
Magnetsensorik für elektrische Antriebe / MiniCODER für Hochfrequenz-Spindeln in WZM

Dr. Peter Velling
CTO

Agenda

- Lenord+Bauer at a glance
- Our Encoder Kit: **MiniCODER + target wheel**
 - a journey over decades to high resolution and GMR sensors
 - machine tool : high frequency spindles application
- Smart MiniCODER
 - from analog to digital interfaces
 - additional data acquisition
- applications

Lenord+Bauer is a strong global partner always close to customer applications since 1965



**Based on development and production centre in Germany
an international sales & support network is supported**

Dr. Peter Velling, CTO

Products: Embedded hardware and software solutions integrated into compact robust mechanical designs

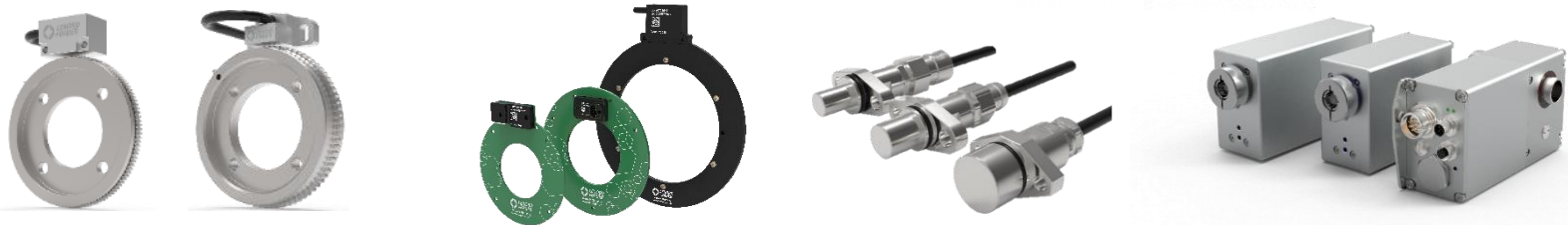
