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How Magnetic Encoders Pave the Way for Migration from Standalone Modular Encoders to Integrated Designs

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Orlando

Stronger.

Outline

- Timken introduction
- Overview of optical and magnetic modular encoders
- How an optical encoder works
- How a magnetic encoder works
- Features that make integration beneficial
  - Big tolerances (gap and radial)
  - Harsh environments (debris/oils, high temps)
  - Very small
  - Programmable
- Programmable magnetic features
- Harsh-environment integrated applications
- Specific application in detail

The Timken Company Overview

- Industrial components manufacturer serving diversified markets, including:
  - Aerospace
  - Mining
  - Energy/wind
  - Rail
  - Construction
  - Truck
  - Automotive
  - Distribution

- Established in 1899
- Headquartered in Canton, Ohio
- Global footprint with operations in 30 countries

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16+ Years in the Sensor Business

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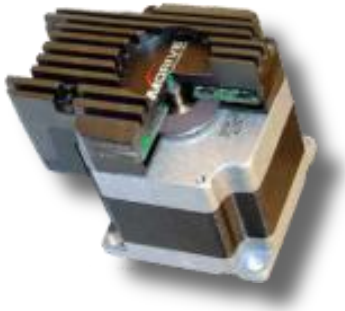
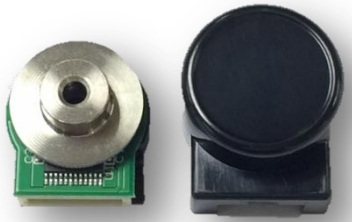
Supplier of high-performance integrated Hall encoder products serving industrial, off-highway and critical vehicle systems





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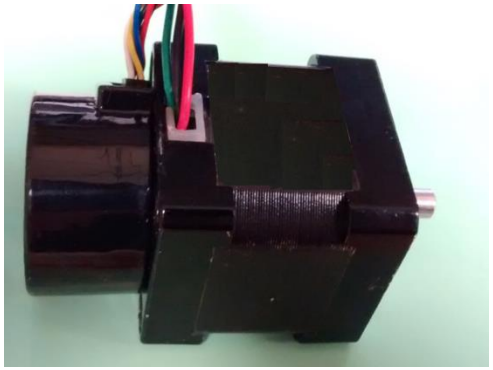
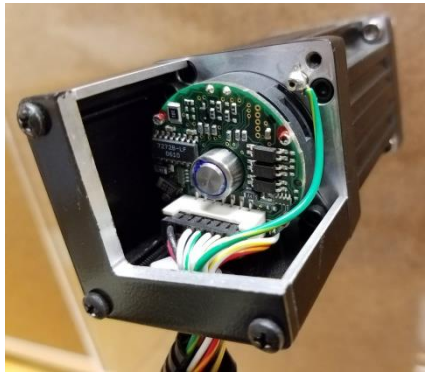
Modular Encoders

- Bolted on (not integrated)
- Selection of options in the encoder allows for easy customization
- Helpful if there are many configurations or low to medium volumes
- Not cost-effective for higher volumes





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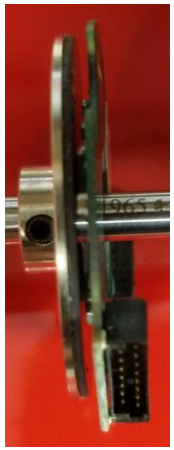
Evolution from Optical to Magnetic



Clean environment	Harsh environment
Small gap; tight tolerances	Forgiving on tolerances
Big — two-sided (LED/disk/sensor)	Thin — one-sided (chip/magnet)
Delicate disk	Robust magnet on steel

