TMR3102

TMR Magnetic Rotary Encoder

Description

The TMR3102 is a contactless, high-precision, and high-speed magnetic rotary encoder sensor, which integrated with tunneling magnetoresistance (TMR) sensors and CMOS digital signal processing circuitry.

The TMR3102 senses the single pole-pair magnet rotation above the chip by TMR sensors, collects the rotating magnetic field signal, transmits it to the digital processing unit, and calculates the rotation angle. TMR3102 outputs 12-bit absolute position signal through SPI communication protocol. At the same time, it is able to output analog and PWM signals, with rotational speed up to 20,000 RPM.

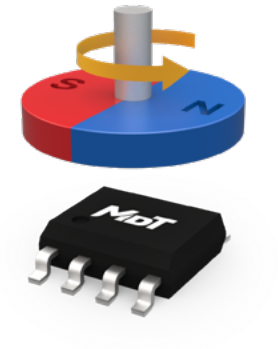
Features and Benefits

- Tunneling magnetoresistance (TMR) technology
- Contactless measurement
- Available in Analog and PWM interfaces output
- 12-bit absolute position output in SPI mode
- Programmable zero position
- Angular repeatability < ±0.2°
- Speeds up to 20,000 RPM
- Adaptive supply voltage: 3.3 V to 5 V
- RoHS & REACH compliant

Applications

- Contactless angular position measurement
- Brushless motor position sensing
- Rotary speed sensing
- Rotary angular sensing

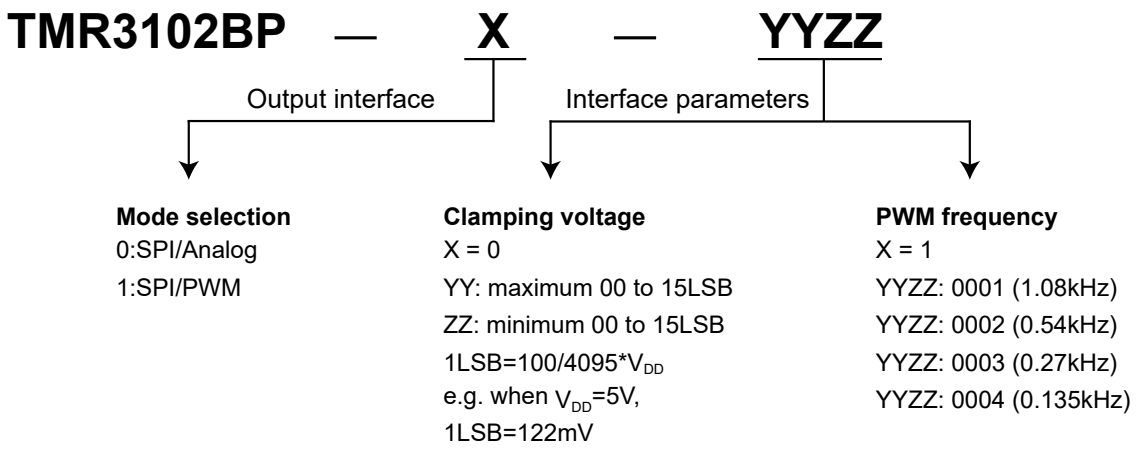
SOP8



Selection Guide

Part Number(*)	Output Interface	SPI Interface Voltage	Operating Temperature	Package	Packing Form
TMR3102BP-0-0000	SPI / Analog	3.3 V to 5 V	-40 °C to 125 °C	SOP8	Tape & Reel
TMR3102BP-1-0001	SPI / PWM	3.3 V to 5 V	-40 °C to 125 °C	SOP8	Tape & Reel

Note: *Please contact MDT local sales representative for more model's information.



