Mastering Magnetic Sensing:
Reducing Environmental Errors through Differential Techniques

November 2024

Session 1 will Begin at 8 AM PST | 11 AM EST | 5 PM CET

Agenda

- Magnetic Sensing Basics
- Accuracy in Magnetic Sensing
- Sources of Interference
- Differential Sensing
- Case Studies / Examples
- Q&A

Accuracy in Magnetic Sensing

Systematic

- Can be Calibrated

Random

- Can be Filtered

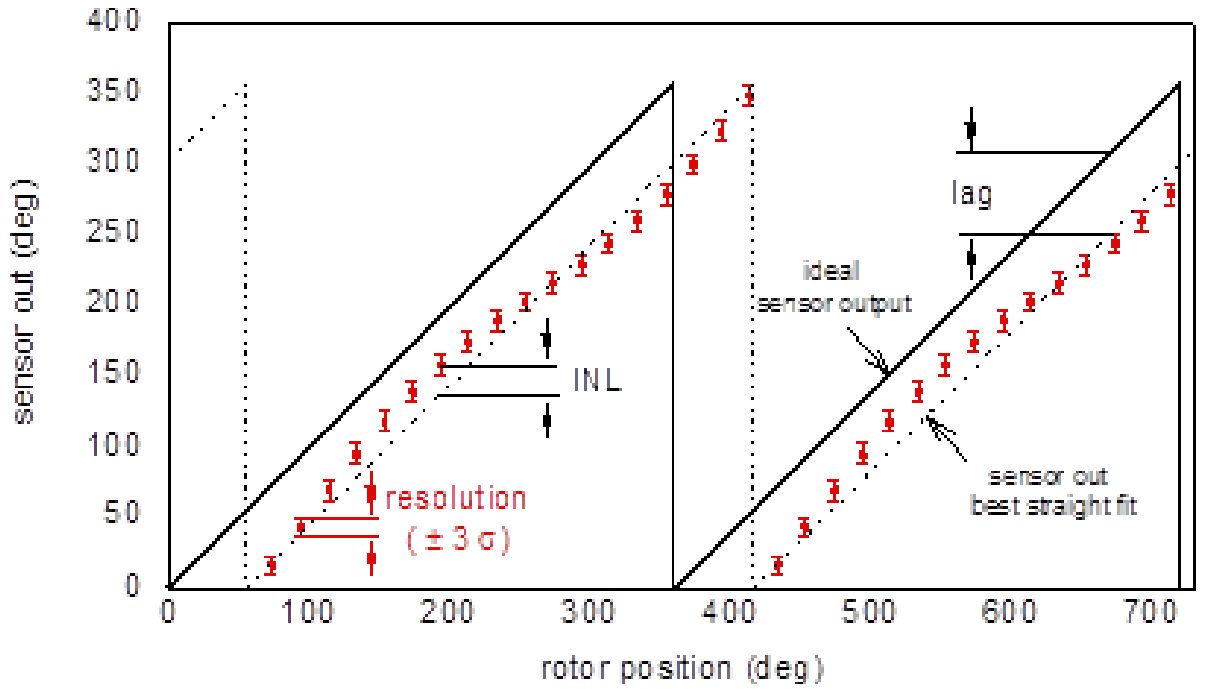
External Influence

- Shield / Shunt / Use Differential Technique

Systematic Error Sources

1. Integral Non-Linearity (INL)
2. Magnetic Misalignment with Sensor (Position Sensing)
3. Latency

Latency Error	Comp A	MA600
Latency	10µs	0µs
At 30k RPM	**1.8°**	**0°**



Random Error Sources

Noise:

- Resolution captures impact from noise.
- Noise can be reduced by filtering, but this reduces sensor bandwidth.

Challenges:

- Determining of the sensor's real resolution.
- Understanding the relationship between resolution and BW.

