Magnetiske og induktive sensorer

Måle med:

- Spole
  - Luftkjerne
  - Ferromagnetisk kjerne
- Hall sensor
- Magneto resistiv sensor
  - AMR
  - GMR
  - (CMR)
- Fluxgate sensor
- SQUID

Hva kan vi måle:

- AC felt
- DC felt
- Ferromagnetiske materialer
- Ledende materialer

Ekstrautstyr:

- Magnet
- Eksitasjons spole

Hall effect (3.8)

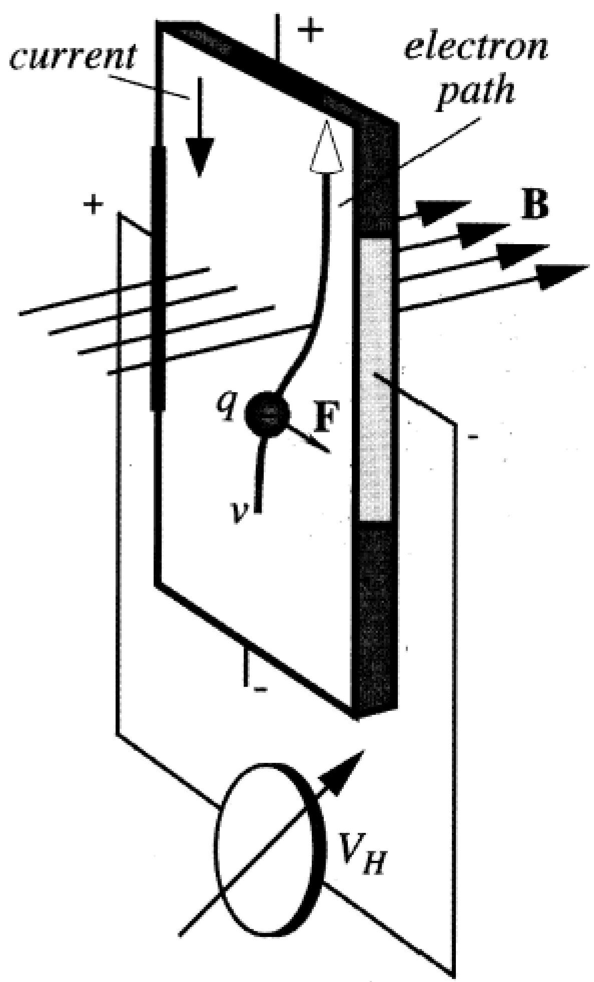
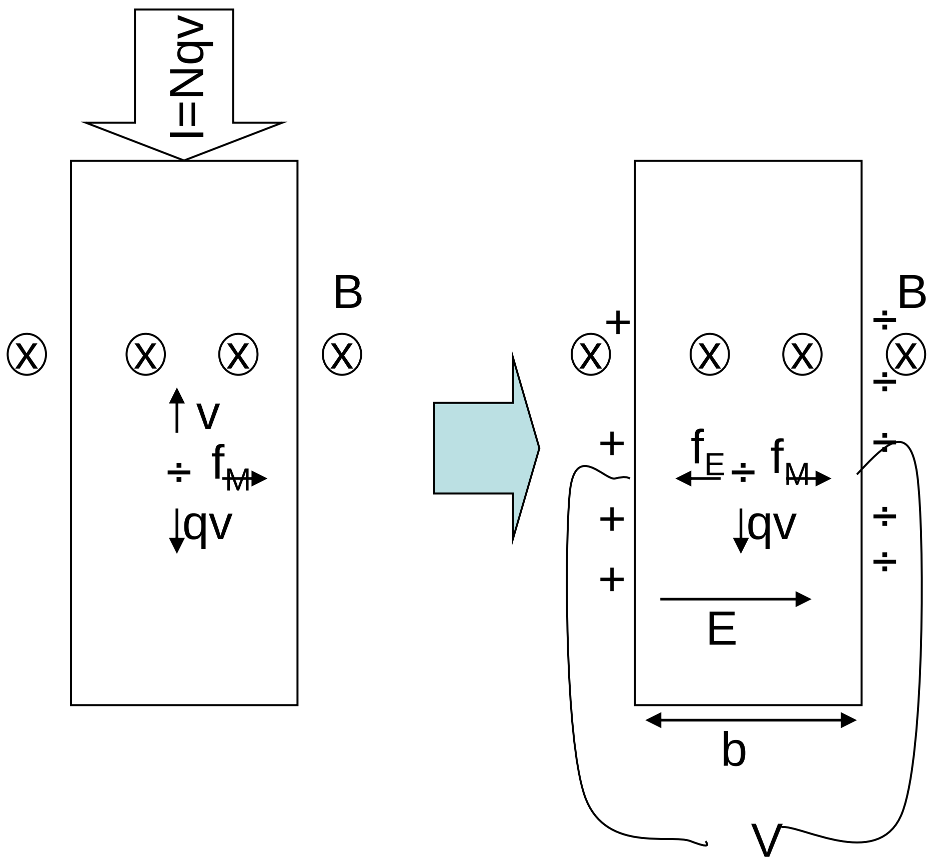


Fig. 3.30. Hall effect sensor. A magnetic field deflects movement of electric charges.