Catalogue

1. Pin Configuration

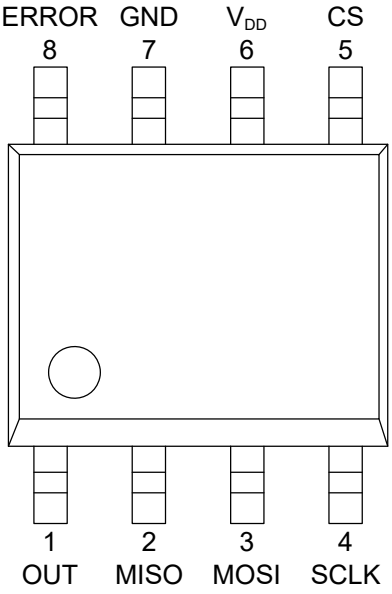


Figure 1. Pin configuration (SOP8)

Pin Number	Name	Input/Output	Signal type	Function
1	OUT	Output	Analog or digital	Analog linear output or PWM output
2	MISO	Output	Digital	SPI data out
3	MOSI	Input	Digital	SPI data in
4	SCLK	Input	Digital	SPI clock
5	CS	Input	Digital	SPI chip select
6	V_{DD}	Input	Power supply	Power supply
7	GND	Input	GND	GND
8	ERROR	Output	Digital	Error signal

2. Functional Block Diagram

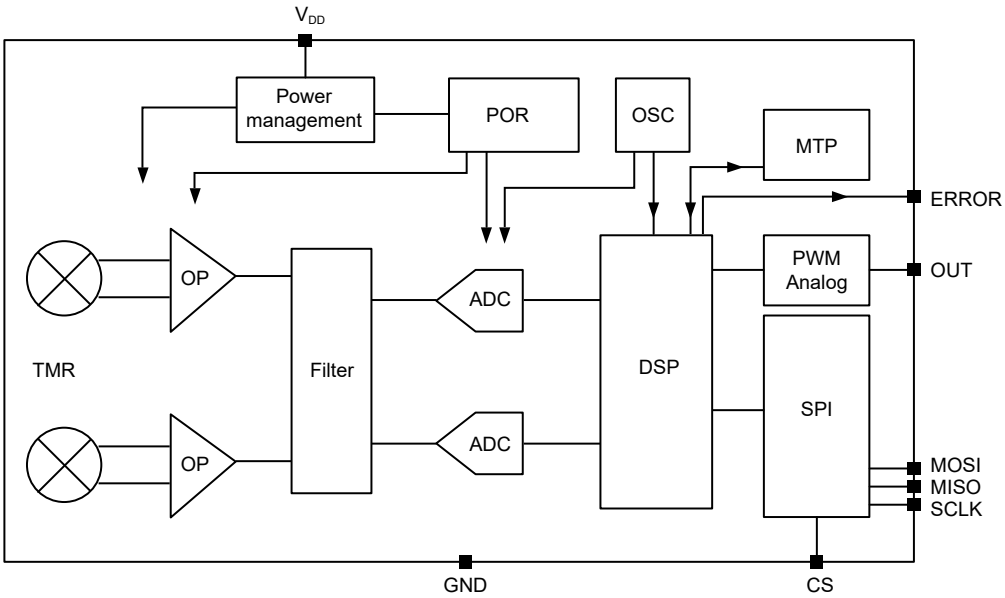


Figure 2. TMR3103 functional block diagram

Block	Function
TMR	TMR sensor element
OP	Amplifier
Filter	Filter
ADC	Analog-to-digital converter
DSP	Digital signal processing
POR	Power-on reset
Power management	Power management
SPI	SPI output interface
OSC	Oscillator
MTP	Multiple-Time Programmable memory
PWM / Analog	Pulse-width modulation signal / Analog output interface

3. Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit
Supply voltage	V_{DD}	-	6	V
Magnetic flux density	B	-	4000	Gs
Operating ambient temperature	T_A	-40	125	°C
Storage ambient temperature	T_{STG}	-40	150	°C
Ambient humidity (no dew)	HMD	10	90	%RH
ESD performance (HBM)	V_{ESD}	-	2	kV

The Absolute Maximum Rating parameters is only a condition to ensure that the chip is not permanently damaged. For normal operating conditions, please refer to Electrical Specifications.