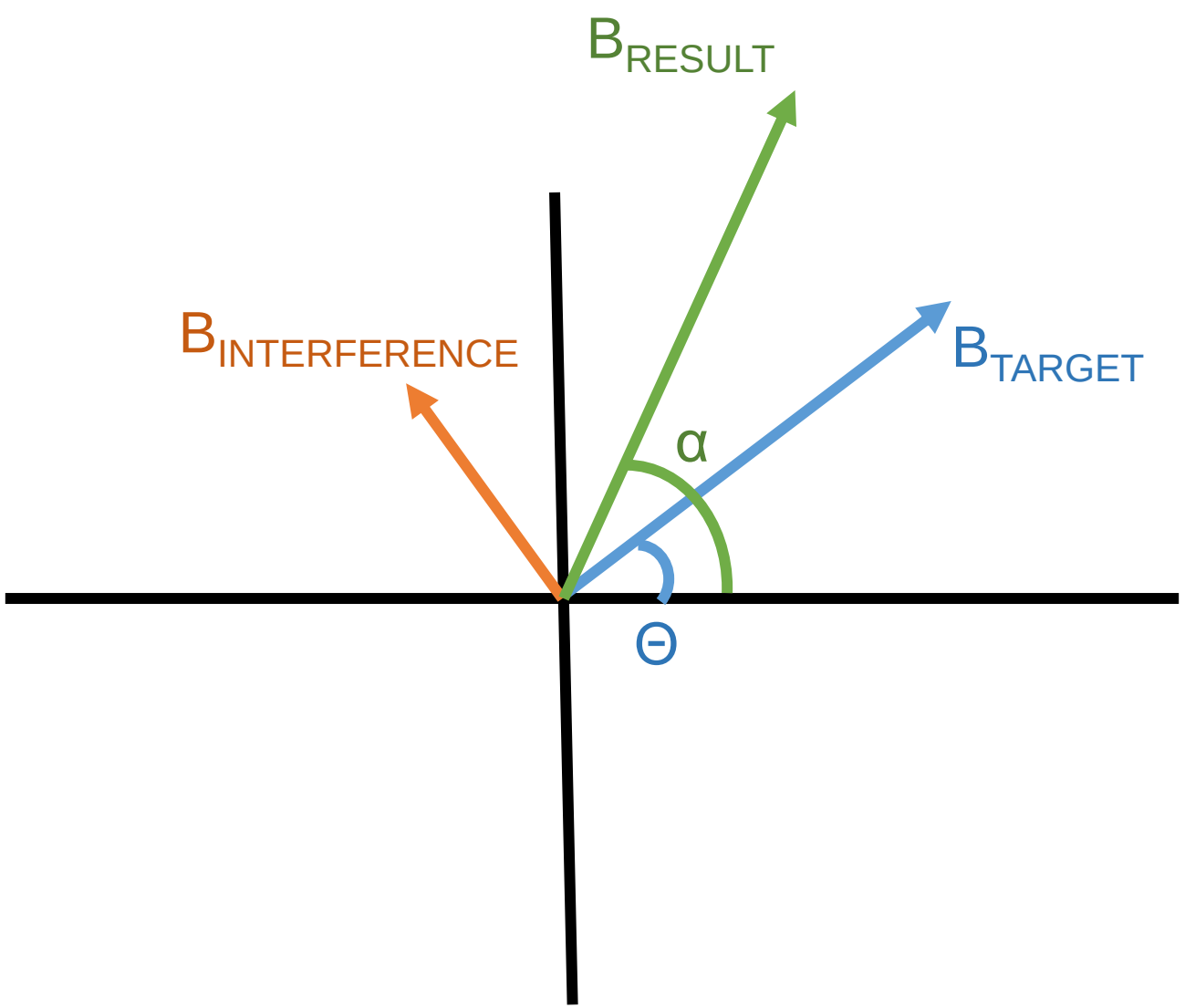
MagAlpha MA702

Effective resolution		3σ deviation of the noise distribution	11.0	11.8	12.8	bits
Noise RMS			0.01	0.02	0.03	deg

MCS1806

Noise density	I_{ND}	Input referred noise density		200		$\mu A_{(RMS)}/\sqrt{Hz}$
Noise	I_N	Input referred, 1nF on FILT (60kHz bandwidth)		50		$mA_{(RMS)}$

External Magnetic Field Effect



The target field points to a direction indicating the angle (Θ).

The interference field is introduced, and the worst-case scenario is when $B_{INTERFERENCE}$ is orthogonal to B_{TARGET}.

