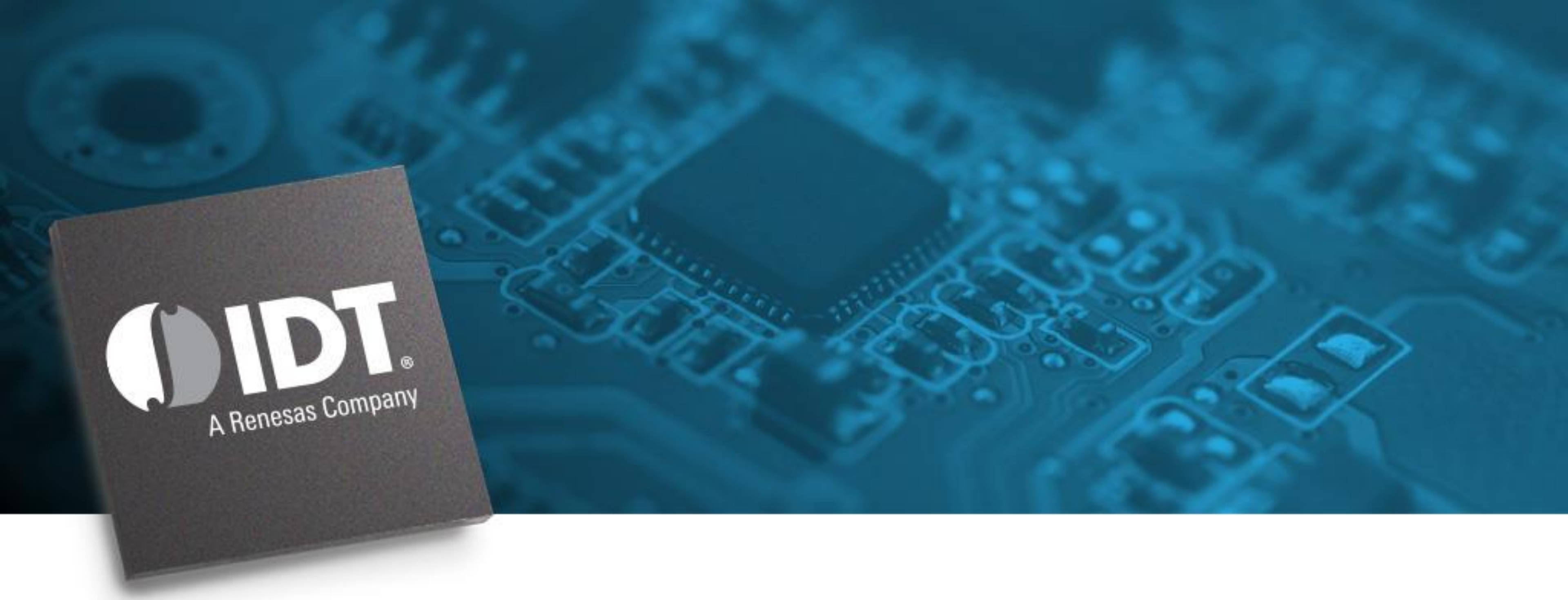
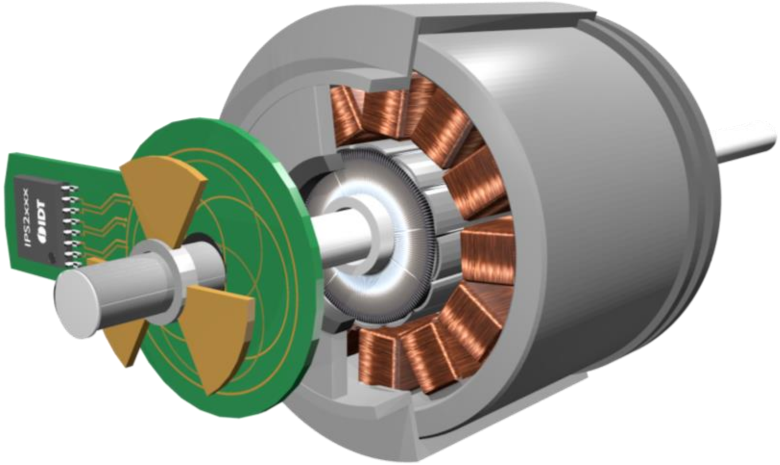


Inductive Position Sensors

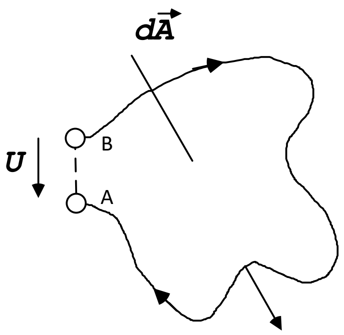
IDT
A Renesas Company



Josef Janisch, Sr. Product Manager
June, 2019

IDT inductive sensors: Basic principle

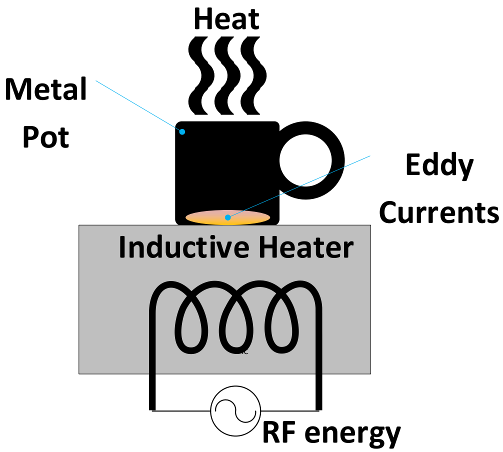
The basic principle for IDT's inductive position sensors is based on two fundamental physical principles that have been discovered over 150 years ago:



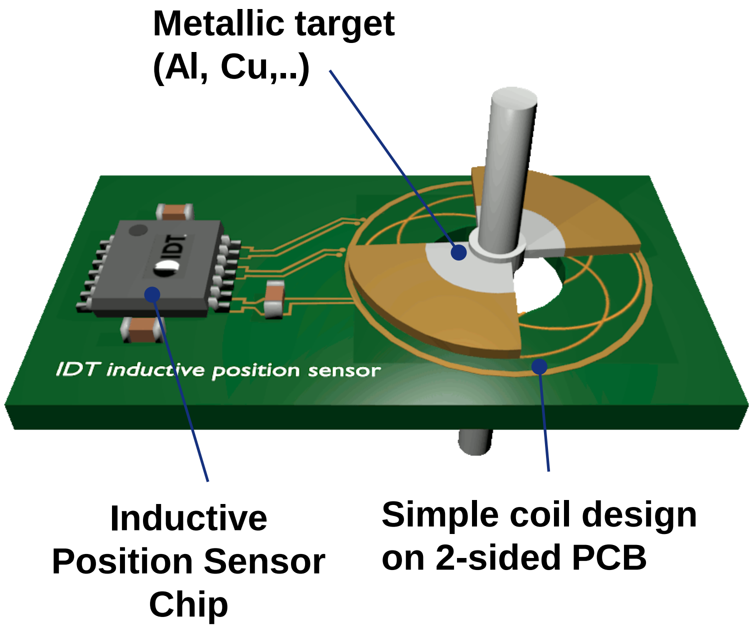
$$U = \frac{d\Phi}{dt}, \Phi = \int_{A(t)} \vec{B} * d\vec{A}$$

1. Induction in a wire loop
   - Formulated by M.Faraday, J.Henry and HC Oersted
   - First published by Michael Faraday in 1831

2. Eddy currents
   - *Diiscovered by Léon Foucault* (1819–1868)
   - Dissipation of energy by a metallic target in a high frequency magnetic field

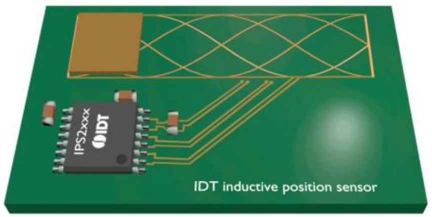


Why inductive position sensing ?

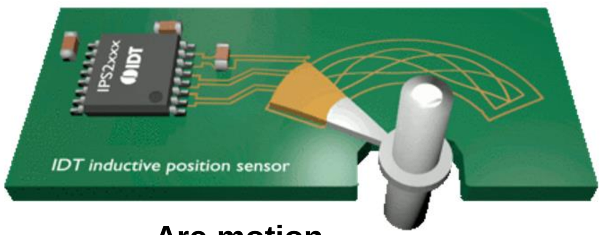


- Contactless → **no wear-out**
- No magnet needed → **lower BOM**
- Total magnetic stray field immunity - ISO 11452-8 compliant
  → **no shielding required**
- Absolute position sensing
  → **true power-on, maximum torque for e-motors**
- Full circle, semi circle, arc, on-axis, off-axis, linear coil designs
  → **flexible**
- Low stack-up, down to ~2-3 mm sensor height
  → **small form factor**
- Coil size from few mm‘s to several hundreds of millimeters
  → **adaptable to any application**
- Compensation of air gap variations
  → **scalable; tolerant to target misalignment**
- Compliant to auto standards - AECQ-100, ESD, EMC, ASIL
  → **suitable for safety critical automotive applications**
- Qualified from -40 up to +160°C ambient temperature
  → **suitable for high temperature range**

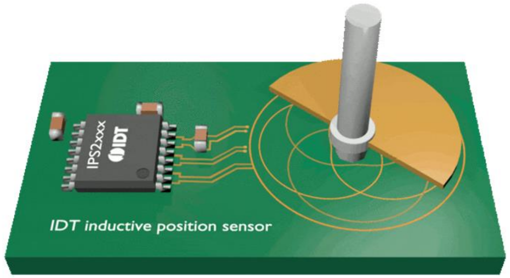
Typical Inductive Position Sensing Applications: Linear, Arc Motion, Rotation



