

# Robust and Low Cost Motor Speed Measurement

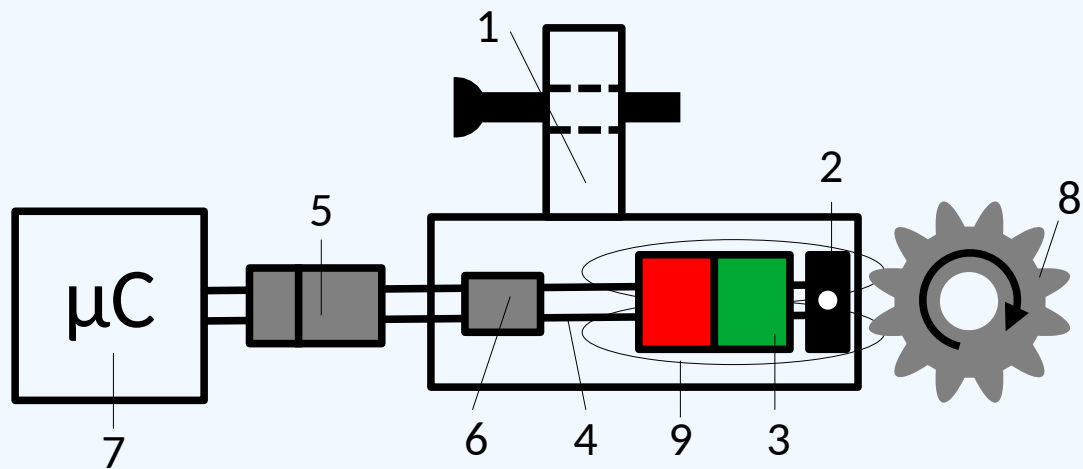
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- Performance and environmental conditions
- Additional features
- Standardization and sensor kit approach
- Sensor fusion concept: low cost torque measurement with speed sensors

# Magnetic Sensors for Motor Speed Measurement - Structure



1. Housing, flange with screw
2. Sensor chip / coil system
3. Back-bias magnet
4. Electrical connection/wire
5. Connector
6. Optional (protecting) circuit
7. External controller (ECU)
8. Steel target wheel
9. Magnetic field



# Magnetic Sensors for Motor Speed Measurement – Costs and Performance

Characteristics	Value	Remark
System costs	<15 € for ≈10 k/a	Standard sensor + gear wheel
Frequency range	0...≈20 kHz	Tooth frequency
Speed range	0... ≈60,000 1/min	For a 20 teeth gear wheel
Air gap range	0...≈4.5 mm	Depending on technology
Output interface (on-board)	Analog, TTL, PWM, digital	Depending on sensor chip
Diagnostic functions	several	Depending on sensor chip
IP protection	IP class up to IP69K	Depending on design
Temperature range	-40°C...125°C (150°C)	Depending on design
Mechanics	High vibration immunity	Requirements tbd.

# Magnetic Sensors for Motor Speed Measurement – Additional Features

Feature	Remark
Direction detection	On-board or in controller unit
Diagnostic functions	Several e.g. air gap, supply voltage...
Vibration detection / suppression	Depending on sensor chip
Run-out immunity (gear wheel)	Requirements tbd.
Air gap shock immunity (gear wheel)	Requirements tbd.
Immunity to external magnetic fields	With differential measurement chip
ESD protection	Up to 20 kV HBM
EMC protection	Requirements tbd.
Over- and reverse voltage protection	Requirements tbd.

