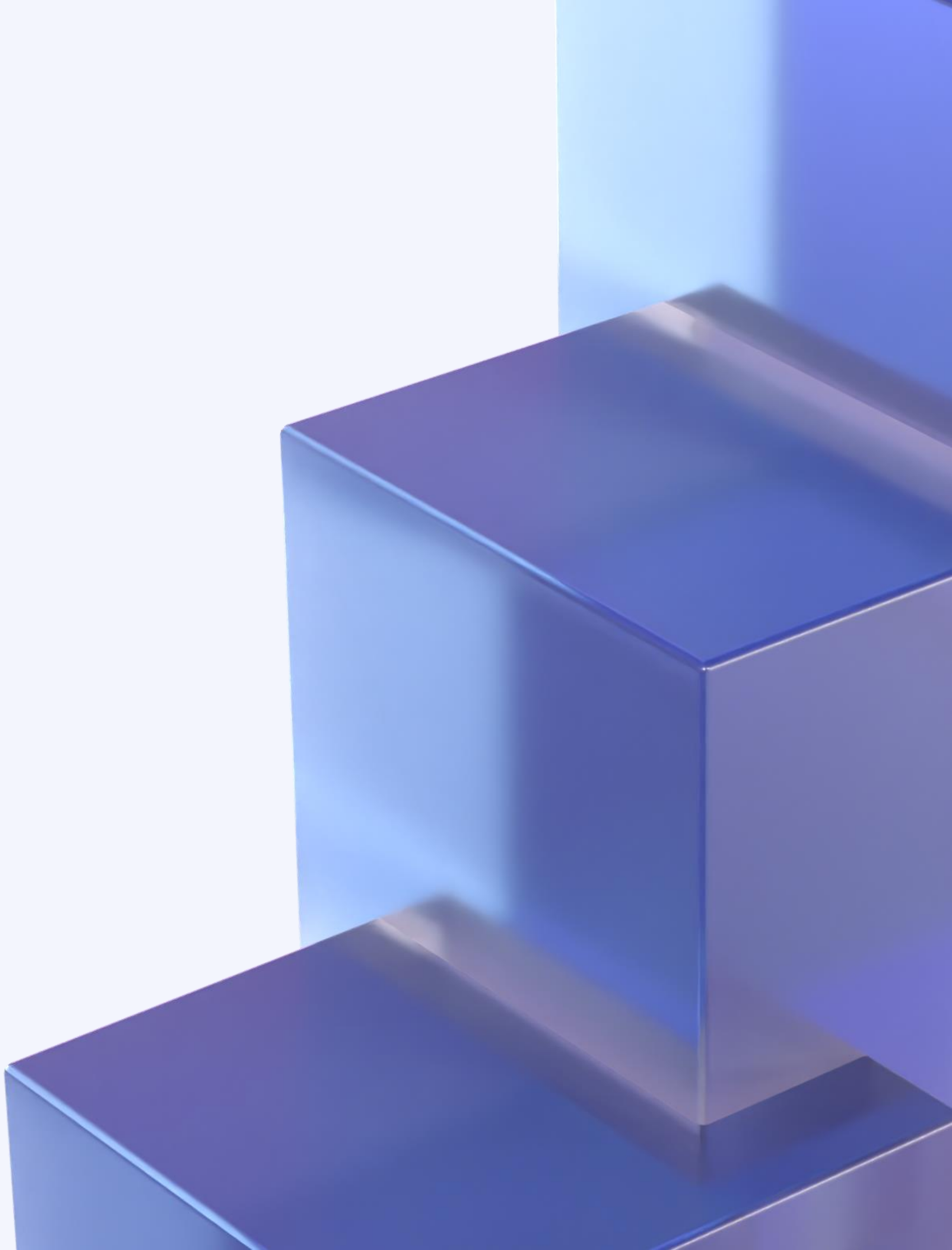
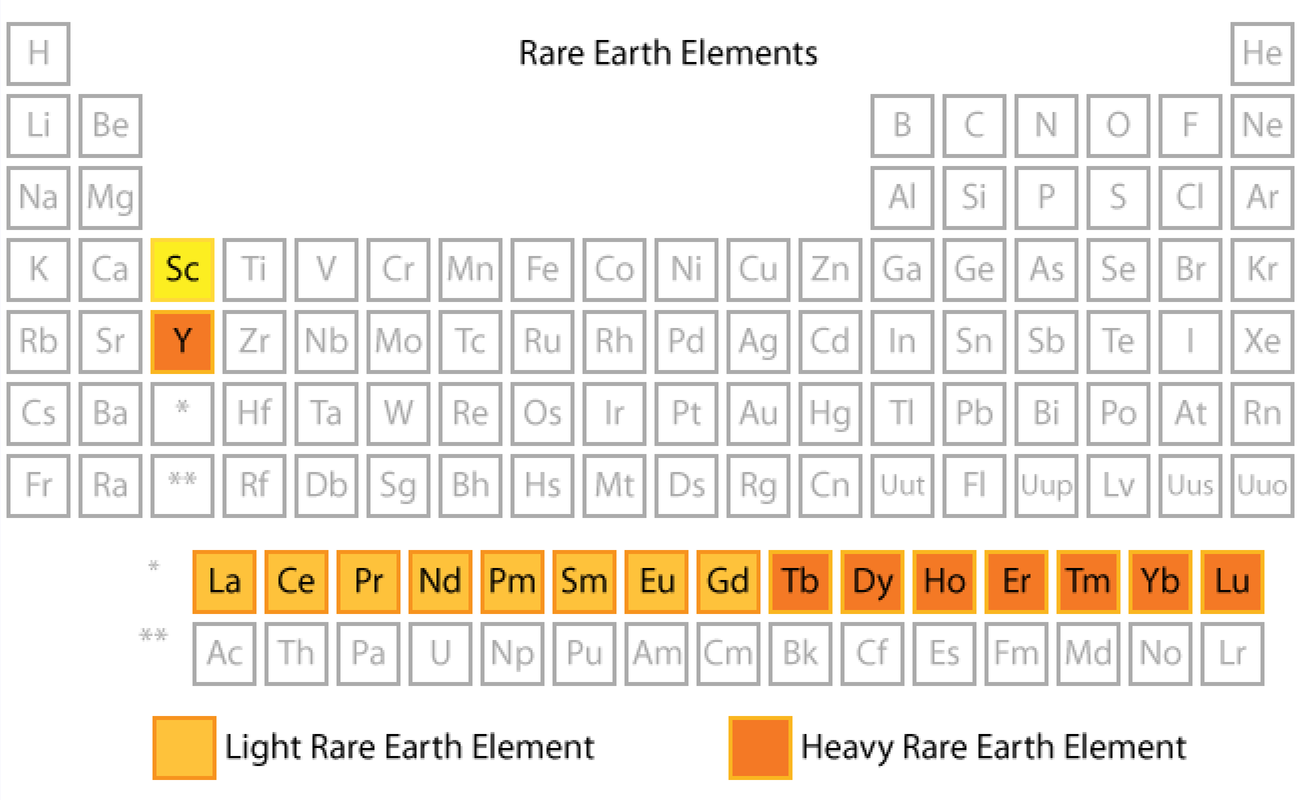
The Rare-Earth Scarcity Challenge