4. Electrical Specifications

V_{DD} = 3.3 V to 5 V, T_A = 25 °C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	V_{DD}	-	3.3	-	5	V
Supply current	I_{DD}	No output load	-	8	10	mA
MISO output voltage	V_{OUT}	-	-0.3	-	V_{DD}	V
MISO output current	I_{OUT1}	-	-1.25	-	1.25	mA
Input voltage	V_{IN1}	MOSI, CS, SCLK	-0.3	-	V_{DD}	V

5. Signal Conversion Specifications

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Measurement range	A_{range}	-	0	-	360	Deg
Absolute resolution	RES_{SDC}	-	-	12	-	bit
Nonlinearity error	INL_{OPT}	-	-	-	±1	Deg
Nonlinearity error in full temperature range	INL_{drift}	-40 °C to 125 °C	-	-	±1.2	Deg
Differential nonlinearity	DNL	-	-	-	±0.132	Deg
Hysteresis	HYS	-	-	-	±0.308	Deg
Repeatability	A_{repeat}	-	-	-	±0.2	Deg
Output delay	T_D	-	-	5	10	μs
Rotation speed	R_{speed}	-	-	-	20000	RPM

6. Digital Interface Signals

CS, SCLK, MOSI, MISO

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Input threshold high	$V_{I(HI)}$	-	3.3	-	-	V
Input threshold low	$V_{I(LO)}$	-	-	-	1	V
Output threshold high	$V_{O(HI)}$	I = 1 mA	V_{DD} - 0.5	-	-	V
Output threshold low	$V_{O(LO)}$	I = 1 mA	-	-	0.5	V
Output load capacitance	C_L	-	-	-	100	pF

7. Analog Output Characteristics

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Output load resistance	R_L	-	-	10	-	kΩ
Output load capacitance	C_L	-	-	10	-	nF
Minimum resolution of digital-to-analog conversion	DAC_{LSB}	12bit	-	0.024	-	$\%V_{DD}$
Integral nonlinearity of digital-to-analog conversion	DAC_{INL}	-	-	-	±1.5	Deg
Differential nonlinearity of digital-to-analog conversion	DAC_{DNL}	-	-	-	±0.5	Deg
Analog output noise	DAC_{noise}	-	-	-	±2	LSB
Proportional error	E_{rm}	-	-0.3	-	0.3	%

8. PWM Characteristics

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
PWM frequency	F_{PWM}	Programmable	-10 %	1.08 0.54 0.27 0.135	+10 %	kHz
Rise time	t_{rise}	10 nF load	-	-	1	μs
Fall time	t_{fall}	10 nF load	-	-	1	μs

9. Magnetic Field Specification

Recommended magnet: cylindrical NdFeB magnet, Φ6 mm × 2.5 mm, radial magnetization

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Diameter of magnet	d_{mag}	-	3.0	6.0	20	mm
Thickness of magnet	t_{mag}	-	-	2.5	-	mm
Mounting distance	D_{in}	Recommend magnet (Φ6 mm)	-	6	-	mm
Magnetic field	H_{ext}	Sensor surface	-	300	-	Gs
Center deviation between magnet and sensor	x_{dis}	-	-	-	0.25	mm
Center deviation between sensor and package	x_{pac}	-	-0.15	-	0.15	mm
Angle deviation of the sensor within package	φ_{pac}	-	-3	-	3	Deg
Sensor to package clearance	h_{pac}	-	-	0.4	-	mm

10. Output mode

10.1 SPI output

TMR3102 provides the 4-wire SPI interface for user programming in common mode 1 (CPOL = 0, CPHA = 1). Data communication is only enabled when the CS pin is set to “L”. The MOSI pin carries the serial input data that will be written to the IC upon the falling edge of the SCLK signal. The serial output data is available to read at the MISO pin upon the rising edge of the SCLK signal.