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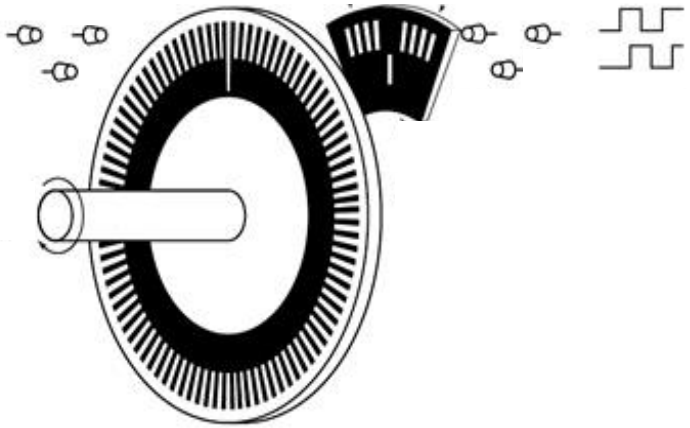
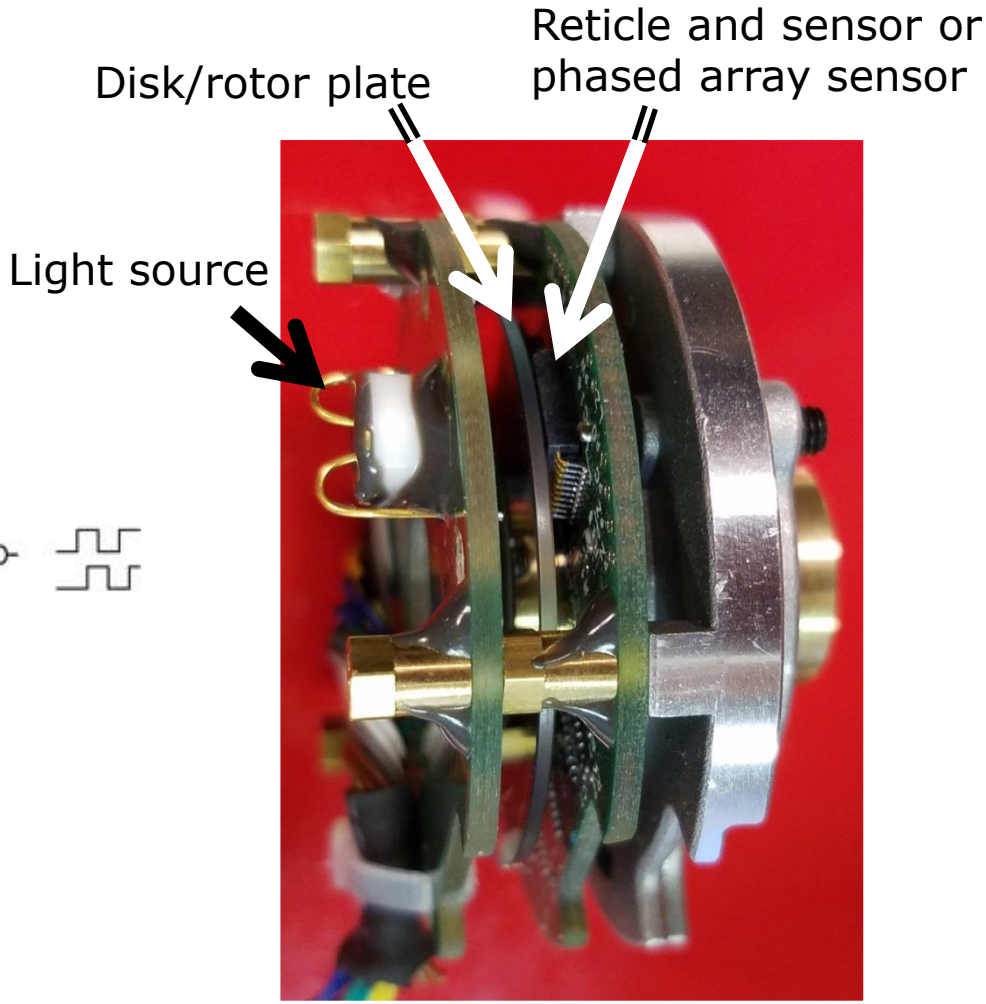
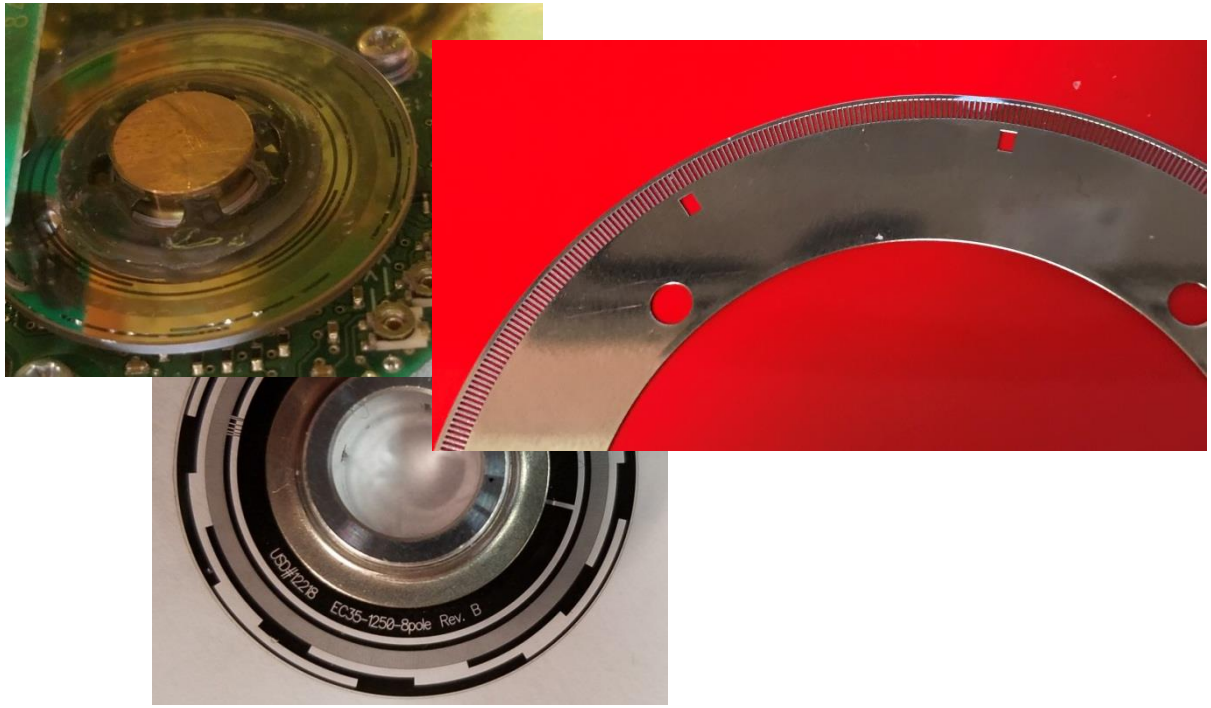
Optical Encoder Workings