Gedanken experiment



$$f_M = f_E$$

$$qvB = qE$$

$$E = \frac{I}{Nq} B$$

Geometry

Hall coefficient

$$V = bE = b\frac{1}{Nq} BI$$

Characteristics

Table 3.2. Typical Characteristics of a Linear Hall Effect Sensor.

Control current	3 mA
Control resistance, R_i	2.2 kΩ
Control resistance versus temperature	+0.8%/°C
Differential output resistance, R_0	4.4 k Ω
Output offset voltage	5.0 mV (at $B = 0$ G)
Sensitivity	60 µV/G
Sensitivity versus temperature	+0.1%/°C
Overall sensitivity	20 V/ΩkG
Maximum magnetic flux density, B	Unlimited

Source: Ref. [27].

Table 1.1 Magnetic field strengths (A m^{-1}) in a variety of situations, showing a range of 19 orders of magnitude

10^{14}	~10^8 Tesla	Surface of neutron stars
10^8	← 100 Tesla	Implosive magnets (microsecond duration)
2–5×10^7		Pulsed electromagnets (microsecond duration)
1–3×10^7		High field electromagnets
1–1.5×10^7		Superconducting magnets
1–2×10^6		Laboratory electromagnet
1×10^6	← Tesla	Strongest permanent magnets
10^2	(126 µT) typisk 50 µT	Earth's magnetic field on the surface
10		Stray fields from electrical machinery
1		Urban magnetic noise level
5×10^{-2}		Contours for geomagnetic anomaly maps
10^{-4}		Magnetocardiograms
10^{-5}		Fetal heartbeat
10^{-6}		Magnetic field from human brain
10^{-8}	10^{-14} Tesla	Limits of detection for SQUIDS

The equivalent magnetic induction $\boldsymbol{B}$ in free space, measured in tesla, can be obtained by multiplying these values by $4\pi\times10^{-7}$ H m^{-1}.