System level
Application



Integration level



Sensor-actuator level

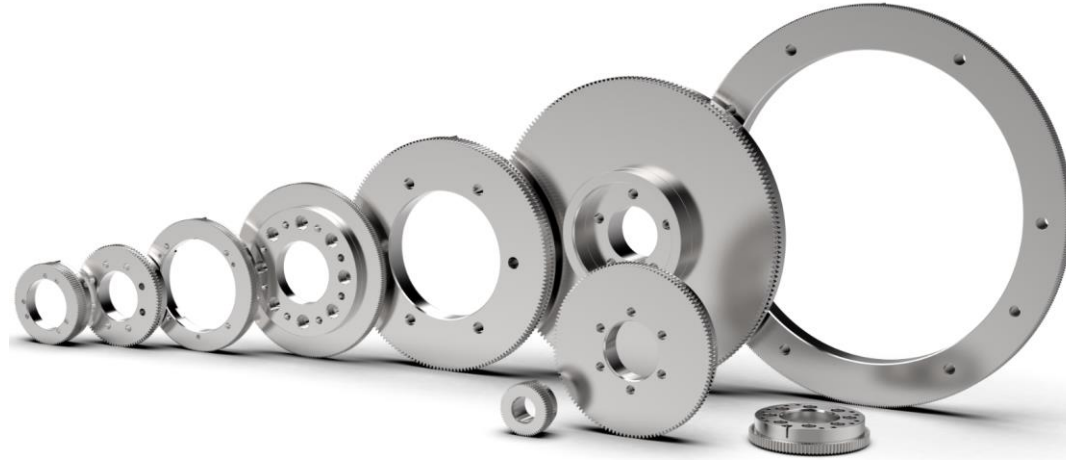


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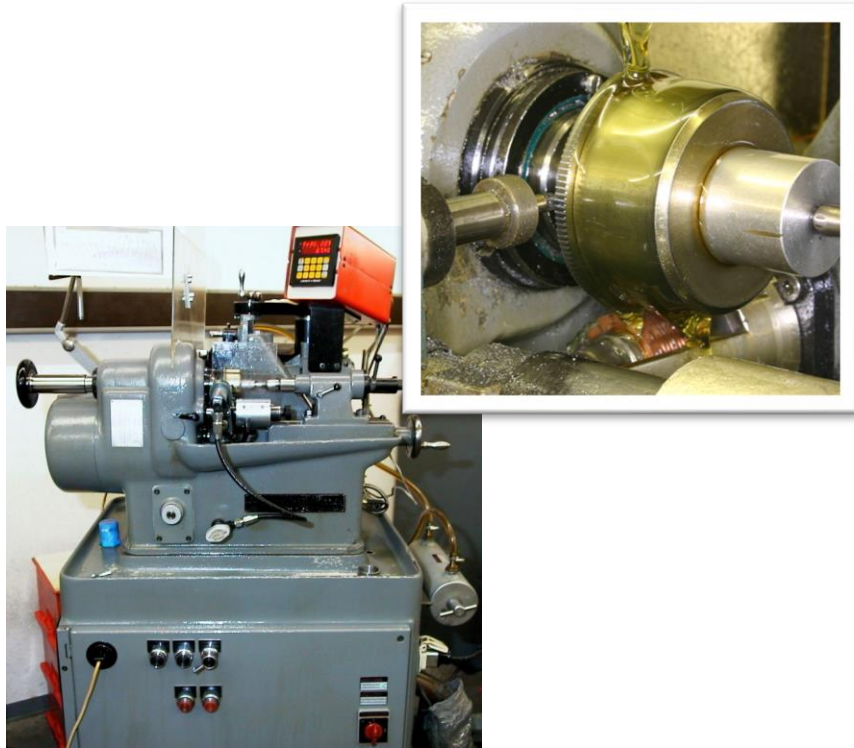
Robust passive ferromagnetic target wheel: Encoder Kit based on sensor head with back bias magnet



- **Target wheel with module 0,2 / 0,3 / 0,4 / 0,5 ... (2,5)**
 - flexible in size including customized features
 - cost effective production from one piece to >10.000 pcs
 - tolerances typically in the range of 15µm down to 5µm
- ONE sensor head fits to all diameter

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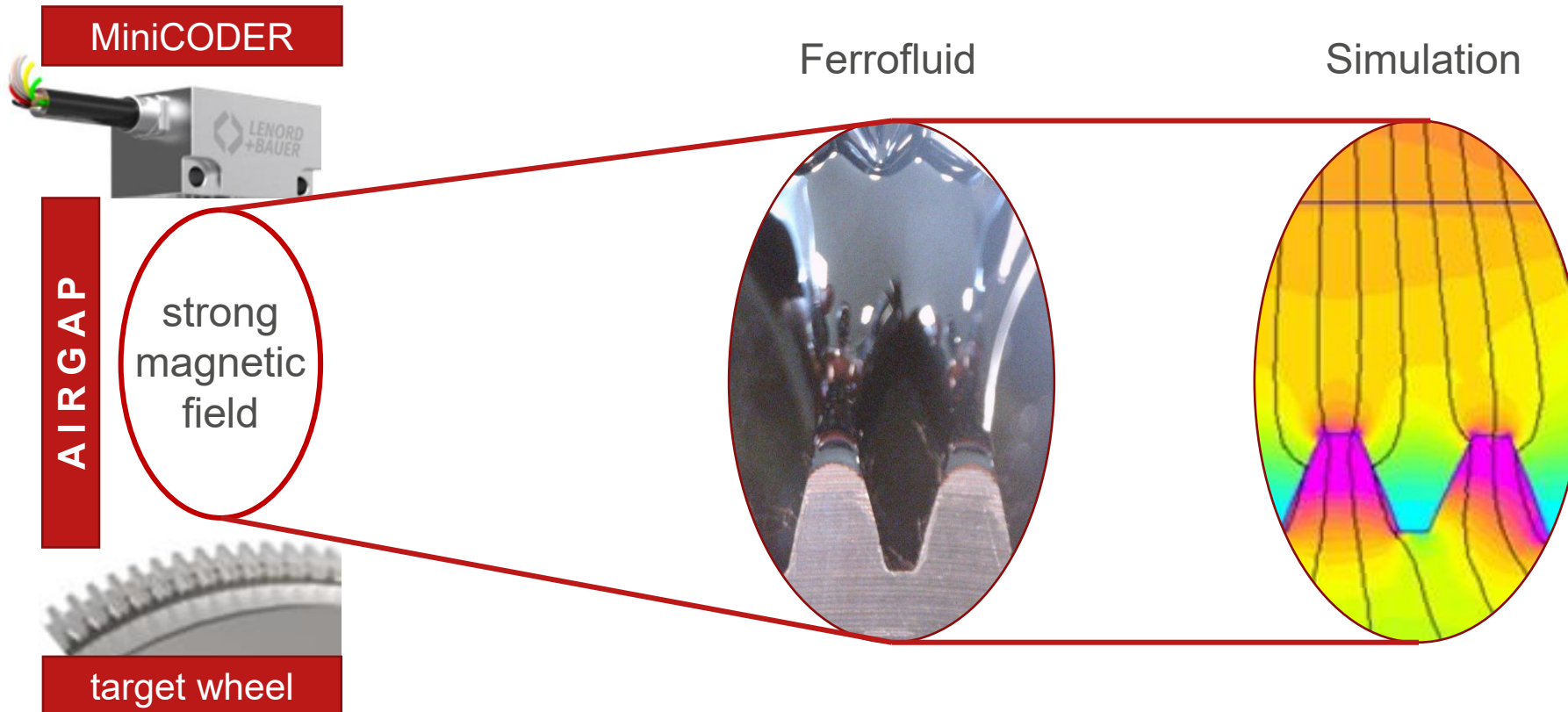
From a manual handling process to a fully automated multi-axis CNC machine tool process