Innovative Designs for Magnetic Position Sensing





Rare-Earth Elements (REEs) are a group of 17 metallic elements, including the 15 lanthanides plus yttrium and scandium

A distinction is made between Light Rare-Earth Elements (LREs) and Heavy Rare-Earth Elements (HREs)

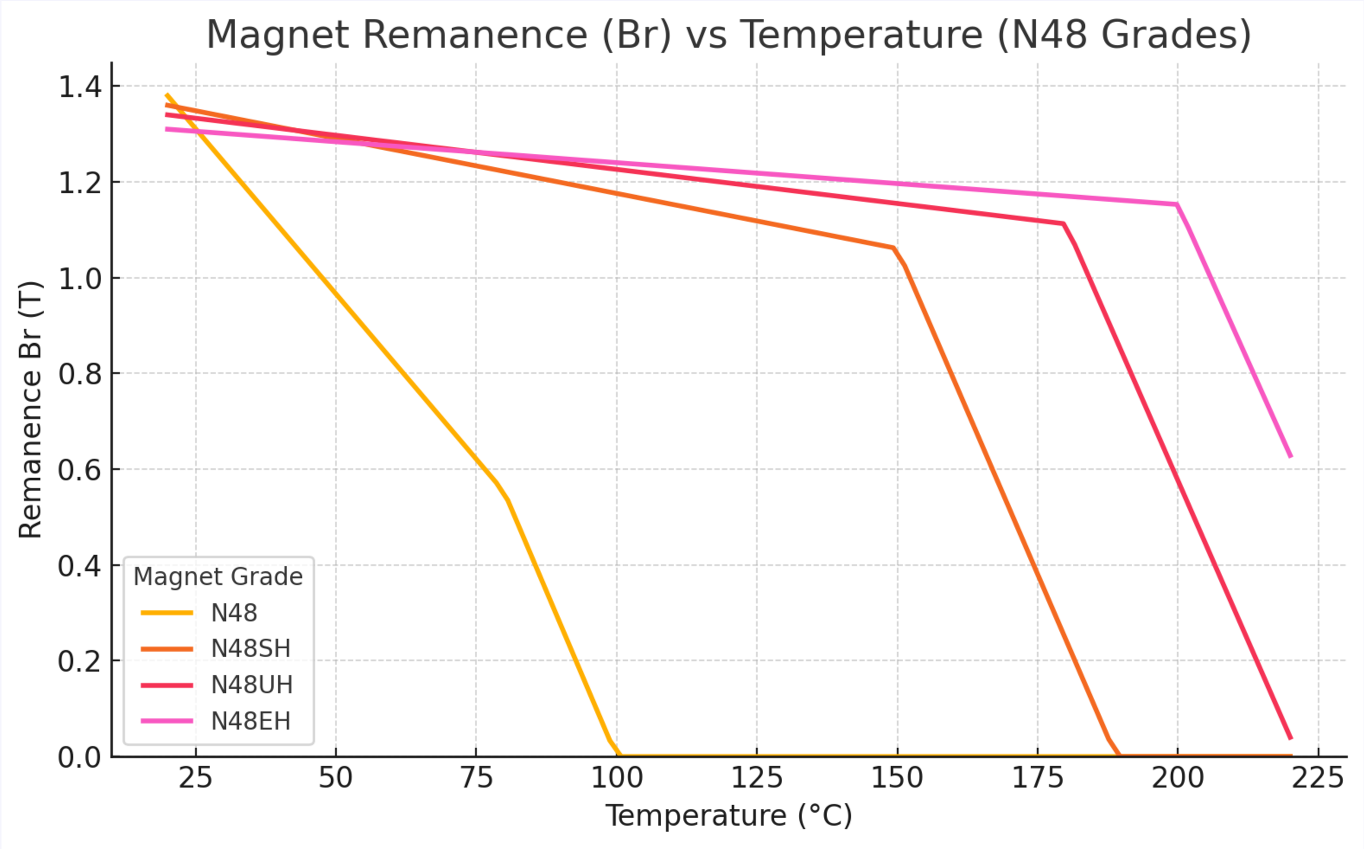
Magnetic Material Comparison

Commonly used target magnets

	Ceramic / Ferrite	Injection Molded NdFeB	Compresion Bonded NdFeB	SmCo	Sintered NdFeB
Br max [T]	0.2-0.4	0.3-0.8	0.3-0.8	0.9-1.1	1.1-1.4
Coercivity [kA/m]	160	400	400	3200	900
Max Temp [°C]	250	160	160	500	220
Material Cost	Low	Med	Med	Highest	High
Unique Property	Cost	Complex shapes	Machinable	Temperature	High Br
Rare-Earth restriction	None	None	None	Heavily restricted	Restrictions on doping materials

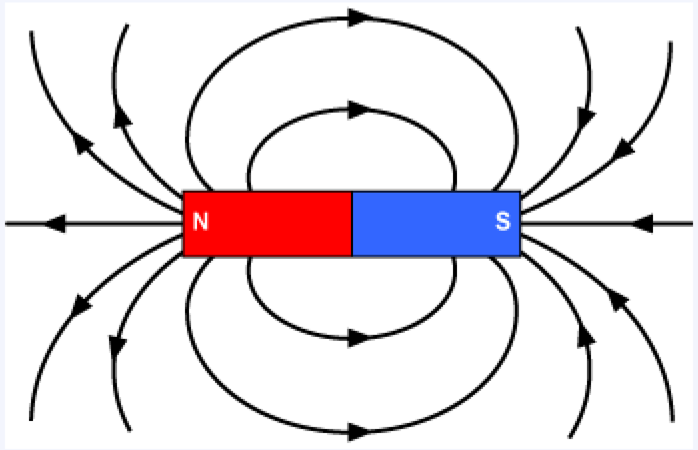
There are typically 4-7 temperature grades:

- **Standard**, M, H, **SH**, **UH**, **EH**, AH
- Higher grades are increasingly more expensive
- This is due to the manufacturing – for higher temperature grades, HREs are added in increasing relative quantities



