MLX90425

Triaxis® Position Sensor IC
Datasheet

Melexis
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Features and Benefits

- Triaxis® Hall Technology
- On Chip Signal Processing for Robust Absolute Position Sensing
- ASIL READY BY MELEXIS ISO26262 ASIL-B Safety Element out of Context
- AEC-Q100 Qualified (Grade 0)
- Robust to external magnetic stray fields
- Programmable Measurement Range
- Programmable Linear Transfer Characteristic up to 17 points
- Ratiometric analog or PWM output
- Packages RoHS compliant
  - Single Die SOIC-8
  - PCB-less Single Die SMP-3

SOIC-8 (DC)

SMP-3 (VE)

Description

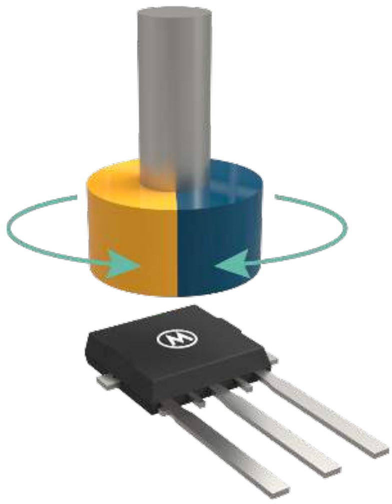
The MLX90425 is a monolithic magnetic position sensor IC. It consists of a Triaxis® Hall magnetic front end, an analog to digital signal conditioner, a DSP for advanced signal processing and a programmable output stage driver.

The MLX90425 is sensitive to the differential magnetic field perpendicular to the IC surface (Z-axis). This allows the MLX90425, with the correct magnetic design, to decode the absolute position of a rotating on-axis magnet above or below the sensor (e.g. rotary position from 0° to 360°). It enables the design of non-contacting position sensors that are frequently required in automotive and industrial applications.

The MLX90425 provides either a ratiometric analog or a pulse width modulated (PWM) output. Programming the sensor, after assembly into the application, increases the accuracy of the system thanks to the multi-point programmable linearization function.

Application Examples

- Pedal Position Sensor
- Throttle Position Sensor
- Ride Height Position Sensor
- Transmission Position Sensor
- Steering Wheel Position Sensor
- Non-Contacting Potentiometer



Angular Rotary – 360° Stray field Robust

Ordering Information

Product	Temp.	Package	Option Code	Packing Form	Definition
MLX90425	G	DC	ABA-600	RE	Angular Rotary 360° Stray field Robust Analog / PWM version
MLX90425	G	VE	ABA-600	RE/RX	Angular Rotary 360° Stray field Robust Analog / PWM version

Table 1 – Ordering codes

Temperature Code:	G : from -40°C to 160°C Some parts can be exposed to higher temperatures for a limited time [(1)]
Package Code:	DC : SOIC-8 package (see 17.1) VE : SMP-3 package (PCB-less single mold, see 17.2)
Option Code - Chip revision	**AAA**-123 : **Chip Revision** ▪ ABA: MLX90425 production version
Option Code - Application	AAA-123 : **1-Application - Magnetic configuration** ▪ 6: Angular Rotary 360° Stray field Robust
Option Code	AAA-123 : **2-Programming Option** ▪ 0: Standard (Analog output)
Option Code - Trim & Form	AAA-123 : **3-Package Option** ▪ 0: Standard
Packing Form:	-RE : Tape & Reel ▪ VE: 2500 pcs/reel ▪ DC: 3000 pcs/reel -RX : Tape & Reel, similar to RE with parts face-down
Ordering Example:	MLX90425GDC-ABA-600-RE For an analog version in SOIC-8 package, delivered in reels of 3000pcs.

Table 2 - Ordering codes information

[1] The devices can be used up-to an ambient temperature of +180°C. For a description of the conditions, refer to the sub-sections labelled "High-temperature Extension"(4.1, 5.1, 8.2.1, 10.1.1, 10.2.3, 12.5.4).

Contents

1. Functional Diagram and Application Modes

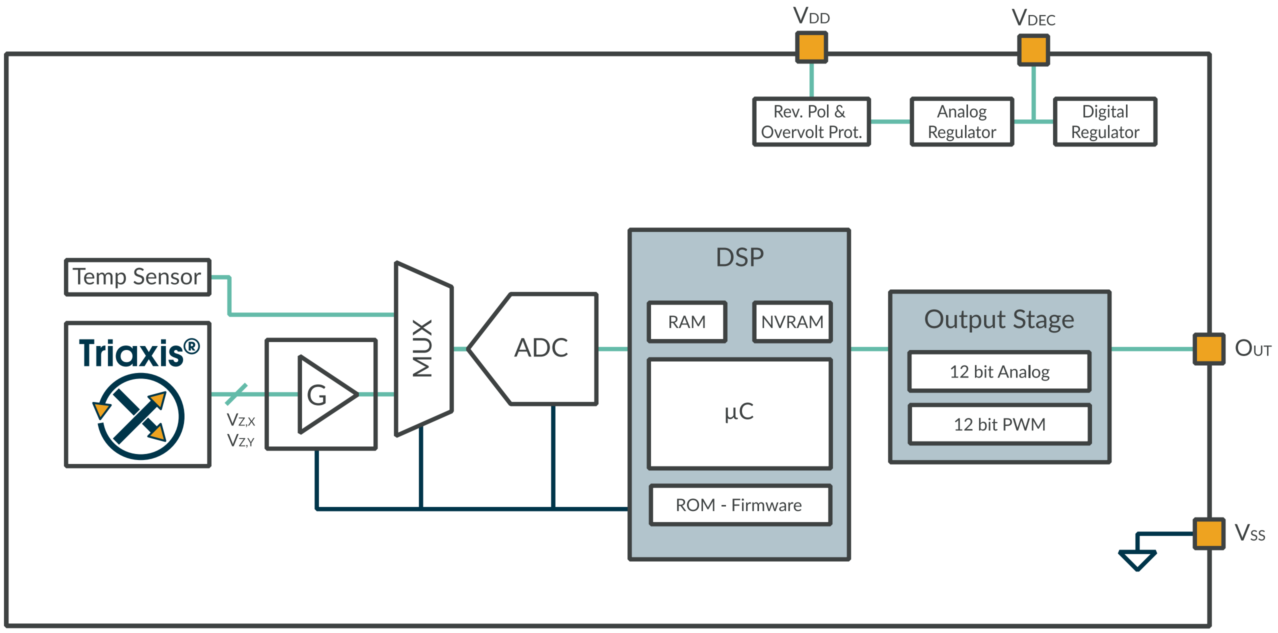


Figure 1 - MLX90425 Block diagram

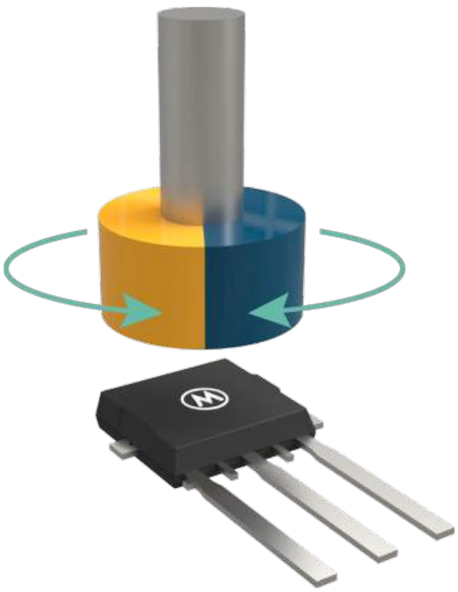


Figure 2 - Angular Rotary – 360° Stray field Robust

2. Glossary of Terms

Name	Description
ADC	Analog-to-Digital Converter
AWD	Absolute Watchdog
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
DAC	Digital-to-Analog Converter
%DC	Duty Cycle of the output signa,l i.e. T_{ON} /(T_{ON} + T_{OFF})
DP	Discontinuity Point
DCT	Diagnostic Cycle Time
DSP	Digital Signal Processing
ECC	Error Correcting Code
EMC	Electro-Magnetic Compatibility
EoL	End of Line
FHTI	Fault Handling Time Interval
FIR	Finite Impulse Response
Gauss (G)	Alternative unit for the magnetic flux density (10G = 1mT)
HW	Hardware
IMC	Integrated Magnetic Concentrator
INL / DNL	Integral Non-Linearity / Differential Non-Linearity
IWD	Intelligent Watchdog
LSB / MSB	Least Significant Bit / Most Significant Bit
N.C.	Not Connected
NVRAM	Non-Volatile RAM
PCB	Printed Circuit Board
POR	Power-On Reset
PSF	Product Specific Functions
PWL	Piecewise Linear
PWM	Pulse Width Modulation
RAM	Random Access Memory
ROM	Read-Only Memory
SEooC	Safety Element out of Context
SMP	Single-Mold Package with integrated discrete components (capacitors)
TC	Temperature Coefficient (generally in ppm/°C)
Tesla (T)	SI-derived unit for the magnetic flux density (Vs/m^2)

Table 3 - Glossary of terms

3. Pin Definitions and Descriptions

3.1. Pin Definition for SOIC-8

Pin #	Name	Description
1	V_{DD}	Supply
2	$Test_1$	For Melexis factory test
3	$Test_2$	For Melexis factory test
4	N.C.	Not connected
5	OUT	Output
6	N.C.	Not connected
7	V_{DEC}	Decoupling pin
8	V_{SS}	Ground

Table 4 - SOIC-8 pins definition and description

Test pins are internally grounded when in application mode. For optimal EMC behavior always connect the Test and N.C. pins to the ground of the PCB.

3.2. Pin Definition for SMP-3

SMP-3 package offers advanced components integration in a single mold compact form.

Pin #	Name	Description
1	V_{DD}	Supply
2	OUT	Output
3	V_{SS}	Ground

Table 5 - SMP-3 pins definition and description

4. Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit	Condition
Supply Voltage	V_{DD}		28 37	V	< 48h < 60s; $T_{AMB} \leq 35°C$
Reverse Voltage Protection	$V_{DD\text{-}rev}$	-14 -18		V	< 48h < 1h
Positive Output Voltage	V_{OUT}		28 34	V	< 48h < 1h
Reverse Output Voltage	$V_{OUT\text{-}rev}$	-14 -18		V	< 48h < 1h
Internal Voltage	V_{DEC}		3.6	V	< 1h
	$V_{DEC\text{-}rev}$	-0.3		V	< 1h
Positive $Test_1$ pin Voltage	V_{Test1}		6	V	< 1h
Reverse $Test_1$ pin Voltage	$V_{Test1\text{-}rev}$	-3		V	< 1h
Positive $Test_2$ pin Voltage	V_{test2}		3.6	V	< 1h
Reverse $Test_2$ pin Voltage	$V_{test2\text{-}rev}$	-0.3		V	< 1h
Operating Temperature	T_{AMB}	-40	+160	°C	
Junction Temperature [2]	T_J		+175	°C	
Storage Temperature	T_{ST}	-55	+170	°C	
Magnetic Flux Density	B_{max}	-1	1	T	

Table 6 - Absolute maximum ratings

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

[2] *Find package thermal dissipation values in section 17.2*

4.1. High-Temperature Extension Absolute Maximum Ratings

The MLX90425 can be exposed to high-temperature within the range [160, 180] °C for a limited duration. The device continues to operate with degraded performances according to the values listed in the following table. This extension is only valid for the SMP-3 package.

Parameter	Symbol	Min	Max	Unit	Condition
Supply Voltage	V_{DD}		5.5	V	T_{AMB} = 180°C, see [3]
Reverse Voltage Protection	V_{DD-rev}	-14		V	T_{AMB} = 180°C, < 1h
Positive Output Voltage	V_{OUT}		26	V	T_{AMB} = 180°C, < 1h
Reverse Output Voltage	$V_{OUT-rev}$	-14		V	T_{AMB} = 180°C, < 1h
Operating Temperature	T_{AMB}	-40	180	°C	< 250h
Junction Temperature	T_J		190	°C	< 250h
Storage Temperature	T_{ST}	-55	190	°C	< 250h

Table 7 - High-temperature extension absolute maximum ratings

Exceeding any of the absolute maximum ratings may cause permanent damage.

Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

5. General Electrical Specifications

General electrical specifications are valid for temperature range [-40, 160] °C and supply voltage range [4.5, 5.5] V unless otherwise noted.