- **Target wheel with module 0,2 / 0,3 / 0,4 / 0,5 ...**
 - mechanically robust up to very high rotation speed
 - scalable to high volume with customer specific features

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MiniCODER: Visualisation of magnetic field effects while Ferrofluid follows magnetic field strength



- Ferrofluid follows magnetic field as expected from simulation
- MiniCODER: fully potted metal housing with back bias magnet

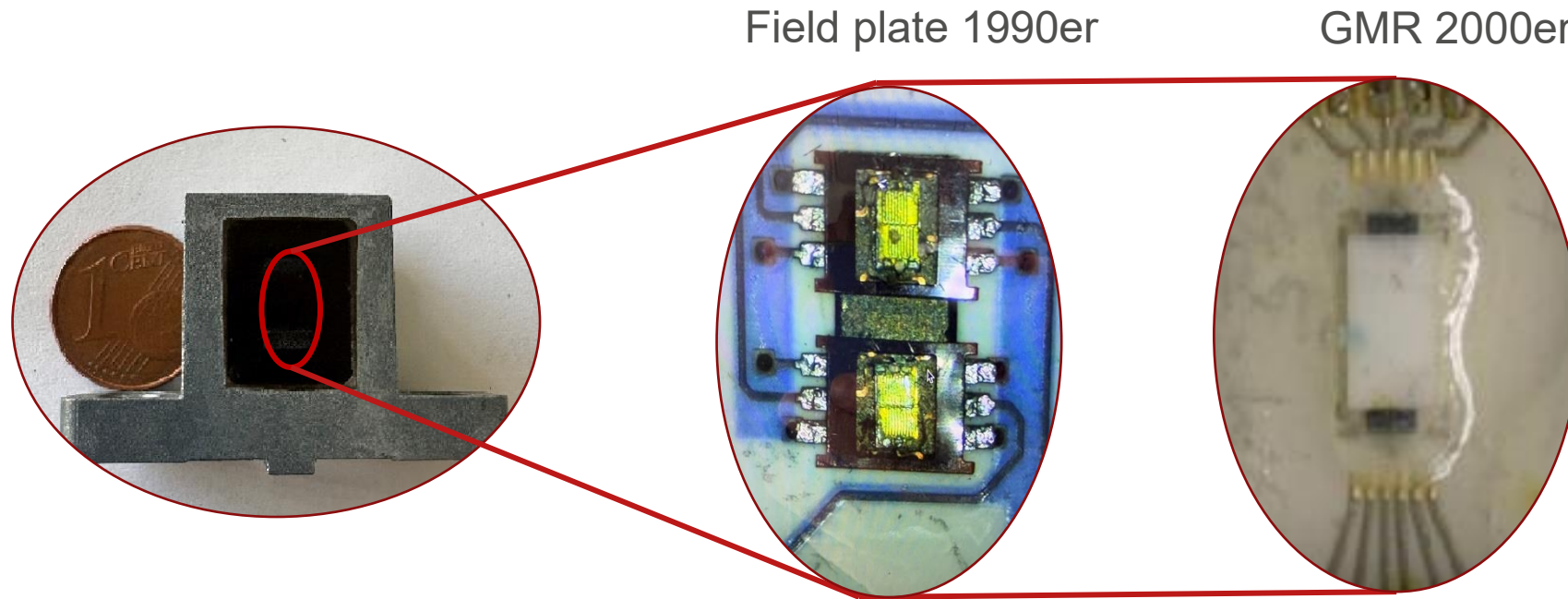
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MiniCODER: Setup with Ferrofluid and ferromagnetic target wheel with module 1