Design Adjustments

High B_R magnets that can perform at high temp are increasingly difficult to source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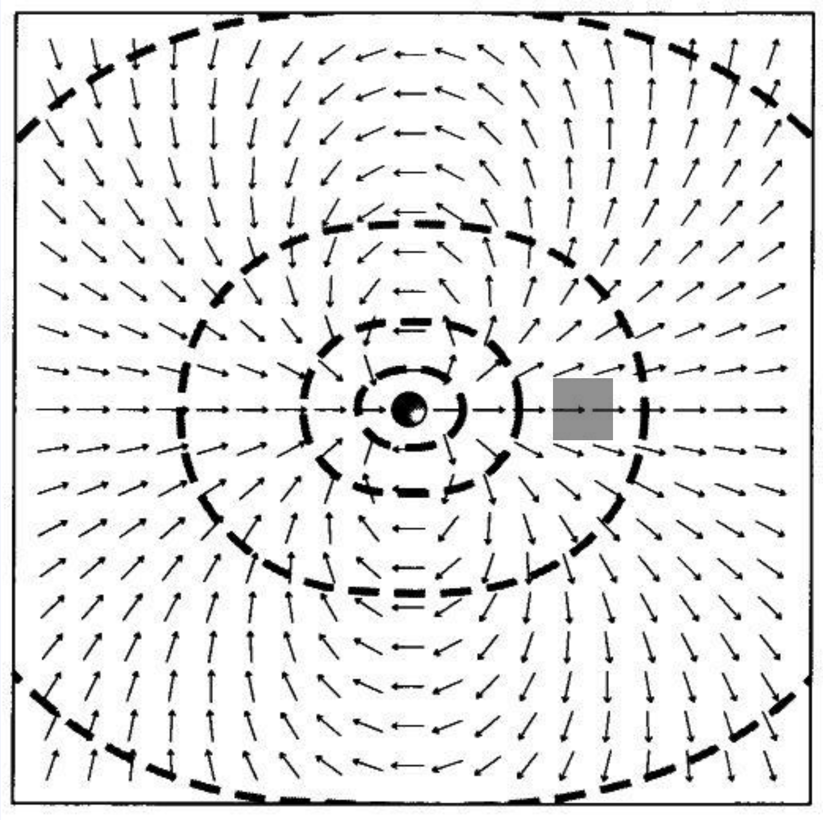
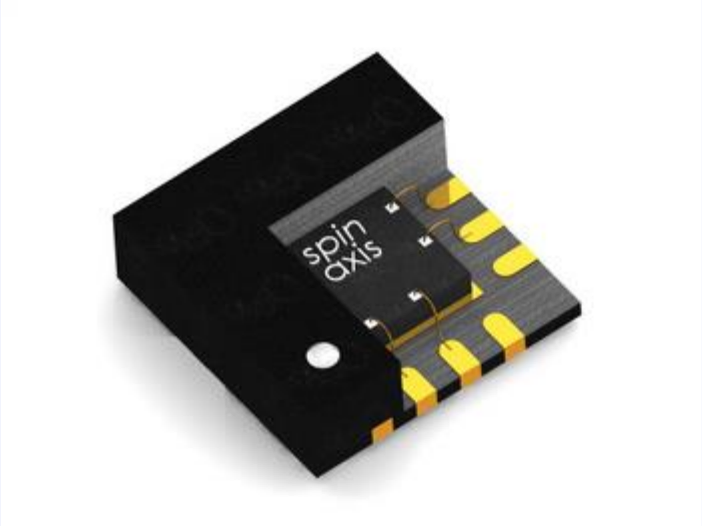
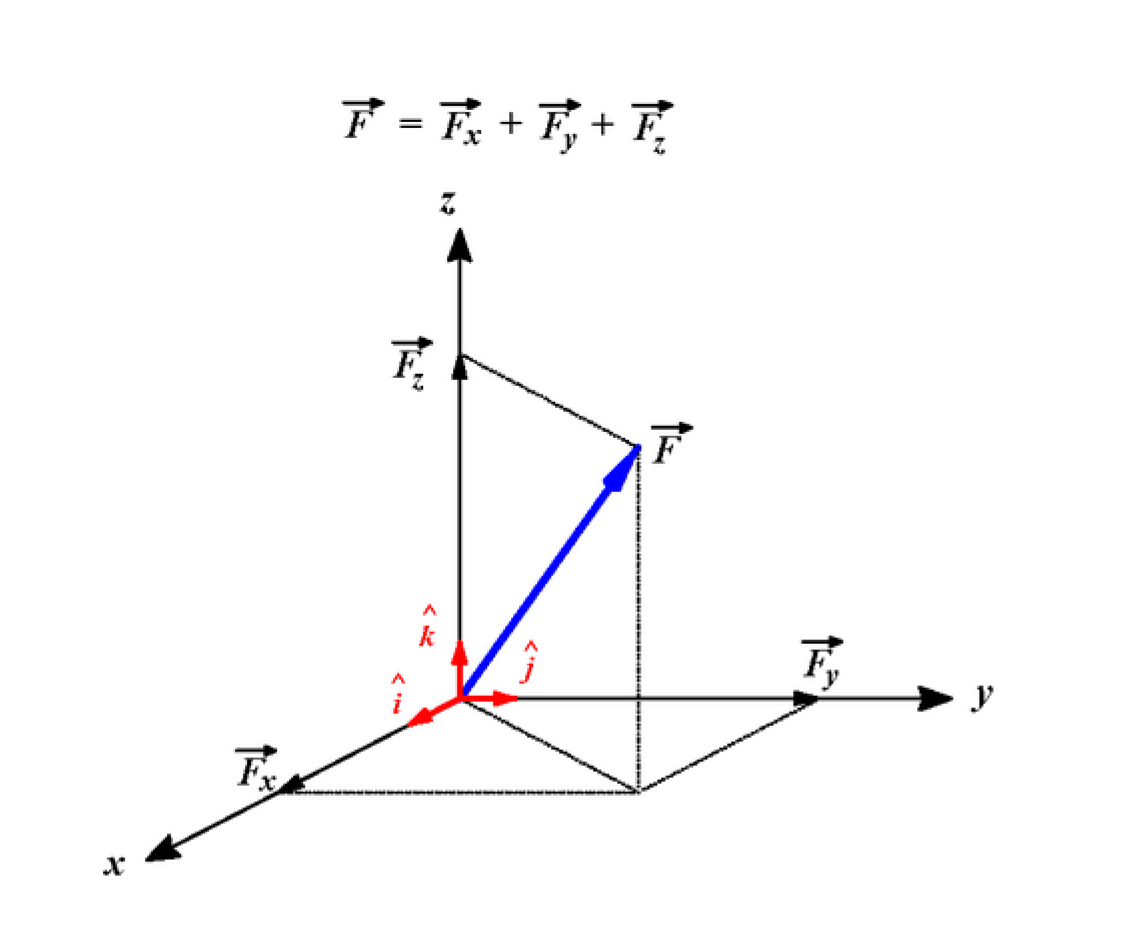



spin
axis



Magnetic Position Sensor as a Point Field Sensor

A magnetic sensor sees one thing: The component(s) of the magnetic field vector at the “point” of the Hall sensor(s)

Electrical

- More sensitive sensor component
- Change sensor filter
- Find a sensor sensitive to an axis with higher flux density

Magnetic

- Increase magnet size
- Change magnetization orientation
- Change number of poles

