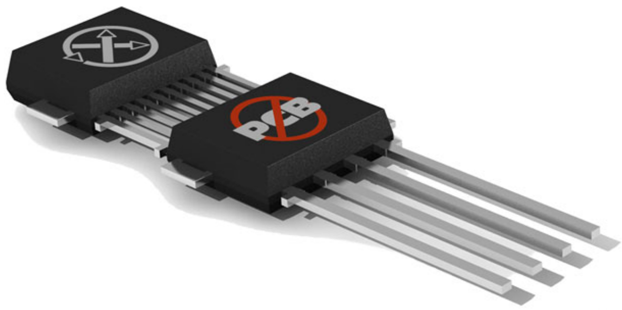
MLX90364
Triaxis® Position Sensor Assembly

Features and Benefits

Absolute Rotary & Linear Position Sensor IC
Robust Dual Mold Package (DMP) feat. 4 Decoupling Capacitors (ESD/EMC)
Reliable NoPCB Module Integration
Triaxis Hall Technology
Simple Magnetic Design
Programmable Transfer Characteristic (Multi-Points – Piece-Wise-Linear)
Selectable Output Mode: Analog (Ratiometric) – Pulse Width Modulation (PWM)
12 bit Resolution - 10 bit Thermal Accuracy
Open/Short Diagnostics
On Board Diagnostics
Over-Voltage Protection
Under-Voltage Detection
48 bit ID Number option
Automotive Temperature Range
AEC-Q100 & AEC-Q200 Qualified
DMP-4 RoHS Compliant



Applications

Absolute Rotary Position Sensor
EGR Valve Position Sensor
Throttle Position Sensor
Ride Height Position Sensor
Absolute Linear Position Sensor
Turbo Actuator
Clutch, Shift & Fork Position Sensor
Float Level Sensor

Ordering Information

Part No.	Temperature Suffix	Package Code	Die Revision	Option code
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	200-TU
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	200-RE
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	200-RX
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	201-TU
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	201-RE
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	201-RX
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	203-TU
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	203-RE
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ABB	203-RX
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	200-TU
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	200-RE
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	200-RX
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	201-TU
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	201-RE
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	201-RX
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	203-TU
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	203-RE
MLX90364	L (− 40°C to + 150°C)	VS [DMP-4]	ADB	203-RX

Convention: 200 refers to straight leads while 201 and 203 refer to trimmed-and formed-leads (see Section …)
TU refers to Tube, RE to tape-on-reel/face-up (live bug), RX to tape-on-reel/face-down (dead bug)
Example: MLX90364LVS-ADB-201-RE

1. Functional Diagram

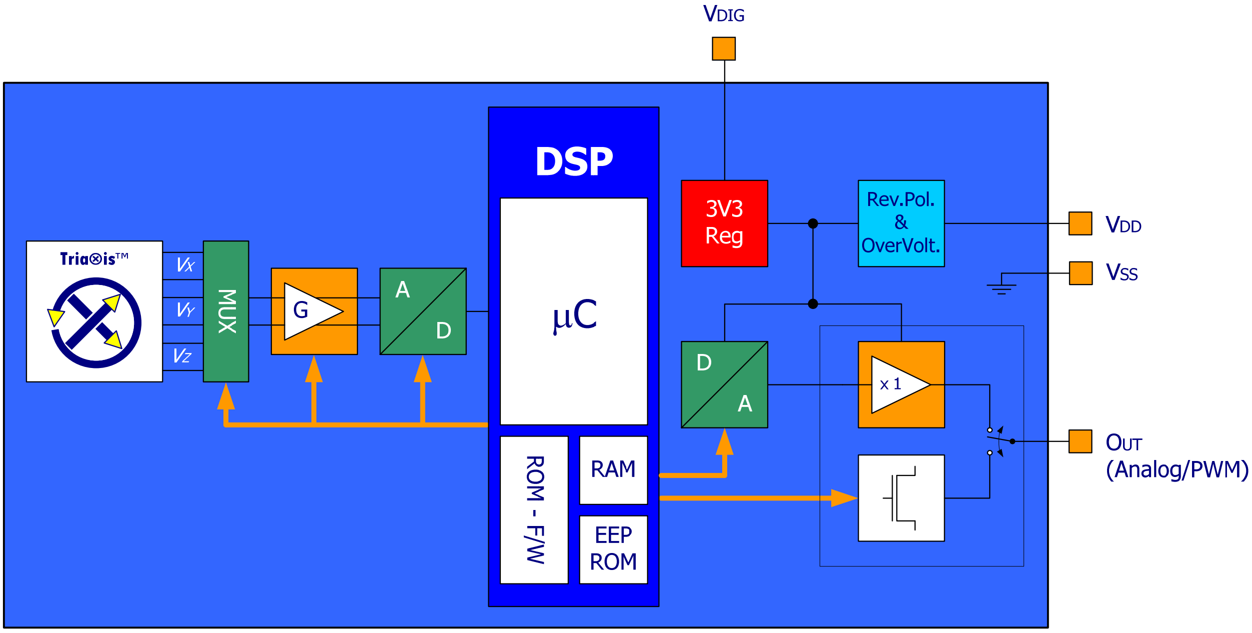


Figure 1 - MLX90364 Block Diagram

2. Description

The MLX90364 Triaxis® Position Sensor Assembly is a high accuracy linear and angular position sensor which eliminates need for inclusion of a printed circuit board (PCB) within sensing modules.

This device is based on a Dual Mold Package (DMP) construction, which integrates a Triaxis position sensing die together with the decoupling capacitors necessary to meet the strenuous ESD and EMC requirements. No PCB is needed.

The Triaxis position sensing die is nothing but the one used for the MLX90365 in conventional surface-mount packages (SOIC-8 – single die & TSSOP-16 – dual die).

The decoupling capacitors are 4 identical 100nF/X8R well suited for package integration and the target operating temperature range.

Similarly to other Triaxis products, the MLX90364 is sensitive to the flux density applied orthogonally and parallel to the IC surface i.e. the 3 components of the flux density applied to the IC (i.e. B_X, B_Y and B_Z).

This allows the MLX90364 with the correct magnetic circuit to decode the absolute position of any moving magnet (e.g. rotary position from 0 to 360 Degrees or linear displacement, stroke).

MLX90364 reports a programmable ratiometric analog output signal compatible with any resistive potentiometer or programmable linear Hall sensor. Through programming, the MLX90364 provides also a digital PWM (Pulse Width Modulation) output characteristic.

MLX90364 Triaxis® Position Sensor Assembly enables the realization of position sensor modules for which a PCB is no longer needed: this yield to an increase of the electrical, mechanical and environmental robustness of the final application.

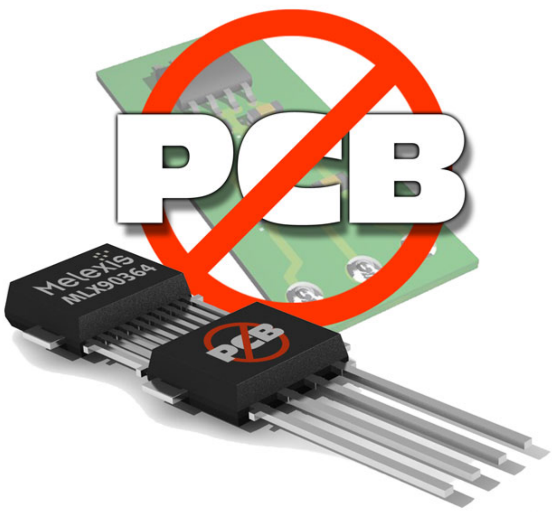


Figure 2 – NoPCB – MLX90364 makes conventional PCB redundant

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3. Glossary of Terms – Abbreviations – Acronyms

- Gauss (G), Tesla (T): Units for the magnetic flux density – 1 mT = 10 G
- TC: **T**emperature **C**oefficient (in ppm/Deg.C.)
- NC: **N**ot **C**onnected
- PWM: **P**ulse **W**idth **M**odulation
- %DC: **D**uty **C**ycle of the output signal i.e. T_{ON} /(T_{ON} + T_{OFF})
- ADC: **A**nalog-to-**D**igital **C**onverter
- DAC: **D**igital-to-**A**nalog **C**onverter
- LSB: **L**east **S**ignificant **B**it
- MSB: **M**ost **S**ignificant **B**it
- DNL: **D**ifferential **N**on-**L**inearity
- INL: **I**ntegral **N**on-**L**inearity
- RISC: **R**educed **I**nstruction **S**et **C**omputer
- ASP: **A**nalog **S**ignal **P**rocessing
- DSP: **D**igital **S**ignal **P**rocessing
- CoRDiC: **Co**ordinate **R**otation **Di**gital **C**omputer (i.e. iterative rectangular-to-polar transform)
- EMC: **E**lectro-**M**agnetic **C**ompatibility
- ALS: **A**nalog **L**ow **S**peed
- AHS: **A**nalog **H**igh **S**peed
- DLS: **D**igital **L**ow **S**peed
- DHS: **D**igital **H**igh **S**peed
- DMP: **D**ual **M**old **P**ackage

4. Pinout

Pin #	
1	VSS (Ground)
2	VDD
3	OUT
4	VSS (Ground)

5. Absolute Maximum Ratings

Parameter	Value
Supply Voltage, VDD (overvoltage)	+ 24 V
Reverse Voltage Protection	– 12 V (breakdown at -14 V)
Positive Output Voltage	+ 18 V (breakdown at 24 V)
Output Current (I_{OUT})	+ 30 mA (in breakdown)
Reverse Output Voltage	– 0.3 V
Reverse Output Current	– 50 mA (in breakdown)
Operating Ambient Temperature Range, T_A	– 40°C … + 150°C
Storage Temperature Range, T_S	– 40°C … + 150°C
Magnetic Flux Density	± 1 T

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

6. Description

As described on the block diagram the three vector components of the magnetic flux density (B_X, B_Y and B_Z) applied to the IC are sensed through the sensor front-end. The respective Hall signals (V_X, V_Y and V_Z) are generated at the Hall plates and amplified.

The analog signal processing is based on a fully differential analog chain featuring the classic offset cancellation technique (Hall plate 2-Phases spinning and chopper-stabilized amplifier).

