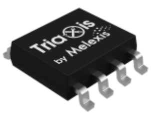
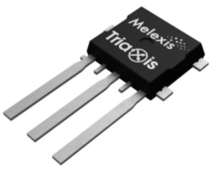
Features and Benefits

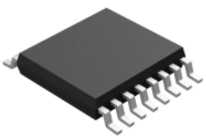
- Triaxis® Hall Technology
- On Chip Signal Processing for Robust Absolute Position Sensing
- ISO26262 ASIL B Safety Element out of Context
- AEC-Q100 Qualified (Grade 0)
- Robust to external magnetic stray fields
- Programmable Measurement Range
- Programmable Linear Transfer Characteristic with up to 17 points
- SENT Output - SAE J2716 APR2016
- Enhanced serial data communication
- Packages RoHS compliant
  - Single Die - SOIC-8
  - PCB-less Single-die SMP-3
  - TSSOP-16_EP package (stacked-dice)
  - SMP-4 package (stacked-dice)



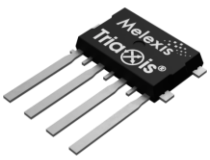
SOIC-8 (DC)



SMP-3 (VE)



TSSOP-16_EP (GO)



SMP-4 (VD)

Application Examples

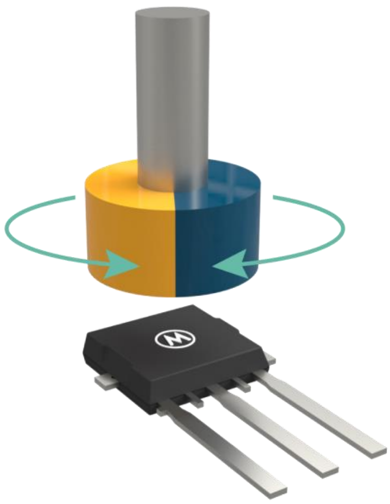
- Pedal Position Sensor
- Throttle Position Sensor
- Ride Height Position Sensor
- Transmission Position Sensor
- Steering Wheel Position Sensor
- Non-Contacting Potentiometer

Description

The MLX90426 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 MLX90426 is sensitive to the differential magnetic field perpendicular to the IC surface (Z-axis). This allows the MLX90426, 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 MLX90426 provides SENT frames encoded according to a Single Secure Sensor A.3 (H.4) or Dual Throttle Position Sensor A.1 (H.1) format. The circuit delivers enhanced serial messages providing error codes, and user-defined values.



Angular Rotary – 360° Stray field Robust

Ordering Information

Product	Temp.	Package	Option Code	Packing Form	Definition
MLX90426	G	DC	ACB-630	RE	Angular Rotary 360° Stray field Robust SENT version
MLX90426	G	VE	ACB-630	RE/RX	Angular Rotary 360° Stray field Robust SENT version
MLX90426	G	GO	BAB-630	RE	Angular Rotary 360° Stray field Robust SENT version Stacked-dice in TSSOP
MLX90426	G	VD	BAB-630	RE	Angular Rotary 360° Stray field Robust SENT version Stacked-dice in SMP4

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 16.1) VE: SMP-3 package (PCB-less single mold, see 16.2) GO: TSSOP-16_EP package (see 16.3) VD: SMP-4 package (PCB-less single mold, see 16.4)
Option Code - Chip revision	**AAA**-123 : **Chip Revision** ▪ ACB: MLX90426 Single Die production version ▪ BAB: MLX90426 Stacked Dice production version
Option Code - Application	AAA-**1**23 : **1-Application - Magnetic configuration** ▪ 6: Angular Rotary 360° Stray field Robust
Option Code	AAA-1**2**3 : **2-Programming Option** ▪ 3: Standard SENT
Option Code - Trim & Form	AAA-12**3** : **3-Package Option** ▪ 0: Standard
Packing Form:	-RE : Tape & Reel ▪ VE: 2500 pcs/reel ▪ DC: 3000 pcs/reel ▪ GO: 4500 pcs/reel ▪ VD: 2500 pcs/reel -RX : Tape & Reel, similar to RE with parts face-down
Ordering Example:	MLX90426GVE-ACB-630-RX For a SENT version in SMP-3 package, delivered in reel of 2500pcs, parts face-down.

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, 8.2.1, 8.3.3,12.5.4).*

Contents

1. Functional Diagram and Application Modes

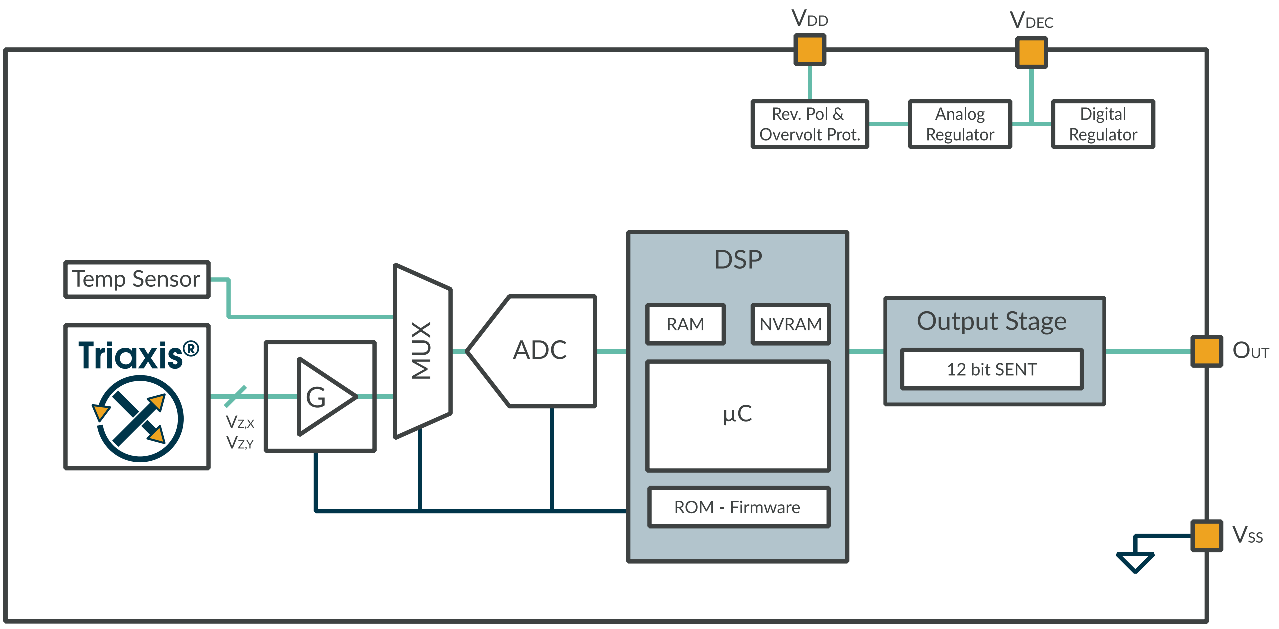


Figure 1 – MLX90426 Single Die and Stacked Dice Block diagram.

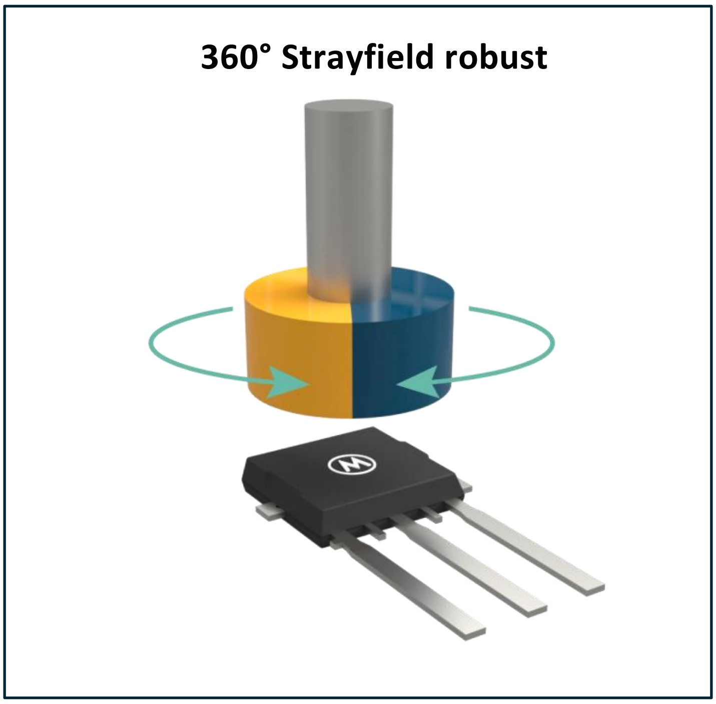


Figure 2 – Application mode

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 signal 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
LNR	LiNeaRization
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)
TSSOP-16_EP	TSSOP-16 Exposed Pad

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 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

3.3. Pin Definition for TSSOP-16_EP

Pin #	Name	Description
1	N.C.	Not connected
2	V_{DEC1}	Decoupling pin die 1 [(2)]
3	OUT_1	Output die 1
4	$Test_{11}$	For Melexis factory test
5	V_{SS1}	Ground die 1
6	V_{DD1}	Supply die 1
7	$Test_{21}$	For Melexis factory test
8	N.C.	Not connected
9	V_{DEC2}	Decoupling pin die 2 [(3)]
10	N.C.	Not connected
11	OUT_2	Output die 2
12	$Test_{12}$	For Melexis factory test
13	V_{SS2}	Ground die 2
14	V_{DD2}	Supply die 2
15	$Test_{22}$	For Melexis factory test
16	N.C.	Not connected

Table 6 – TSSOP-16_EP Pin definition and description

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

3.4. Pin Definition for SMP-4

SMP-4 package offers a redundant stacked-dice package with advanced components integration in a single mold compact form.

Pin #	Name	Description
1	OUT1	Output (die 1)
2	V_{SS}	Ground (common to die 1 [(2)] and die 2 [(3)])
3	V_{DD}	Supply (common to die 1 and die 2)
4	OUT2	Output (die 2)

Table 7 – SMP-4 Pin definition and description

[(2)] Die 1 – bottom die.
[(3)] Die 2 – top die.

4. Absolute Maximum Ratings

Parameter		Symbol	Min	Max	Unit	Condition
Supply Voltage	Positive	V_{DD}		28 37	V	< 48h < 60s; $T_{AMB} \leq 35°C$
	Reverse	$V_{DD\text{-}rev}$	-14 -18		V	< 48h < 1h
Positive Output Voltage	Positive	V_{OUT}		28 34	V	< 48h < 1h
	Reverse	$V_{OUT\text{-}rev}$	-14 -18		V	< 48h < 1h
Internal Voltage	Positive	V_{DEC}		3.6	V	< 1h
	Reverse	$V_{DEC\text{-}rev}$	-0.3		V	< 1h
Positive Test$_1$ pin Voltage	Positive	V_{Test1}		6	V	< 1h
	Reverse	$V_{Test1\text{-}rev}$	-3		V	< 1h
Positive Test$_2$ pin Voltage	Positive	V_{test2}		3.6	V	< 1h
	Reverse	$V_{test2\text{-}rev}$	-0.3		V	< 1h
Operating Temperature		T_{AMB}	-40	+160	°C	
Junction Temperature [4]		T_J		+175	°C	
Storage Temperature		T_{ST}	-55	+170	°C	
Magnetic Flux Density		B_{max}	-1	1	T	

Table 8 – 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.

4.1. High-Temperature Extension Absolute Maximum Ratings

The MLX90426 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 and SMP-4 packages.

Parameter	Symbol	Min	Max	Unit	Condition
Supply Voltage [5]	V_{DD}		5.5	V	T_{AMB} = 180°C
Reverse Voltage Protection	$V_{DD\text{-}rev}$	-14		V	T_{AMB} = 180°C, < 1h
Positive Output Voltage	V_{OUT}		26	V	T_{AMB} = 180°C, < 1h
Reverse Output Voltage	$V_{OUT\text{-}rev}$	-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 9 – High-temperature extension absolute maximum ratings for SMP-3 and SMP-4

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

[4] *Find package thermal dissipation values in section 16.2*
[5] *Higher supply voltages will increase the die temperature above the max junction temperature T_J*

4.2. Isolation Specification

Valid for the TSSOP-16_EP package.

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Isolation Resistance	R_{isol}	4	-	-	MΩ	Between dice

Table 10 – Isolation resistance

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	10	11.5	mA	Single die
	I_{DD}	17	20	24	mA	Stacked Dice [(6)]
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 11 – Supply system electrical specifications

[6] The stacked dice configuration necessitates minor design alterations to facilitate dice stacking, including the duplication of a subset of pads. These adjustments result in a minimal increase in current consumption per die.

Electrical Parameter	Symbol	Min	Typ.	Max	Unit	Condition
External pull-up Voltage	V_{ext}			V_{DD}	V	SENT Receiver supply voltage
Output Short Circuit Current Limit	$I_{OUTshort}$	10		35	mA	
Output Load	R_L	10		55	kΩ	Pull-up to $V_{ext} = V_{DD}$
Low state voltage [7]	V_{OL}			0.5	V	0.52mA DC load current
High state voltage [7]	V_{OH}	4.1			V	0.10mA DC load current
Output leakage in Digital Open-drain & Hi-Z modes [8]	$I_{leakpuOd}$			100	µA	Pull-up to $V_{ext} > V_{DD}$
	I_{leakpu}			20	µA	Pull-up to $V_{ext} \leq V_{DD}$
Passive Diagnostic Output Level (Broken-Wire Detection)	$BV_{SS}PU$	99.5	100		$\%V_{DD}$	Broken V_{SS} line and Pull-up to V_{ext}, $R_L \geq 1$ kΩ
	$BV_{DD}PU$	92.5 97.0	98.7 99.5		$\%V_{DD}$	Broken V_{DD} line and Pull-up to V_{ext}, $R_L \leqslant 25$ kΩ Pull-up to V_{ext}, $R_L \leqslant 10$ kΩ

Table 12 – Output electrical specifications

[7] *Compliant with SAE J2716 Revised APR2016*
[8] *The digital output level is thereby defined by the external voltage and pull-up or pull-down resistor.*

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

Table 13 – General timing specifications

6.2. Timing Definitions

6.2.1. Start-up Behavior

In SENT mode, the start-up time consists of two values. The first one, T_{init}, is the time needed for the circuit to be ready to start acquiring an angle. In SENT mode, at that time, the IC starts transmitting initialisation frames. The second value, T_{stup}, is the time when the first valid angle is transmitted.

These definitions are illustrated in the following figure (Figure 3) where τ_{init} represents the sensor internal initialization sequence.

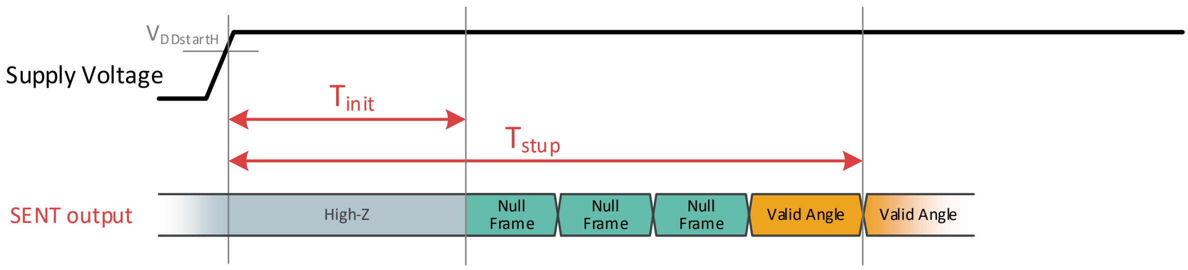


Figure 3 – Start-up time definition

6.2.2. Latency (average)

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 MLX90426 for regulation calculations.

