

Transition detection

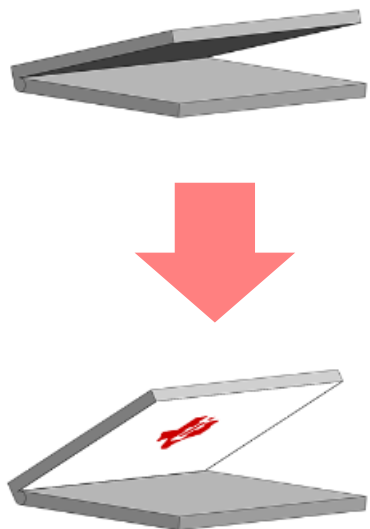
TI Precision Labs – Magnetic sensors

Presented by Patrick Simmons

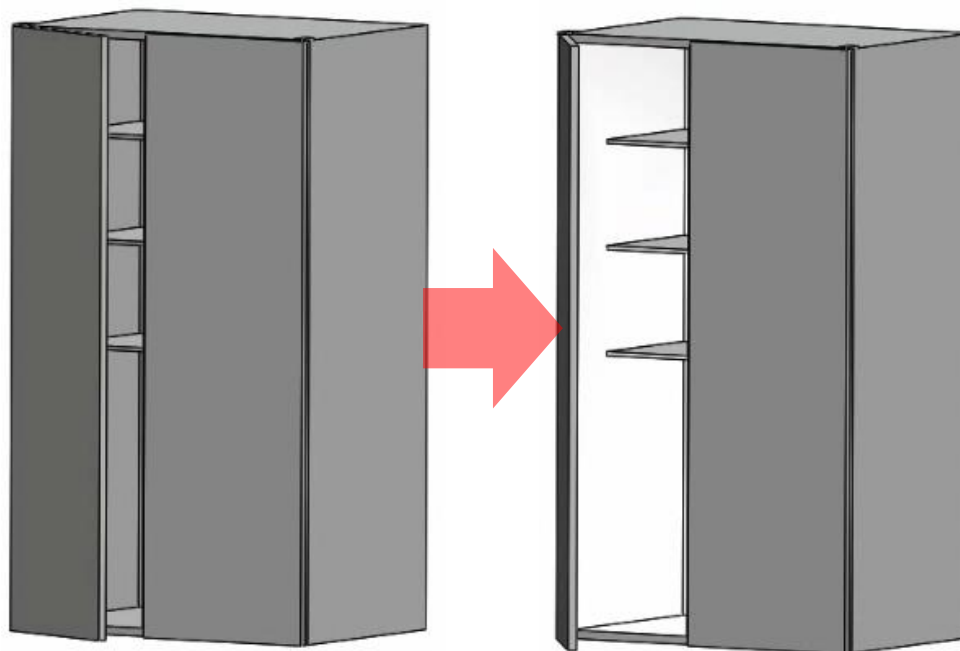
Prepared by Patrick Simmons

Applications

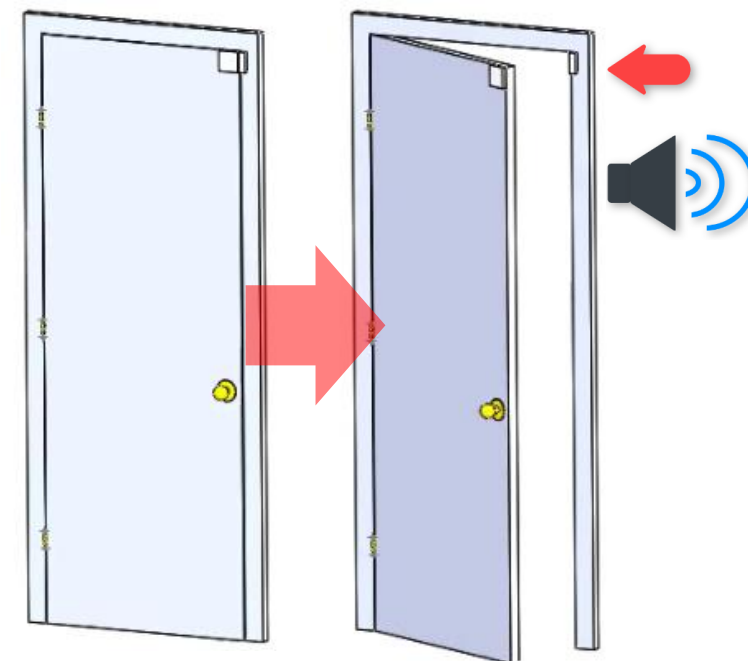
Laptop screen
turns on when
lid opened



Refrigerator
light turns on
when door
opened



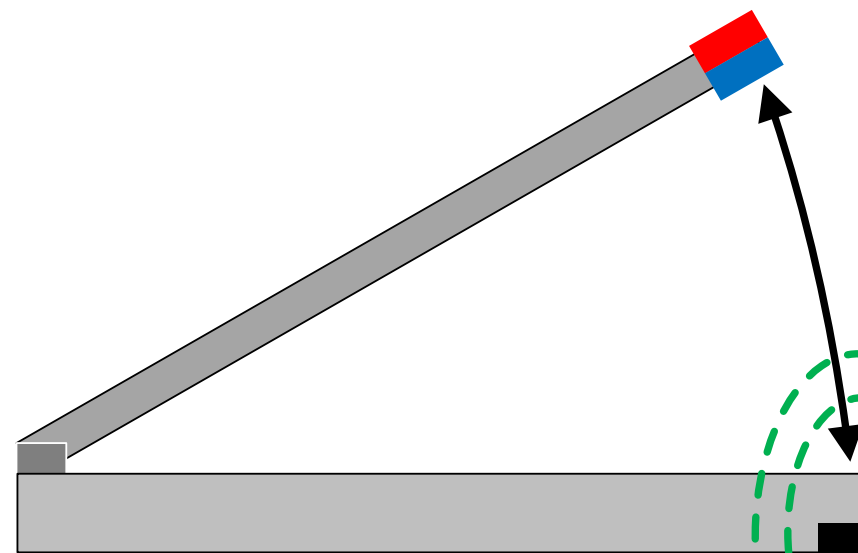
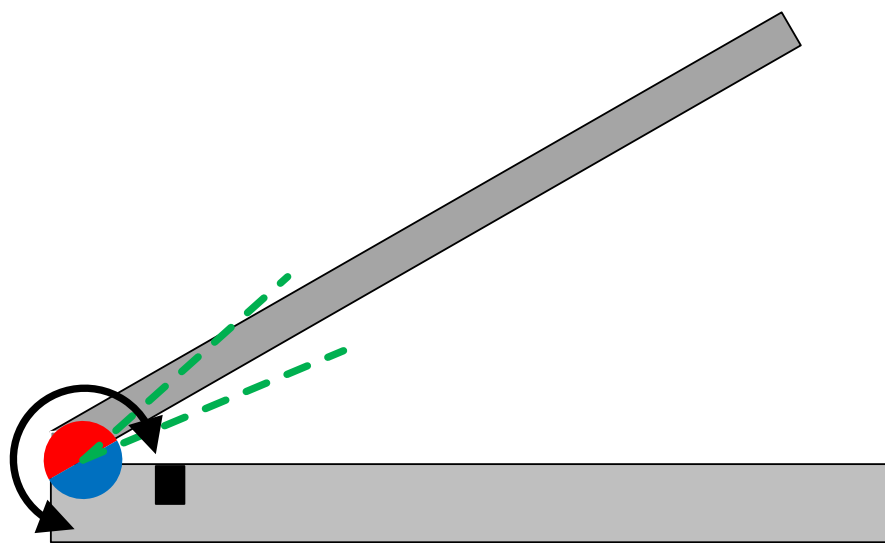
Door alarm
triggered on
when door
opened



Design process overview

1. Identify general implementation.
2. Define mechanical constraints including tolerances.
3. Determine B-field curve for various magnets within price point.
4. Determine suitable devices within price point.
5. Iterate.