The conditioned analog signals are converted through an ADC (15 bits) and provided to a DSP block for further processing. The DSP stage is based on a 16 bit RISC micro-controller whose primary function is the extraction of the position from two (out of three) raw signals (after so-called front-end compensation steps) through the following function:

$$\alpha = \angle(V_1, k \cdot V_2)$$

where alfa is the magnetic angle <(B1, B2), V_1 = V_X or V_Y or V_Z , V_2 = V_X or V_Y or V_Z and k is a programmable factor to match the amplitude of V_1 and k V_2.

The DSP functionality is governed by the micro-code (firmware – F/W) of the micro-controller which is stored into the ROM (mask programmable). In addition to the magnetic angle extraction, the F/W controls the whole analog chain, the output transfer characteristic, the output protocol, the programming/calibration and also the self-diagnostic modes.

The magnetic angular information is intrinsically self-compensated vs. flux density variations. This feature allows therefore an improved thermal accuracy vs position sensor based on conventional linear Hall sensors.

In addition to the improved thermal accuracy, the realized position sensor features excellent linearity performances taking into account typical manufacturing tolerances (e.g. relative placement between the Hall IC and the magnet).

Once the position (angular or linear stroke) information is computed, it is further conditioned (mapped) vs. the target transfer characteristic and it is provided at the output(s) as either a ratiometric analog output level through a 12 bit DAC followed by a buffer or a digital PWM output.

For instance, the analog output can be programmed for offset, gain and clamping to meet any rotary position sensor output transfer characteristic:

Vout(α) = ClampLo	for $\alpha \leq \alpha$min
Vout(α) = Voffset + Gain $\times$ α	for αmin $\leq \alpha \leq \alpha$max
Vout(α) = ClampHi	for $\alpha \geq \alpha$max

where Voffset, Gain, ClampLo and ClampHi are the main adjustable parameters for the end-user.

The linear part of the transfer curve can be adjusted through a multi-point calibration:

This back-end step consists into either

- up to 4 arbitrary points (5 segments + clamping levels) calibration or
- a Piece-Wise-Linear (PWL) output transfer characteristics - 17 equidistant points w/ programmable origin over 16 different angle ranges from 65 to 360 degrees.

The calibration parameters are stored in EEPROM featuring a Hamming Error Correction Coding (ECC).

The programming steps do not require any dedicated pins. The operation is done using the supply and output nodes of the IC. The programming of the MLX90364 is handled at both engineering lab and production line levels by the Melexis Programming Unit PTC-04 with the dedicated MLX90364 daughterboard and software tools (DLL – User Interface).

7. MLX90364 Electrical Specification

DC Operating Parameters at V_{DD} = 5V (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Nominal Supply Voltage	V_{DD}		4.5	5	5.5	V
Supply Current	Idd	Slow mode[1] Fast mode[1]		8.5 13.5	12 15	mA mA
POR Rising Level	POR LH	Supply Under Voltage In reference to On-chip digital voltage V_{DIG}	2.4	2.7	3	V
POR Falling Level	POR HL	Supply Under Voltage In reference to On-chip digital voltage V_{DIG}	2	2.3	2.6	V
POR Hysteresis	POR Hyst	Hysteresis on POR signal In reference to On-chip digital voltage V_{DIG}	0.3	0.4	0.6	V
ASP Start Rising Level	LT4V LH	Startup Level of ASP	3.5		4.1	V
ASP Start Falling Level	LT4V HL	Startup Level of ASP	3.4		4	V
ASP Start Hysteresis	LT4V Hyst	Startup Level of ASP	0.1		0.5	V
PTC Entry Rising Level	MT7V LH	VDD level for PTC entry	6.6		7.2	V
PTC Entry Falling Level	MT7V HL	VDD level for PTC entry	6.5		7.1	V
PTC Entry Hysteresis	MT7V Hyst	VDD level for PTC entry	0.1		0.4	V
Switch Off Rising Level	LT11V LH		8.6		14	V
Switch Off Falling Level	LT11V HL		8.5		13.9	V
Switch Off Level Hysteresis	LT11 Hyst		0.1		1	V
Output Current	Iout	Analog Output mode	-15		15	mA
Output Short Circuit Current	I_{short}	Vout = 0 V Vout = 5 V Vout = 14 V (T_A = 25°C)			15 15 18	mA mA mA
Output Load	R_L	Pull-down to Ground Pull-up to 5V	1 1	10 10	∞ ∞	kΩ kΩ
Analog Saturation Output Level	Vsat_lo	Pull-up load $R_L \geq$ 10 kΩ to 5 V Pull-up load $R_L \geq$ 1 kΩ to 5V Pull-up load $R_L \geq$ 5 kΩ to 14V		0.5 2 2	2 3 3	%V_{DD}
	Vsat_hi	Pull-down load $R_L \geq$ 5 kΩ Pull-down load $R_L \geq$ 10 kΩ	94 96	96 98		%V_{DD}
Active Diagnostic Output Level / Digital Output Saturation Level	Diag_lo	Pull-up load $R_L \geq$ 1 kΩ to 5V Pull-up load R_L = 1 kΩ to 5V Pull-up load $R_L \geq$ 5 kΩ to 14V	1	2 1.5 2	3 2 3	%V_{DD}
	Diag_hi	Pull-down load $R_L \geq$ 10kΩ Pull-down load $R_L \geq$ 5kΩ Pull-down load R_L = 5kΩ	96 94 97	98 96 97.5		%V_{DD}

[1] See section 9 for details concerning Slow and Fast mode

Passive Diagnostic Output Level (Broken Track Diagnostic) [2]	$BV_{SS}PD$	Broken V_{SS} & Pull-down load $R_L \leq 10$ kΩ (Hi-Z) Pull-down load $R_L \leq 25$ kΩ (Hi-Z)	0 0		4[2] 10	$\%V_{DD}$
	$BV_{SS}PU$	Broken V_{SS} & Pull-up load $R_L \geq 1$kΩ	99	100		$\%V_{DD}$
	$BV_{DD}PD$	Broken V_{DD} & Pull-down load $R_L \geq 1$kΩ		0	1	$\%V_{DD}$
	$BV_{DD}PU$	Broken V_{DD} & Pull-up load $R_L \leq 10$kΩ (Hi-Z)	96		100	$\%V_{DD}$
Clamped Output Level	Clamp_lo	Programmable	0		100	$\%V_{DD}$[3]
	Clamp_hi	Programmable	0		100	$\%V_{DD}$[3]
Digital output RON	RON	Diag_Low Diag_High	15 120		30 300	Ohm

As an illustration of the previous table, the MLX90364 fits the typical classification of the output span described on the Figure 4.

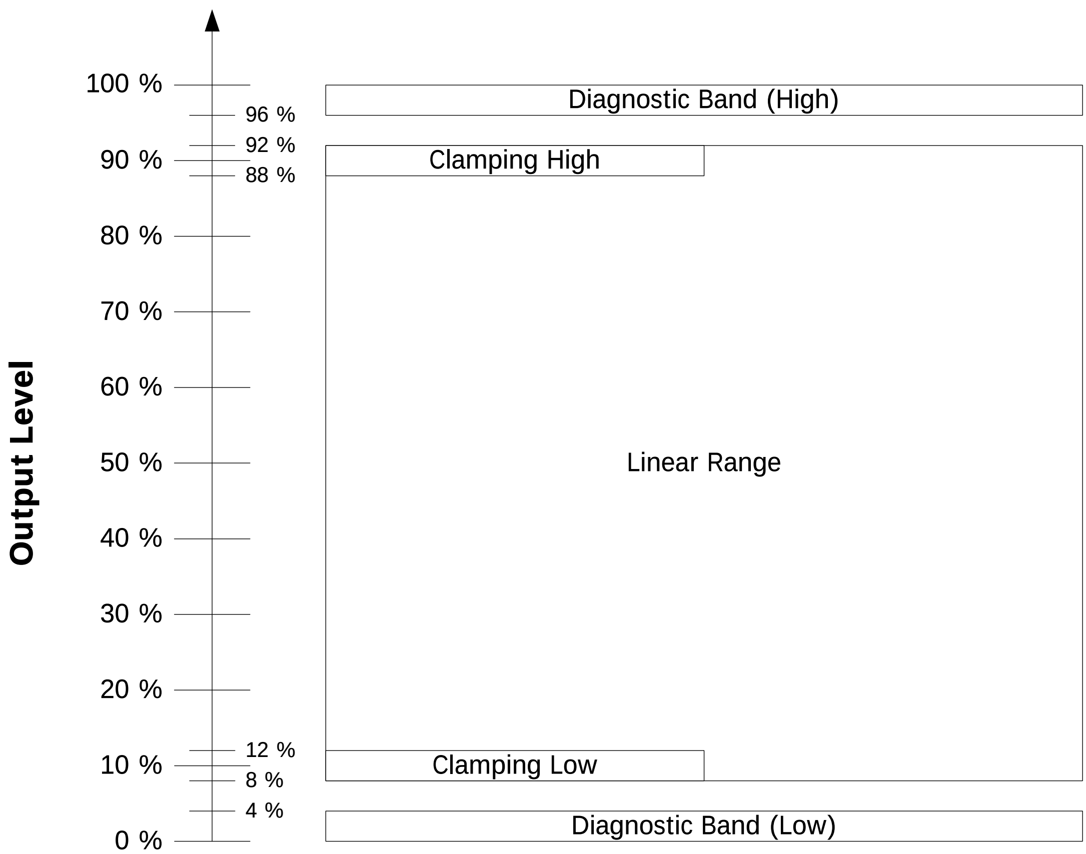


Figure 4 – Example of Output Span Classification for typical application.

