Rotor Position Sensors for Hybrid Drives and Electric Drives

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Introduction
1.1 EV & HEV as a long term trends

**Electric motor for vehicles**
- Estimated **9** million vehicles by 2020
  - Europe (CAFE): **95 g CO₂/km**
  - US (Government): **110 g CO₂/km**
- **1,x e-motors per vehicles**
- Rising market looking for high volume cost effective & high performance solutions
1.2 Which Electric Motor will be used?

**Electric motors for HEV / Plug-in HEV / EV**

- **Asynchronous electrical motors:**
  - **Advantages:**
    - Relative mature technology
    - no magnet, low cost
  - **Drawbacks:**
    - Low power density
    - Difficult torque control

- **Synchronous electrical motors:**
  - **Advantages:**
    - High power density
    - High efficiency
  - **Drawbacks:**
    - Higher cost
    - Magnet aging @ high temperature
The control system of **synchronous motors** needs position feedback in order to calculate the phase currents necessary for obtaining the desired torque with maximum efficiency.
Rotary Position Sensors
2.1 Resolvers

Provide two AC analog signals representing sine and cosine of $\theta$.

- **Advantages**
  - Absolute position information at power on
  - Robustness
  - High temperature range
  - Not sensitive to pollution
  - High accuracy

- **Drawbacks**
  - Potential interference with magnetic stray fields
  - Requires high excitation currents
  - Analog output signals
  - Needs external conditioning circuit
  - Requires precise positioning of the stator
  - High cost
The ideal Rotary Position Sensor for electric motors would have high accuracy and robustness like resolvers, combined with additional features like:

- Improved immunity to magnetic stray fields
- Flexible design
- High compactness
- Reduced cost
- High accuracy
- Digital signal

EMPOS is a new generation rotary position sensor, based on eddy current measurement, that was designed to meet these requirements.
3.1 Working Principle
Mechanical & Electrical interfaces
4.1 Product Customisation

- Patented pattern of printed coil windings
- Automated PCB Patterns Generation
- Simple and cost effective target
- Teeth number depends of motor poles number
4.2 Assembly on Electric motor

- Possible fixation on metallic support without influence on measurement
- Robust to harsh environments of elec. motors and gear boxes
- TW thickness depend on vibrational constraints
### 4.4 Electrical interface - offer

#### Analog interface without carrier signal
- **EMPOS**: ASIC
- **VDD**: Sin, Cos, Gnd
- **MCU**: ARCT, uContr

#### Analog interface with carrier signal:
- Improved noise immunity
- Standard RDC
- **EMPOS**: ASIC
- **VDD**: Out_Sin, Out_Cos, Mod, Gnd
- **MCU**: RDC, uContr

#### Digital Serial Interface SSI++:
- EMC Immunity
- No RDC needed, cost saving
- **EMPOS**: ASIC, RS-422 Transceiver
- **VDD**: SSI_ClkP, SSI_ClkN, SSI_DataP, SSI_DataN, Gnd
- **MCU**: RS-422 Transceiver, uContr
Performances
5.1 Sensor accuracy @ low speed

- **Linearity error with temperature change**
- **Linearity error with axial displacement of 0.5 mm**
- **Linearity error with radial displacement of 0.5mm**

- **All effect cumulated linearity error < 1° electrical**
  - Temperature
  - Assembly tolerances
5.2 High speed performance optimisation

Sensor errors influence increase @ high speed
5.3 EMC Performances

**EMISSION**
- 150kHz – 2GHz
- CISPR 25 – 48 to 25 dB µV/m
- compliant

**IMMUNITY**
- RF (200-3000MHz):
  - 70V/m to 140V/m
  - ISO 11452-2
- AF (15Hz-30kHz):
  - 300A/m to 10A/m
  - ISO 11452-8
- compliant
Conclusion
6.1 Conclusion

There is a high demand in high performance sensors for synchronous motors.

EMPOS is an innovative sensor based on eddy current technology.

It offers flexible and easy mechanical integration.

It is compatible with 3 electrical interfaces, analog and digital.

The performance has been improved at high speed for optimum power efficiency.