Magnetic Sensor (3D)

- AMR Sensor

Please send corrections (or suggestions) to youngwlim@hotmail.com.

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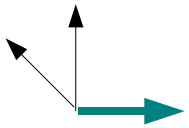
Magnetic Anisotropy (1)

Magneto-crystalline Anisotropy

- **An intrinsic property of a ferri-magnet**
- **Magnetization curve along different crystal directions**

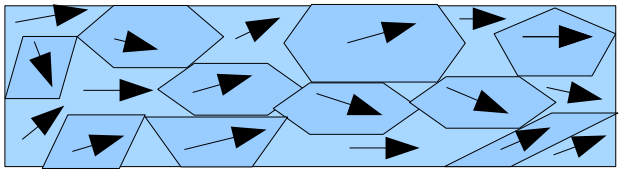
- **Easy direction**
- **Hard direction**
- **Intermediate direction**

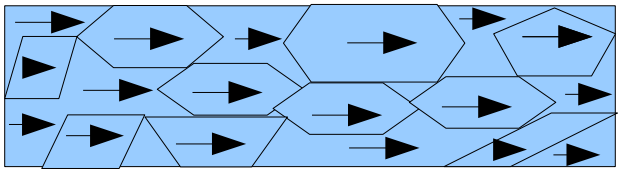
Magnetic Anisotropy (2)



Easy direction

Magnetization

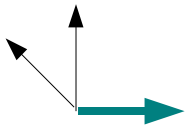




Permalloy Resistor

: NiFe (ferri-magnet)

Permalloy Resistor (1)



Easy direction

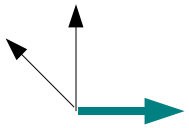
R_{max}: small current

: parallel current direction

R_{min}: large current

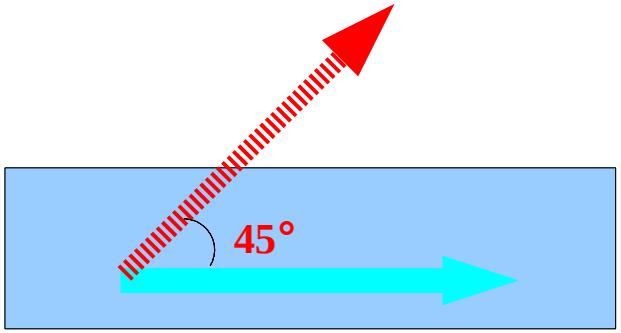
: perpendicular current direction

Permalloy Resistor (2)



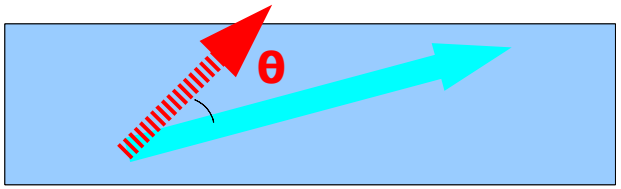
Easy direction

Fix the direction of current



External Magnetic Field changes

- **the magnetization direction of permalloy**
- **the resistance**
- **the current**