Electrical Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Supply Voltage	V_{DD}	4.5	5	5.5	V	
Supply Current	I_{DD}	8.5	10	11.5	mA	
Start-up Level (rising)	$V_{DDstartH}$	3.85	4.00	4.15	V	
Start-up Hysteresis	$V_{DDstartHyst}$		100		mV	
PTC Entry Level (rising)	V_{PROV0}	5.85	6.05	6.25	V	Supply overvoltage detection
PTC Entry Level Hysteresis	$V_{PROV0Hyst}$	100	175	250	mV	
Under voltage detection	V_{DDUVL}	3.75	3.90	4.05	V	Supply voltage low threshold
Under voltage detection hysteresis	$V_{DDUVHyst}$		100		mV	
Regulated Voltage	V_{DEC}	3.2	3.3	3.4	V	Internal analog voltage

Table 8 - Supply system electrical specifications

[3] *Higher supply voltages will increase the die temperature above the max junction temperature T_J*

Electrical Parameter	Symbol	Min	Typ.	Max	Unit	Condition
External Pull-up Voltage	V_{ext}			18 V_{DD}	V	Output Pull-up voltage in open-drain NMOS mode or analog mode Output Pull-up voltage in digital Push-Pull mode
Output Short Circuit Current Limit	$I_{OUTshort}$	10		35	mA	
Output Load	R_L	5	10		kΩ	Analog output
		5		100	kΩ	Digital output in Push-Pull mode PWM pull-up to V_{DD}, PWM pull-down to V_{SS}
		1.5 5 1.5		25 18 25	kΩ	Digital output in open-drain mode PMOS, pull-down to V_{SS} NMOS, pull-up to $V_{ext} \le 18V$ NMOS, pull-up to $V_{ext} = V_{DD}$
Analog output Saturation Level [4]	V_{satA_lo}		0.5 3.3	1.2 7.4	$\%V_{DD}$	Pull-up to V_{ext} $R_L \ge 10$ kΩ, $V_{ext} \le V_{DD}$ $R_L \ge 5$ kΩ to $V_{ext} \le 18V$
	V_{satA_hi}	97.0 95.0	99.0 98.0		$\%V_{DD}$	Pull-down to V_{SS} $R_L \ge 10$ kΩ $R_L \ge 5$ kΩ
Digital output level push-pull mode [4]	V_{satD_lopp}			1.2	$\%V_{DD}$	Pull-up to $V_{ext} \le V_{DD}$, $R_L \ge 10$ kΩ
	V_{satD_hipp}	97.0 95.0			$\%V_{DD}$	Pull-down to V_{SS}, $R_L \ge 10$ kΩ Pull-down to V_{SS}, $R_L \ge 5$ kΩ
Digital output level open-drain mode	$V_{satLoOd}$	0		10	$\%V_{ext}$	Pull-up to $V_{ext} \le 18V$, $I_L \le 3.4mA$
	$V_{satHiOd}$	90		100	$\%V_{DD}$	Pull-down to V_{SS}, $I_L \le 3.4mA$
Digital output leakage open-drain mode [5]	$I_{leakpuOd}$			100	µA	Pull-up to $V_{ext} > V_{DD}$
				20	µA	Pull-up to $V_{ext} = V_{DD}$
				20	µA	Pull-down to V_{SS}
Digital output Resistance	R_{on}	27	50	130	Ω	Valid for high and low digital levels

[4] Typical values are representative of a temperature of 35°C and a supply voltage of 5V. Min-Max values are representative of a temperature of 160°C and a supply voltage of 4.5V.

[5] Measured leakage when the open-drain transistor is inactive. The digital output level depends on V_{ext}, R_L and the leakage current.

Electrical Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Passive Diagnostic Output Level (Broken-Wire Detection)	$BV_{SS}PD$		1.2 0.5	4.0 1.6	$\%V_{DD}$	Broken V_{SS} line and Pull-down to V_{SS}, $R_L \leq 25$ kΩ Pull-down to V_{SS}, $R_L \leq 10$ kΩ
	$BV_{SS}PU$	99.5	100		$\%V_{ext}$	Broken V_{SS} line and Pull-up to V_{ext}, $R_L \geq 1$ kΩ
	$BV_{DD}PD$		0	0.5	$\%V_{DD}$	Broken V_{DD} line and Pull-down to V_{SS}, $R_L \geq 1$ kΩ
	$BV_{DD}PU$	92.5 97.0	98.5 99.5		$\%V_{ext}$	Broken V_{DD} line and Pull-up to V_{ext}, $R_L \leq 25$ kΩ Pull-up to V_{ext}, $R_L \leq 10$ kΩ

Table 9 - Output electrical specifications

5.1. High-Temperature Extension Electrical Specifications

When the MLX90425 is exposed to high-temperatures within the range [160, 180] °C and the supply voltage remains in the range [4.5, 5.5] V, the output pull-up voltage range shall remain within the limits of the supply voltage.

Electrical Parameter	Symbol	Min	Typ	Max	Unit	Condition
External Pull-up Voltage	V_{ext}			V_{DD}	V	Output Pull-up voltage in open-drain NMOS mode or analog mode

Table 10 - High-temperature electrical specifications

6. Timing Specifications

Timing specifications are valid for temperature range [-40, 160] °C and supply voltage range [4.5, 5.5] V unless otherwise noted.

6.1. General Timing Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Main Clock Frequency	F_{CK}	22.8 -5	24	25.2 5	MHz $\%F_{ck}$	Including thermal and lifetime drift
Main Clock initial tolerances	$\Delta F_{CK,0}$	-1		1	$\%F_{ck}$	T=35°C, trimming resolution
Main Clock Frequency Thermal Drift	$\Delta F_{CK,T}$	-3.5		3.5	$\%F_{ck}$	Relative to clock frequency at 35°C. Ageing effect not included
1MHz Clock Frequency	F_{1M}	0.95 -5	1	1.05 5	MHz $\%F_{1M}$	Including thermal and lifetime drift
Analog Diagnostics DCT[6]	DCT_{ANA}		11.8	12.4	ms	Continuous acquisition mode (see 6.2), for analog and PWM.
Digital Diagnostics DCT[6]	DCT_{DIG}		18.7	19.7	ms	
Fail Safe state duration [7]	T_{FSS}	5		33	ms	For digital single-event faults

Table 11 - General timing specifications

6.2. Continuous Acquisition Mode

In this mode, the sensor continuously acquires an angle at a fixed rate and updates its output when the information is ready. The acquisition rate is defined by the angle measurement period $T_{angleMeas}$. The PWM output frequency is asynchronous with the angle measurement sequence and controlled by the T_FRAME parameter.

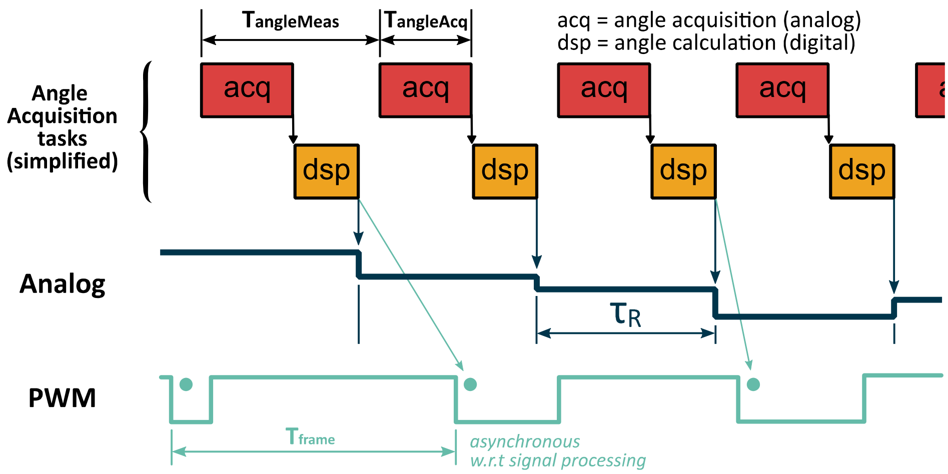


Figure 3 - Continuous Acquisition Timing Mode

[6] *Max value includes the clock tolerances*

[7] *Programmable parameter. Defines the time between a reset due to digital fault to the first valid data. Min. value defined by OUT_DIAG_HIZ_TIME (see Table 24 in chapter 11 for details).*

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Angle acquisition time	$T_{angleAcq}$		210		µs	Default factory settings
Internal Angle Measurement Period	$T_{angleMeas}$		512		µs	Default factory settings

Table 12 - Continuous acquisition timing mode

6.3. Timing Definitions

6.3.1. Startup Time

In analog mode, the start-up time τ_{SU} is defined by the duration between rising of the supply voltage and the output being set to the voltage level of the measured angle. During the start-up phase, the sensor output remains in a high impedance state. The output driver is enabled only when the sensor is able to transmit a valid angle.

In PWM mode, the start-up phase consists of three phases of durations $T_{stup[1:3]}$. The first phase ends when the sensor output leaves high impedance state and starts to drive a voltage. The end of the second phase T_{stup2} is reached when an angle is ready to be transmitted and indicated by the first synchronization edge of the PWM signal. The start-up phase is considered complete after T_{stup3} when the first angle has been transmitted, which happens one PWM period after T_{stup2}.

These definitions are illustrated in the following figure (Figure 4) where τ_{init} represents the sensor internal initialization sequence.

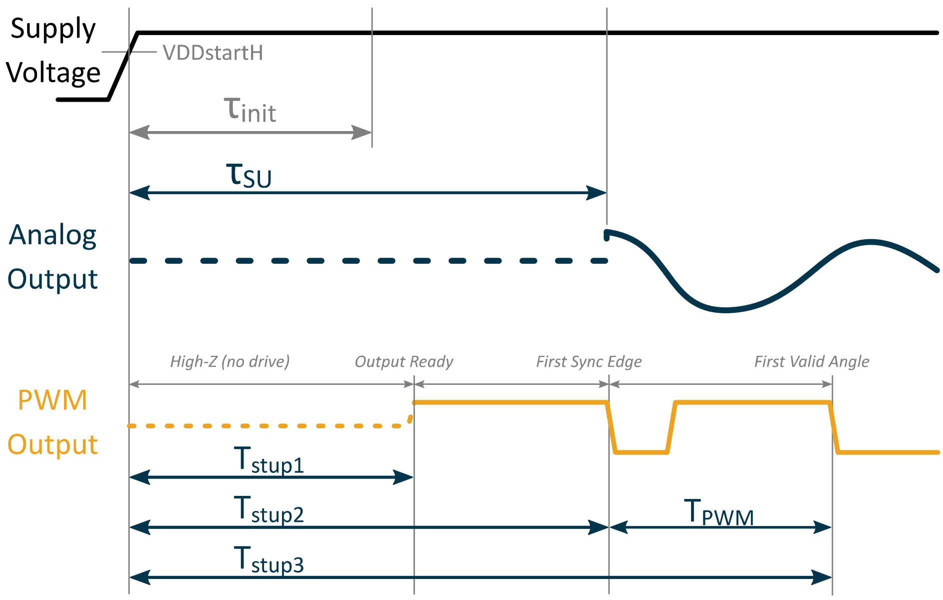


Figure 4 - Startup time definition

6.3.2. Latency (average)

The sensor latency is the average lag between the movement of the detected object (magnet) and the response of the sensor output. This value is representative of the time constant of the MLX90425 when used in a regulation loop.

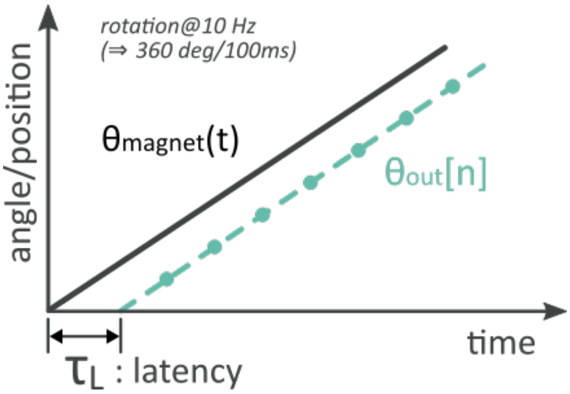


Figure 5 - Definition of latency

6.3.3. Step Response (worst-case)

The Step Response T_{wcStep} is defined as the maximal delay between a change of position of the magnet and the 100% settling time of the sensor output, with full angle accuracy with regards to filtering. This worst-case is happening when the movement of the magnet occurs just after a measurement sequence has begun. The Step Response consists of the sum of:

- $\delta_{mag,measSeq}$, the delay between the magnetic step and the end of the measurement sequence
- $T_{angleMeas}$, the internal angle measurement period
- $\delta_{measSeq,trans}$, the delay between the end of the measurement sequence and the beginning of the transmission of the angle information
- T_{trans}, the duration of the transmission of the angle information, which depends on the output protocol

The worst-case occurs when the magnetic step is just after the beginning of a measurement sequence. In other words, when $\delta_{mag,measSeq}$ equals the length of the measurement sequence $\tau_{measSeq}$. This gives:

$$\mathrm{T_{wcStep}} = \tau_{measSeq} + T_{angleMeas} + \delta_{measSeq,trans} + T_{trans}$$

In analog output mode, the angle information is immediately available after the end of the internal measurement period and the transmission delay is negligible. The last two terms of the above equation can be nulled. When using a PWM output protocol, the last two terms of the equation are, in the worst-case condition, both equal to a PWM frame duration T_{PWM}. The Figure 6 shows a practical case of a step response for both an analog and PWM output.