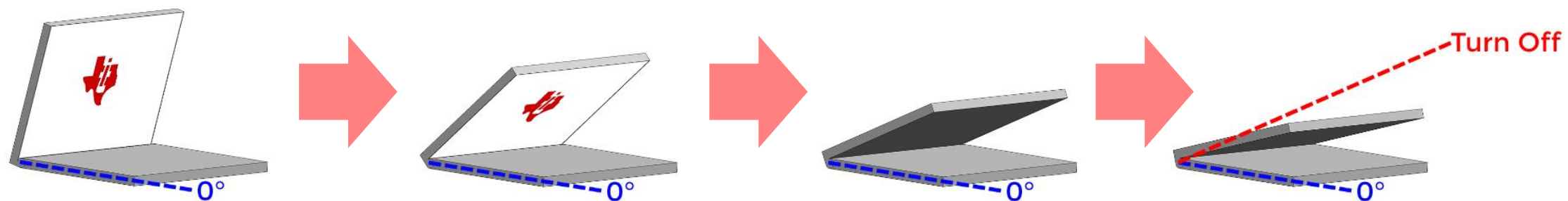
General implementation



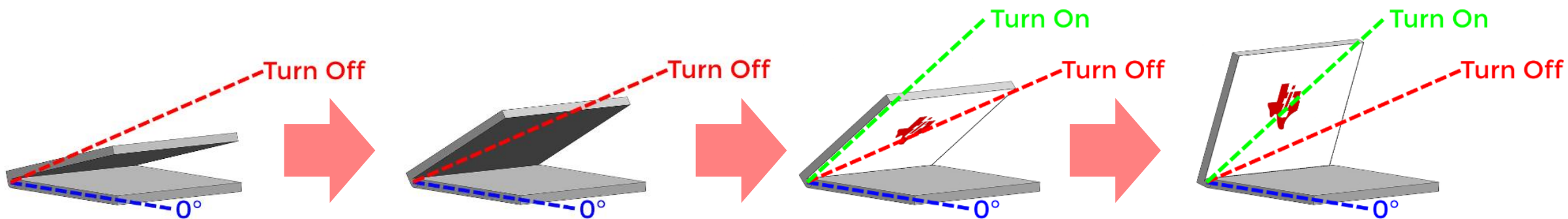
Design process overview

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Off and On Transition Points

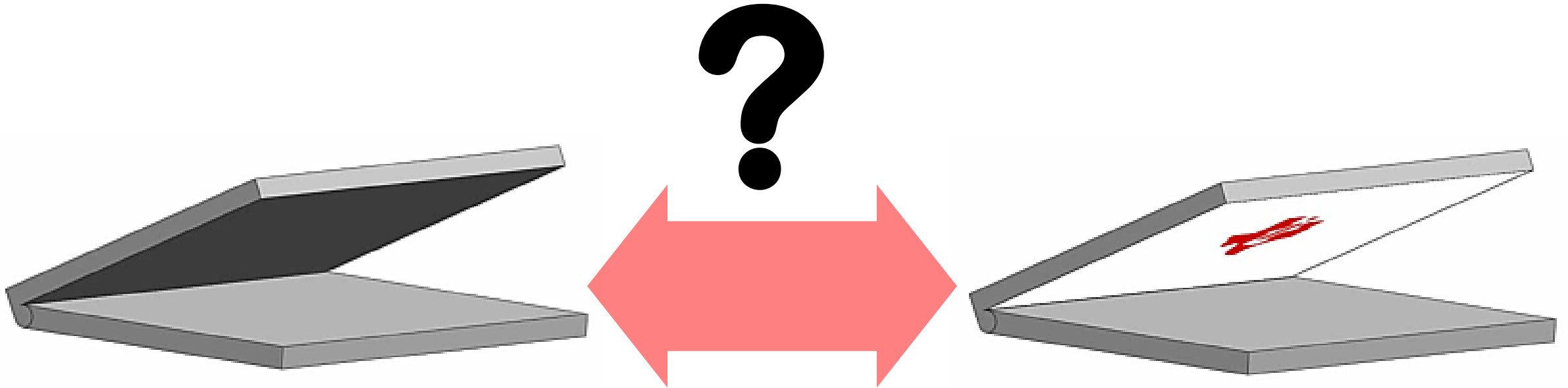


Off and On Transition Points



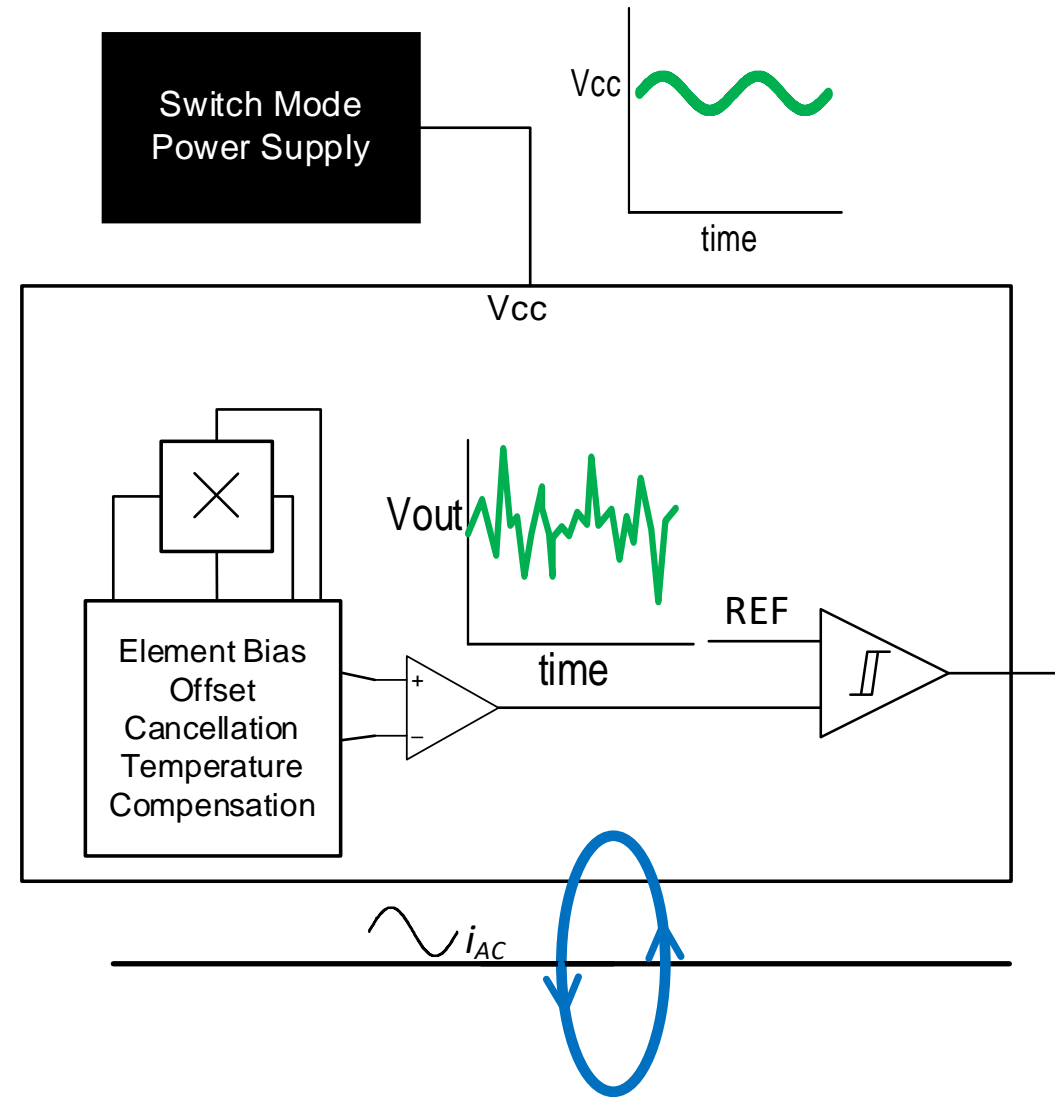
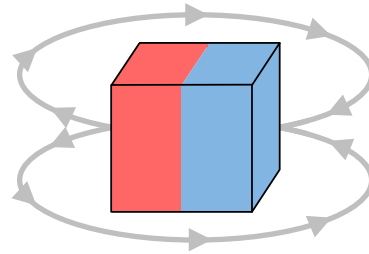
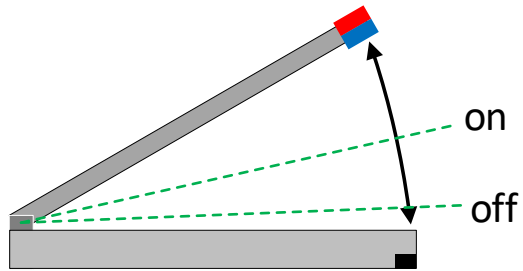
Hysteresis

(Design with no hysteresis or insufficient hysteresis)