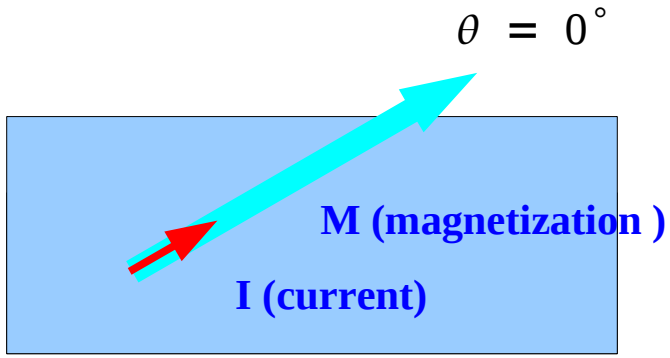
$H_{applied}$

R_{max} and R_{min}

The current direction is fixed

R_{max} : small current

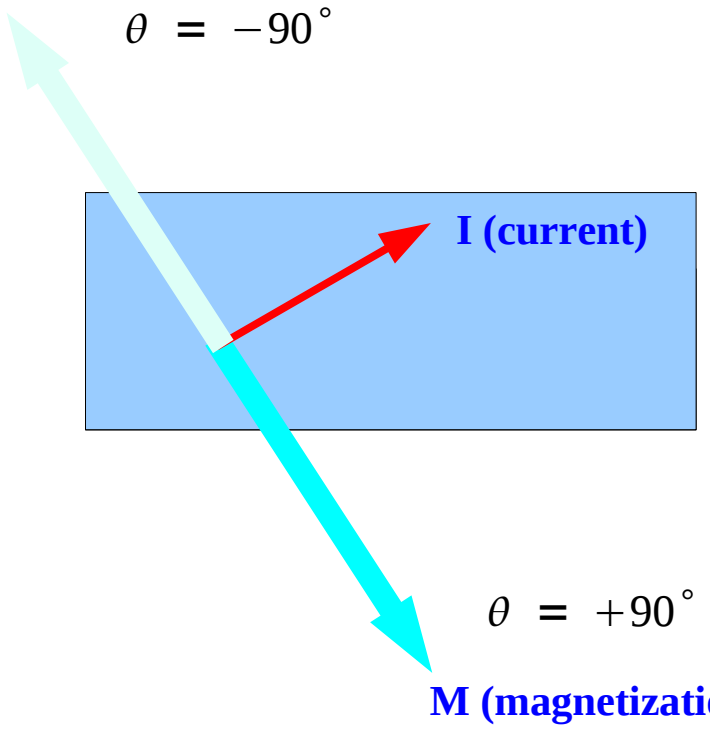
: parallel current direction



$\theta = 0^{\circ}$

R_{min} : large current

: perpendicular current direction

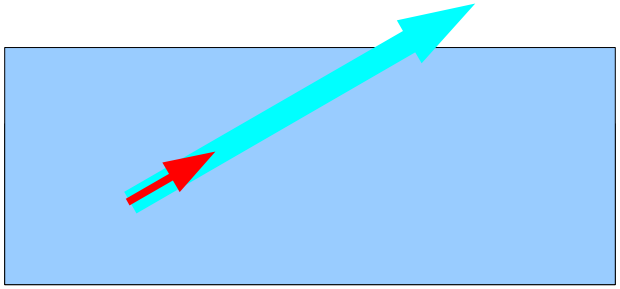


R(θ) Modelling

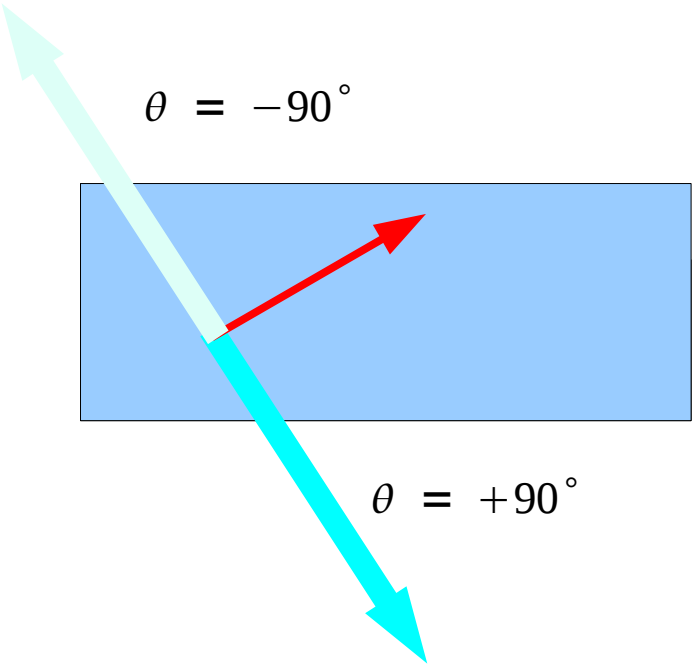
$$R(\theta) = R_{max} \sin^2\theta + R_{min} \cos^2\theta$$