2 For detailed information, see also section 16
3 Clamping levels need to be considered vs the saturation of the output stage (see Vsat_lo and Vsat_hi)

8. MLX90364 Timing Specification

DC Operating Parameters at V_{DD} = 5V (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Main Clock Frequency	Ck	Slow mode[4] Fast mode[4]	6.4 9.9	6.5 10.0	6.6 10.1	MHz MHz
Main Clock Frequency Thermal Drift	Δ^TCk				± 10%	Ck_{NOM}
Output Refresh Rate		Slow mode Fast mode		660 400		µs µs
Step Response Time	Ts	SlewRate effect excluded Slow mode[4], Filter=0[6] Slow mode[4], Filter=1[6] Slow mode[4], Filter=2[6] Fast mode[4], Filter=0[6] Fast mode[4], Filter=1[6] Fast mode[4], Filter=2[6]		 1.32 1.98 2.64 0.80 1.2 1.6	 2.18 2.9 3.63 1.32 1.76 2.2	 ms ms ms ms ms ms
Watchdog	Wd	Slow Mode (Ck = 6 MHz) See Section 16		4.58		ms
Phase Shift	PS	Slow mode[4], Filter=0[5]		0.422		Deg/Hz
Start-up Cycle	Tsu	SlewRate effect excluded Slow mode Fast mode		 12.5 7.5	 15 10	 ms ms
Analog Output Slew Rate		Mode 1 from C_{OUT} = 47 nF to 330 nF Mode 4 up to C_{OUT} = 330 nF		37 2.5		V/ms V/ms

[4] See section 13 for details concerning Slow and Fast mode activation
[5] See section 15.5 for details concerning Filter parameter

9. *MLX90364 PWM Timing Specification*

DC Operating Parameters at VDD = VPU = 5V (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Digital Output Rise Time		LOW SIDE DRIVER – Mode 5 R_L = 1 kΩ PU		80	130	µs
		PUSH-PULL – Mode 7 R_L = 1 kΩ PU		27	50	µs
Digital Output Fall Time		LOW SIDE DRIVER – Mode 5 R_L = 1 kΩ PU		27	50	µs
		PUSH-PULL – Mode 7 R_L = 1 kΩ PU		27	50	µs

10. MLX90364 Accuracy Specification

10.1. Normal Magnetic range: 20 mT ≤ B < 70 mT

DC Operating Parameters at V_{DD} = 5V (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
ADC Resolution on the raw signals sine and cosine[6]	R_{ADC}			15		bits
Thermal Offset Drift #1[7] at the DSP input (excl. DAC and output stage)		Temperature suffix E Temperature suffix K Temperature suffix L	-60 -60 -90		+60 +60 +90	LSB_{15} LSB_{15} LSB_{15}
Thermal Offset Drift #2 (DAC and Output Stage)			-0.25		+0.25	$\%V_{DD}$
Thermal Drift of Sensitivity Mismatch[8]		XY axis – Temp. suffix E XY axis – Temp.suffix K & L XZ (YZ) axis – Temp. suffix E XZ (YZ) axis – Temp. suffix K & L	- 0.3 - 0.5 -1 -1		+ 0.3 + 0.5 +1 +1	% % % %
Magnetic Angle phase error		T_A = 25°C – XY axis T_A = 25°C – XZ (YZ) axis	-0.3 -10		0.3 10	Deg. Deg.
Thermal Drift of Magnetic Angle phase error		XY axis, XZ (YZ) axis		0.01		Deg.
XY – Intrinsic Linearity Error[9]	Le	T_A = 25°C – factory trimmed "k"	-1		1	Deg
XZ (YZ) - Intrinsic Lin. Error[11]	Le	T_A = 25°C – "k" not trimmed	-20	±2.5	20	Deg
Analog Output Resolution	R_{DAC}	12b DAC (Theoretical, Noise free) INL (before EOL calibration) DNL	 -4 0.05	0.025 1	 +4 3	$\%V_{DD}/LSB_{12}$ LSB_{12} LSB_{12}
Output stage Noise		Clamped Output		0.05	0.075	$\%V_{DD}$
Noise pk-pk[10]		Slow mode, Filter=2 Fast mode, Filter=0		0.10 0.15	0.2 0.25	Deg Deg
Ratiometry Error (Analog output only)		4.5V ≤ V_{DD} ≤ 5.5V LT4V ≤ V_{DD} ≤ MT7V	-0.1 -1		+0.1 +1	$\%V_{DD}$ $\%V_{DD}$

6 16 bits corresponds to 15 bits + sign. Internal computation is performed using 16 bits.

7 For instance, in case of a rotary position sensor application, Thermal Offset Drift #1 equal ± 60LSB_{15} yields to max. ± 0.5 Deg. angular error for the computed angular information (output of the DSP). This is only valid if k = 1. "MLX90364 Front-End Application Note" will be released for more details.

8 For instance, in case of a rotary position sensor application, Thermal Drift of Sensitivity Mismatch equal ± 0.5% yields to max. ± 0.15 Deg. angular error for the computed angular information (output of the DSP). See "MLX90364 Front-End Application Note" for more details.

9 The Intrinsic Linearity Error refers to the IC itself (offset, sensitivity mismatch, orthogonality) taking into account an ideal rotating field for B_X and B_Y. Once associated to a practical magnetic construction and the associated mechanical and magnetic tolerances, the output linearity error increases. However, it can be improved with the multi-point end-user calibration. The intrinsic Linearity Error for Magnetic angle XZ and YZ can be reduced through the programming of the k factor.. See "MLX90364 Front-End Application Note" & "MLX90364 Back-End Application Note" for more details.

10 Noise pk-pk (peak-to-peak) is here intended as 6 times the Noise standard Deviation. The application diagram used is described in the recommended wiring. For detailed information, refer to section Filter in application mode (Section 15.5).

10.2. Extended Range #1 : 15 mT ≤ B < 20 mT

DC Operating Parameters at V_{DD} = 5V (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
ADC Resolution on the raw signals sine and cosine	R_{ADC}		-120		+120	bits
Thermal Offset Drift #1 at the DSP input (excl. DAC and output stage)		Temperature suffix K Temperature suffix L	-120 -180		+120 +180	LSB_{15} LSB_{15}
Noise pk-pk		Slow mode, Filter=2 Fast mode, Filter=0			60 75	LSB_{15} LSB_{15}

10.3. Extended Range #2: 10 mT ≤ B < 15 mT

DC Operating Parameters at V_{DD} = 5V (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
ADC Resolution on the raw signals sine and cosine	R_{ADC}		-180		+180	bits
Thermal Offset Drift #1 at the DSP input (excl. DAC and output stage)		Temperature suffix K Temperature suffix L	-180 -270		+180 +270	LSB_{15} LSB_{15}
Noise pk-pk		Slow mode, Filter=2 Fast mode, Filter=0			90 112	LSB_{15} LSB_{15}

11. MLX90364 PWM Accuracy Specification

DC Operating Parameters at V_{DD} = 5V +/- 10 % (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
PWM Output Resolution	R_{PWM}	12 bits		0.025		%DC/LSB
PWM % DC Jitter[11]	J_{DC}	LOW SIDE DRIVER – Mode5 200Hz, RL = 1 kΩ PU 1000Hz, R_L = 1 kΩ PU PUSH-PULL – Mode7 200Hz, RL = 1 kΩ PU 1000Hz, R_L = 1 kΩ PU		 0.015 0.03 0.015 0.03	 0.075 0.09 0.075 0.09	%DC
PWM Freq Jitter[12]	J_{PWM}	LOW SIDE DRIVER – Mode5 100-1000 Hz, R_L = 1 kΩ PU PUSH-PULL – Mode7 100-1000 Hz, R_L = 1 kΩ PU		 0.05 0.05	 0.2 0.2	Hz
PWM % DC thermal drift		LOW SIDE DRIVER – Mode5 100Hz, R_L = 1 kΩ PU 200Hz, RL = 1 kΩ PU 1000Hz, R_L = 1 kΩ PU PUSH-PULL – Mode7 100Hz, R_L = 1 kΩ PU 200Hz, RL = 1 kΩ PU 1000Hz, R_L = 1 kΩ PU		 0.02 0.02 0.02 0.02 0.02 0.02	 0.03 0.03 0.05 0.03 0.03 0.05	%DC

Parameter	Symbol	Test Conditions
PWM TON, Tperiod	T_{ON} T_{PWM}	Trigger level = 50 % VPush-pull
Rise time Fall time		10% and 90% of amplitude
Jitter	J on J period	± 3 σ for 1000 successive acquisitions
Duty Cycle	% DC	T_{on} / T_{Period}

[11] Jitter is defined by ± 3 σ for 1000 successive acquisitions with clamped output.
[12] Jitter is defined by ± 3 σ for 1000 successive acquisitions with clamped output.

12. MLX90364 Magnetic Specification

DC Operating Parameters at VDD = 5V (unless otherwise specified) and for TA as specified by the Temperature suffix (E or K or L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Magnetic Flux Density	B_X, B_Y[13]		20	50	70[14]	mT
Magnetic Flux Density	B_Z[14]		24	50	130	mT
Magnetic Field Norm	Norm	$\sqrt{[B_X^2 + B_Y^2 + (Bz/GainIMC)^2]}$	20	50	70	mT
IMC Gain[15]	GainIMC		1.2	1.5	1.8	
Magnet Temperature Coefficient	TCm		-2400		0	ppm/°C

13. MLX90364 CPU & Memory Specification

The DSP is based on a 16 bit RISC µController. This CPU provides 2.5 Mips while running at 10 MHz.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
ROM				7		kB
RAM				256		B
EEPROM				128		B

[13] The condition must be fulfilled for at least one field BX, BY or BZ.
[14] Above 70 mT, the IMC starts saturating yielding to an increase of the linearity error. Below 20 mT, the performances slightly degrade due to a reduction of the signal-to-noise ratio, signal-to-offset ratio… See Sections 10.2 and 10.3.
[15] This is the magnetic gain linked to the Integrated Magneto Concentrator structure. It applies to BX and BY and not to BZ. This is the overall variation. Within one lot, the part to part variation is typically ± 10% versus the average value of the IMC gain of that lot.