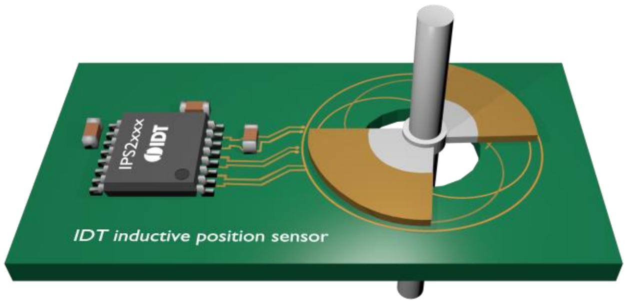
Linear motion



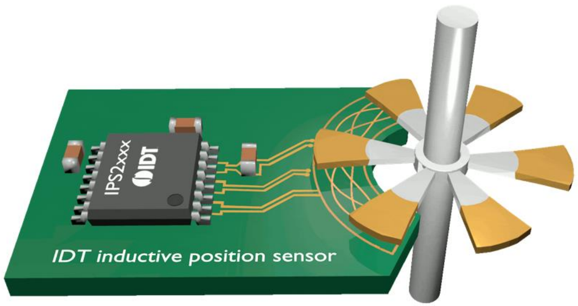
Arc motion,
Small angle rotation



Rotation,
On-Axis, end of shaft, 1x360°



Rotation,
Off-axis, 1x360°

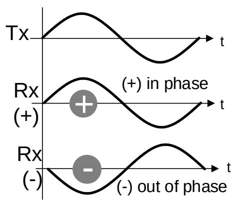


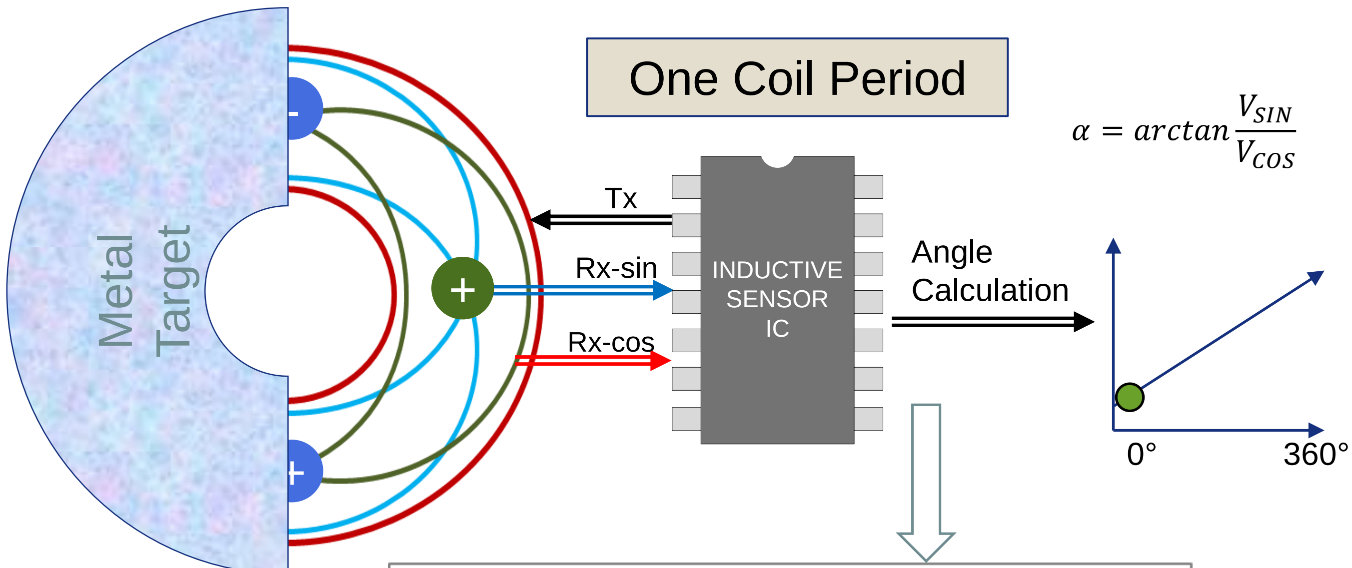
Rotation,
Side shaft, 6x60°

IDT Inductive sensors : rotary, ≤360°

Applications:

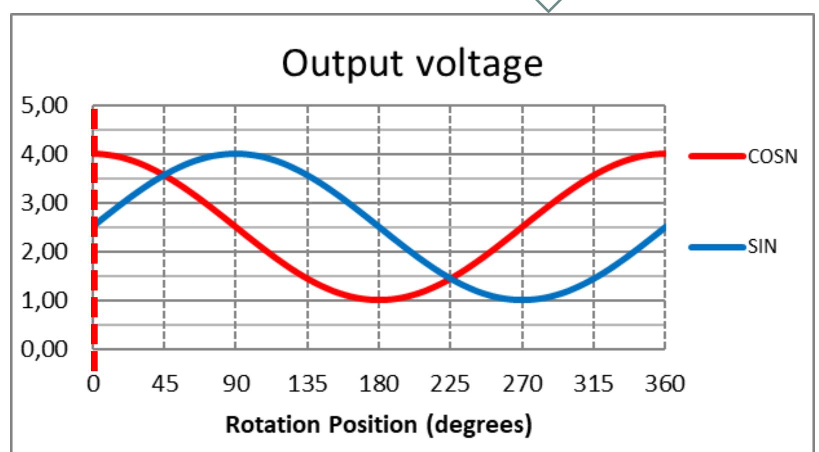
- 360° on-axis & off-axis rotary sensors (general)
- Steering wheel sensors
- Rotary knobs, etc..





Coil design with target (example):

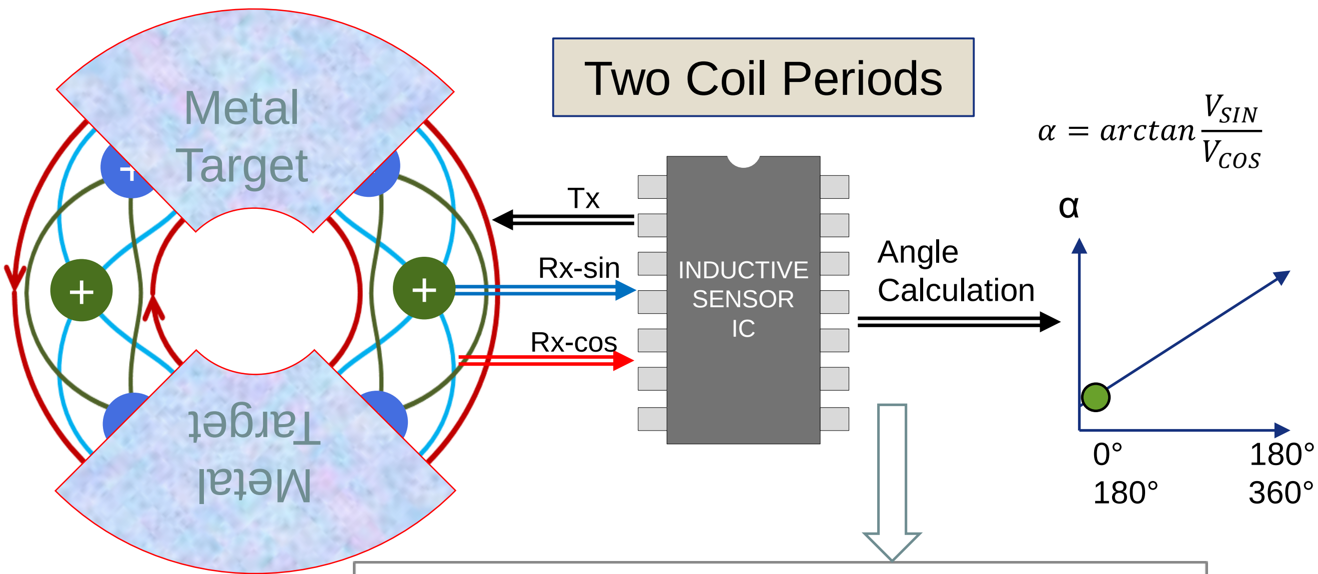
- Full turn movement: 360°
- Target length ~50% of coil period length, shown = 180° target, 360° coil period length