$$= R_{min} + (R_{max} - R_{min}) \sin^2\theta$$

$\theta = 0^\circ$



$\theta = -90^\circ$



$\theta = +90^\circ$

$$R(0) = R_{min} \cos^2 0 + R_{max} \sin^2 0$$

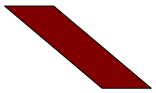
$$R(0) = R_{min}$$

$$R(\pm 90) = R_{min} \cos^2(\pm 90) + R_{max} \sin^2(\pm 90)$$

$$R(\pm 90) = R_{max}$$

Barber Pole Biasing

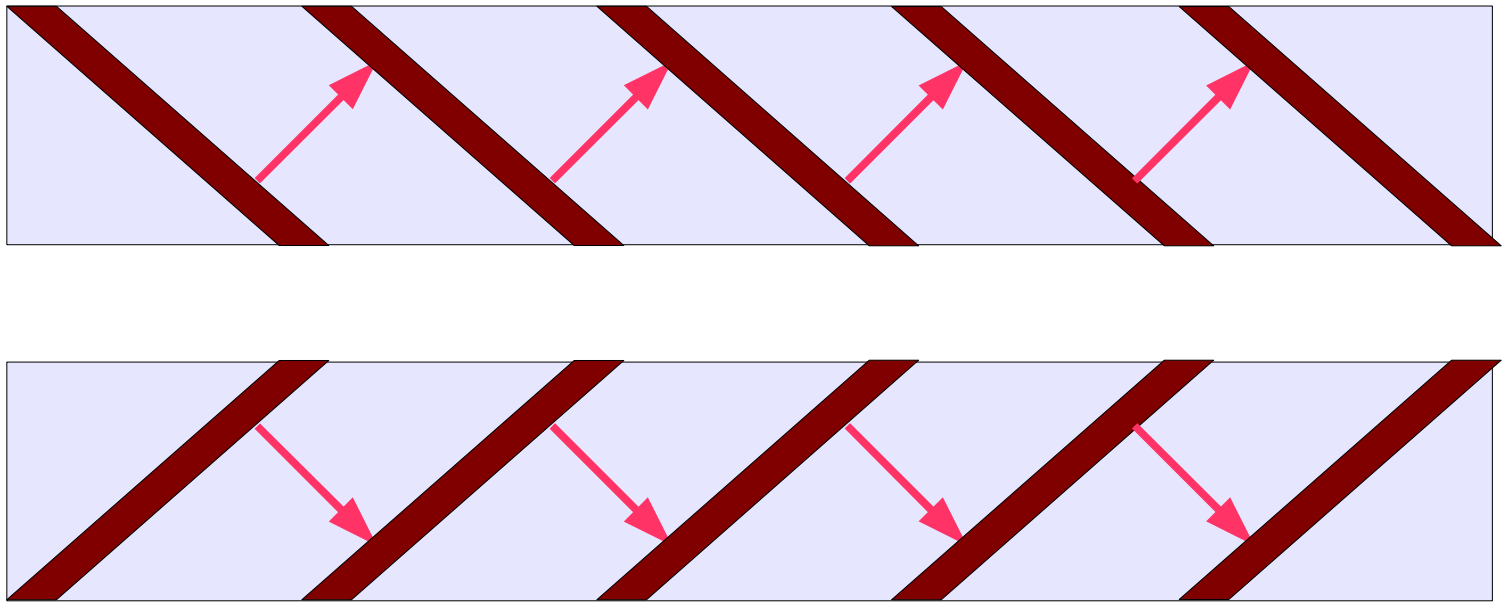
How the current direction is fixed?