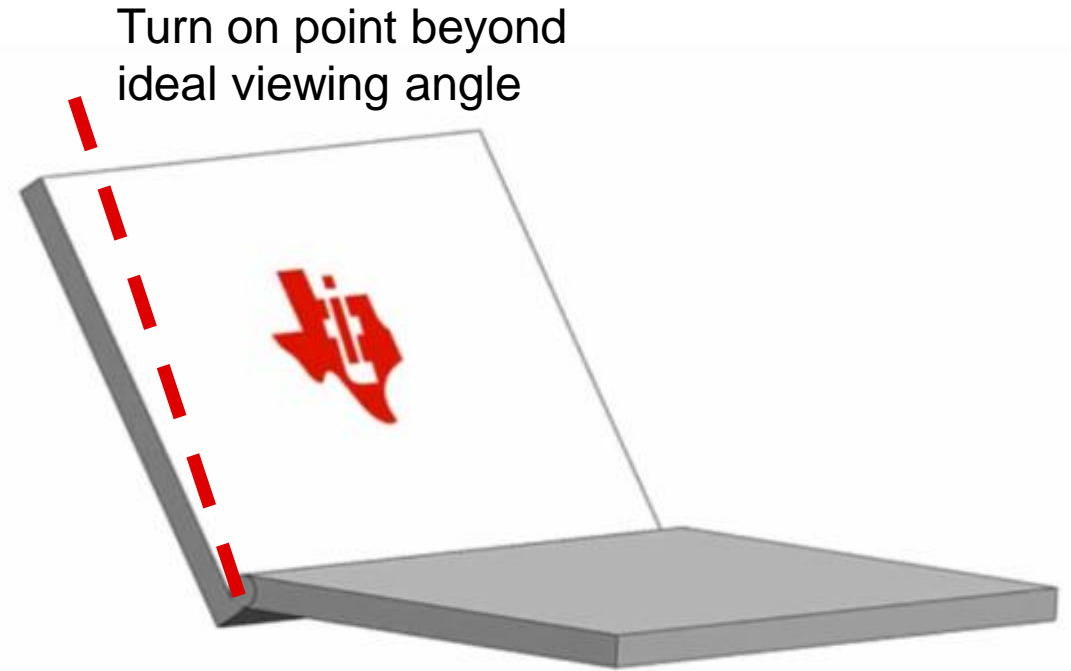
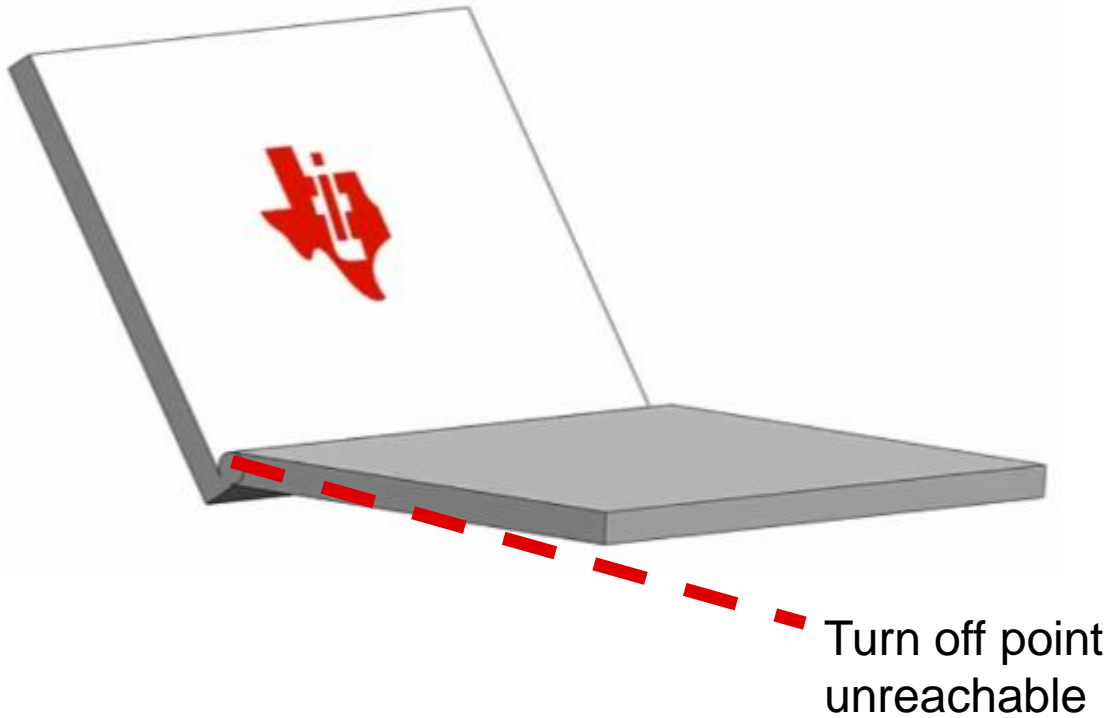
(laptop flickering like fluorescent lights in Hollywood Horror flick)

Hysteresis



Hysteresis

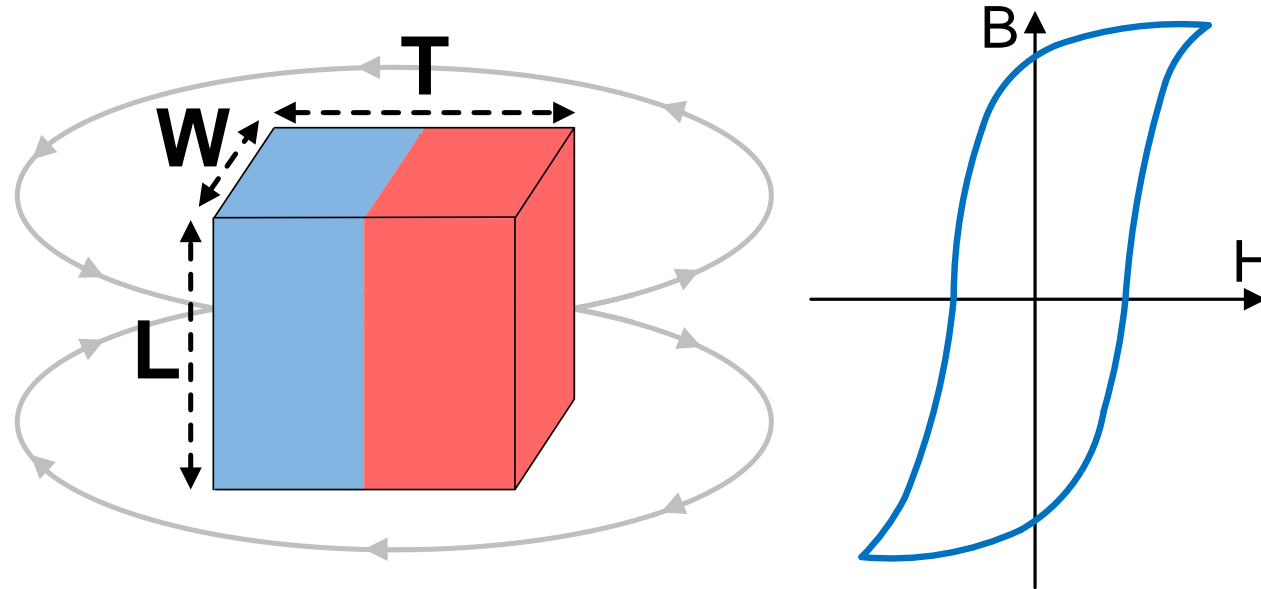
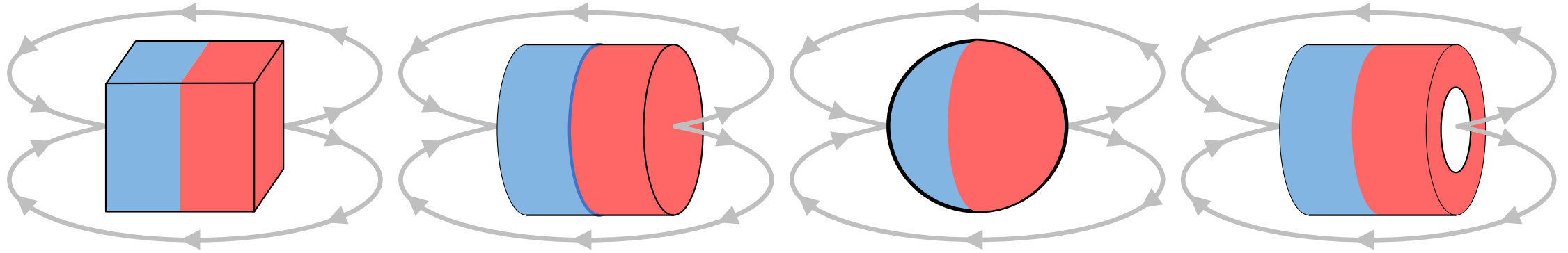
(Improper Design with Hysteresis)