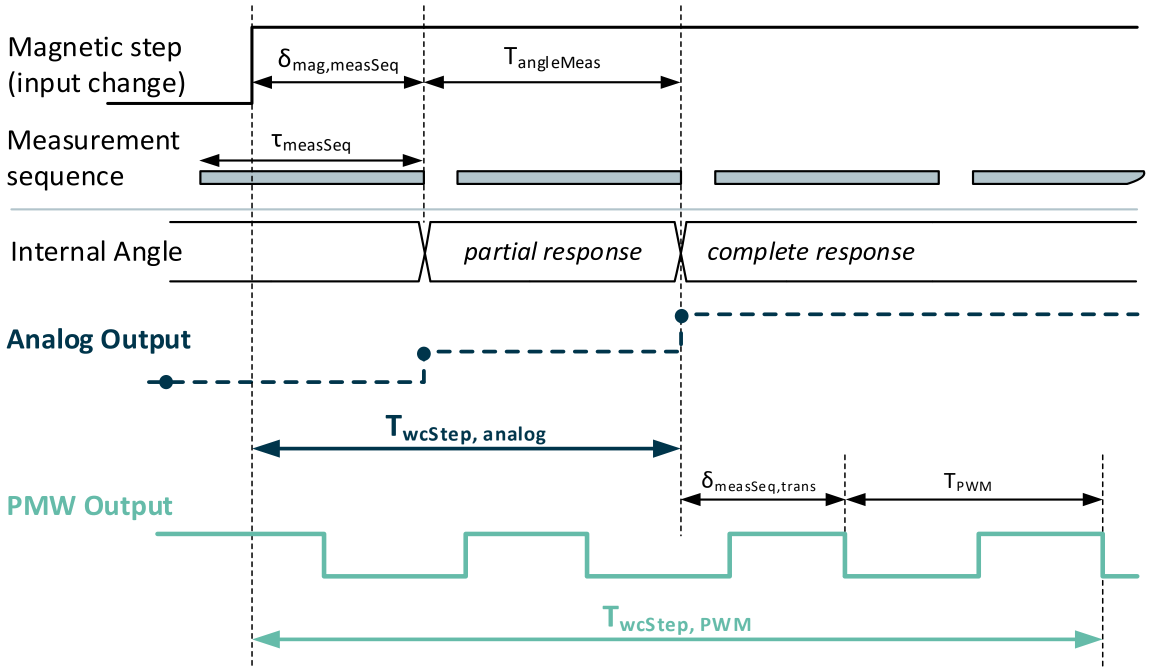


Figure 6 - Step response definition

6.4. Analog Output Timing Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Output refresh period [8]	$T_{angleMeas}$		512	538	µs	Default factory setting
Latency	τ_L		225	237	µs	Filter 0
Step response	T_{wcStep}		837 1349 2373	879 1416 2492	µs	Filter 0, Filter 1, Filter 2 (see 12.4 Filtering)
Start-up time	τ_{SU}		4.0	4.5	ms	
Safe startup time[6]	$T_{SafeStup}$		16.8	17.7	ms	COLD_SAFE_STARTUP_EN = 1 (see Table 24)
Slew-rate	S_R			120 200	V/ms	C_{OUT} = 100nF C_{OUT} = 10nF

Table 13 - Analog output timing specifications

[8] *In analog mode, the output refresh period matches the internal angle measurement period.*

6.5. PWM Output Timing Specifications

For the parameters in below table, maximum timings correspond to minimal frequencies and vice versa.

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
PWM Frequency	F_{PWM}	100		2000	Hz	
PWM Frequency Initial Tolerances	$\Delta F_{PWM,0}$	-1		1	$\%F_{PWM}$	T=35°C, can be trimmed at EOL
PWM Frequency Thermal Drift	$\Delta F_{PWM,T}$	-3.5		3.5	$\%F_{PWM}$	
PWM Frequency Drift	ΔF_{PWM}	-5		5	$\%F_{PWM}$	Over temperature and lifetime
PWM startup time [9]	T_{stup1}		4.1		ms	Default factory setting Up to output ready
	T_{stup2}		5.2		ms	Default factory setting Up to first sync. Edge T_{stup1} + T_{PWM}
	T_{stup3}		6.3		ms	Default factory setting Up to first data received T_{stup2} + T_{PWM}
PWM Safe startup time			18.5	19.5	ms	F_{PWM} = 1kHz, up to first edge. COLD_SAFE_STARTUP_EN = 1 (see Table 24)

Table 14 - PWM timing specifications

[9] *Typ. value specified according to the typical PWM frequency. Max. value can be obtained by scaling with the PWM frequency drift accordingly.*

7. Magnetic Field Specifications

Magnetic field specifications are valid for temperature range [-40, 160] °C unless otherwise noted.

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Number of magnetic poles	N_P		2			
Magnetic Flux Density in Z	B_z			200	mT	in absolute value
Useful Magnetic Flux Density Norm	ΔB_z	10[10]	20	240	$\frac{mT}{mm}$	$\sqrt{\left(\frac{\Delta B_Z}{\Delta X}\right)^2 + \left(\frac{\Delta B_Z}{\Delta Y}\right)^2}$ (ΔB_Z mode) see 12.3 for sensing mode description.
Hall Plates spacing	ΔX, ΔY		1.70		mm	Distance between the two hall plates of a measurement axis.
Magnet Temperature Coefficient	TC_m	-2400		0	$\frac{ppm}{°C}$	
Fieldstrength Resolution	$\Delta B_{z,norm}$	0.075	0.1	0.125	$\frac{mT}{mm\ LSB}$	
Field Too Low Threshold	$\Delta B_{Z,TH\_LOW}$	2	3	15	$\frac{mT}{mm}$	Typ. is recommended value to be set by user (see 12.5.5)
Field Too High Threshold	$\Delta B_{Z,TH\_HIGH}$	100	310	310	$\frac{mT}{mm}$	Typ. is recommended value to be set by user (see 12.5.5)

Table 15 - Magnetic specifications for standard application

The magnetic performances are listed in chapter 8.2. The Figure 7 defines under which conditions nominal or high-temperature performances apply.

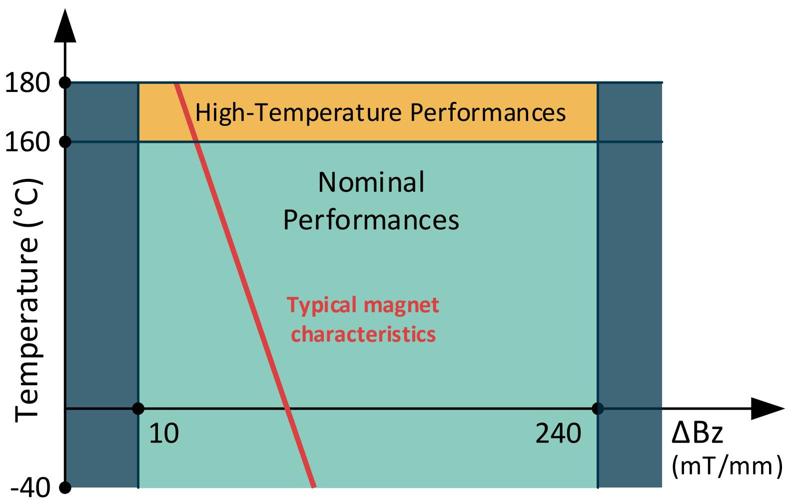


Figure 7 - Useful magnetic signal definition

[10] Only valid under the conditions of Figure 7. Outside of the "Limited Performances" zone, the performances are further degraded due to a reduction of the signal-to-noise ratio and signal-to-offset ratio.

8. Accuracy Specifications

Accuracy specifications are valid for temperature range [-40, 160] °C and supply voltage range [4.5, 5.5] V unless otherwise noted.

8.1. Definitions

8.1.1. Intrinsic Linearity Error

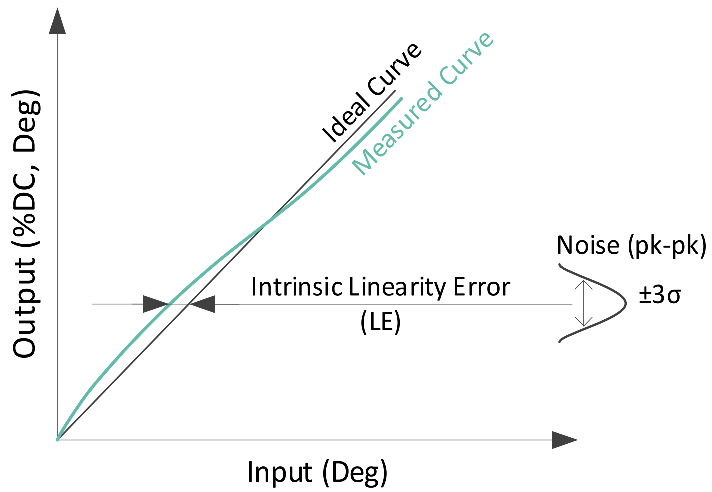


Figure 8 - Sensor accuracy definition

The illustration of Figure 8 depicts the intrinsic linearity error in new parts. The Intrinsic Linearity Error refers to the error sources of the IC (offset, sensitivity mismatch, orthogonality error) considering an ideal magnetic field. Once associated to a practical magnetic construction and its respective mechanical and magnetic tolerances, the output linearity error increases. The linearity error can be improved with the multi-point end-user calibration (see 12.2). As a consequence, this error is not the critical factor in application when it is calibrated away.

8.1.2. Total Angle Drift

After calibration, the output angle of the sensor might still change due to temperature change and aging. This error is defined as the total drift $\partial\theta_{TT}$:

$$\partial\theta_{TT} = \max\{\theta(\theta_{IN}, T, t) - \theta(\theta_{IN}, T_{RT}, t_0)\}$$

where θ_{IN} is the input angle, T is the temperature, T_{RT} is the room temperature, and t is the elapsed lifetime after calibration. t_0 represents the start of the sensor operating life. Note that the total drift $\partial\theta_{TT}$ is always defined with respect to the angle at room temperature. In this datasheet, T_{RT} is typically defined at 35°C unless stated otherwise. The total drift is valid for all angles along the full mechanical stroke.

8.2. Performances

Valid before EoL calibration and for all applications under nominal performances conditions described in chapter 5 and chapter 7.

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Intrinsic Linearity Error	$L_{E\_\Delta BZ}$	-1.2		1.2	Deg.	
Noise [11]			0.40 0.19 0.20	0.50 0.24 0.25	Deg.	Filter = 0, $\Delta B_z \geq$ 10mT/mm Filter = 0, $\Delta B_z \geq$ 20mT/mm Filter = 2, $\Delta B_z \geq$ 10mT/mm
Total Drift [12]	$\partial\theta_{TT_{XY}}$	-0.9		0.9	Deg.	Relative to 35°C
Hysteresis [13]				0.1	Deg.	$\Delta B_z \geq$ 10mT
Stray Field Immunity				0.35	Deg.	$\Delta B_z \geq$ 20mT/mm In accordance with ISO11452-8:2015, at 30°C with stray field of 4kA/m from any direction

Table 16 - Nominal magnetic performances

8.2.1. High-Temperature Extension Performances

When the MLX90425 is exposed to high-temperatures within the range [160, 180] °C and the supply voltage remains in the range [4.5, 5.5] V, the following magnetic performances apply.

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Intrinsic Linearity Error	$L_{E\_\Delta BZ}$	-1.4		1.4	Deg.	
Noise [11]			0.48 0.24 0.24	0.60 0.30 0.30	Deg.	Filter = 0, $\Delta B_z \geq$ 10mT/mm Filter = 0, $\Delta B_z \geq$ 20mT/mm Filter = 2, $\Delta B_z \geq$ 10mT/mm
Total Drift [12]	$\partial\theta_{TT_{XY}}$	-1.1		1.1	Deg.	Relative to 35°C
Hysteresis [13]				0.1	Deg.	$\Delta B_z \geq$ 10mT/mm
Stray Field Immunity				0.35	Deg.	$\Delta B_z \geq$ 20mT/mm In accordance with ISO11452-8:2015, at 30°C with stray field of 4kA/m from any direction

Table 17 – High-temperature magnetic performances

11 ±3σ

12 Verification done on new and aged devices in an ideal magnetic field. An additional application-specific error arises from the non-ideal magnet and mechanical tolerance drift.