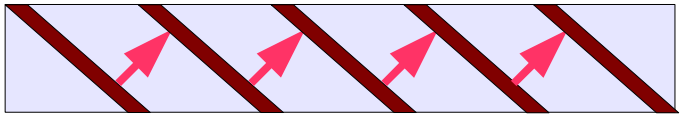
Shortening Bars

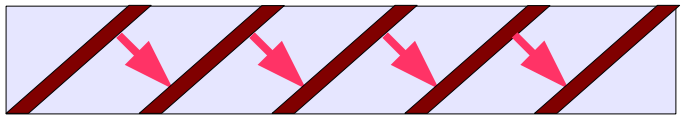
Barber Pole Biasing

: the shortest path

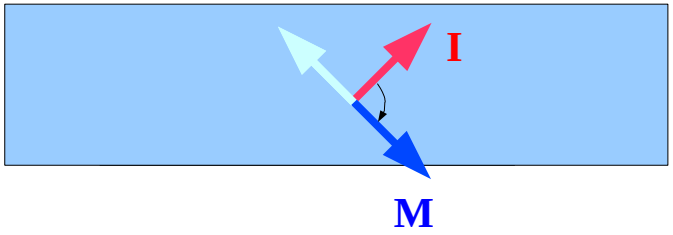


Angle between I and M



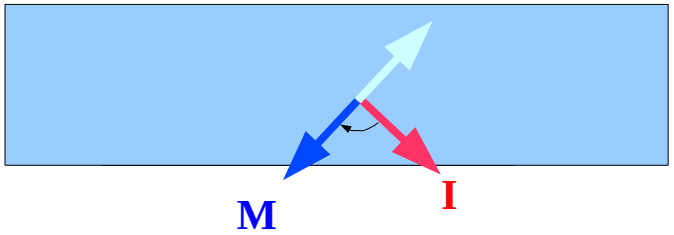


$\theta = -90^\circ$



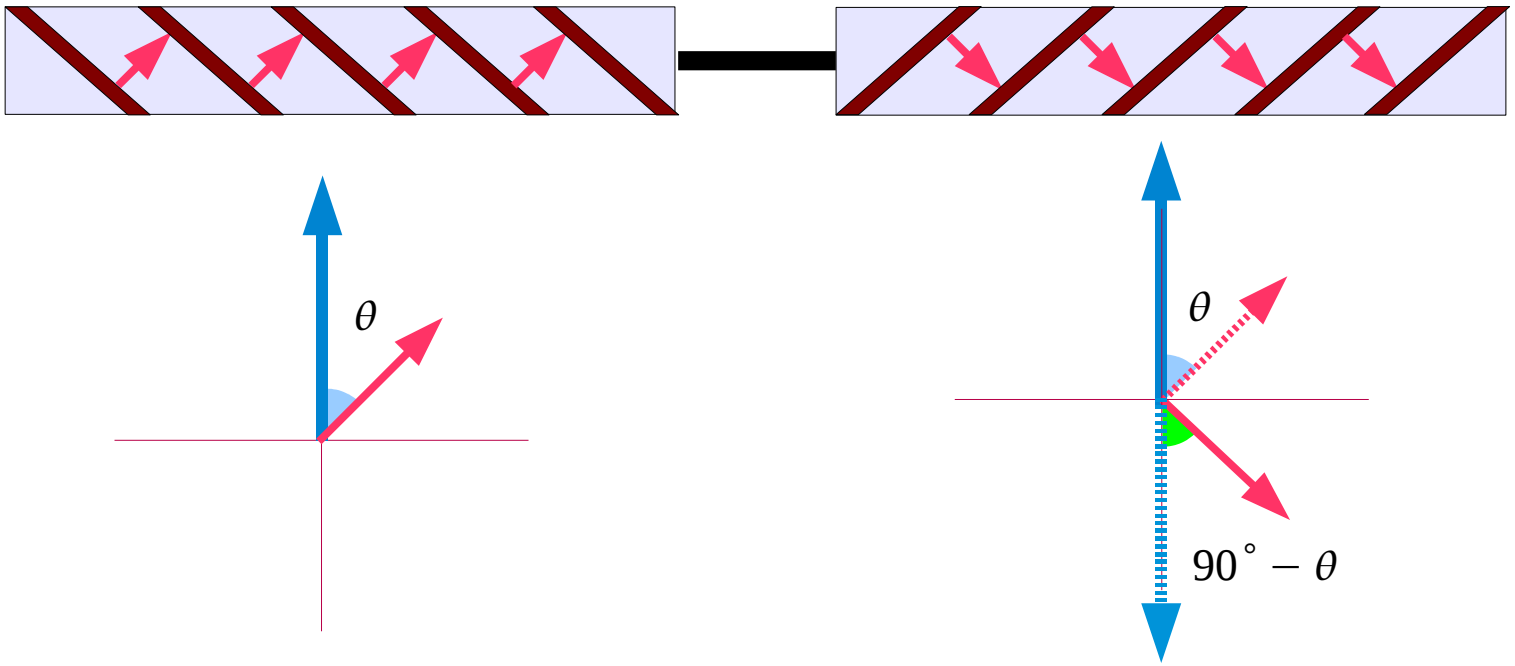
$\theta = +90^\circ$

$\theta = -90^\circ$



$\theta = +90^\circ$

$R_A(\theta)$ and $R_B(\theta)$ Modelling

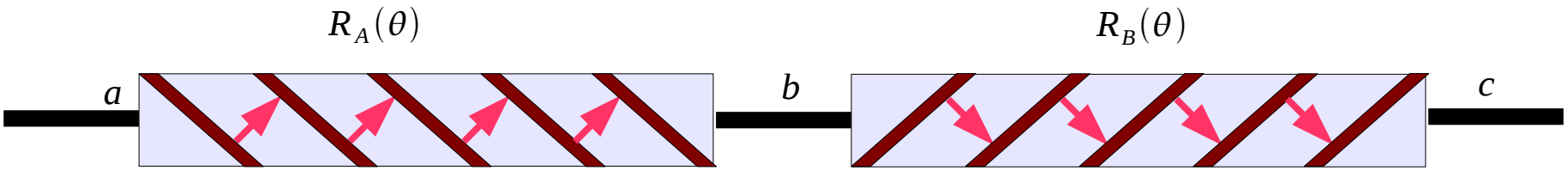