IDT Inductive sensors : rotary, ≤180°

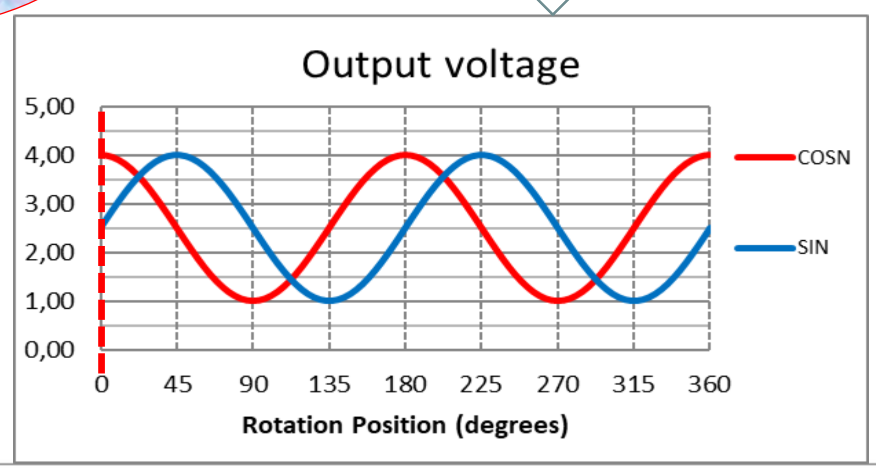
Applications:

- ≤180 ° on-axis & off-axis rotary sensors (general)
- Valve sensors
- Robots, Motors, etc..



Coil design with target (example):

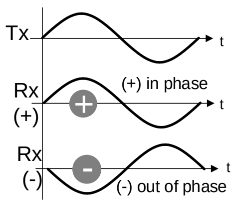
- Up to half turn movement: ≤180°
- Target length ~50% of coil period length, shown = 90° target, 180° coil period length

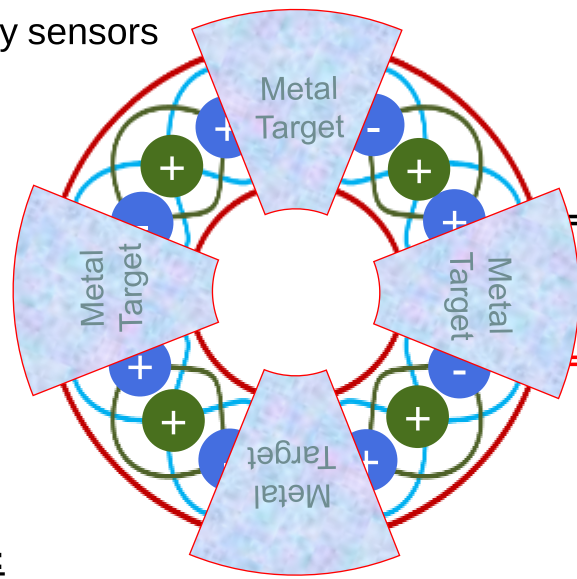


IDT Inductive sensors : rotary, ≤90°

Applications:

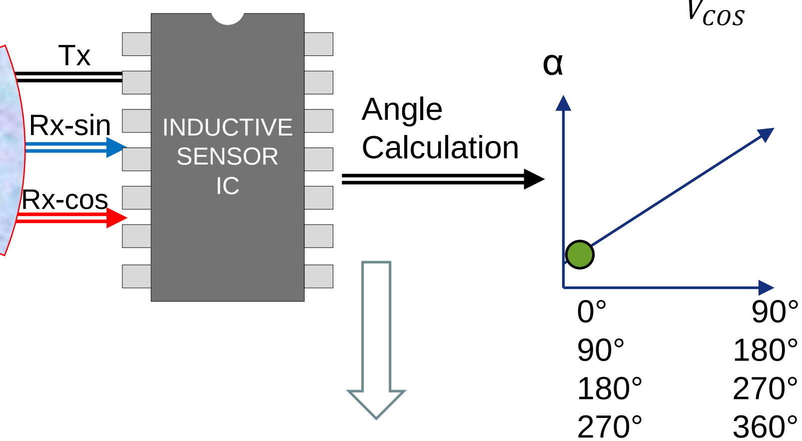
- Benefit: best coil arrangement for compensating misalignment and tilt
- ≤90 ° on-axis & off-axis rotary sensors
- Pedal sensors
- Robots, Motors, etc..





