Self supplying wireless inductive speed sensor concept

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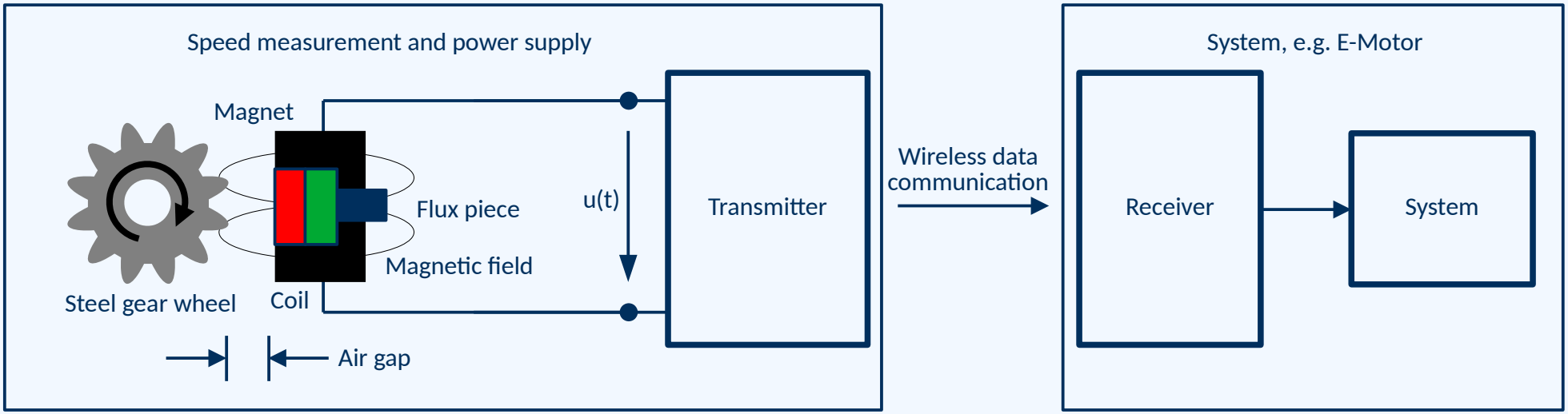
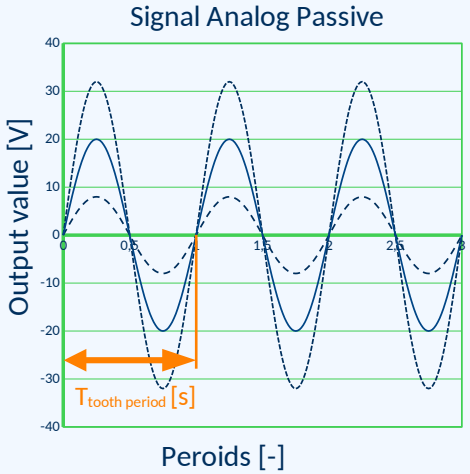
Task description

Tasks:

- Rotational speed measurement, e.g. E-Motor speed
- Wireless, galvanically isolated and self supplied
- Simple, reliable and small
- Parameter model for energy production
- Solutions for optical and RF signal transmission