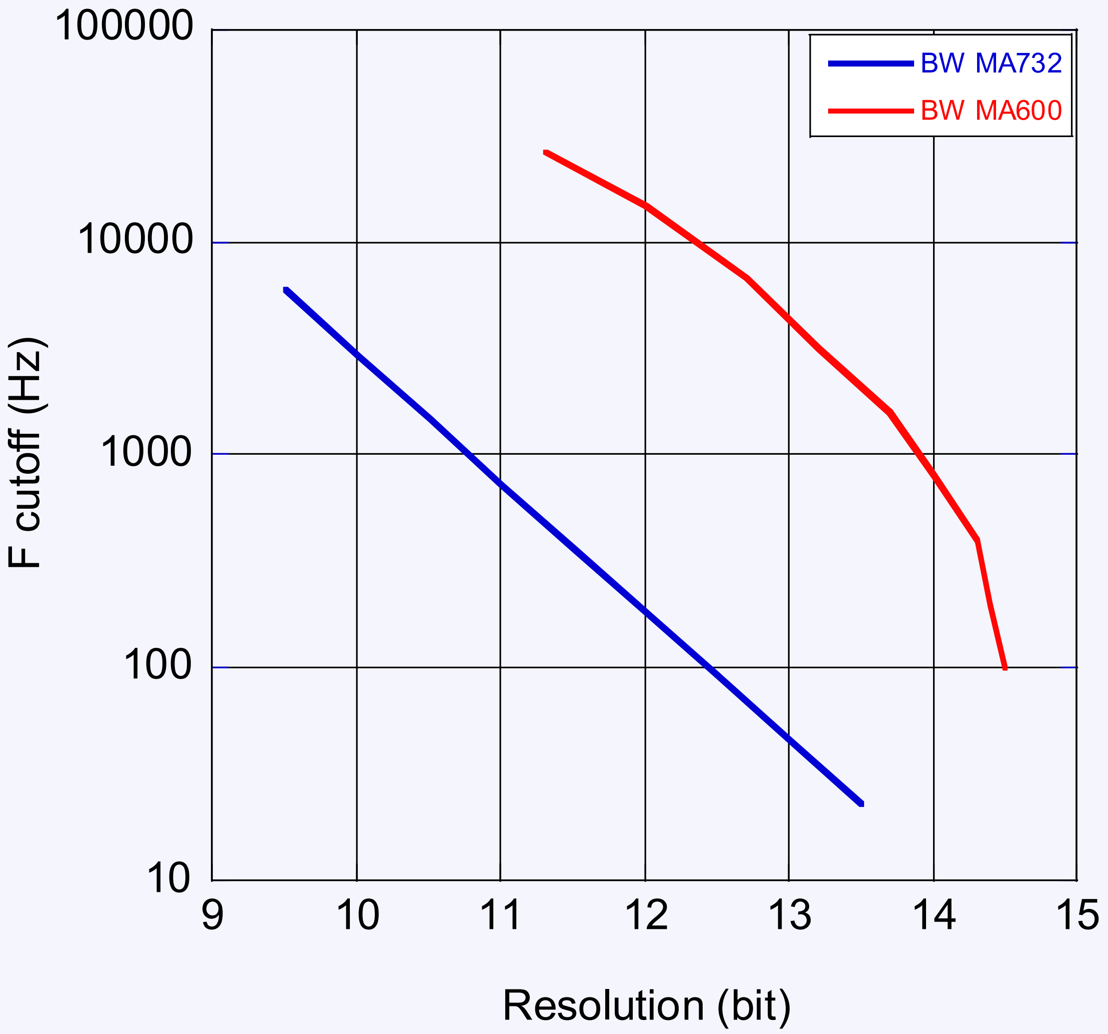
Mechanical

- Smaller air gap
- Move sensor to area of higher flux density

More sensitive sensor component

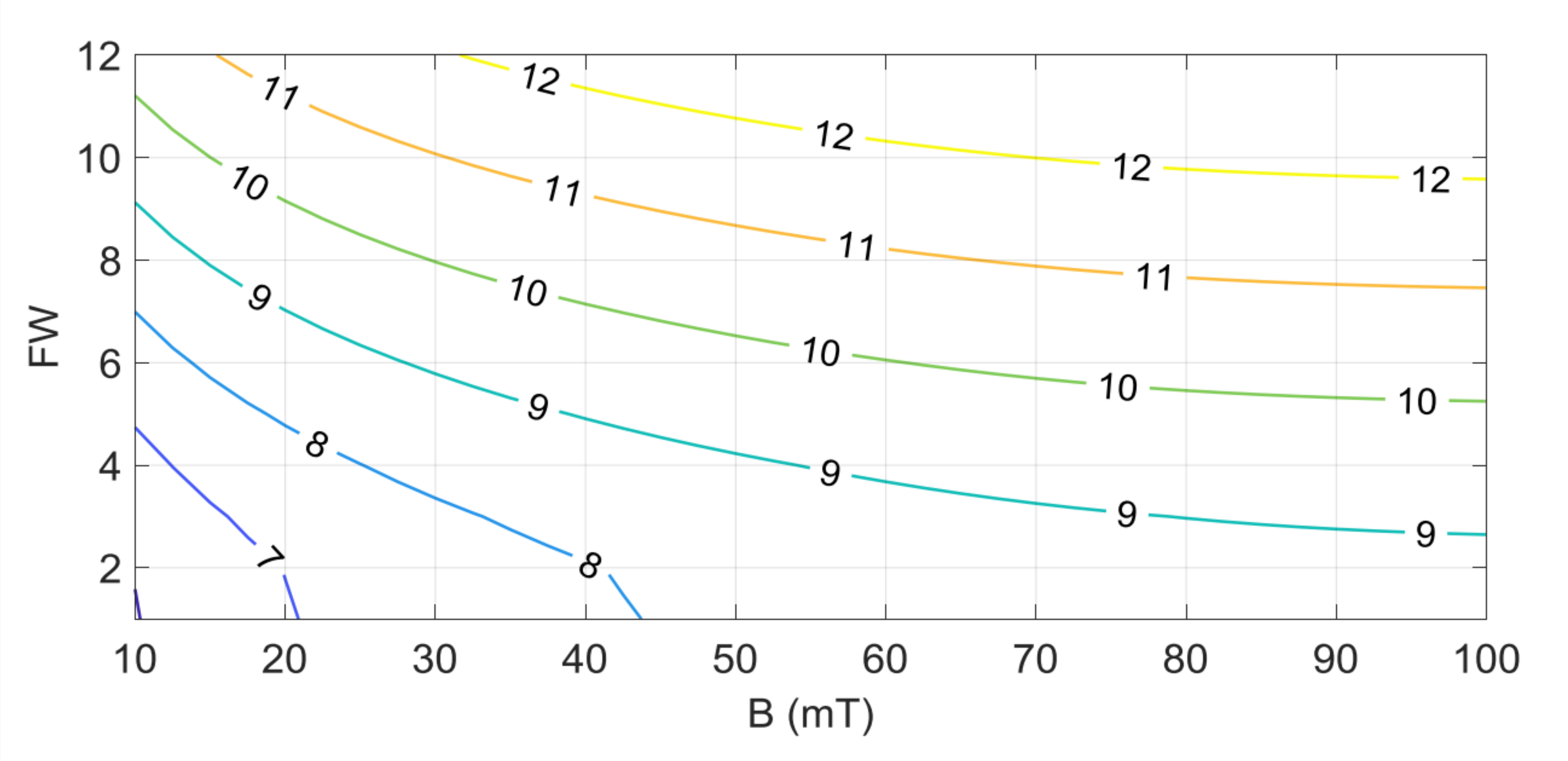
E.g. MA702 to MA600A

Tradeoff: Cost

