

1 General description

1.1 Features & benefits

- Arcminaxis® Technology: combines multi-axis sensing with Vernier Technology.
- Reduces the complexity and effort involved in assembling robotic joints
- Pitch-independent, one IC fits various magnets
- Large air gap sensor to magnet (1.0-1.5 mm nominal)
- Generous magnet-sensor placement tolerance of ± 0.5 mm
- 18-bit resolution
- Triaxis® Hall Technology
- Communication via fast SPI interface
- Output modes:
 - SPI/differential SSI
- TSSOP-16 Sensor Package RoHS compliant
- 3.3 V supply
- Temperature range -20°C to 85°C

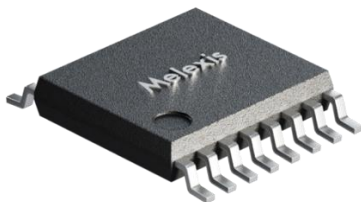


Figure 1. Sensor Chip in TSSOP-16 package

1.2 Application examples

- Absolute Rotary Position Sensor
- High Resolution Encoder
 - Robotic Joint Encoder

1.3 Description

The MLX90384 is a four-component set (a,b,c,d), providing a flexible solution for your high-accuracy magnetic encoder needs.

a) All options include a sensor chip with two monolithic magnetic position sensors providing two independent sensing spots, each consisting of a Triaxis® Hall magnetic front end, analog-to-digital converter, hardware for high-speed signal conditioning, and a 10 MHz high-speed SPI interface. The ICs are both configured to be sensitive to a first magnetic flux density component parallel with the chip plane and to a second component perpendicular to the chip.

b) A Vernier-type magnet with two tracks is included, enabling optimal system integration. The MLX90384 sensor chip measures the axial and tangential magnetic components of both tracks and transmits this information to a microcontroller which in turn generates the accurate angular position as well as the counted turn out of this information.

c) A partially precompiled software library adjustable for any ARM microcontroller is provided to calibrate and operate the system.

d) Also included is a complete hardware reference design to build your own encoder solution based on a), b) and c).



Figure 2. The Arcminaxis® Vernier sensing concept combines two sensing spots with orthogonal components

2 Ordering Information

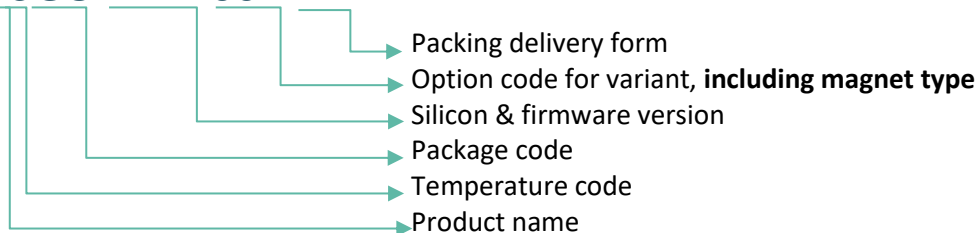
To help ensure seamless, easy integration in your application, we offer different MLX90384 versions that include a compatible magnet for your MLX90384 encoder system.

The Software for the MLX90384 encoder system is provided by Melexis and must be programmed into the used microcontroller.

Order Code	Temperature range (°C)	Package	Packing	Definition
MLX90384SGO-BAA-001-TU MLX90384SGO-BAA-001-RE	-20 to 85	TSSOP-16	Tube Reel	MLX90384 Sensor chip with magnet 1
MLX90384SGO-BAA-002-TU MLX90384SGO-BAA-002-RE	-20 to 85	TSSOP-16	Tube Reel	MLX90384 Sensor chip with magnet 2
MLX90384SGO-BAA-003-TU MLX90384SGO-BAA-003-RE	-20 to 85	TSSOP-16	Tube Reel	MLX90384 Sensor chip with magnet 3
MLX90384SGO-BAA-004-TU MLX90384SGO-BAA-004-RE	-20 to 85	TSSOP-16	Tube Reel	MLX90384 Sensor chip with magnet 4

Table 1 - MLX90384 Order Codes

MLX90384SGO-BAA-001-RE



Temperature Code:	S: -20 °C to 85 °C
Package Code:	GO: TSSOP-16 package (Dual-Die side-by-side)
Silicon & firmware version:	BAA: Chip Revision BAA: MLX90384 production version
Option Code for variant, including magnet type:	001: Application - Magnetic configuration 001: Magnet MLXMAGNT-VER-001 consisting of a magnet ring set ID14/OD24 002: Magnet MLXMAGNT-VER-002 for 6mm shaft mounting ID06/OD24 003: Magnet MLXMAGNT-VER-003 larger diameter Vernier magnet ID25/OD42 004: Magnet MLXMAGNT-VER-004 single magnet ring with two tracks ID16/OD24
Packing Form:	Low volume production: TU (Tubes) 80 pcs/tube for TSSOP-16 package, GO code - The magnets are shipped in tubes or trays Mass production: RE (Tape & Reel) 4500 pcs/reel for TSSOP-16 package, GO code - The magnets are shipped in tubes or trays

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3 MLX90384 Magnet

3.1 Magnet types

The MLX90384 magnets delivered by Melexis in the MLX90384 encoder system are Vernier type magnets with two tracks. They are made of ferrite material with a temperature coefficient of about -2000 ppm/K for the magnetic field strength.

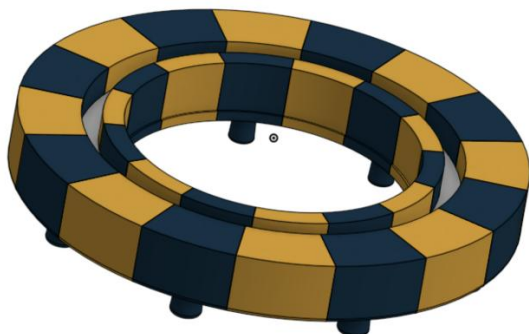
Melexis offers the magnets in the following versions:

Magnet Type	Description
MLXMAGNT-VER-001	Magnet ring set to be mounted into a holder ID14/OD24
MLXMAGNT-VER-002	Overmolded magnet with brass bushing for direct mounting on a $\varnothing 6$ mm shaft ID06/OD24
MLXMAGNT-VER-003	Larger diameter magnet with 14/13 pole pairs ID25/OD42
MLXMAGNT-VER-004	Single magnet ring with two tracks ID16/OD24 (maximum flexibility)

Table 3 - MLX90384 Magnet type

3.2 Magnet Specification

MLXMAGNT-VER-001



MLXMAGNT-VER-002

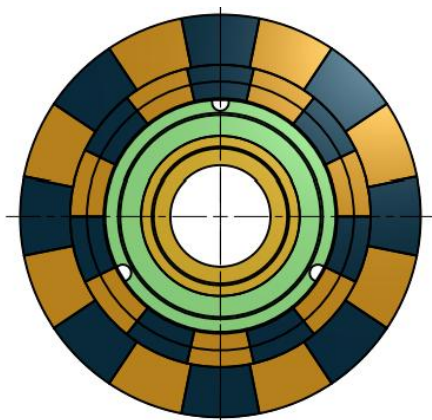


Figure 3. Magnet schematics for MLXMAGNT-VER-001 and MLXMAGNT-VER-002

The left picture shows a simplified version of magnet **MLXMAGNT-VER-001** allowing for a large inner clearance for this magnet size, whereas the right picture shows the **MLXMAGNT-VER-002** version with overmolding and an inner brass bushing for press-fit mounting on a $\varnothing 6$ mm shaft.