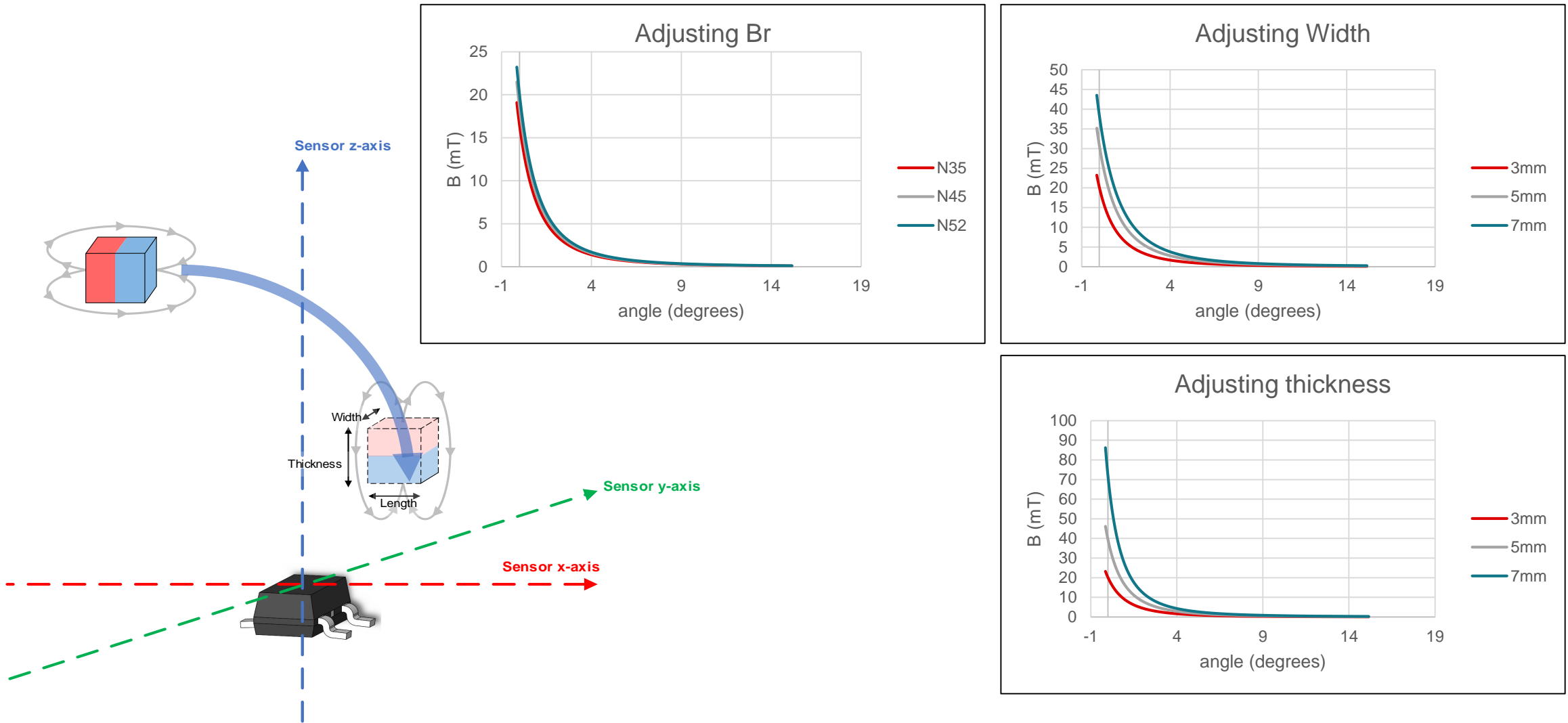
Design process overview

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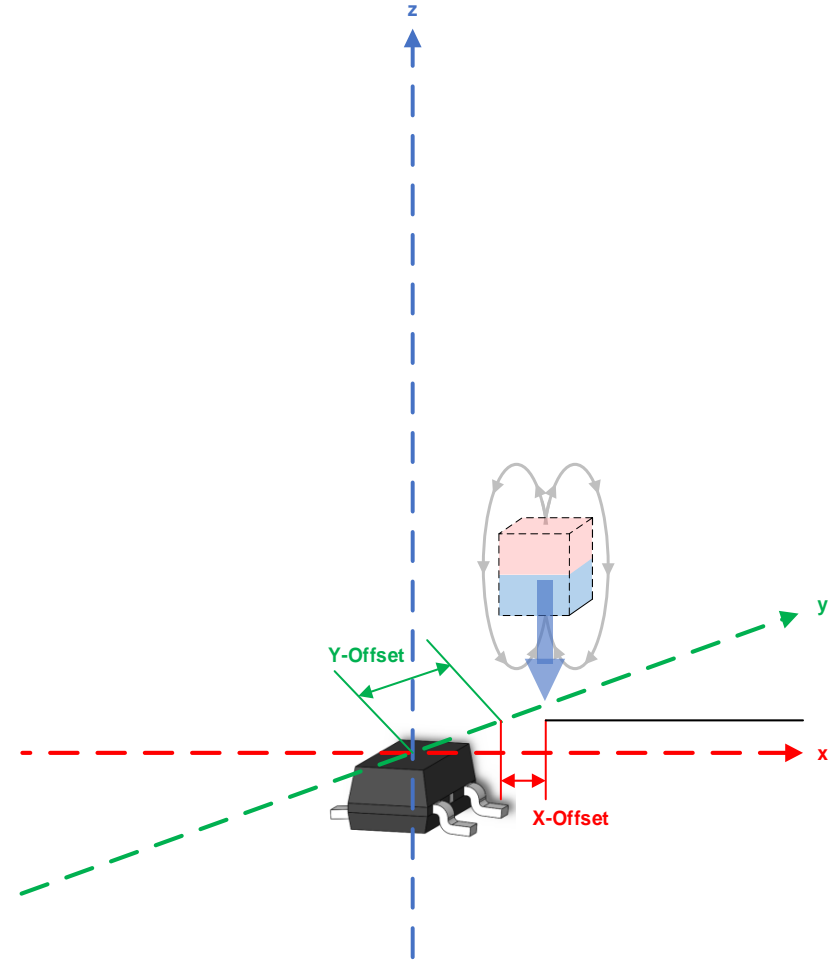
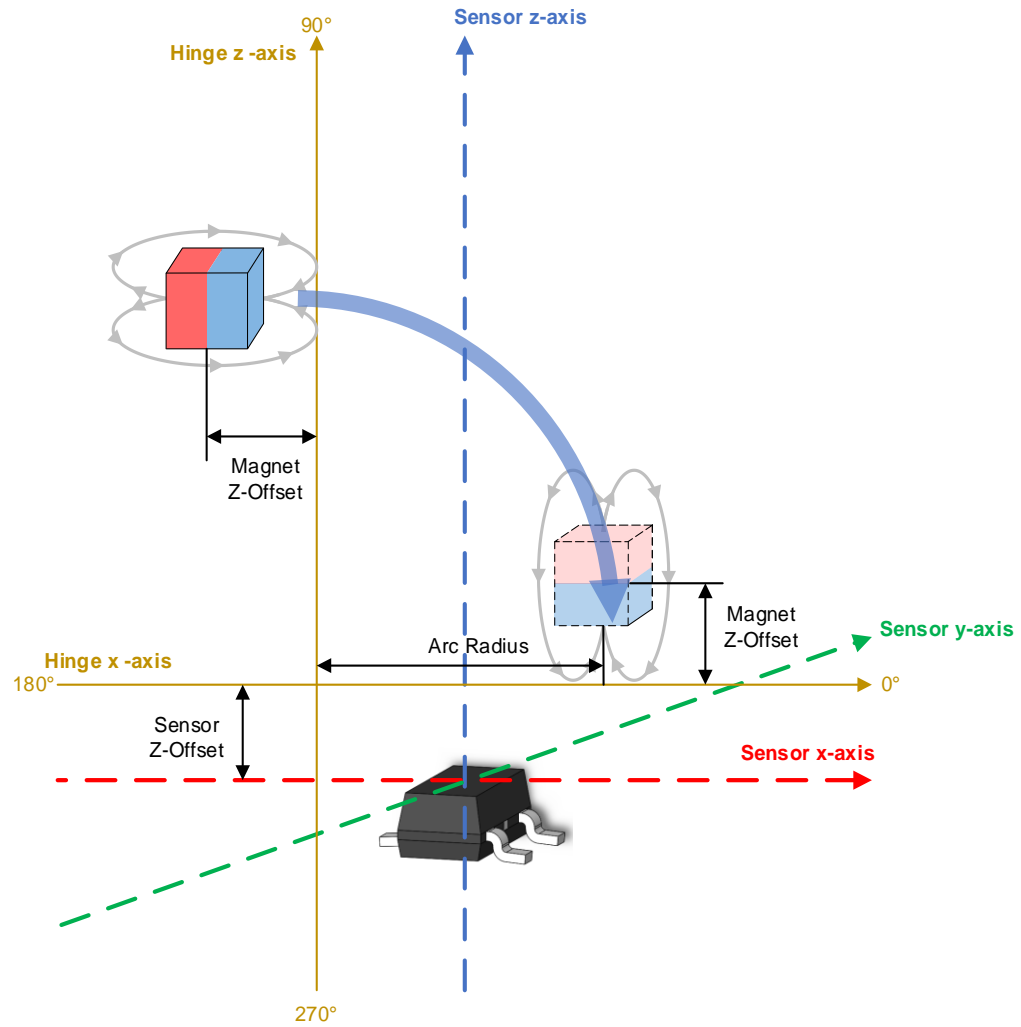
Selecting a magnet