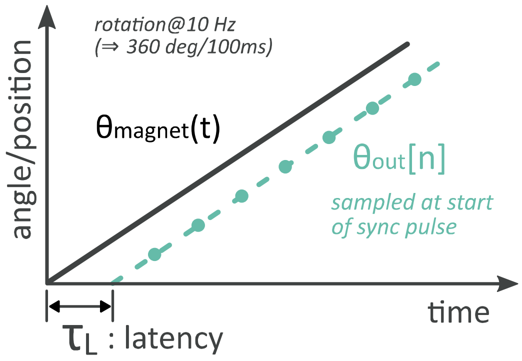


Figure 4 – Definition of latency

6.2.3. Step Response (worst-case)

Step response is defined as the 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. Step response therefore consists of the sum of:

- $\delta_{mag,frameEnd}$, the delay between magnetic step and the end of the frame,
- $\delta_{frameEnd,frameEndPartial}$, the delay between the end of the frame when the magnetic step occurred and the end of the frame which carries the partial response,
- $T_{frame,no\ PP}$, the frame length excluding the pause pulse (PP), which carries the complete response.

The Figure 5 depicts the step response when applied to a SENT with pause output format.

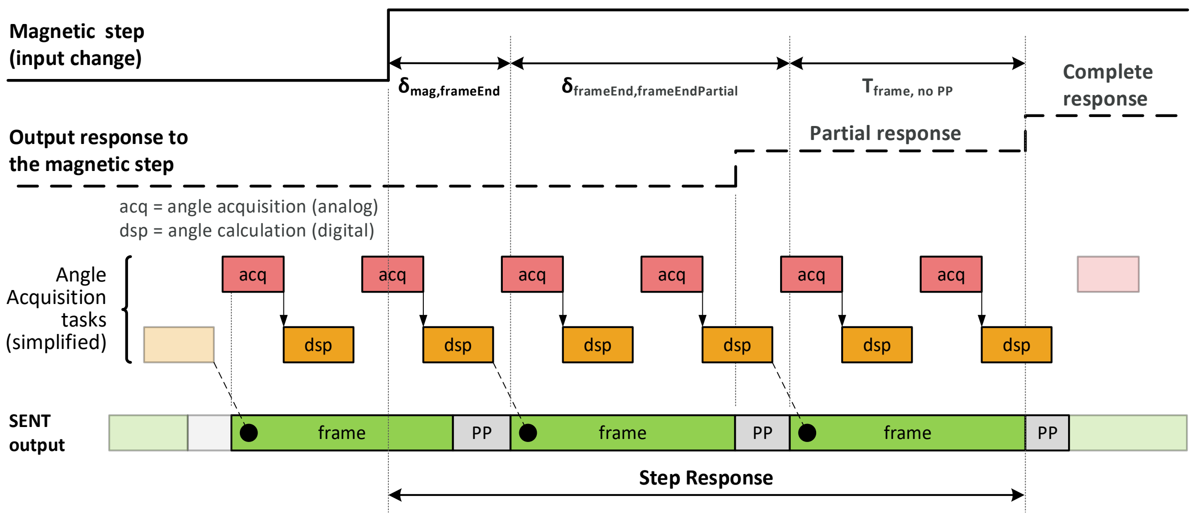


Figure 5 – Step response definition

6.3. SENT Output Timing Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Tick time [9]			3		µs	
SENT edge rise Time	T_{rise}		12.5	18	µs	Between 1.1V and 3.8V
SENT edge fall Time	T_{fall}		5.3	6.5	µs	
Slow Message cycle length			576 432		frames	Extended sequence (32 frames) Short sequence (24 frames)

Table 14 – SENT Output timing specifications

6.3.1. Continuous Synchronous Acquisition Mode

In its default factory settings, the MLX90426 outputs a SENT frame of constant length, regardless of the data content (SENT with pause pulse). The length of the SENT frame is defined by T_{frame} and expressed in a number of ticks (see T_FRAME in sections 11 and 12.1). In continuous synchronous acquisition mode, the angle acquisition is synchronised with the SENT frame, as depicted in Figure 6.

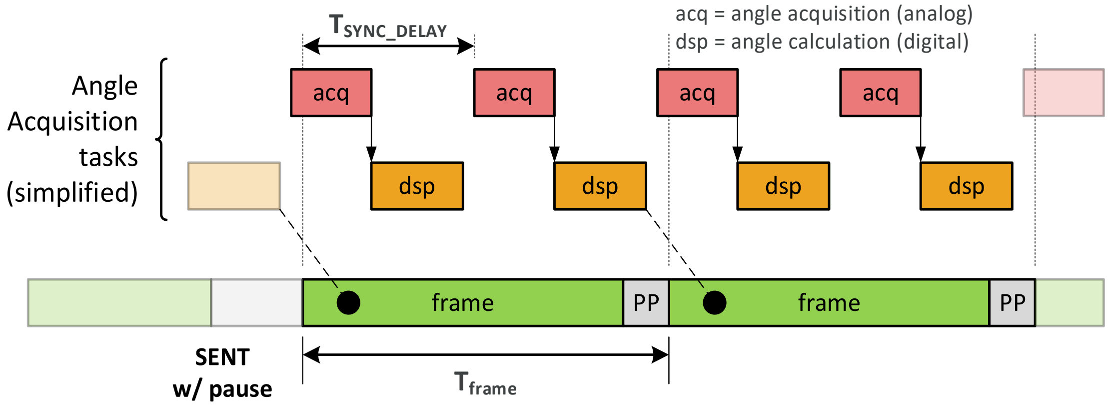


Figure 6 – Continuous synchronous timing mode

The detailed default setting of the SENT protocol is as follows:

- Protocol: SENT with pause
- Tick time: 3µs
- SENT format: A.3 (H.4)
- Number of angle acquisitions per SENT frame: 2
- DSP linearization: 16 points

The corresponding timing specifications are listed in Table 15.

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
SENT frame tick count	N_{Tframe}	294			ticks	
Output refresh period	T_{frame}		882	927	µs	Ppc = N_{Tframe}= 294
SENT start-up time	T_{stup}			5.9	ms	Until first valid angle received

[9] *The MLX90426 has a fixed tick time of 3 µs. It cannot be changed.*

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Average Latency [10] [11] [12]	τ_L		1.32 1.75	1.57 2.03	ms	Filter 1 Filter 2 (see 12.4 Filtering)
Step Response [11] [12]	T_{wcStep}			2.25 2.71 3.64	ms	Filter 0 Filter 1 Filter 2 (see 12.4 Filtering)
Analog Diagnostics Cycle	DCT_{ANA}			10.7	ms	Ppc = N_{Tframe}= 294
Digital Diagnostics Cycle	DCT_{DIG}		18.7	19.7	ms	
Safe start-up Time	$T_{SafeStup}$			18.9	ms	COLD_SAFE_STARTUP_EN = 1 (see Table 29)
Fail safe state duration [13]	T_{FSS}	5	20	33	ms	For digital single-event faults

Table 15 – Synchronous SENT mode timing specifications

6.3.2. Continuous Asynchronous Acquisition Mode

Optionally, the MLX90426 can be configured to operate with variable SENT frame length (SENT without pause). In continuous asynchronous acquisition mode, the sensor acquires angles at a fixed internal rate. At the beginning of each new SENT frame, the sensor fetches the latest calculated angle an transmit it in the SENT frame according to the selected format. In this mode, latency and step response depends on the data content and the delay between the angle availability and its transmission.

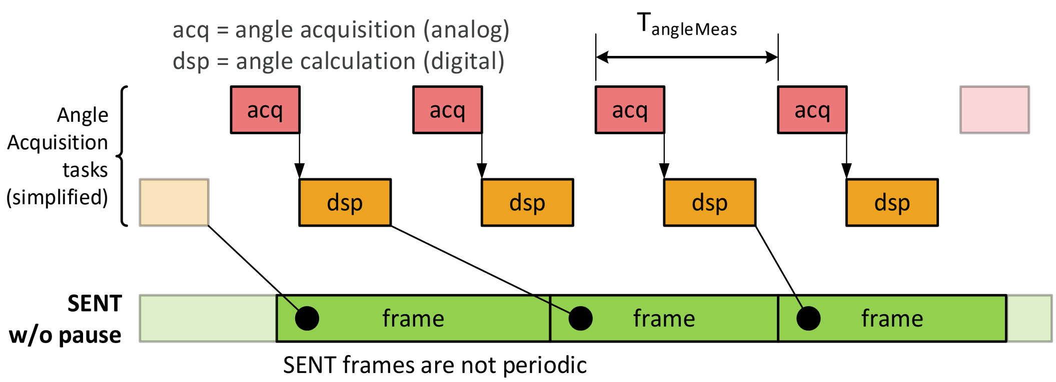


Figure 7 – Continuous asynchronous timing mode

When configured in the continuous asynchronous acquisition mode, the detailed default setting is as follows. The corresponding timing specifications are listed in Table 16.

- Protocol: SENT without pause
- Tick time: 3µs
- SENT format: A.3 (H.4)
- DSP linearization: 16 points

[10] Typ. values assumes typical clock and an average SENT frame (212 ticks, excluding pause pulse).
[11] Max values assumes min clock frequency and the longest SENT frame (270 ticks, excluding pause pulse).
[12] Data is considered available after the CRC nibble and before the pause pulse.
[13] 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 29 for details).

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Internal angle measurement period	$T_{angleMeas}$		512	538	µs	Asynchronously to the output protocol
Output refresh period	T_{frame}		810	851	µs	Npp = 270, longest frame w/o pause
SENT start-up time	T_{stup}			5.2	ms	Until first valid angle received
Average Latency [14]	τ_L	0.86 1.10 1.59	1.33 1.59 2.10	1.85 2.12 2.66	ms	Filter 0, Filter 1, Filter 2 (see 12.4 Filtering)
Step Response [15]	T_{wcStep}			2.70 3.24 4.31	ms	Filter 0, Filter 1, Filter 2 (see 12.4 Filtering)
Analog Diagnostics Cycle	DCT_{ANA}		11.8	12.4	ms	
Digital Diagnostics Cycle	DCT_{DIG}			19.7	ms	
Safe start-up Time	$T_{SafeStup}$			18.4	ms	COLD_SAFE_STARTUP_EN = 1 (see Table 29)
Failsafe State Duration[13]	T_{FSS}	5	20	33	ms	For digital single-event faults

Table 16 – Asynchronous SENT mode timing specifications

[14] In asynchronous mode, the latency varies due to the frame length variation and the The range for the average latency is provided (including clock drift). The average latency varies based on the programmable items configuration and the data being transmitted.
[15] Max values assumes a clock drift of 5% and the longest SENT frame (270 ticks).

7. Magnetic Field Specifications

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

7.1. Magnetic Field Specifications for MLX90426 Single Die

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Number of magnetic poles	N_P		2			
Magnetic Flux Density in Z	B_z			130	mT	in absolute value
Useful Magnetic Flux Density Norm	ΔB_z	10 [16]	20	150	$\frac{mT}{mm}$	$\sqrt{\left(\frac{\Delta B_Z}{\Delta X}\right)^2 + \left(\frac{\Delta B_Z}{\Delta Y}\right)^2}$ 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	145	310	$\frac{mT}{mm}$	Typ. is recommended value to be set by user (see 12.5.5)

Table 17 – Magnetic specifications for standard application

The magnetic performances are listed in chapter 8.2. The Figure 8 defines under which conditions nominal, limited or high-temperature performances apply.

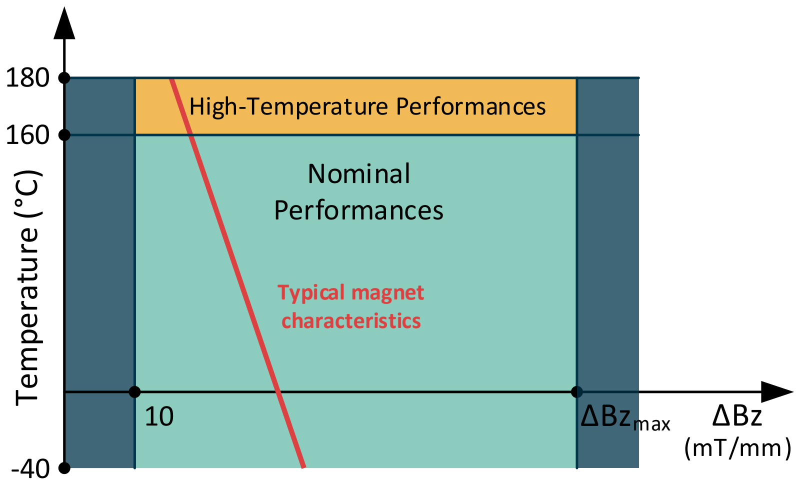


Figure 8 – Useful magnetic signal definition

[16] *Only valid under the conditions of Figure 8. 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.*

7.2. Magnetic Field Specifications for MLX90426 Stacked Dice

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			130	mT	in absolute value
Useful Magnetic Flux Density Norm	ΔB_z	12 [17]	20	168	$\frac{mT}{mm}$	$\sqrt{\left(\frac{\Delta Bz}{\Delta X}\right)^2 + \left(\frac{\Delta Bz}{\Delta Y}\right)^2}$
Hall Plates spacing	ΔX, ΔY		1.55		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
Field Too High Threshold	$\Delta B_{Z,TH\_HIGH}$	100	160	310	$\frac{mT}{mm}$	Typ. is recommended value to be set by user

Table 18 – Magnetic specifications for standard application

The magnetic performances are listed in chapter 8.3. The Figure 9 defines under which conditions nominal or high-temperature performances apply.