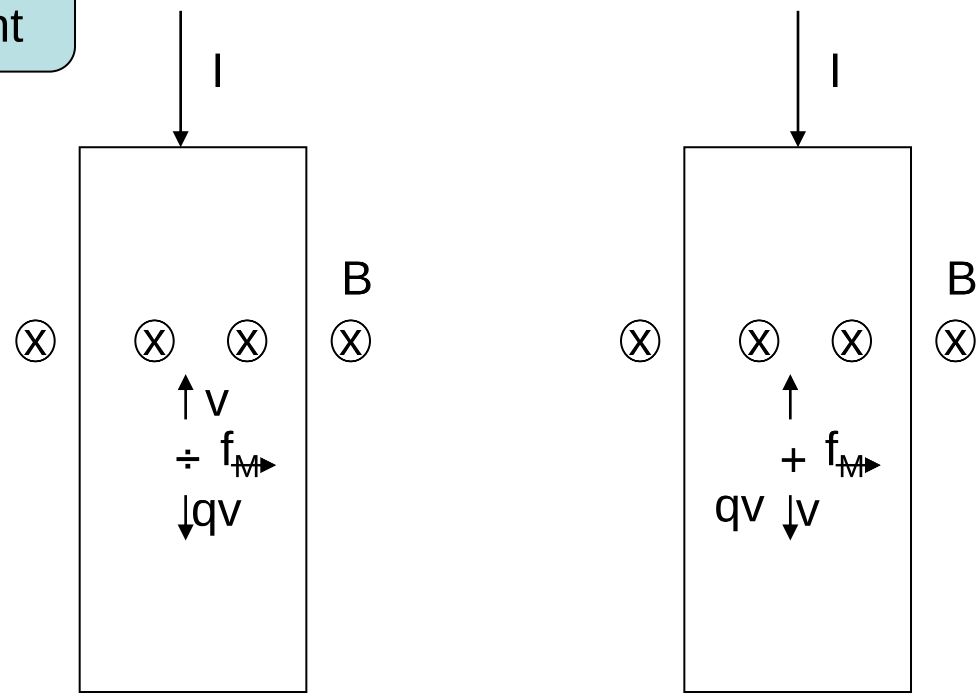
Gauss = 100 µTesla tilsvarer ca 80 A/m

To akse melexis hall sensor

Material characterization

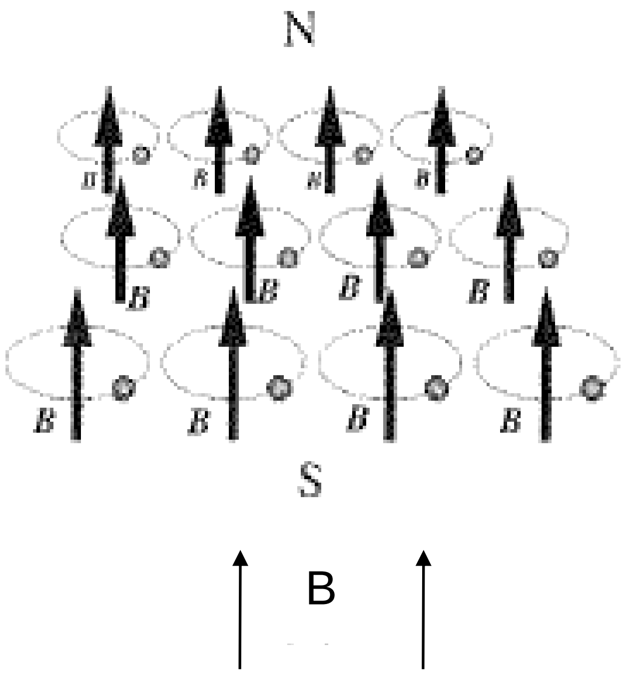
Hall coefficient

$$V = b\frac{1}{Nq}BI$$



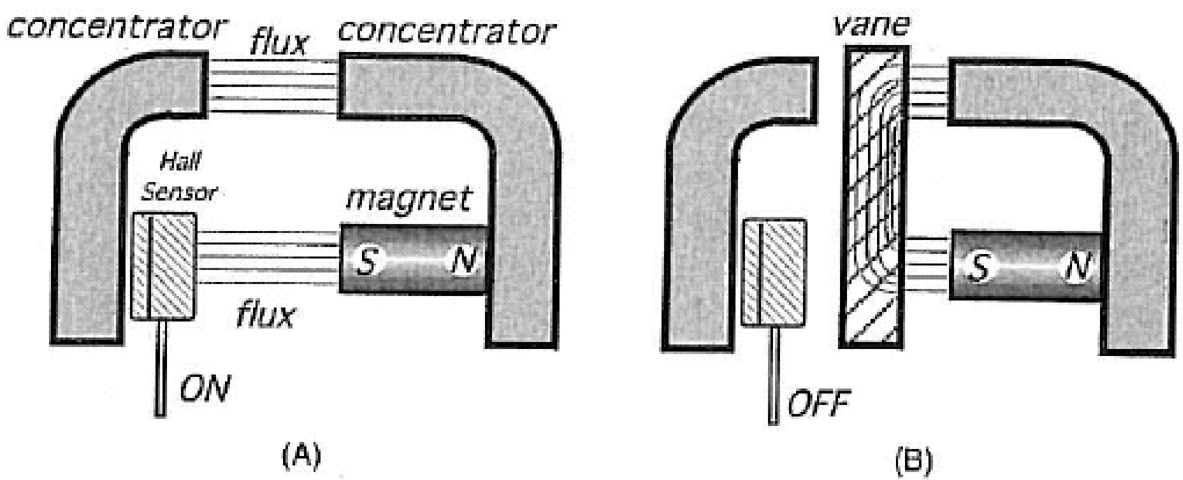
Polarity of induced voltage can be used to determine the polarity of majority carriers

Feltforsterkning av dipoler

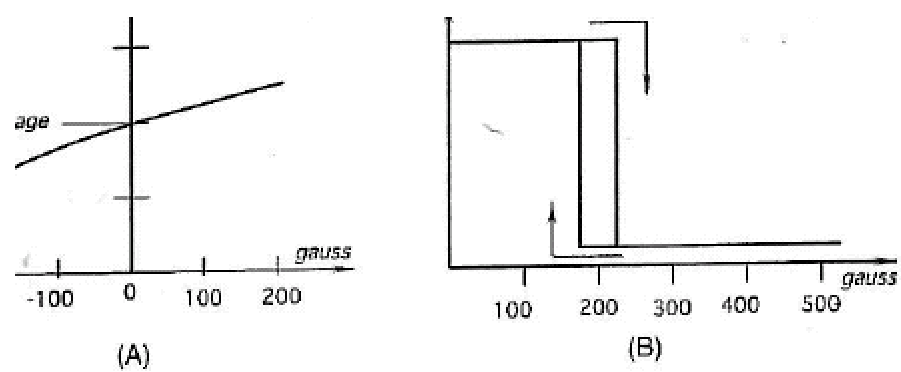


$$\oint \vec{B}\cdot d\vec{l} = \mu_r \mu_0 i$$

Permanent magnet - Hall sensor



;. 7.16. The Hall effect sensor in the interrupter switching mode: (A) the magnetic flux turns sensor on; (B) the magnetic flux is shunted by a vane. (After Ref. [6].)