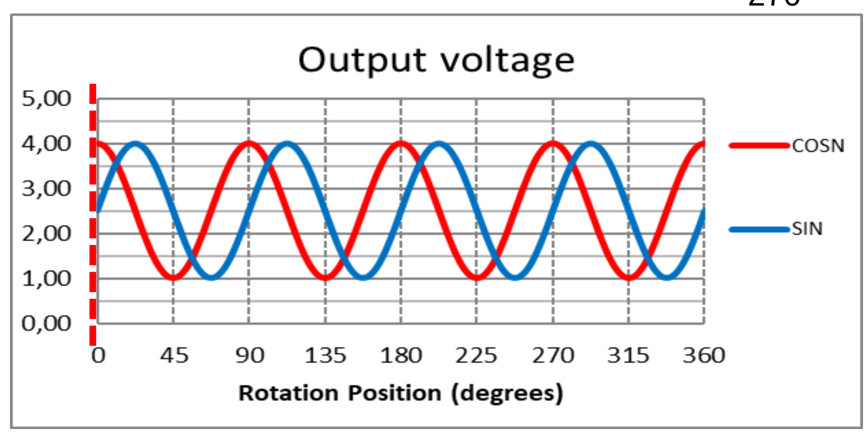
Four Coil Periods

$$\alpha = arctan\frac{V_{SIN}}{V_{COS}}$$



Coil design with target (example):

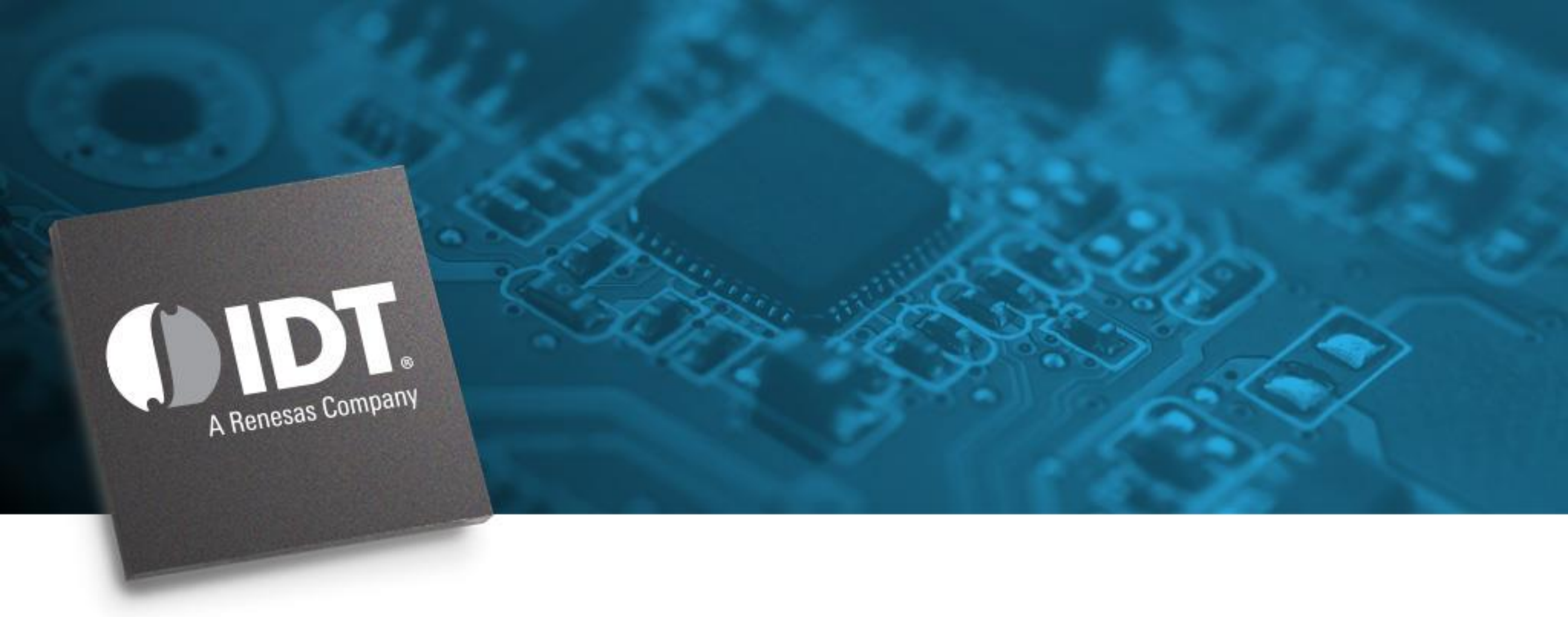
- Up to ¼ turn movement: ≤90°
- Target length ~50% of coil period length, shown = 45° target, 90° coil period length



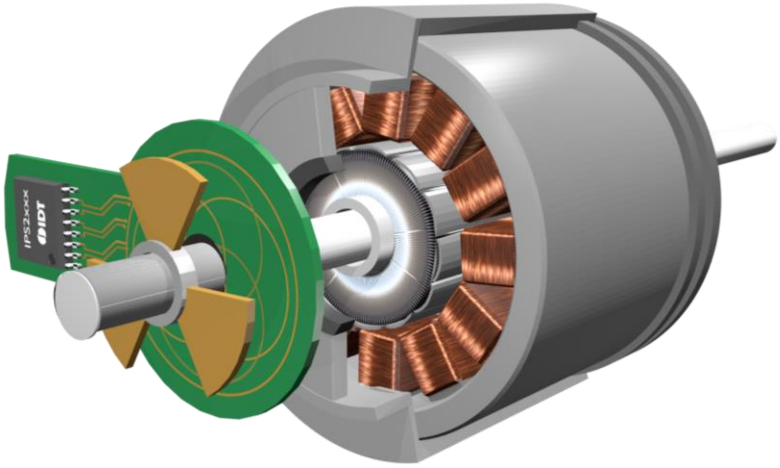
Rotor Position Sensing Technology Comparison