The result is a vector addition of $B_{INTERFERENCE}$ with B_{TARGET}, and the angular deflection is calculated as $\arctan(B_{INTERFERENCE} / B_{TARGET})$

Field Strength Examples

The amplitude of the interfering field depends on a few different factors:

- Permanent magnet size, material, and shape
- Current density in a nearby conductor
- Distance from the interference source to the sensor element

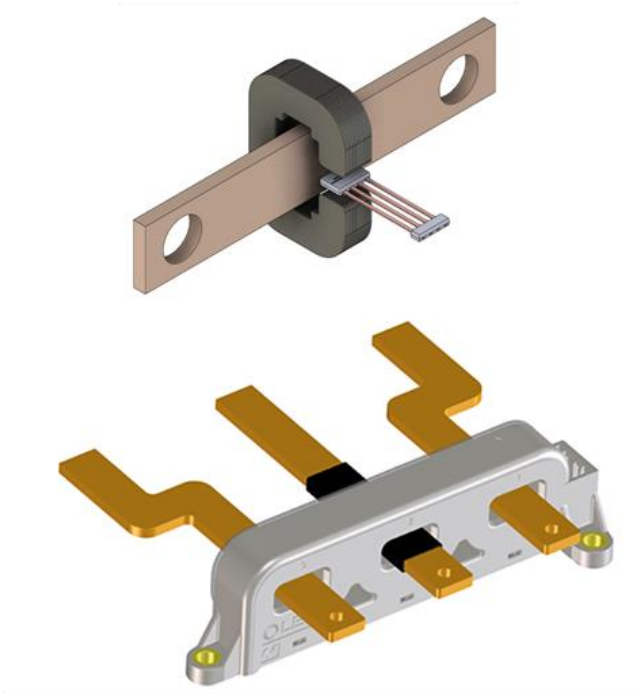
	Neodymium			Ferrite			Current-Carrying Conductor		
Distance (mm)	**d = 5mm**	**d = 10mm**	**d = 20mm**	**d = 5mm**	**d = 10mm**	**d = 20mm**	**I = 30A**	**I = 50A**	**I = 100A**
1	100	152	182	32.1	48.8	58.4	6	10	20
10	2.8	14.7	52.4	0.9	4.7	16.8	0.6	1	2
20	0.5	2.9	15.4	0.2	0.9	4.9	0.3	0.5	1
50	0	0.2	1.7	0.0	0.1	0.5	0.12	0.2	0.4

Deflection in Degrees

	Neodymium			Ferrite			Current-Carrying Conductor		
Distance (mm)	**d = 5**	**d = 10mm**	**d = 20mm**	**d = 5mm**	**d = 10mm**	**d = 20mm**	**I = 30A**	**I = 50A**	**I = 100A**
1	73	79	81	47	58	63	11	18	34
10	5	26	60	2	9	29	1	2	4
20	1	6	27	0	2	9	1	1	2
50	0	0	3	0	0	1	0	0	1