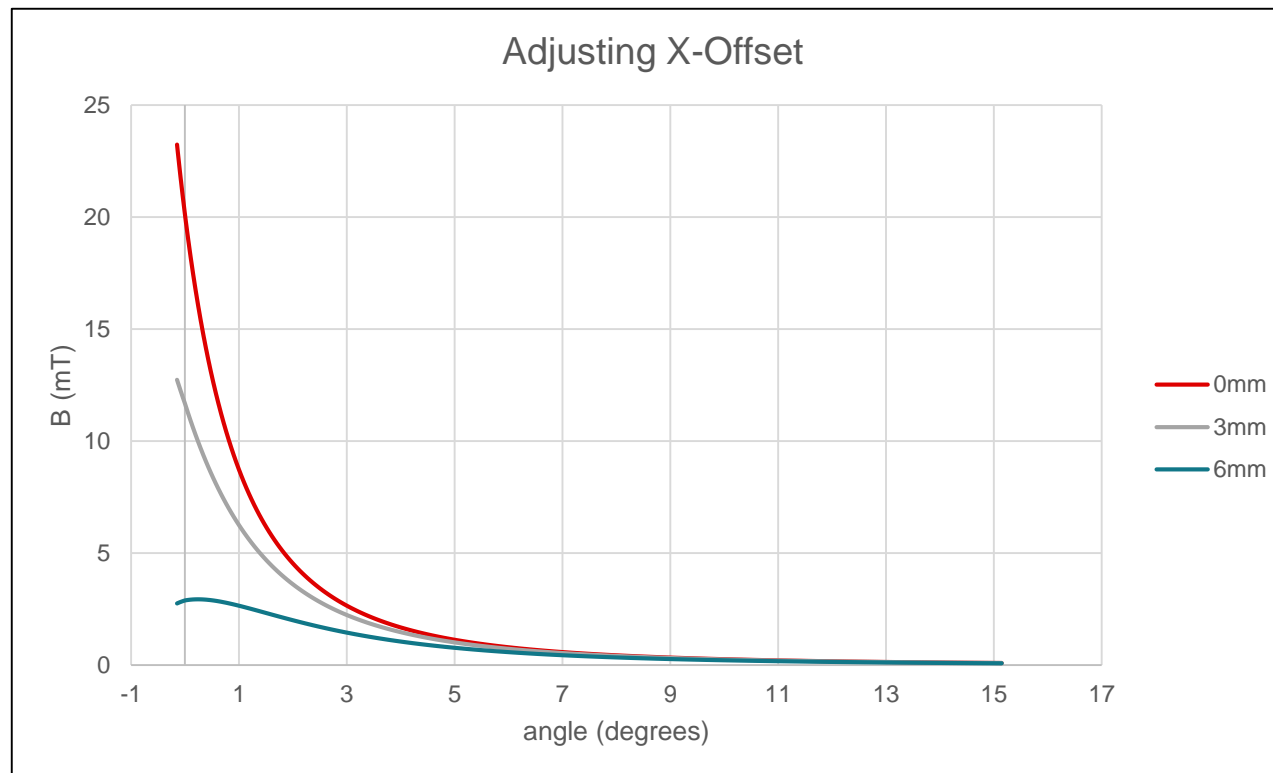
Magnet properties vs. measured field behavior



Magnet placement



Magnet placement vs. measured field behavior



Design process overview

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Selecting the right device

Recommended type of devices

- Omnipolar switch or unipolar switch

Key specifications

7.6 Magnetic Characteristics

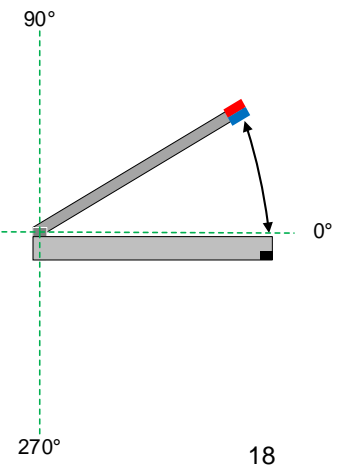
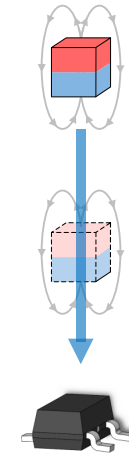
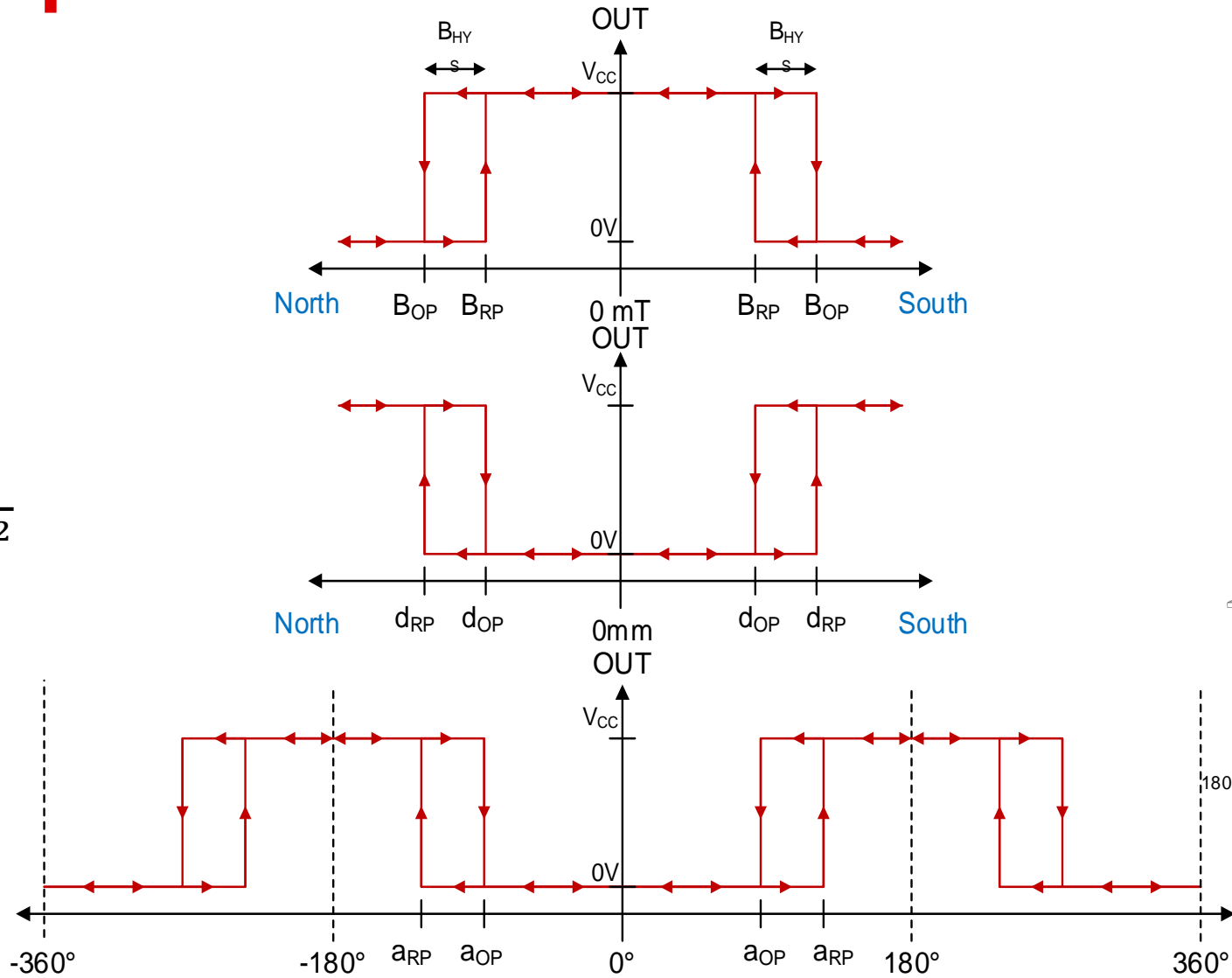
for $V_{CC} = 1.65V$ to $5.5V$, over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
DU VERSION						
B_{OP}	Magnetic threshold operate point	OUT1 pin (north)	-3.9	-2.5	-1.2	mT
		OUT2 pin (south)	1.2	2.5	3.9	
B_{RP}	Magnetic threshold release point	OUT1 pin (north)	-3.5	-1.8	-0.9	mT
		OUT2 pin (south)	0.9	1.8	3.5	
B_{HYS}	Magnetic hysteresis: $ B_{OP} - B_{RP} $	Each Output	0.1	0.7	1.9	mT