Technology	Sensor element	Moving part	Pro‘s and Con‘s
Hall	On-chip sensor	Magnet	Small, only on-axis, expensive magnet, limited magnetic stray field immunity
Magneto-Resistive	On-chip sensor	Magnet	Small, not immune to magnetic stray fields →shielding required, expensive magnet
Resolver Low end	Coils on iron core	Metal target	Robust, immune to stray fields large form factor
Resolver High end	Coils on iron core	Coil on iron core	High accuracy, robust, immune to stray fields expensive, large form factor, RDC (resolver to digital converter IC) required
Inductive	PCB printed coil	Metal target	Low BOM, no magnet, immune to stay fields, robust, high accuracy, on- and off-axis capable, adaptable coil designs, some minimum PCB space for coils required

IDT. A Renesas Company



IPS2: High Speed Inductive Position Sensors



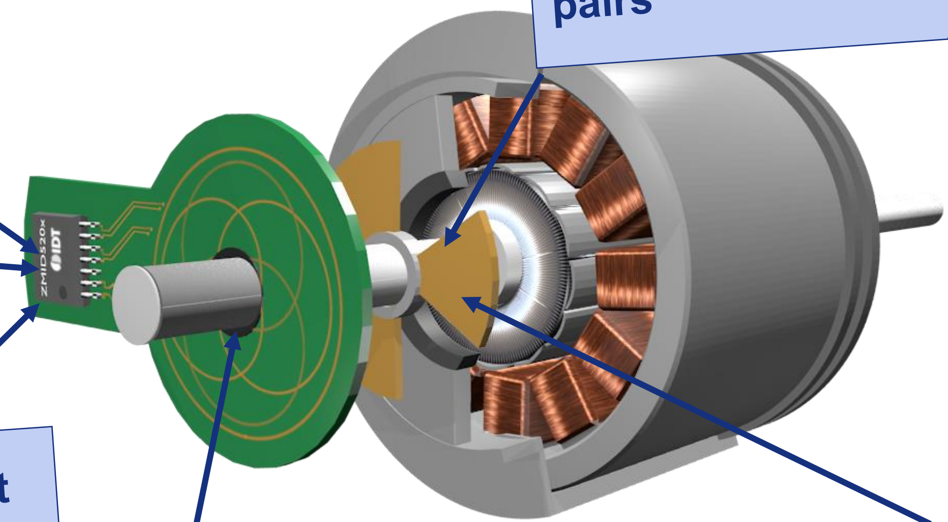
June 2019

IPS2: a New Era in Motor Commutation

Total stray field immunity - ISO 11452-8 compliant!

Ultra high speed: up to 600krpm (electrical). Low latency: 5µs

Demodulated sine/cosine output ➔ no Resolver to Digital Converter needed!



Can be adapted to any number of pole-pairs

Through-shaft, End of shaft or Side shaft mounting

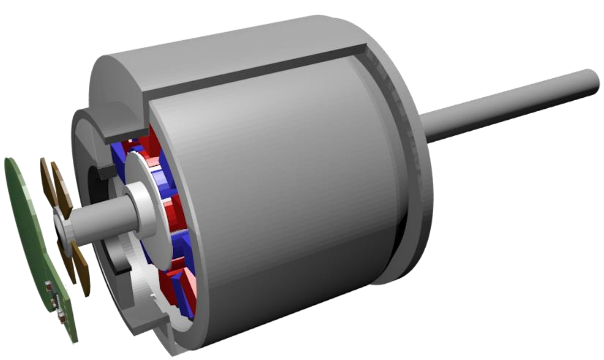
No magnet needed! Low BOM.