13 The MLX90425 has no IMC and therefore no intrinsic source of magnetic hysteresis

9. Memory Specifications

Parameter	Symbol	Value	Unit	Note
ROM	ROM_{size}	16	kB	1-bit parity check per 32-bit word (single error detection)
RAM	RAM_{size}	512	B	1-bit parity check per 16-bit word (single error detection)
NVRAM	$NVRAM_{size}$	128	B	6-bit ECC per 16-bit word (single error correction, double error detection)

Table 18 - Memory specifications

10. Output Protocol Description

10.1. Analog Output Description

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Thermal analog output Drift				0.2	$\%V_{DD}$	
Analog Output Resolution	R_{DAC}		12		bit	12-bit DAC (theoretical)
		-4		+4	LSB12	INL (before EoL calibration), output between 3-97%V_{DD}
		-1.5		1.5	LSB12	DNL
Ratiometric Error		-0.05 -0.1		0.05 0.1	$\%V_{DD}$	$4.5V \leq V_{DD} \leq 5.5V$ $V_{DDUVL} \leq V_{DD} \leq V_{PROVO}$

Table 19 - Analog output accuracy

10.1.1. High-Temperature Extension Analog Output Description

When the MLX90425 is exposed to high-temperatures within the range [160, 180] °C and the supply voltage remains in the range [4.5, 5.5] V, the following analog output accuracy performances apply.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Thermal analog output Drift				0.25	$\%V_{DD}$	
Ratiometric Error		-0.1		0.1	$\%V_{DD}$	$4.5V \leq V_{DD} \leq 5.5V$

Table 20 - High-temperature analog output accuracy

10.2. PWM Output Description

10.2.1. Definition

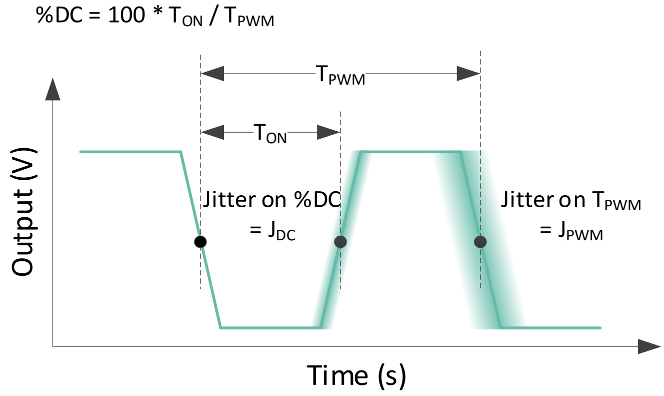


Figure 9 - PWM signal definition

Parameter	Symbol	Test Conditions
PWM period	T_{PWM}	Trigger level = 50% V_{DD}
Rise time, Fall time	t_{rise}, t_{fall}	Between 10% and 90% of V_{DD}
Jitter	J_{DC} J_{PWM}	±3σ for 1000 successive acquisitions with clamped output
Duty Cycle	%DC	100 * T_{ON} / T_{PWM}

Table 21 - PWM signal definition

10.2.2. PWM performances

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
PWM period	T_{PWM}	0.5		10	ms	Configurable through the T_FRAME parameter
PWM Output Resolution	R_{PWM}		0.024		%DC/LSB12	
PWM %DC Jitter	J_{DC}			0.03	%DC	C_{OUT} = 10nF, R_L = 10kΩ Push-pull, 2KHz
PWM Period Jitter	J_{PWM}			500	ns	2KHz, PWM_LOW_SR=0
PWM %DC thermal drift			0.02	0.05	%DC	C_{OUT} = 10nF, R_L = 10kΩ Push-pull, 2KHz

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Rise/Fall Time PWM	T_{rise_fall}	2.5	5.0	7.5	µs	Fast slope [14], C_{OUT} ≤ 15nF [15][16] Push-pull or open-drain
	T_{rise_fall}	3.7	8	12	µs	Slow slope [14], C_{OUT} ≤ 22nF Push-pull or open-drain

Table 22 - PWM signal specifications

10.2.3. High-Temperature Extension PWM Performances

When the MLX90425 is exposed to high-temperatures within the range [160, 180] °C and the supply voltage remains in the range [4.5, 5.5] V, the following PWM signal specifications apply.

Parameter	Symbol	Min	Typ	Max	Unit	Condition
PWM %DC thermal drift			0.05	0.1	%DC	C_{OUT} = 10nF, R_L = 10kΩ Push-pull, 2KHz

Table 23 - High-Temperature PWM Signal Specifications

[14] The fast and slow slope configuration can be controlled through the PWM_LOW_SR parameter (see Table 24 in chapter 11)

[15] The 10nF output capacitor included in the SMP-3 package needs to be considered in the 15nF limit.

[16] If the total load current at the output is high enough to trigger the current limit protection, then the slopes will be determined by the maximum output current drive of around 15mA (typical value).

11. End-User Programmable Items

Parameter	PSF value	Description	Default Value	# bits
GENERAL CONFIGURATION				
USER_ID[0:5]	98 .. 103	Reserved for end-user to program information for traceability. Not compatible with a used patch area	-	8
WARM_TRIGGER_LONG	93	Add delay for PTC entry level	0	1
MUPET_ADDRESS	97	Address to which the slave device will answer	0	2
SENSOR FRONT-END				
GAINMIN	2	Minimum Virtual Gain	0	6
GAINMAX	3	Maximum Virtual Gain	48	7
GAINSATURATION	4	Enable gain saturation	0	1
SENSING_MODE	17	0: ΔBZ, angular rotary 360° stray field robust 1-3: Do not use	0	2
FILTERING				
FILTER	12	FIR filter bandwidth selection 0: no filter (default) 1: FIR11 2: FIR1111 3: Do not use	0	2
LINEAR TRANSFER CHARACTERISTIC				
4POINTS	11	Enable 4 points PWL linearization	0	1
CLAMPHIGH	19	High clamping value of angle output data	50%	12
CLAMPLOW	14	Low clamping value of angle output data	50%	12
CW	15	Magnet rotation direction	0	1
DP	10	DSP discontinuity point	0	13
LNRS0	22	4-pts - Slope coefficient before reference point A	-	16
LNRAX LNRBX LNRCX LNRDX	25 35 46 58	4-pts - X Coordinate for reference points A,B,C,D	-	16
LNRAY LNRBY LNRCY LNRDY	30 41 53 63	4-pts - Y Coordinate for reference points A,B,C,D	-	16
LNRAS LNRBS LNRCS LNRDS	32 43 55 65	4-pts - Slope coefficient for reference points A,B,C,D	-	16

Parameter	PSF value	Description	Default Value	# bits
LNRY0 LNRY1 LNRY2 LNRY3 LNRY4 LNRY5 LNRY6 LNRY7 LNRY8 LNRY9 LNRY10 LNRY11 LNRY12 LNRY13 LNRY14 LNRY15 LNRY16	24 26 31 34 37 42 45 48 54 57 60 64 67 70 75 77 79	17-pts / 16 segments - Y coordinate point [0:16]	10% 15% 20% 25% 30% 35% 40% 45% 50% 55% 60% 65% 70% 75% 80% 85% 90%	12
OUTSLOPE_COLD	81	Slope coefficient at cold of the programmable temperature-dependent offset	0	8
OUTSLOPE_HOT	82	Slope coefficient at hot of the programmable temperature-dependent offset	0	8
USEROPTION_SCALING	16	Enable output scaling 2x after linearization	0	1
WORK_RANGE	104	Working Range 17 points	0	4
WORK_RANGE_GAIN	7	Post DSP Gain Stage	16	8
		DIAGNOSTICS		
COLD_SAFE_STARTUP_EN	50	Normal (0) or safe start-up (1) after power-on reset	0	1
DIAG_EN	40	Diagnostics global enable. **Do not modify!**	1	1
DIAG_FIELDTOOHIGHTHRES	69	Field strength limit over which a fault is reported	14	4
DIAG_FIELDTOOLOWTHRES	62	Field strength limit under which a fault is reported	0	4
DIAGDEBOUNCE_STEPDOWN	28	Diagnostic debouncing step-down time used for recovery time setting	1	2
DIAGDEBOUNCE_STEPUP	29	Diagnostic debouncing step-up time used for hold time setting	1	2
DIAGDEBOUNCE_THRESH	39	Diagnostic debouncing threshold	1	3
MEMLOCK	52	Enable NVRAM write protection	0	2
OUT_DIAG_HIZ_TIME	90	Recovery time when a transient digital failure is detected. Maximum value is 28 (0x1C) Timeout = (5 + OUT_DIAG_HIZ_TIME) * 1ms	15	5

Parameter	PSF value	Description	Default Value	# bits
PWM_DC_FAULT_BAND	86	PWM Upper or Lower band for analog fault reporting	0	1
PWM_DC_FAULT_VAL	85	PWM Duty Cycle in case of analog fault	0	3
PWM_DC_FIELDTOOLOW_BAND	72	PWM Upper or Lower band for analog fault reporting in case of Field Strength Too Low	-	1
PWM_DC_FIELDTOOLOW_VAL	73	PWM Duty Cycle in case of Field Strength Too Low	-	3
ROUT_LOW	91	Select output impedance for PTC communication	1	1
DAC_REPORT_MODE_ANA	21	Defines the DAC state in analog-fault report mode Refer to the Safety Manual	0	2
PWM_REPORT_MODE_ANA	89	Defines the PWM state in analog-fault report mode Refer to the Safety Manual	0	1
OUTPUT CONFIGURATION				
ABE_OUT_MODE	92	Output-amplifier mode selection: 0: Analog output (12-bit DAC) 1: Digital output with open-drain NMOS 2: Digital output with open-drain PMOS 3: Digital output with Push-Pull	0	2
PROTOCOL	94	Selection of the output protocol and its corresponding timing mode: 0: Analog Output (continuous synchronous angle acquisition) 1: PWM Output (continuous asynchronous angle acquisition)	0	1
T_FRAME	84	Output PWM period PWM period = 4us * T_FRAME	250	12
ABE_CURR_LIMITER	105	Enables slow PWM slopes	0	1
PWM_POL	88	Invert the PWM polarity	0	1

Table 24 - MLX90425 end-user programmable items table

Performances described in this document are only achieved by adequate programming of the device. To ensure desired functionality, Melexis recommends to follow its programming guide and to contact its technical or application service.

12. Description of End-User Programmable Items

12.1. Output modes and protocols

The MLX90425 offers an analog output mode and a digital output mode using the PWM protocol.

12.1.1. Output Modes

The parameter ABE_OUT_MODE defines the output stage mode (outside of fail-safe state) in application.

ABE_OUT_MODE	Description	Comments
0	Analog output (12-bit DAC)	Default
1	Digital output with open-drain NMOS	Requires a pull-up resistor on the output
2	Digital output with open-drain PMOS	Requires a pull-down resistor on the output
3	Digital output with push-pull	

Table 25 - Output mode selection

12.1.2. Protocol

The parameter PROTOCOL defined the measurement timings mode and the corresponding output protocol.

PROTOCOL	Description
0	Continuous synchronous angle acquisition, analog output (DAC)
1	Continuous asynchronous angle acquisition, PWM

Table 26 - Protocol selection

12.1.3. PWM Protocol

If a digital output mode is selected, the output signal is a Pulse Width Modulation (PWM) digital signal.

The PWM polarity is selected by the PWM_POL parameter:

- PWM_POL = 0 for a low level at 100%
- PWM_POL = 1 for a high level at 100%

The PWM frequency is selected in the range [100, 2000] Hz by the T_FRAME parameter (12-bit value), defining the period time in the range [0.5, 10] ms. Minimum allowed value for T_FRAME is therefore 125 (0x7d).

$$T_{PWM} = \frac{4}{10^6} \times T_F RAME$$

The PWM slope is configurable through the parameter PWM_LOW_SR. When set to 0, fast PWM slopes are selected. Conversely, when set to 1, slow PWM slopes are selected to reduce conducted EMC emissions on the output.

PWM timings specifications in the scope of the MLX90425 can be found in section 6.5 while PWM signal characteristics such the rise time, fall times, jitter, can be found in section 10.2.

12.2. Output Transfer Characteristic

There are 2 different possibilities to define the transfer function (LNR) as specified in Table 27.

- With 4 arbitrary points (defined by X and Y coordinates) and 5 slopes
- With 17 equidistant points for which only the Y coordinates are defined

Output Transfer Characteristic	4POINTS
4 Arbitrary Points	1
17 Equidistant Points	0

Table 27 - Output transfer characteristic selection table

12.2.1. Clockwise Parameter

The CW parameter defines the magnet rotation direction.

Rotation Direction	CW
Clockwise	1
Counter Clockwise	0

Table 28 - Magnet rotation selection table

Counter clockwise is the defined by

- the 1-4-5-8 pin order direction for the SOIC-8 package
- the 1-2-3 pin order direction for the SMP-3 package

Clockwise if defined by the reverse pin order. Refer to the package drawings in chapter 17.

12.2.2. Discontinuity Point (or Zero Degree Point)

The Discontinuity Point defines the 0° point on the circle. The discontinuity point places the new origin at any location of the trigonometric circle. The DP is used as reference for all angular measurements.

$$\text{New Angle} = \text{Angle} - \text{DP}$$

The DP parameter is encoded using a signed 13-bit format (two's complement). The new angle and the input angle are expressed in LSB12.

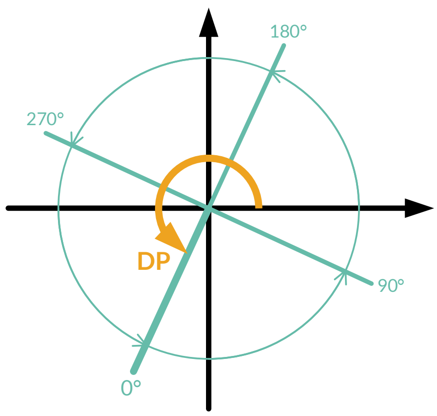


Figure 10 - Discontinuity point positioning (for CW=0)

12.2.3. 4-Pts LNR Parameters

The LNR parameters, together with the clamping values, define the transfer function between the internal digital representation of the angle and the output signal.

The shape of the MLX90425 four points transfer function from the internal angle to the output value is described in the following figure (Figure 11). Seven segments can be programmed using points and slopes. The segments beyond the clamping levels are necessarily flat.

Two to six calibration points are available, reducing the overall non-linearity of the IC by almost an order of magnitude each time. Three or more calibration point will be preferred by customers looking for excellent non-linearity figures. Two-point calibrations will be preferred by customers looking for a cheaper calibration set-up and shorter calibration time.