Due to their difference in pole-pair count, the Master and Nonius magnets **MLXMAGNT-VER-001** and **MLXMAGNT-VER-002** are manufactured separately and then assembled to form the Vernier magnet for the MLX90384 encoder system. The magnet **MLXMAGNT-VER-001** is delivered in a transport holder to keep the two Master and Nonius in place.

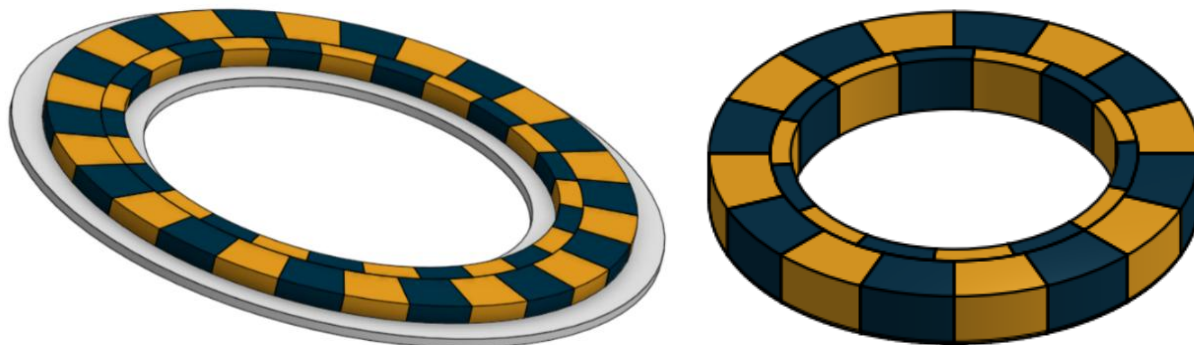


Figure 4. Magnet schematics for MLXMAGNT-VER-003 and MLXMAGNT-VER-004

The figure shows on the left side the **MLXMAGNT-VER-003** with the Master and the Nonius track made as one piece on top of a metal base. The 25 mm diameter inner hole allows easy pass-through of cables with connectors.

On the right side the picture shows **MLXMAGNT-VER-004**, which is the improved version of **MLXMAGNT-VER-001**. This updated design provides 2 mm more space on its inner diameter while keeping the same outer diameter. The **MLXMAGNT-VER-004** is also 1 mm thinner than its predecessor, with a single-piece design that simplifies handling and installation.

3.3 Magnet Dimensions

The dimensions of the magnets as well as the number of pole pairs Npp are presented in the table below. For comprehensive details, including manufacturing tolerances, please refer to the detailed mechanical drawings provided in subsequent sections.

Magnet #	Inner diameter ID [mm]*	Outer diameter OD [mm]*	Thickness [mm]*	Npp Master track	Npp Nonius track
MLXMAGNT-VER-001	14	24	4.5**	8	7
MLXMAGNT-VER-002	6	24	6	8	7
MLXMAGNT-VER-003	25	42	1.8	14	13
MLXMAGNT-VER-004	16	24	3.5	8	7

Table 4 - Magnet dimensions

* for tolerances, see detailed mechanical drawings

** without transport holder

3.5 Detailed mechanical drawing of MLXMAGNT-VER-002

This magnet configuration contains a brass bushing in the center and is designed for press-fit mounting on a 6 mm shaft.

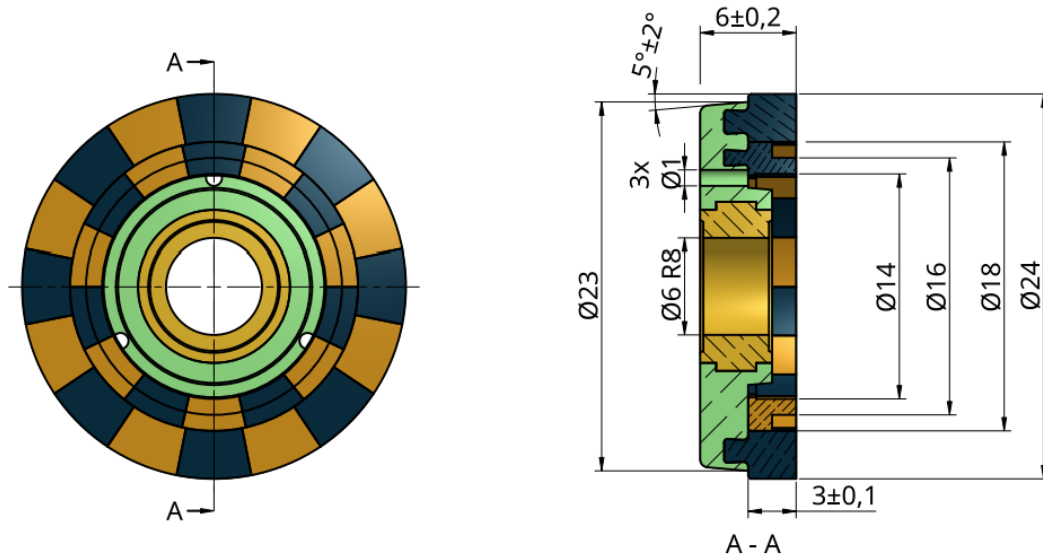


Figure 7. Dimensions of MLXMAGNT-VER-002. Unless specified otherwise, dimensions are millimetres.

3.6 Detailed mechanical drawing of MLXMAGNT-VER-003

This magnet is made as one piece without separation between the tracks. The inner hole of 25mm diameter allows easy pass through of cables with connectors.