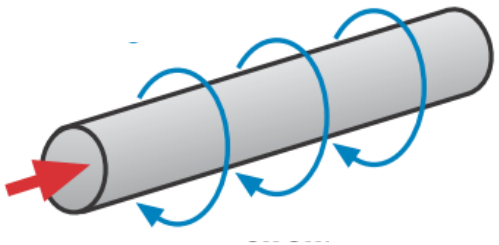
Methods of Shunting External Fields

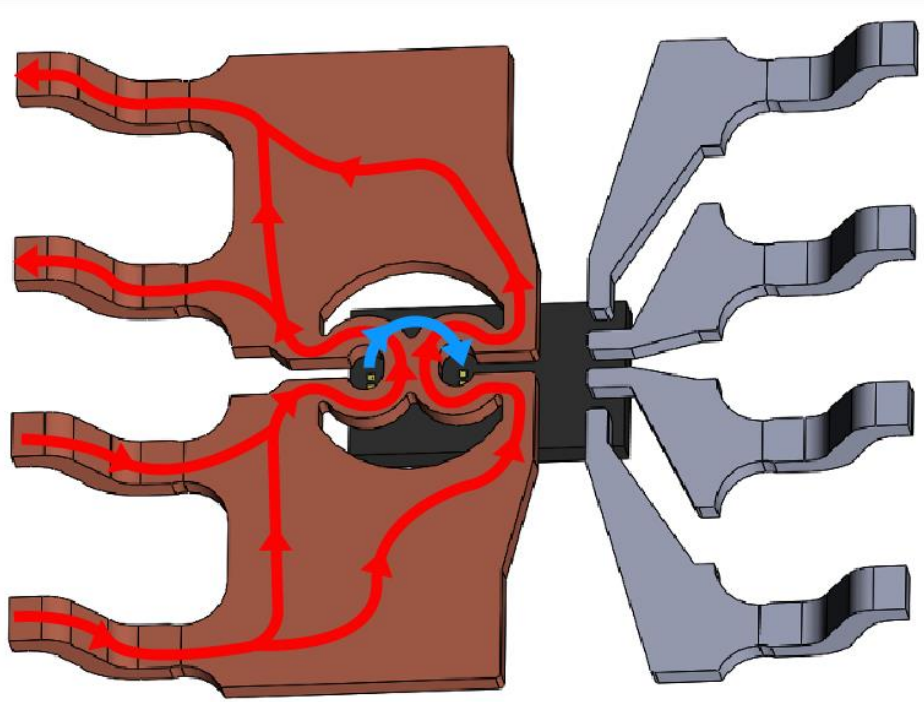
Conventional Core



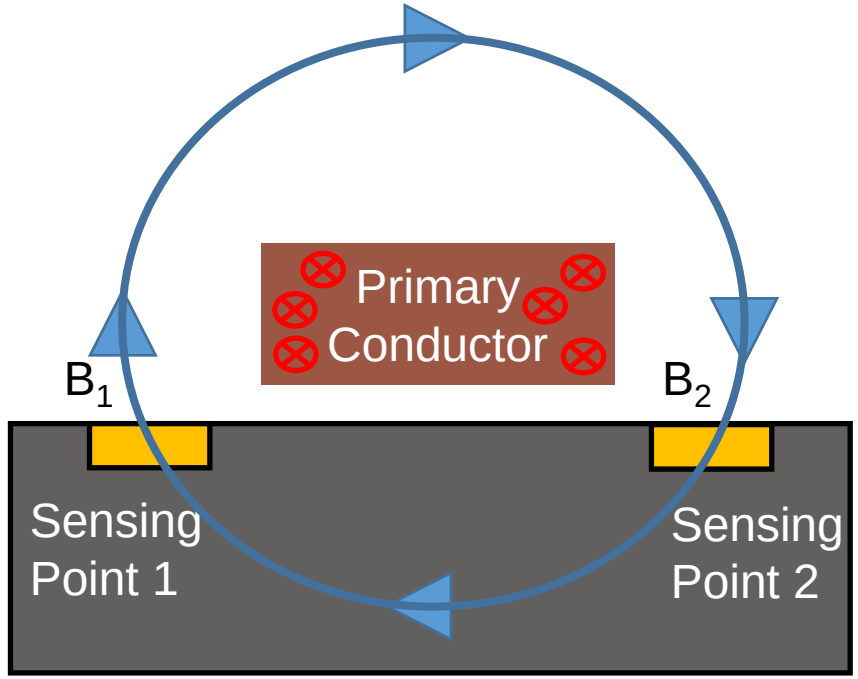
Large Air Gap Core (“Shield”)