Basic Concept





Speed measurement: Tooth period duration

Power supply: Signal voltage

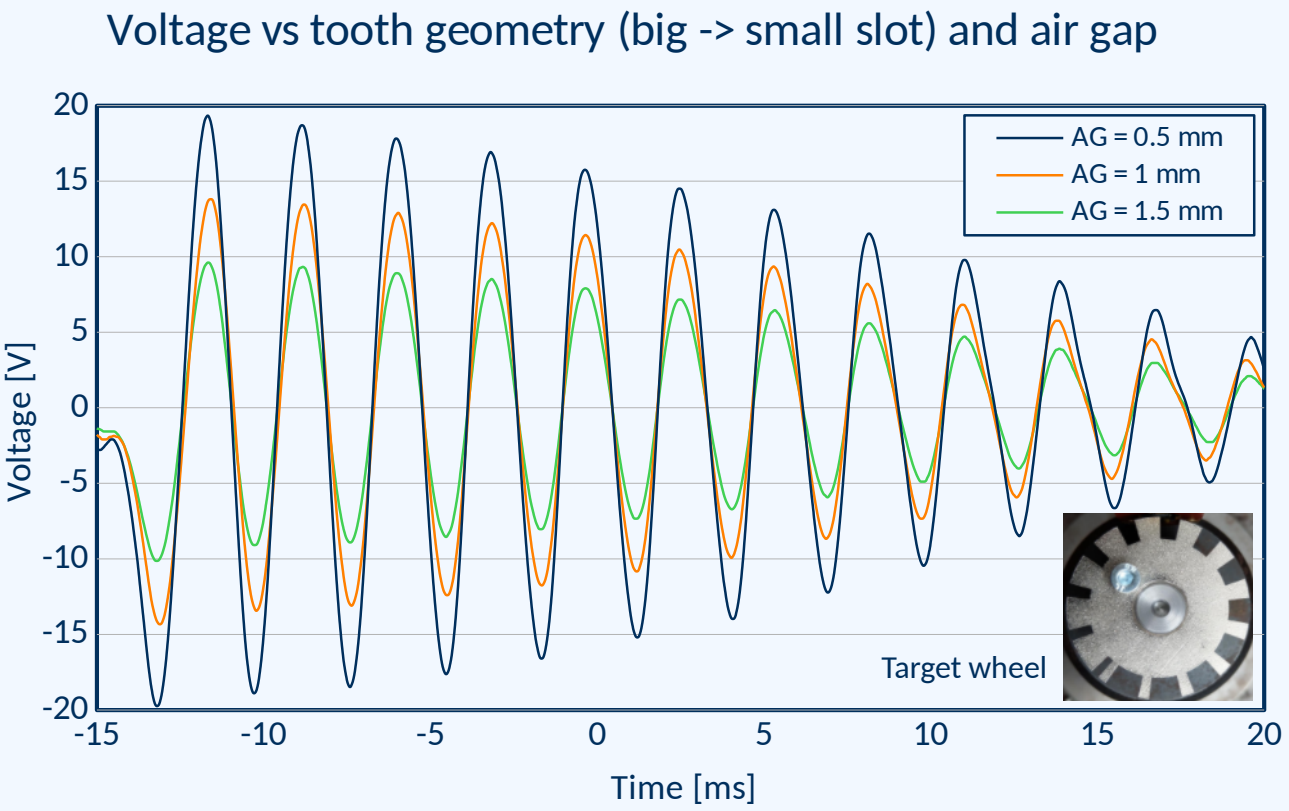
Basic dependencies:

- Speed ↑ → frequency ↑
- Speed ↑ → voltage ↑
- Air gap ↑ → voltage ↓
- Speed ↑ + air gap ↓ → power ↑

Relevant System Parameters and Dependencies

1) Small dimensions: depending on application
2) Adapt and optimize tooth-slot geometry to magnetic circuit → maximum energy production
3) Target wheel diameter, shape and amount of teeth
4) Magnetic circuit: coil, magnet and flux piece parameters
5) Speed range
6) Air gap target wheel – magnetic circuit
7) Impedance matching
8) Adjustment with supply power demand of transmitter
9) Receiver requirement (not in focus)
10) Further / secondary parameters: temperature range, EMC, regulatory rule…