;. Transfer functions of a linear (A) and a threshold (B) Hall effect sensor.

$$n\Phi_B = Li,$$

$$v = -\frac{d(n\Phi_B)}{dt} = -L\frac{di}{dt}.$$

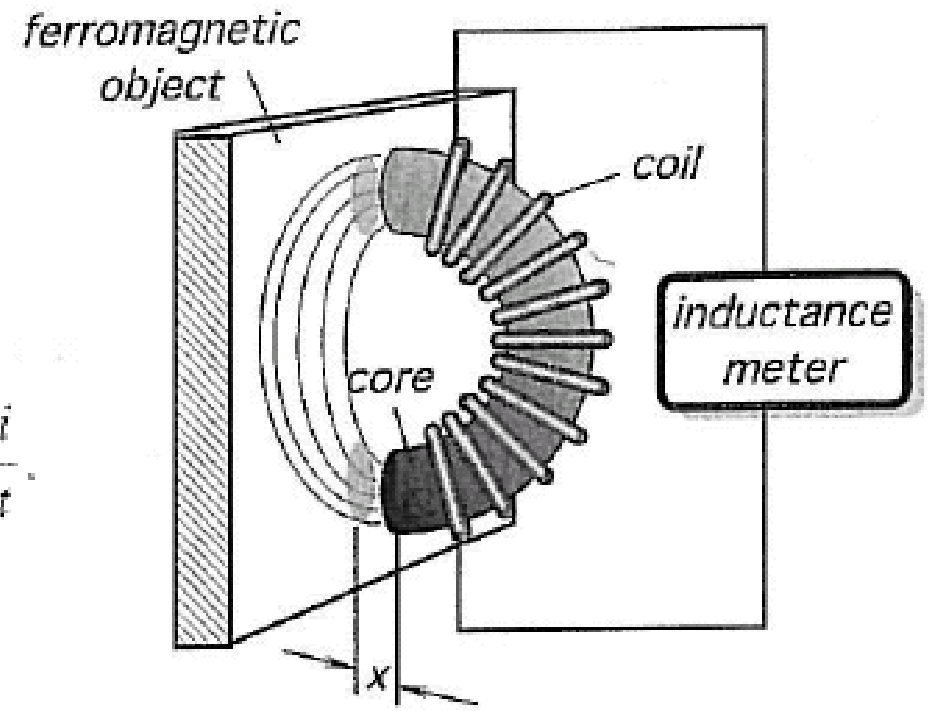


Fig. 7.12. A transverse inductive proximity sensor.

Magneto resistive sensorer (MRS)

3 ”effekter”:

- Anisotropic magneto resistive (AMR)
- Giant magneto resistive (GMR)
- Colossal magneto resistive

AMR sensor:

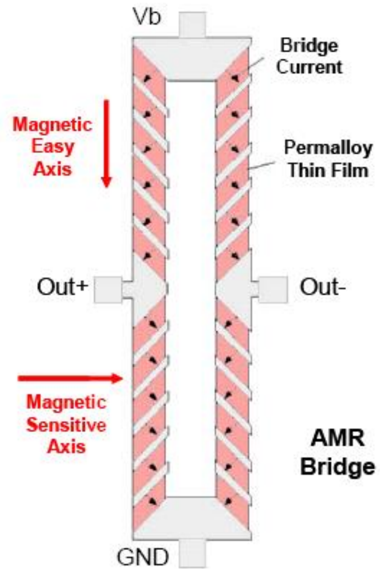


Figure 2 - AMR Sensor Bridge

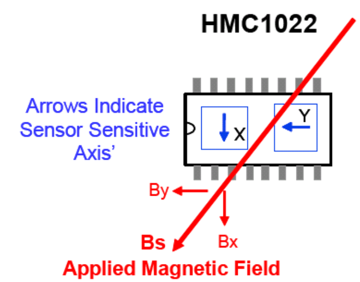


Figure 3 - 2-Axis Magnetic Field Sensing

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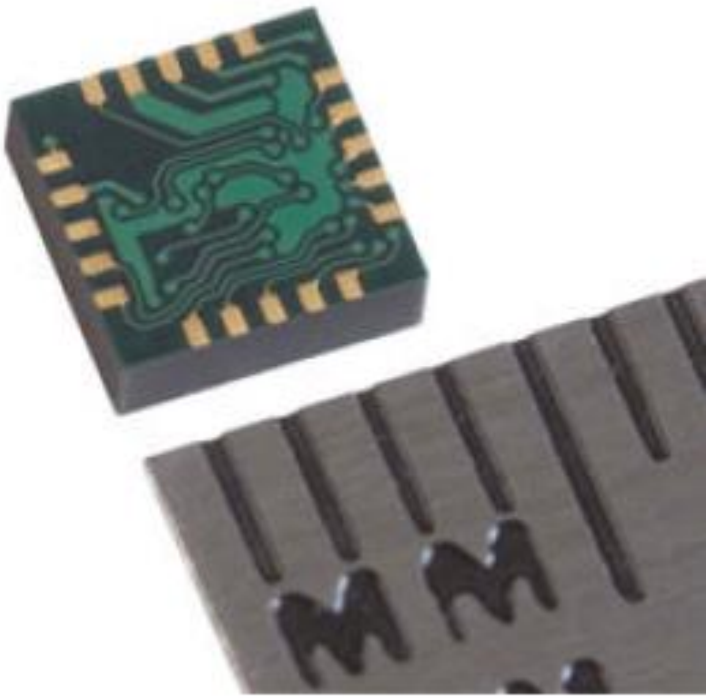
Vehicle Detection Using AMR Sensors