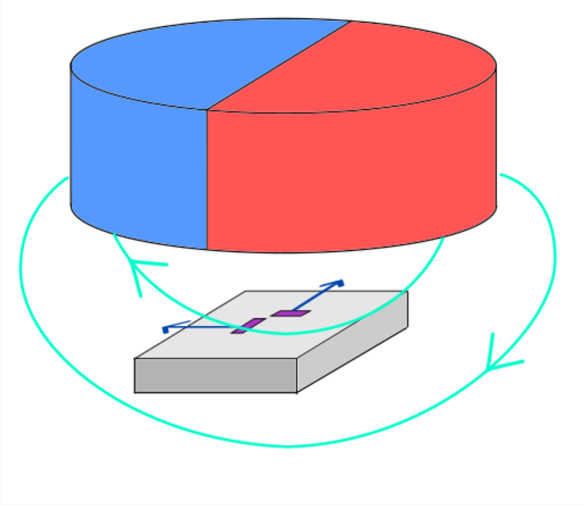


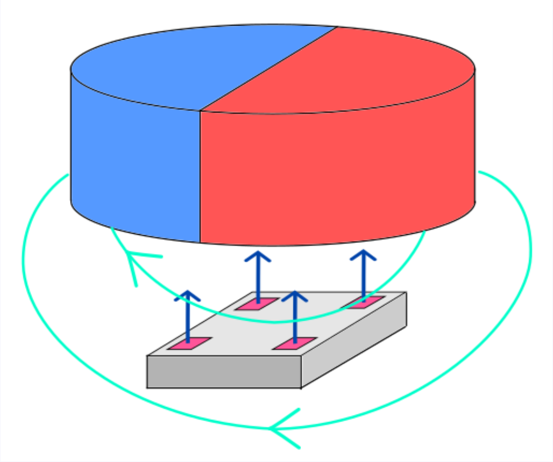
Change sensor filter window

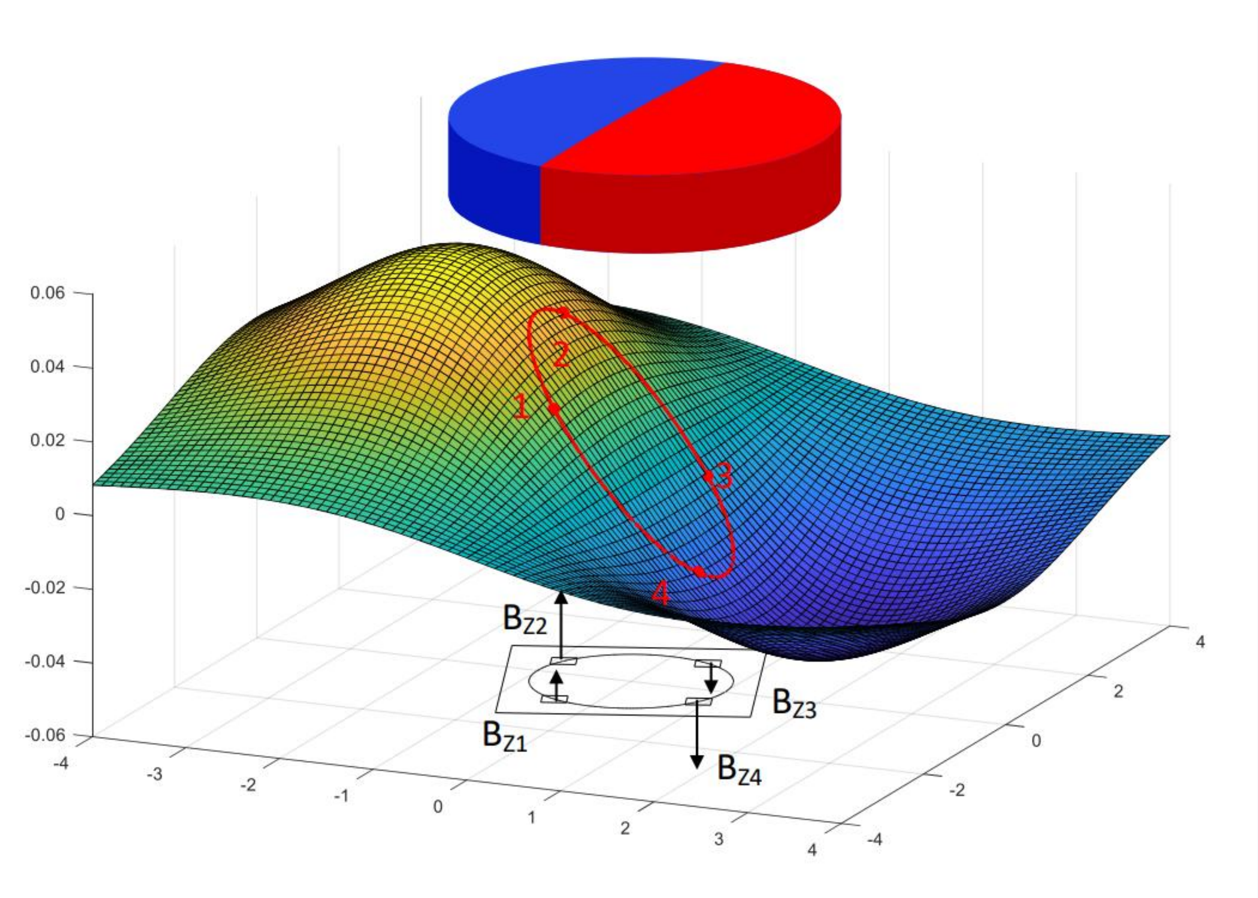
Tradeoff: Dynamic Bandwidth



Change sensing axis