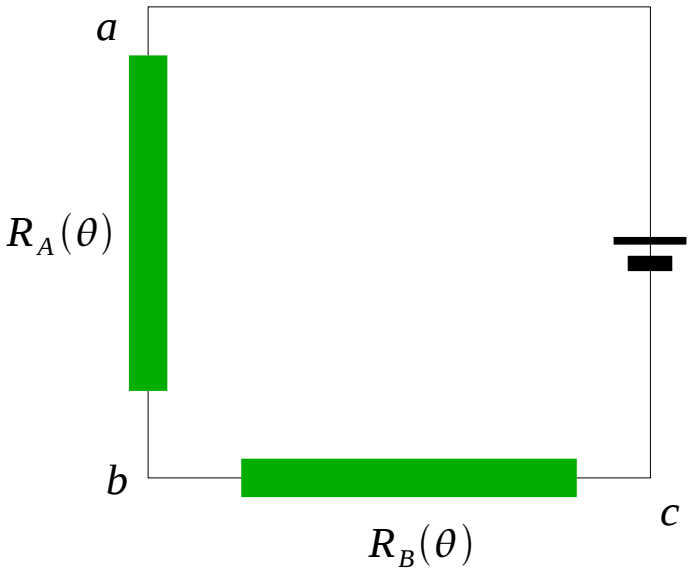
$$R_A(\theta) = R_{max} \sin^2\theta + R_{min} \cos^2\theta$$

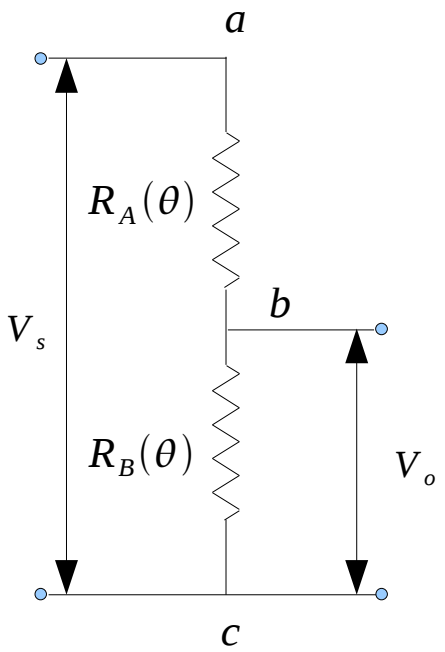
$$R_B(\theta) = R_{max} \sin^2(90 - \theta) + R_{min} \cos^2(90 - \theta)$$

$$R_B(\theta) = R_{max} \cos^2\theta + R_{min} \sin^2\theta$$

Voltage Divider







$$R_A(\theta) = R_{max} \sin^2\theta + R_{min} \cos^2\theta$$

$$R_B(\theta) = R_{max} \cos^2\theta + R_{min} \sin^2\theta$$

References

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