3-akse AMR kompass



Honeywell :3-Axis Digital Compass IC HMC5843

I^2C: Inter IC (Buss)

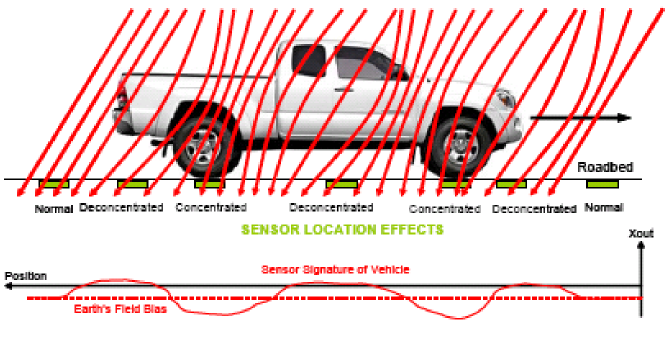
HMC5843

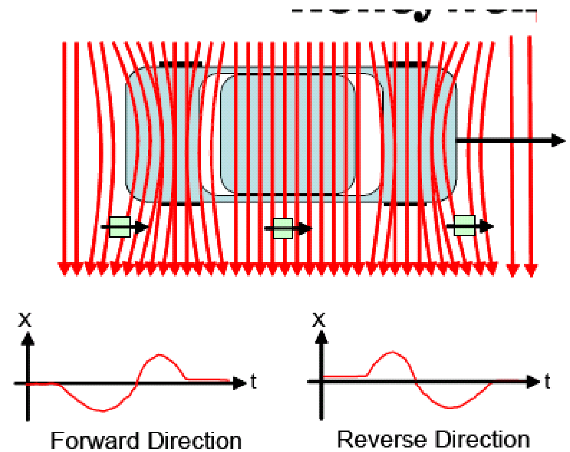
SPECIFICATIONS (* Tested at 25°C except stated otherwise.)

Characteristics	Conditions*	Min	Typ	Max	Units
Power Supply					
Supply Voltage	AVDD Referenced to AGND	2.5		3.3	Volts
	DVDD Referenced to DGND	1.6	1.8	2.0	Volts
Current Draw	Sleep Mode (dual supplies)	-	2.5	-	uA
	Idle Mode (dual supplies)	-	240	-	uA
	Measurement Mode	-	0.8	-	mA
	AVDD = 2.5 volts, DVDD = 1.8 volts				
	Sleep Mode (single supply)	-	110	-	uA
	Idle Mode (single supply)	-	340	-	uA
	Measurement Mode	-	0.9	-	mA
	AVDD = 2.5 volts				
Performance					
Field Range	Full scale (FS) – total applied field	-4		+4	gauss
Cross-Axis Sensitivity	Cross field = 0.5 gauss, Happlied = ±3 gauss		±0.2%		%FS/gauss
Disturbing Field	Sensitivity starts to degrade. Use S/R pulse to restore sensitivity.			20	gauss
Max. Exposed Field	No perming effect on zero reading			10000	gauss
Measurement Period	Output Rate = 50Hz (10Hz typ.)		-	10	msec
I²C Address	7-bit address		0x1E		hex
	8-bit read address		0x3D		hex
	8-bit write address		0x3C		hex
I²C Rate	Controlled by I²C Master	-10		+10	%
I²C bus pull-up	Internal passive resistors		50		kilo-ohms
I²C Hysteresis	Hysteresis of Schmitt trigger inputs on SCL				
	and SDA - Fall (DVDD=1.8V)		0.603		Volts
	Rise (DVDD=1.8V)		1.108		Volts
Self Test	Positive and Negative Bias Mode		±0.55		gauss
Mag Dynamic Range	3-bit gain control	±0.7	±1.0	±4.0	gauss
Linearity	Full scale input range			0.1	±% FS
Gain Tolerance	All gain/dynamic range settings		±5		%
Bandwidth	-3dB point		10		kHz
Resolution	AVDD=3.0V, GN		7		milli-gauss
Signal-to Noise Ratio		70			dB
Turn-on Time			200		us
General					
ESD Voltage				700	V
Operating Temperature	Ambient	-30		85	°C
Storage Temperature	Ambient, unbiased	-40		125	°C
Weight	Nominal		50		milli-grams