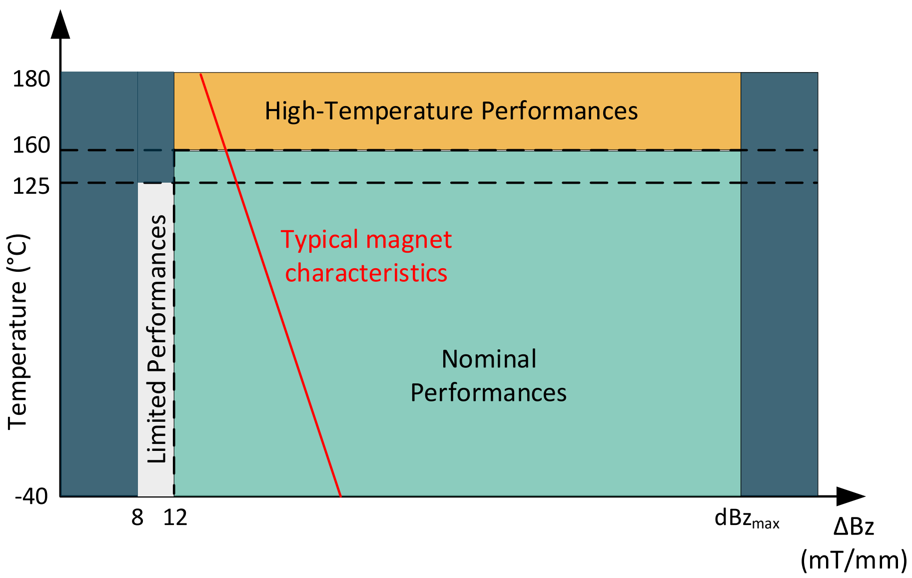


Figure 9 – Useful magnetic signal definition

(17) *Only valid under the conditions of Figure 9. 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

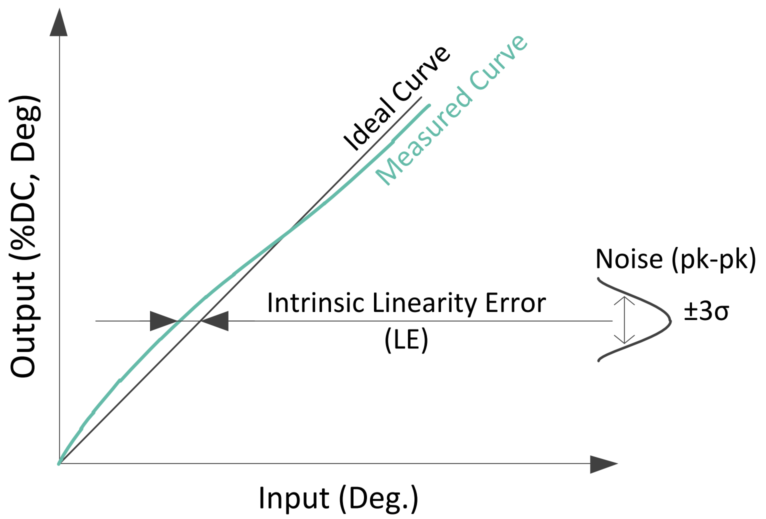


Figure 10 – Sensor accuracy definition

The illustration of Figure 10 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. Single die 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 [18]			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 [19]	$\partial\theta_{TT\_XY}$	-0.9		0.9	Deg.	Relative to 35°C
Hysteresis [20]				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 19 – Nominal magnetic performances

8.2.1. High-Temperature Extension Performances

When the MLX90426 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 [8]			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 []	$\partial\theta_{TT\_XY}$	-1.1		1.1	Deg.	Relative to 35°C
Hysteresis [20]				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 20 – High-Temperature Magnetic Performances

[18] $\pm 3\sigma$.
[19] 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.
[20] The MLX90426 has no IMC and therefore no intrinsic source of magnetic hysteresis.

8.3. Stacked dice performances

8.3.1. Nominal Performances

Valid before EoL calibration and for all applications under nominal performances conditions (chapter 7).

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Intrinsic Linearity Error	$L_{E\_\Delta BZ}$	-1.3		1.3	Deg.	
Noise (18)			0.40 0.28 0.20	0.50 0.35 0.25	Deg.	Filter = 0, $\Delta B_z \geq$ 12mT/mm Filter = 0, $\Delta B_z \geq$ 20mT/mm Filter = 2, $\Delta B_z \geq$ 12mT/mm
Total Drift (19)	$\partial\theta_{TT\_XY}$	-1.0		1.0	Deg.	Relative to 35°C
Hysteresis (20)				0.1	Deg.	$\Delta B_z \geq$ 12mT
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 21 – Nominal magnetic performances

8.3.2. Limited Performances

Valid before EoL calibration and for all applications under limited performances conditions (see section 7.2).

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Intrinsic Linearity Error	$L_{E\_\Delta BZ}$	-1.3		1.3	Deg.	
Noise (18)			0.52 0.40 0.26	0.65 0.50 0.33	Deg.	Filter = 0, $\Delta B_z \geq$ 8mT/mm, 125°C Filter = 0, $\Delta B_z \geq$ 12mT/mm, 160°C Filter = 2, $\Delta B_z \geq$ 8mT/mm, 125°C
Total Drift (19)	$\partial\theta_{TT\_XY}$	-1.0		1.0	Deg.	Relative to 35°C
Hysteresis (20)				0.1	Deg.	$\Delta B_z \geq$ 10mT
Stray Field Immunity				0.70	Deg.	$\Delta B_z \geq$ 10mT/mm In accordance with ISO11452-8:2015, at 30°C with stray field of 4kA/m from any direction

Table 22 – Limited magnetic performances

8.3.3. High-Temperature Extension Performances

When the MLX90426 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. This extension is only valid for the SMP-3 and SMP-4 packages.

Parameter	Symbol	Min	Typ.	Max	Unit	Condition
Intrinsic Linearity Error	$L_{E\_\Delta BZ}$	-1.3		1.3	Deg.	
Noise [18]				0.4 0.7	Deg.	Filter = 0, ΔB_z = 20mT/mm, 180°C Filter = 0, ΔB_z = 12mT/mm, 180°C
Total Drift [19]	$\partial\theta_{TT\_XY}$	-1.0		1.0	Deg.	Relative to 35°C
Hysteresis [20]				0.1	Deg.	$\Delta B_z \geq$ 10mT/mm

Table 23 – High-temperature magnetic performances

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 word 16b (single error correction, double error detection)

Table 24 – Memory specifications

10. Output Protocol Description

10.1. Single Edge Nibble Transmission (SENT) SAE J2716

The MLX90426 provides a digital output signal compliant with SAE J2716 Revised APR2016.

10.1.1. Sensor Message Definition

The MLX90426 repeatedly transmits a sequence of pulses, corresponding to a sequence of nibbles (4 bits), with the following sequence:

- Calibration/Synchronization pulse period 56 clock ticks to determine the time base of the SENT frame
- One 4-bit Status and Serial Communication nibble pulse
- A sequence six 4-bit data nibbles pulses representing the values of the signal(s) to be transmitted. The number of nibbles will be fixed for each application of the encoding scheme (i.e. Single Secure sensor format A.3, Throttle position sensor A.1)
- One 4-bit Checksum nibble pulse
- One optional pause pulse

See also SAE J2716 APR2016 for general SENT specification.

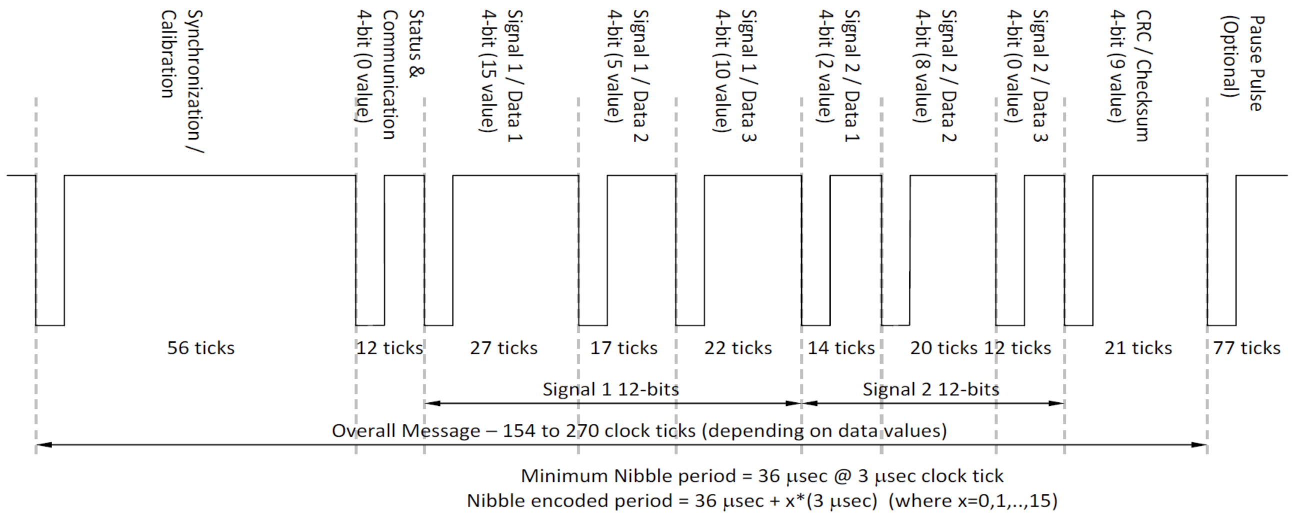


Figure 11 – SENT message encoding example for two 12-bit signals

10.1.2. Sensor Message Frame Contents

The SENT output of the MLX90426 transmits a sequence of data nibbles, according to the following configurations:

Description	Symbol	Min	Typ.	Max	Unit	Description
Clock tick time	Tick Time		3		µs	Normal SENT, 3µs tick time
Number of data nibbles	Xdn		6			
Frame duration w/o pause	Npp	154		270	ticks	6 data nibbles
Frame duration w/ pause	Ppc	294	294	922	ticks	6 data nibbles
Sensor type			A.1 A.3			Dual Throttle Position sensor Single Secure sensor

Table 25 – SENT protocol frame definition

10.1.3. SENT Format Option

The default SENT data frame format of MLX90426 is a Single Secure Sensor A.3 (H.4). The MLX90426 SENT transmits a sequence of data nibbles; according to the single secure sensor format defined in SAE J2716 appendices H.4 and A.3. The frame six data nibbles are made of the 12-bit angular value, an 8-bit rolling counter and an inverted copy of the most significant nibble of the angular value.

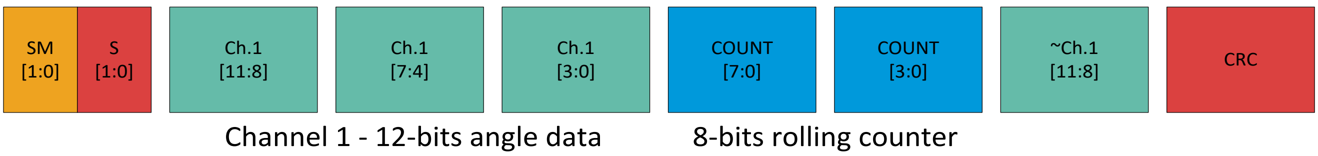


Figure 12 – H.4 frame format

Optionally, the MLX90426 can be configured in a Dual Throttle Position Sensor A.1 (H.1). The MLX90426 SENT transmits a sequence of six data nibbles with a 12-bit channel 1 and 12-bit channel 2 format defined in SAE J2716 appendices H.1 and A.1. The first chaannel contains the magnetic angle measurement and the second channel can be configured to output any data, for instance the internal sensor temperature or an inverted value of the magnetic measurement. See Table 29, SENT_FAST_CHANNEL_2 for a detailed list of options.

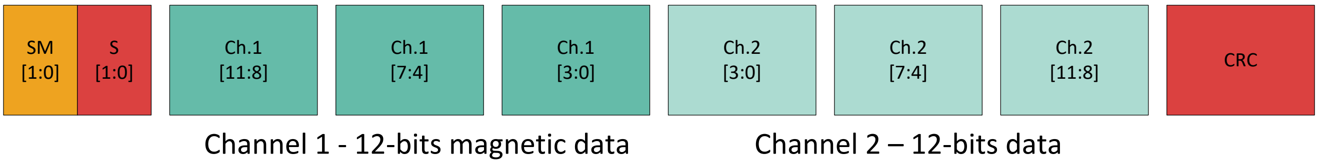


Figure 13 – H.1 frame format

10.1.4. Start-up Behavior

Once the digital start-up is complete, the circuit will send initialisation frame until the angle measurement initialisation sequence is complete (see section 6.2.1). These initialisation frames content can be chosen with the SENT_INT_GM parameter.

SENT_INIT_GM	Initialisation frame value	Comments
0	0x000	SAE compliant, default
1	0xFFF	Specific OEM requirement

Table 26 – Initialization frame content definition

10.1.5. Output Configuration

The output resistive load, e.g. the external pull-up resistor, should be carefully selected because the MLX90426 has a built-in high order low pass filter. A large resistive load will deteriorate the generated SENT signal until it eventually won't be compliant with the SENT specifications anymore (fall times, min and max output voltages). The values in Table 12 should be respected, which means it is not recommended to have a resistive load value smaller than 10kΩ or higher than 55 kΩ.

The output capacitance shall also be properly chosen. Together with the output resistive load, they shall match the transmission speed, i.e. tick time, to allow an appropriate time constant for the transmission of the SENT signal. Details can be found in section 14.1.

10.1.6. Enhanced Serial Message (ESM) channel

A Serial Message (SM) is transmitted sequentially in bit number 3 and 2 of the status and communication nibble. One serial message frame stretches over 18 consecutive SENT data frames. All 18 frames must be successfully received for the corresponding serial data to be received (no errors, calibration pulse variation, data nibble CRC error, etc.).

Enhanced serial message with 12-bit data and 8-bit message ID is used (SAE J2716 APR2016 5.2.4.2, Figure 5.2.4.2-2). According to the standard, SM[0] contains a 6-bit CRC followed by a 12-bit data. Message content is defined by a 8-bit message ID transmitted in the SM[1] channel. Correspondence between ID and message content is defined in the table below (Table 27).

By default, a short sequence continually transmits a cycle of 24 serial messages. An extended sequence can be selected, increasing the cycle to 32 serial messages. Additionally, the norm of the magnetic field measured by the sensor can be added to the end of the sequence (short or extended).

#	8-bit ID	Item	Source data
		Short Sequence	
1	0x01	Diagnostic error code	Current status code from RAM
2	0x06	SENT standard revision	0x004 from ROM
3	0x01	Diagnostic error code	Current status code from RAM
4	0x05	Manufacturer code	0x006 from ROM
5	0x01	Diagnostic error code	Current status code from RAM
6	0x03	Channel 1 / 2 Sensor type	0x050 from ROM
7	0x01	Diagnostic error code	Current status code from RAM
8	0x07	Fast channel 1: X1	SENT_CHANNEL_X1 from NVRAM
9	0x01	Diagnostic error code	Current status code from RAM
10	0x08	Fast channel 1: X2	SENT_CHANNEL_X2 from NVRAM
11	0x01	Diagnostic error code	Current status code from RAM
12	0x09	Fast channel 1: Y1	SENT_CHANNEL_Y1 from NVRAM
13	0x01	Diagnostic error code	Current status code from RAM
14	0x0A	Fast channel 1: Y2	SENT_CHANNEL_Y2 from NVRAM
15	0x01	Diagnostic error code	Current status code from RAM
16	0x23	(Internal) temperature	Current temperature from RAM
17	0x01	Diagnostic error code	Current status code from RAM
18	0x29	Sensor ID #1	SENT_SENSOR_ID1 from NVRAM
19	0x01	Diagnostic error code	Current status code from RAM
20	0x2A	Sensor ID #2	SENT_SENSOR_ID2 from NVRAM
21	0x01	Diagnostic error code	Current status code from RAM
22	0x2B	Sensor ID #3	SENT_SENSOR_ID3 from NVRAM
23	0x01	Diagnostic error code	Current status code from RAM
24	0x2C	Sensor ID #4	SENT_SENSOR_ID4 from NVRAM
		Extended Sequence	
25	0x01	Diagnostic error code	Current status code from RAM
26	0x90	OEM Code #1	SENT_OEM_CODE1 from NVRAM
27	0x01	Diagnostic error code	Current status code from RAM
28	0x91	OEM Code #2	SENT_OEM_CODE2 from NVRAM
29	0x01	Diagnostic error code	Current status code from RAM
30	0x92	OEM Code #3	SENT_OEM_CODE3 from NVRAM
31	0x01	Diagnostic error code	Current status code from RAM
32	0x93	OEM Code #4	SENT_OEM_CODE4 from NVRAM
		Field Norm Extension	

#	8-bit ID	Item	Source data
25 or 33	0x01	Diagnostic error code	Current status code from RAM
26 or 35	0x80	Magnetic field Norm	Field Strength corrected from RAM

Table 27 – SENT slow channel data sequence

10.1.7. Enhanced Serial Message Error Codes

Every other Serial Message returns the diagnostic error code of the MLX90426. When the Serial Message 8-bit ID is 0x01, the 12-bit Serial Message data field contains error flags as described in the Table 28. The error code is one-hot encoded and therefore each bit corresponds to one or several diagnostics. Only the first error detected during a diagnostics cycle is reported, and the serial message error code will be updated after every diagnostics cycle (see DCT_{ANA}, Table 15 and Table 16). The Serial Message error and status bit will only be cleared out once all the errors have disappeared. This mechanism ensures that only one error at a time takes control of the error debouncing counter (see 12.5.2).