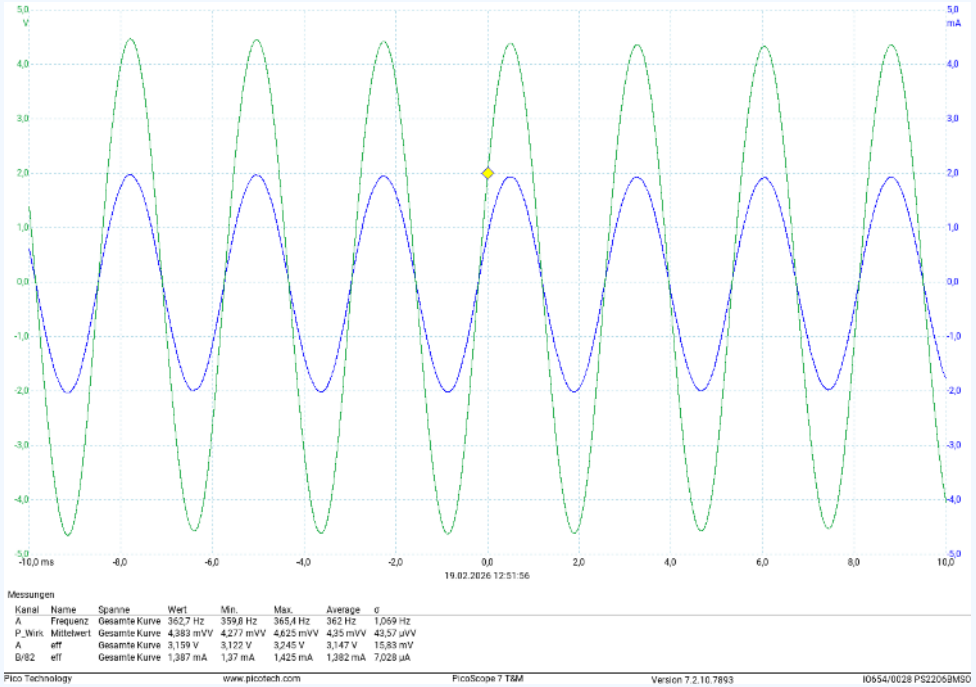
Dependency – Tooth Geometry and Air Gap

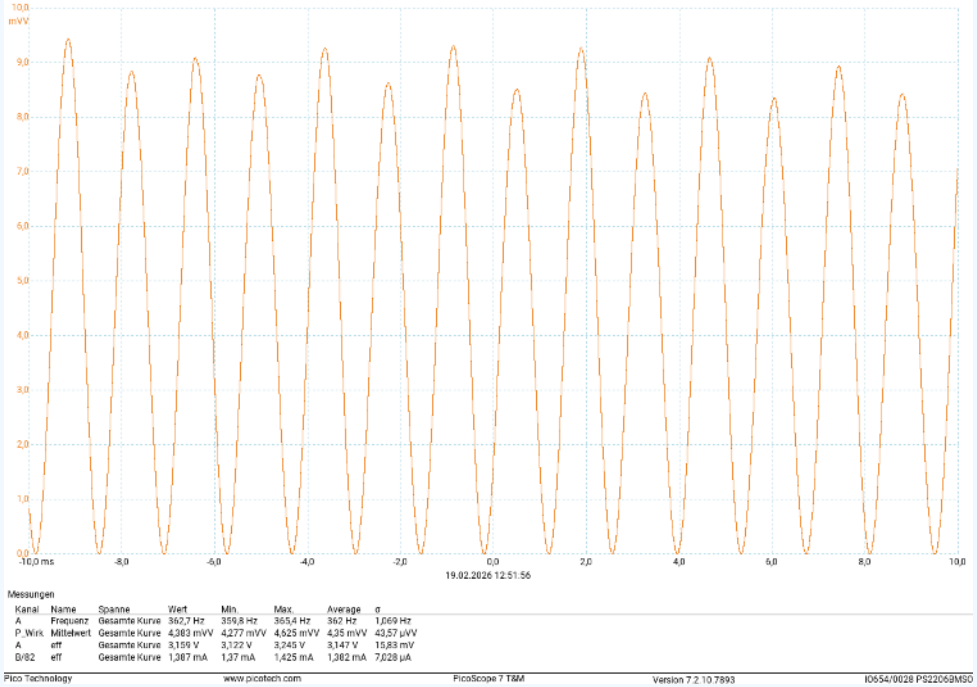


Parameters:

- Multi-geometry target wheel
- Target wheel: 42 mm
- 13 teeth, Pitch: 10 mm
- Air gap: 0.5 to 1.5 mm
- Tooth frequency: 324 Hz
- Target speed: 1500 rpm
- Load: 1 MΩ (scope impedance)
- 8800 windings
- Inner coil diameter: 8.5 mm
- Outer coil diameter: 13 mm
- Length coil: 16 mm
- Ohmic resistance: 457 Ω
- Front ferrite magnet
- Ferrite flux piece

Dependency – Tooth Frequency and Air Gap - Shape





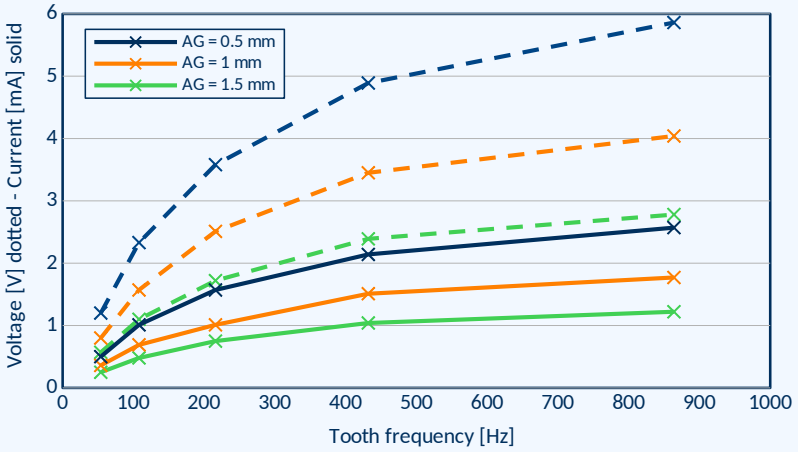
Typical synchronous measurement: green → voltage / V; blue → current / mA; orange → Power / mW