- Just for visualisation: Ferrofluid follows magnetic field strength

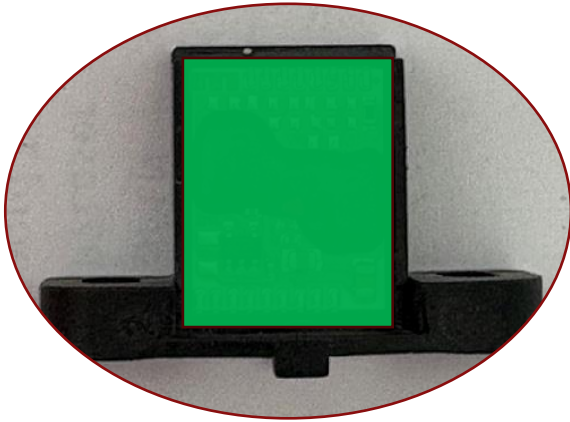
MiniCODER: Evolution from field plate to GMR means change from manual placing to 3d micro engineering



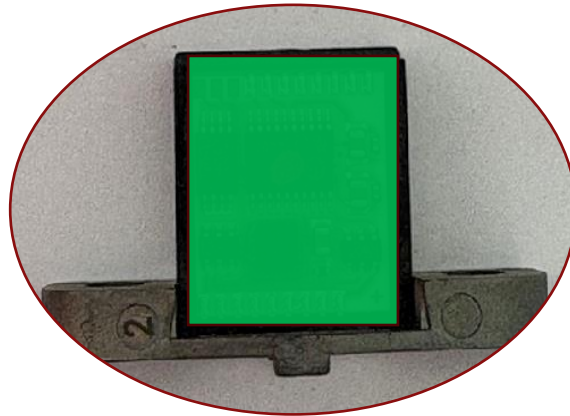
- Strong reduction in sensor size offers new applications
- Production process changed in total!
- New challenges came across like strong impact of magnetic field orientation

MiniCODER: Electronic evolution from ceramic-to-FR4 means transition from special to standard processing