14. MLX90364 End-User Programmable Items

Parameter	Comments	Default Values Standard	# bit
Output mode	Define the output stage mode	4	3
DIAG	Diagnostic mode (Low/Hi)	0	1
ADIAG	Analog diagnostic option (Low/Hiz or HiZ/Hi)	0	1
HS	High speed mode (6MHz or 10MHz)	0	1
MAPXYZ	Mapping fields for output angle	MLX	3
CLAMP_HIGH	Clamping High (50%)	50%	16
CLAMP_LOW	Clamping Low (50%)	50%	16
FILTERFIRST	Filtering before linear correction	1h	1
FILTER	Filter mode selection	0h	2
k (SMISM)	Sensitivity mismatch factor	MLX	16
GAINMIN	Low threshold for virtual gain	00h	8
GAINMAX	High threshold for virtual gain	29h	8
PWMPOL	PWM polarity	0	1
PWMLATCH	PWM register latched on PWM edge	1	1
PWMT	PWM Frequency	1B58h	16
DP	Discontinuity point	0000h	15
CCW	Counter Clock Wise	0h	1
FHYST	Hysteresis filter	0h	8
MELEXISID1	Melexis identification reference	MLX	16
MELEXISID2	Melexis identification reference	MLX	16
MELEXISID3	Melexis identification reference	MLX	16
CUSTOMERID4	Customer identification reference	0h	16
3POINTS	Selection of correction method 3 or 16 pts	1h	1
LNR_S0	3pts – Initial Slope	0h	16
LNR_A_X	3pts – AX Coordinate	7FFFh	16
LNR_A_Y	3pts – AY Coordinate	0	16
LNR_A_S	3pts – AS Coordinate	0	16
LNR_B_X	3pts – BX Coordinate	FFFFh	16
LNR_B_Y	3pts – BY Coordinate	0	16
LNR_B_S	3pts – BS Coordinate	0	16
LNR_C_X	3pts – CX Coordinate	FFFFh	16
LNR_C_Y	3pts – CY Coordinate	FFFFh	16
LNR_C_S	3pts – CS Coordinate	0	16
LNR_D_X	3pts – DX Coordinate	FFFFh	16
LNR_D_Y	3pts – DY Coordinate	FFFFh	16
LNR_D_S	3pts – DS Coordinate	0	16
W	16pts – Output angle range	0h	4
LNR_Y0/ CUSTOMERID1	16pts – Y-coordinate point 0 / Cust. id reference	N/A	16
LNR_Y1/ CUSTOMERID2	16pts – Y-coordinate point 1 / Cust. id reference	N/A	16
LNR_Y2/ CUSTOMERID3	16pts – Y-coordinate point 2/ Cust. id reference	N/A	16
LNR_Yn	16pts – Y-coordinate point n	N/A	16
LNR_Y16	16pts – Y-coordinate point 16	N/A	16
HAMHOLE	Hamming code recovery	3131h	16
LOCK	Lock byte	00h	8

15. Description of End-User Programmable Items

15.1. Output Mode

The MLX90364 output type is defined by the Output Mode parameter.

Parameter	Value	Description
Analog Output Mode	1 4	Analog Rail-to-Rail for $Cout_{min}$ = 47nF Analog Rail-to-Rail for $Cout_{max}$ = 330nF
PWM Output Mode	5 6 7	Low Side (NMOS) High Side (PMOS) Push-Pull

15.1.1. Analog Output Mode

The Analog Output Mode is a rail-to-rail and ratiometric output with a push-pull output stage configuration allows the use of a pull-up or pull-down resistor.
With respect to the application diagram described in section 15, Melexis recommendation is Analog Out Mode 4. Mode 1 is also compliant with this diagram.

15.1.2. PWM Output Mode

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

The PWM polarity is selected by the PWMPOL1 parameter:

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

The PWM frequency is selected by the PWMT parameter. The following table provides typical code for different target PWM frequency and for both low and high speed modes.

PWM Frequency Code (PWMT)				
Oscillator Mode	Pulse-Width Modulation Frequency (Hz)			
	100	200	500	1000
Low Speed (Ck_{NOM} = 6.5 MHz)	32500	16250	6500	3250
High Speed (Ck_{NOM} = 10 MHz)	50000	25000	10000	5000

The PWM Latch freezes the output value at the beginning of the PWM period. If not enabled the PWM output might be updated before the PMW period is finished, resulting in a inconsistent duty cycle.

Notes:

- A more accurate trimming can be performed to take into account initial tolerance of the main clock.
- The PWM frequency is subjected to the same tolerances as the main clock (see $\Delta^{T}Ck$).

15.2. Output Transfer Characteristic

There are 2 different possibilities to define the transfer function (LNR):

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

Parameter	LNR type	Value	Unit
COUNTERCLOCKWISE	**Both**	**0 → CounterClockWise** **1 → ClockWise**	**LSB**
DP	Both	0 … 359.9999	deg
LNR_A_X LNR_B_X LNR_C_X LNR_D_X	Only 4 pts	0 … 359.9999	deg
LNR_A_Y LNR_B_Y LNR_C_Y LNR_D_Y	Only 4 pts	0 … 100	%
LNR_S0 LNR_A_S LNR_B_S	Only 4 pts	0 … 17	%/deg
LNR_C_S LNR_D_S	Only 4 pts	-17 … 0 … 17	%/deg
LNR_Y0 LNR_Y1 … LNR_Y16	Only 16 pts	-50 … + 150	%
W	Only 16 pts	65.5 … 360	Deg
CLAMP_LOW	Both	0 … 100	%
CLAMP_HIGH	Both	0 … 100	%

15.2.1. Enable scaling Parameter (only for LNR type 4 pts)

This parameter enables to scale LNR_x_Y from -50% - 150% according to the following formula

$$(\text{Scaled Out})\%V_{DD} = 2 \times \text{Out}\%V_{DD} - 50\%$$

15.2.2. CLOCKWISE Parameter

The CLOCKWISE parameter defines the magnet rotation direction.

- CCW is defined by the 1-2-3-4 pin order direction for the Dual Mold Package.
- CW is defined by the reverse direction: 4-3-2-1 pin order direction for the Dual Mold Package.

Refer to the drawing in the sensitive spot positioning sections (Section 20.5)

15.2.3. 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.

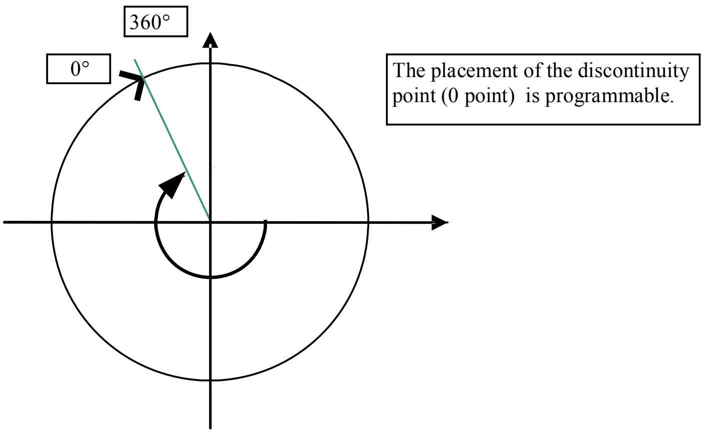


Figure 5 - Discontinuity Point Positioning

15.2.4. 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 MLX90364 transfer function from the digital angle value to the output voltage is described by the drawing below. Six 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.

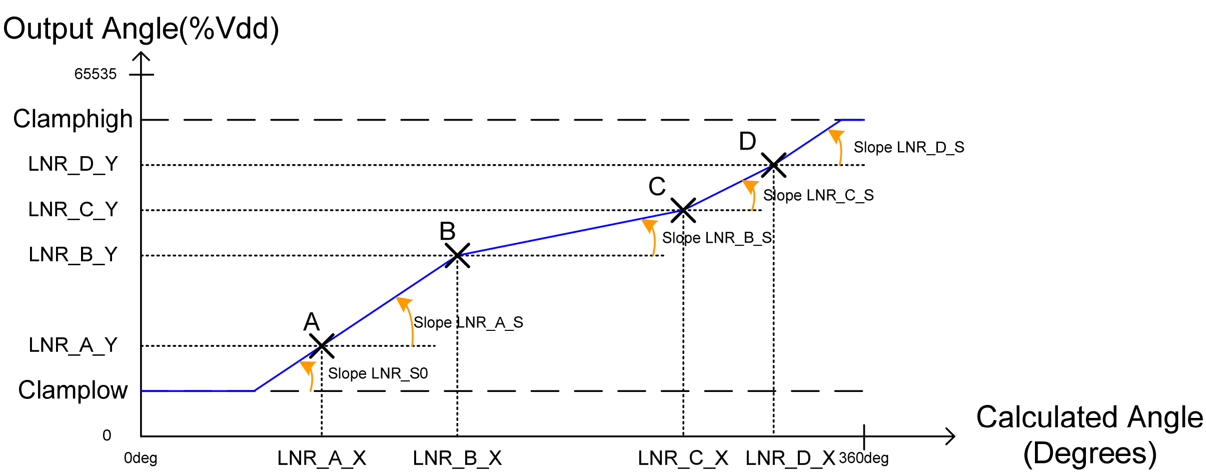


Figure 6

15.2.5. 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 MLX90364 transfer function from the digital angle value to the output voltage is described by the drawing below. In the 16-Pts mode, the output transfer characteristic is Piece-Wise-Linear (PWL).

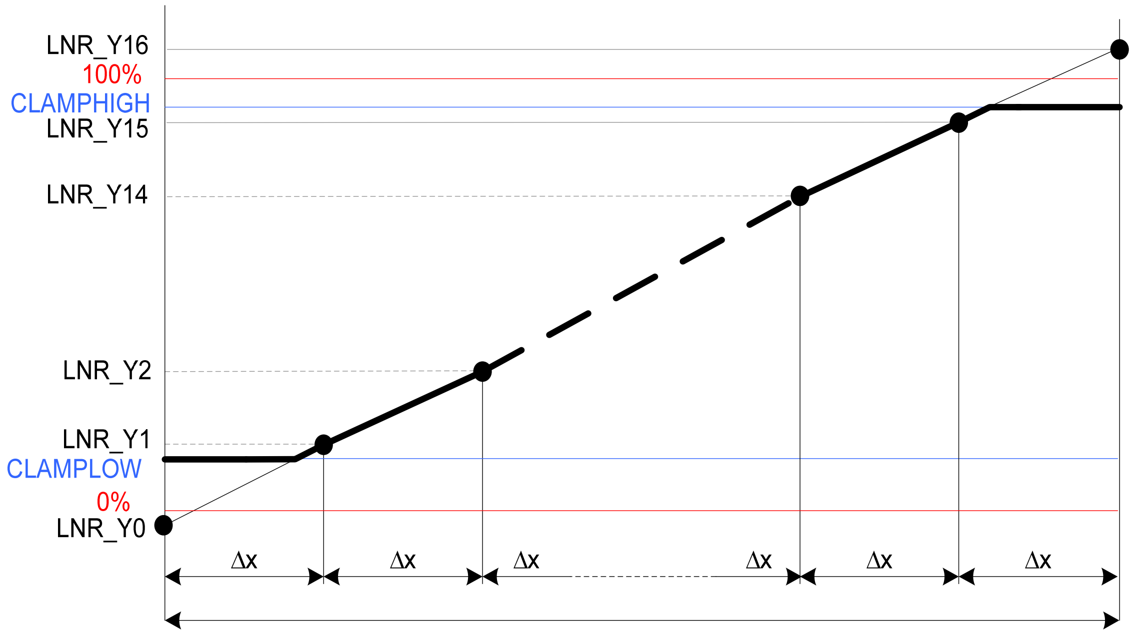


Figure 7 - Input range from 65.5° up to 360°

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.

