

TMR Sensors

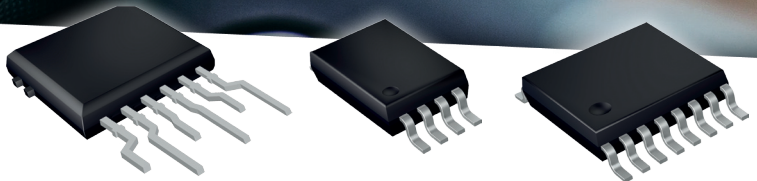
Products Guide for Automotive and Industrial Applications



BLDC



ANGLE



TAS214x, TAS414x, TAB4140, TAA6140, ASA 2310

TMR-Bridge Angle Sensors for Position Sensing Applications

TAS214x, TAS414x, TAB4140 and TAA6140 are highly sensitive analog TMR sensors. They are able to measure angles up to 360° with high accuracy and stability in a wide range of temperature and magnetic field variations.

TAS214x and TAS414x are pure TMR-bridge angle sensors providing SIN/COS outputs.

In addition to redundancy, TAB4140 and TAA6140 include an output amplification, well suited for remote applications.

As an alternative, the analog TMR sensors of the TAS family can be connected to the ASA 2310 – a signal conditioning IC for remote sensing applications with best-in-class EMC performance including enhanced applicative compensation features and safety supervision.

In combination with a microcontroller and a small piece of software these sensors offer outstanding angular measurement performances in safety-critical automotive applications.

Features

- Specialized angle sensor for use under harsh environmental conditions.
- High reliability and low FIT rates allow operation in safety-critical applications

- Simple circuitry and low number of external components allow fast and easy development.
- Diagnostic capability through direct monitoring of the sensor elements.
 - Dual- and triple-die version to reach highest safety standard
 - Optional signal amplification with differential or single-ended outputs
- In combination with simple algorithms running in micro-controllers, the remaining very low angular drift over temperature can be compensated and allows to be operated in the complete magnetic field range without any changes in angular precision.

Physical Characteristics

- Recommended supply voltage range: 3 V to 5.5 V
- Current consumption at 5 V
 - 2 mA (TAS214x)
 - 4 mA (TAS414x)
- Wide temperature range:
 $T_A = -40\text{ °C to }+150\text{ °C}$
- Wide magnetic field range:
 - 20 mT to 120 mT (standard range)
 - 80 mT to 120 mT (with lower accuracy)
 - higher magnetic fields with restrictions
- Angle accuracy:
 $\pm 0.6\text{ to }0.8\text{ deg. @ }20\text{ mT to }80\text{ mT}$

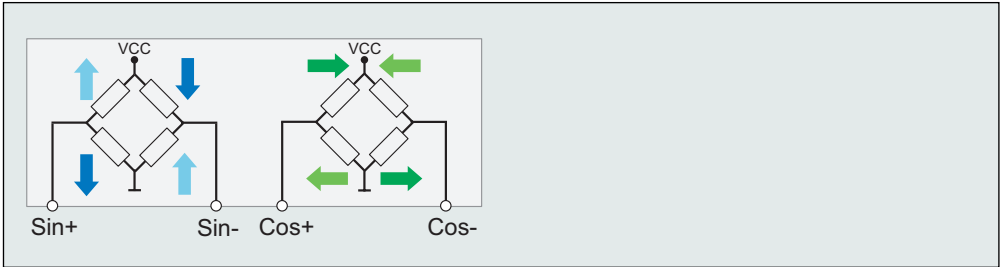
Typical Applications

- Absolute rotary angle sensor
- EPS motor-shaft angle sensor
- EPS angle sensor
- Throttle position sensor
- Resolver replacement