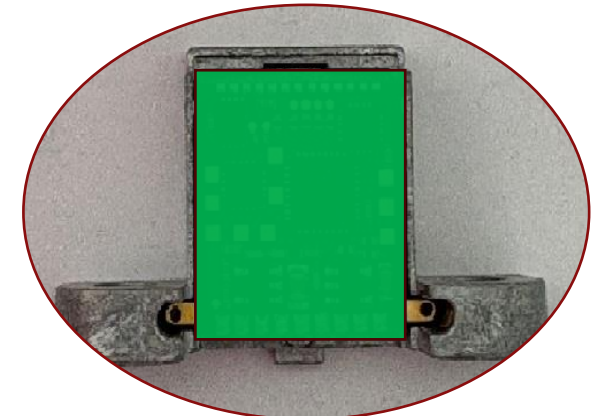
1990: Discrete on ceramics



2005: Integrated on ceramics

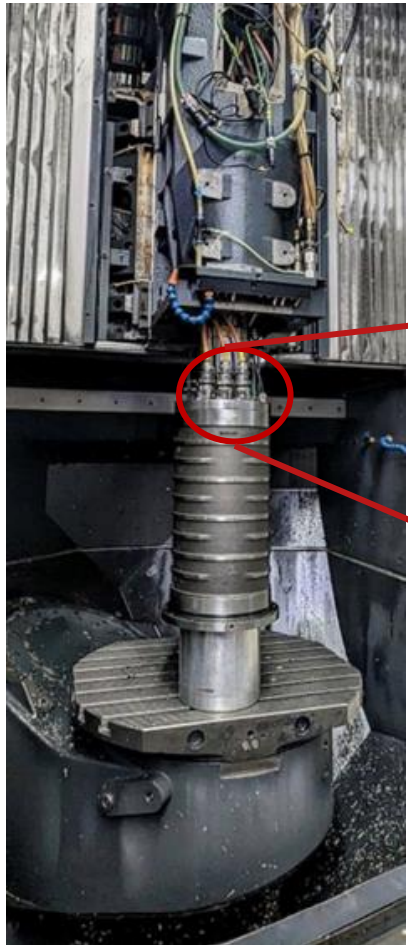


2025: fully integrated on FR4



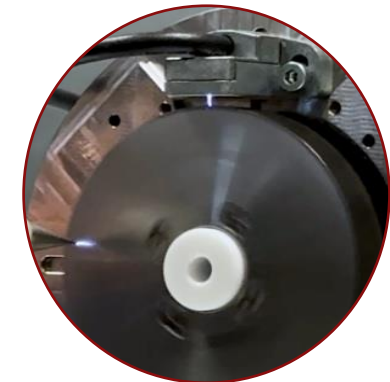
- 1990: manual soldering above pre-heated ceramics, fast feedback & hard lessons
- 2005: sensor and IC development with reliable partners, network increases rapidly
- 2025: transition to standard high volume processing for analog and digital interfaces
- 2025+: smart sensors including MEMS technology, software defines functionality

What really happens: motorspindles are running permanently at strong overloads and high temperatures



spindle service Deuschle

- **Strong contamination inside the spindle**
 - dirt and moisture by cooling liquids
 - abrasion and lubrication from the bearings
- **Axial and radial axis displacement**
 - strong loads to the spindle bearings
 - airgap reduction from 200 μm ... down to zero
- **Very high EMI radiation / ESD**

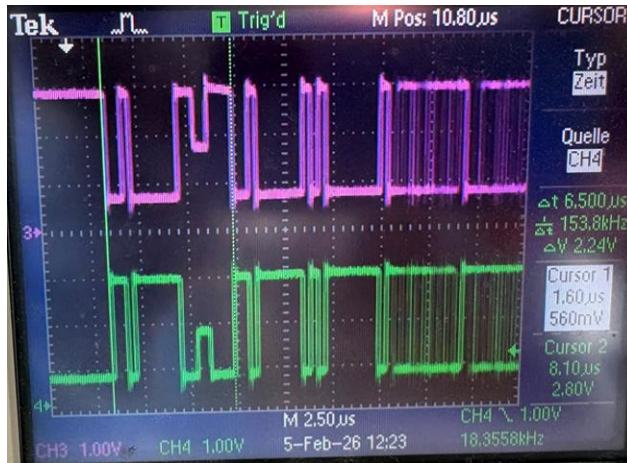


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Smart MiniCODER: Digital interfaces offers new features, defines new requirements and re-defines main focus!

8 Byte data: 96 Bit x 0,4µs = 36 µs



- digital protocol specifications
 - request time: 125 µs / 100 µs ...
 - response time: 2.5 µs / ...