Load → ≈2.3 kΩ (2.2 kΩ + Shunt 82 Ω)

Dependency – Tooth Frequency and Air Gap

Air Gap / mm		54	108	216	432	864	Tooth frequency / Hz
		250	500	1000	2000	4000	Speed / rpm
0.5	U / V	1.2	2.33	3.58	4.89	5.86	
	I / mA	0.5	1.01	1.57	2.14	2.57	
	P / mW	0.65	2.37	5.82	10.46	15.05	
1	U / V	0.8	1.57	2.51	3.45	4.04	
	I / mA	0.36	0.69	1.01	1.51	1.77	
	P / mW	0.29	1.08	2.74	5.22	7.15	
1.5	U / V	0.57	1.1	1.72	2.39	2.78	
	I / mA	0.25	0.48	0.75	1.04	1.22	
	P / mW	0.14	0.52	1.29	2.48	3.41	

Voltage / current vs. air gap and tooth frequency

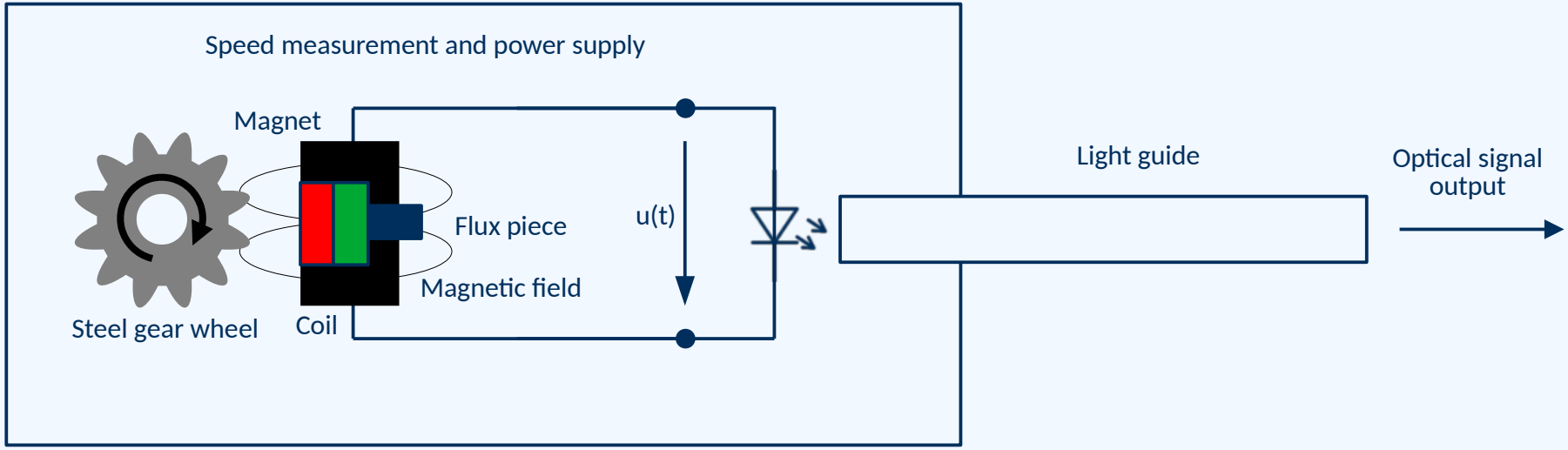


Parameters:

- Equidistant target wheel
- Target wheel: 42 mm
- 13 teeth
- Pitch 10 mm (Tooth : Slot; 1 : 2)
- Air gap: 0.5 to 1.5 mm
- Load: ≈2.3 kΩ
- Effective values