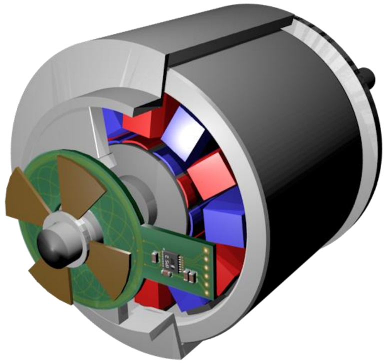
IPS2: Designed around the Motor

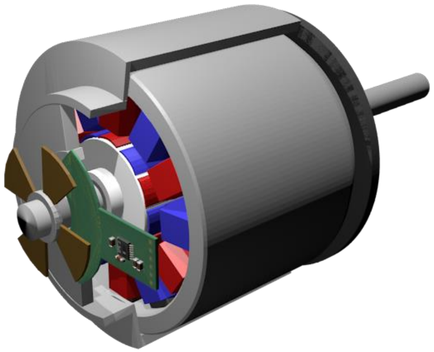
End-of-Shaft

Through-Shaft

Side-Shaft



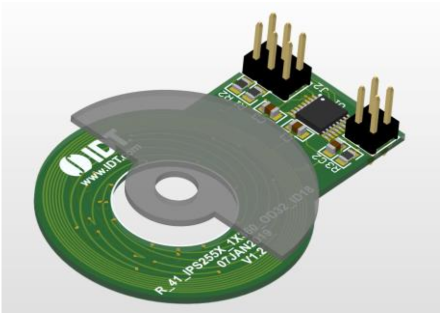


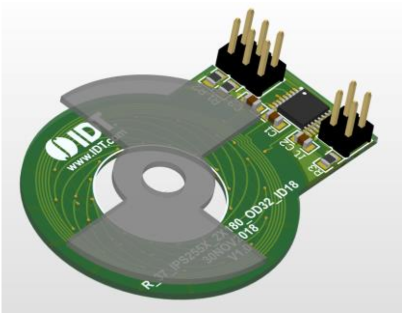


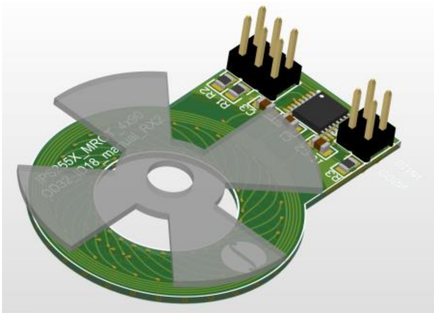
1 pole-pair

2 pole-pairs

N pole-pairs







IPS2 product family

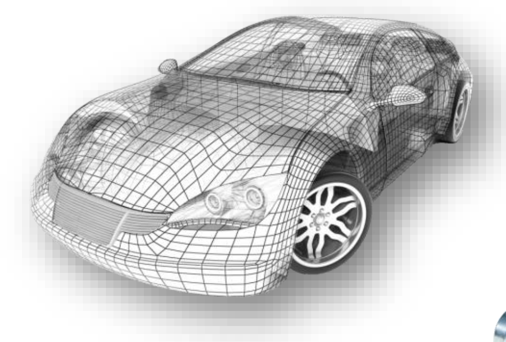
IPS2200

Industrial Version

Industrial Robots, Cobots etc
Automation
General Purpose Motors
Pumps
Small non Automotive Vehicles

IPS2550

Automotive Version

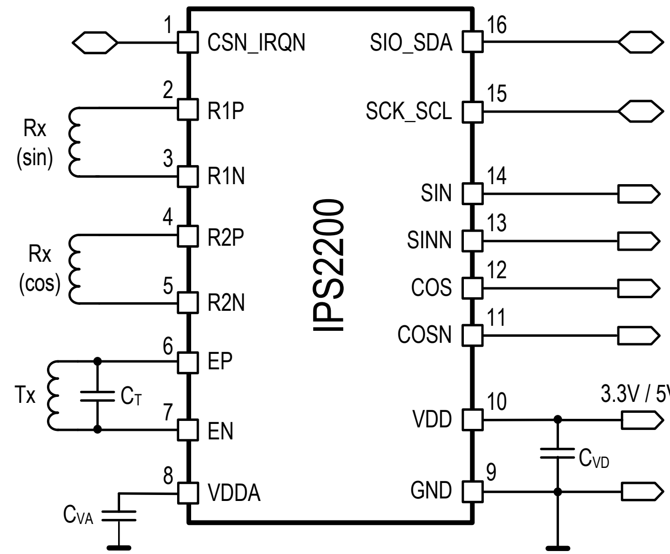


Traction Motors
Belt Starter Generators
Park Lock Actuators
EPS Motors
Pumps

IPS2200: High-Speed Position Sensor

Samples available

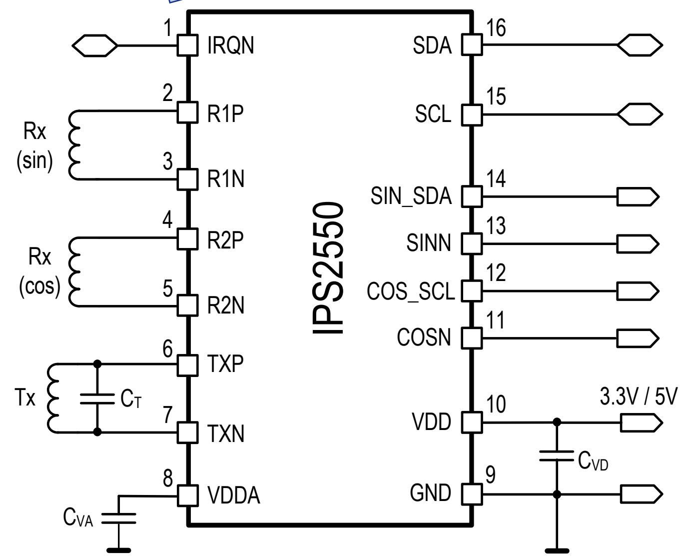
- Interface: sin/cos single ended or differential
- Qualified for Industrial market
- Temperature range: -40° to 125° C ambient
- Voltage Supply: 3.3V ±10% or 5.0V ±10%
- Rotational Speed: up to 250.000 (el) rpm
- Propagation delay: programmable; <10µs
- Overvoltage, reverse polarity, short-circuit protected
- Digital programming interface: I²C or SPI
- AB incremental pulse outputs
- Diagnostics interrupt to external MCU
- TSSOP-16



IPS2550: High-Speed Position Sensor

Samples available December 2019

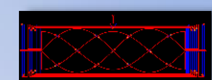
- Interface: sin/cos single ended or differential
- Automotive AECQ100 Grade-0 Designed & Qualified
- Temperature range: -40° to 160° C ambient
- FuSa: supports ASIL-C @ single, ASIL-D @ dual IC
- Voltage Supply: 3.3V ±10% or 5.0V ±10%
- Rotational Speed: up to 600.000 (el) rpm
- Propagation delay: 4µs
- Overvoltage, reverse polarity, short-circuit protected
- Programming over digital interface or analog outputs
- Diagnostics interrupt to external MCU
- AGC to compensate air-gap variations
- TSSOP-16 with exposed pad

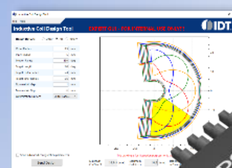


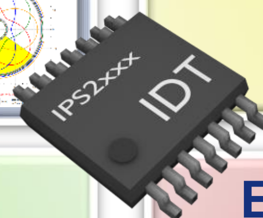
Robust support tools

PCB coil design

- Design (tool available for download)
- Gerber files
- Simulation (on request)
- Optimization (on request)
- Verification (fees apply)