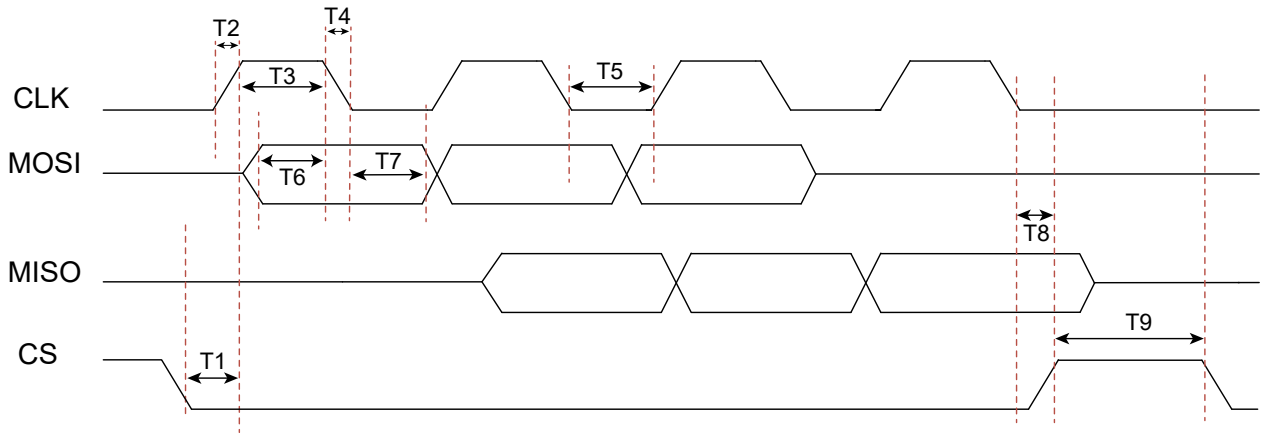


Figure 3. SPI timing diagram

Signal	Definition	Min.	Typ.	Max.	Unit
T1	SPI start-up time	-	150	-	ns
T2/T4	Clock signal rising/falling time	-	-	25	ns
T3	Clock signal HIGH period	150	-	-	ns
T5	Clock signal LOW period	150	-	-	ns
T6	Input signal setup time	100	-	-	ns
T7	Input signal sampling hold time	100	-	-	ns
T8	SPI closing time	-	150	-	ns
T9	SPI reading interval	4	-	-	μs

Reading angular values

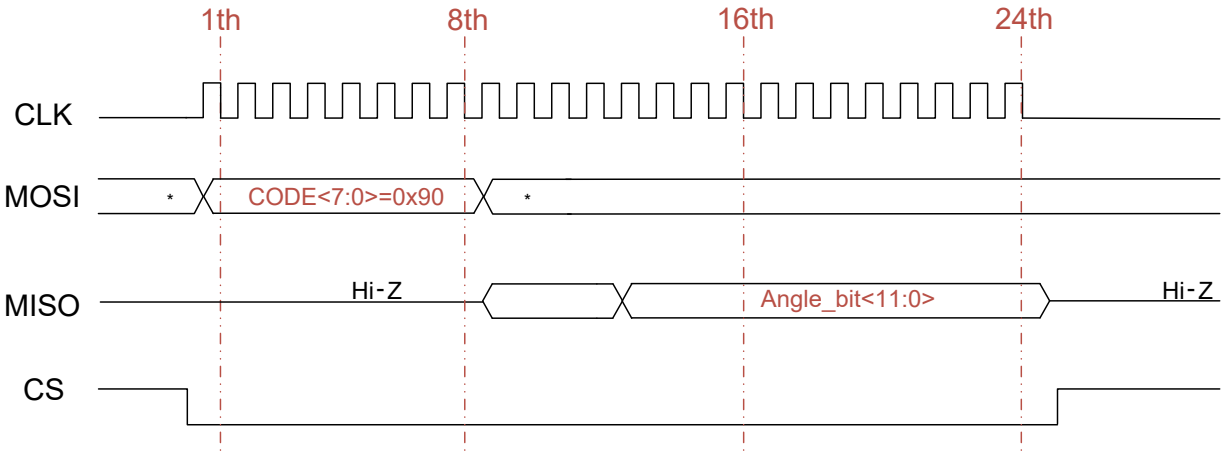


Figure 4. SPI timing diagram in reading angular values

Opcode< 7:0 >=0 x 90 (MSB first), angular value output < 11:0 > (MSB first)

