Scope

This application note provides some guidelines to select a magnet to be used in combination with the MLX90316. Only the End-of-Shaft magnetic circuit is considered and the associated performances vs. eccentricity (i.e. off-axis between the magnet rotating center and the sensitive area of the IC) are shown for several magnets.

Note: Through-Shaft (or Hollow Shaft) magnetic circuit will be described in a separate forthcoming Application Note.

Related Documents, Products and Tools

The documentation and information on the products and tools listed below can be found on Melexis website www.melexis.com

Related Products

MLX90316 Tria⊗is™ Rotary Position Sensor
MLX91204 Sine/Cosine Tria⊗is™ Rotary Position Sensor

Related Documents

Applications Note Front-End Calibration
Applications Note Back-End Calibration (Release in May 06)
Applications Note Hall Applications Guide

Related Tools

PTC04 Programmer for Melexis PTC devices

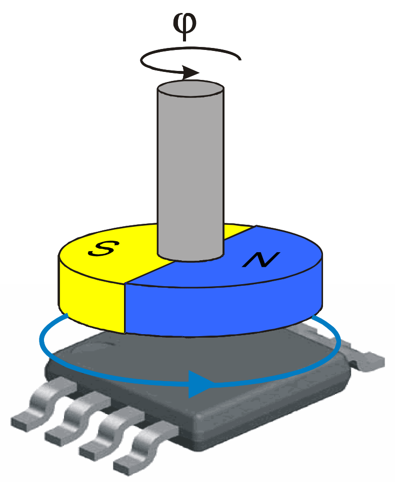


Figure 1 – MLX90316

Introduction

The Tria⊗is™ Rotary Position Sensor measures the two orthogonal components of a magnetic field applied parallel to the IC surface. The Figure 1 shows a typical example of an End-of-Shaft Application for which a diametrally magnetized magnet is rotating above the IC. In the sensor plane, the two components of the flux density (i.e. B_X and B_Y) represent a sine- and cosine-wave while the magnet rotates (Figure 2). With the integrated DSP (Digital Signal Processing) circuit those signals are transformed into a linear angular information (0 to 360 Deg) through an arctangent operation on the ratio V_Y/V_X.

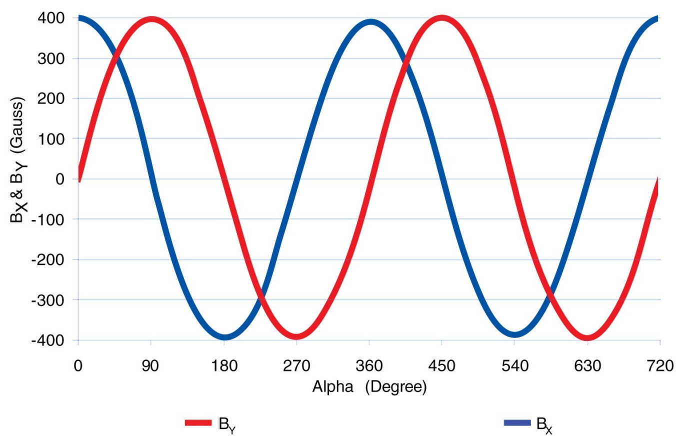


Figure 2 – B_X and B_Y for the Figure 1

Mechanical Description

The mechanical alignment between axis of rotation, magnet position and sensor position strongly determines measurement accuracy. Mechanical alignment errors (Figure 3) can result in additional offset, phase shift, amplitude change and non-linearity vs. the ideal Sine and Cosine output curves.

Whereas offset, phase and amplitude are easily trimmed and compensated at the IC level (see the Application Note on the Front-End Calibration of MLX90316), linearity errors due to off-axis (between sensor and the rotating magnet) in the XY plane (eccentricity) are ideally compensated though a linearization of the output transfer characteristic. In most cases the best solution is to choose a magnet big enough to limit linearity to a tolerable value for the predefined mechanical tolerances.