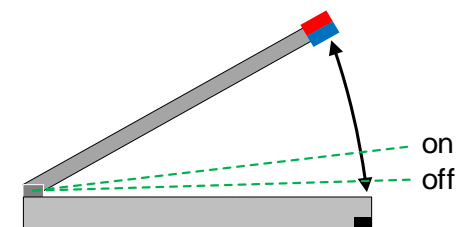
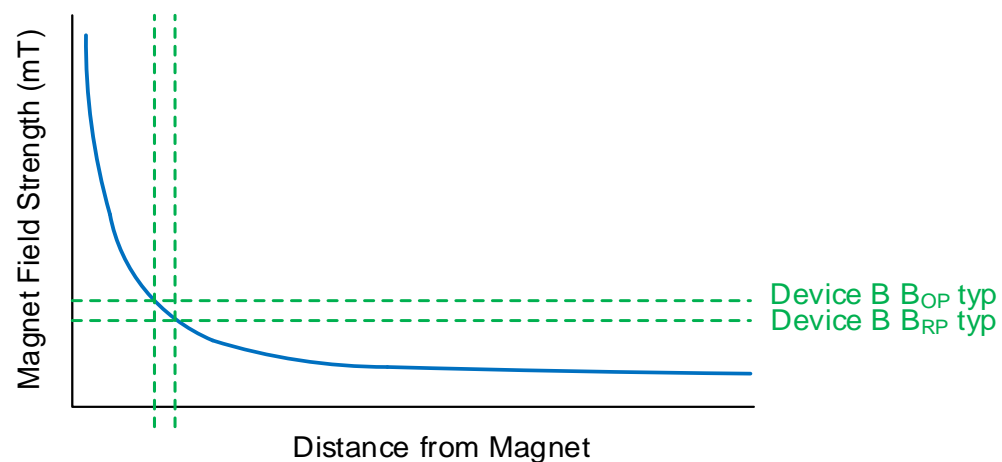
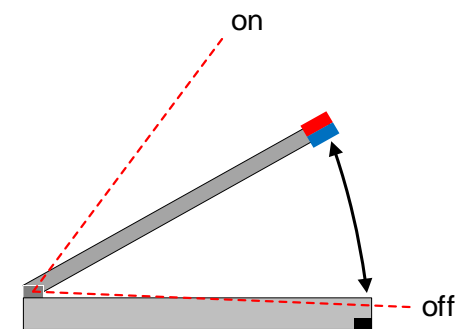
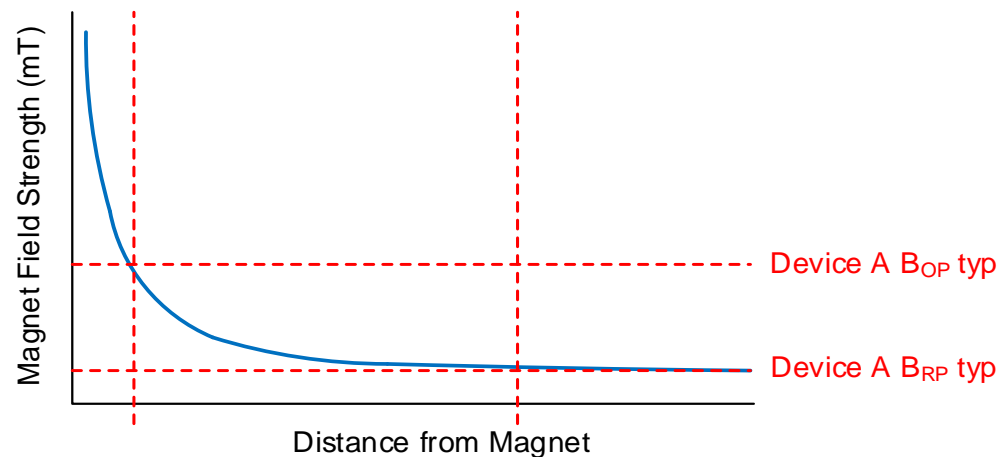
Sensor output

$$|B| \propto \frac{1}{\text{distance}^2}$$

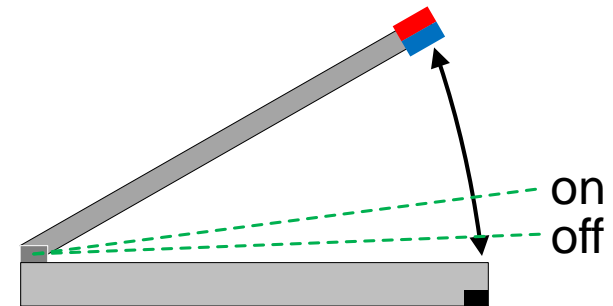
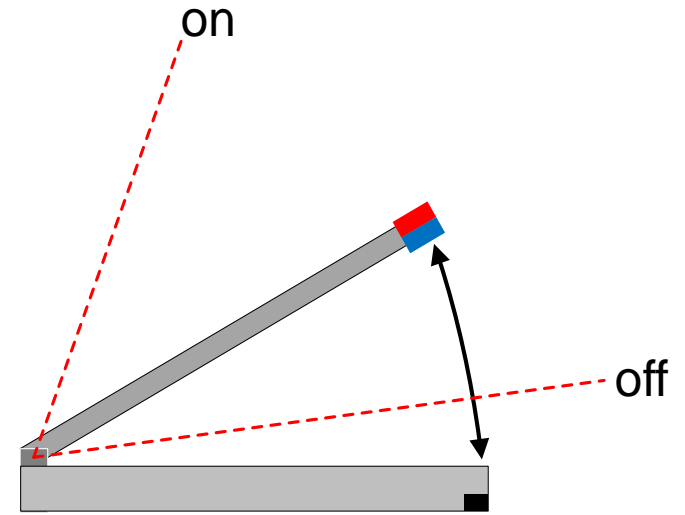
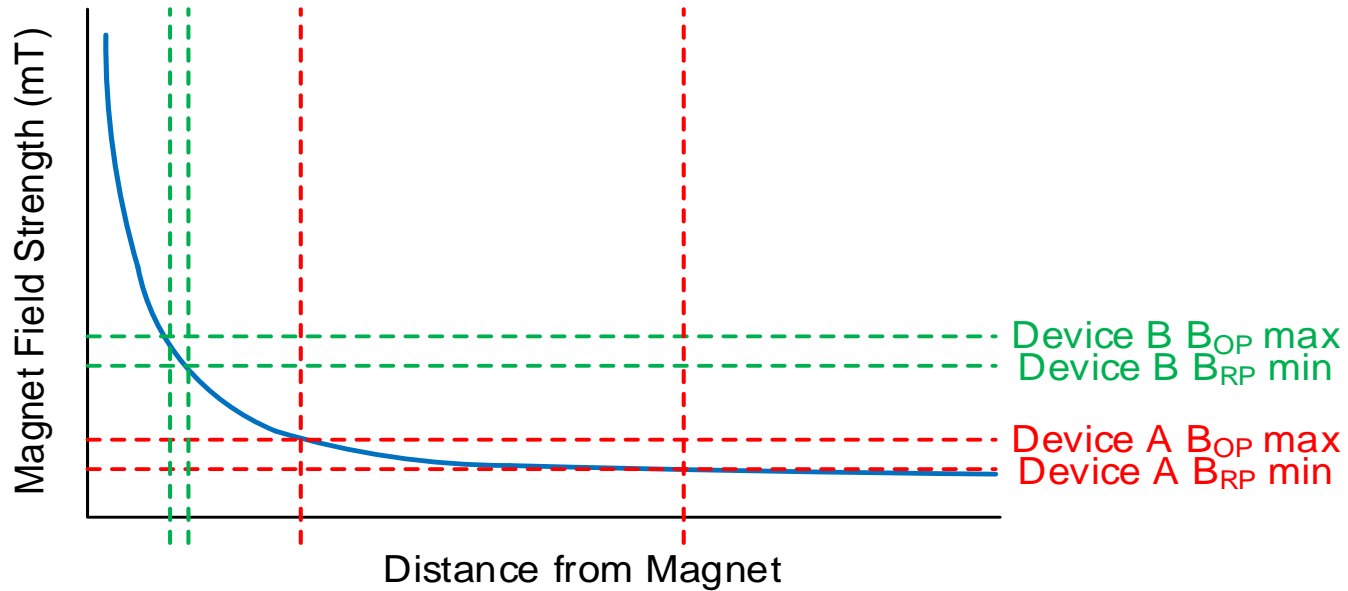
$$|B| \propto \frac{1}{\text{angle}}$$