The MSB acts either as an error flag or can be kept high regardless of the error status. See section 12.5.6.

Bit Nb	12 Bit Data (hex)	Diagnostic	Comments
-	0x000 / 0x800	No error	Programmable (See section 12.5.6)
0	0x801	GAINOOS	Magnetic Signal Conditioning Gain Clamping
1	0x802	FieldTooLow	Fieldstrength is below defined low threshold (see section 12.5.3)
2	0x804	FieldTooHigh	Fieldstrength is above defined high threshold (see section 12.5.3)
3	0x808	ADCclip	ADC is saturated, either low or high
4	0x810	ADC_test	ADC made wrong conversion
5	0x820	Analog Supply Monitors	Detects VDDA (VDEC) over and under voltage or VDD under voltage
6	0x840	Digital Supply Monitors	Detects VDDD (1.8V internal digital supply) overvoltage
7	0x880	RoughOffset	Hall Element offset monitor
8	0x900	Over-Under Temp / ADCdrop	Temperature sensor monitor (see 12.5.3) / ADC conversion interruption
9	0xA00	DSP overflow / HE_Bias / Analog Front End	DSP overflow / Hall Element biasing issue / Analog front end self-test
10	0xC00	Supply Bias Current / Stress Range	Current biasing system monitor / Stress Sensor Readout
11	0x800	Extra Error Flag	set to one if any error present (only when SENT_DIAG_STRICT = 1). Otherwise, always high.

Table 28 – SENT serial message error code for enhanced serial message

11. End-User Programmable Items

Parameter	PSF value	Description	Default Value	# bits
		GENERAL CONFIGURATION		
USER_ID[0:5]	95 .. 102	Reserved for end-user to program information for traceability. Not compatible with a used patch area	-	8
WARM_TRIGGER_LONG	124	Add delay for PTC entry level	0	1
MUPET_ADDRESS	128	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	47	7
GAINSATURATION	4	Enable gain saturation	0	1
SENSING_MODE	23	0: ΔB_Z, angular rotary 360° stray field robust 1-3: Do not use	0	2
		FILTERING		
FILTER	24	FIR filter bandwidth selection 0: no filter 1: FIR11 (default) 2: FIR1111 3: Do not use	1	2
		LINEAR TRANSFER CHARACTERISTIC		
4POINTS	18	Enable 4 points PWL linearization	0	1
CLAMPHIGH	22	High clamping value of angle output data	4088	12
CLAMPLOW	16	Low clamping value of angle output data	1	12
CW	17	Magnet rotation direction.	0	1
DP	11	DSP discontinuity point	0	13
LNRS0	25	4-pts - Slope coefficient before reference point A	-	16
LNRAX LNRBX LNRCX LNRDX	28 38 49 61	4-pts - X Coordinate for reference points A,B,C,D	-	16
LNRAY LNRBY LNRCY LNRDY	33 44 56 68	4-pts - Y Coordinate for reference points A,B,C,D	-	16
LNRAS LNRBS LNRCS LNRDS	35 46 58 70	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	27 29 34 37 40 45 48 51 57 60 63 69 72 75 78 81 84	17-pts / 16 segments - Y coordinate point [0:16]	1 256 512 767 1023 1278 1534 1789 2045 2300 2555 2811 3066 3322 3577 3833 4089	12
OUTSLOPE_COLD	86	Slope coefficient at cold of the programmable temperature-dependent offset.	0	8
OUTSLOPE_HOT	87	Slope coefficient at hot of the programmable temperature-dependent offset.	0	8
T_SYNC_DELAY	9	SENT - ADC synchronization delay (SENT with pause pulse only)	144	8
TWO_ANGLES_FRAME	131	Enable 2 angle measurements per SENT frame (SENT with pause pulse only)	1	1
USEROPTION_SCALING	19	Enable output scaling 2x after linearization	0	1
WORK_RANGE	132	Working Range 17 points	0	4
WORK_RANGE_GAIN	8	Post DSP Gain Stage	16	8
		DIAGNOSTICS		
COLD_SAFE_STARTUP_EN	53	Normal (0) or safe start-up (1) after power-on reset	0	1
DIAG_EN	43	Diagnostics global enable. **Do not modify!**	1	1
DIAG_FIELDTOOHIGHTHRES	119	Field strength limit over which a fault is reported.	14	4
DIAG_FIELDTOOLOWTHRES	120	Field strength limit under which a fault is reported.	3	4
DIAGDEBOUNCE_STEPDOWN	31	Diagnostic debouncing step-down time used for recovery time setting	1	2
DIAGDEBOUNCE_STEPUP	32	Diagnostic debouncing step-up time used for hold time setting	1	2
DIAGDEBOUNCE_THRESH	42	Diagnostic debouncing threshold	1	3

Parameter	PSF value	Description	Default Value	# bits
MEMLOCK	55	Enable NVRAM write protection	0	2
OUT_DIAG_HIZ_TIME	122	Recovery time when a transient digital failure is detected. Timeout corresponds to DCT_{DIG} for the default value. For recovery time of 2 DCT_{DIG} it is recommended to program 0x14	0	5
ROUT_LOW	123	Select output impedance for PTC communication	1	1
SENT_DIAG_STRICT	12	Option of analog fault reporting in the SENT slow message	0	1
SENT_REPORT_MODE_ANA	129	Defines the error message within SENT frame in diagnostic mode. Refer to the Safety Manual (chap. 13)	0	2
		OUTPUT CONFIGURATION		
NIBBLE_PULSE_CONFIG	13	Sets the SENT nibble high/low-time configuration: 0: 7 fixed ticks high time 1: 5 fixed ticks low time	1	1
PROTOCOL	125	Selection of the measurement timing mode and the corresponding output protocol 0: continuous asynchronous angle acquisition, SENT without pause pulse 1: continuous synchronous angle acquisition, SENT with pause pulse	1	1
T_FRAME	89	SENT with pause pulse period in ticks of 3us	294	12
		SENT PROTOCOL OPTIONS		
SENT_FAST_CHANNEL_2	67	Definition of data transmitted in the SENT fast channel 2 in case SENT_FC_FORMAT=0 0: Temperature sensor (SP ID 0x23) 1: 0xFF9(d4089) - CH1 2: RAM data (RAMPROBE_PTR) 3: 0xFFF(d4095) - CH1	3	2
SENT_FC_FORMAT	91	SENT frame format option 0: Format H.1 (A.1, Two 12-bit Fast Channels) 1: Format H.4 (A.3, Single secure sensor)	1	1
SENT_INIT_GM	66	Initialization frame data until first valid data 0: 0x000 1: 0xFFF(d4095) error code	0	1
SENT_LEGACY_CRC	65	Enable legacy CRC calculation	0	1

Parameter	PSF value	Description	Default Value	# bits
		0: The CRC recommended by SAE J2716 is calculated		
SERIAL_CONFIG	92	Serial Message configuration 0: Serial Message is disabled 1: Serial Message is enabled	1	1
SENT_SLOW_EXTENDED	130	Serial Message Sequence definition 0: Short Sequence Serial Message 1: Extended Sequence Serial Message	0	1
SENT_SLOW_EXTENSION	6	Serial Message extension configuration 0: without field norm extension 1: with field norm extension	1	1
SENT_CHANNEL_X1	104	Part of ESM: Fast-channel 1 - X1	0	12
SENT_CHANNEL_X2	105	Part of ESM: Fast-channel 1 - X2	0	12
SENT_CHANNEL_Y1	107	Part of ESM: Fast-channel 1 - Y1	0	12
SENT_CHANNEL_Y2	109	Part of ESM: Fast-channel 1 - Y2	0	12
SENT_OEM_CODE1 SENT_OEM_CODE2 SENT_OEM_CODE3 SENT_OEM_CODE4	74 76 79 82	Part of ESM: OEM code [1:4] (only when 4POINTS = 1)	-	12
SENT_SENSOR_ID1 SENT_SENSOR_ID2 SENT_SENSOR_ID3 SENT_SENSOR_ID4	111 112 114 116	Part of SSM/ESM: Sensor ID-[1:4]	-	12

Table 29 – MLX90426 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. SENT Output Mode Options

The parameter PROTOCOL defines the measurement mode and the corresponding output protocol.

PROTOCOL	Description
0	Continuous asynchronous angle acquisition, SENT without pause pulse
1	Continuous synchronous angle acquisition, SENT with pause pulse

Table 30 – MLX90426 protocol selection

When using the SENT with pause pulse protocol, the parameter T_FRAME controls the SENT frame duration. By default, the period is 294 ticks. This parameter is encoded on 12 bits. Its value shall remain within the range specified in section 10.1.

The frame format, and therefore the data available in the fast channels, is selected using the SENT_FC_FORMAT parameter. Refer to section 10.1.3 for a description of these SENT frame format.

SENT_FC_FORMAT	Description
0	Dual Throttle Position Sensor A.1 (H.1)
1	Single Secure Sensor A.3 (H.4), default

Table 31 – MLX90426 frame format selection

When using the H.1 format, the parameter SENT_FAST_CHANNEL_2 can be used to control what data will be output on the 2nd fast channel

SENT_FAST_CHANNEL_2	Description
0	Internal temperature sensor (SP ID 0x23)
1	0xFF9(d4089) - CH1
2	RAM data (RAMPROBE_PTR)
3	0xFFF(d4095) - CH1

Table 32 – MLX90426 fast channel 2 data selection

The SENT protocol allows to either fix the number of ticks for the high time of fix the number of ticks for the low time in the SENT nibble pulses. This can be done using NIBBLE_PULSE_CONFIG parameter.

NIBBLE_PULSE_CONFIG	Description
0	Fixed high time (7 ticks)
1	Fixed low time (5 ticks), default

Table 33 – MLX90426 nibble pulses configuration

The enhanced serial message channel can be enabled or disabled using the SERIAL_CONFIG parameter.

SERIAL_CONFIG	Description
0	Serial Message is disabled
1	Serial Message is enabled, default

Table 34 – MLX90426 enhanced serial message configuration

When the enhanced serial message is enabled, it is possible to control which of the short sequence or the extended sequence is used with the SENT_SLOW_EXTENDED parameter (see section 10.1.6).

SENT_SLOW_EXTENDED	Description
0	Short Sequence Serial Message, default
1	Extended Sequence Serial Message

Table 35 – MLX90426 serial sequence message definition

When the enhanced serial message is enabled, it is possible to add the field norm to the serial message cycle with the SENT_SLOW_EXTENSION parameter (see section 10.1.6).

SENT_SLOW_EXTENSION	Description
0	without field norm extension
1	with field norm extension, default

Table 36 – MLX90426 extended sequence definition

12.2. Output Transfer Characteristic

There are 2 different possibilities to define the transfer function (LNR) as specified in Table 37.

- 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 37 – 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 38 – 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
- the 1-8-9-16 pin order direction for the TSSOP-16_EP package
- the 1-2-3-4 pin order direction for the SMP-4 package

Clockwise if defined by the reverse pin order. Refer to the package drawings in chapter 16.

12.2.2. Discontinuity Point (or Zero Degree Point)

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

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

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

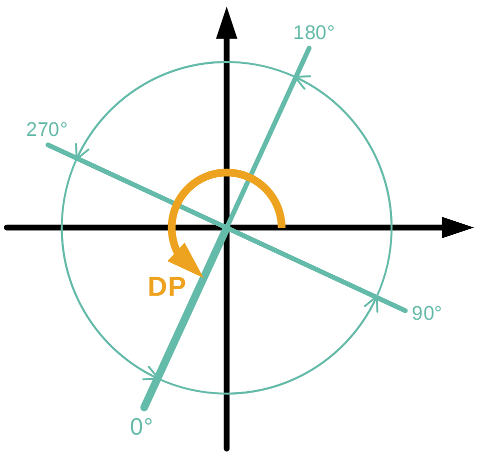


Figure 14 – Discontinuity point positioning

12.2.3. 4-Pts LNR Parameters

The LNR parameters, together with the clamping values, fully define the relation (the transfer function) between the digital angle and the output signal.

The shape of the MLX90426 four points transfer function from the digital angle value to the digital output is described in the following figure (Figure 15). Seven segments can be programmed but the clamping levels are necessarily flat.

Two, three, or even six calibration points are then available, reducing the overall non-linearity of the IC by almost an order of magnitude each time. Three or six 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.

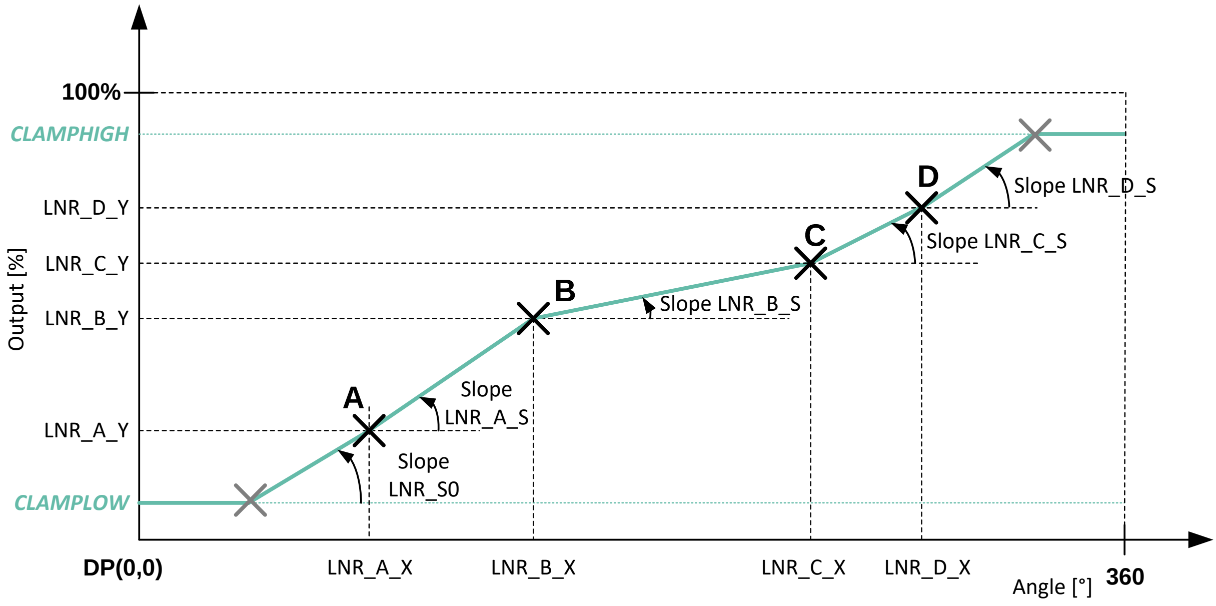


Figure 15 – 4pts linearization parameters description

12.2.4. 17-pts LNR Parameters

The LNR parameters, together with the clamping values, fully define the relation (the transfer function) between the digital angle and the output signal.

The shape of the MLX90426 seventeen points transfer function from the digital angle value to the output voltage is described in the Figure 15. In the 17-Pts mode, the output transfer characteristic is Piece-WiseLinear (PWL).