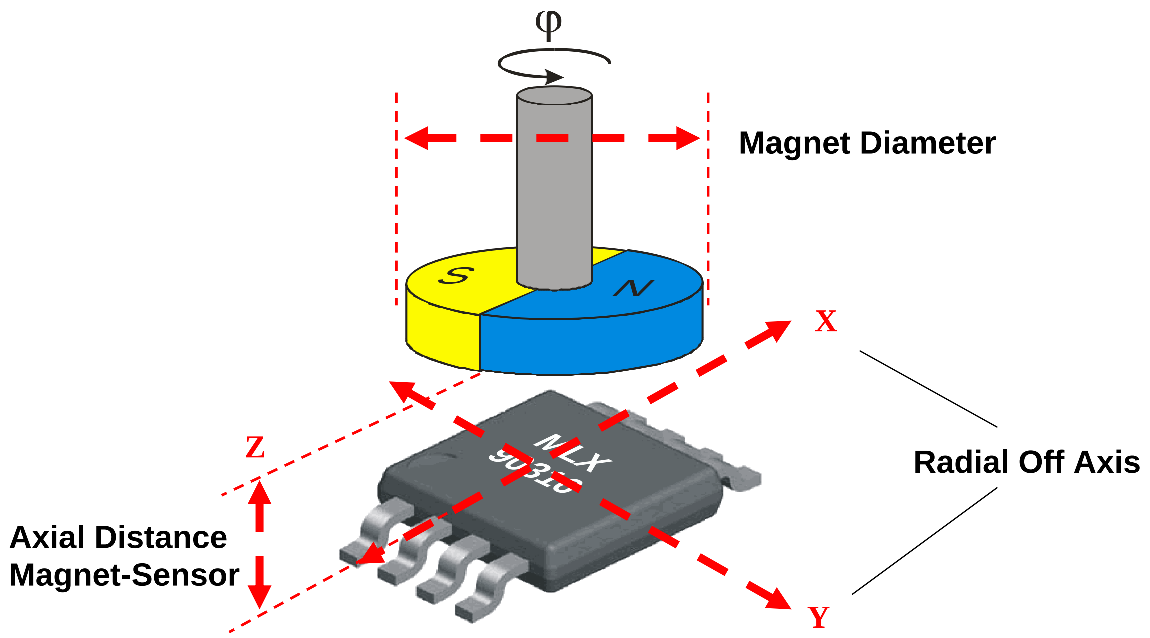


Figure 3: Mechanical Setup for Angular Sensing with MLX90316

The axial working distance between Magnet and Sensor is defined by the saturation effects (electrical or magnetic) for the lower limit and by the required signal-to-offset or signal-to-noise ratio for the higher limit.

Note: The MLX90316 features an automatic gain control (AGC) loop to adapt to the amplitude of the available field i.e. the higher the gain, the higher the noise. The MLX91204 does not feature such an AGC loop.

Radial Off-axis & Magnet Diameter

Off-axis position due to production tolerances, mechanical play, vibration will lead to non-linearity of the angle output signal. The Figure 4 shows the non-linearity for a given setup with a disk shape magnet D15H4 (Diameter = D = 15 mm - Height = H = 4 mm). The airgap between magnet surface and sensitive area of MLX90316 is 5mm.