Optical Disks

- Photo etched
- Stainless, mylar or glass
- Very small slots subject to contamination/condensation



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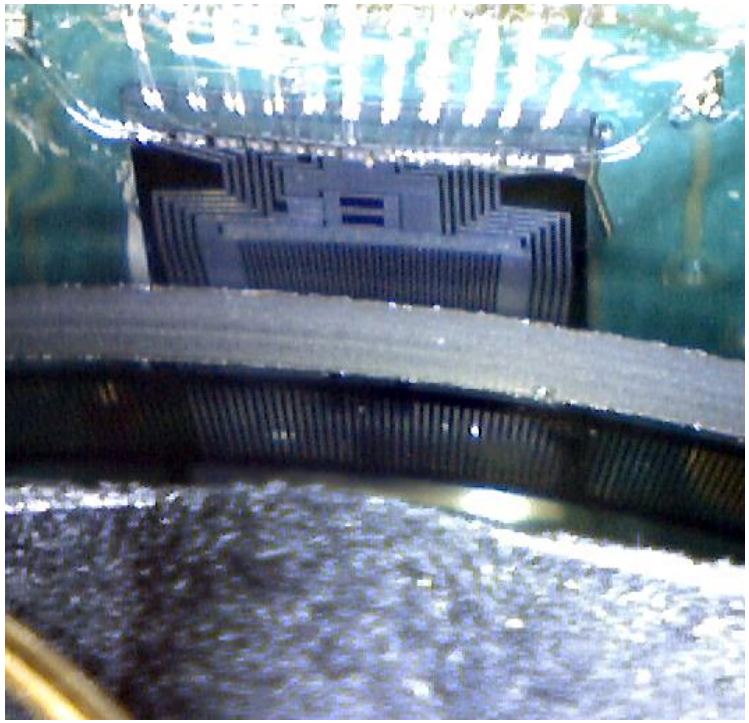
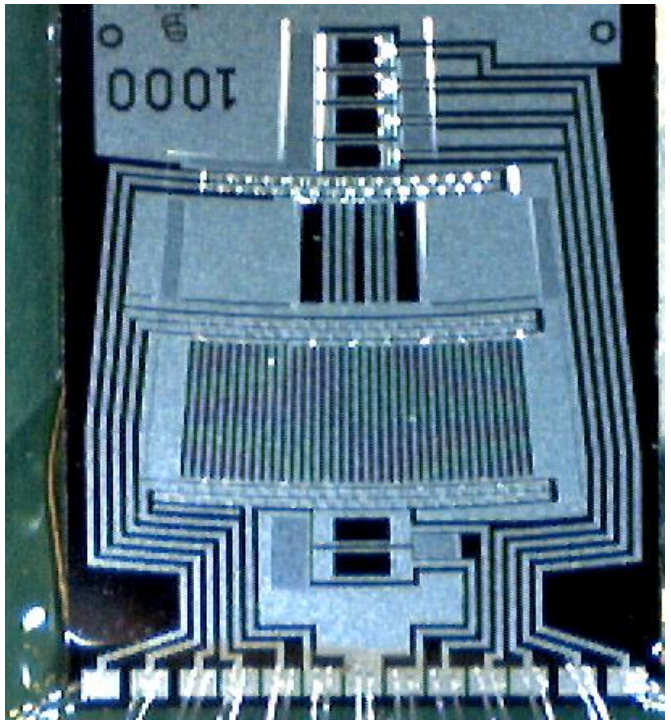
Built-In Reticle/Phased Array