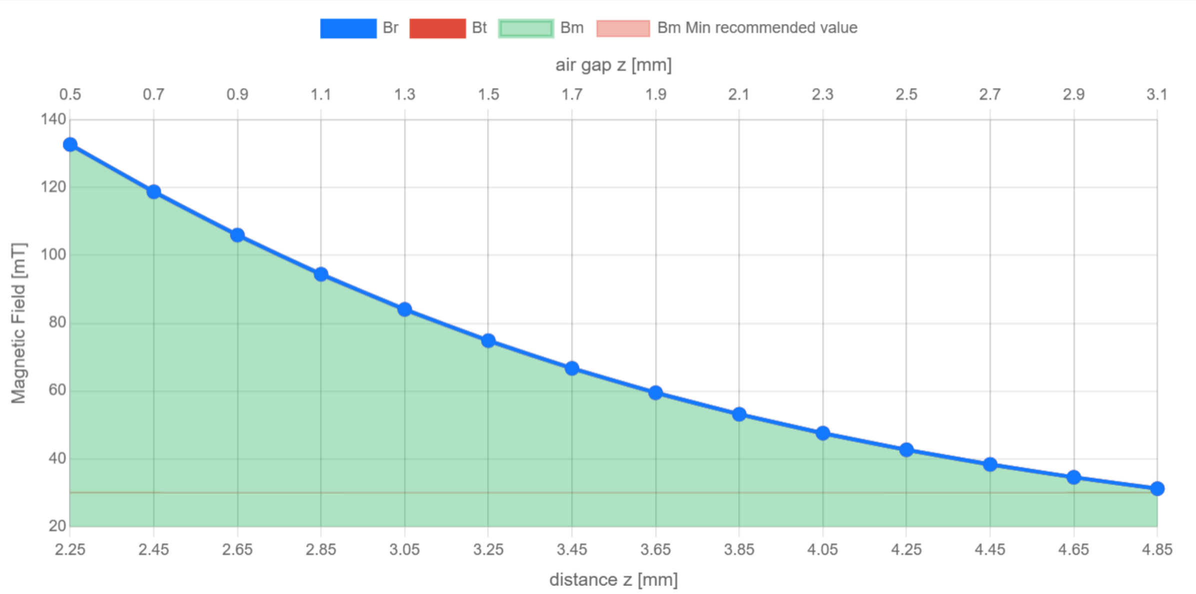


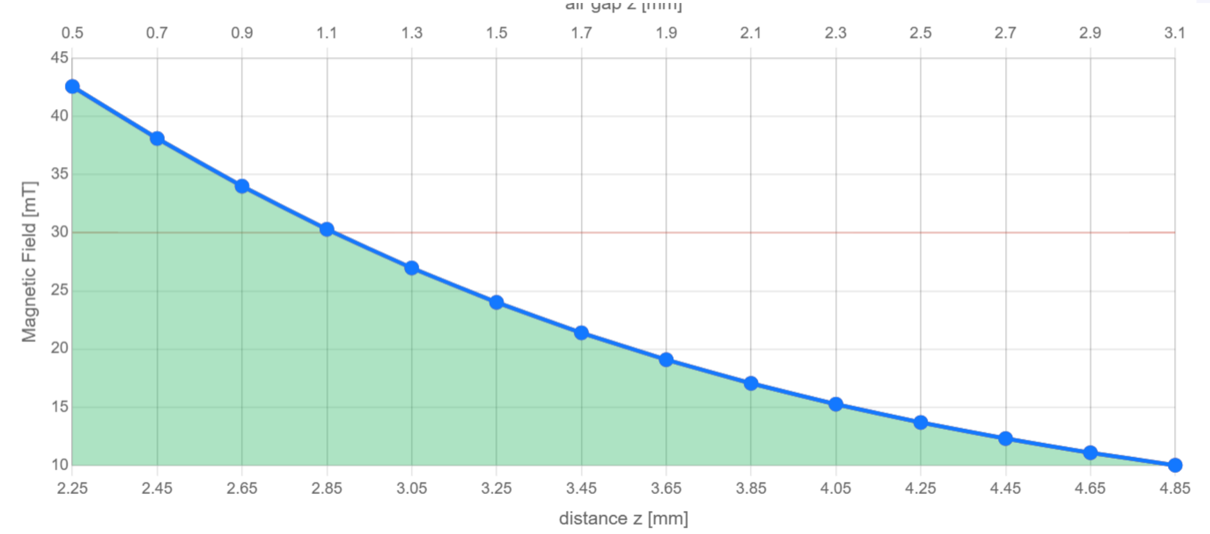




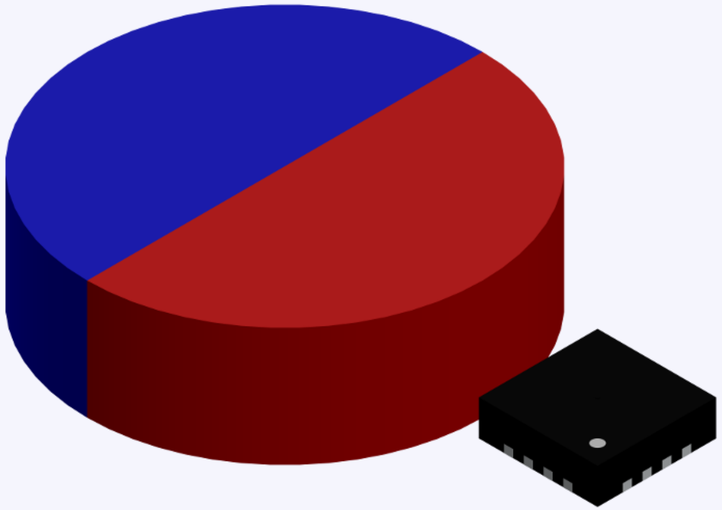
Reduce the air gap

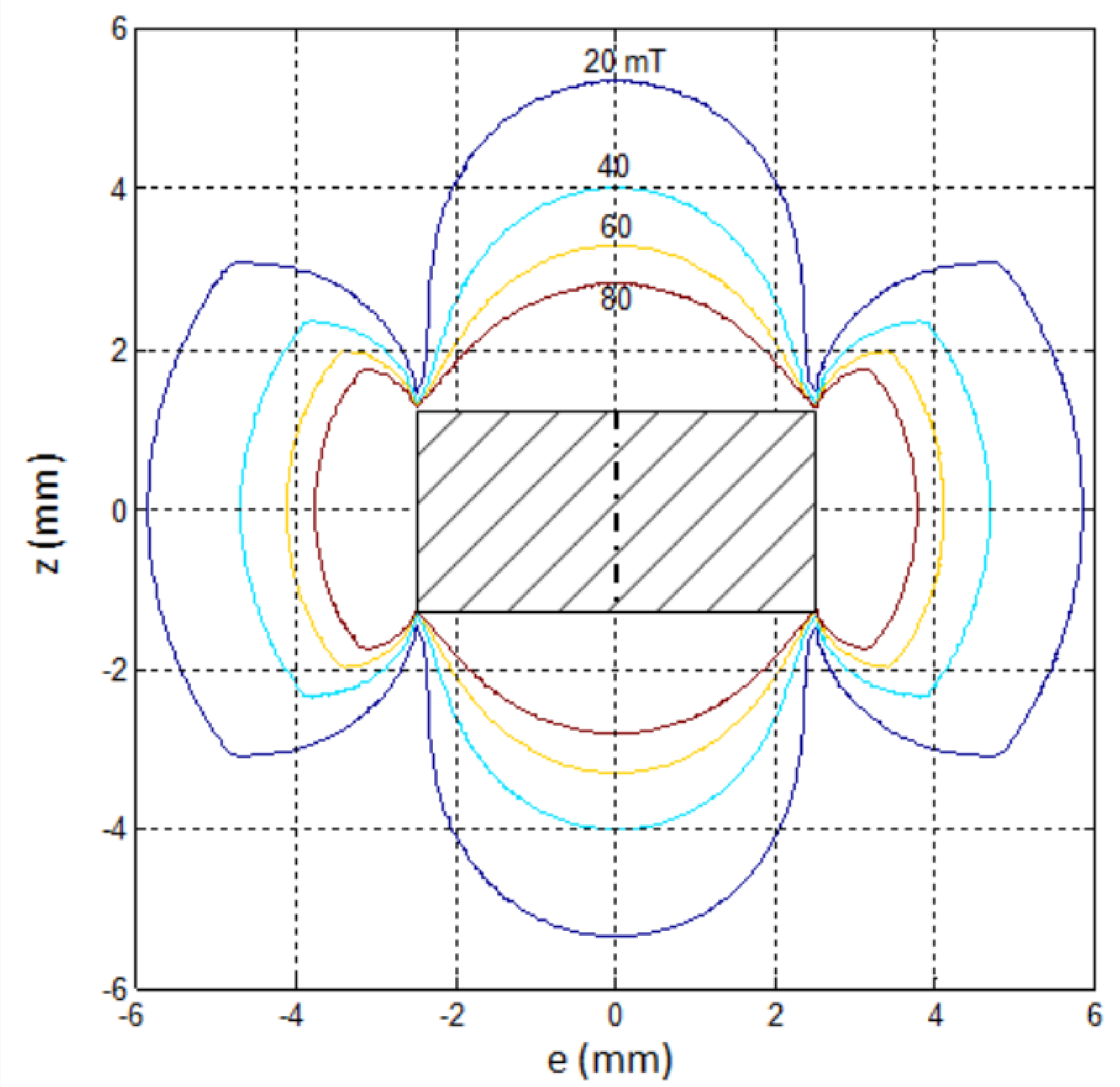
Tradeoff: Mechanical Tolerance Stack-up





