

TLE500x
TLE501x
GMR-Based Angular Sensor

Application Note
GMR Angle Error Extension

V 1.2

Sensors



Never stop thinking

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TLE500x GMR-Based Angular Sensor

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Page	Subjects (major changes since last revision)
All	Term “accuracy” was changed with “angle error” for better formulation
7	Corrected Cross-references

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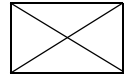


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1 Influences on iGMR angle sensor error

The specification of iGMR sensor components defines absolute angle error for certain defined operating conditions (magnetic field range, temperature). Typically the sensor elements operate well for operating conditions outside the given range of the specification. This application note quantifies the impact to the overall angle error of iGMR sensors, namely the TLE5009, TLE5011, TLE5012 and TLE5012B. All angle errors listed relates to the **angle error including lifetime drift and temperature variation**.

This application note describes the main contributors impacting iGMR angle error and explains how to calculate the resulting angle error if operating the devices under different magnetic field and temperature ranges.

Main contributors for

- **Increased magnetic fields in combination with elevated temperatures** results in increased lifetime drift of the device. This angle error adder is not present at 0 hour operation but happens irreversibly over lifetime operation. On the other side, a reduced temperature ranges offers the potential to operate the iGMR sensor at higher magnetic fields without any impact on the specified angle error. In [Section 2.4](#) these angle error adders are quantified.
- Operation of the iGMR sensor at lower magnetic fields than specified leads to an increased angle error due to anisotropy and hysteresis effects. This angle error is completely reversible, it appears if the magnetic field drops below the value given in the specification and it immediately disappears after re-entering the specified magnetic field range.

Both effects are cumulative and must be added. The calculation of the final resulting angle error is done in the following manner.

Specified angle error given the product datasheet (base angle error)

PLUS

Angle error adder due to increased magnetic fields (see [Figure 1](#))

PLUS

Angle error adder due to operation at lower magnetic fields (see [Figure 2](#))

Some exemplary calculations are done in [Section 2](#). In [Section 2.4](#) you can find for each product tables with the maximum angle error adder for all evaluated operating conditions. The "base angle error" has to be taken from the datasheet of each product.

1.1 Angle error impact of increased magnetic fields as function of temperature

Increased magnetic fields in combination with elevated temperatures results in increased lifetime drift of the device. This angle error adder is not present at 0 hour operation but happens irreversibly over lifetime operation. On the other side, reduced temperature ranges offer the potential to operate the iGMR sensor at higher magnetic fields without any impact on the specified angle error.

The magnetic fields in the table below refer to the magnetic field applied at room temperature. The evaluation was done using magnets with a temperature coefficient of $-0,13\%/K$ and assumes that the magnet faces the same temperature as the sensor.

Valid for TLE5012(B), TLE5011, TLE5009		Maximum magnetic field @ 25°C	
		60mT	70mT
Max. operating temperature Tj	150°C	0,16°	0.32°
	125°C	0,10°	0,21°
	100°C	0°	0.10°
	85°C	0°	0°

Figure 1 Angle error impact of increased magnetic fields as function of temperature

1.2 Angle error impact due to operation at lower magnetic fields than specified

Operation of the iGMR sensor at lower magnetic fields than specified leads to an increased angle error due to anisotropy and hysteresis effects. This angle error is completely reversible, it appears if the magnetic field drops below the value given in the specification and it immediately disappears after re-entering the specified magnetic field range.

The magnetic fields in the table below refer to the magnetic field applied at room temperature. The evaluation was done using magnets with a temperature coefficient of -0,13%/K and assumes that the magnet faces the same temperature as the sensor.

Product	Adder if operating down to	
	25mT	20mT
TLE5011, TLE5012(B)	0,1°	0.2°
TLE5009	0°	0,1°

Figure 2 Angle error impact due to operation at lower magnetic fields than specified

2 Calculation Examples

This section shows some practical examples of how the angle error is modified when extending the magnetic range.