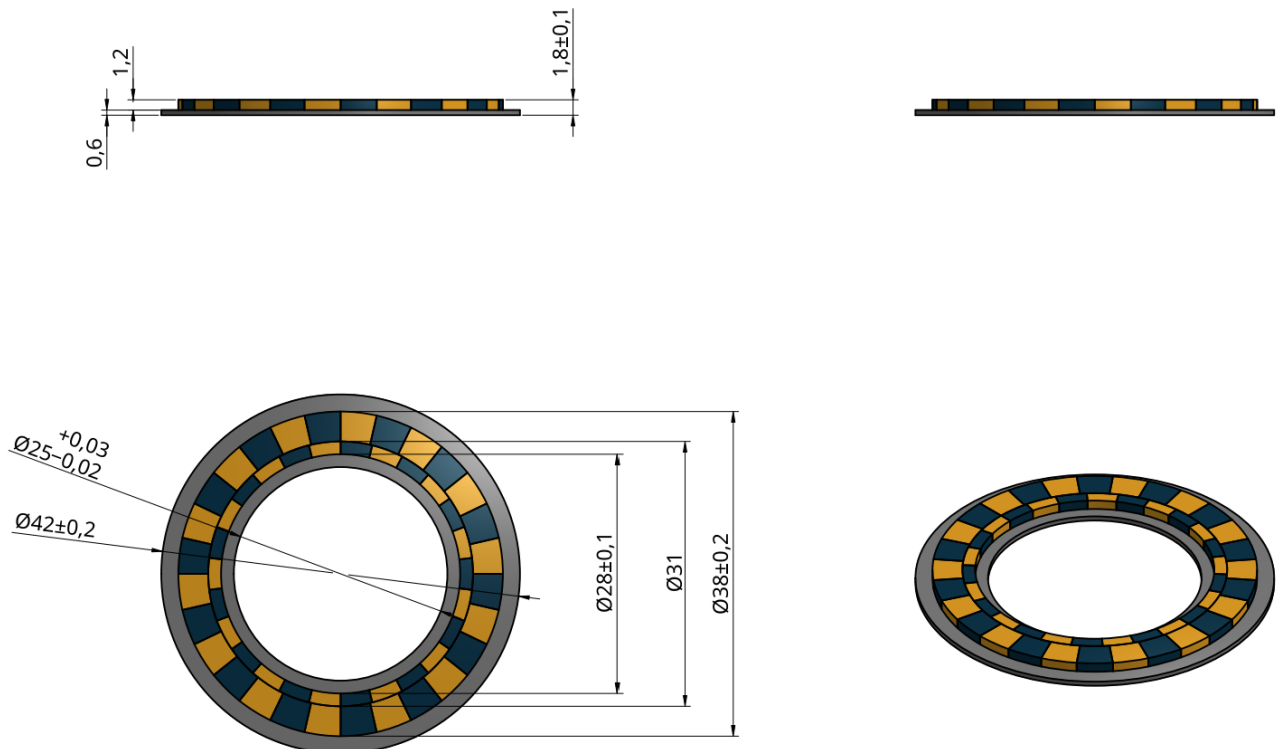


Figure 8. Dimensions of MLXMAGNT-VER-003. Unless specified otherwise, dimensions are millimetres.

3.7 Detailed mechanical drawing of MLXMAGNT-VER-004

MLXMAGNT-VER-004 is the improved version of **MLXMAGNT-VER-001**. This updated design is made as one piece without separation between the tracks and provides 2 mm more space on its inner diameter while keeping the same outer diameter. The **MLXMAGNT-VER-004** is also 1 mm thinner than its predecessor.

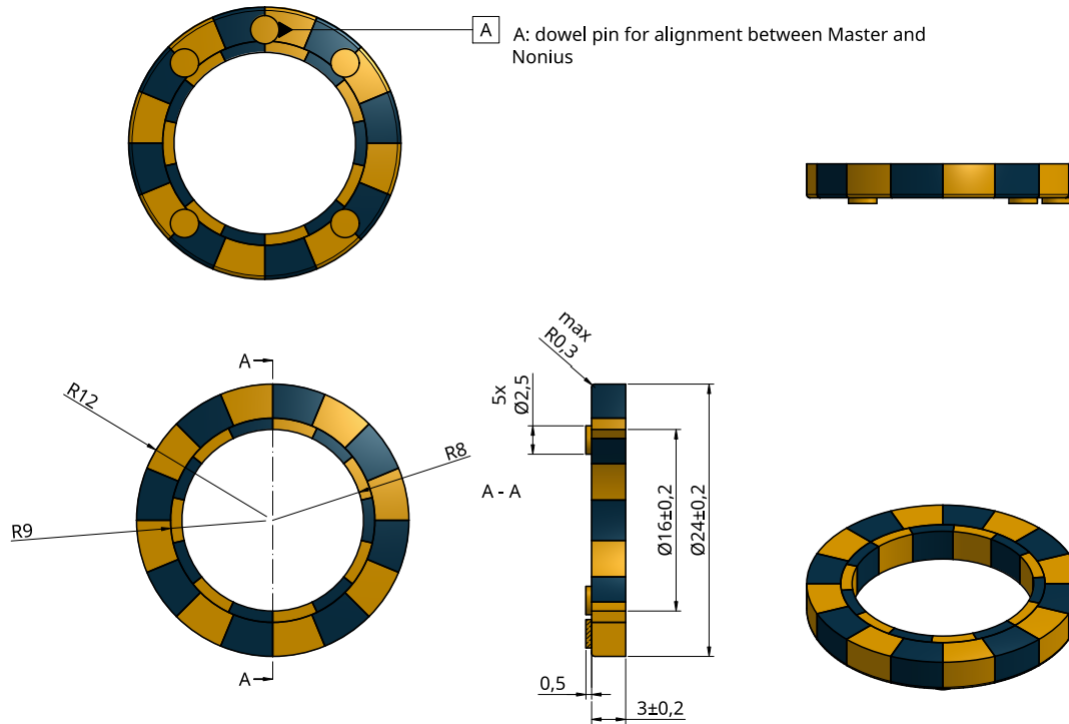


Figure 9. Dimensions of MLXMAGNT-VER-004. Unless specified otherwise, dimensions are millimetres.

3.8 Magnetic Field Specification

The tables below list the typical field amplitudes seen by the two sensing spots in nominal position (see Table 13) and 25°C with respect to the full magnet.

3.8.1 MLXMAGNT-VER-001 and MLXMAGNT-VER-002

	Master Sensing Spot	Nonius Sensing Spot
Axial Field Amplitude Bz	40 mT	16 mT
Tangential Field Amplitude Bx	33 mT	25 mT
Amplitude drift 35°C to -20°C	+10%	
Amplitude drift 35°C to +85°C	-10%	

Table 5 - Magnetic flux density at sensor for nominal assembly position MLXMAGNT-VER-001/-002

3.8.2 MLXMAGNT-VER-003

	Master Sensing Spot	Nonius Sensing Spot
Axial Field Amplitude Bz	27 mT	15 mT
Tangential Field Amplitude Bx	27 mT	15 mT
Amplitude drift 35°C to -20°C	+10%	
Amplitude drift 35°C to +85°C	-10%	

Table 6 - Magnetic flux density at sensor for nominal assembly position for MLXMAGNT-VER-003

3.8.3 MLXMAGNT-VER-004

	Master Sensing Spot	Nonius Sensing Spot
Axial Field Amplitude Bz	41 mT	21 mT
Tangential Field Amplitude Bx	34 mT	16 mT
Amplitude drift 35°C to -20°C	+10%	
Amplitude drift 35°C to +85°C	-10%	

Table 7 - Magnetic flux density at sensor for nominal assembly position for MLXMAGNT-VER-004

4 MLX90384 Sensor Chip

The MLX90384 sensor chip is a high-performance magnetic position sensor composed of two silicon circuits, each with a two-axis sensing spots for measuring axial and tangential field components representing the Sine and a Cosine signals of a two-track Vernier magnet.