- Top metal layer on the IC/sensor
- Has to match the line width of the disk
- Very costly and time-consuming to change





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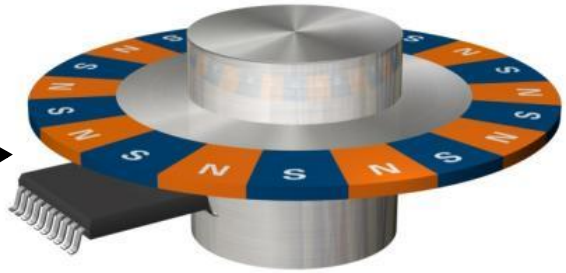
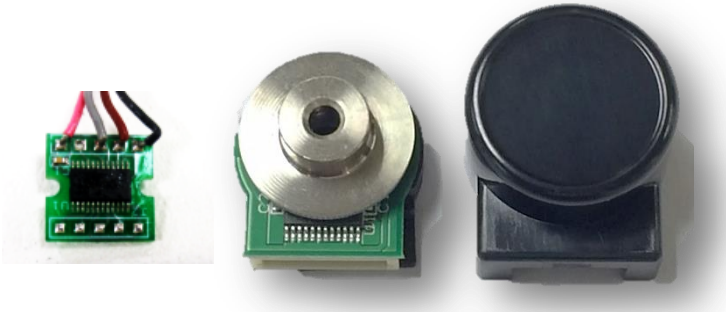
Magnetic Encoders

- Single chip Hall effect or magneto resistor application-specific integrated circuit (ASIC) with on-chip signal processing
- On-axis designs use a single pole pair magnet on the end of the shaft (AMS and Avago)
- Off-axis designs use a ring magnet with 16 to 64 pole pairs plus an optional 1 to 12 pole pair commutation track (Timken)





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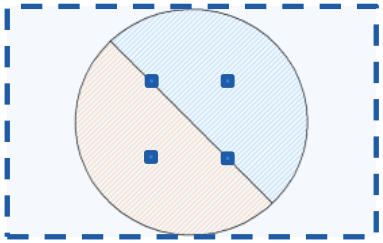
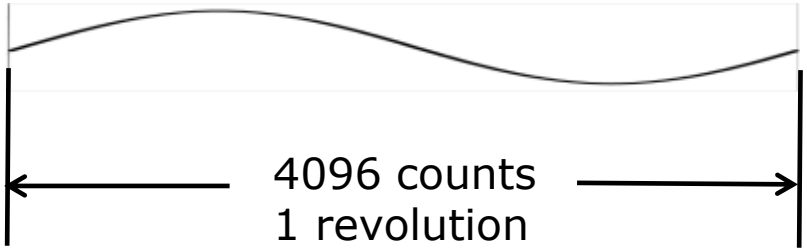
Theory of Operation for Magnetic Encoders