2.1 TLE5012 and TLE5012B with 30-70mT @ -40°C to 150°C

The **TLE5012** and **TLE5012B** have a specified angle error of **1°** over lifetime and temperature including autocalibration as far as the magnetic field is within the specified range of **30-50 mT**.

If the **TLE5012** or **TLE5012B** are used with an increased magnetic field range of **30-70mT** it can be done, knowing that the angle error would be modified as shown in [Figure 1](#) and [Equation \(1\)](#).

Angle error modification 50-70 mT (1)

$$1^{\circ} + 0,32^{\circ} = 1,32^{\circ}$$

2.2 TLE5012 and TLE5012B with 20-50mT @ -40°C to 150°C

The **TLE5012** and **TLE5012B** have a specified angle error of **1°** over lifetime and temperature including autocalibration as far as the magnetic field is within the specified range of **30-50 mT**.

If the **TLE5012** or **TLE5012B** are used with a decreased magnetic field range of **20-50mT** it can be done, knowing that the angle error would be modified as shown in [Figure 2](#) and [Equation \(2\)](#) and [Equation \(3\)](#)

Angle error modification 20-25 mT (2)

$$1^{\circ} + 0,2^{\circ} = 1,2^{\circ}$$

Angle error modification 25-30 mT (3)

$$1^{\circ} + 0,1^{\circ} = 1,1^{\circ}$$

Now the worst case is taken, which would be [Equation \(2\)](#), **1,2°** angle error.

2.3 TLE5012 and TLE5012B with 20-70mT @ -40°C to 150°C

The **TLE5012** and **TLE5012B** have a specified angle error of **1°** over lifetime and temperature including autocalibration as far as the magnetic field is within the specified range of **30-50 mT**.

If the **TLE5012** or **TLE5012B** are used with an extended magnetic field range of **20-70mT** it can be done, knowing that the angle error would be modified as shown in [Figure 1](#) and [Figure 2](#) and [Equation \(4\)](#), [Equation \(5\)](#) and [Equation \(6\)](#)

Angle error modification 20-25 mT (4)

$$1^{\circ} + 0,32^{\circ} + 0,2^{\circ} = 1,52^{\circ}$$

Angle error modification 25-30 mT (5)

$$1^{\circ} + 0,32^{\circ} + 0,1^{\circ} = 1,42^{\circ}$$

Angle error modification 50-70 mT (6)

$$1^{\circ} + 0,32^{\circ} + 0,0^{\circ} = 1,32^{\circ}$$

Now the worst case is taken, which would be [Equation \(4\)](#), **1,52°** angle error.

2.4 Angle error for different operating conditions

The following tables give the angle error adders at different operating conditions that comes on top to the values given in the specification.

		Max operating temp. T _j			
		85°C	100°C	125°C	150°C
Magnetic field range @25°C	30-50 mT	0,00°	0,00°	0,00°	0,00°
	30-60 mT	0,00°	0,00°	0,10°	0,16°
	30-70 mT	0,00°	0,10°	0,21°	0,32°
	25-50 mT	0,10°	0,10°	0,10°	0,10°
	25-60 mT	0,10°	0,10°	0,20°	0,26°
	25-70 mT	0,10°	0,20°	0,31°	0,42°
	20-50 mT	0,20°	0,20°	0,20°	0,20°
	20-60 mT	0,20°	0,20°	0,30°	0,36°
	20-70 mT	0,20°	0,30°	0,41°	0,52°

Figure 3 Angle error adder for different operating conditions for TLE5011, TLE5012 and TLE5012B

		Max operating temp. T _j			
		85°C	100°C	125°C	150°C
Magnetic field range @25°C	25-50 mT	0,00°	0,00°	0,00°	0,00°
	25-60 mT	0,00°	0,00°	0,10°	0,16°
	25-70 mT	0,00°	0,10°	0,21°	0,32°
	20-50 mT	0,10°	0,10°	0,10°	0,10°
	20-60 mT	0,10°	0,10°	0,20°	0,26°
	20-70 mT	0,10°	0,20°	0,31°	0,42°

Figure 4 Angle error adder for different operating conditions for TLE5009

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