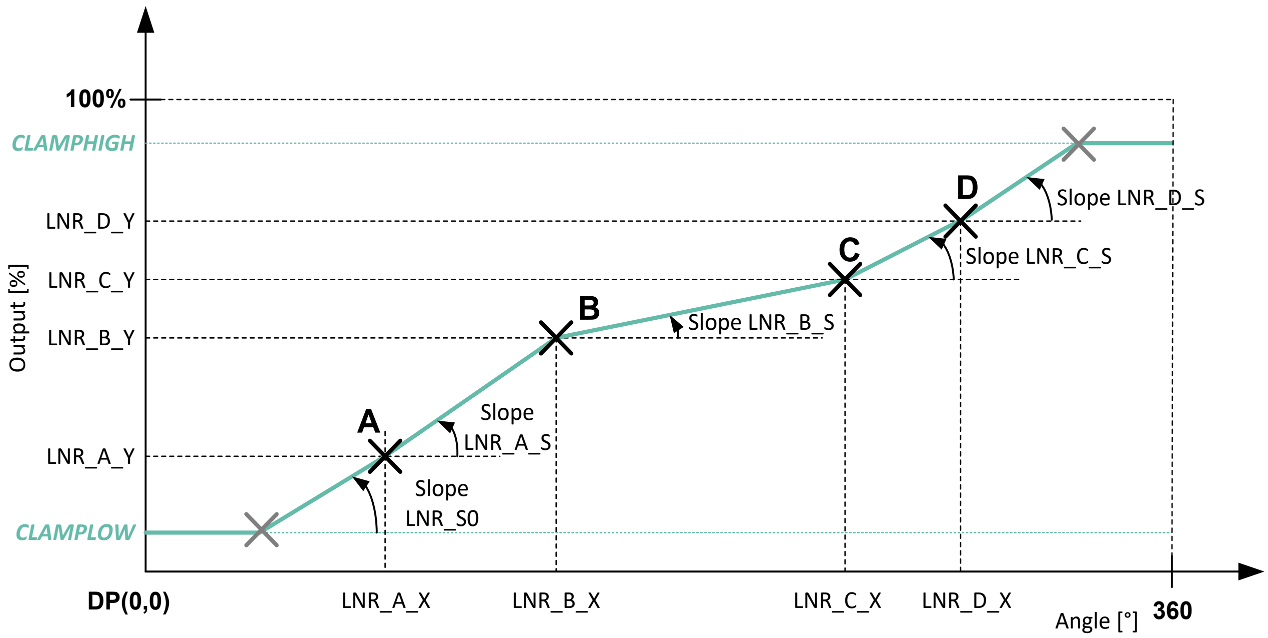


Figure 11 - 4pts linearization parameters description

12.2.4. 17-Pts LNR Parameters

The LNR parameters, together with the clamping values, define the transfer function between the internal digital representation of the angle and the output signal.

The shape of the MLX90425 seventeen points transfer function from the internal angle to the output value is described in the Figure 12. In the 17-Pts mode, the output transfer characteristic is Piecewise Linear (PWL).

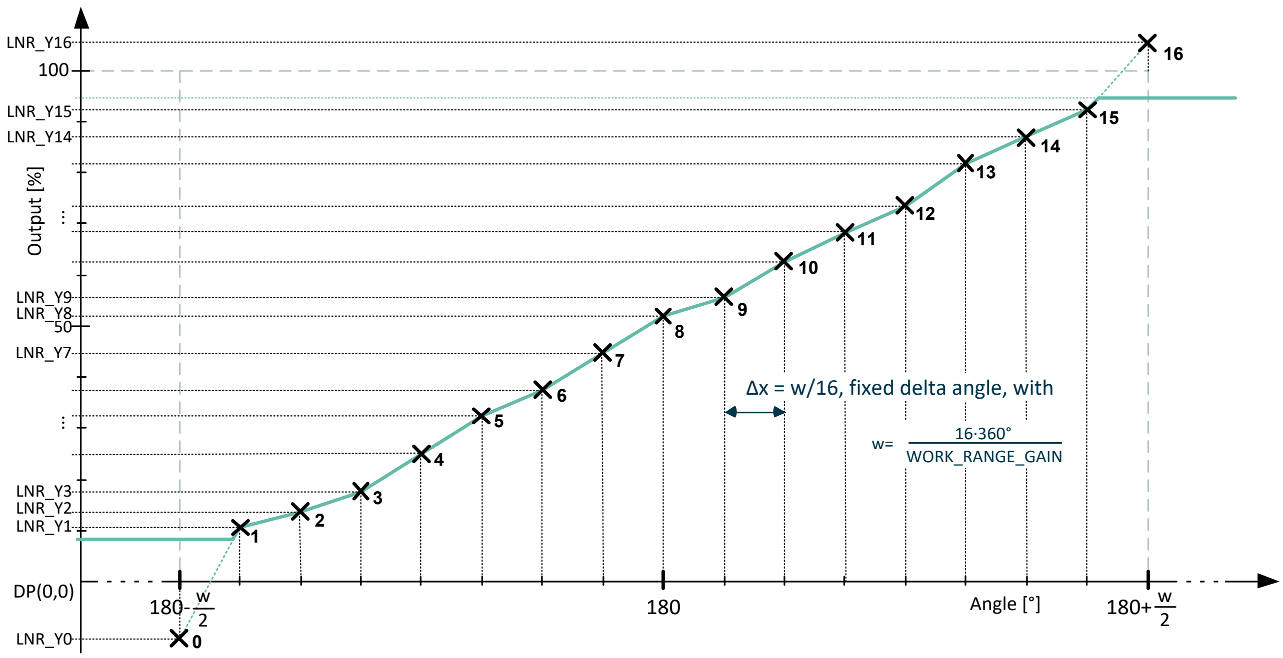


Figure 12 - 17pts linearization parameters description

All the Y-coordinates can be programmed from -50% up to +150% to allow clamping in the middle of one segment (like on the figure), but the output value is limited to CLAMPLOW and CLAMPHIGH values. Between two consecutive points, the output characteristic is interpolated.

12.2.5. WORK_RANGE Parameter for Angle Range Selection

The parameter WORK_RANGE determines the input range on which the 16 segments are uniformly spread. This parameter is provided for compatibility with former versions of Melexis Triaxis sensors.

For full featured working range selection, see section 12.2.6. For WORK_RANGE parameter, following table applies.

WORK_RANGE	Range	Δx 17pts	WORK_RANGE	Range	Δx 17pts
0	360.0°	22.5°	8	180.0°	11.3°
1	320.0°	20.0°	9	144.0°	9.0°
2	288.0°	18.0°	10	120.0°	7.5°
3	261.8°	16.4°	11	102.9°	6.4°
4	240.0°	15.0°	12	90.0°	5.6°
5	221.5°	13.8°	13	80.0°	5.0°
6	205.7°	12.9°	14	72.0°	4.5°
7	192.0°	12.0°	15	65.5°	4.1°

Table 29 - Work range for 360° periodicity

Outside of the selected range, the output will remain at clamping levels.

12.2.6. WORK_RANGE_GAIN Parameter for Angle Range Selection

Alternatively, the range for the angle can be selected using the WORK_RANGE_GAIN parameter, which applies a fixed gain to the transfer characteristics. WORK_RANGE_GAIN is coded on 8 bits where the 4 MSb defines the integer part and the 4 LSb the fractional part (in power of twos). Therefore, the following equation applies to define the angle range *w*:

$$w = \frac{16 * 360}{WORK\_RANGE\_GAIN}$$

Both minimal and maximal angles are then defined by:

$$\theta_{min} = \frac{360 - w}{2} \; ; \; \theta_{max} = \frac{360 + w}{2}$$

where θ_{min} corresponds to the angle yielding 0% output and θ_{max} the angle giving a 100% output.

Using WORK_RANGE_GAIN parameter, the anchor point is kept at *180* and the range is symmetrically set around this value. It creates a zoom-in of the angle around this point.

The following table gives some values as examples.

WORK_RANGE_GAIN	Factor	Range (w)	θmin	θmax	Δx 17pts
0x10	1	360°	0°	360°	22.5°
0x20	2	180°	90°	270°	11.3°
0x40	4	90°	135°	225°	5.6°
0xFF	15.94	22.6°	168.7°	191.3°	1.41°

Table 30 - Working range defined by WORK_RANGE_GAIN parameter

Outside of the working range, the output will remain at clamping levels.

12.2.7. Thermal OUTSLOPE Offset Correction

Two parameters, OUTSLOPE_HOT and OUTSLOPE_COLD, are used to add a temperature dependent offset. In the MLX90425, this offset is applied to the angle just before the clamping function.

The offset shift is computed using the device internal linearized temperature as depicted in the figure below (Figure 13).

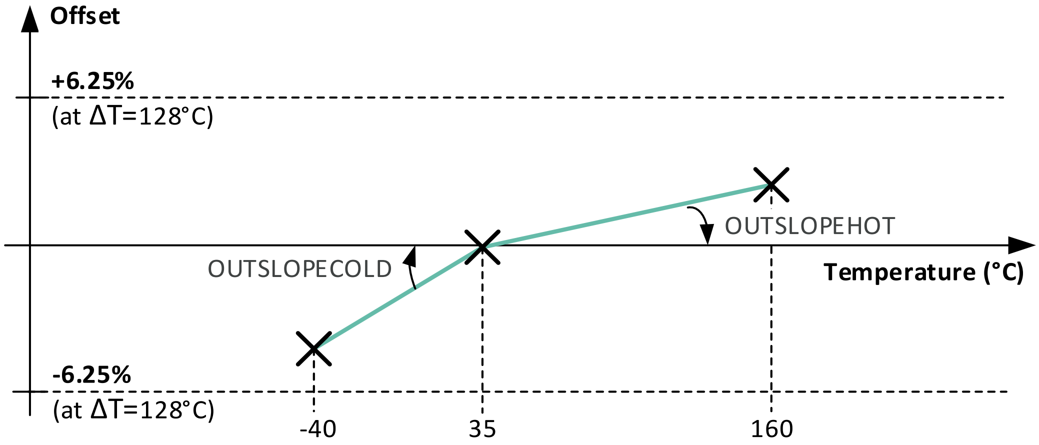


Figure 13 - Temperature compensated offset

The thermal offset can be added or subtracted to the output, before the clamping. The span of this offset is ±6.25% of the full output scale for a temperature difference of 128°C. Two thermal coefficients are defined depending on whether the linearized temperature is below (OUTSLOPE_COLD) or above (OUTSLOPE_HOT) the 35°C anchor point.

If the device internal temperature is higher than 35°C then:

$$\text{Compensated Angle} = \text{Angle} - \Delta T \cdot \frac{\text{OUTSLOPE\_HOT}}{64}$$

If the device internal temperature is lower than 35°C then:

$$\text{Compensated Angle} = \text{Angle} - \Delta T \cdot \frac{\text{OUTSLOPE\_COLD}}{64}$$

Each of the two thermal coefficients is encoded using an 8-bit two's complement signed format. The thermally compensated angle and the input angle are expressed in LSB12, while the linearized temperature difference ΔT is expressed in °C.

12.2.8. Clamping Parameters

The clamping levels are two independent values to limit the output voltage range in normal operation. The CLAMPLOW parameter adjusts the minimum output level. The CLAMPHIGH parameter sets the maximum output level. Both parameters have 12 bits of adjustment and are available for all LNR modes. The values are encoded in fractional code, from 0% to 100%

12.3. Sensor Front-End

The SENSING_MODE parameter defines which sensing mode and fields are used to calculate the angle. The different possibilities are described in the tables below. This 2-bit value selects the first (B1) and second (B2) field components according to the Table 32 content.

Parameter	Value
SENSING_MODE	[0:2]
GAINMIN	[0:47]
GAINMAX [17]	[0:48]
GAINSATURATION	[0:1]

Table 31 - Sensing Mode and Front-End Configuration

SENSING_MODE	B1	B2	Motion
0	$\frac{\Delta B_Z}{\Delta X}$	$\frac{\Delta B_Z}{\Delta Y}$	ΔBZ, angular rotary 360° stray field robust
1, 2, 3	N/A	N/A	Do not use

Table 32 - Sensing mode description

GAINMIN and GAINMAX define the thresholds of the gain monitor diagnostic. Whenever the virtual gain is strictly outside of these limits, the diagnostic reports a fault. When GAINMIN = 0 or GAINMAX > 47, the corresponding fault reporting is disabled.

If GAINSATURATION is set, then the virtual gain is held between GAINMIN and GAINMAX values. The saturation of the gain applies before the diagnostic is checked. Therefore, the gain monitor diagnostic can be considered inactive.

12.4. Filtering

The MLX90425 features 2 low-pass FIR filter modes controlled with FILTER = 1…2. FILTER = 0 corresponds to no filtering. The transfer function is described by:

$$y_n = \frac{1}{\sum_{i=0}^{j} a_i} \sum_{i=0}^{j} a_i x_{n-i}$$

This filter characteristic is given in the Table 33.

FILTER	0	1	2
Type	Disable	Finite Impulse Response (FIR)	
Coefficients a_i	1	11	1111
Title	No filter	ExtraLight	Light
DSP cycles (j= nb of taps)	1	2	4
Efficiency RMS (dB)	0	3.0	6.0

Table 33 - FIR filter characteristics

[17] *A value of 48 (0x30) or above disables the diagnostic.*

12.5. Programmable Diagnostics Settings

12.5.1. Diagnostics Global Enable

DIAG_EN should be kept to its default value (1) to retain all functional safety abilities of the MLX90425. This feature shall not be disabled.

12.5.2. Diagnostic Debouncer

A debouncing algorithm is available for analog diagnostic reporting. Enabling this debouncer will increase the FHTI of the device. Therefore, Melexis recommends keeping the debouncing of analog faults off by not modifying below described values. The factory default settings mentioned in chapter 11 should be used.

