Magnetic Sensor (3A)

- Magnetic Sensor Type
- Magnetic Sensor Characteristics

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Magnetic Sensor Type – Physical Effect

Physical Effect	Magnetic Sensor Type
Hall Effect	Hall Effect Sensor
Magnetoresistance (MR) (MR)	MR sensor
	AMR (Anisotropic MR) sensor
	GMR (Giant MR) sensor
Josephson Effect + Magnetic Flux Quantization	Superconducting Quantum Interference Device (SQUID) sensor

Magnetic Sensor Type – Magnetic Field

Magnetic Field	Characteristics	Type
Low (~1μG)	Medical, Military	SQUID, search coil
Medium (1μG ~ 10G)	Earth's field sensor	Fluxgate, MI, AMR
High (10G~)	Using permanent magnet	Reed switch, MR, GMR, Hall

Principles of Operation (1)

The transport of electrons through an electrical device is affected by the presence of an external magnetic field. (deflected electrons)

Hall Effect:

- **A charge build-up → voltage difference**

Magneto-resistance Effect:

- **Increasing current path length → increasing resistance**

Josephson Effect:

- **DC Josephson: no voltage drop ($I < I_c$), resistive mode ($I > I_c$)**
- **AC Josephson: frequency is controlled by the voltage**

Principles of Operation (2)

MR (Magneto-Resistance) Effect:

- **Current path becomes longer and narrower**
- **Increasing resistance**

AMR (Anisotropic Magneto-Resistance) Effect:

- **Electrical resistance depends on the angle between the direction of electrical current and the orientation of magnetic field**

GMR (Giant Magneto-Resistance) Effect:

- **Alternating layers of ferromagnetic and nonmagnetic materials**
- **An external magnetic field changes magnetic moments:**

  anti-parallel (high resistance) → parallel (low resistance)

Hall Sensor Types – Materials

Material	Output Voltage	Temp Range	Temp Ratio	Driving Source	Magnet Field	Cost
InSb	Large	Small	Large	Voltage	Saturate	Cheap
InAs		Small	Medium		Offset change	
GaAs	Small	Large	Small	Current	Wide range	
Ge		Small	Small	Current	Good linearity	Expensive

Hall Sensor Types – Driving Source

Material	Linearity	Temp Char	Offset Voltage	Circuit Complexity
Constant Current	Good	Good	Large	Complex
Constant Voltage	Bad	Bad	Small	Simple

Hall IC

One Chip

→ **Hall Sensor**

\+ **Amplification Circuit**

\+ **Temperature Correction Cirucuit**

- **Linear Hall IC**

  output voltage is

  linearly proportional to magnetic field strength

- **Digital Hall IC**

  Schmitt Trigger

References

[1] http://en.wikipedia.org/
[2] Nam Ki Min, Sensor Electronics, Dong-il Press