As shown in the block diagram Figure 7, each of the sensing channels has its own Triaxis Hall sensor frontend, amplification chain, ADC and output stages.

4.1 Functional Block Diagram

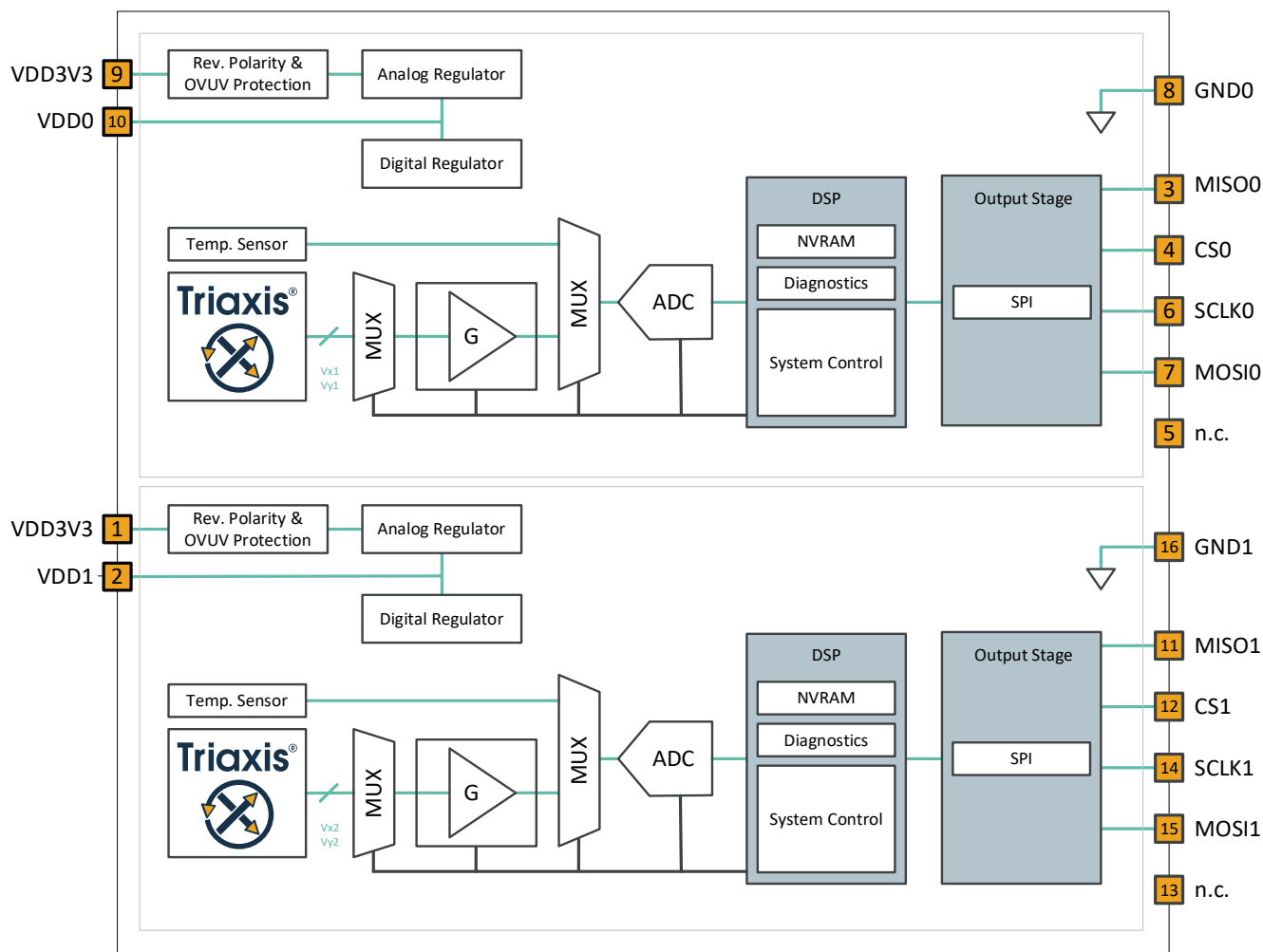


Figure 10. TSSOP-16 Dual die block diagram

The distance of the two sensing spots inside the package is 1.9 mm so that for nominal position, the master sensor is positioned above the center of the master track and the nonius sensor right between master and nonius track.

4.2 TSSOP-16 package with sensing spots

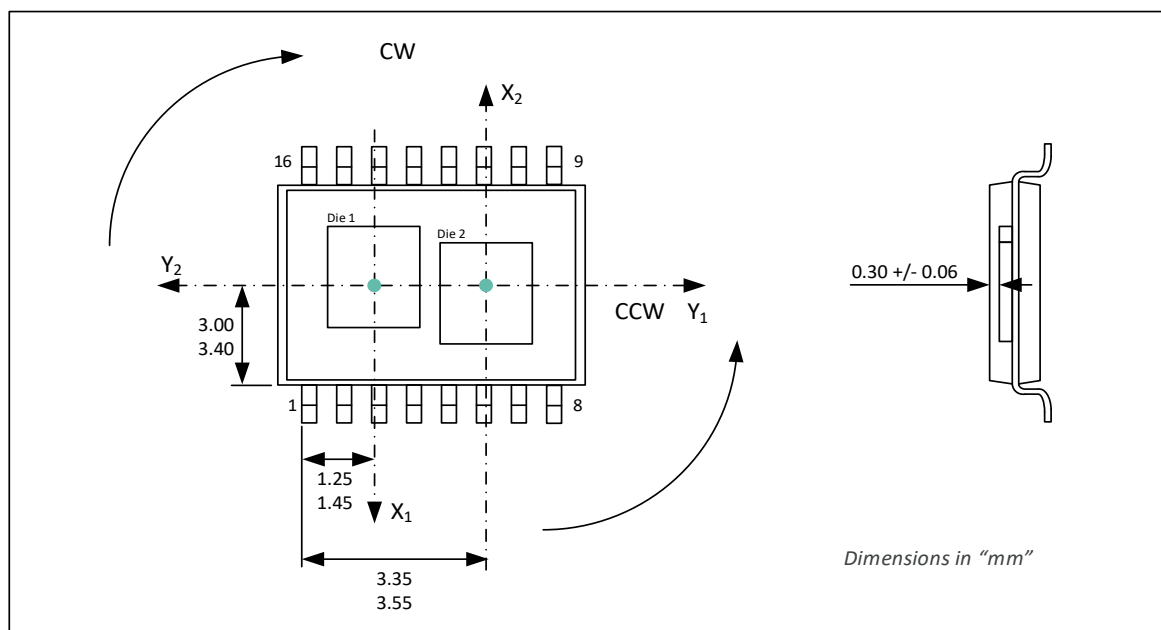
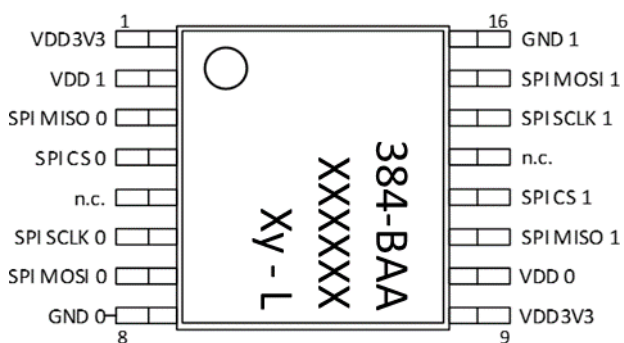