FANUC



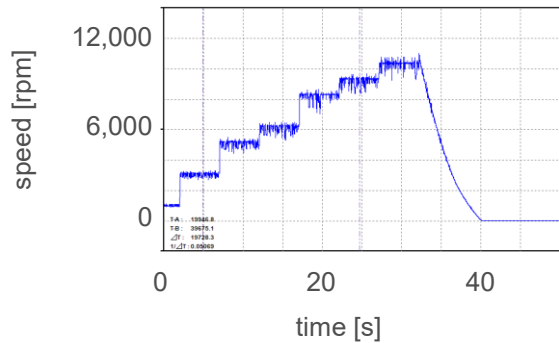
BiSS-C

- **Sensors are Enabler for Condition-Monitoring, called CPS**
 - digital product passport, rpm-histogram
 - temperature, airgap a/r, vibration data x/y/z in **Realtime**: up to 96 bit
 - motor protection, process optimization, condition monitoring, new business models
- **Focus on digital protocols and Software Framework**
 - data analysis inside sensor absolutely necessary
 - warnings, rms-values, FFT to support **Realtime / Timing**



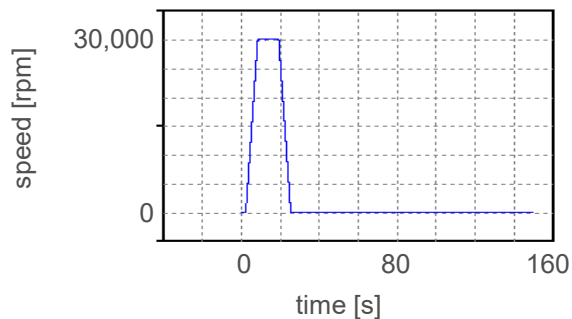
MiniCODER: Test with FANUC digital interface

High speed and dynamic test scenario



First tests fails
@10.000 rpm

- test environment
 - FANUC Control & Drive Units
 - speed test up to 30.000 rpm
 - first tests fails while Jitter increase
 - protocol communication dropped off

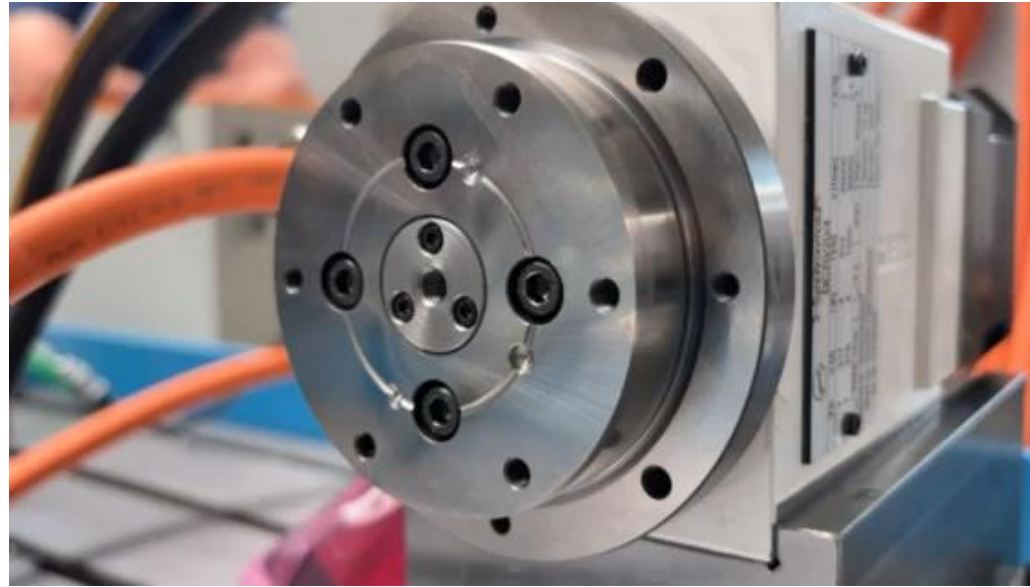


After optimization
@30.000 rpm

- **Lenord+Bauer software framework**
 - optimization of signal conditioning
 - MH-SSI, FANUC, HAAS, BiSS-C

T I M I N G is not negotiable !