Vehicle detection

Earths magnetic field





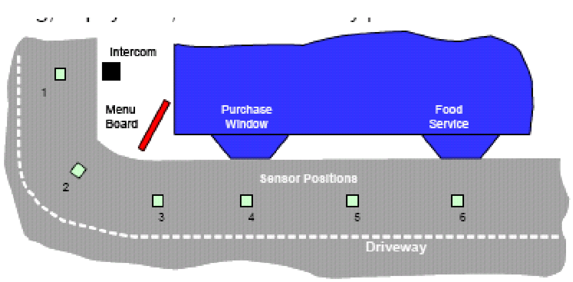
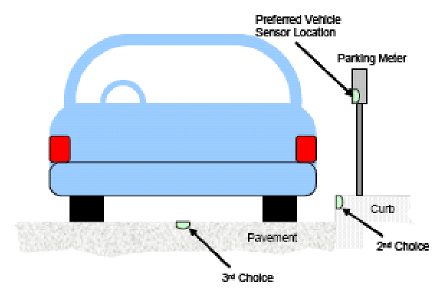


Figure 17 - Fast Food Vehicle Detection Example



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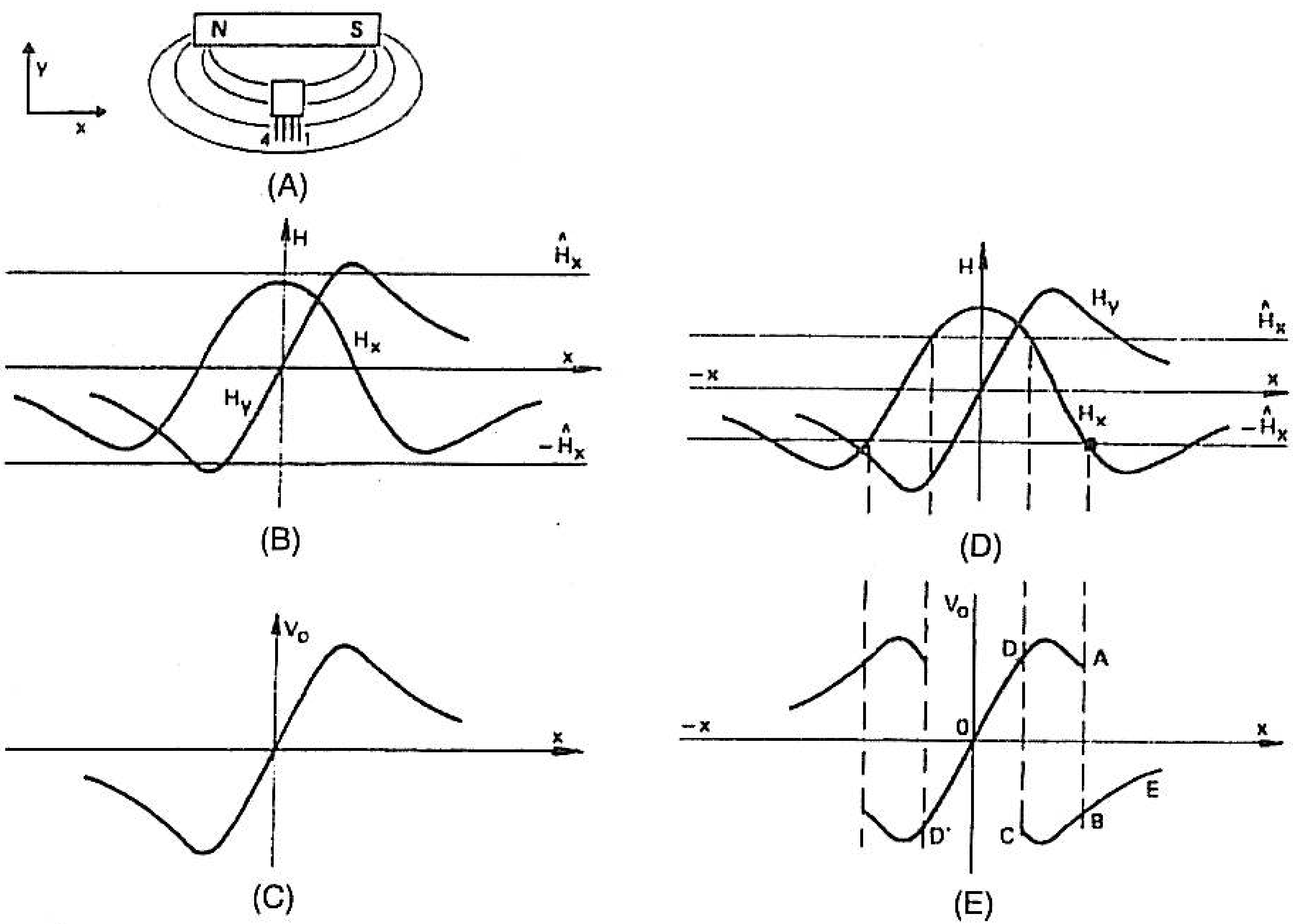
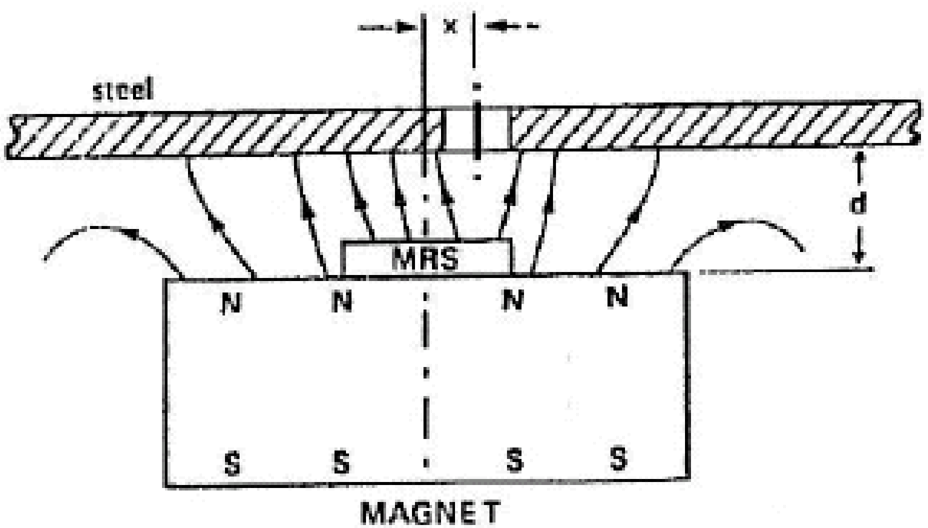
Vehicle Detection Using AMR Sensors