Figure 11. Indication of the locations of the two sensitivity spots for nonius track (die 1) and master track (die 2)

To build an encoder with the MLX90384 magnet and the MLX90384 sensor, additional components including a microcontroller with embedded software (delivered by Melexis) are required. The Microcontroller is communicating via the two high-speed SPI interfaces with the two sensing channels. The complete reference design is provided by the MLX90384 reference design document, separately provided by MyMelexis: <https://www.melexis.com/en/mymelexis-login>.

4.3 Pin description for TSSOP-16 package

For optimal EMC and ESD behavior, connect the unused pins to 'Gnd'. This interface for communication between the sensor chip and microcontroller is implemented with SPI protocol. Communication between the microcontroller and a host system is possible with SPI and SSI, for details see Application note.



Pin #	Designation	Pin#	Designation
1	VDD3V3	16	GND1
2	VDD1	15	SPI MOSI1
3	SPI MISO0	14	SPI SCLK1
4	SPI CS0	13	not connected
5	not connected	12	SPI CS1
6	SPI SCLK0	11	SPI MISO1
7	SPI MOSI0	10	VDD0
8	GND0	9	VDD3V3

Table 8 - TSSOP-16 package pinout for SPI communication

4.4 Absolute Maximum Ratings

Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute maximum-rated conditions may affect the device reliability.

Parameter	Symbol	Min.	Max.	Unit	Condition
Supply Voltage at VDD Pin	V_{DD}	-0.3	6.0	V	
Supply Voltage at VDD3V3 Pin	V_{DD}	-0.3	4.0	V	
I/O Pin Voltage	V_{PIN}	-0.3	$V_{DD}+0.3$	V	
ESD CDM Robustness	V_{CDM}	-500	500	V	All pins, according to AEC-Q100-011
		-750	750	V	Package corner pins
ESD HBM Robustness	V_{HBM}	-2.0	2.0	kV	
Operating Temperature	T_{AMB}	-40.0	150.0	°C	Valid only for the IC
Junction Temperature	T_J		+175	°C	
Storage Temperature	T_{st}	-55	+170	°C	
Magnetic Flux Density	B_{max}	-1	1	T	

Table 9 - Absolute Maximum Ratings

Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute maximum-rated conditions for extended periods may affect the device reliability.

4.5 Electrical operating conditions & specifications

Unless otherwise specified, the electrical specifications of the MLX90384 sensor chip are valid for a temperature range of [-20, 85] °C and specified nominal supply voltage ranges.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Voltage	V_{DD}	3	3.3	3.6	V	Pins VDD3V3 & VDD0/VDD1 shorted
Supply tolerance	ΔV_{DD}	-5		+5	% V_{DD}	
Supply Current*	I_{DD}			20.0	mA	excluding output I/F

Table 10 - Electrical operating conditions in 3.3 V operating mode

*the supply current is for the MLX90384 sensor chip without the additional microcontroller required for the encoder system

4.5.1 Input channel specification

The specification for the input channels of the MLX90384 sensor chip are as follows:

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Input Low Voltage Detection Level		25.0	35.0	42.0	% V_{DD}	
Input High Voltage Detection Level		52.0	60.0	75.0	% V_{DD}	
Input Hysteresis Level		18.0	25.0	42.0	% V_{DD}	
Input Voltage Range		0		100	% V_{DD}	

Table 11 - Input channel specifications

4.5.2 Output channel specification

The output driver for the MISO output pin is configured by default in push/pull mode with the specifications described below. Each output pin voltage ranges from 0 V to VDD external supply. The rise and fall time specifications are listed in the following table.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Rise/Fall Time Push-Pull Mode	$T_{\text{rise_fall_pp}}$	3.3		15.0	ns	LH or HL from 75 % VDD to 25 % VDD for 50 pF load in 5 V mode
		4.0		18.0	ns	LH or HL from 75 % VDD to 25 % VDD for 50 pF load in 3.3 V mode

Table 12 - Interface output timing specifications for 50pF load

4.5.3 SPI Clock Frequency Specifications

This section is describing the SPI clock frequency used between the STM32 microcontroller and the MLX90384 sensor chip. The nominal value is the frequency used by the software of the STM32 microcontroller.

This communication is handled by the STM32 micro controller indicated in the reference design.

The capacitance C_L refers to the max. load on the signal wire.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
SPI Clock Frequency	f_{SCLK}		6.3		MHz	$C_L \leq 50 \text{ pF}, f_{\text{ac}} \geq 2f_{\text{SCLK}}$