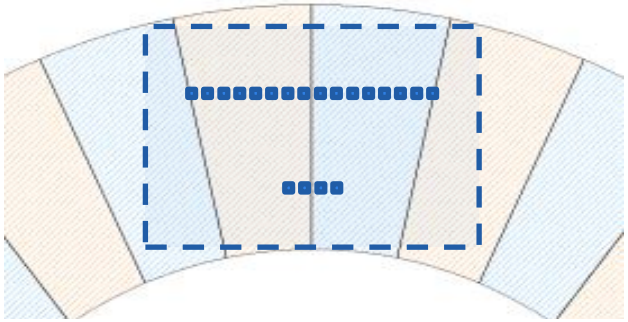
On-axis
1 pole pair

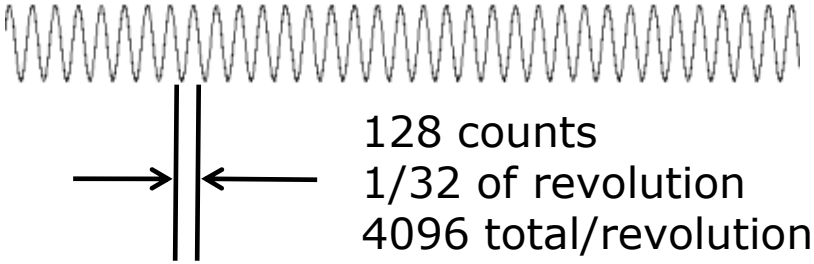




Deep interpolator required to get
full resolution from 1 revolution

Off-axis
32 pole pairs





Shallow interpolator used to get
1/32 of the resolution from 1 pole pair

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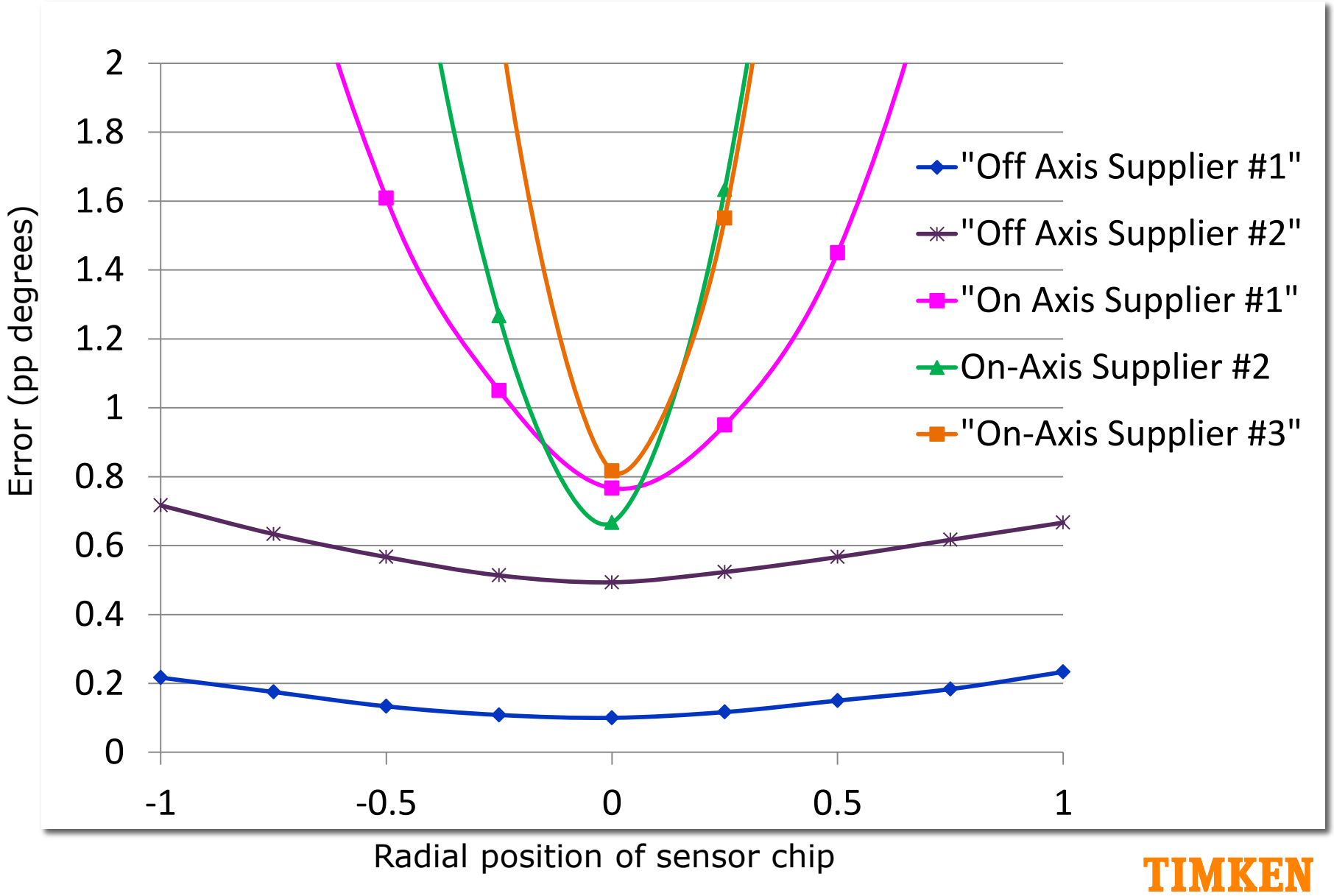
Accuracy vs. Radial Position at 1mm Gap