MPS's Differential Hall-Based Sensing



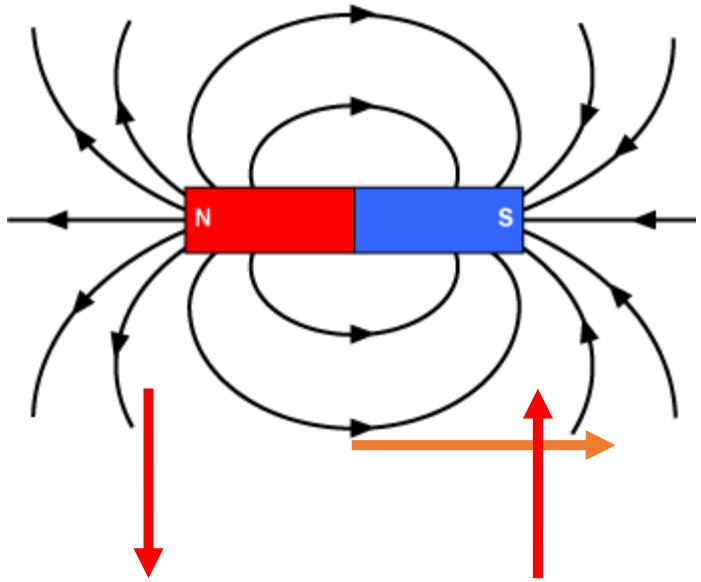


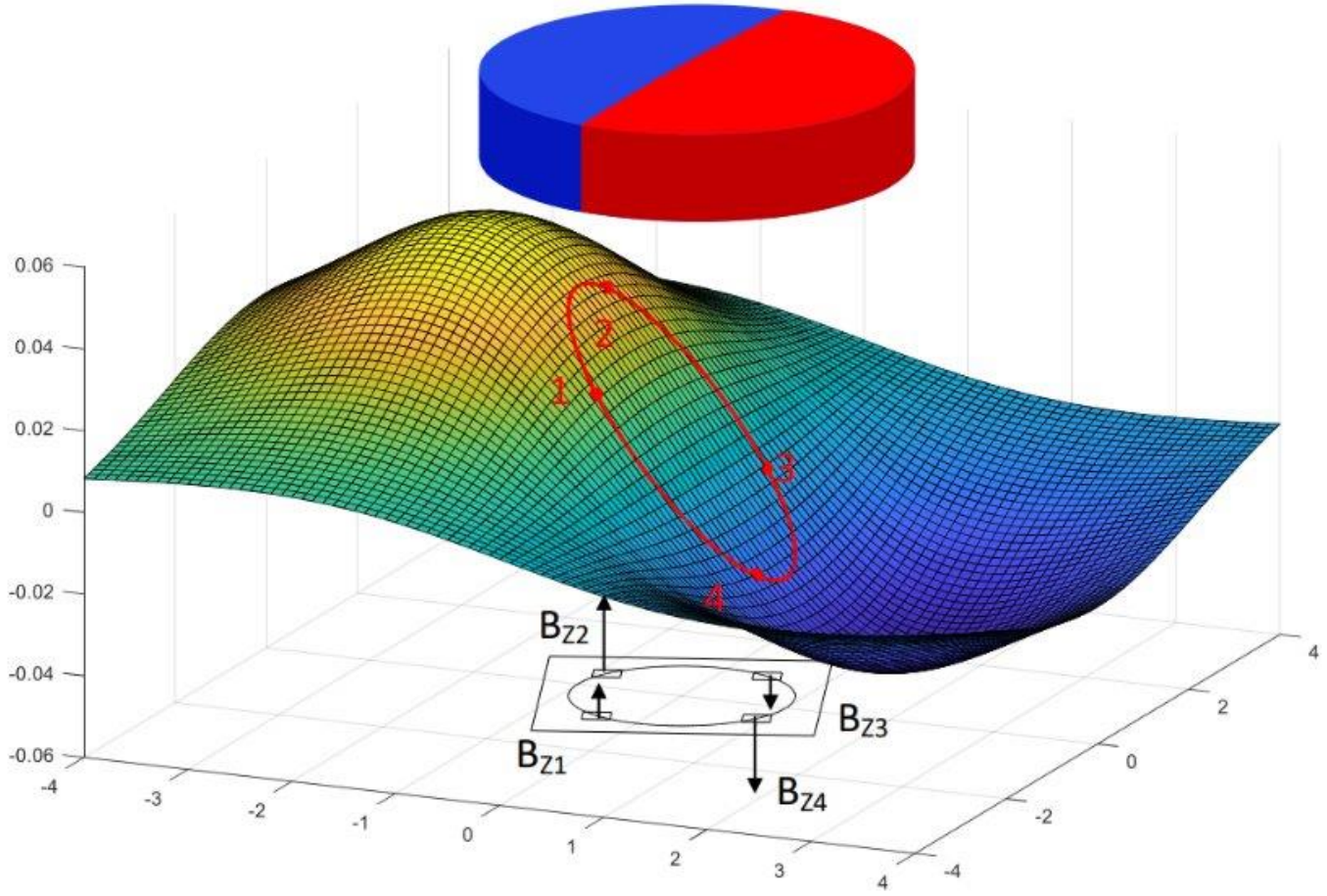
Ampere's Law: B ∝ I



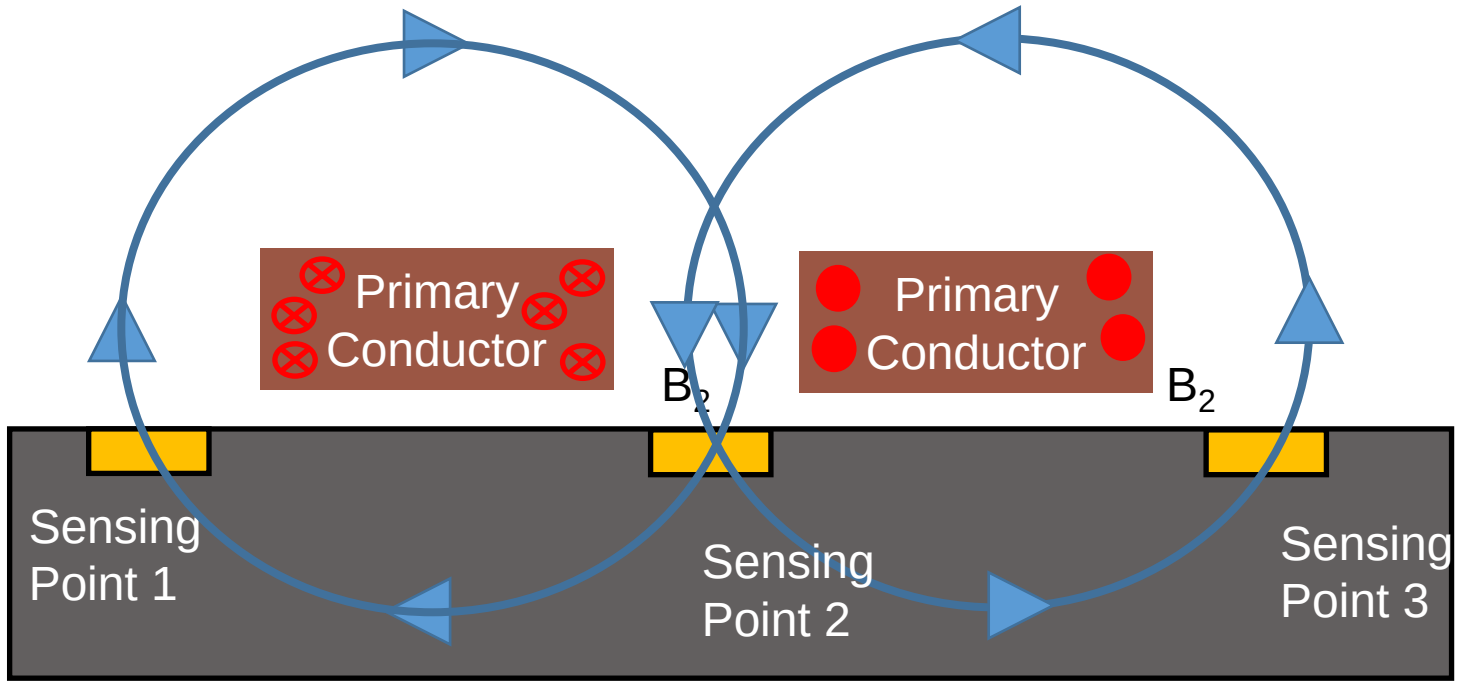
$$B_{measure} = B_1 - B_2$$