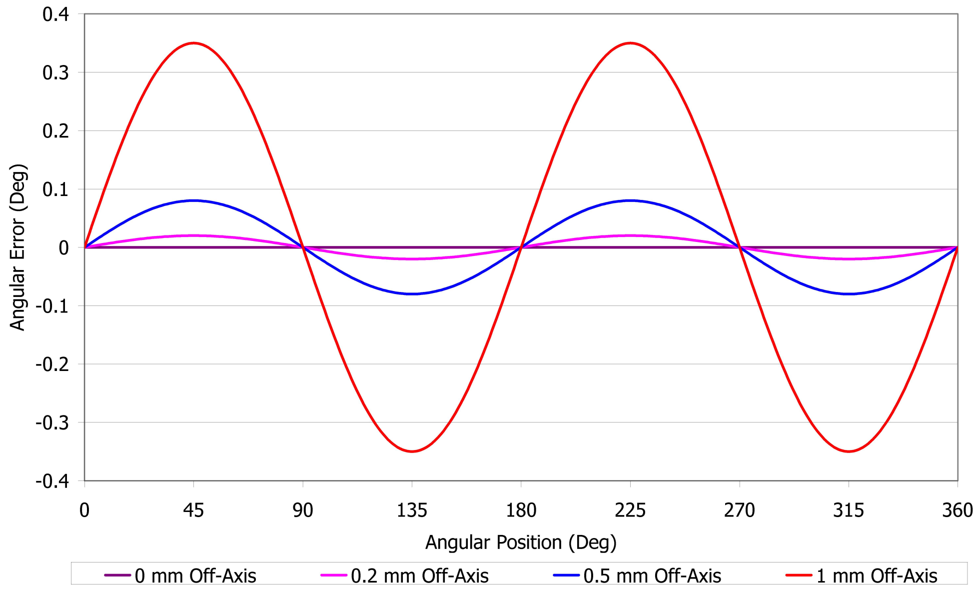


Figure 4: Magnet D15H4 - Linearity Error due to Off-Axis Magnet-IC

Angular errors due to a given off-axis misalignment will become smaller with an increasing diameter of the magnet. The Figure 5 below helps to estimate the required magnet diameter for given manufacturing tolerances plus lifetime wear-out if a predefined non-linearity (angle error) shall not be exceeded.

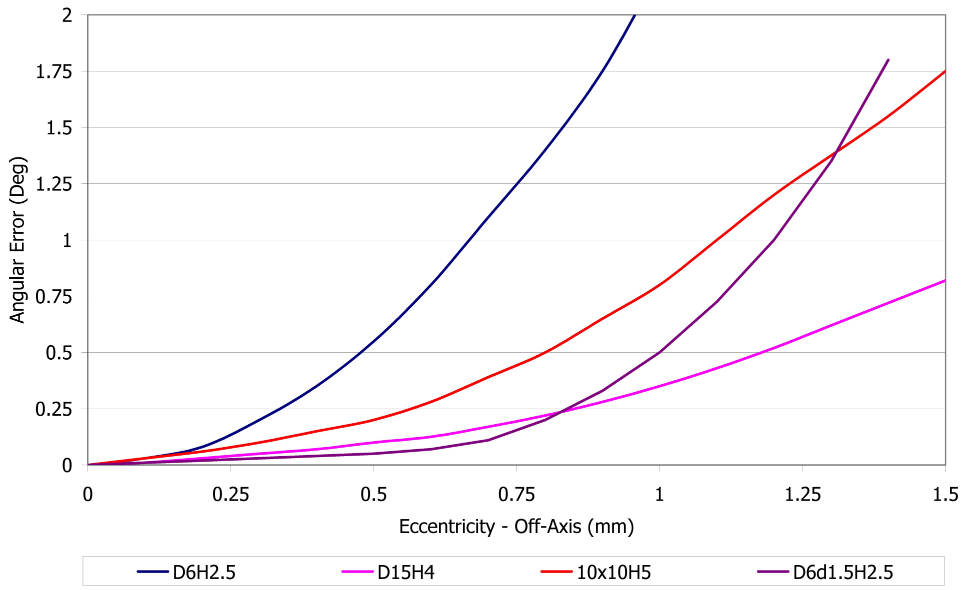


Figure 5: Angle Error vs. Eccentricity/Off-Axis for different Magnets (see also the table below)

Example

If maximum expected eccentricity due to production/manufacturing positioning tolerances (incl. lifetime wear-out) is 0.5 mm and maximum admitted non-linearity is 0.2 Deg. (0.05% of 360 Deg. full scale). Then a magnet of 10 mm diameter is a good choice.

However, choosing a magnet as big as possible will not lead to the best result:

- Large magnets can be less homogeneous (hot spots on the magnet surface will also create angular errors)
- Strong fields require a bigger distance between sensor and magnet to avoid saturation effects (flux density has to be kept below 70 mT)
- Big magnets are more expensive

Typically the magnet diameter has to be 10 x bigger than the max. eccentricity for less than 1 Deg non-linearity error and 20 x bigger for less than 0.3 Deg non-linearity.

Axial Distance between Sensor and Magnet - Airgap

The Magnet should also be selected vs. the airgap range (axial distance) in the given application. Horizontal flux density needs to be within 20 and 70 mT (i.e. 45 mT ± 25 mT) at the IC level.