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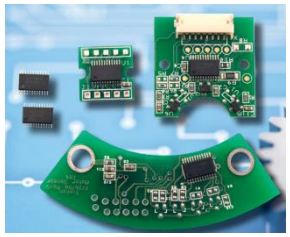
Magnetic Sensors — Overview



Features make integration simple, fast and cost-effective:

- Larger air gap — less precision required in manufacturing
- Wide radial tolerances (off-axis) — less precision required in manufacturing
- Harsh environment — doesn't need extra protection from debris, oil, condensation, etc.
- Small size — sensor reads from one side, easily packages into tight/small areas and can fit in only 3.5mm (0.138) axial length of space
- Handles higher temperatures (to at least 125°C)
- Many programmable features

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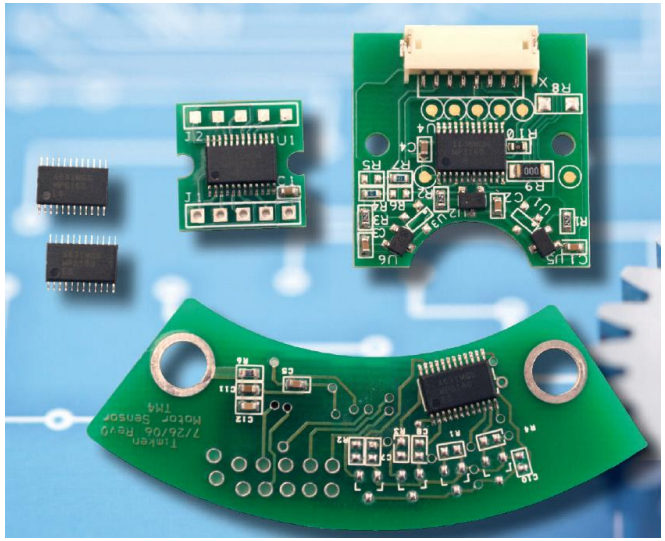
Magnetic Sensors — Programmable Features



- Multiplier for different resolutions
- Pole spacing/resolution works with a number of magnetic target disks
- Index — on/off and pulse width
- Line driver or open collector outputs
- Enable analog sin/cos outputs
- Commutation and index locations (on-axis)

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Evolution from External to Integrated

Large	Small
Expensive	Economical
Long installation time	Fast installation

Integrated Magnetic Encoder Production Applications

Number of years in production in parentheses

- Automotive steering systems (10+)
- E-bicycles (6+)
- Mining trucks (6+)
- Tractors (5+)
- Farm equipment (4+)
- Medical equipment (6+)
- Servo motors (6+)
- Off-road transmissions (9+)
- Stepper motors (6+)

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Example of Integration into a Motor

- Schneider M-Drive motors
- Same axial length of motor before and after integration
- Sensor chip uses existing PCB
- Different resolutions available from the same chip

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Conclusion

- Magnetic encoders make integration more simple, cost-effective and advantageous:
  - Big tolerances (gap and radial)
  - Withstand harsh conditions (debris/oils, high temps)
  - Very small
  - Programmable (multiplier, pole spacing, index)
- Integrated applications are proven in harsh environments

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Booth 210

Abstract

How Magnetic Encoders Pave the Way for Migration from Standalone Modular Encoders to Integrated Designs

Bolt-on modular encoders allow for a wide variety of options, but can be costly to operate. Integrated optical encoders save on costs but are less flexible; for example, it can be difficult to tool up disks with various resolutions.

Integrated magnetic encoders are cost-effective ***and*** offer more flexibility because they are programmable (resolution, line driver and index options). Magnetic encoders have the advantages: smaller size; compatibility with dirty and harsh environments; proven to be robust in high-performance applications in a variety of equipment.

Applications of both modular and integrated designs will be discussed.

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