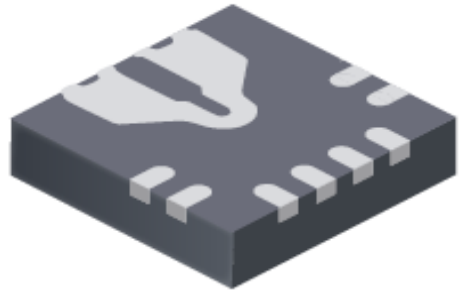
Differential Position Sensing





Gradient Immunity



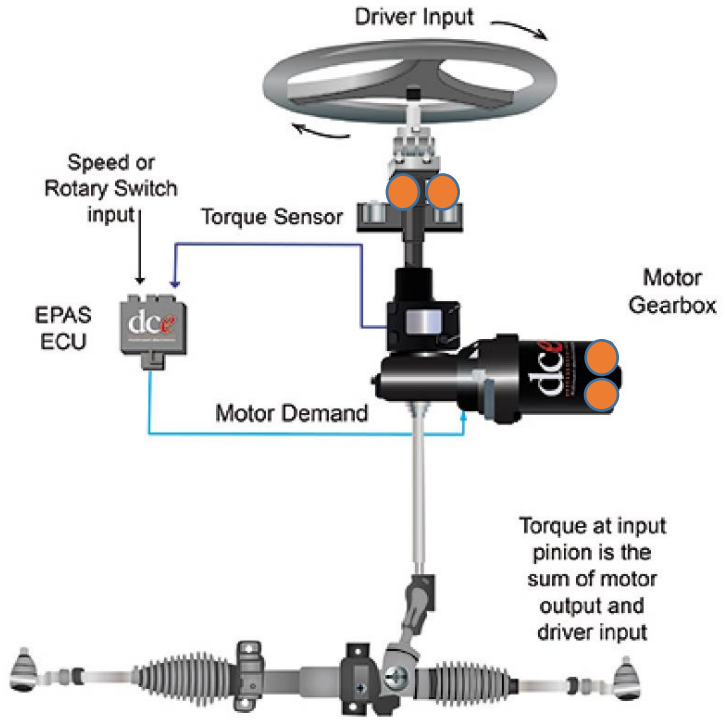


$$B_{measure} = 2B_2 - B_1 - B_3$$

Automotive: ASIL-D Electronic Power Steering (EPS)

Motion Control and Position Sensing