# Magnetic Sensors for Motor Speed Measurement – Standardization

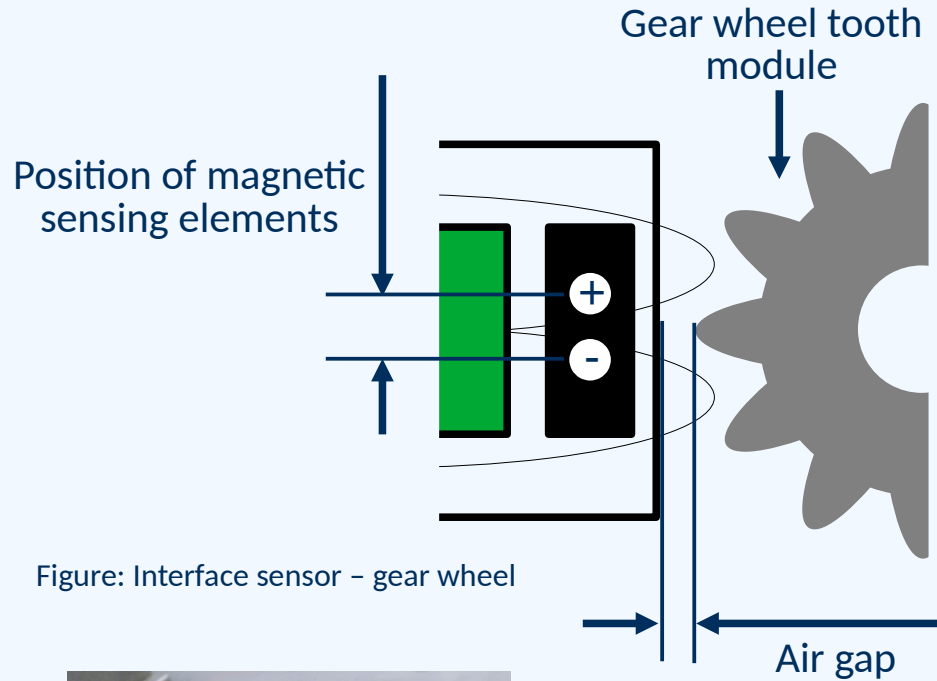


Figure: Interface sensor – gear wheel

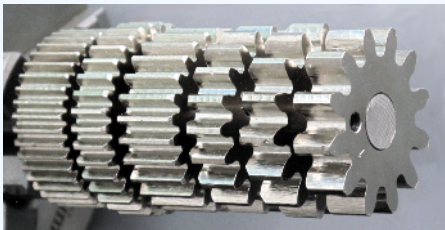


Image: Different gear wheel tooth modules (1...3)

## Standardization approach:

- Optimization of sensor and gear wheel
- Relevant interface parameter:
  - Magnetic local resolution of the sensor
  - Geometry / tooth module of the gear wheel

## Benefit:

- Constant performance for different target wheel diameters
- Best fit of a standard sensor in product kits and various product modifications
- Forward and reverse system compatibility approach possible

# Magnetic Sensors for Motor Speed Measurement – Overview

- Big measurement range
- Low-cost solution
- Low installation space
- Robust mechanical design
- Easy mounting and connection
- Big temperature range
- Simple standardization / product kit
- Easy compatibility management
- For harsh environmental conditions: e.g. high temperature, oil, dust...
- Robust electrical signal
- Easy to replace
- Overall function, including diagnostic, in one chip
- Many additional features available

# Sensor Fusion – Torque Sensor based on Speed Sensors

Concept:

- Measure the phase shift of two speed sensors signals
- Transfer the phase shift information to a torque value by using the stiffness value of a transmission rod

Signal phase shift value  $\rightarrow$  mechanical twist angle  $\rightarrow$  torque value

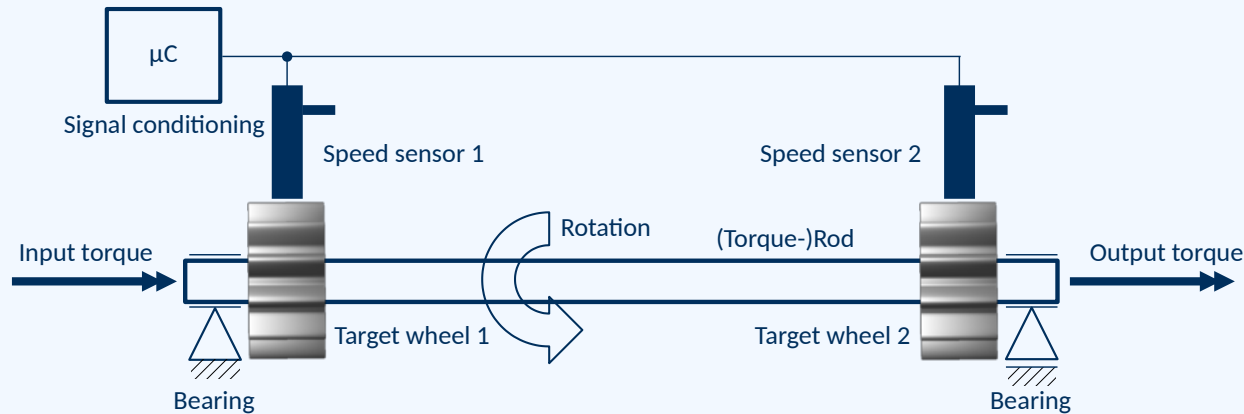


Figure: Torque measurement based on speed measurement



# Sensor Fusion – Torque Sensor based on Speed Sensors

Concept:

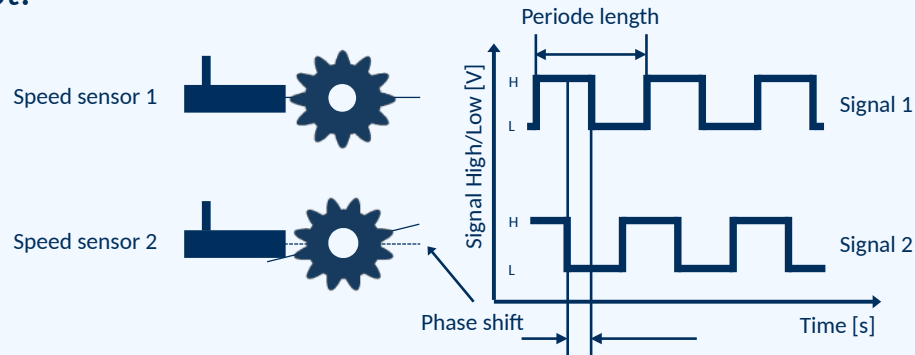
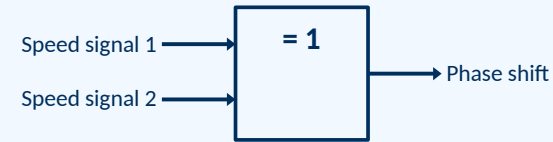


Figure: Signal phase shift with torque impact



Speed signal 1	Speed signal 2	XOR Output
0 V	0 V	0 V
0 V	5 V	5 V
5 V	0 V	5 V
5 V	5 V	0 V

Figure: Exemplary torque value evaluation based on XOR-logic

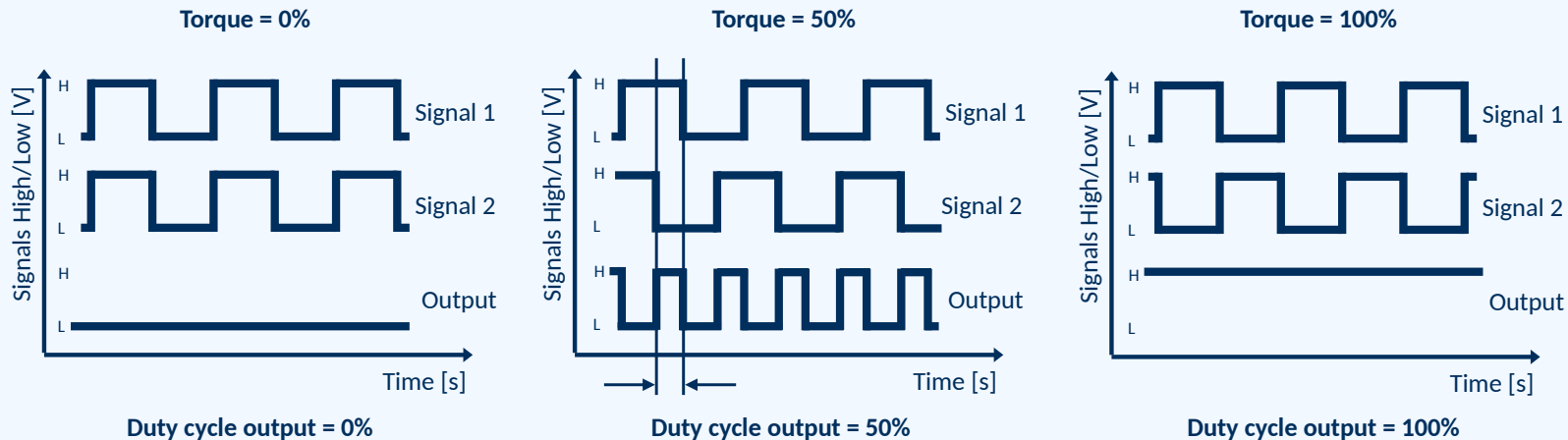


Figure: Speed signals and related torque value for torque = 0%, 50% and 100%

## Summary

- Magnetic speed sensors are **simple, robust and low-cost**
- Magnetic speed sensors can be used in **harsh environmental conditions**
- Magnetic speed sensors enable a lot of **additional features**
- Magnetic speed sensors can be **standardized easily**
- Magnetic speed sensors **support compatibility requirements for product kits**
- Magnetic speed sensors **support forward and reverse compatibility requirements**
- Magnetic speed sensors can support higher system functions with sensor fusion: e.g. **torque measurement, position detection, angle measurement...**

## Last Slide

ONRASens do not manufacture and do not sell sensors

ONRASens provides sensor concept, design-in and sensor strategy consulting services for sensor technologies

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