The parameter W determines the input range on which the 17 points (16 segments) are uniformly spread:

W	Range	Δx
0 (0000b)	360.0deg	22.5deg
1	320.0deg	20.0deg
2	288.0deg	18.0deg
3	261.8deg	16.4deg
4	240.0deg	15.0deg
5	221.5deg	13.8deg
6	205.7deg	12.9deg
7	192.0deg	12.0deg
8	180.0deg	11.3deg
9	144.0deg	9.0deg
10	120.0deg	7.5deg
11	102.9deg	6.4deg
12	90.0deg	5.6deg
13	80.0deg	5.0deg
14	72.0deg	4.5deg
15 (1111b)	65.5deg	4.1deg

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

15.2.6. CLAMPING Parameters

The clamping levels are two independent values to limit the output voltage range. The CLAMPLOW parameter adjusts the minimum output voltage level. The CLAMPHIGH parameter sets the maximum output voltage level. Both parameters have 16 bits of adjustment and are available for both LNR modes. In analog mode, the resolution will be limited by the D/A converter (12 bits) to 0.024%VDD. In PWM mode, the resolution will be 0.024%DC.

15.3. Identification

Parameter	Value
MELEXISID1 MELEXISID2 MELEXISID3	0 … 65535 0 … 65535 0 … 65535
CUSTOMERID1 CUSTOMERID2 CUSTOMERID3 CUSTOMERID4	0 … 65535 0 … 65535 0 … 65535 0 … 65535

Identification number: 64 bits (4 words) freely useable by Customer for traceability purpose.

Those 64 bits are only available if the 3pts-LNR. For the 16-Pts LNR, the corresponding EEPROM area of CUSTOMERID1,2,3 are used by the LNR function.

15.4. Sensor Front-End

Parameter	Value
HS	0 = Slow mode 1 = Fast mode
MAPXYZ	0 .. 5
k (or SMISM)	0 .. 65535
GAINMIN GAINMAX	0 … 41

15.4.1. HIGHSPEED Parameter

The HIGHSPEED parameter defines the main frequency for the DSP.

- HIGHSPEED = 0 selects the Slow mode with a 6.5 MHz master clock (nominal).
- HIGHSPEED = 1 selects the Fast mode with a 10.0 MHz master clock (nominal).

For better noise performance, the Slow Mode must be enabled.

15.4.2. MAPXYZ

The MAPXYZ parameter defines which fields are used to calculate the angle. The different possibilities are described in the tables below.

MAPXYZ	Angle definition
0	$\angle XY = \angle\left(k \cdot B_X , B_Y\right)$
1	$\angle YX = \angle\left(B_X , k \cdot B_Y\right)$
2	$\angle XZ = \angle\left(k \cdot B_X , B_Z\right)$
3	$\angle ZX = \angle\left(B_Z , k \cdot B_Z\right)$
4	$\angle YZ = \angle\left(k \cdot B_Y , B_Z\right)$
5	$\angle ZY = \angle\left(B_Y , k \cdot B_Z\right)$

15.4.3. k parameter

The k parameter defines the sensitivity mismatch between the 2 selected axis used for the angular calculation. Its value is defined through an unsigned 16 bits value from 0.0 to 1.0. Typical values are between 0.5 and 1.

The MAPXYZ is defined in factory to be 0 or 1. For an end-user XY-application, don't overwrite this parameter.

15.4.4. GAINMIN and GAINMAX Parameters

GAINMIN and GAINMAX define the boundaries within the virtual gain setting is allowed to vary. Outside this range, the output is set in diagnostic mode.

15.5. Filter

Parameter	Value
FILTER	0 … 2
FHYST	0 … 31
FILTERFIRST	0 or 1

The MLX90364 includes 2 types of filters:

- Hysteresis Filter: programmable by the FHYST parameter
- Low Pass FIR Filters controlled with the FILTER parameter

Note: if the parameter FILTERFIRST is set to "1", the filtering is active on the digital angle (prior to the output mapping). If set to "0", the filtering is active on the output transfer function (after the output mapping).

Melexis recommends to program FILTERFIRST to 1 in order to be compliant with any Linear compensation on the Output.

15.5.1. Hysteresis Filter

The FHYST parameter is a hysteresis filter. The output value of the IC is not updated when the digital step is smaller than the programmed FHYST parameter value. The output value is modified when the increment is bigger than the hysteresis. The hysteresis filter reduces therefore the resolution to a level compatible with the internal noise of the IC. The hysteresis must be programmed to a value close to the noise level.

15.5.2. FIR Filters

The MLX90364 features 2 FIR filter modes controlled with Filter = 1…2. Filter = 0 corresponds to no filtering. The transfer function is described below:

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

The filters characteristics is given in the following table:

Filter No (j)	0	1	2
Type	Disable	Finite Impulse Response	
Coefficients a_i	1	11	1111
Title	No filter	ExtraLight	Light
99% Response Time	1	2	4
Efficiency RMS (dB)	0	3.0	6.0

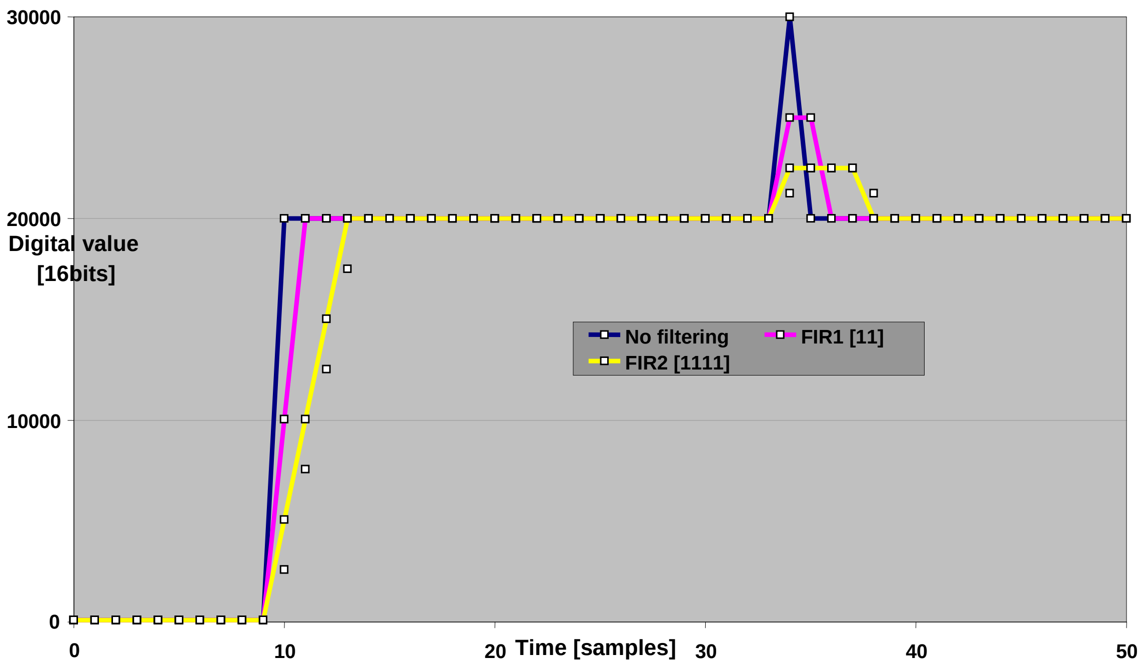


Figure 8 - Step and impulse response of the different filters

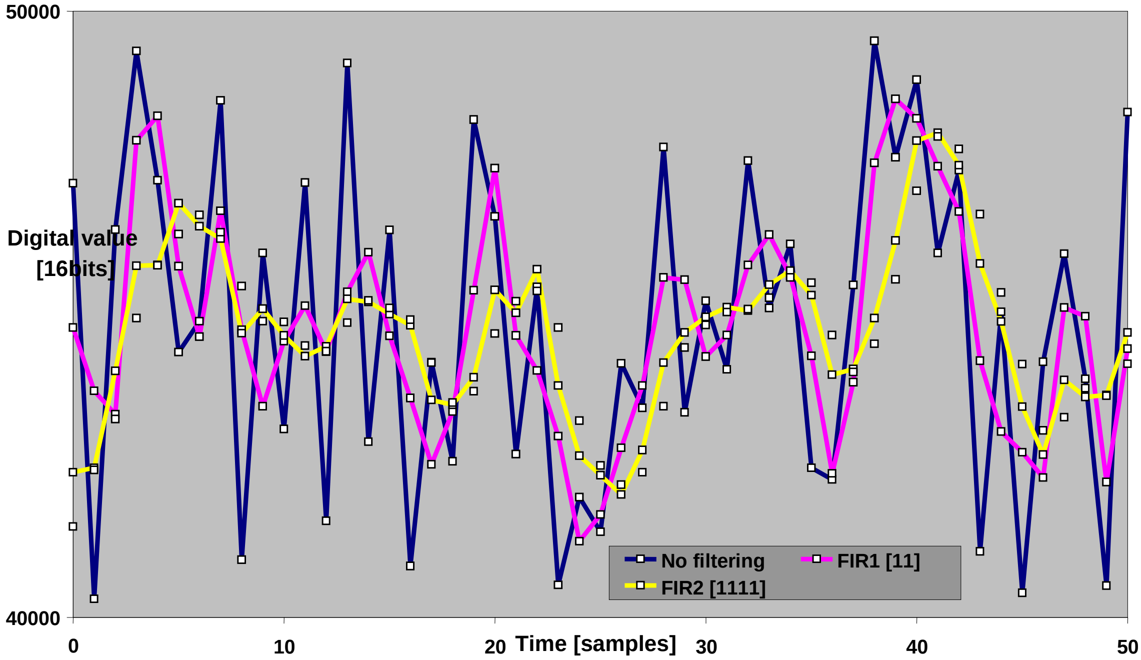


Figure 9 - Noise response of the different filter

15.6. Programmable Diagnostic Settings

Parameter	Value	Unit
DIAG	0 or 1	
ADIAG	0 or 1	
HAMHOLE	0 or 3131h	

15.6.1. DIAG and ADIAG parameters

When analog mode is selected, DIAG and ADIAG allow selecting all diagnostic modes:

Mode	Type	Description
With pull-up ADIAG = 0	DIAG = 0 DIAG = 1	Diagnostic Low Diagnostic Hi (HiZ + pull-up)
With pull-down ADIAG = 1	DIAG = 0 DIAG = 1	Diagnostic Low (HiZ + pull-down) Diagnostic Hi

For digital mode, only DIAG is used:

Digital mode	Type	Description
5 – Open drain NMOS	DIAG = 0 DIAG = 1	Diagnostic Low Diagnostic Hi (HiZ + pull-up)
6 – Open drain PMOS	DIAG = 0 DIAG = 1	Diagnostic Low (HiZ + pull-down) Diagnostic Hi
7 – Push-pull output	DIAG = 0 DIAG = 1	Diagnostic Low Diagnostic Hi

15.6.2. PWM Diagnostic

PWMDiagMode Table:

PWMDIAGMode						
3	2	1:0	Diagnostic Type	Diagnostic Level		
EN	Type	Level[1:0]				
0	x	x	Level Diag. Analog		0 or 100% depending on DIAG (OSMOD)	
				WeakMagnet	LostMagnet	Failure
				GAINmax < GAIN	41 < GAIN	Diagnostic
	0	00	Low	0.5 x ClampLow	0.5 x ClampLow	0.25 x ClampLow
	0	01	Low	0.5 x ClampLow	0.25 x ClampLow	0.25 x ClampLow
	0	10	Low	0.25 x ClampLow	0.25 x ClampLow	0.25 x ClampLow
1	0	11	Low	0.5 x ClampLow	0.5 x ClampLow	static low
	1	00	High	100% - 0.5 x (100% - ClampHigh)	100% - 0.5 x (100% - ClampHigh)	100% - 0.25 x (100% - ClampHigh)
	1	01	High	100% - 0.5 x (100% - ClampHigh)	100% - 0.25 x (100% - ClampHigh)	100% - 0.25 x (100% - ClampHigh)
	1	10	High	100% - 0.25 x (100% - ClampHigh)	100% - 0.25 x (100% - ClampHigh)	100% - 0.25 x (100% - ClampHigh)
	1	11	High	100% - 0.5 x (100% - ClampHigh)	100% - 0.5 x (100% - ClampHigh)	static high

The PWM diagnostics are not compatible with the ResetOnFault parameter. To enable the PWM diagnostics the ResetOnFault should be set to 0.

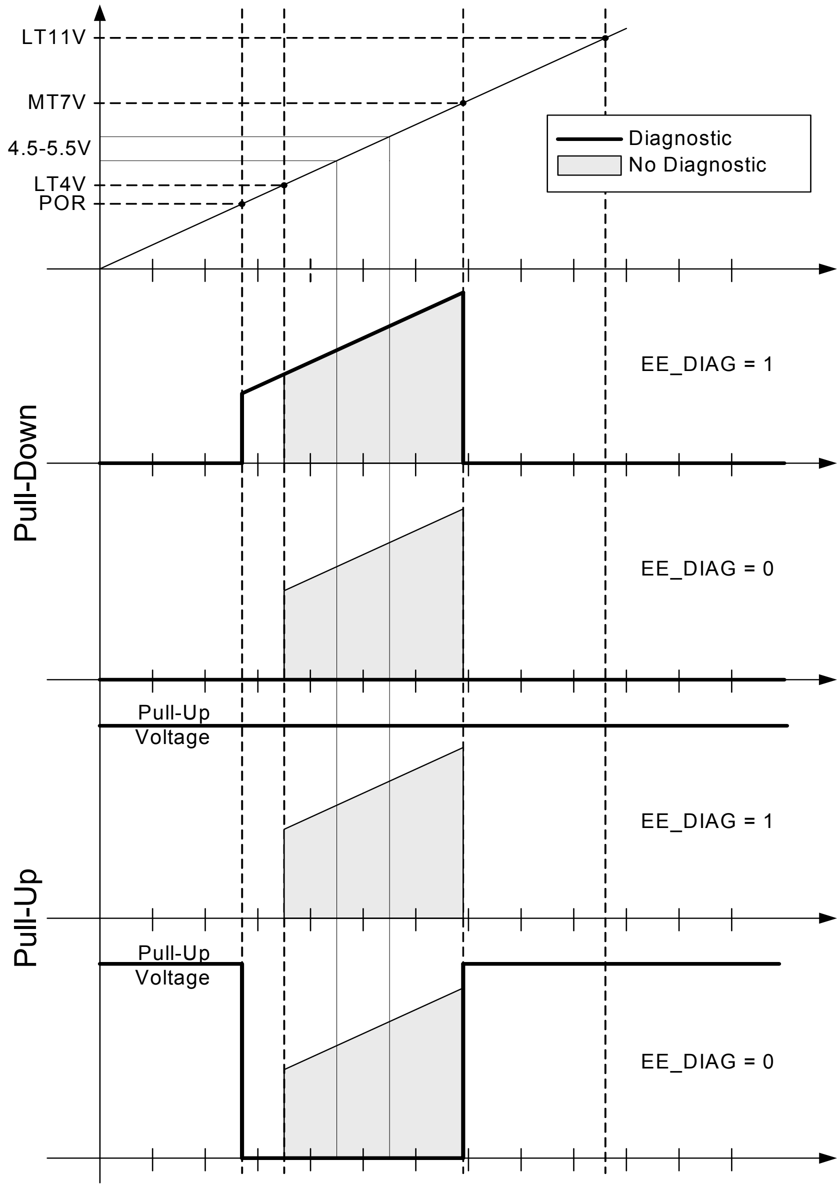


Figure 10 - Output voltage in diagnostic modes over supply voltage.

15.6.3. HAMHOLE Parameter

The HAMHOLE parameter enables or disables the memory recovery based on Hamming codes in case of EEPROM CRC error. By default, the memory recovery and EEPROM CRC check are disabled (Hamhole=3131h). These two features are enabled automatically when locking the part (see paragraph 13.7).

15.7. Lock

The LOCK parameter locks all the parameters set by the user. Once the lock is enabled, it is not possible to change the EEPROM values anymore as PTC communication in writing mode is not available anymore.

Note that the lock bit should be set by the solver function “MemLock”.

15.8. EEPROM endurance

Although the EEPROM is used for Calibration Data Storage (similarly to an OTPROM), the MLX90364 embedded EEPROM is qualified to guarantee an endurance of minimum 1000 write cycles at 125˚C for (engineering/calibration purpose).

16. MLX90364 Self Diagnostic

The MLX90364 provides numerous self-diagnostic features. Those features increase the robustness of the IC functionality as it will prevent the IC to provide erroneous output signal in case of internal or external failure modes ("fail-safe").

	Action	Effect on Outputs	Remark
ROM CRC Error at start up (64 words including Intelligent Watch Dog - IWD)	CPU Reset [16]	Diagnostic low/high[18]	All the outputs are already in Diagnostic low/high - (start-up)
ROM CRC Error (Operation - Background task)	Enter Endless Loop: - Progress (watchdog Acknowledge) - Set Outputs in Diagnostic low/high	Immediate Diagnostic low//high[18]	
RAM Test Fail (Start up)	CPU Reset	Diagnostic low/ high [18]	All the outputs are already in Diagnostic low/high (start-up)
Calibration Data CRC Error (Start-Up)	Hamming Code Recovery		Start-Up Time is increased by 3 ms if successful recovery
Hamming Code Recovery Error (Start-Up)	CPU Reset	Diagnostic low/high[18]	See section HAMHOLE
Calibration Data CRC Error (Operation - Background)	CPU Reset	Diagnostic low/high[18]	
ADC Clipping (ADC Output is 0000h or 7FFFh)	Set Outputs in Diagnostic low/high Normal mode and CPU Reset If recovery	Immediate Diagnostic low/high[18]	
Norm Too Low (< 25 %)	Set Outputs in Diagnostic low/high Normal mode and CPU Reset If recovery	Immediate Diagnostic low/high[18]	If no magnet IC in Diag. mode.
LostMagnet	Set PWMDiag	see PWMDiagMode table	only in PWM mode
WeakMagnet	Set PMWDiag	see PWMDiagMode table	only in PWM mode
Rough Offset Clipping (RO is = 0d or = 127d)	Set Outputs in Diagnostic low/high Normal mode, with immediate recovery without CPU reset	Immediate Diagnostic low/high[18]	
Gain Clipping (Gain < GAINMIN or Gain > GAINMAX)	Set Outputs in Diagnostic low/high Normal mode, and CPU Reset If recovery	Immediate Diagnostic low/high[18]	See also Section GAINMIN and GAINMAX.
MLX90364 Fault Mode continues…			

[16] CPU reset means

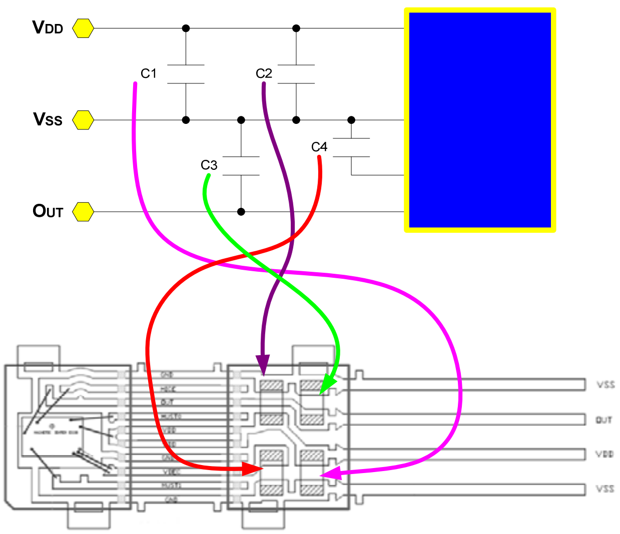
1. Core Reset (same as Power-On-Reset). It induces a typical start up time.
2. Periphery Reset (same as Power-On-Reset)
3. Fault Flag/Status Lost