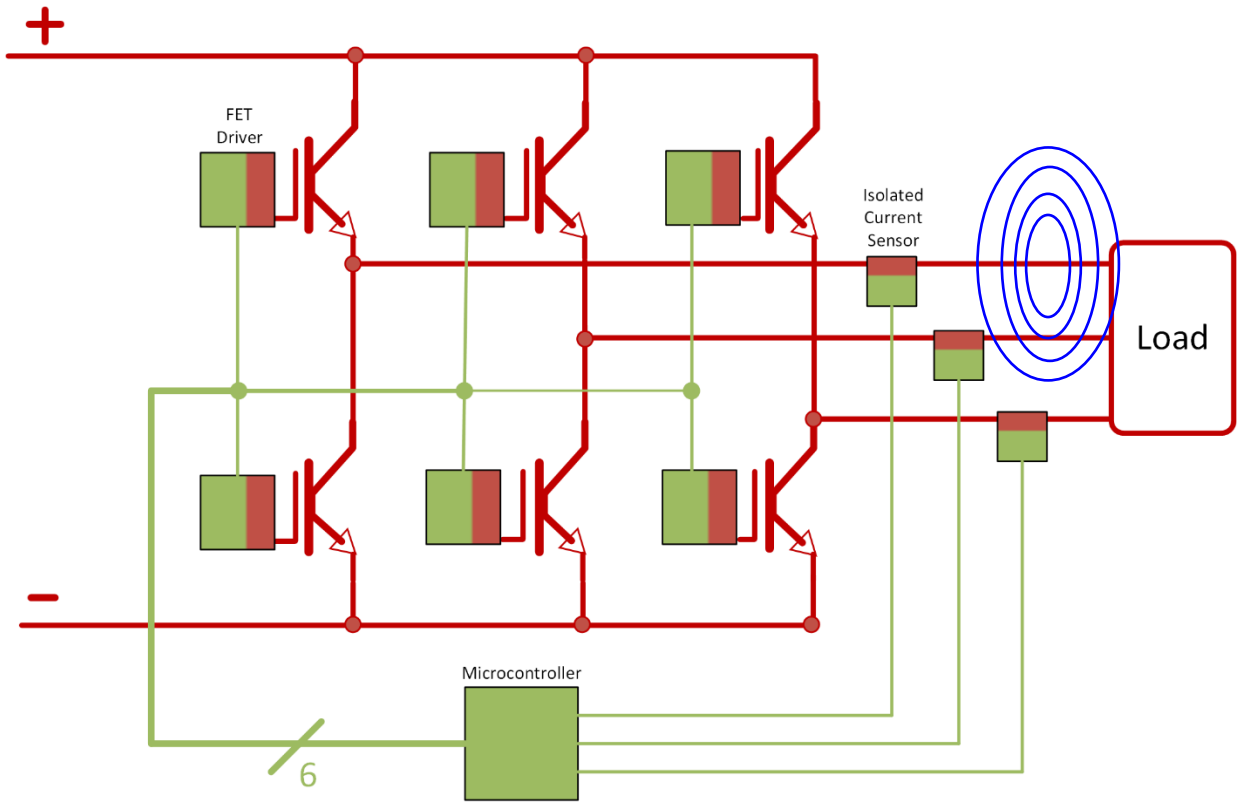
- Application: Electronic Power Steering (EPS)
- Features/Benefits:
  - Wide Operating Temp Range: -40°C to +150°C
  - Available in AEC-Q100 Grade 0/1
  - ASIL-D Solution:
    - MAQ79010FS