The absolute angular value θ in 0° to 360° can be calculated from the equation below:

$$\theta = \frac{\sum_{i=0}^{11} 2^{Angle<i>}}{4096} \times 360°$$

10.2 Analog output

TMR3102 integrates a 12-bit ADC to convert absolute angle to linear analog output. The output mode needs to be programmed to be an analog voltage output as shown in Figure 5.

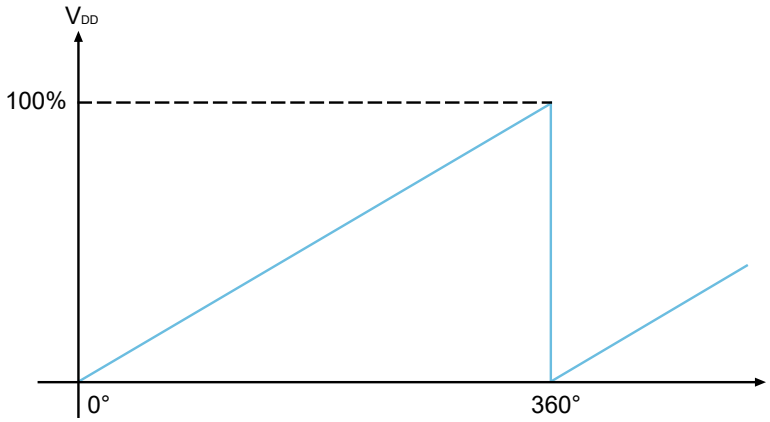


Figure 5. Waveform of analog output

A typical application circuit for analog mode is provided in Figure 6. It is recommended to connect an external decoupling capacitor C1 (typical value 10 nF, maximum 100 nF) and pull-up resistor R1 (typical value 10 kΩ) for analog output circuit to obtain better performance.

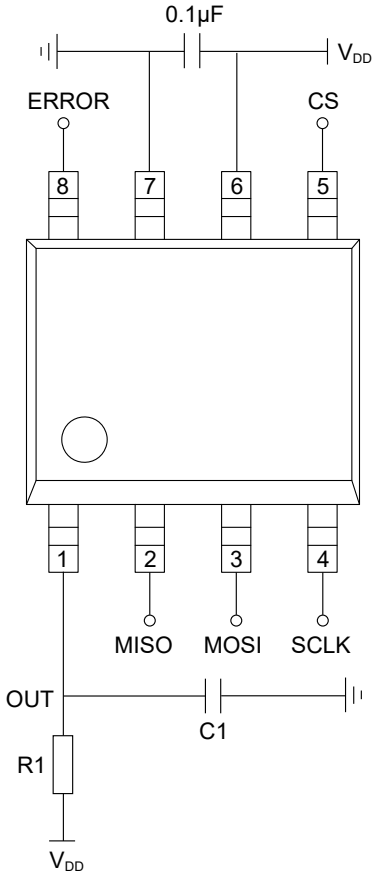


Figure 6. Schematic circuit of analog mode

The high clamping voltage (Clamp_High) and low clamping voltage (Clamp_Low) of analog output characteristic curves are both programmable as shown in Figure 7.