Shift sensor to area of higher flux density

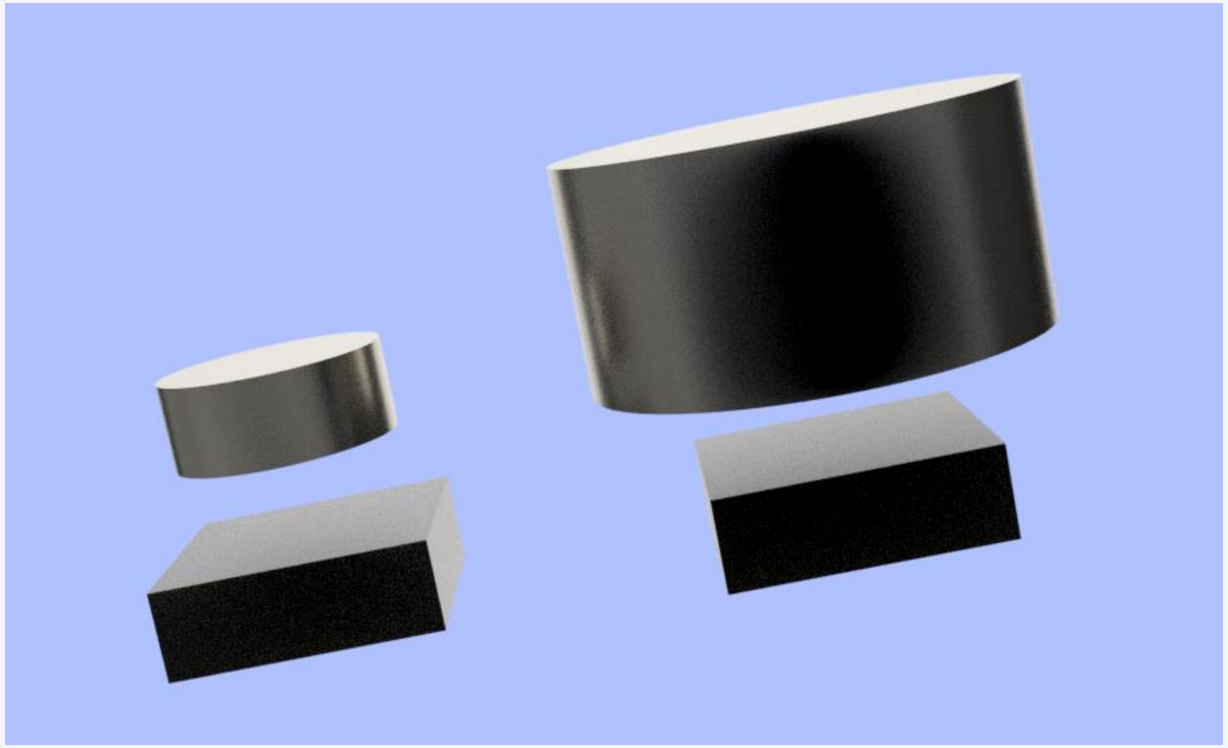




Increase magnet size

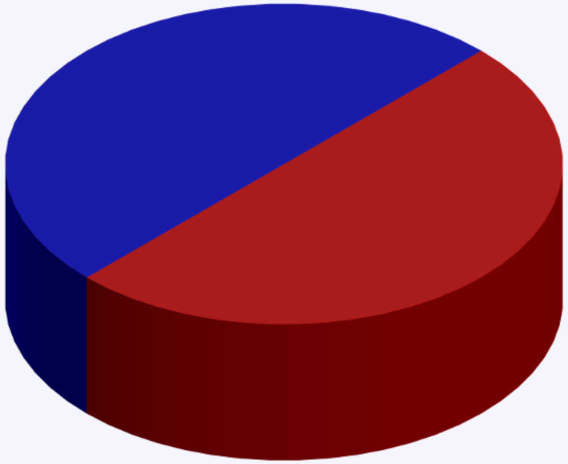
Neodymium 2.5 mm D x 1 mm H magnet
https://tinyurl.com/2yo3z8hx