Parameter	Description
DIAGDEBOUNCE_STEPDOWN	Decrement values for debouncer counter. The counter is decremented once per evaluation cycle when no analog fault is detected.
DIAGDEBOUNCE_STEPUP	Increment value for debouncer counter. The counter is incremented once per evaluation cycle when an analog fault is detected.
DIAGDEBOUNCE_THRESH	Threshold for debouncer counter to enter diagnostic mode. When set to 0, debouncing is off and analog faults are reported immediately after detection.

Table 34 - Diagnostic debouncing parameters

Once an analog monitor detects an error, it takes control of the debouncing counter. This counter will be incremented by DIAGDEBOUNCE_STEPUP value each time this specific monitor is evaluated and the error is still present. When the debouncing counter reaches the value defined by DIAGDEBOUNCE_THRESH, an error is reported on the error channel, and the debouncing counter stays clamped to this DEBOUNCE_THRESH value (see section 12.5.6 for PWM error reporting). Once the error disappears, each time its monitor is evaluated, the debouncing counter is decremented by DIAGDEBOUNCE_STEPDOWN value. When the debouncing counter reaches zero, the error disappears from the reporting channel and the debouncing counter is released. To implement proper reporting times, one should refer to the FHTI, see chapter 13.3. The reporting and recovery time are defined in the table below (valid for DIAGDEBOUNCE_THRESH > 0).

Parameter	Min	Max
Reporting Time	$DCT \cdot \left(\left\lceil \frac{THRESH}{STEPUP} \right\rceil - 1\right)$	$DCT \cdot \left(\left\lceil \frac{THRESH}{STEPUP} \right\rceil\right)$
Recovery Time	$DCT \cdot \left(\left\lceil \frac{THRESH}{STEPDOWN} \right\rceil\right)$	$DCT \cdot \left(\left\lceil \frac{THRESH}{STEPDOWN} \right\rceil + 1\right)$
	$\left\lceil \frac{x}{y} \right\rceil$	is the ceiling function of x divided by y

Table 35 - Diagnostic reporting and recovery times

12.5.3. Over/Under Temperature Diagnostic

DIAG_TEMP_THR_HIGH defines the threshold for over temperature detection and is compared to the linearized value of the temperature sensor T_{LIN}. DIAG_TEMP_THR_LOW defines the threshold for under temperature detection and is compared to the linearized value of the temperature sensor T_{LIN}.

One can get the physical temperature T_{PHY} of the die from T_{LIN} using following formula

$$T_{PHY} = \frac{T_{LIN}}{8} - 73.15$$

T_{PHY} is expressed in °C and the T_{LIN} is expressed in LSB12.

Unlike T_{LIN}, DIAG_TEMP_THR_LOW and DIAG_TEMP_THR_HIGH are encoded using 8-bit unsigned values. Therefore, a factor of 16 must be considered when comparing either threshold to T_{LIN}.

The following table summarizes the characteristics of the linearized temperature sensor and the encoding of the temperature monitor thresholds.

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
T_{LIN} resolution	Res_{TLIN}	-	0.125	-	°C	12-bit range
T_{LIN} refresh rate	$F_{S,TLIN}$	-	200	-	Hz	
T_{LIN} linearity error	T_{LinErr}	-10	-	10	°C	from -40 to 160°C
Low temperature threshold	DIAG_TEMP _THR_LOW	-	8	-	LSB12	Fixed value, corresponds to -57°C
High temperature threshold	DIAG_TEMP _THR_HIGH	-	136	-	LSB12	Fixed value, corresponds to 199°C
High/low temperature threshold resolution	Res_{Tthr}	-	2	-	°C	12-bit range

Table 36 - Linearized temperature sensor characteristics

12.5.4. High-Temperature Extension Over-Temperature Diagnostic

When operating at a junction temperature up to 175°C, the MLX90426 retains all its diagnostic features. There's no risk of false-positive. Above this temperature, the overheating monitor enters its detection range. The default configuration of this monitor reports a typical junction temperature of 199°C. Due to temperature sensor tolerances and noise at high temperatures, Melexis recommends to increase the safety margin above 15°C. Consequently, if the sensor operates up to 190°C of junction temperature, Melexis cannot guarantee that the overheating monitor will not report an error and recommends to adapt the overheating monitor threshold to 207°C. This can be done by reprogramming a custom device configuration (patch) shown in Table 14 below. Contact a Melexis representative for further information.

Parameter	Patch Content
PATCH2_ADDRESS	0x396A
PATCH2_I	0x008C

Table 37 - High-temperature extension patch to prevent false-positive on overheating monitor

12.5.5. Field Strength and Field Monitoring Diagnostics

Field Strength is compensated over the operating temperature range and represents a reliable image of the differential field intensity generated by the magnet. The lower and upper limits for this diagnostic are set with the parameters described in the following table. Both parameters are encoded on four bits. They start at the respective “min” value and increase by “step” with each additional LSB.

Parameter	Min	Max	Step	Unit
DIAG_FIELDTOOLOWTHRES	0	15	1	mT/mm
DIAG_FIELDTOOHIGHTHRES ([18])	100	310	15	mT/mm

Table 38 – Field Monitor Diagnostic limits

12.5.6. Analog Mode Diagnostic Reporting

When in analog mode, a digital fault is reported by configuring the OUT pin in high-impedance. Conversely, an analog fault is reported by pulling the OUT pin to the V_{satD_Iopp} low level (refer to Table 9).

This behavior is only valid for the factory default settings. Other reporting behaviors and further information on the safe-states are available in the safety manual of the MLX90425.

12.5.7. PWM Mode Diagnostic Reporting

When in PWM mode, a digital fault is reported by configuring the OUT pin in high-impedance.

When reporting an analog fault, the parameter PWM_DC_FAULT_BAND and PWM_DC_FAULT_VAL can be used to specify the 12-bit output level. The parameter PWM_DC_FAULT_BAND is used to define the BAND within which the output level is set.

PWM_DC_FAULT_BAND	Description
0	The Low band [0:CLAMPLOW] is selected
1	The High band [CLAMPHIGH:4095] is selected

Table 39 - Output level band selection in case of an analog fault

The parameter PWM_DC_FAULT_VAL selects a value in the specified band

$$\text{Low band output level} = \text{PWM\_DC\_FAULT\_VAL} \cdot \left(\frac{\text{CLAMPLOW}}{8}\right)$$

$$\text{High band output level} = 4095 - \text{PWM\_DC\_FAULT\_VAL} \cdot \left(\frac{\text{CLAMPHIGH}}{8}\right)$$

Correspondingly, the parameters PWM_DC_FIELDTOOLOW_BAND and PWM_DC_FIELDTOOLOW_VAL can be used to specify the 12-bit output level in case of a field strength too low event.

This reporting behavior is only valid for the factory default settings, with the exception of the aforementioned parameters in this section. Other reporting behaviors and further information on the safe-states are available in the safety manual of the MLX90425.

[18] *When this parameter is set to the maximum value of 15 (0xF), the FIELD_TOO_HIGH diagnostic is disabled (see Table 15)*

13. Functional Safety

13.1. Safety Manual

The safety manual, available upon request, contains the necessary information to integrate the MLX90425 component in a safety related item, as a Safety Element Out-of-Context (SEooC).

In particular, it includes:

- The description of the Product Development lifecycle tailored for the Safety Element.
- An extract of the Technical Safety concept.
- The description of Assumptions-of-Use (AoU) of the element with respect to its intended use, including:
  - assumptions on the device safe state;
  - assumptions on fault tolerant time interval and multiple-point faults detection interval;
  - assumptions on the context, including its external interfaces;
- The description of safety analysis results (at the device level, to be used for the system integration), HW architectural metrics and description of dependent failures initiators.
- The description and the result of the functional safety assessment process; list of confirmation measures and description of the independency level.

13.2. Safety Mechanisms

The MLX90425 provides numerous self-diagnostic features (safety mechanisms). Those features increase the robustness of the IC functionality either by preventing the IC from providing an erroneous output signal or by reporting the failure.

Legend
● High coverage
○ Medium coverage
ANA: Analog hardware failure reporting mode, described in the safety manual
High-Z: A special failure reporting mode where the output is set in high-impedance mode (no HW fail-safe mode/timeout, no SW safe startup)
DIG: Digital hardware failure reporting mode, described in the safety manual
At Startup: A HW fault present at time zero is detected before the first frame is transmitted.
DIAG_EN: This safety mechanism can be disabled by setting DIAG_EN = 0 (see chapter 12.5.1). This option should not be used in application mode!

Table 40 - Self diagnostic legend

Category and safety mechanism name	Front-end	ADC	DSP	Back-end	Support. Func.	Module & Package	Reporting mode	At startup	DIAG EN
Signal-conditioning Diagnostic	●	●	○			●			
Magnetic Signal Conditioning Voltage Test Pattern	●	○	○				ANA	NO	●
Magnetic Signal Conditioning Rough Offset Clipping check	●		○				ANA	NO	●
Magnetic Signal Conditioning Gain Monitor & Clamping	●		○			●	ANA	YES	●
Mag. Sig. Cond. Failure Control by the Chopping Technique	●						n/a	n/a	
A/D Converter Test Pattern		●					ANA	NO	●
ADC Conversion errors & Overflow Errors		●					ANA	YES	●
ADC Common Mode Monitor		●					n/a	YES	
Flux Monitor (Rotary mode)	●	○				●	ANA	NO	●

Category and safety mechanism name	Front-end	ADC	DSP	Back-end	Support. Func.	Module & Package	Reporting mode	At startup	DIAG EN
Digital-circuit Diagnostic		●	●		○				
RAM Parity, 1-bit per 16-bit word, ISO D.2.5.2			●				DIG	YES	
ROM Parity, 1-bit per 32-bit word, ISO D.2.5.2			●				DIG	YES	
NVRAM 16-bit signature (run-time) ISO D.2.4.3, by means of SW CRC-CCITT16			●				DIG	NO	
NVRAM Double Error Detection ECC ISO D.2.4.1			●				DIG	YES	
Logical Monitoring of Program Sequence ISO D.2.9.3 via Watchdog "IWD" (CPU clock) ISO D.2.9.2			●		○		DIG	NO	●
Watchdog "AWD" (separate clock) ISO D2.9.1			●		○		DIG	YES	
CPU Errors "Invalid Address", "Wrong opcode"			●		○		DIG	YES	
ADC Interface Checksum		●					DIG	NO	●
ADC Internal Errors		○					DIG	YES	
DSP Test Pattern (atan2)			●		○		DIG	NO	●
Critical Ports Monitoring			●				DIG	NO	●
ADC Data Adder Test - Range Check and Buffer alignment		○					DIG	YES	●
ADC Data Adder Error		○					DIG	YES	
DSP Overflow	○	○	●				ANA	NO	●

Category and safety mechanism name	Front-end	ADC	DSP	Back-end	Support. Func.	Module & Package	Reporting mode	At startup	DIAG EN
System-level Diagnostic					●	●			
Supply Voltage Monitors (all supply domains except VDD_OV & POR)					●	●	ANA	YES	●
External Supply Over-voltage Monitor					●	●	High-Z	YES	
Digital Supply Under-voltage Monitor (Power-on Reset)					●	●	High-Z	YES	
Overheating Monitor	○	○	○	○	○	●	ANA	YES	●
Warning/Reporting Mechanisms									
HW Error Controller			●	●	●		DIG	n/a	
HW Fail-safe mode with timeout			●	●	●		High-Z	n/a	
Analog-type Error management	●	●			●		ANA	n/a	
Safe start-up mode			●		●		DIG	n/a	
Mechanisms executed at start-up only									
RAM March-C HW Test at start-up			●		●		DIG	YES	

Table 41 - MLX90425 list of self-diagnostics with characteristics

13.3. Fault Handling Time Interval

The Fault handling Time Interval (FHTI) is the time interval between the start of the first frame with invalid position value without notice, and the end of the last frame preceding a fail-safe state of the IC.

The following table provides the worst-case FHTI for both an analog fault and a digital fault in MLX90425.

Case	FHTI	Comment
Analog Fault	$DCT_{ANA} + 2\ T_{frame}$	Refer to section 6.1 for the DCT_{ANA} value In analog mode, T_{frame} = 0ms In PWM mode, $T_{frame} = T_{PWM}$ (see sections 10.2.2 and 12.1.3)
Digital Fault	DCT_{DIG}	Refer to section 6.1 for the DCT_{DIG} value

Table 42 - Worst-case FHTI

The FHTI values provided here are valid only for the default factory settings. A full list of timings is available in the safety manual of the MLX90425, including cycle times, execution times and reporting times for every implemented safety mechanism.