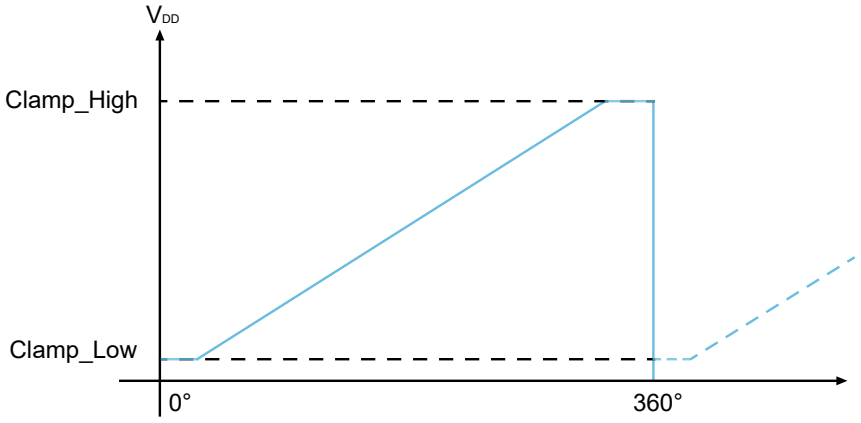


Figure 7. Schematic of clamping voltage in analog waveform

The xMR310X calibration kit and corresponding host computer software is provided for the convenience of customer calibration and settings. The clamping voltage in analog mode of TMR3102 sensor can be set by this xMR310X calibration kit.

10.3 PWM output

TMR3102 supports pulse width modulation (PWM) output. The duty cycle of PWM is a logic signal which proportional to the magnetic field angle. The duty cycle is limited by the minimum value (1/4096 of the period) and the maximum value (4095/4096 of the period), so the duty cycle varies from 1/4096 to 4095/4096 with the resolution of 12-bits. Figure 8 shows one period of the PWM signal, and the period (T) is $1/F_{PWM}$。

F_{PWM} supports 1.08 kHz, 0.54 kHz, 0.27 kHz, and 0.135 kHz these four frequencies.

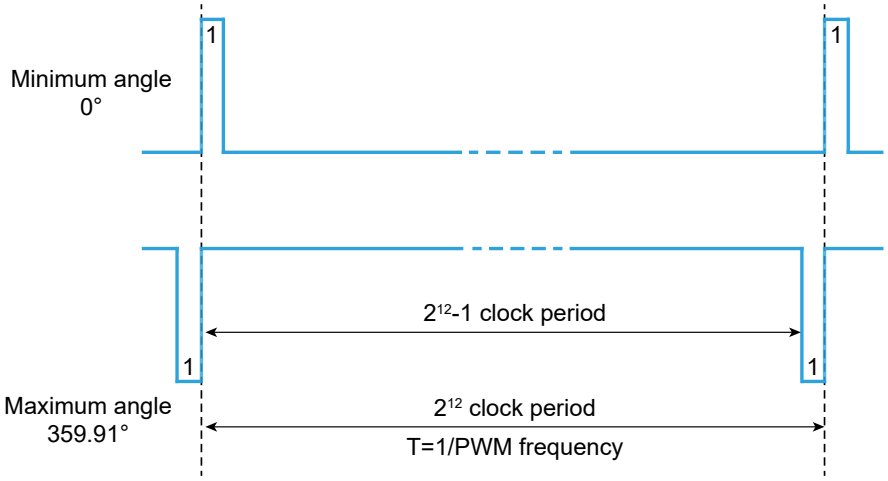


Figure 8. Waveform of PWM mode output signal

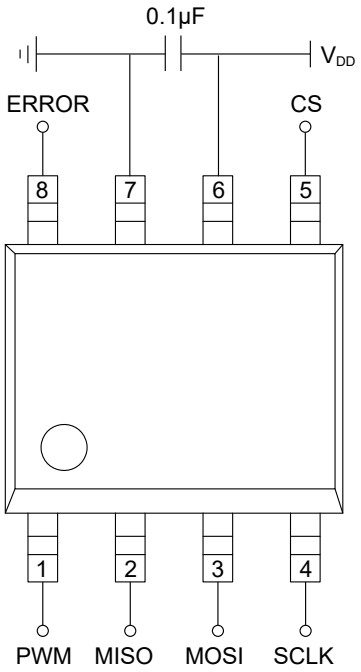


Figure 9. Schematic circuit of PWM mode

The xMR310X calibration kit and corresponding host computer software is provided for the convenience of customer calibration and settings. The output mode and the PWM frequency of TMR3102 sensor can be set by this xMR310X calibration kit.