Ferrite 5 mm D x 2.5 mm H magnet
https://tinyurl.com/2yo3z8hx

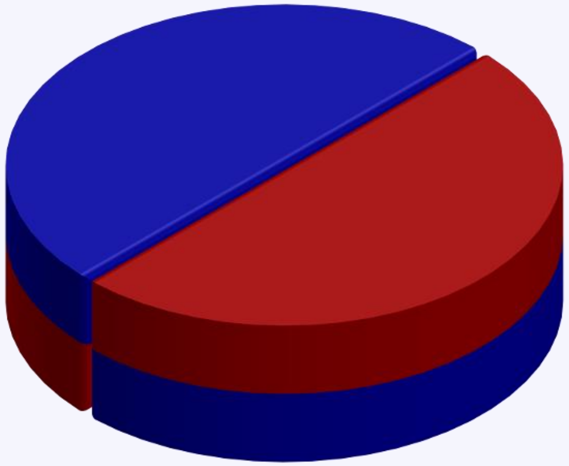


Change magnetization orientation

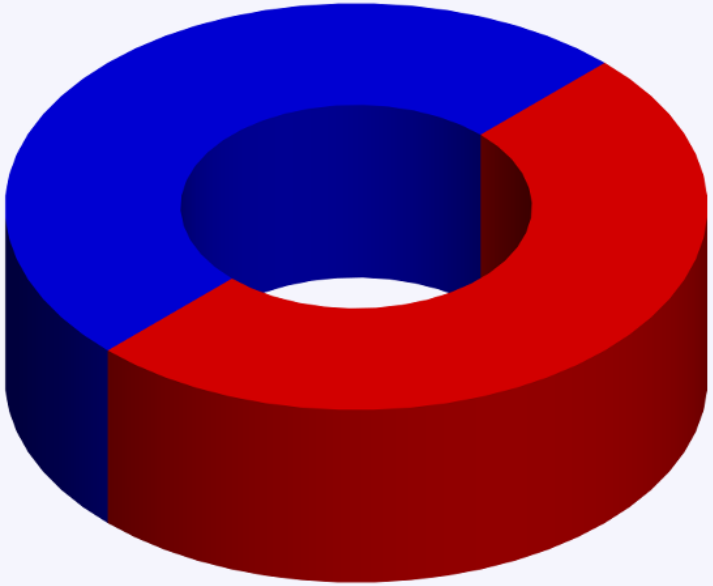
Diametral magnetization

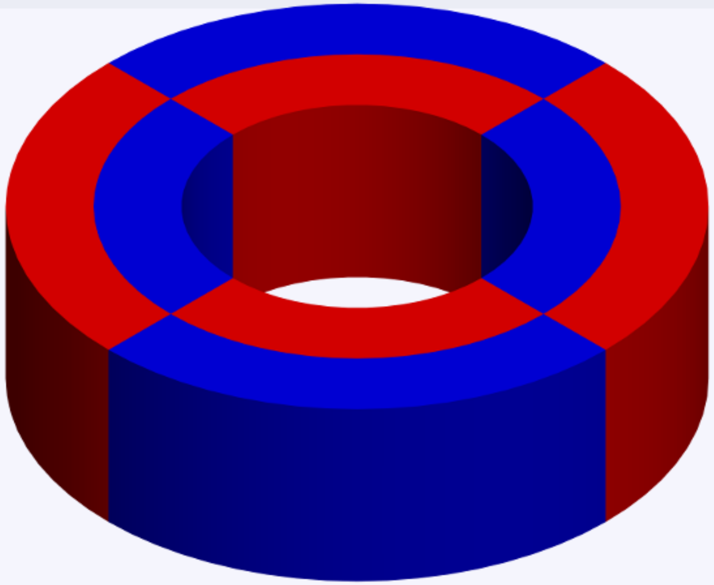


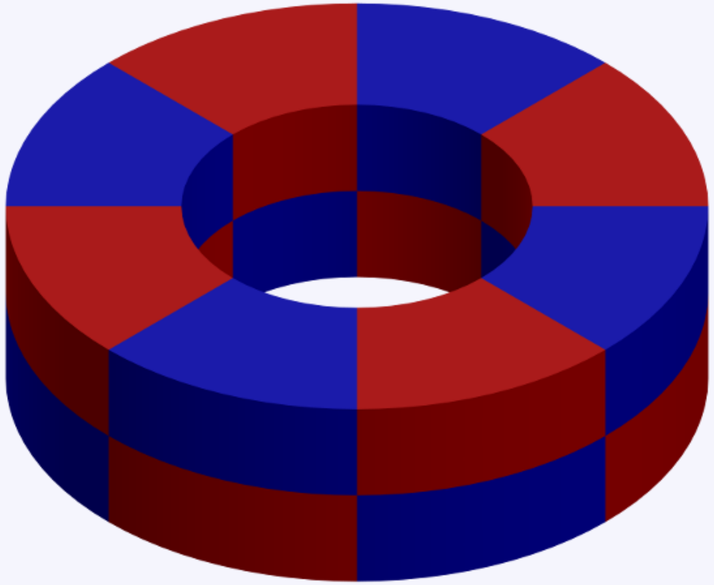
Biaxial magnetization



Change number of poles

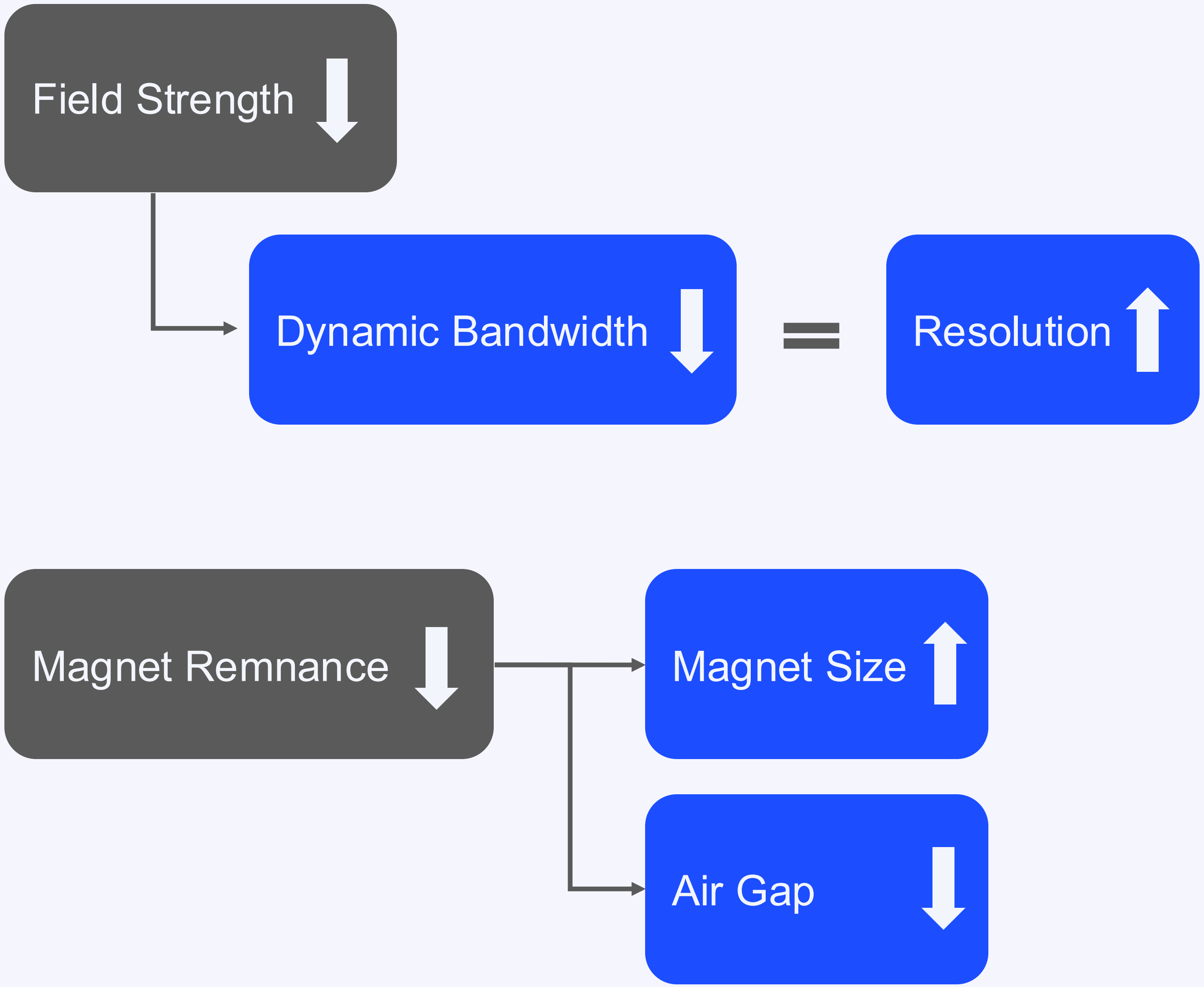






Tradeoff: Absolute Angle Detection

Tradeoff Review



Electrical

- More sensitive sensor component
  - MA600A
- Change sensor filter
  - MA600A, MA732, MA330
- Find a sensor sensitive to an axis with higher flux density
  - MA900, MV300

Mechanical

- Smaller air gap
- Move sensor to area of higher flux density
- Utilize MPS Sensor simulation software

Magnetic

- Increase magnet size
- Change magnetization orientation
- Change number of poles
- Utilize MPS Sensor simulation software

http://sensors.monolithicpower.com

Questions

Thank You!