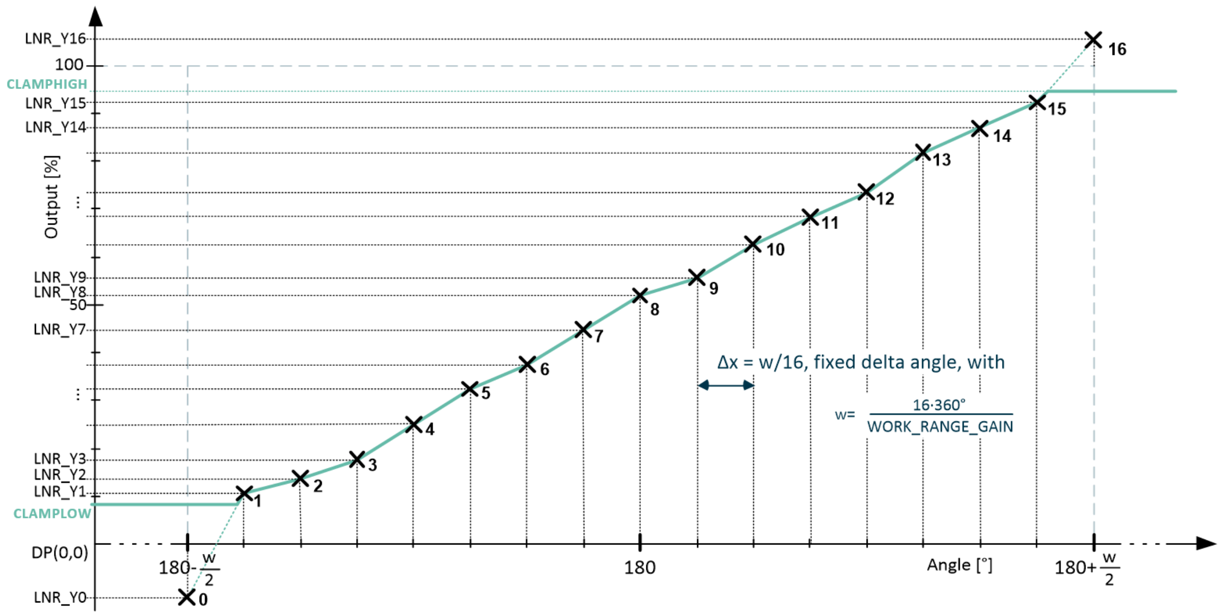


Figure 16 – 17-pts linearization parameters description

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 17-pts		WORK_RANGE	Range	Δx 17-pts
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 39 – 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 17-pts
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 40 – 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 MLX90426, 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 17).

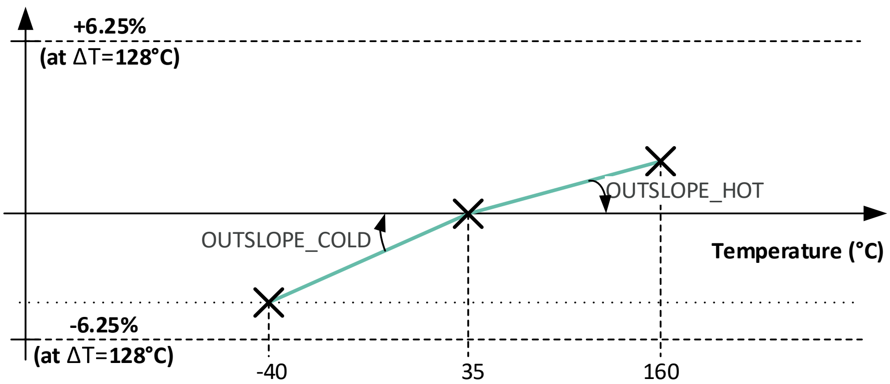


Figure 17 – Temperature compensated offset

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 four 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 42 content.

Parameter	Value
SENSING_MODE	[0:2]
GAINMIN	[0:47]
GAINMAX [21]	[0:48]
GAINSATURATION	[0:1]

Table 41 – Sensing mode and front-end configuration

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

Table 42 – 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 MLX90426 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 43.

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

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 43 – FIR filter characteristics

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 MLX90426. 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 44 – 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 12.5.2 for SENT error message codes). 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 45 – 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}

T_{LIN} is encoded using the SENT standard for temperature sensor.

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

$$T_{PHY}[°C] = \frac{T_{LIN}}{8} - 73.15$$

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}.

$$DIAG\_TEMP\_THR\_(LOW/HIGH) = \frac{T_{LIN}}{16}$$

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}	- 8	-	8	°C	from -40 to 160°C
		- 2		6	°C	from -35 to 125°C
Low temperature threshold	DIAG_TEMP _THR_LOW	-	8	-	LSB8	Fixed value, corresponds to -57°C
High temperature threshold	DIAG_TEMP _THR_HIGH	-	136	-	LSB8	Fixed value, corresponds to 199°C
High/low temperature threshold resolution	Res_{Tthr}		2		°C	8-bit range

Table 46 – 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	0x3B0F
PATCH2_INSTRUCTION	0x008C

Table 47 – 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 [22]	100	310	15	mT/mm

Table 48 – Field Monitor Diagnostic limits

12.5.6. SENT Mode Diagnostic Reporting

In the presence of a digital fault, the OUT pin will enter a high-impedance mode. Conversely, an analog fault is reported by raising the SENT status bit S0 (refer to section 10.1.3).

The parameter SENT_DIAG_STRICT controls the behavior of the MSB in the ESM error code (see bit 11 in Table 28).

SENT_DIAG_STRICT	Description
0	The MSB (in 11 in Table 28) in the ESM error reporting is fixed high, even if no error needs to be reported.
1	The MSB in the ESM error reporting acts as an error reporting flag.

Table 49 – MSB behavior selection of the Enhanced Serial Message error code

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 MLX90426.

[22] *When this parameter is set to the maximum value of 15 (0xF), the FIELD_TOO_HIGH diagnostic is disabled (see Table 17).*

13. Functional Safety

13.1. Safety Manual

The safety manual, available upon request, contains the necessary information to integrate the MLX90426 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 MLX90426 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 according to the SENT protocol definition.

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 start-up)
DIG: Digital hardware failure reporting mode, described in the safety manual
At Start-up: 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 50 – Self diagnostic legend

Category and safety mechanism name	Front-end	ADC	DSP	Back-end	Support. Func.	Module & Package	Reporting mode	At start-up	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 start-up	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	●
SENT Fall Collision detection (SENT pulse generator)			●				DIG	NO	●

Category and safety mechanism name	Front-end	ADC	DSP	Back-end	Support. Func.	Module & Package	Reporting mode	At start-up	DIAG EN
Communication Interface Diagnostic				●					
SENT Protection Against Re-configuration at Run-time				●			DIG	NO	●
SENT Frame Counter & Redundant Nibble				●			n/a	n/a	
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 51 – MLX90426 list of self-diagnostics with characteristics

13.3. Fault Handling Time Interval

The Fault handling Time Interval (FHTI) is defined as the time interval between the occurrence of a fault causing a malfunction in the MLX90426 and the end of the last frame preceding the transition into the defined fail-safe state.

The following table provides the worst-case FHTI for both an analog fault and a digital fault in MLX90426.

Case	FHTI	Comment
Analog Fault	DCT_{ANA} + 2 T_{frame}	Refer to section 6.3 for the DCT_{ANA} and T_{frame} values
Digital Fault	DCT_{DIG}	Refer to section 6.3 for the DCT_{DIG} value

Table 52 – Worst-case FHTI

The FHTI values provided here are valid only for the default factory settings.

14. Recommended Application Diagrams

14.1. Wiring with the MLX90426 in SOIC-8 Package

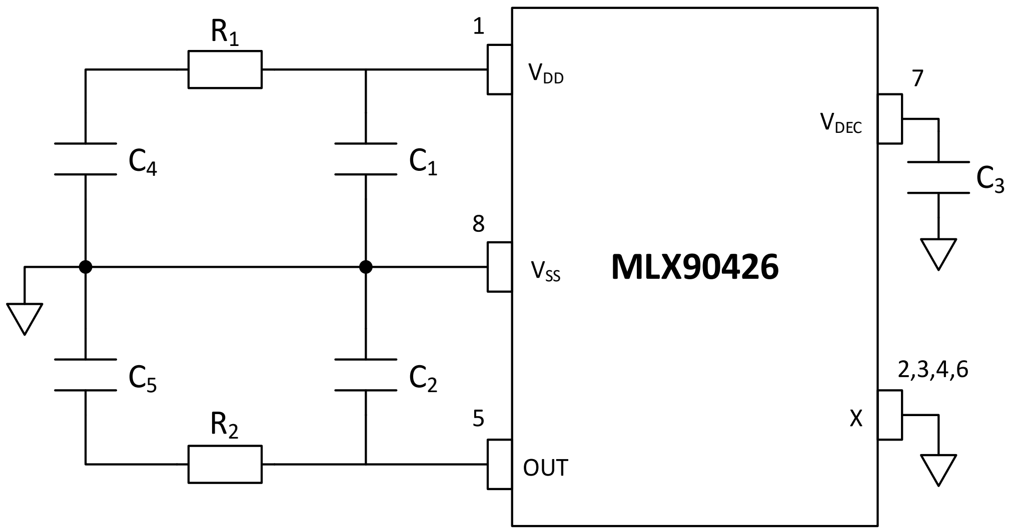


Figure 18 – Recommended wiring for the MLX90426 in SOIC-8 package

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

Table 53 – Recommended values for the MLX90426 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 MLX90426 in SMP-3 Package (built-in capacitors)

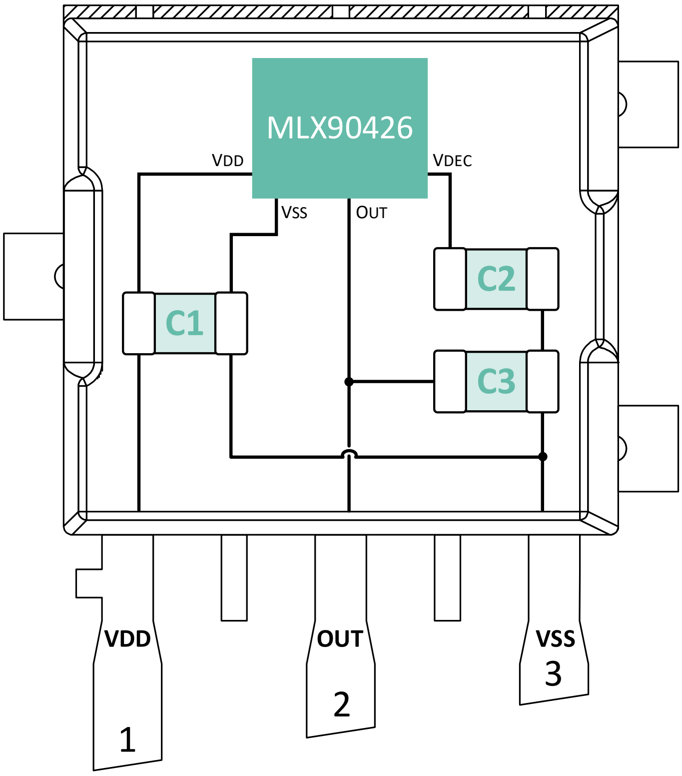


Figure 19 – Internal wiring of the MLX90426 in SMP-3

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

Table 54 – SMP-3 capacitors configuration

14.3. Wiring with the MLX90426 in TSSOP-16_EP Package

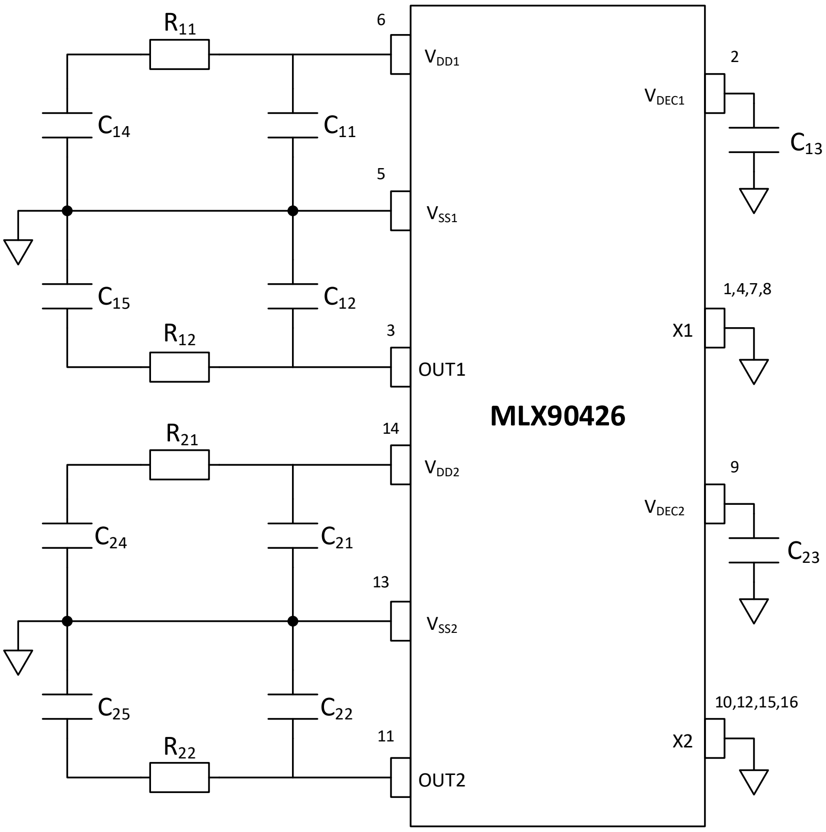


Figure 20 – Recommended wiring for the MLX90426 in TSSOP-16_EP package (dual die)

Component	Min	Typ.	Max	Remark
C_{x1}	100nF	220nF	-	
$C_{x2}(C_L)$	4.7nF	10nF	22nF	
C_{x3}	100nF	100nF	220nF	
C_{x4}	-	-	1nF	
C_{x5}	-	-	1nF	Optional, for improved EMC robustness
R_{x1}	-	-	10 Ω	
R_{x2}	-	-	-	

Table 55 – Recommended values for the MLX90426 in TSSOP-16_EP Package

For best EMC performance, C_{x1}, C_{x2} and C_{x3} 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_{x4}, C_{x5}) and a 10 Ohm resistor added in series with the supply line (R_{x1}).