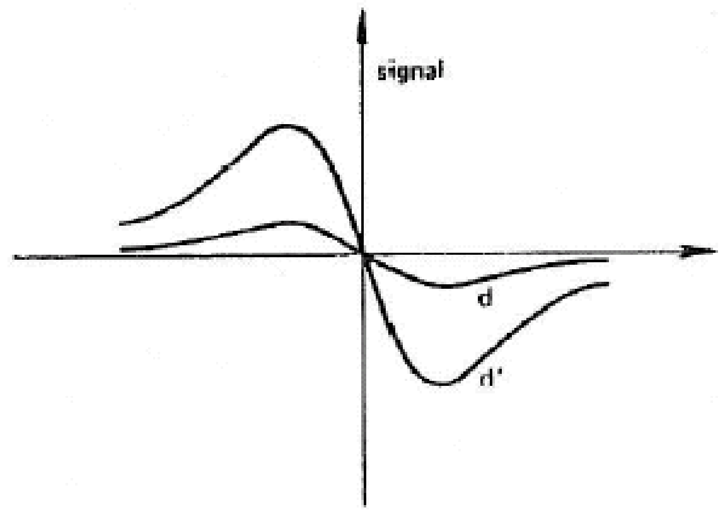


:. **7.19.** Magnetoresistive sensor output in the field of a permanent magnet as a function of its ɔlacement x parallel to the magnetic axis (A–C). The magnet provides both the axillary and ısverse fields. Reversal of the sensor relative to the magnet will reverse the characteristic. and E) Sensor output with a too strong magnetic field.