11. Mechanical Angle Orientation

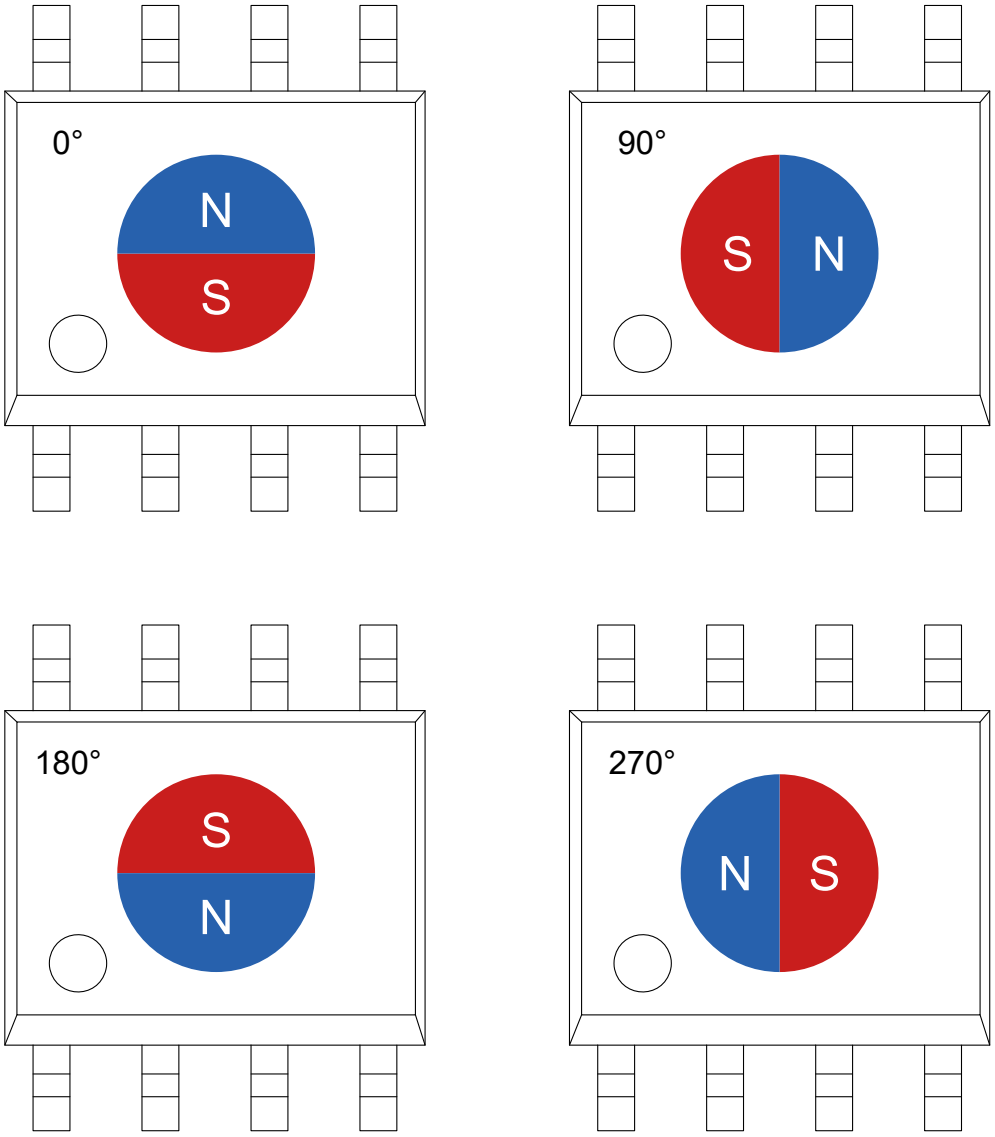


Figure 10. Definition of the magnetic field orientation measured by TMR3102

12. Dimensions

SOP8 Package

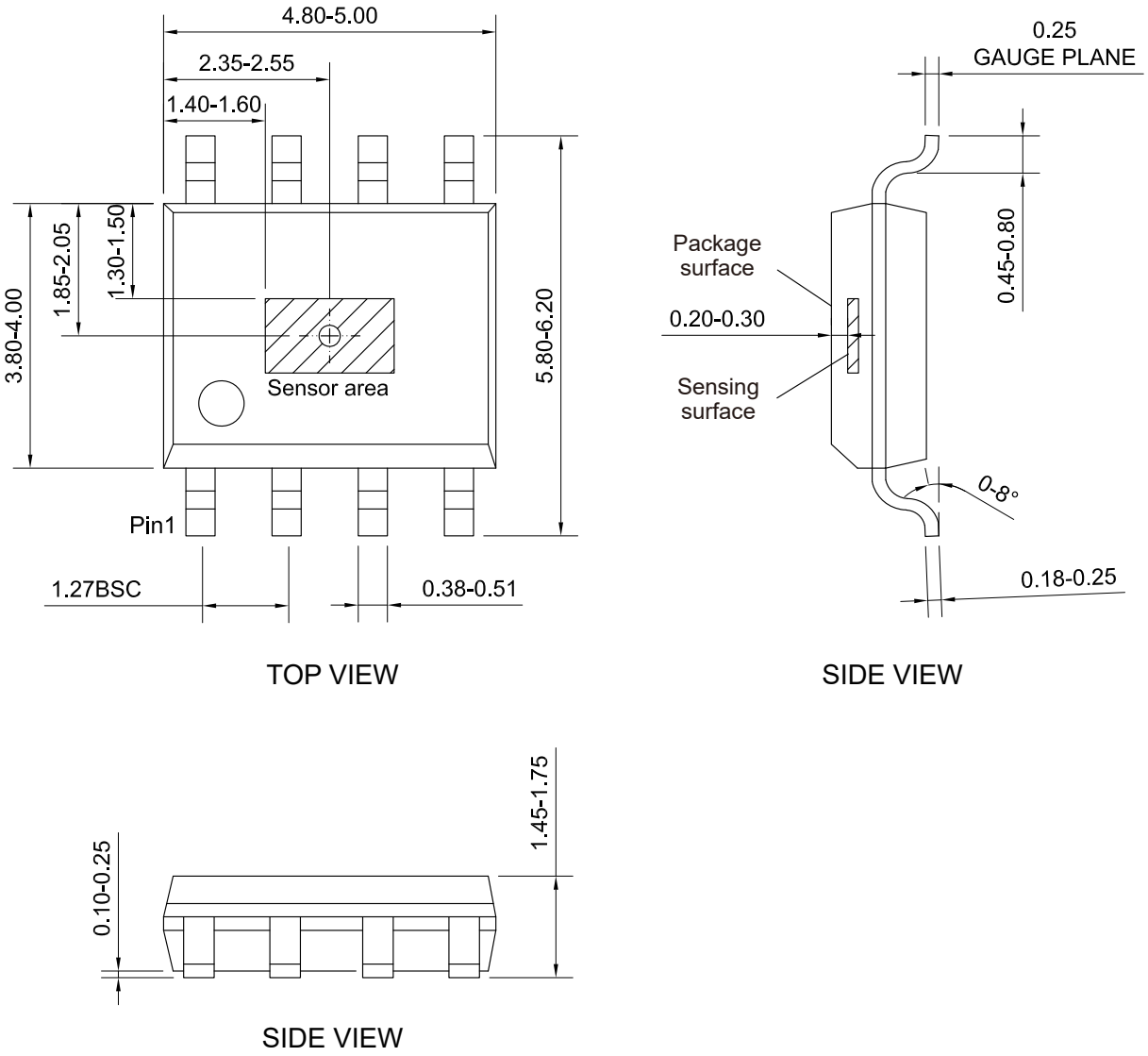


Figure 11. Package outline of SOP8 (unit: mm)

Recycling

The product(s) in this document need to be handed over to a qualified solid waste management services company for recycling in accordance with relevant regulations on waste classification after the end of the product(s) life.

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