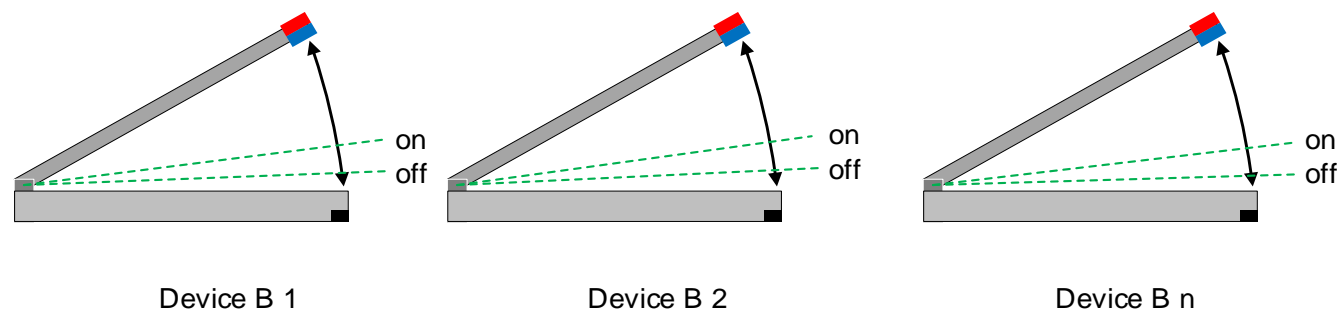
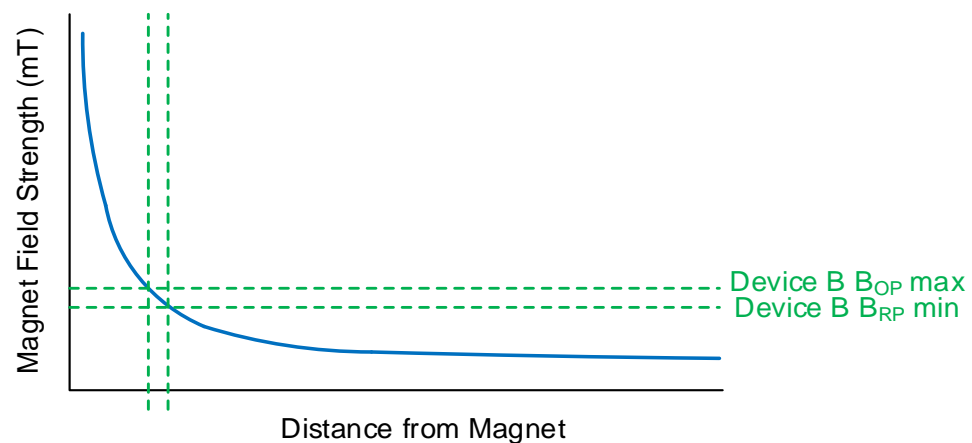
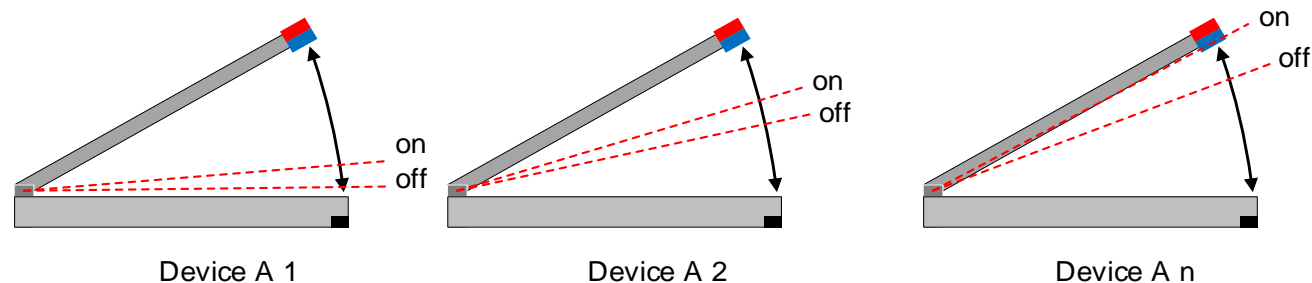
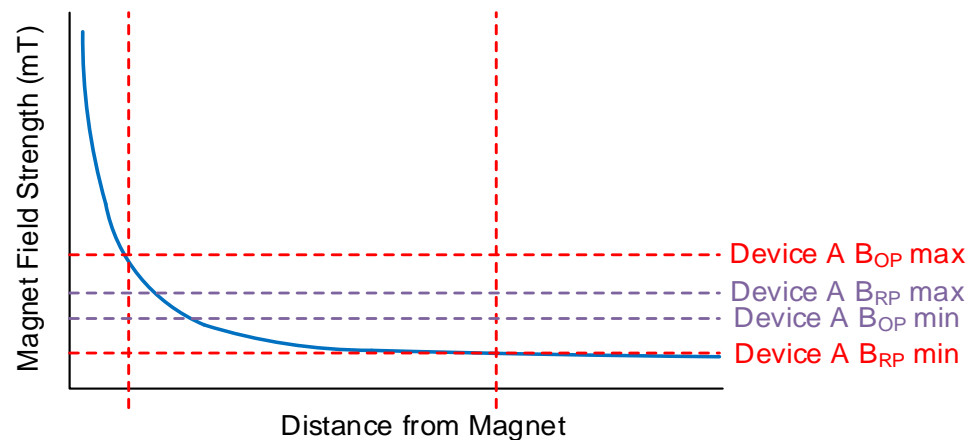
Design challenges – Hysteresis region size



Design challenges – Non-linear field strength



Design challenges – Transition region variation

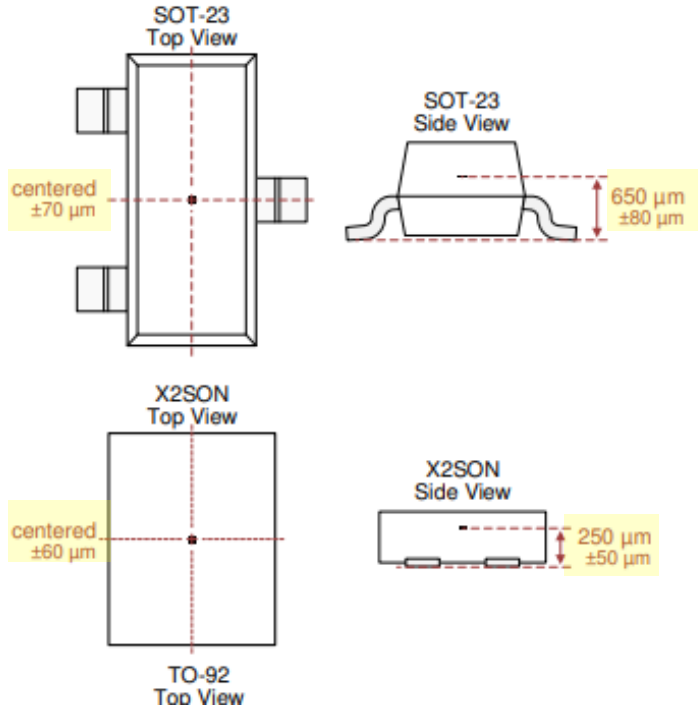
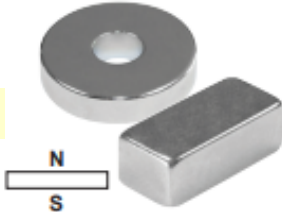


Design challenges - Mechanical variation

Features

- Operates best at temperatures below 180°F (82°C)
- Tolerance $\pm 0.005''$ on all dimensions

NOTE: Avoid grinding, as flash fires may occur from rare earth material dust particles. Crystalline structured material is easily chipped, cracked or broken.

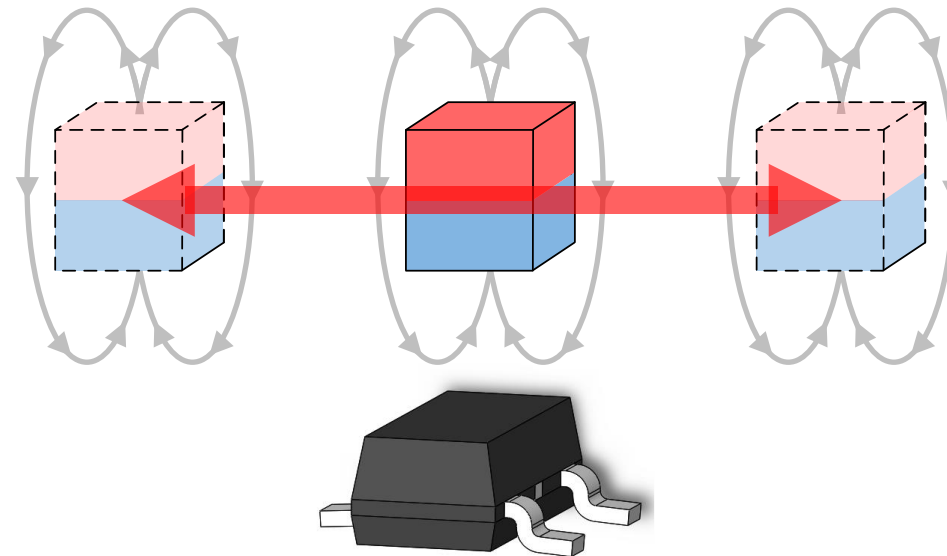


Printed Circuit Board Thickness:

Thickness tolerances may vary 10% (min. $\pm 0.005''$)