14.4. Wiring with the MLX90426 in SMP-4 Package (built-in capacitors)

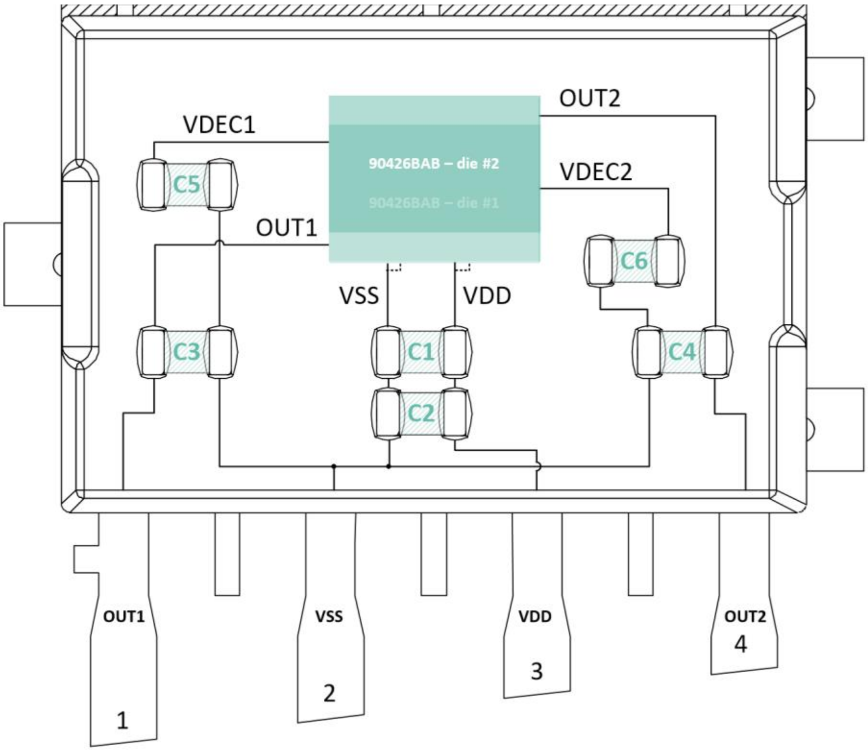


Figure 21 – Internal wiring of the MLX90426 in SMP-4

Component	Value	Remark
C1 C2	220nF	Supply capacitor
C3 C4	10nF	Output capacitor
C5 C6	100nF	Decoupling capacitor

Table 56 – SMP-4 capacitors configuration

15. IC handling and assembly

15.1. 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* [23]

15.2. 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* [23].

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 [23] 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*[23].

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 [23]

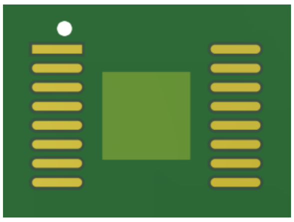
For other specific process, contact Melexis via www.melexis.com/technical-inquiry

[23] *www.melexis.com/ic-handling-and-assembly*

15.3. Soldering recommendations for the Exposed Pad (EP) in TSSOP-16

The MLX90426 in a TSSOP-16 stacked dice configuration comes with an exposed pad. This package is necessary to enable sufficient space for the die stacking. The exposed pad is **not** used to improve the thermal dissipation of the IC. Consequently, the ICs are isolated with regards to the exposed pad, both electrically and thermally. To guarantee product performance and electrical safety, the following guidelines shall be followed when designing the PCB.

A copper pad of adequate size shall be placed under the exposed pad on the PCB. For electrical safety and optimal EMC and noise performance, the copper pad on the PCB shall remain electrically inactive (not connected to any electrical net) and covered by solder mask. It is recommended not to solder the package exposed pad to the PCB.



When the exposed pad is soldered, the following remarks shall be taken into consideration:

- a stencil of minimal thickness of 150um shall be used
- when possible, dispensing shall be limited to two dots of 1mm diameter

a limited force of 1N to 2 N should be applied to the TSSOP package to secure wetting contact of the exposed pad to solder paste

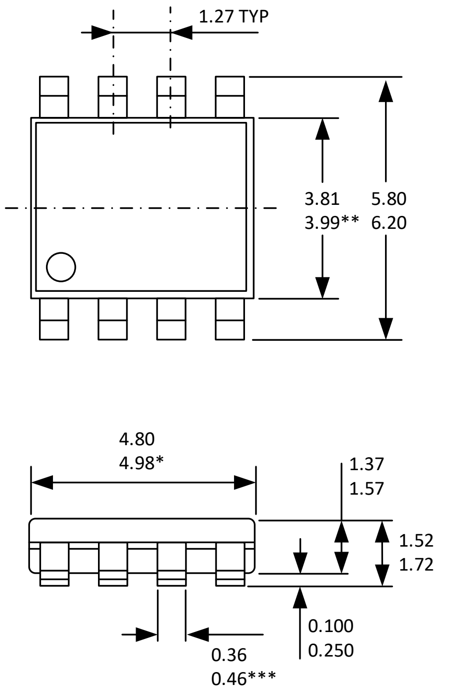
15.4. Environment and sustainability

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

16. Package Information

16.1. SOIC-8 – Package Information

16.1.1. 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.

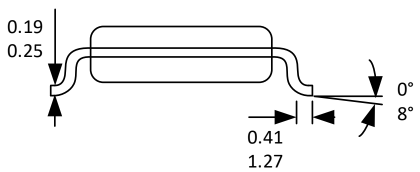


Figure 22 – SOIC-8 package outline drawing

16.1.2. SOIC-8 – Pinout and Marking

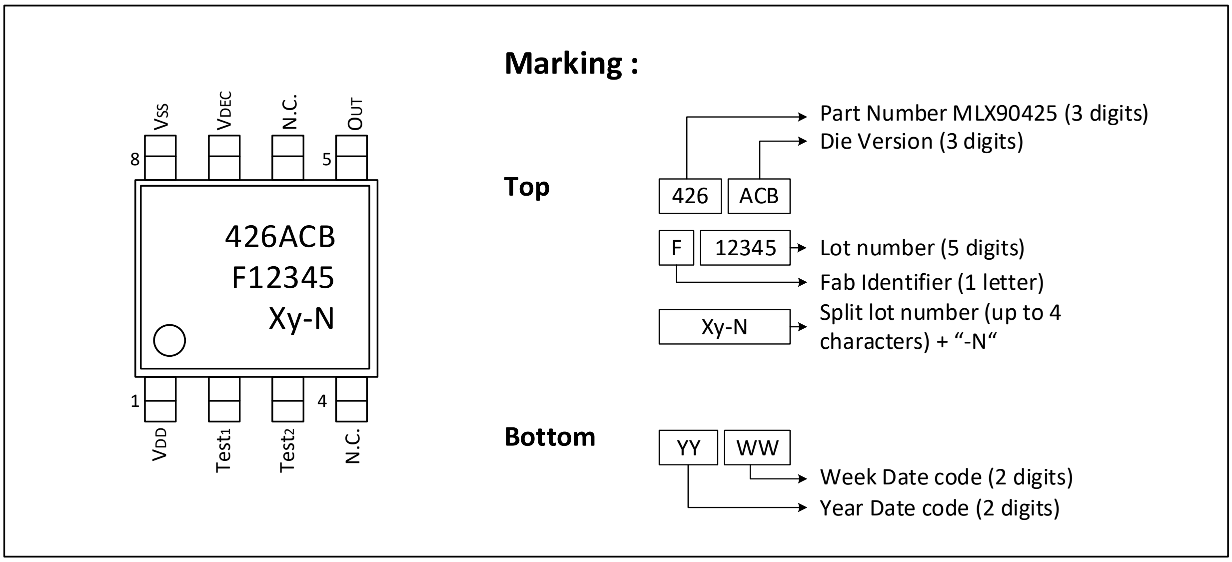


Figure 23 – SOIC-8 pinout and marking

16.1.3. SOIC-8 – Sensitive Spot Positioning

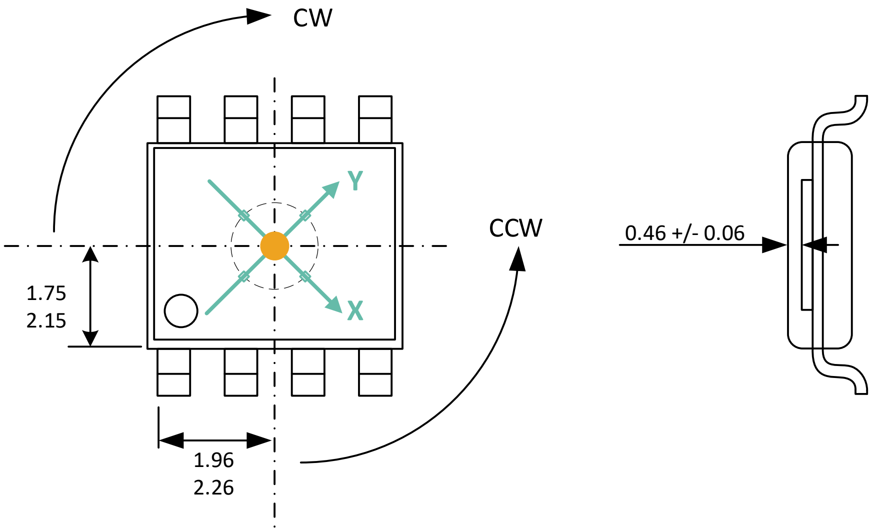


Figure 24 – SOIC-8 sensitive spot position

16.1.4. SOIC-8 – Angle Detection

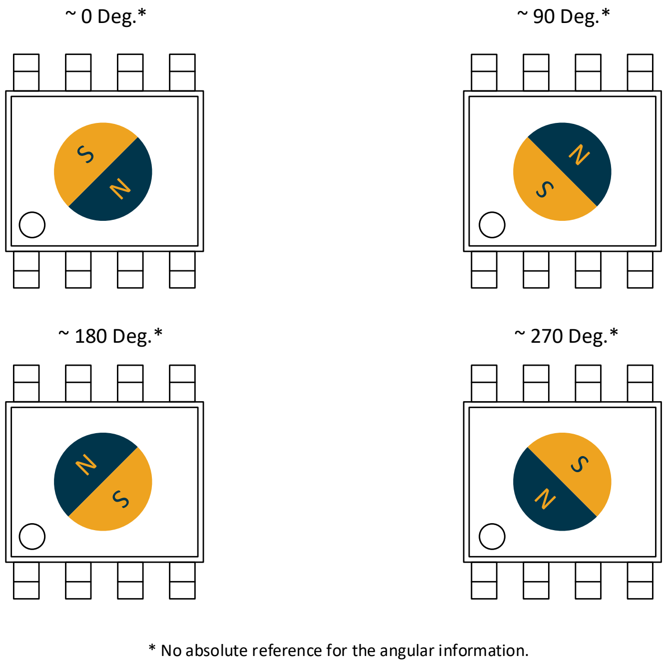
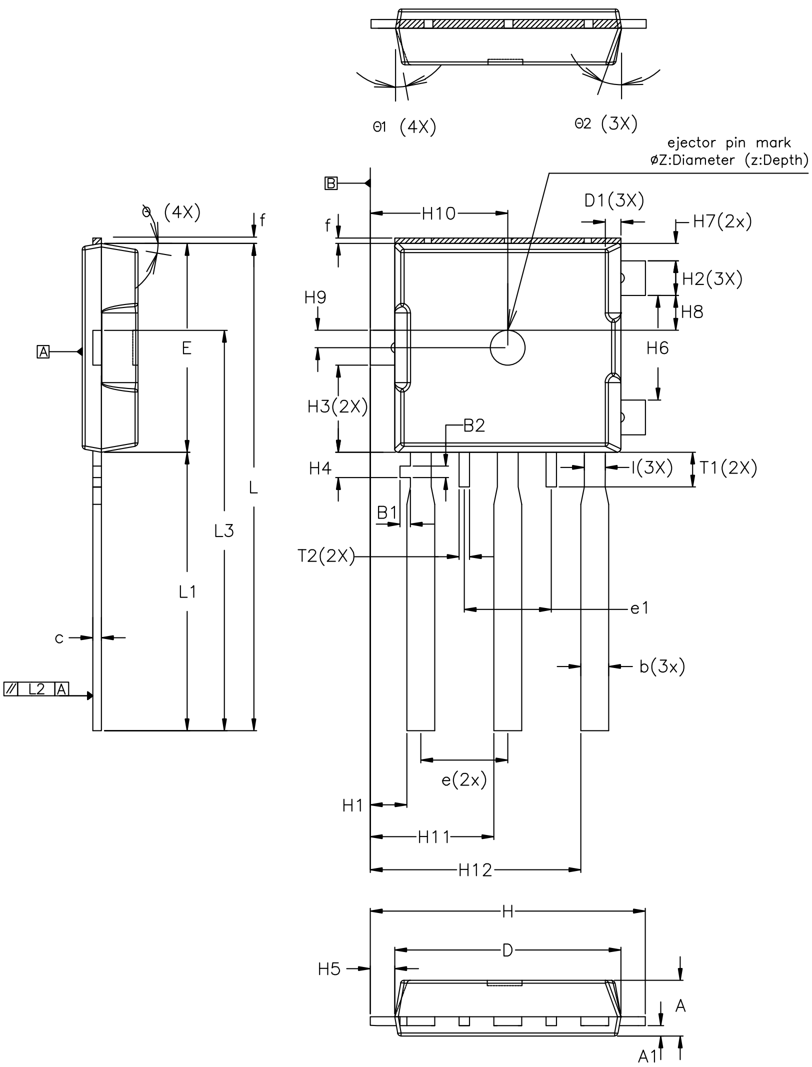


Figure 25 – SOIC-8 angle detection

The MLX90426 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.

16.2. SMP-3 – Package Information

16.2.1. 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°
øZ	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 26 – SMP-3 package outline drawing

