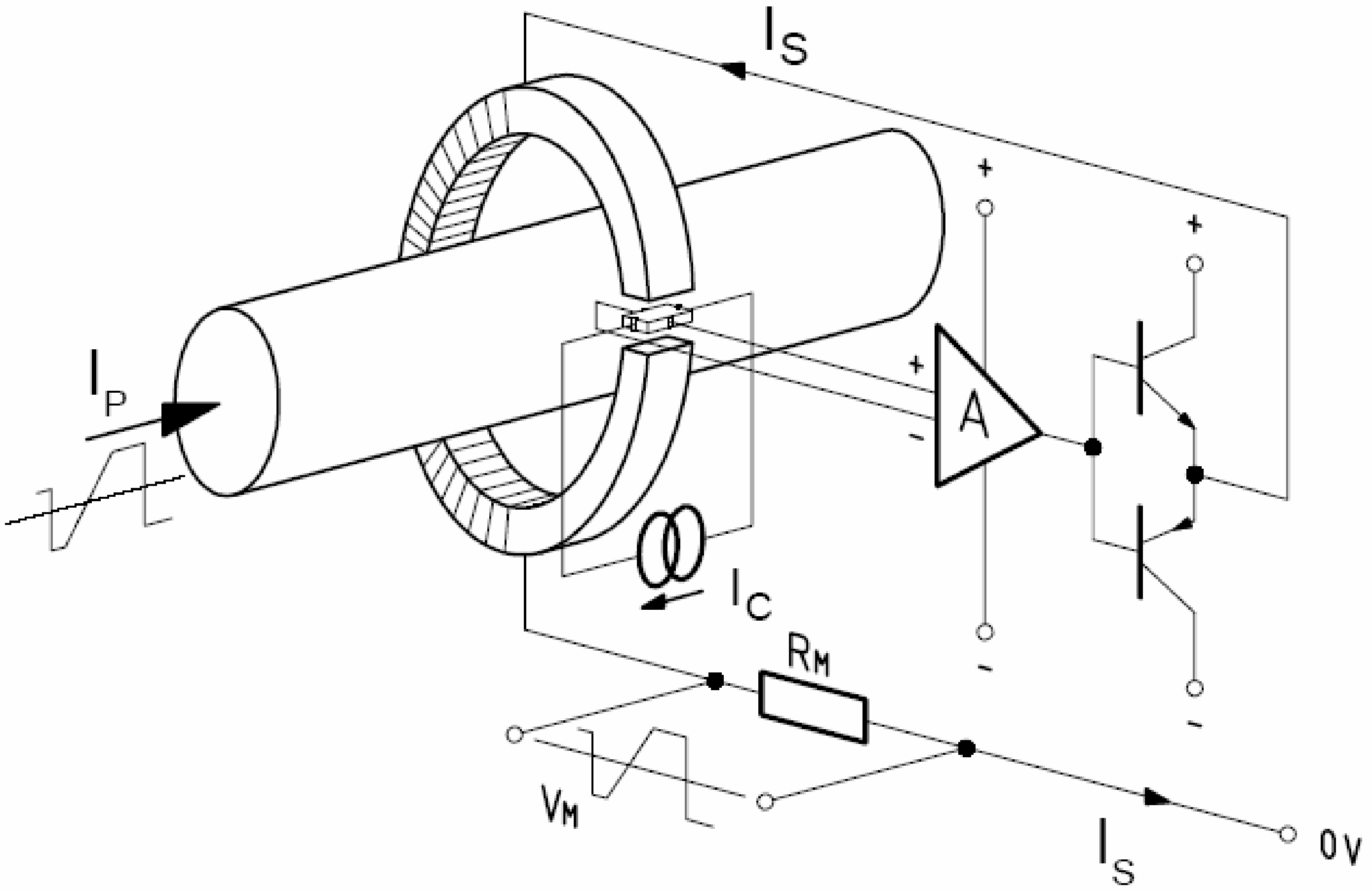
Measurement accuracy Accuracy depends on various factors such as electrical parameters or parameters linked to the environment conditions (ambient temperature, etc.).
For the arrangement, described above, with a magnetic field perpendicular to the current, we obtain: $VH = (K/d) \cdot IC \cdot B$ where K is the Hall constant for the material used, and d the thickness of the thin sheet. Such an arrangement is referred to as Hall generator.

The Hall effect generators show a certain dependence of the Hall sensitivity and the offset voltage VOT on temperature, which can, however, be greatly compensated by the electronic circuit of the current transducer.

Hall effect closed loop current transducers

The closed loop transducers (also called compensation or zero flux transducers) have an integrated compensation circuit by which the performance of the current transducers using the Hall effect can be markedly improved.

Closed loop Hall element current transducer



Compesating measurement

Closed loop Hall element current transducer

Whereas the open loop current transducers give a V_{OUT} output voltage proportional to the amplified V_H Hall voltage, the closed loop transducers supply a secondary current I_S proportional to V_H which acts as counter-reaction signal in order to compensate the induction created by the primary current B_P by an opposed secondary induction B_S.

The secondary current I_S, reduced by the turns ratio, is much lower than I_P, because a winding with N_S turns is used to generate the same magnetic flux (ampere-turns).

One thus selects: $N_P \bullet I_P = N_S \bullet I_S$

The B_S induction is thus equivalent to B_P and their respective ampere-turns counter-balance each other (compensate). The system thus operates at zero magnetic flux.