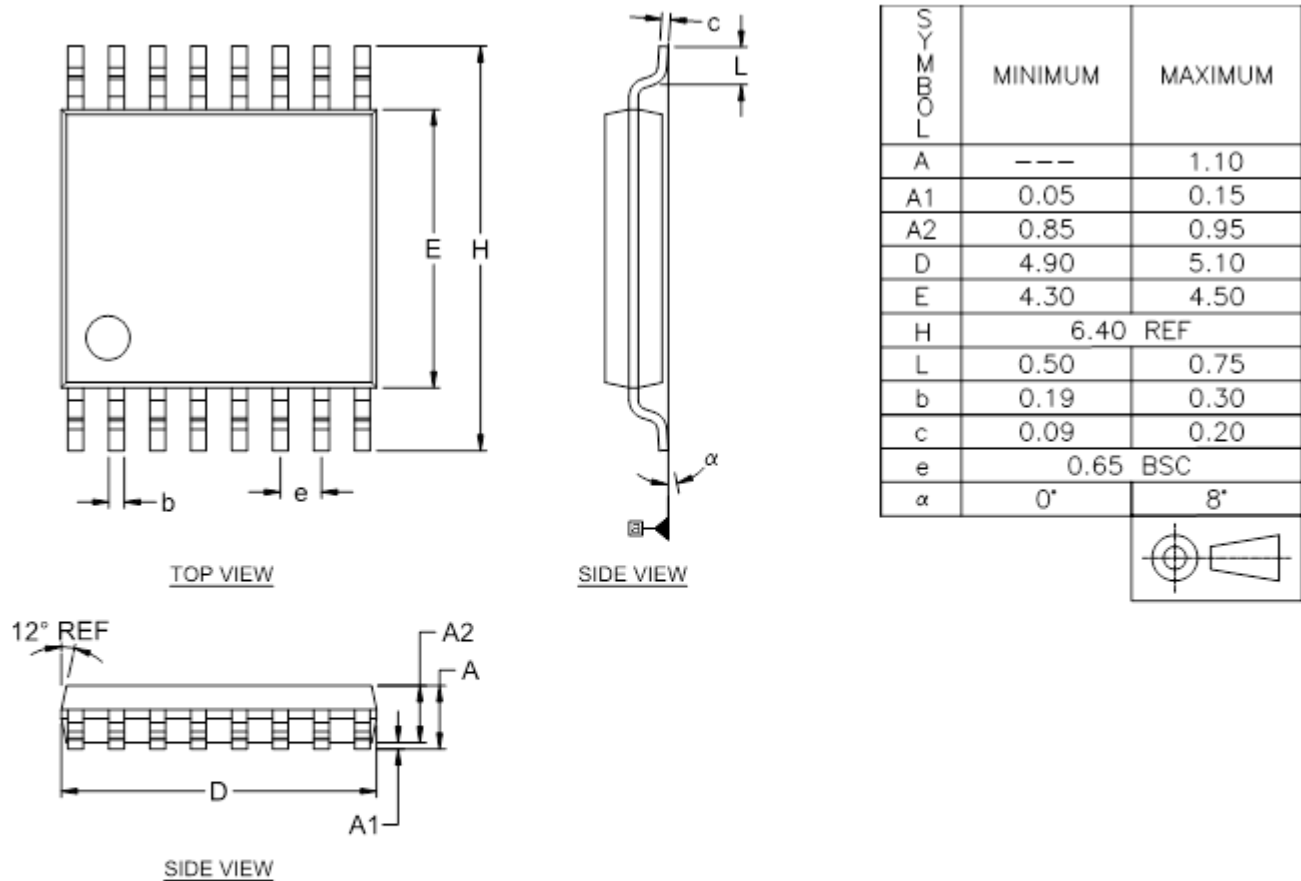
Table 13 - SPI Timing Specification

5 Package, IC handling and assembly

5.1 Package information for TSSOP-16 package

5.1.1 Package dimensions

The following drawing indicates the dimensions of the MLX90384 Sensor package



NOTE :

1. ALL DIMENSIONS IN MILLIMETERS (mm) UNLESS OTHERWISE STATED.
2. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS OF MAX 0.15 mm PER SIDE.
3. DIMENSION E DOES NOT INCLUDE INTERLEADS FLASH OR PROTRUSIONS OF MAX 0.25 mm PER SIDE.
4. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION OF MAX 0.08 mm.
5. LEAD TO LEAD COPLANARITY MAX 0.100 MILLIMETERS (mm) WITH RESPECT TO SEATING PLANE α.

Figure 12. MLX90384 TSSOP-16 package dimensions

5.1.2 TSSOP-16 package pinout and package marking

The drawing below shows the package pinout and marking.

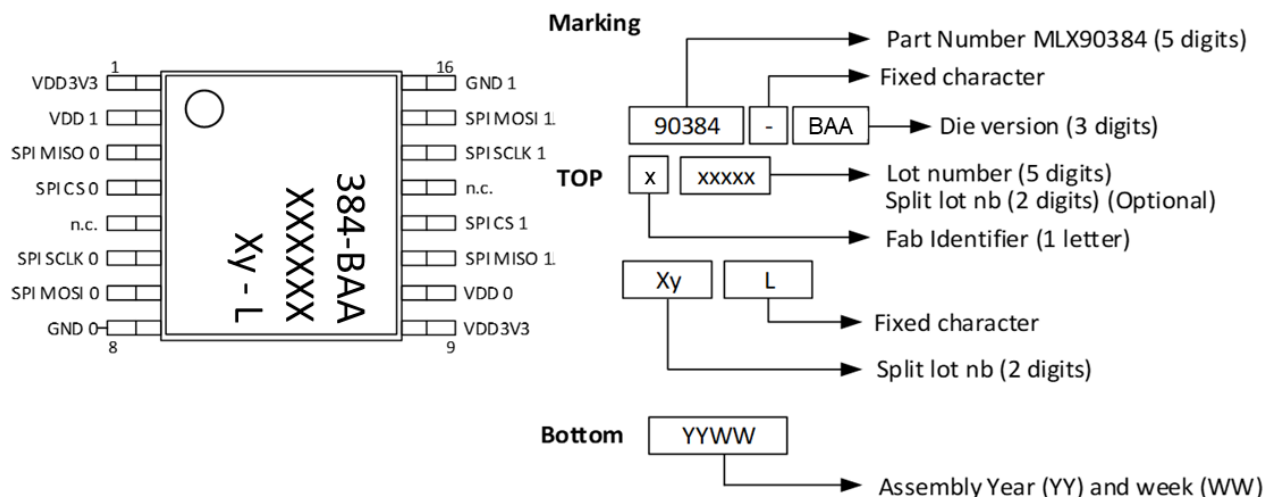


Figure 13. The package indicates the part and lot # for full traceability and identification

5.2 Storage and handling of plastic encapsulated ICs

Plastic encapsulated ICs shall be stored and handled according to their MSL categorization level (specified in the packing label) as per J-STD-033. Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). The component assembly shall be handled in EPA (Electrostatic Protected Area) as per ANSI S20.20 For more information refer to Melexis [Guidelines for storage and handling of plastic encapsulated ICs](#) ^(a)

5.3 Assembly of encapsulated ICs

For Surface Mounted Devices (SMD, as defined according to JEDEC norms), the only applicable soldering method is reflow.

For Through Hole Devices (THD), the applicable soldering methods are reflow, wave, selective wave and robot point-to-point. THD lead pre-forming (cutting and/or bending) is applicable under strict compliance with Melexis [Guidelines for lead forming of SIP Hall Sensors](#) ⁽²⁾.

Melexis products soldering on PCB should be conducted according to the requirements of IPC/JEDEC and J-STD-001. Solder quality acceptance should follow the requirements of IPC-A-610.

For PCB-less assembly refer to the relevant application notes ⁽²⁾ or contact Melexis.

Electrical resistance welding or laser welding can be applied to Melexis products in THD and specific PCB-less packages following the [Guidelines for welding of PCB-less devices](#) ⁽²⁾.