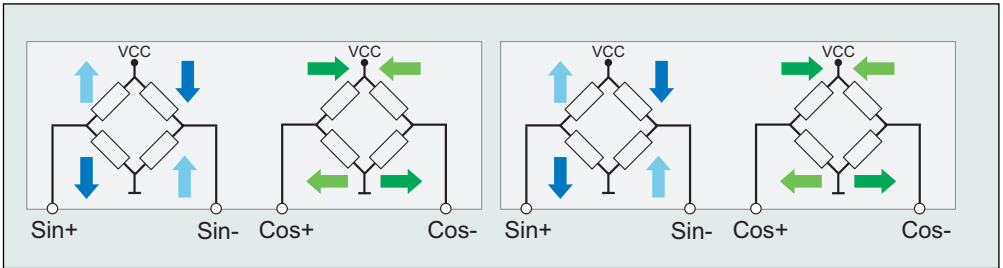
Benefits

- Very high output differential voltages (1.5 V_{PP} or 3.0 V_{PP}) at $V_{SUP} = 5\text{ V}$, allow direct connection to ADCs and provide high signal resolution over temperature
- Simple IC-controlled read-out of analog voltages
- “Fail safe” and ASIL D supported at system level (TAS414x, TAB4140, TAA6140)
- No external trimming components required
- Suitable for operation with wide range of supply voltages
- Small single-mold packages available:
 - TSSOP8 for TAS214x
 - TSSOP16 for TAS414x, TAB4140 and TAA6140
 - QFN16 for TAS4142
- AEC-Q100 qualified (Grade 0)

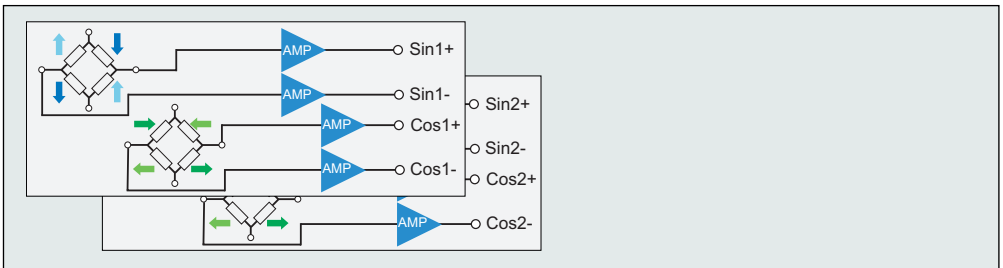
Internal Circuitry



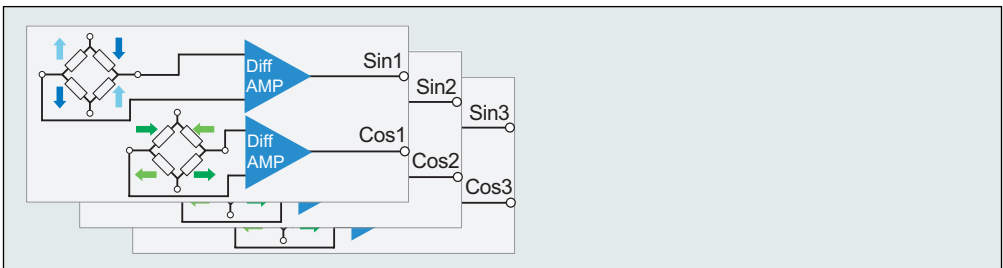
Internal circuitry of TAS214x (one die)



Internal circuitry of TAS414x (two dies)



Internal circuitry of TAB4140 (two dies)



Internal circuitry of TAA6140 (three dies)

Direction of pinned layer magnetization



TAD214x, TAD4140

High-Precision TMR Angle Sensors with Digital Output

TAD214x and TAD4140 are TMR angle sensors which allow absolute angle measurement of up to 360°. Based on the Tunnel Magneto-Resistive (TMR) effect, they offer high sensitivity and best angle accuracy needed for demanding automotive applications.

The internal digital signal processing allows outstanding angular measurement performance. Stability in a wide range of temperature, and magnetic field variations is also achieved.

The sensors are pre-calibrated at manufacturing and additionally offer in-application calibration modes.

The “Static compensation” targets the elimination of angle errors caused by mechanical misalignment between magnet and sensor.