...MLX90364 Fault Mode

Fault Mode	Action	Effect on Outputs	Remark
ADC Monitor (Analog to Digital Converter)	Set Outputs in Diagnostic low/high. Normal Mode with immediate recovery without CPU Reset	Immediate Diagnostic low/high(18)	ADC Inputs are Shorted and connected to Vref. ADC output is compared to a fixed value.
Undervoltage Mode	At Start-Up, wait Until VDD > LT4V. During operation, CPU Reset after 3 ms debouncing.	- VDD < POR level => Output high impedance - POR level < VDD < ~LT4V => Output in Diagnostic low/high[17].	
Firmware Flow Error	CPU Reset	Immediate Diagnostic low/high(18)	Intelligent Watchdog (Observer)
Read/Write Access out of physical memory	CPU Reset	Immediate Diagnostic low/high(18)	100% Hardware detection
Write Access to protected area (IO and RAM Words)	CPU Reset	Immediate Diagnostic low/high(18)	100% Hardware detection
Unauthorized entry in “SYSTEM” Mode	CPU Reset	Immediate Diagnostic low/high(18)	100% Hardware detection
VDD > MT7V	Set Output High Impedance (Analog)	Pull down resistive load => Diag. Low Pull up resistive load => Diag. High	100% Hardware detection
VDD > LT11V	IC is switched off (internal supply) CPU Reset on recovery	Pull down resistive load => Diag. Low Pull up resistive load => Diag. High	100% Hardware detection
Broken VSS	CPU Reset on recovery	Pull down resistive load < 10kΩ => Diag. Low Pull up resistive load (any value) => Diag. High	100% Hardware detection
Broken VDD	CPU Reset on recovery	Pull down resistive load (any value) => Diag. Low Pull up resistive load < 10kΩ => Diag. High	100% Hardware detection
Temperature Monitor	Set Outputs in Diagnostic low/high. Normal Mode with immediate recovery without CPU Reset	Immediate Diagnostic low/high(18)	Temperature Sensor 1 is compared to temperature sensor 2

[17] The diagnostics can be selectable between Diagnostic Low/Diagnostic High by setting the bits EE_DIAG and EE_ADIAG (for analog modes only). See section Programmable Diagnostic Settings for the Diagnostic Output Level specifications.

17. Built-in Capacitors and recommended Application Diagrams



C1 = C2 = C3 = C4 = 100 nF

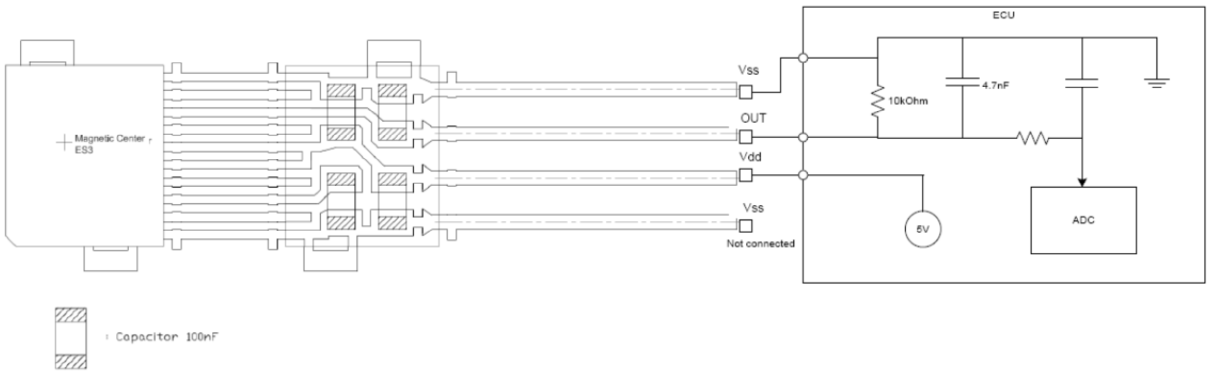


Figure 12 – Recommended wiring for the MLX90364 in DMP-4

Either Vss pin can be used for grounding, but always leave 1 floating.
Built-in capacitors are ceramic multilayer type X8R with value of 100nF each.
The capacitors are specifically suited for high temperature applications with stable capacitance value (+/-15%) up to 150 DegC.
The capacitors are assembled using a gluing method instead of soldering to be more reliable towards thermal/mechanical stress.
The maximum rated voltage is 25V.

18. Standard information regarding manufacturability of Melexis products with different lead pre-forming and soldering/welding processes

For Dual Mold Package, please refer to the following document (available upon request):
Application Note Hall Sensors in Dual Mold Packages – (Doc#: 390110000001)

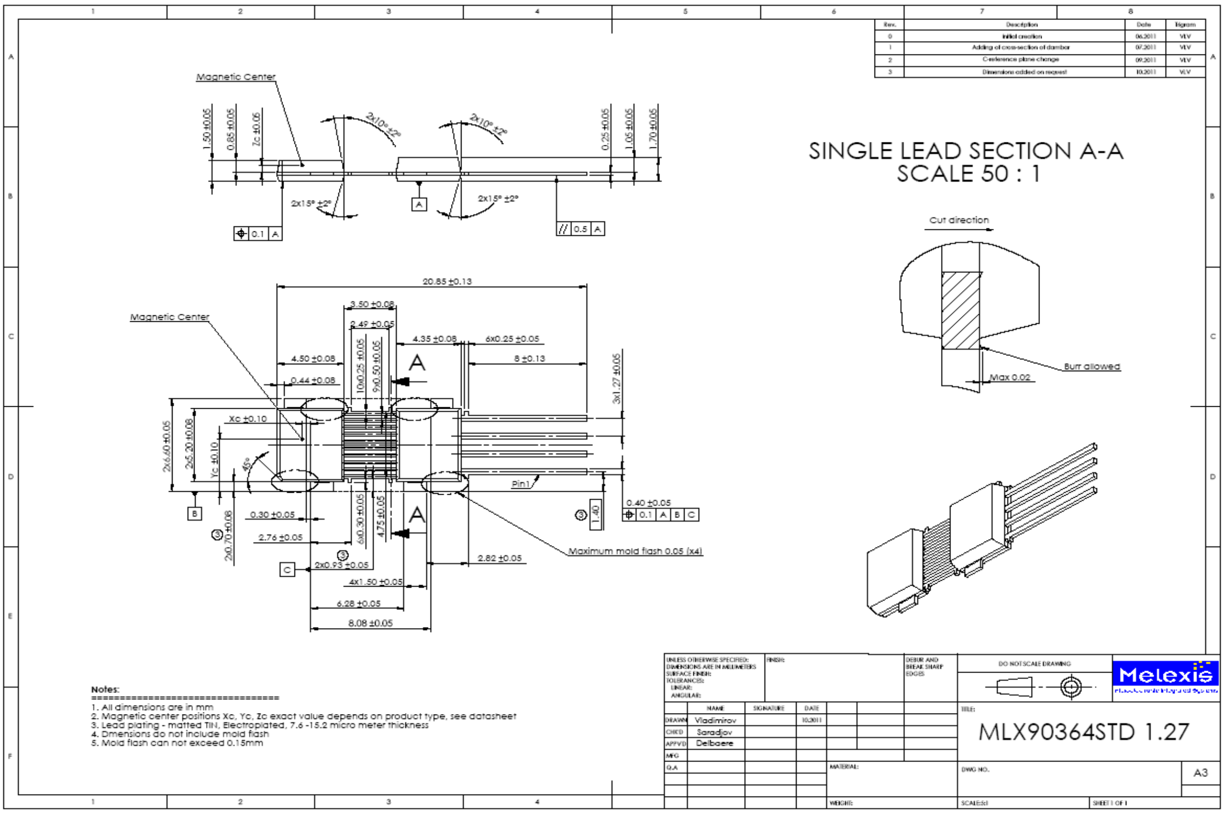
For more information on the lead free topic please see quality page at our website:
http://www.melexis.com/quality.aspx

19. ESD Precautions

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD).
Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