Permanent field 1

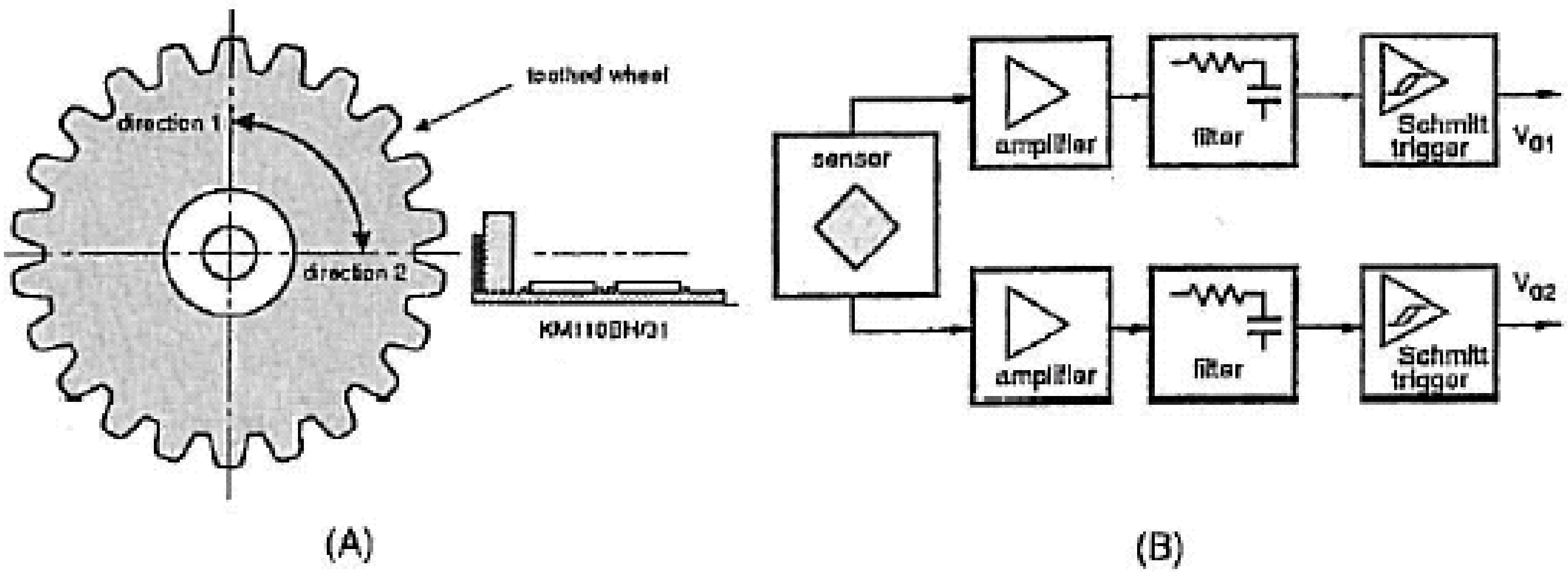


(A)



(B)

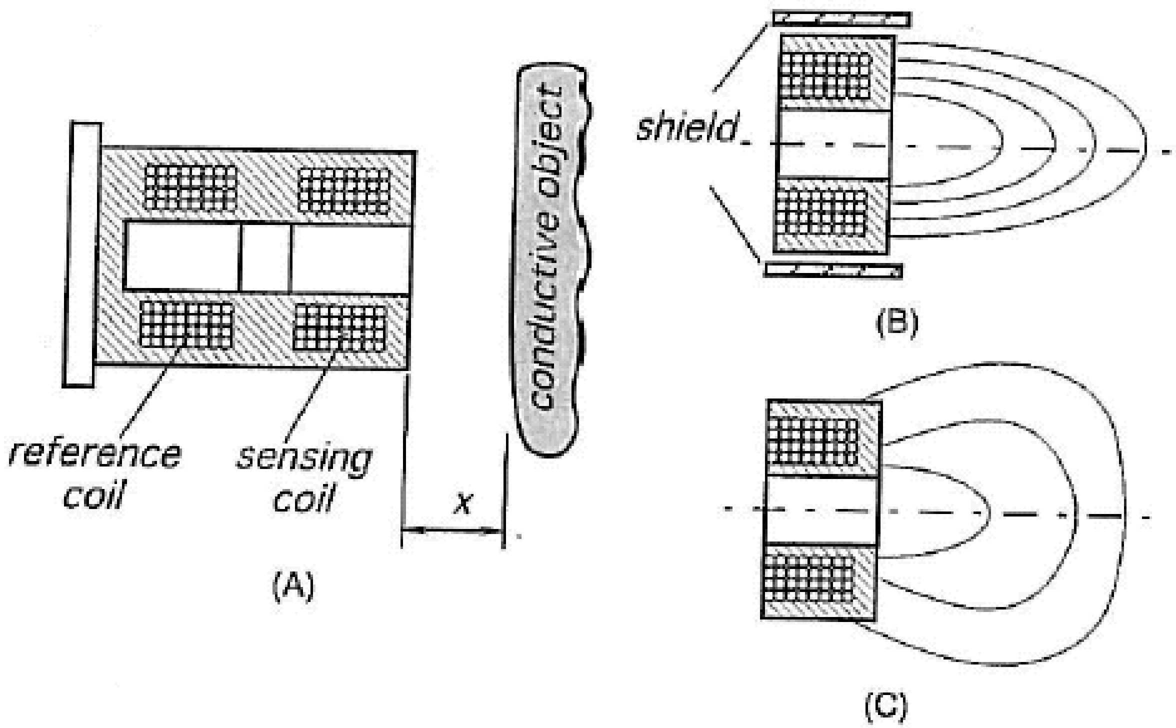
Permanent field 2



:. **7.22.** (A) Optimum operating position of a magnetoresistive module. Note a permanent gnet positioned behind the sensor. (B) Block diagram of the module circuit.

Eddy current sensor

7.4 Inductive and Magnetic Sensors 26:



7.11. (A) Electromagnetic proximity sensor; (B) sensor with the shielded front end; (C)
iielded sensor.