In 360° multi-turn operation, TAD214x and TAD4140 achieve excellent angle accuracy by using the “Dynamic compensation” mechanism, which eliminates magnetic, temperature, and life-time effects.

TAD214x and TAD4140 support various output Interfaces such as UVW (Hall Switch Emulation Mode), PWM, ENC (Encoder Mode), SPI, SENT, and SPC.

To reduce system costs and provide automotive system level EMC/ESD protection, TAD2140 integrates six capacitors and one resistor.

Features

- Two TMR bridges including signal processor unit in one TO6 or TSSOP16 package
 - Fully redundant version with two signal processor units and two times two TMR bridges in one TSSOP16 package (TAD4140)
- Various and configurable digital outputs:
 - UVW (Hall Switch Emulation Mode)
 - PWM
 - ENC (Encoder Mode)
 - SENT SAE J2716 rev 3 (TAD2140)
 - SPI
- High EMC/ESD performance for automotive system level (TAD 2140)
- ASIL B ready device with several diagnostic functions and status reporting
- Internal diagnostic capability including direct monitoring of the sensor elements
- Continuous in-operation self-tests:
 - Magnet loss detection
 - Maximum rotation speed detection
 - Over/undervoltage detection
 - Internal sensor fails
 - Signal processing supervision
 - Register CRC

Physical Characteristics

- Performance-dependent current consumption down to 12.5 mA depending on interface
- Wide operating temperature range:
 - $T_A = -40\text{ °C}$ to 157 °C (TAD2140)
 - $T_A = -40\text{ °C}$ to 150 °C (TAD214x & TAD4140)
- Wide magnetic field range:
 - 20 mT to 80 mT (standard range)
 - 80 mT to 120 mT (with lower accuracy)
- Lowest deviation of angle error of just $\pm 0.05^\circ$ @ 20 mT to 80 mT at room temperature
- Guaranteed angle accuracy of $\pm 0.3^\circ$ in multi-turn application (TAD214x)

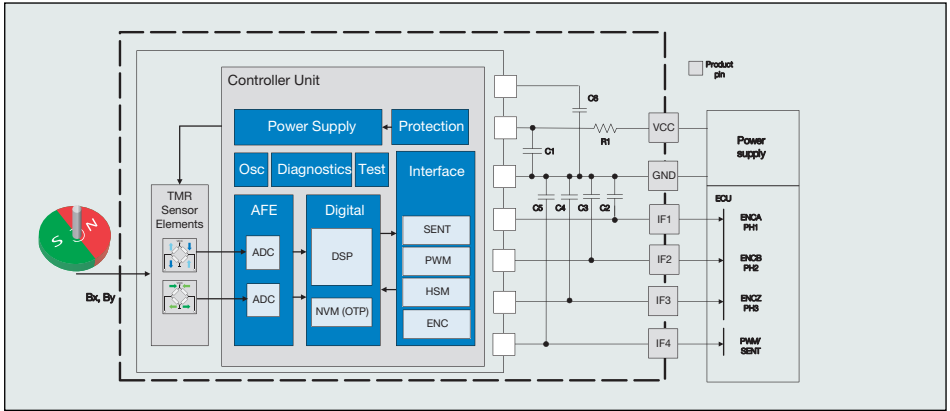
Typical Applications

- BLDC motor commutation e.g. for EPS, wiper
- Absolute angle sensor
- Resolver replacement