Using a small distance between sensor and magnet will increase the danger of either electrical or magnetic saturation. Furthermore imperfections of the magnet material may create magnetic hot spots on the magnet surface which cause local field deflection and eventually result in additional angular errors;

For this reason we advise our customers not to use for example bonded ferrite material with large diameters.

The magnetic saturation level of the MLX90316 is approx. 80 mT. There is neither any damage nor any hysteresis if fields higher than 80 mT are applied.

Using a big distance (small amplitude) will decrease the signal to noise ratio.

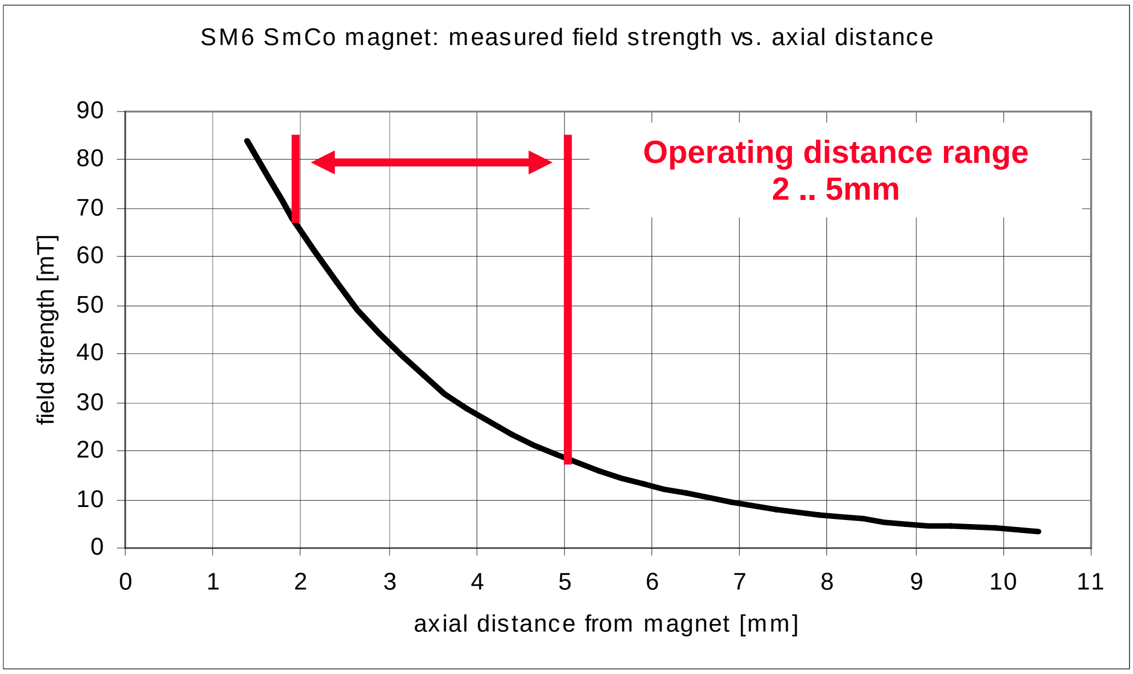
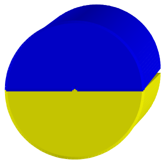
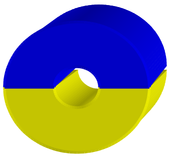
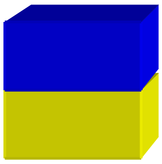
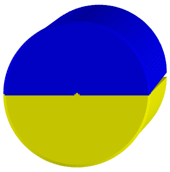


Figure 6: Horizontal Flux Density vs. Axial Distance from Magnet (Airgap)

The Figure 6 shows a typical relation between the field strength and the distance. It is obtained from a measurement on a 6 mm diameter SmCo magnet and 2.5 mm height (D6H2.5). The optimum flux density (20mT to 70mT) is reached with 2 mm to 5 mm airgap between magnet surface and the sensor's sensitive spot.