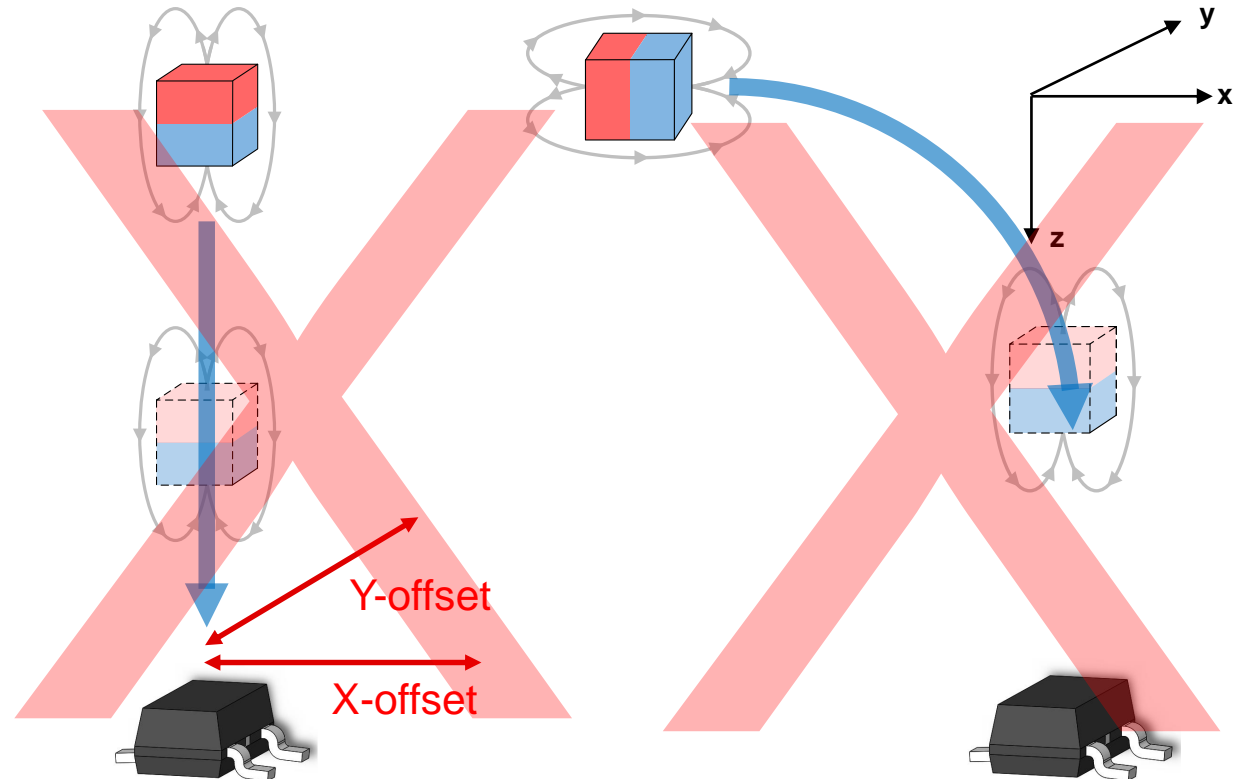
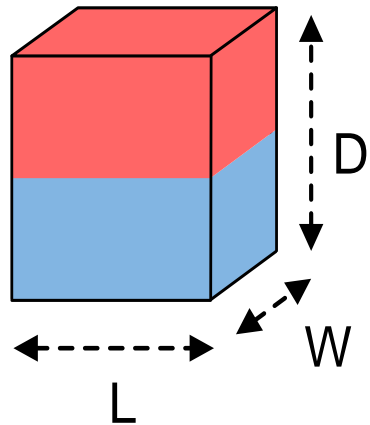
HIGH-PRECISION DRIVE AND LINEAR ENCODER TECHNOLOGY

A high-quality build and components ensure a level of repeatability and accuracy that other pick and place machines in the MC385V2V's price range can't match. High-precision, ball-screw drive, and linear encoders ensure placement accuracy of $30 \mu\text{m}$, 3 Sigma.



Calculation

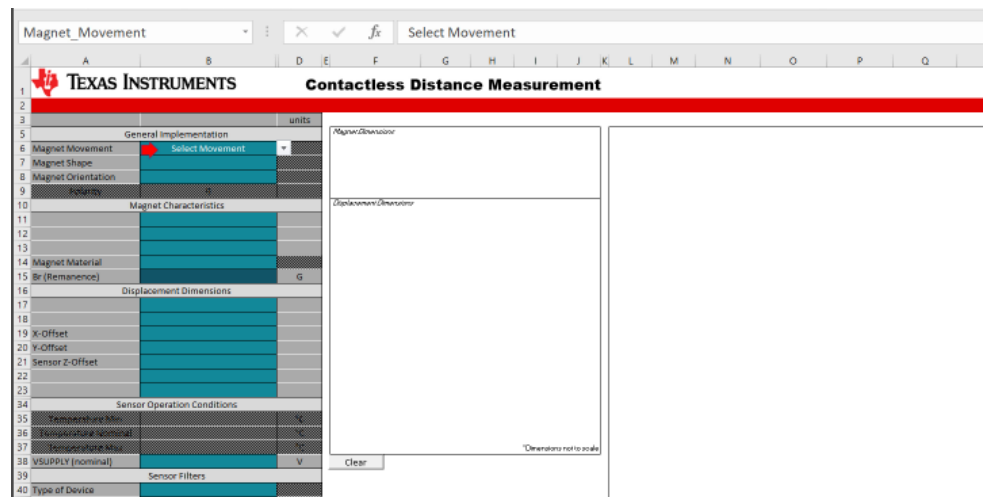
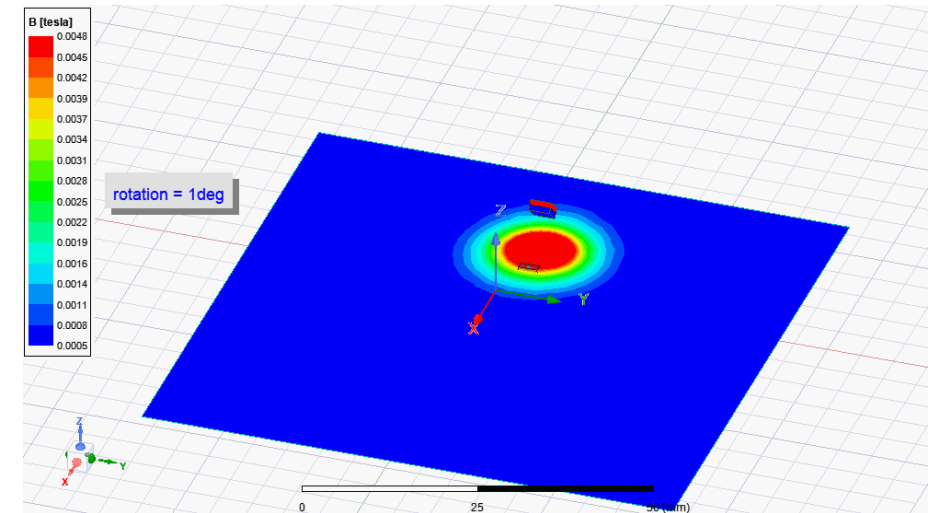
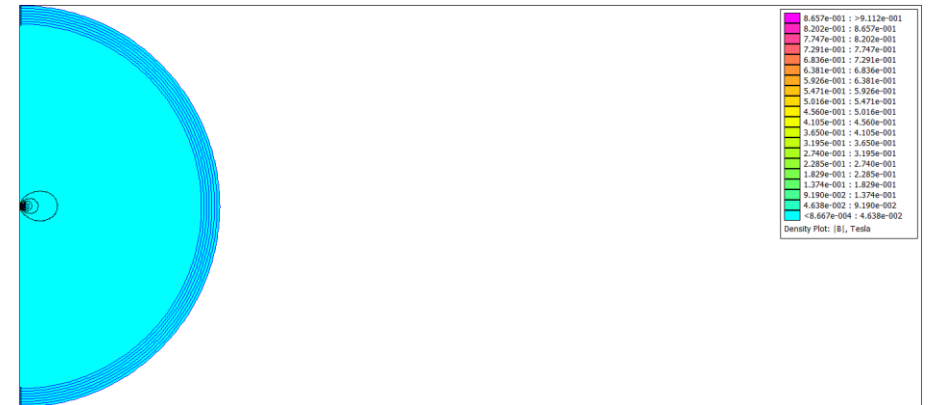
$$B = \frac{B_r}{\pi} \left[\arctan \left(\frac{LW}{2z\sqrt{4z^2 + L^2 + W^2}} \right) - \arctan \left(\frac{LW}{2(D+z)\sqrt{4(D+z)^2 + L^2 + W^2}} \right) \right]$$



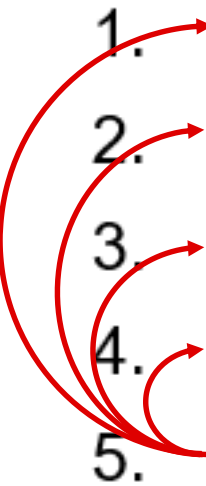
- Does not account for offsets
- Does not account for rotation

Tools

- Finite Element Method Magnetics (FEMM)
- ANSYS
- TI proximity tool



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**To learn more about Magnetic
Position Sensing, visit
ti.com/halleffect.**