Environmental protection of customer assembly with Melexis products for harsh media application, is applicable by means of coating, potting or overmolding considering restrictions listed in the relevant application notes ⁽²⁾

^a www.melexis.com/ic-handling-and-assembly

For other specific process, contact Melexis via www.melexis.com/technical-inquiry

5.4 Environment and sustainability

Melexis is contributing to global environmental conservation by promoting non-hazardous solutions. For more information on our environmental policy and declarations (RoHS, REACH...) visit www.melexis.com/environmental-forms-and-declarations

6 MLX90384 Encoder System

The MLX90384 magnet and sensor chip are key components to realize a high accuracy/resolution encoder system with a nominal of 1 mm to 1.5 mm airgap between sensor and magnet for a temperature range from -20 °C to 85 °C. This section illustrates such a possible system by the Melexis reference design.

6.1 System Reference Design

The encoder reference design shown in Figure 14 uses the three elements delivered by Melexis: The magnet, the sensor chip and the software for the microcontroller. All other components must be provided by the customer. A detailed description of the reference design including full PCB schematics and component list is provided by the MLX90384 Reference design document distributed separately by MyMelexis.

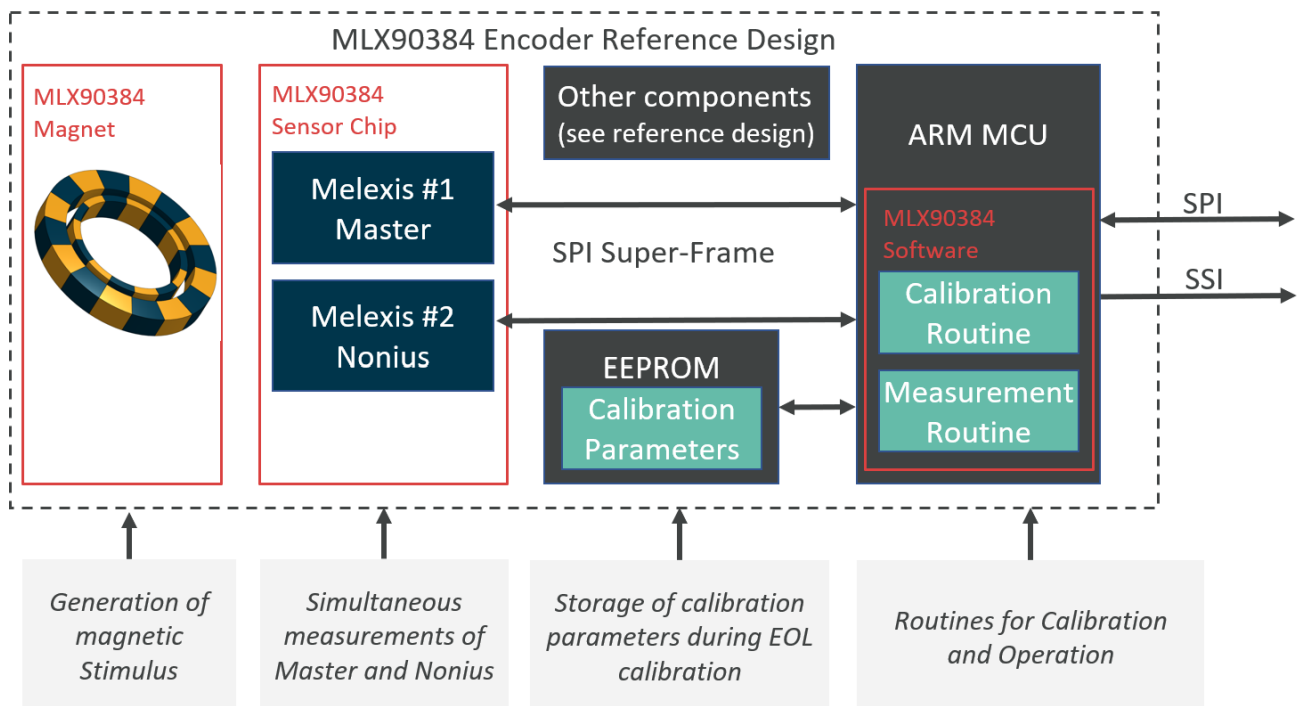


Figure 14. Encoder Reference Design with red marked items delivered by Melexis as product MLX90384

Besides the accuracy of the encoder system, which depends substantially on the calibration process performed in the application and which is typically 0.1 degrees or smaller*, many applications also require very high angular resolution.

Following the reference design, a resolution of up to 18 bits can be reached for typical post gear box application speeds of up to 200 rpm. At higher speeds the system is still functional, but the performance can degrade due to the microcontroller processing time.

The MLX90384 sensor module supports both SPI and differential SSI interfaces. SPI is used for both communication and output, enabling configuration and data retrieval. SSI, on the other hand, provides data output, offering a robust method for transmitting measured values. Refer to the Application Note for detailed implementation.

*The accuracy can also be influenced by stray fields as well as temperature changes and dynamic wear out effects of the overall system.

6.2 System Specification according to Reference Design

6.2.1 Assembly Specification

The installation of the encoder system is done by mounting the magnet on a rotating shaft, mounting the sensor module (readhead) at the right position with respect to the magnet and connecting it to the SPI host controller.

Due to the Melexis Triaxis technology, the requirements for the initial position of the sensor module versus the magnet are substantially relaxed compared with most other magnetic encoder systems on the market.

The picture below shows the three orthogonal dimensions to be respected when placing the sensor chip with respect to the magnet: the radial position x_s , the tangential position t_s and the airgap z_s .

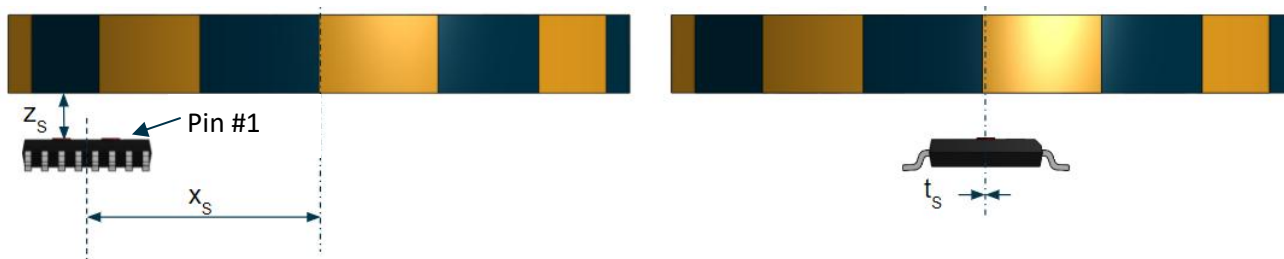


Figure 15. Assembly position of magnet and sensor chip. The chip is mounted with Pins #1 and 16 towards the ring center.

For each of those dimensions a tolerance of $\pm 0.5\text{mm}$ must be respected, as indicated in the table below.