14. Recommended Application Diagrams

14.1. Wiring with the MLX90425 in SOIC-8 Package

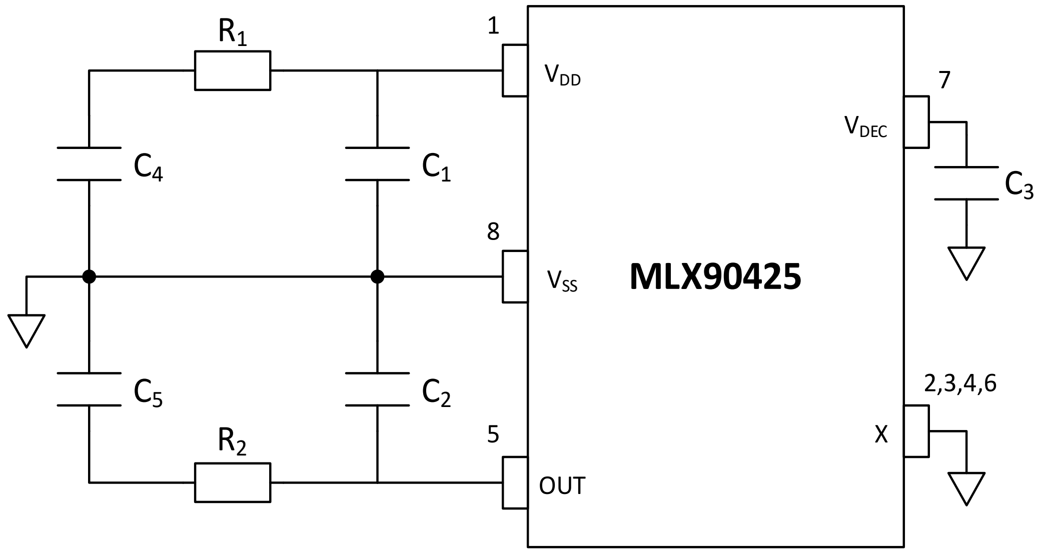


Figure 14 - Recommended wiring for the MLX90425 in SOIC-8 package

Component	Min	Typ.	Max	Remark
C_1	-	220 nF	-	
$C_2(C_L)$	10 nF 4.7 nF	10 nF 4.7 nF	100 nF 22 nF	Analog output PWM output
C_3	-	100 nF	220 nF	
C_4	-	-	1 nF	Optional, for improved EMC robustness
C_5	-	-	1 nF	
R_1	-	-	10 Ω	
R_2	-	-	-	

Table 43 - Recommended values for the MLX90425 in SOIC-8 Package

For best EMC performance, C_1, C_2 and C_3 with typical values need to be placed as close as possible to the IC. To further improve EMC robustness, a 1nF capacitor can be placed close to the connector (C_4, C_5) and a 10 Ohm resistor added in series with the supply line (R_1).

14.2. Wiring with the MLX90425 in SMP-3 Package (built-in capacitors)

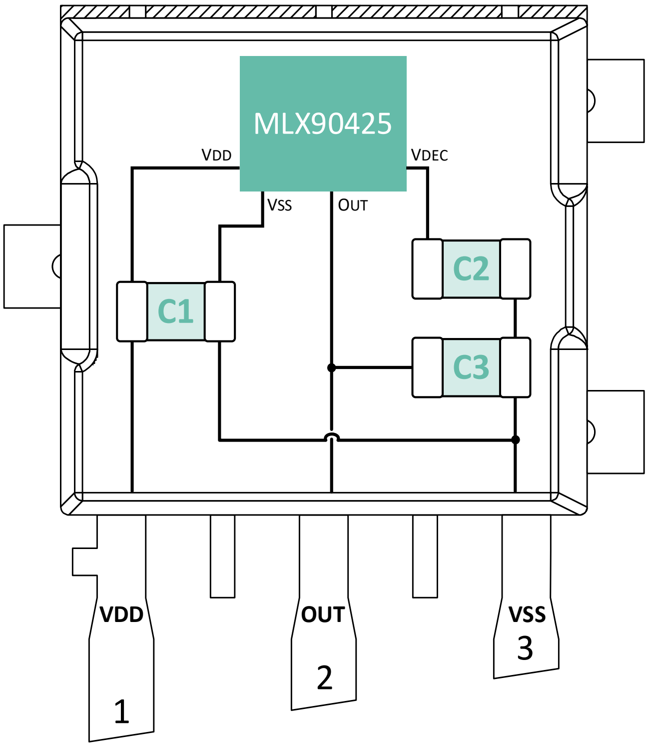


Figure 15 - Internal wiring of the MLX90425 in SMP-3

Component	Value	Remark
C1	220nF	Supply capacitor
C2	100nF	Decoupling capacitor
C3	10nF	Output capacitor

Table 44 - SMP-3 capacitors configuration

15. Standard information regarding manufacturability of Melexis products with different soldering processes

Our products are classified and qualified regarding soldering technology, solderability and moisture sensitivity level according to standards in place in Semiconductor industry.

For further details about test method references and for compliance verification of selected soldering method for product integration, Melexis recommends reviewing on our web site the General Guidelines soldering recommendation (http://www.melexis.com/en/quality-environment/soldering)

For all soldering technologies deviating from the one mentioned in above document (regarding peak temperature, temperature gradient, temperature profile, etc.), additional classification and qualification tests have to be agreed upon with Melexis.

For package technology embedding trim and form post-delivery capability, Melexis recommends consulting the dedicated trim & form recommendation application note : “Lead Trimming and Forming Recommendations” (http://www.melexis.com/en/documents/documentation/application-notes/lead-trimming-and-forming-recommendations).

Melexis is contributing to global environmental conservation by promoting lead free solutions. For more information on qualifications of RoHS compliant products (RoHS = European directive on the Restriction Of the use of certain Hazardous Substances) please visit the quality page on our website: http://www.melexis.com/en/quality-environment.

16. ESD Precautions

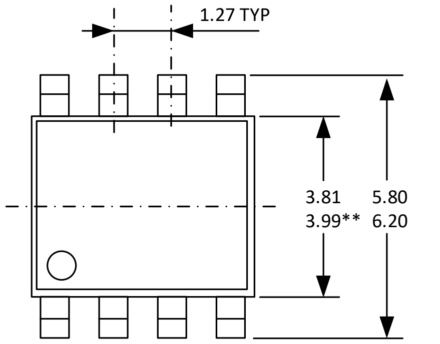
Electronic semiconductor products are sensitive to electrostatic discharges (ESD).

Always observe electrostatic discharge control procedures whenever handling semiconductor products.

17. Package Information

17.1. SOIC-8- Package Information

17.1.1. SOIC-8- Package Dimensions



NOTES:

All dimensions are in millimeters (angles in degrees).
* Dimension does not include mold flash, protrusions or gate burrs (shall not exceed 0.15 per side).
** Dimension does not include interleads flash or protrusion (shall not exceed 0.25 per side).
*** Dimension does not include dambar protrusion. Allowable dambar protrusion shall be 0.08 mm total in excess of the dimension at maximum material condition. Dambar cannot be located on the lower radius of the foot.

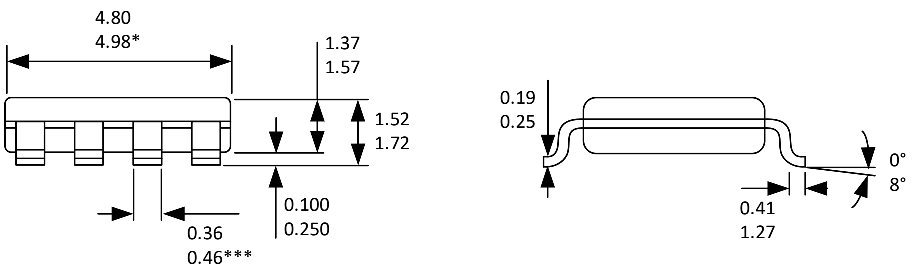


Figure 16 - SOIC-8 package outline drawing

17.1.2. SOIC-8- Pinout and Marking

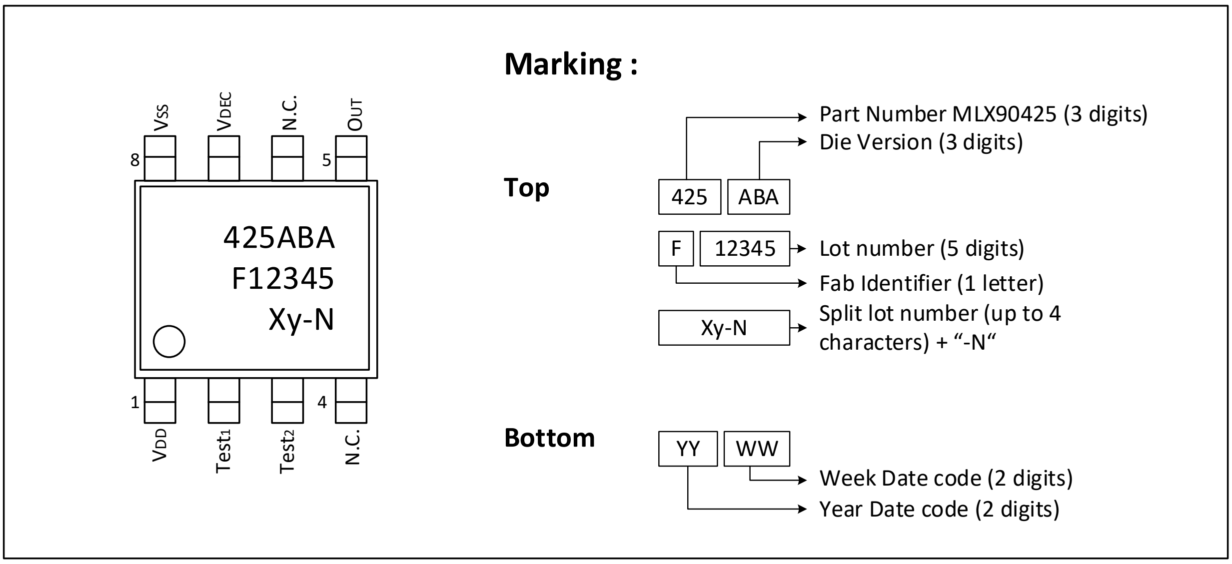


Figure 17 - SOIC-8 pinout and marking

17.1.3. SOIC-8- Sensitive Spot Positioning

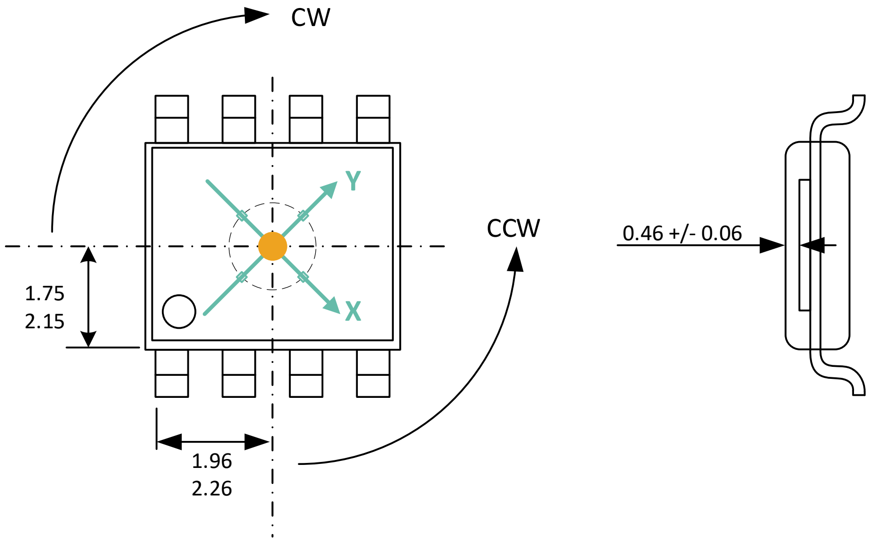


Figure 18 - SOIC-8 sensitive spot position

17.1.4. SOIC-8- Angle Detection

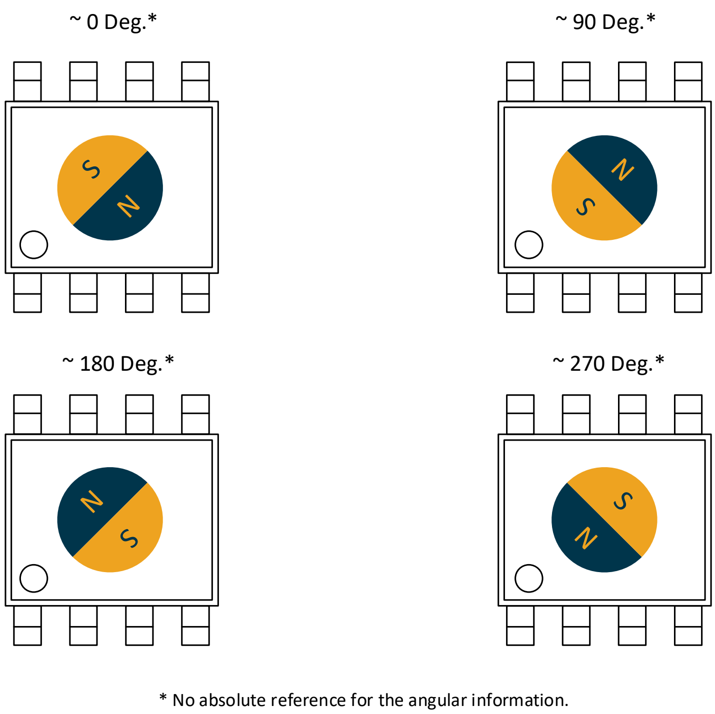
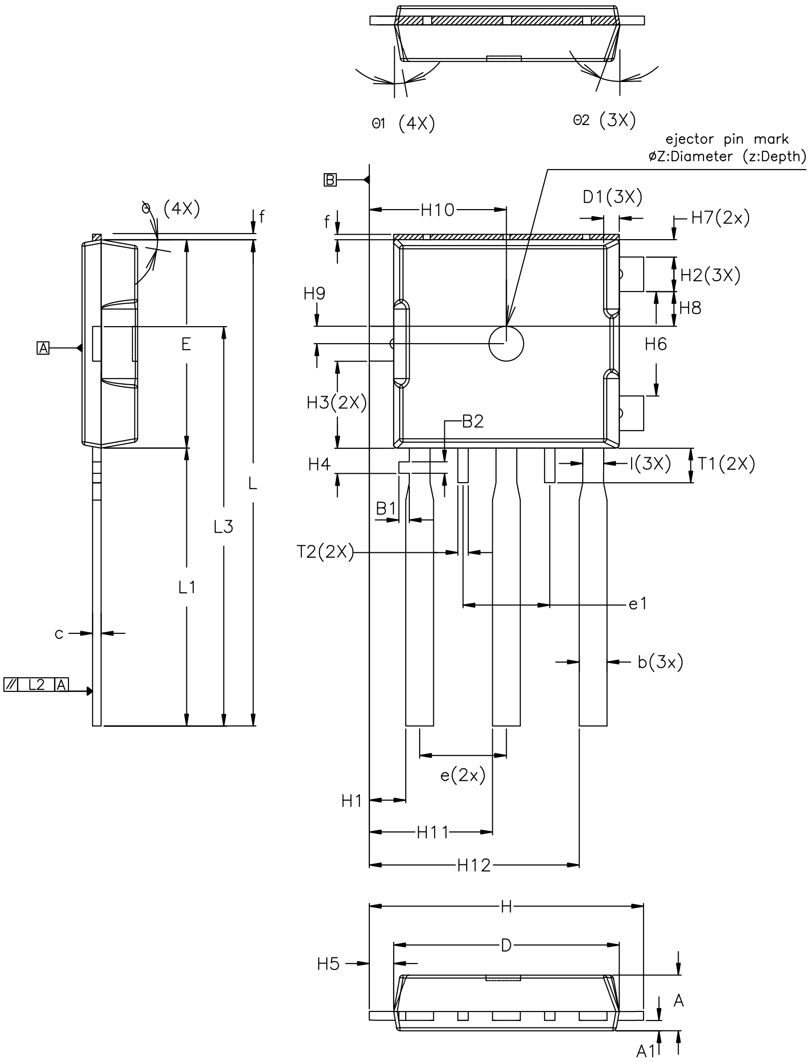