Magnets and Material Properties

Some typical magnets used in this application note:

Magnet	Size (D; w*l) [mm]	Height [mm]	Magnetization	Material (Temperature -40°C…+150°C)
	6	2.5	Diametral	Sintered SmCo Br=900…1100mT
	Outer Ø:6 Inner Ø: 1.5	2.5	Diametral	Sintered SmCo Br=900…1100mT
	10*10	5	Diametral	Anisotropic Ferrite Br=300…500mT
	15	4	Diametral	Bonded NdFeB Br=350…450mT

Material	Strength Br [mT]	Drift [%/°C]
NdFeB	1300	-0.1
SmCo	1000	-0.03
AlNiCo	900	-0.02
Ferrite	300	-0.2
Bonded NdFeB	450	-0.1

Aging: Has to be specified by your supplier.

Application table: **Magnets for MLX90316 Angle Sensor**

Airgap	Eccentricity (production tolerances + life time wearout) *1)	Max admitted non-linearity	Magnet / Magnettype (Discmagnet)	Material type		Recommended Magnet
small (0 – 2mm)	0.5mm	0.3°	D8 h2	NdFeB SmCo	sintered or plastic bonded	
		1°	D6 h3	NdFeB SmCo	sintered or plastic bonded	NdFeB D6 h3.5 SmCo D6 h2.5
	1mm	0.3°	D10 h2	NdFeB SmCo	sintered or plastic bonded	
		1°	D8 h2.5	NdFeB SmCo	sintered or plastic bonded	
middle (2 – 5mm)	0.5mm	0.3°	D10 h3	NdFeB SmCo	sintered or plastic bonded	NdFeB D12 h3
		1°	D6 h3	NdFeB SmCo	sintered, hard ferrite or bonded	NdFeB D6 h3.5 SmCo D6 h2.5
	1mm	0.3°	D20 h4	NdFeB SmCo	sintered or plastic bonded	
		1°	D10 h3	NdFeB SmCo	Sintered, hard ferrite or bonded	NdFeB D12 h3
big (5 – 8mm)	0.5 mm	0.3°	D12 h4	NdFeB	sintered or plastic bonded	
		1°	D8 h4	NdFeB	sintered or plastic bonded	
	1mm	0.3°	D25 h5	NdFeB	sintered or plastic bonded	
		1°	D12 h5	NdFeB	sintered or plastic bonded	

*1) For better eccentricity (< 0.5mm) can obviously be used smaller magnets (smaller diameter)

Material properties

Material		Advantages
NdFeB	Neodymium	• best magnetic characteristic
SmCo	Samarium-Cobalt	• best magnetic characteristic over a wide temperature range
HF	hard ferrite	• cheap
Bonded	pastic bonded	• all magnet shapes can be easy produced • good magnetic characteristic • cheap

Magnetproducer

(Melexis does not take any responsabilty for the magnet quality of the herein listeds)

Company	website	contact person	types of magnet
Magnetfabrik Bonn D - 53119 Bonn	www.magnetfabrik.de	Dr. M. Grönefeld +49 (0) 228 72905-13	HF / SmCo / NdFeB / Plastic Bonded
Magnetfabrik Schrammberg D-78713 Schramberg-Sulgen	www.magnete.de	Herr R. Rapp +49 (0) 7422 519-226	HF / SmCo / NdFeB / Plastic Bonded
Maurer Magnetic CH-8627 Grüningen	www.maurermagnetic.ch	Herr Stettbacher +41 (0)44 936 60 30	HF / SmCo / NdFeB / Plastic Bonded
BBA CH-5001 Aarau	www.bba.ch	Herr Bohny +41 (0)62 836 90 56	HF / SmCo / NdFeB / Plastic Bonded
Precicsion magnetic CH-5242 Lupfig	www.precisionmagnetics.com	Herr M. Albert +41 (0)56 464 21 23	HF / SmCo / NdFeB / Plastic Bonded
Bomatec CH-8181 Höri	www.bomatec.ch	+41 (0)1 872 10 00	HF / SmCo / NdFeB / Plastic Bonded / AlNiCo
SURA MAGNETS AB 614 31 Söderköping	www.suramagnets.se	+46 (0) 121 353 10	HF / SmCo / NdFeB / Plastic Bonded / AlNiCo
Energy Conversion Systems Cary, NC 27511	http://www.ecs-global.net/p_magnets.html	001 910 892-8081	HF / SmCo / NdFeB / Plastic Bonded / AlNiCo