16.2.2. SMP-3 – Marking

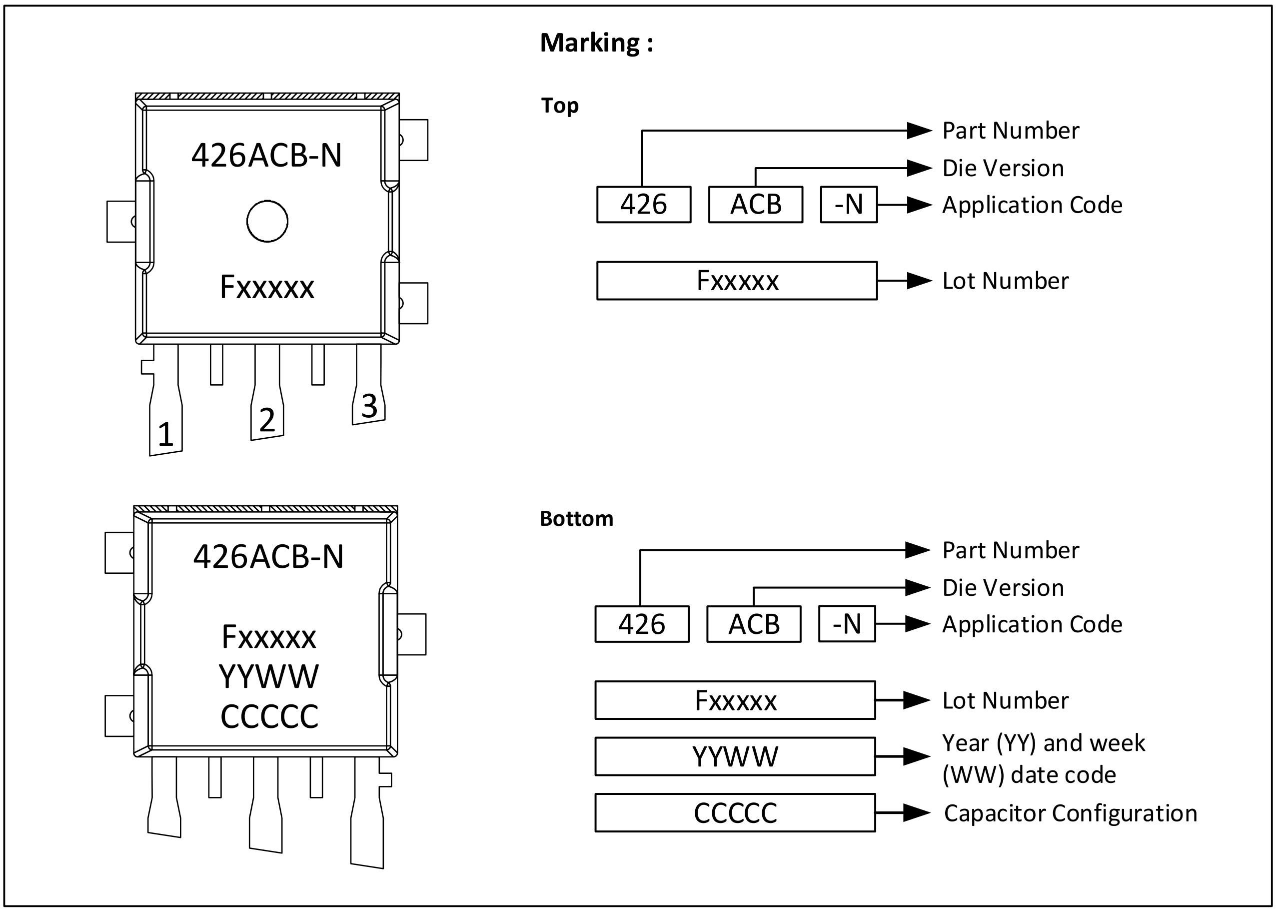


Figure 27 – SMP-3 marking

16.2.3. SMP-3 – Sensitive Spot Positioning

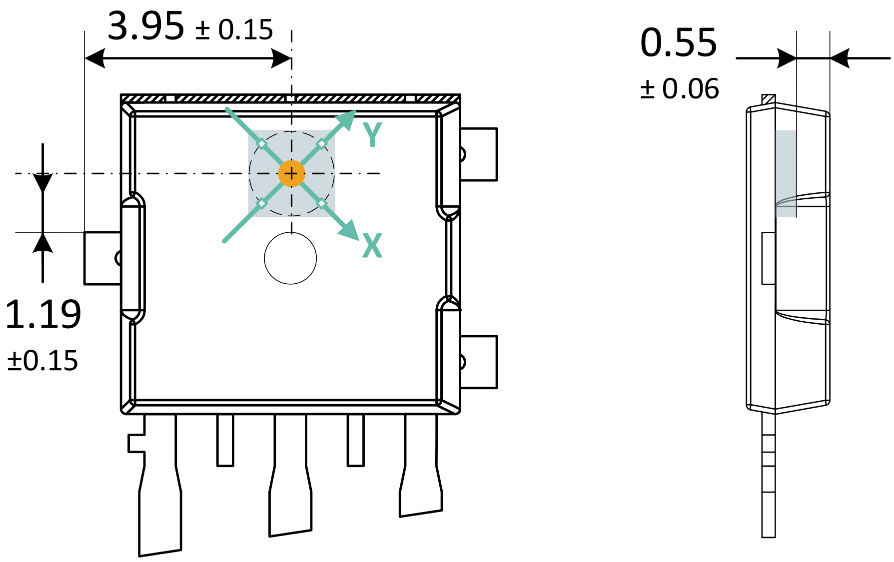


Figure 28 – SMP-3 sensitive spot position

16.2.4. SMP-3 – Angle Detection

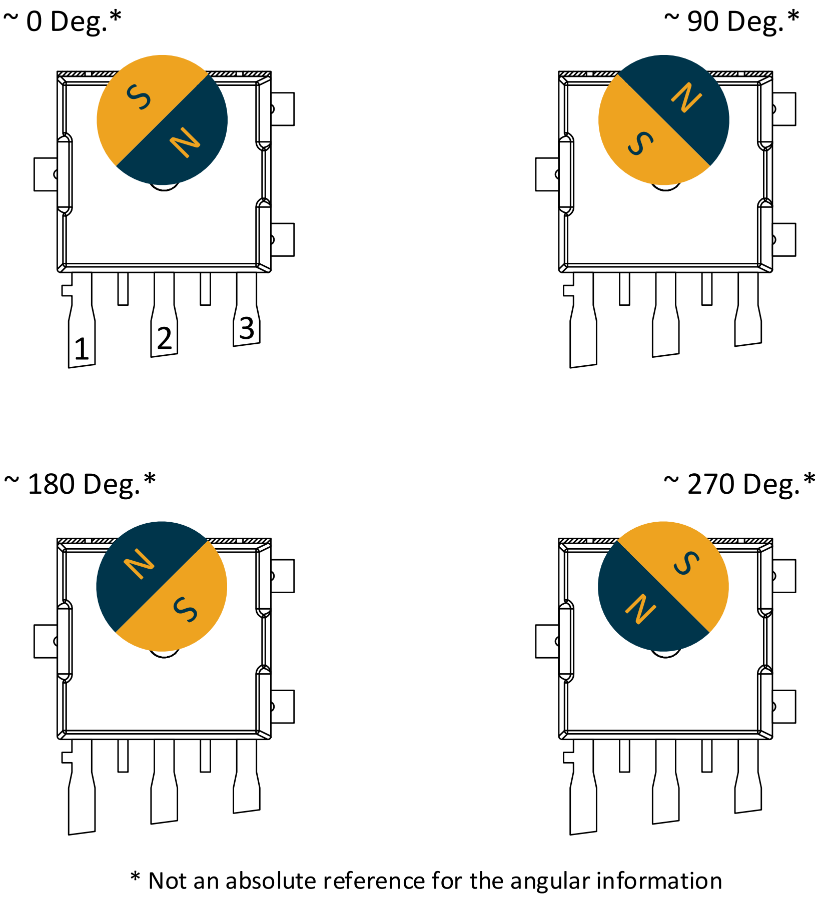
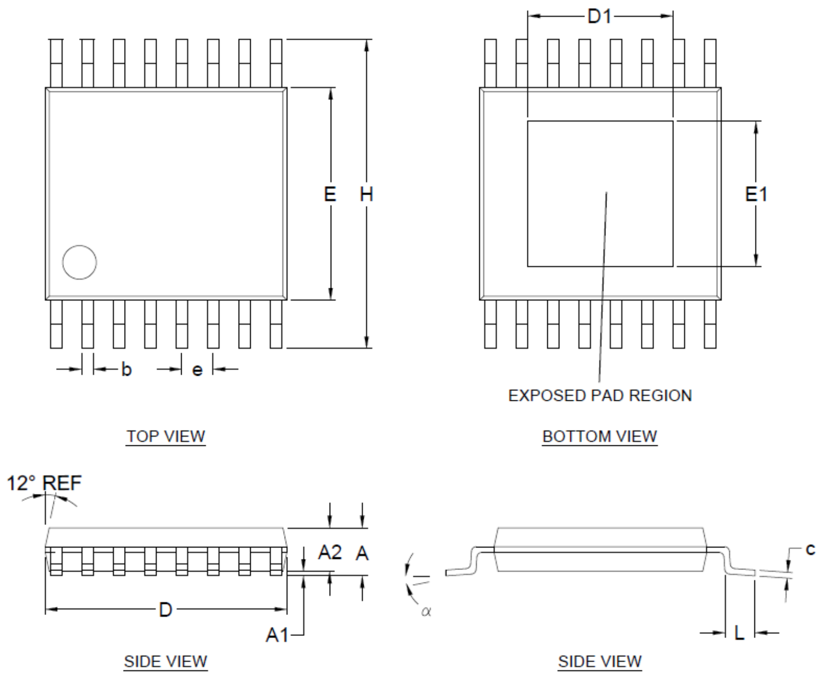


Figure 29 – SMP-3 angle detection

The MLX90426 is an absolute angular position sensor but the linearity error (See section 7.2) does not include the error linked to the absolute reference 0 Deg. This reference can be fixed in the application through the discontinuity point.

16.3. TSSOP-16_EP – Package Information

16.3.1. TSSOP-16_EP- Package Outline Dimensions (POD)



SYMBOL	MINIMUM	MAXIMUM
A	– – –	1.10
A1	0.05	0.15
A2	0.85	0.95
D	4.90	5.10
E	4.30	4.50
D1	2.90	3.10
E1	2.90	3.10
H	6.40 REF	
L	0.50	0.75
b	0.19	0.30
c	0.09	0.20
e	0.65 BSC	
α	0°	8°

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 COPLANARITY SHALL BE MAXIMUM 0.1 mm.