Figure 19 - SOIC-8 angle detection

The MLX90425 is an absolute angular position sensor, but the linearity error (See section 8) does not include the error linked to the absolute reference 0 Deg. This reference can be fixed in the application through the discontinuity point.

17.2. SMP-3- Package Information

17.2.1. SMP-3- Package Outline Dimension (POD)



Dimension	MIN.	NOM.	MAX.
A	1.550	1.600	1.650
A1	0.250	0.290	0.330
B1	0.235	0.300	0.365
B2		0.33 REF	
c	0.250	0.280	0.310
D	6.420	6.500	6.580
D1		0.450 REF	
E	5.920	6.000	6.080
f	0.000	- - -	0.150
H	7.800	7.900	8.000
H1	0.900	1.050	1.200
H2	0.975	1.050	1.125
H3	2.380	2.475	2.570
H4	0.635	0.730	0.825
H5	0.605	0.700	0.795
H6	2.875	2.950	3.025
H7		0.475 REF	
H8	0.875	0.950	1.025
H9	0.410	0.525	0.640
H10	3.835	3.950	4.065
H11	3.400	3.550	3.700
H12	5.900	6.050	6.200

Dimension	MIN.	NOM.	MAX.
L	13.870	14.000	14.130
L1	7.870	8.000	8.130
L2	-0.250	0.000	0.250
L3	11.375	11.525	11.675
I	0.525	0.600	0.675
b	0.770	0.820	0.870
e1		2.500 BSC	
e		2.500 BSC	
Θ	8°	10°	12°
Θ1	8°	10°	12°
Θ2	18°	20°	22°
⌀Z	0.900	1.000	1.100
z	0.025	- - -	0.150
T1	0.870	1.000	1.130
T2	0.225	0.300	0.375

NOTES:

1. DIMENSIONS ARE IN MILLIMETER UNLESS NOTED OTHERWISE.
2. PACKAGE WIDTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15MM PER END. PACKAGE LENGTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25MM PER SIDE.
3. THE PACKAGE TOP MAY BE SMALLER THAN THE PACKAGE BOTTOM. PACKAGE WIDTH AND LENGTH ARE DETERMINED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY EXCLUSIVE OF MOLD FLASH, TIE BAR BURRS, GATE BURRS AND INTERLEAD FLASH.
4. PLATING SPECS: MATTED TIN, ELECTROPLATED, 12 ± 5 MICROMETER (µm) THICKNESS
5. ALL "EARS" ARE CONNECTED TO ELECTRIC GROUND.

Figure 20 - SMP-3 package outline drawing

17.2.2. SMP-3- Marking

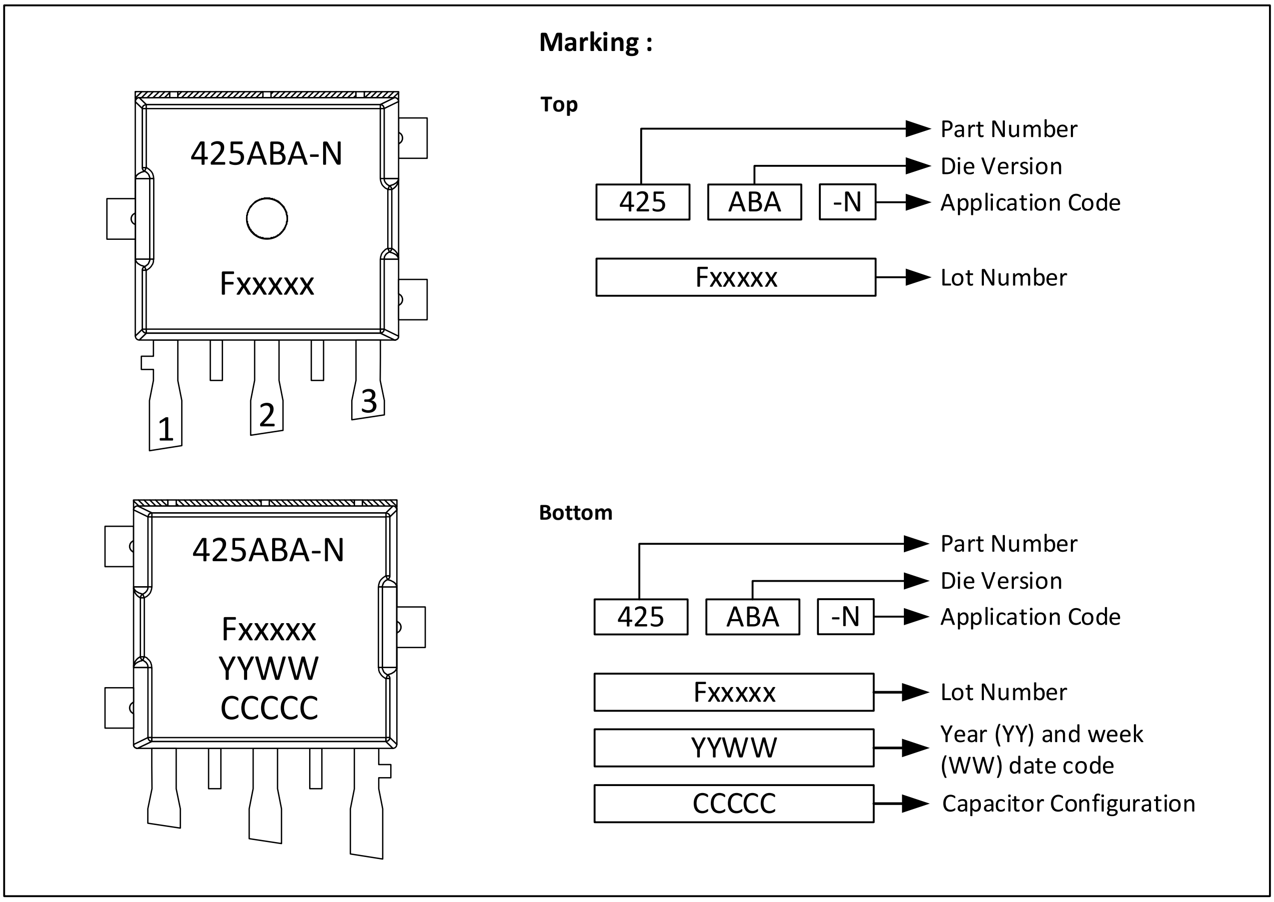


Figure 21 - SMP-3 marking

17.2.3. SMP-3- Sensitive Spot Positioning

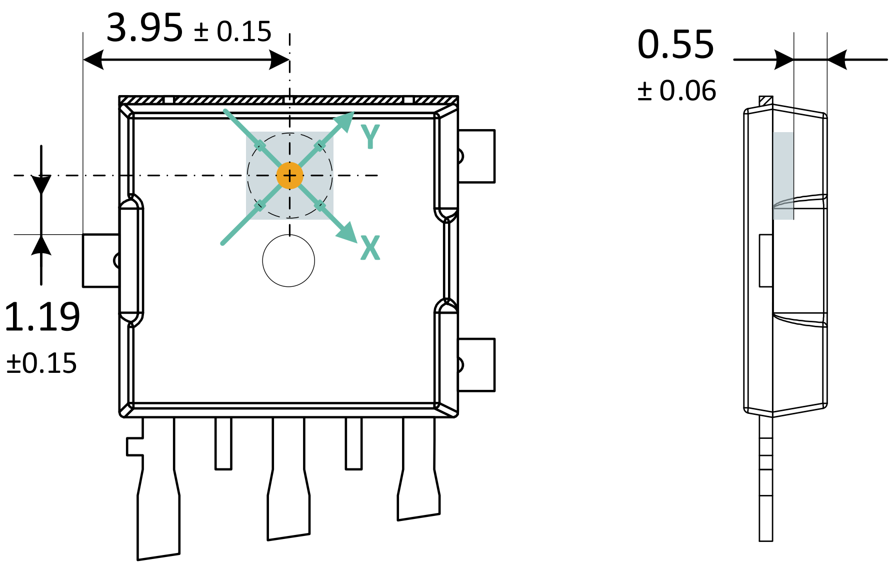


Figure 22 - SMP-3 sensitive spot position

17.2.4. SMP-3- Angle Detection

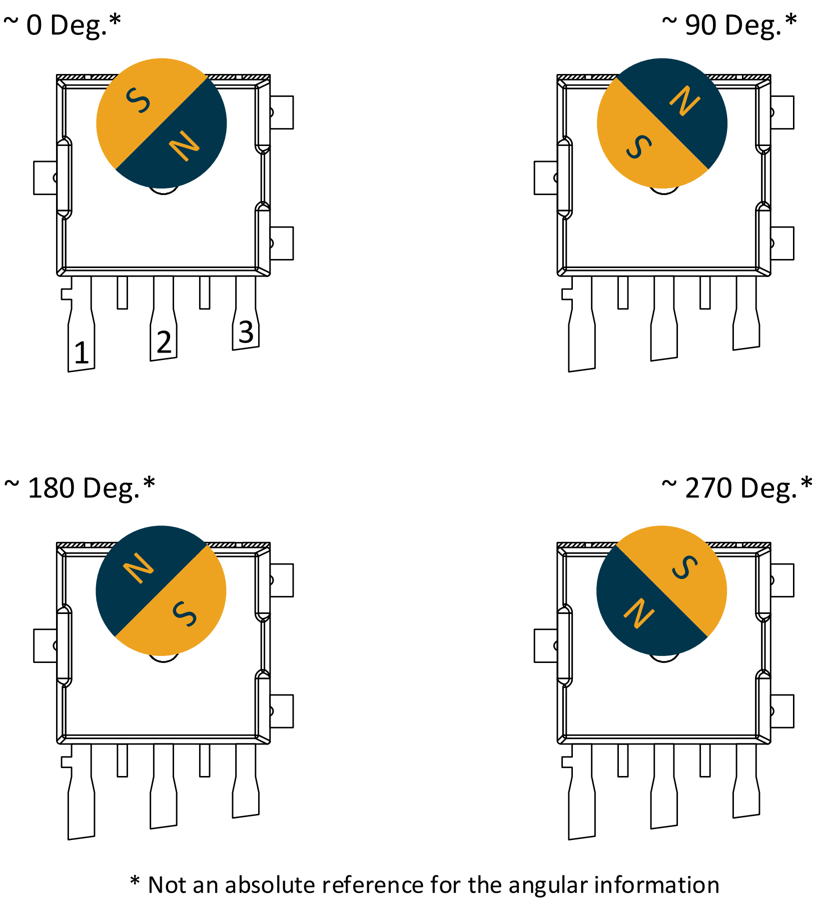


Figure 23 - SMP-3 angle detection

17.3. Packages Thermal Performances

The table below describes the thermal behavior of available packages following JEDEC EIA/JESD 51.X standard.

Package	Junction to case - θjc	Junction to ambient - θja (JEDEC 1s2p board)	Junction to ambient - θja (JEDEC 1s0p board)
SOIC-8	38.8 K/W	112 K/W	153 K/W
SMP-3	34.4 K/W	-	206 K/W [19]

Table 45 – Standard packages thermal performances

[19] PCB-less solutions have been evaluated in a typical application case. Values for these packages are given as informative.

18. Contact

For the latest version of this document, go to our website at www.melexis.com/MLX90425.

For additional information, please get in touch, http://www.melexis.com/sales-contact.

19. Disclaimer

IATF 16949 and ISO 14001 Certified