Target wheel

Optical Signal Transfer with LED



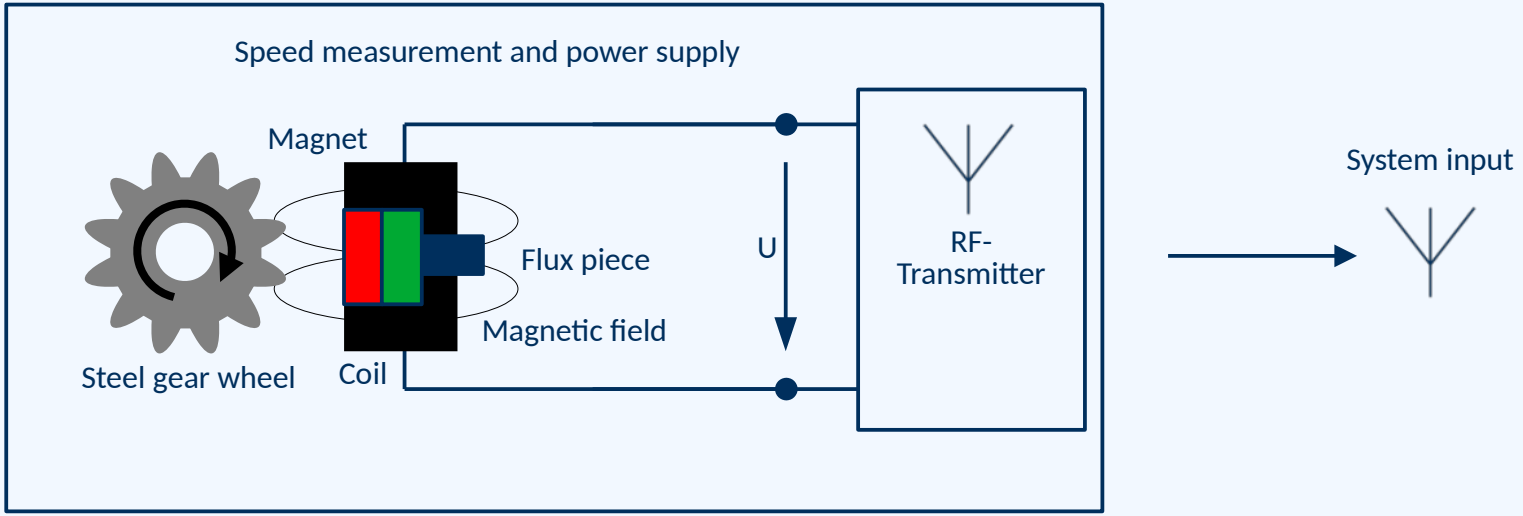
- Very simple and low cost concept
- Ultra-low-power solution
- Only few components
- Main use case: galvanic decoupling, EMC resistance
- Diagnostic functions
- Redundancy and differential measurement easy to implement (in development)

Supply Power: Optical Signal Transfer with LED

- LED, red, 3 mm, 20°, 645 nm
- Flexible plastic light guide, diameter: 1 mm, length: 150 mm
- Standard assembly used: LED, plastic holder, coated light guide, output lens

Air gap / mm	Intensity	Tooth frequency / Hz
0.5	low	39
	medium	65
	high	117
1	low	59
	medium	88
	high	145
1.5	low	85
	medium	121
	high	172

RF Signal Transfer with Transmitter



- High performance data transmission
- Long distance transmission
- Main use case: long distance, through media transmission
- Diagnostic functions
- For specific applications
- More complex and expensive

Supply Power: RF Signal Transfer with Transmitter

Ultra-low-power RF-transmitter available:

- 1.5 V / 2 mA, load value adapted (100% duty cycle)
- 3 V / 1 mA, load value adapted (100% duty cycle)

	Air gap / mm	AC-Values Tooth frequency / Hz	Rectifier included Tooth frequency / Hz
1.5 V / 2 mA	0.5	220	not possible
3 V / 1 mA	0.5	140	190
	1	238	350
	1.5	480	810

Summary

- Sensor concept works
- Many degrees of freedom enable individual design
- Simple, cost-efficient solutions can be implemented
- Wide speed range
- Small dimensions
- No specific components needed
- Application protected by individual know-how
- Multiple additional functions implementable
- Robust signal with difference principle, multi channel…
- Real time ability
- Simple physics, simulation and testing
- For specific and high volume applications

My Offer

ONRAsens support sensor knowledge and application know-how to industrial customers.

From design-in of standard sensor products to complex high volume system integration and strategic consulting.

Independent and optimized for your application.

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Contact and References

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White paper download → https://ONRAsens.com/aktuelles-downloads/

1. Target wheel optimization: „Doppelter Luftspalt“
2. Motor speed measurement: „Kippen oder nicht Kippen?“
3. Torque sensor concept: „Der unsichtbare Drehmomentsensor“

   and much more…