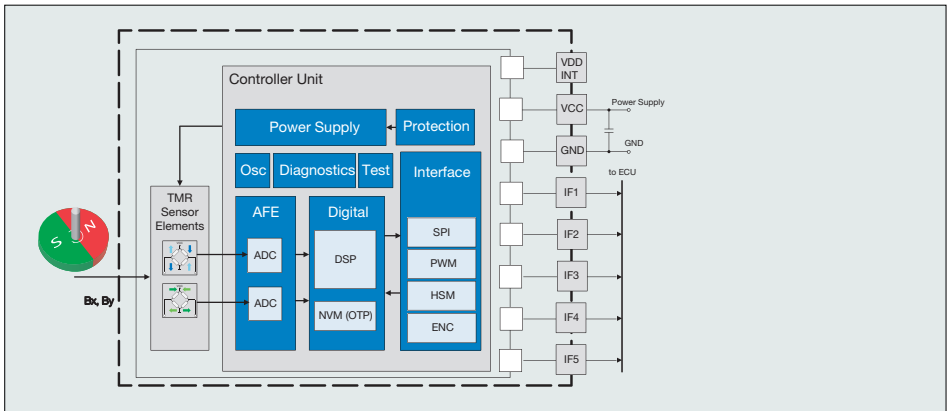
Benefits

- Fast response, high angular accuracy, and advanced compensation algorithms
- Support of ISO 26262: TAD214x rated ASIL B and TAD4140 rated ASIL D
- No PCB required (TAD2140)
- AEC-Q100 qualified (Grade 0)