Parameter	Description	Min.	Nom.	Max.	Unit
Sensor radial position (x_s)	The position of the center of the sensor chip as distance from the magnet center.	9.0	9.5	10.0	mm
Sensor tangential position (t_s)	The position of the center of the sensor as distance from the ideal tangential position.	-0.5	0	0.5	mm
Air gap (z_s)	Distance between the top of the package and the magnet.	1.0	1.5	2.0	mm

Table 14 - Assembly Position and Tolerances for MLXMAGNT-VER-001/-002

Parameter	Description	Min.	Nom.	Max.	Unit
Sensor radial position (x_s)	The position of the center of the sensor chip as distance from the magnet center.	16	16.5	17	mm
Sensor tangential position (t_s)	The position of the center of the sensor as distance from the ideal tangential position.	-0.5	0	0.5	mm
Air gap (z_s)	Distance between the top of the package and the magnet.	1.0	1.5	2.0	mm

Table 15 - Assembly Position and Tolerances for MLXMAGNT-VER-003

Parameter	Description	Min.	Nom.	Max.	Unit
Sensor radial position (x_s)	The position of the center of the sensor chip as distance from the magnet center.	9.0	9.5	10.0	mm
Sensor tangential position (t_s)	The position of the center of the sensor as distance from the ideal tangential position.	-0.5	0	0.5	mm
Air gap (z_s)	Distance between the top of the package and the magnet.	0.5	1.0	1.5	mm

Table 16 - Assembly Position and Tolerances for MLXMAGNT-VER-004

The assembly specifications given in this table guarantee

- the magnetic operating range for the sensor chip over the full temperature range from -20degC to +85degC.
- the system calibration with the software package running on the microcontroller

6.2.2 System Angular Speed

The encoder system works at angular speed between standstill and 200 rpm.

The system update rate and intrinsic delay by the integrated signal and data processing are as follows

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Angle update interval	t_{update}		45		μs	without window filtering
Signal and data processing time	t_{process}		55		μs	Magnetic angle to SPI output

Table 17 - System Speed Specifications valid for all magnets

When the window average filter is used, the update interval remains the same, but due to the averaging, the history of the magnetic angle increases linearly with the number of averaged samples.

6.2.3 System Angular Resolution

The following graph compares the typically measured angular resolution versus the theoretical one. The values are given in bit RMS versus the programmed sample integration at room temperature and for nominal airgap. For each doubling of the averaged samples, the resolution increases by half a bit.

With an integration step of 15 μs and the number of integrated samples n_{int} the integration time t_{int} is calculated by $t_{\text{int}} = n_{\text{int}} * 15 \mu\text{s}$. For very fast readings without any sample integration the resolution is about 15 bit whereas for about 1.5 ms integration time a resolution of 18 bits is reached.

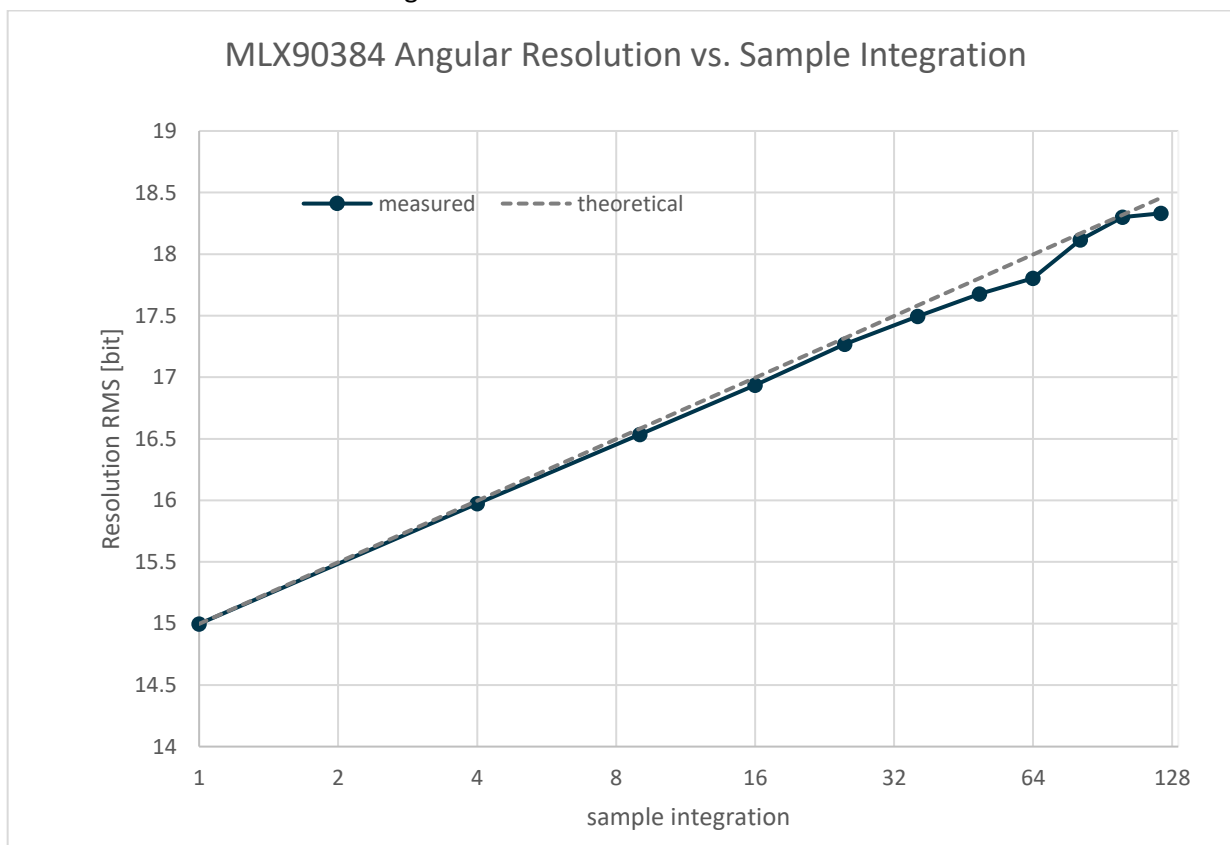


Figure 16. Angular Resolution vs. Integration time (programmable) for the MLX90384 encoder system

6.3 Encoder System Calibration

To deliver accurate angle information, the encoder system must be calibrated by the customer after assembly.
Please refer to **MLX90384 Application Note** for details about the calibration.

7 Glossary of terms & references

7.1 Glossary

Term	Description
NC	Not Connected
ID/OD	Inner Diameter/Outer Diameter

Table 18 - Glossary

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8 Revision history

Revision	Date	Change history
1.0	18-Oct-2024	Initial Version
2.0	26-Nov-2025	SSI interface, magnet 3 and 4 added, magnet drawings updated, switch from OAA to BAA samples, Chapter order adjusted
3.0	13-May-2026	Magnet 4 airgap update, adjustment max speed, other small corrections, style updates, standard information duplicate removed

Table 19 - Revision history

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