MiniCODER: FANUC protocol test @Erwin Junker up to 30.000 rpm



- MiniCODER with FANUC protocol
- Speed test @ 30.000 rpm

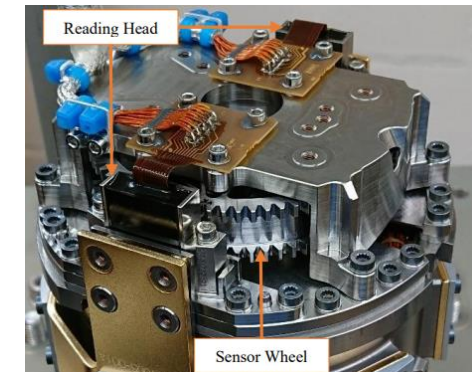
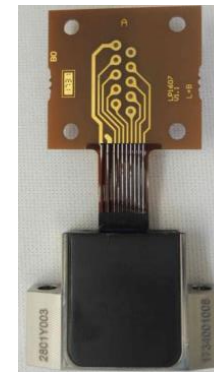
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MiniCODER for space applications: Absolute Encoder Kit for filter wheel adjustment

- Compact GMR-Sensor head
 - operating temperature: -40°C to +60°C
 - Vibration level: 22 g / Shock level: 600 g
- SSI interface
 - resolution up to 18 bit Singleturn
 - reduced motor vibration
 - double head: redundant data acquisition

METOP-SG, ESA/EuMet,
FilterWheelAssembly FWA, weather analysis

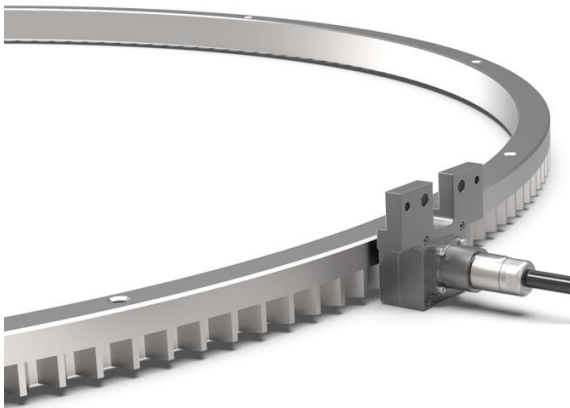


Scheidegger 2019 et.al. / Bolognini 2021 et.al.

Marine Offshore motor-feedback: Incremental and absolute magnetic encoders kits



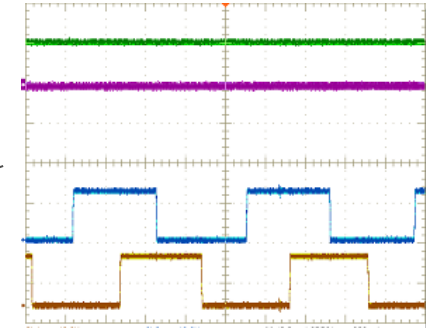
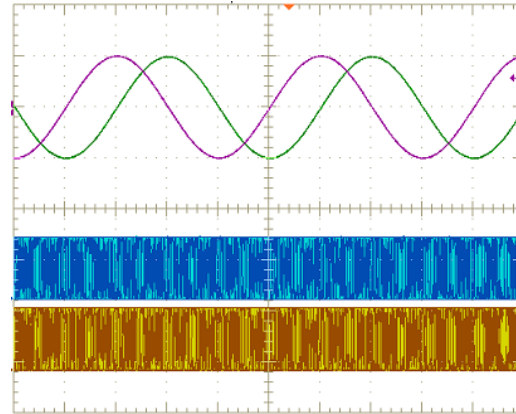
- Pod direct drive / gear-less
- Salty environment
- Low motor vibration level
- Interpolation electronics for high resolution
- huge target wheel diameter >0.5 m



Housed encoder for crane, marine and rail applications: High resolution magnetic incremental encoders



256 teeth and 10 bit interpolation
reaches 262.144 increments



Interpolated signals for
0,0014° resolution

- Extremely harsh conditions: moisture / dirt
- Wide temperature range: -40°C up to 105 °C

XMR-Symposium Wetzlar 2014: Danowski / Stritzke et.al.

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