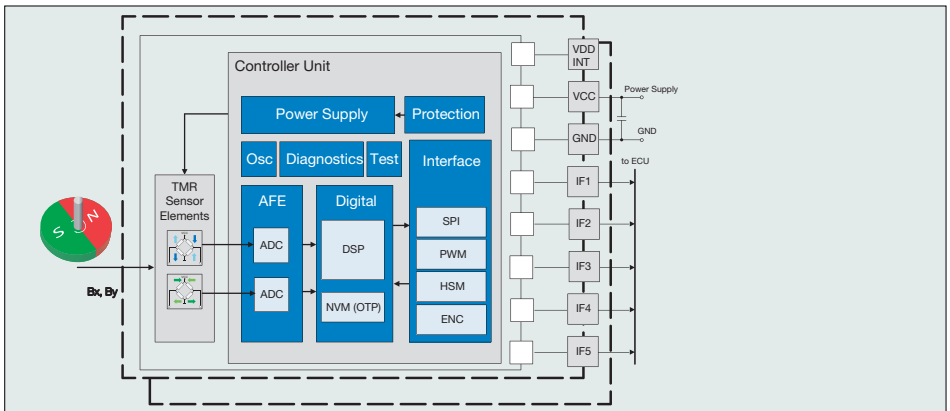
TAD2140, TAD214x, TAD4140



Block diagram of TAD2140 in TO6 package

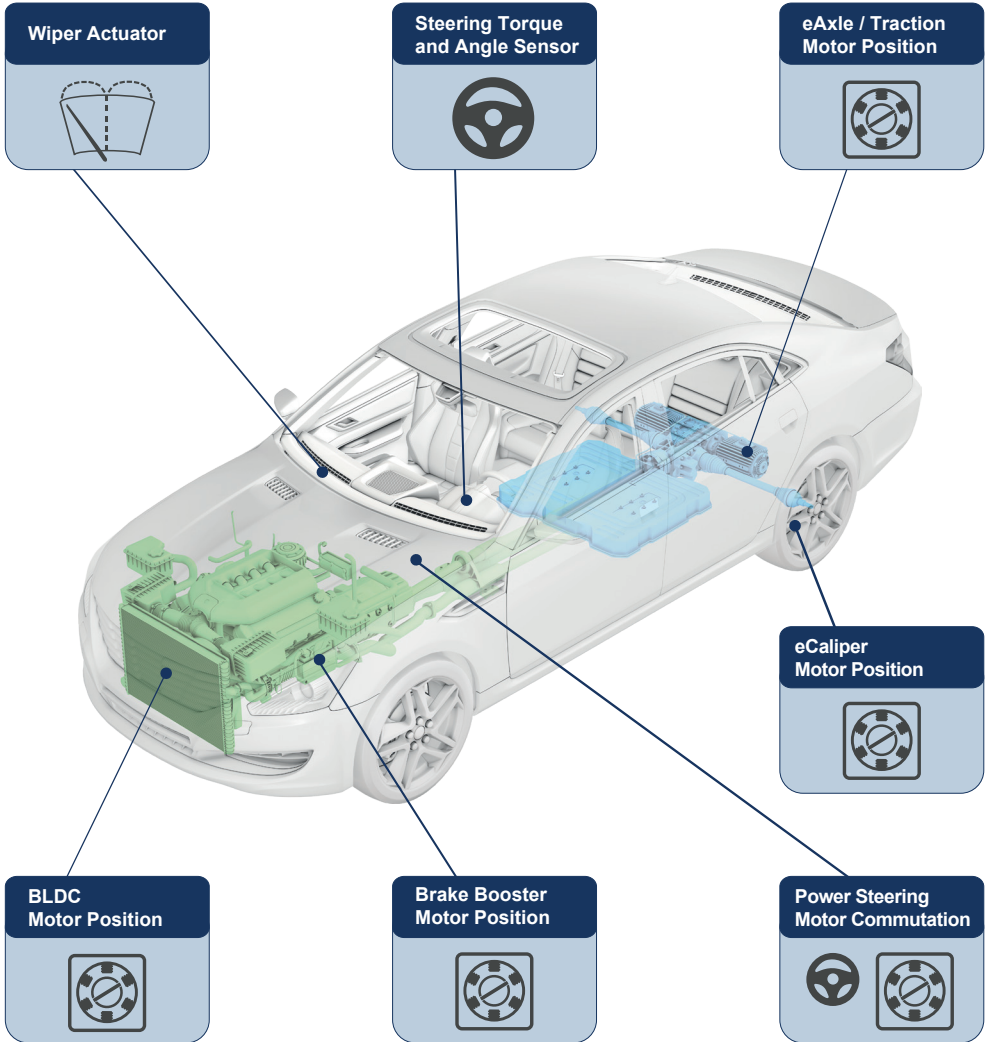


Block diagram of TAD214x



Block diagram of TAD4140 (version with redundancy functionality)

TMR Sensor Applications in a Car



Selection of Sensor Type

| | Analog Sensors | | | | | Digital Sensors | | | |
|---|--|--|--|--|---|---------------------------------|---------------------------------|------------------------------|------------------------------|
| Product Name | TAS2142 | TAS4140 | TAS4142 | TAB4140 | TAA6140 | TAD2140 | TAD2141 | TAD2143 ³⁾ | TAD4140 |
| Number of TMR Systems | 1 | 2 | | 3 | | 1 | | | 2 |
| Typical Angle Accuracy ¹⁾ (T _A =25 °C) | ±0.15° | ±0.1° | ±0.15° | ±0.1° | ±0.1° | ±0.05° | ±0.05° | ±0.05° | ±0.05° |
| Angle Accuracy (T _A =-40 to 150 °C) | ±0.6° | ±0.6° | ±0.8° | ±0.6° | ±0.8° | ±0.3° | ±0.3° | ±0.3° | ±0.35° |
| Output | Analog, Differential 3.0 V _{PP} Sin & Cos | 2 x Analog, Differential 1.5 V _{PP} Sin & Cos | 2 x Analog, Differential 3.0 V _{PP} Sin & Cos | 2 x Analog, Single-ended, amplified Sin & Cos | 3 x Analog, Differential amplified Sin & Cos | Digital (SENT, PWM, ENC, UVW) | Digital (SPI, PWM, ENC, UVW) | Digital (SPI, PWM, ENC, UVW) | Digital (SPI, PWM, ENC, UVW) |
| Number of Outputs | 4 | 8 | 8 | 8 | 6 | 1 | 2 ⁴⁾ | 2 ⁵⁾ | 4 ⁴⁾ |
| Temperature Range | T _A = -40..150 °C | | | | | T _A = -40..157 °C | T _A = -40..150 °C | | |
| Magnetic Field Range | 20...80 mT (typical) 80...120 mT (extended range) | | | | | | | | |
| Detection Range | 360° | | | | | | | | |
| Redundancy | - | YES | YES | YES | YES | - | - | - | YES |
| Self-Diagnosis | - | - | - | - | - | YES | YES | YES | YES |
| Integrated DSP (FSM) | - | - | - | - | - | YES | YES | YES | YES |
| Integrated Capacitors | - | - | - | - | - | YES | - | - | - |
| Packages | TSSOP8 | YES | - | - | - | - | - | - | - |
| | TSSOP16 | - | YES | YES | YES | YES | - | YES | YES |
| | QFN16 | - | - | YES | - | - | - | - | - |
| | TO6 | - | - | - | - | - | YES | - | - |
| Samples | Available | | | | | | | | |