Figure 30 – TSSOP-16_EP Package Outline Dimensions

16.3.2. TSSOP-16_EP- Pinout and Marking

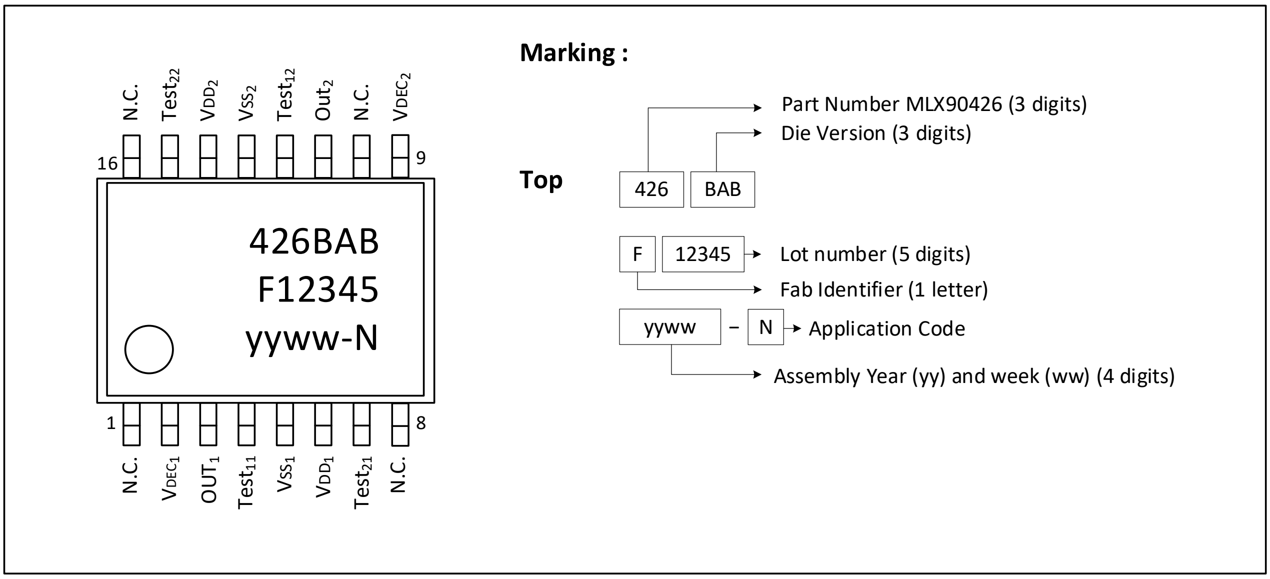


Figure 31 – TSSOP-16_EP Pinout and Marking

16.3.3. TSSOP-16_EP - Sensitive spot positioning

16.3.3.1. Rotary Stray-field Immune

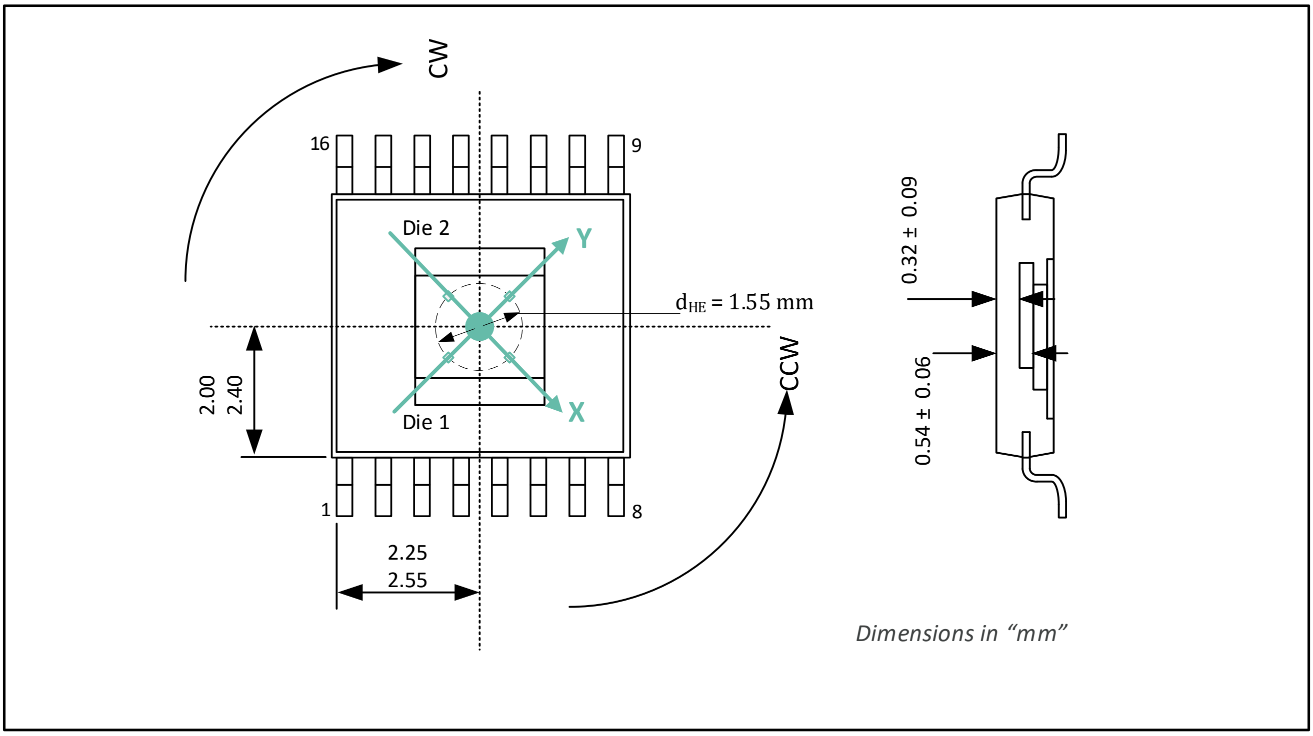


Figure 32 – TSSOP-16_EP sensitive spot for rotary Stray-Field immune mode

16.3.4. TSSOP-16_EP- Angle detection

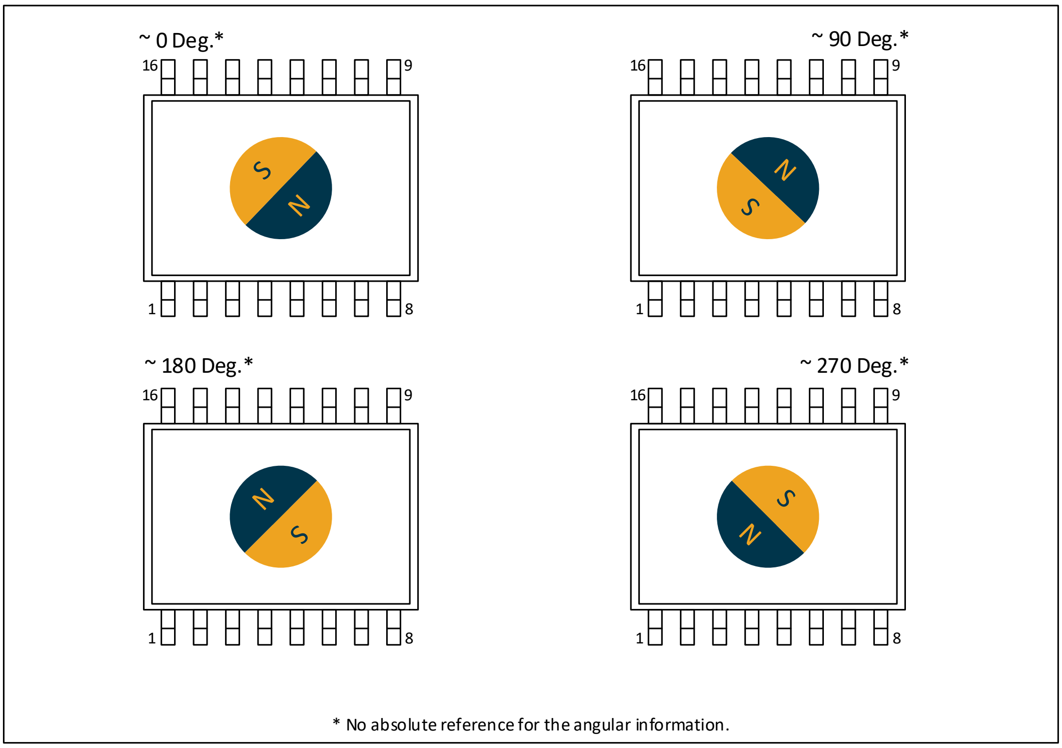
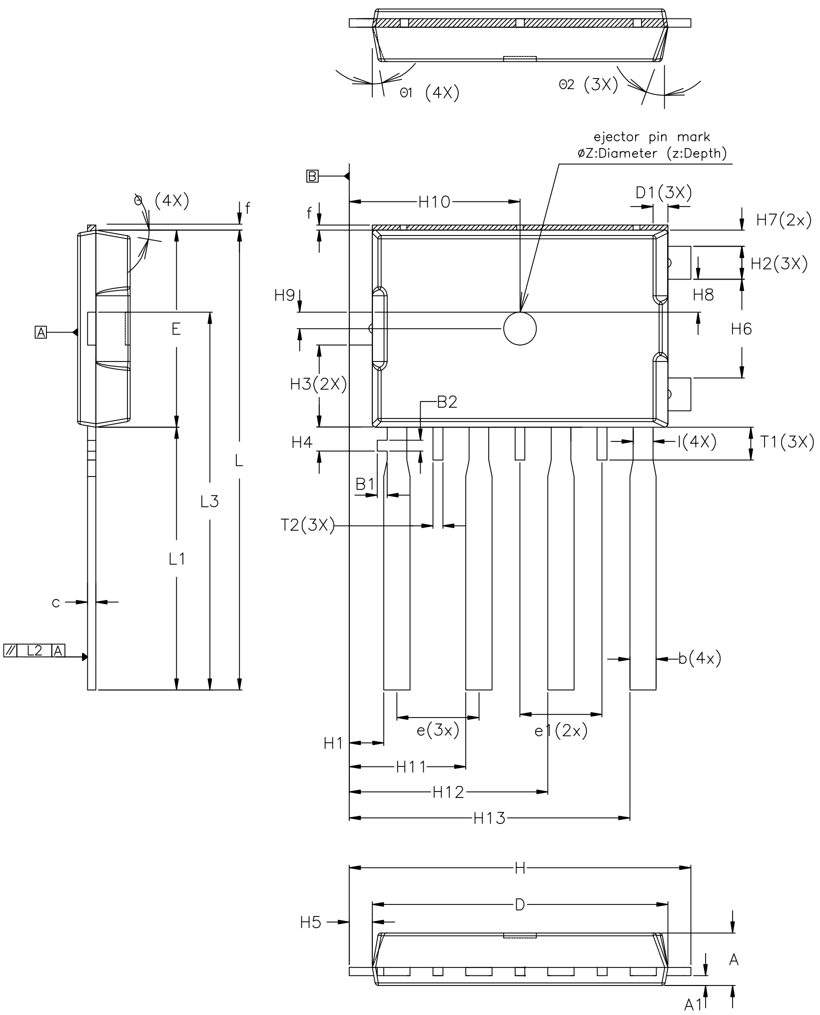


Figure 33 – TSSOP-16_EP Angle Detection

The MLX90426 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. (which can be fixed in the application through the discontinuity point).

16.4. SMP-4 Package Information

16.4.1. SMP-4- Package Outline Dimensions (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	8.920	9.000	9.080
D1		0.450 REF	
E	5.920	6.000	6.080
f	0.000	- - -	0.150
H	10.300	10.400	10.500
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	5.085	5.200	5.315
H11	3.400	3.550	3.700
H12	5.900	6.050	6.200
H13	8.400	8.550	8.700

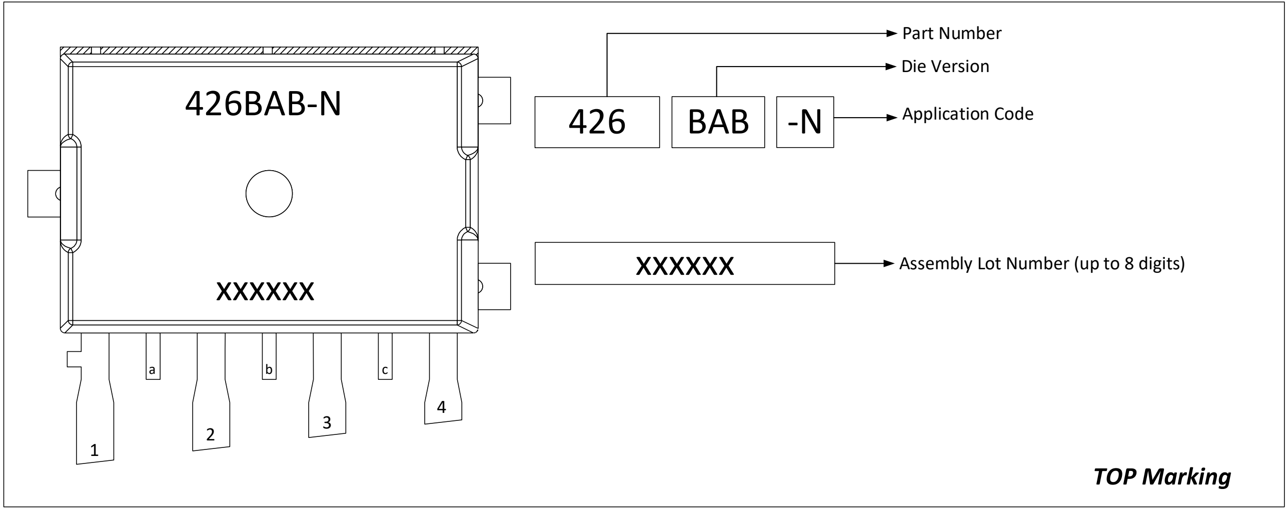
Dimension	MIN.	NOM.	MAX.
L	13.870	14.000	14.130
L1	7.870	8.000	8.130
L2	-0.250	0.000	0.250
L3	11.375	11.525	11.675
I	0.525	0.600	0.675
b	0.770	0.820	0.870
e1		2.500 BSC	
e		2.500 BSC	
Θ	8°	10°	12°
Θ1	8°	10°	12°
Θ2	18°	20°	22°
øZ	0.900	1.000	1.100
z	0.025	- - -	0.150
T1	0.870	1.000	1.130
T2	0.225	0.300	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 34 – SMP-4 Package Outline Dimensions

16.4.2. SMP-4- Pinout and Marking



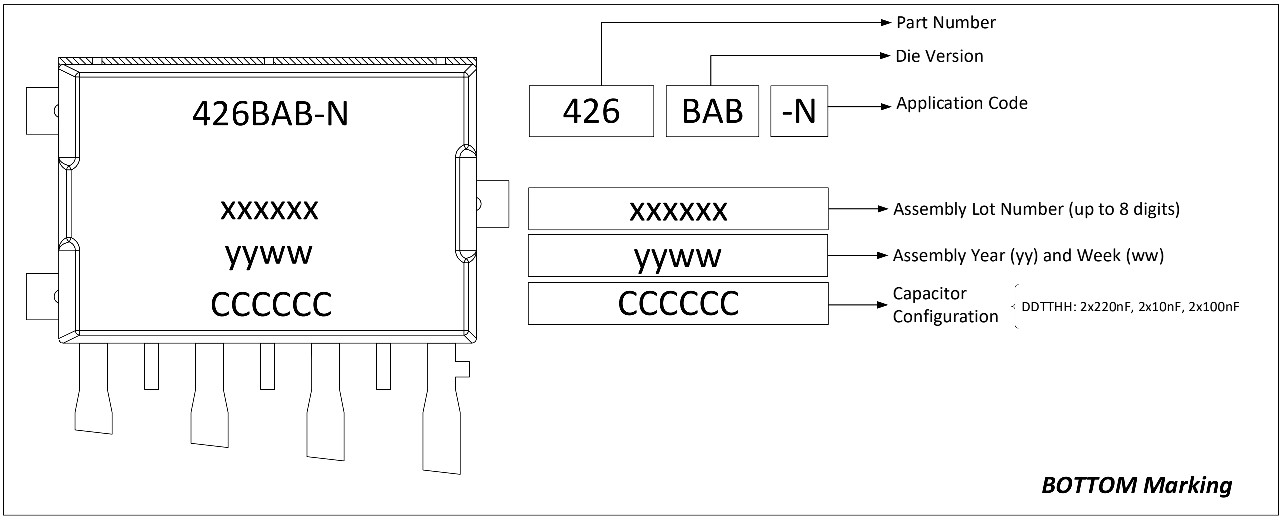


Figure 35 – SMP-4 Pinout and Marking

16.4.3. SMP-4- Sensitive spot positioning

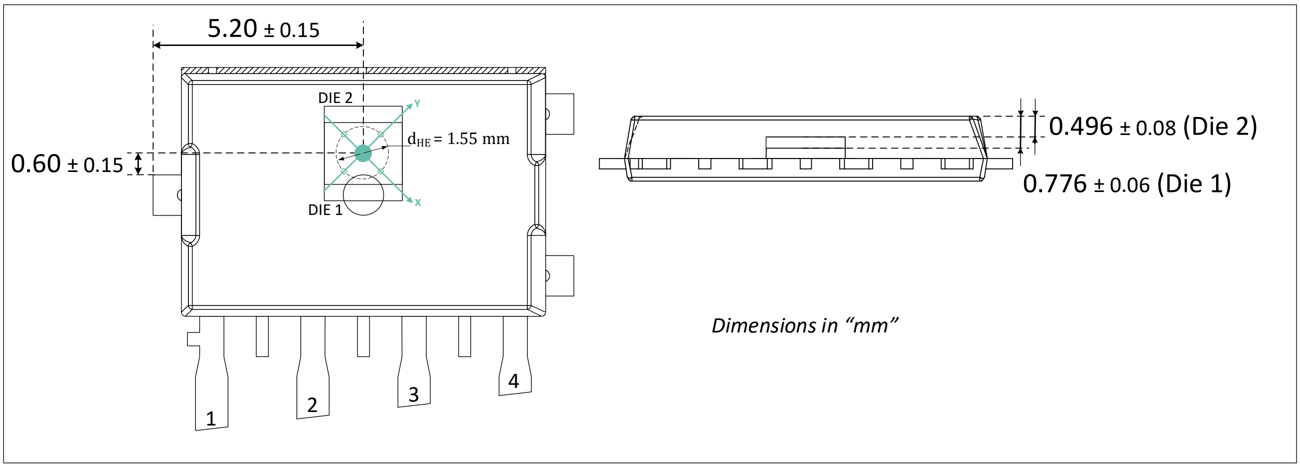


Figure 36 – SMP-4 sensitive spot for rotary Stray-Field immune mode

16.4.4. SMP-4- Angle detection

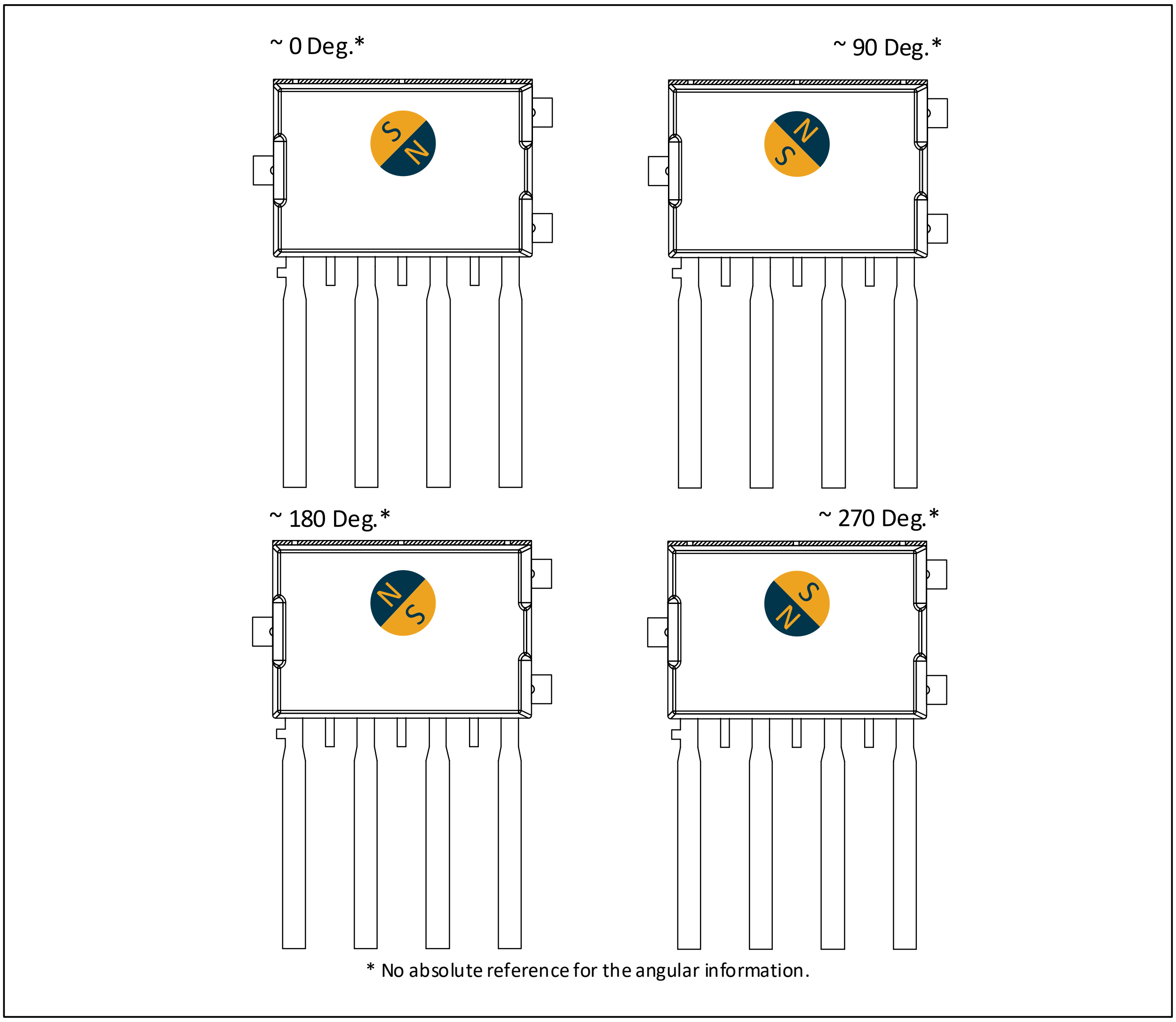


Figure 37 – SMP-4 Angle Detection

The MLX90426 is an absolute angular position sensor but the linearity error (See section 7.2) does not include the error linked to the absolute reference 0 Deg. (which can be fixed in the application through the discontinuity point).

16.5. 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 [24]
TSSOP-16_EP	26 K/W	42 K/W	150 K/W
SMP-4	26 K/W	-	145 K/W [24]

Table 57 – Standard packages thermal performances

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

17. Contact

For the latest version of this document, go to our website at www.melexis.com/MLX90426.

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

18. Disclaimer

IATF 16949 and ISO 14001 Certified