Documentation

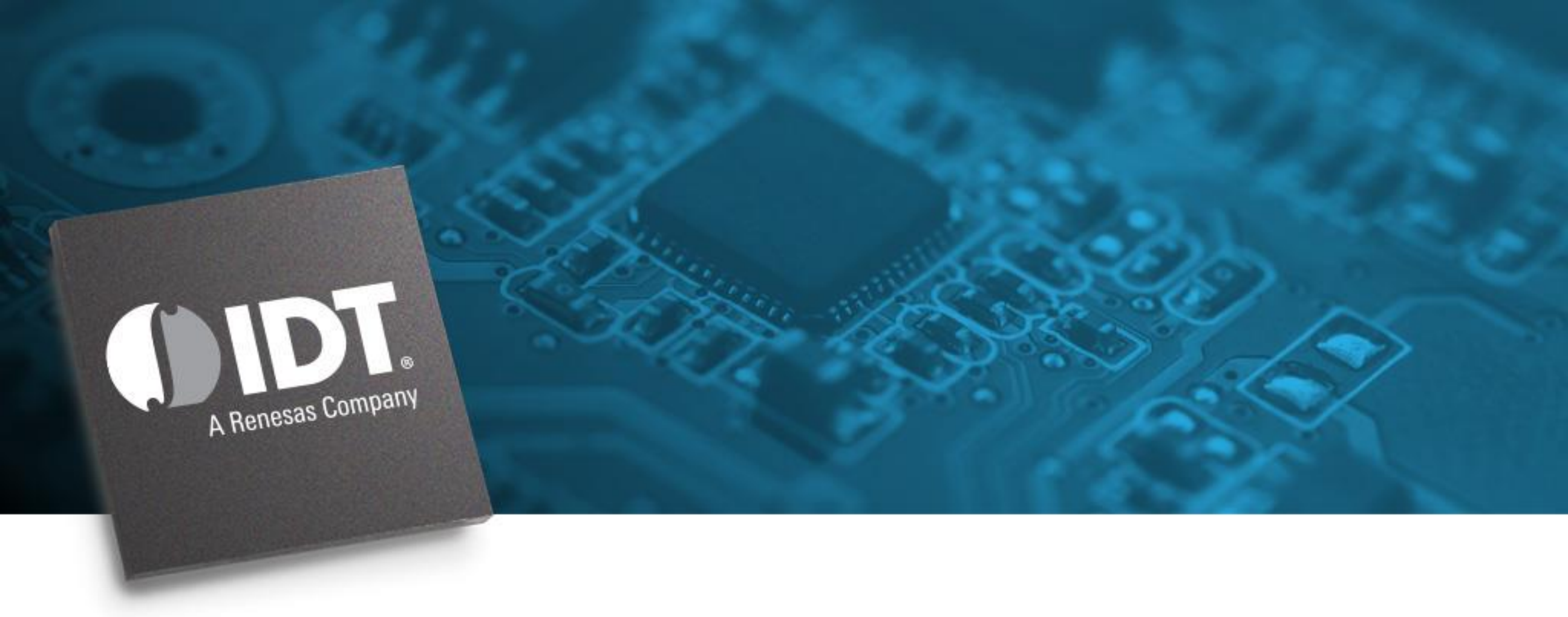
- Datasheets
- Application notes
- Calibration guide

Reference design and evaluation kits

- Gerber layout files (free to download)
- Evaluation kit (orderable)
- Reference Design Catalog

Expert support team

- FAEs
- Applications Engineering
- Systems Engineering



Thank You

Analog Mixed Signal Product Leadership in Growth Markets

See us at Hall 1, Booth 216

Inductive sensors: technical background

Sensor consists of one transmitter coil and two receiver coils, typically traces on a pcb

1st receiver coil = sine shape

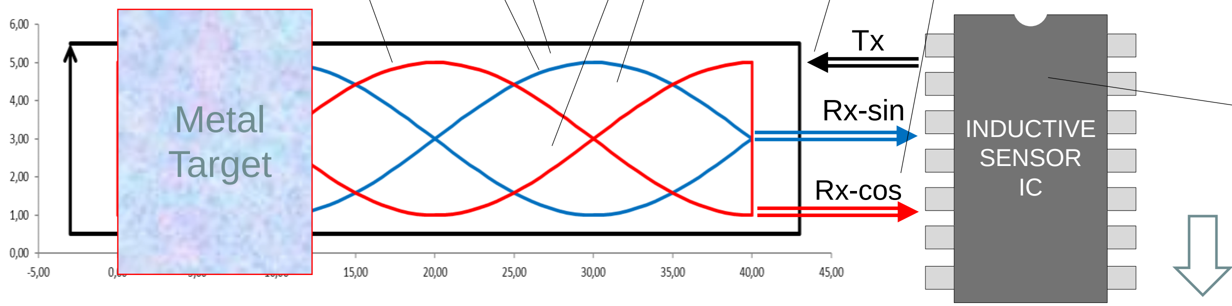
2nd receiver coil = shifted by 90°: cosine shape

Magnetic field induces voltages in the Rx coils.

IC drives high frequency AC current into the transmitter coil, generating an alternating magnetic field

Without target, the serial connection of alternating inverted / non-inverted coil loop segments provides zero output voltage.

IC amplifies, rectifies, and filters the receiver voltages



When a metal target is placed above the coils:
- Magnetic field induces eddy currents in target surface
- Eddy currents generate a counter magnetic field, reducing the flux density underneath the target
- Non-uniform flux density generates a voltage at the receiver coil terminals
- Amplitude and polarity of the Rx-sin / Rx-cos receiver coil voltages change with target position