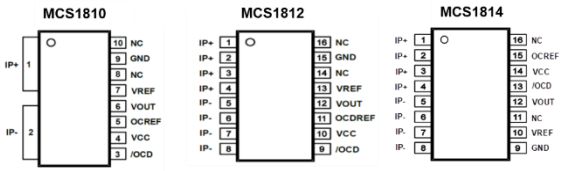


Recommended Products

MAQ79010FS	12-Bit Automotive Differential Angle Sensor with SPI Output. Includes Magnetic Field Diagnostics

Example Application – 3 Phase Current Sensing





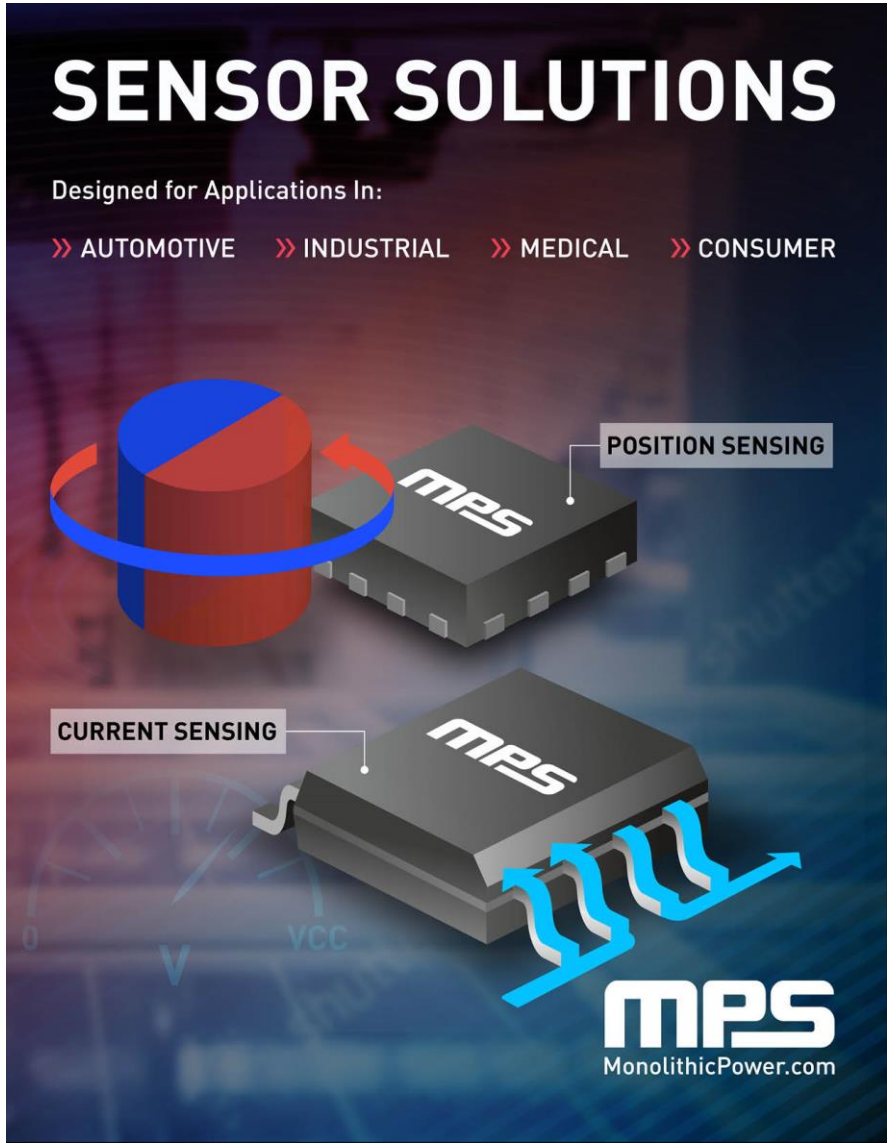
Industrial Inverter

- Application: Motor Drive, UPS, Energy Generation
- Requirements:
  - Wide Operating Temp Range: -40°C to +125°C
  - Isolation from Bus Voltage
  - High Accuracy

MCS(Q)1810/12

- Up to ±100ARMS
- Configurable OCD (1µs Response Time)
- Zero-Current Reference Output VREF
- ±1.5% Total Error
- AEC-Q100 (MCQ181x)

Thank You



For more information, contact:
sensors@monolithicpower.com

Check out our Sensor Solutions brochure at **MonolithicPower.com**

Thank You

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