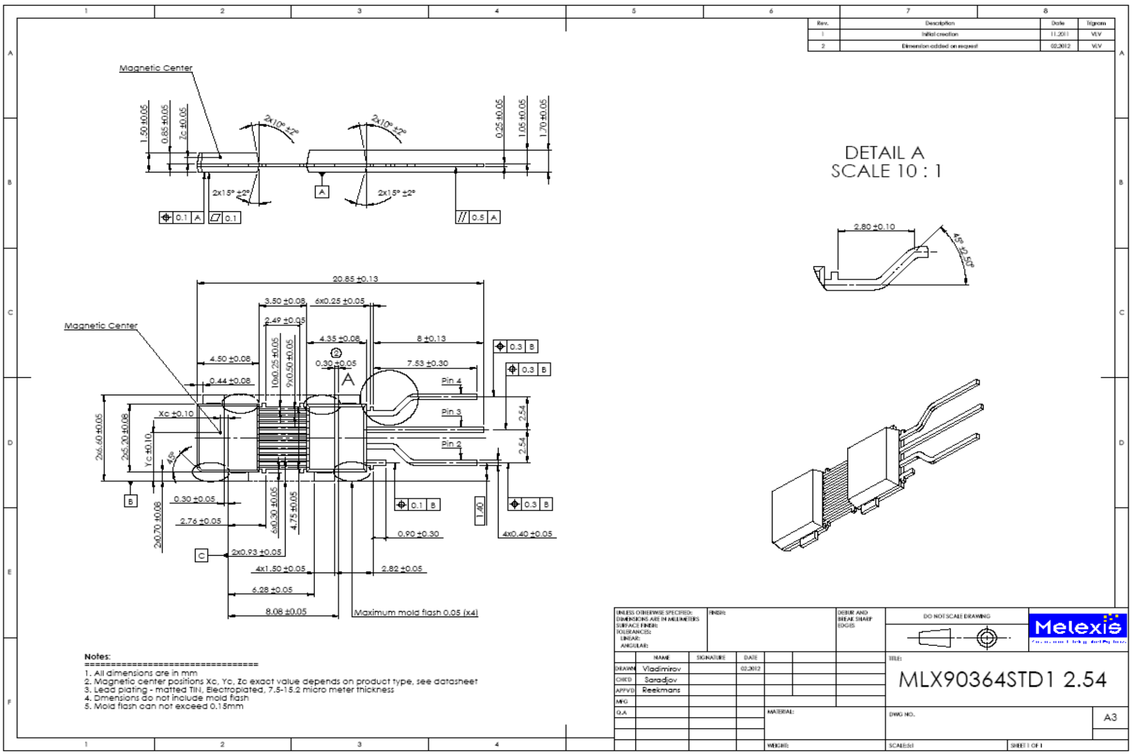
20. Package Information

20.1. DMP-4 – Package Outline Dimensions (POD) – Straight Leads



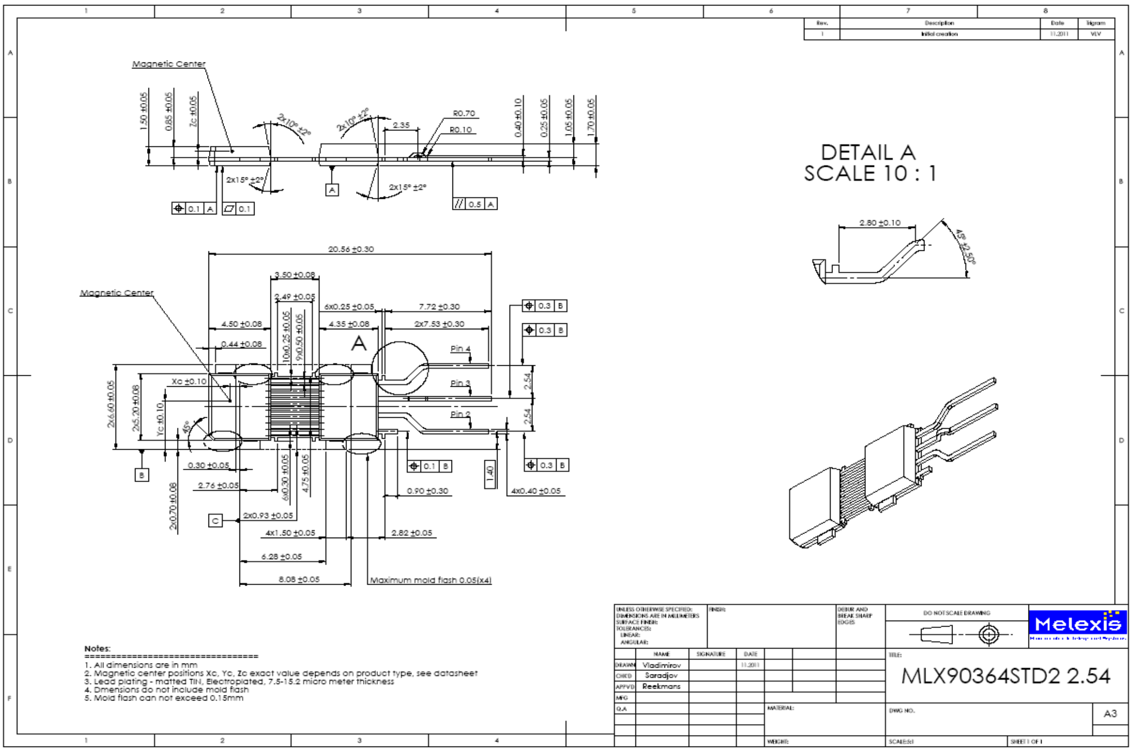
MLX90364LVS-Axx-200

20.2. DMP-4 – Package Outline Dimensions (POD) – Trimmed & Formed Leads [1]



MLX90364LVS-Axx-201

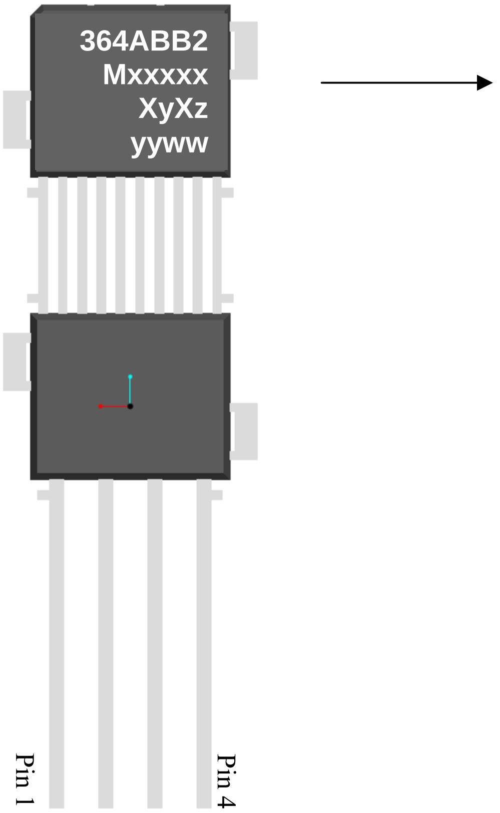
20.3. DMP-4 – Package Outline Dimensions (POD) – Trimmed & Formed Leads [2]



MLX90364LVS-Axx-203

20.4. DMP-4 - Pinout and Marking

Pin #	
1	VSS (Ground)
2	VDD
3	OUT
4	VSS (Ground)



Line 1: MLX project code:

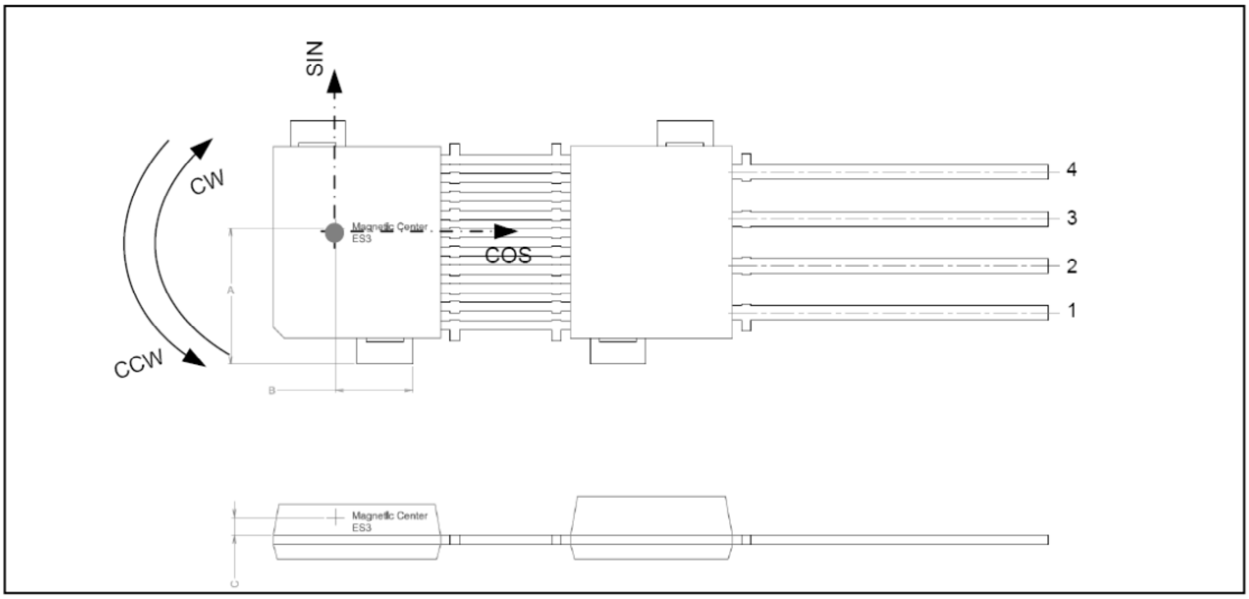
Line 2: wafer lot number

Line 3: Last 4 characters assembly lot number

Line 4: 2 digit year code – 2 digit week code

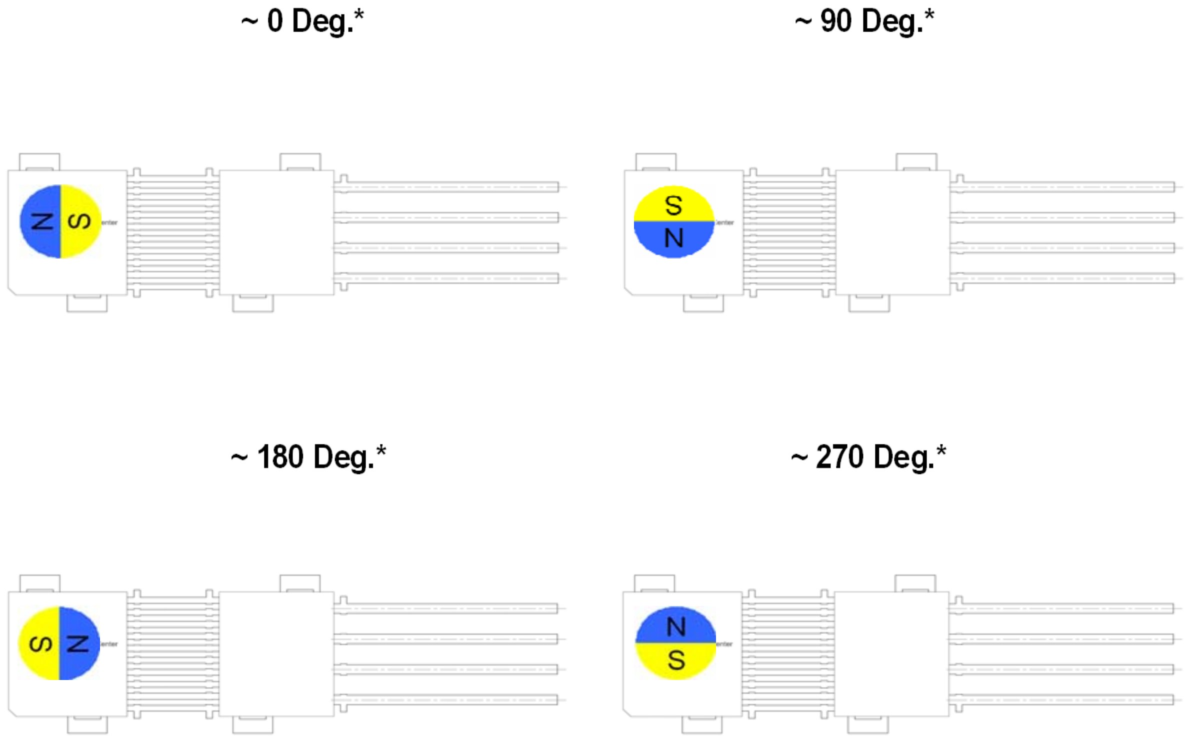
Marking present on both faces of the package.

20.5. DMP-4 - Sensitive Spot Positioning & Sense direction



Magnetic center position	MLX90364LVS-Axx-200
Xc	0.23
Yc	3.67
Zc	0.495

MLX90364 – Reference Angle



* No absolute reference for the angular information.

The MLX90364 is an absolute angular position sensor but the linearity error (See section 0) does not include the error linked to the absolute reference 0 Deg (which can be fixed in the application through the discontinuity point).

21. Disclaimer

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