¹⁾ Excluding lifetime drift

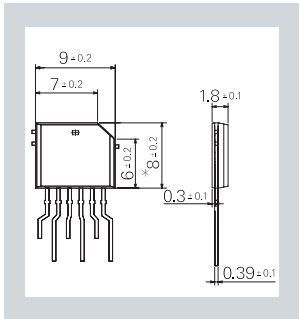
²⁾ Including lifetime drift

³⁾ Industrial grade only available

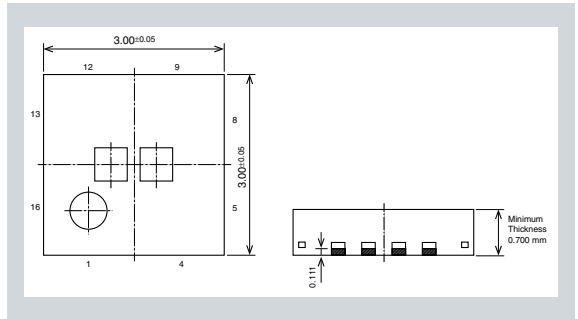
⁴⁾ Only dual outputs IF of SPI and PWM combinations are available.

⁵⁾ Selectable dual outputs IF configuration is available.

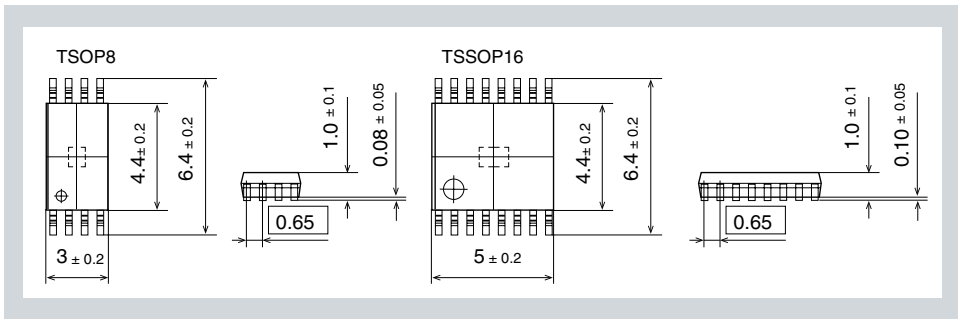
Packages for TMR Sensors



TO 6 package



QFN16 package



TSOP8 package

TSSOP16 package

About TDK Corporation

TDK Corporation is a world leader in electronic solutions for the smart society based in Tokyo, Japan. Built on a foundation of material sciences mastery, TDK welcomes societal transformation by resolutely remaining at the forefront of technological evolution and deliberately “Attracting Tomorrow.” It was established in 1935 to commercialize ferrite, a key material in electronic and magnetic products. TDK’s comprehensive, innovation-driven portfolio features passive components such as ceramic, aluminum electrolytic and film capacitors, as well as magnetics, high-frequency, and piezo and protection devices. The product spectrum also includes sensors and sensor systems such as temperature and pressure, magnetic, and MEMS sensors. In addition, TDK provides power supplies and energy devices, magnetic heads and more. These products are marketed under the product brands TDK, EPCOS, InvenSense, Micronas, Tronics and TDK-Lambda. TDK focuses on demanding markets in automotive, industrial and consumer electronics, and information and communication technology. The company has a network of design and manufacturing locations and sales offices in Asia, Europe, and in North and South America. In fiscal 2022, TDK posted total sales of USD 15.6 billion and employed about 117,000 people worldwide.

Further information about angle sensors can be found in the TDK Product Center on product.tdk.com.