MLX91235

500 kHz Coreless External Primary Current Sensor MLX91235
Datasheet

General description

Features & benefits

- Coreless Technology
  - No need for a ferromagnetic concentrator.
  - Work closely with Melexis to ensure the best possible mechanical integration.
- DSP compensation for high accuracy
  - 0.5% thermal drift from -40°C to 150°C
  - 1% total drift (thermal & lifetime) from -40°C to 150°C
  - Stable noise over temperature
  - Differential sensing with common mode field rejection of 99.9%
- Open calibration via SPI
  - 100% digital calibration
  - Large end-of-line re-programmable sensitivity range from x0.5 to x2
  - Easy in-situ adjustment
- High-speed sensing
  - DC to 500 kHz bandwidth
  - 1.5µs response time
- Protection & diagnostics (via SPI)
  - Overcurrent detection (programmable with 1% accuracy) with 1.33µs detection
  - Temperature monitoring (10-bit)
  - Self-test functionality
- Operating range
  - Supply: 3.3V or 5V
  - Temperature range: -40°C to 165°C
  - Ratiometric output
- ASIL B Safety Element out of Context (SEooC) according to ISO26262
- AEC-Q100 – Grade 0 Automotive Qualified
- RoHS-compliant package SOIC-8

Applications examples

Automotive, e-mobility and beyond:

- Inverter
- Battery Management System (BMS)
- Low voltage DC-DC converters
- Smart battery junction box
- Smart fuse
- Power distribution

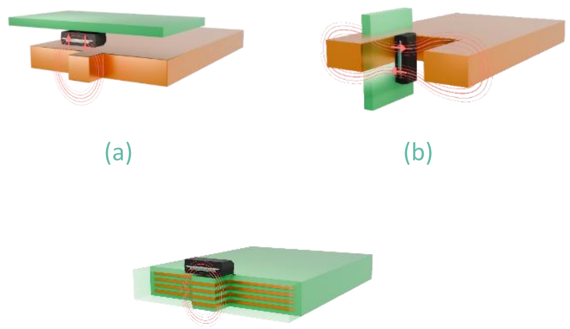
Description

The MLX91235 is a smart high-speed, current sensor IC with built-in stray field immunity, de-signed for measuring current in an external conductor. This conductor can be either a busbar or a PCB trace. It needs to adopt a special shape to generate a gradient magnetic field on the sensor, typically a neckdown is recommended. Consequently, it eliminates the need for external ferromagnetic elements (like C-cores or U-shields), reducing the system's total BoM cost.

Being a monolithic Hall-effect sensor, the MLX91235 accurately measures the differential magnetic flux density applied perpendicularly to its surface. An analog output voltage, proportional to the current of the nearby conductor, but rejecting external common mode magnetic fields can be measured at the output of the sensor.

The transfer characteristic of the MLX91235 is factory-trimmed over temperature, with market leading performance. To cope with placement tolerances in the application assembly, the MLX91235 is programmable (fine gain, offset, overcurrent threshold, …) via a full-duplex SPI interface during end-of-line customer calibration.

Finally, the integrated stress sensor compensates for lifetime effects, ensuring long-term accuracy.



(a) (b) (c)

Figure 1: (a) Busbar neckdown assembly with MLX91235 die-up, (b) Busbar trough-hole with MLX91235 die-down and (c) Power PCB trace with MLX91235 die-down

Available support & tools

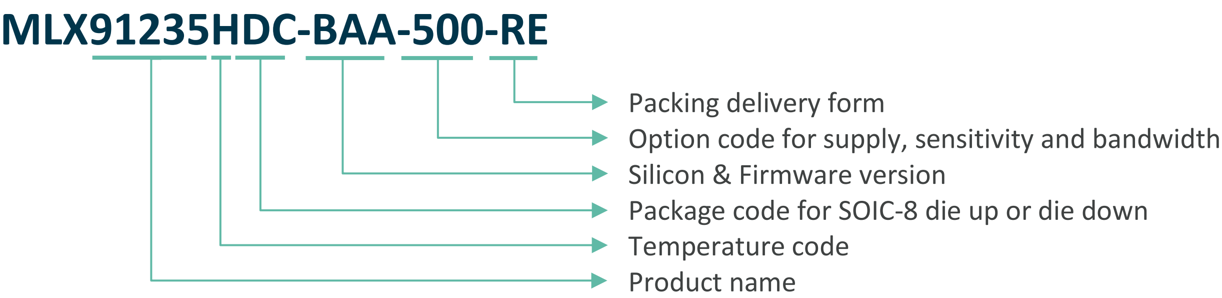
- www.melexis.com/technical-inquiry

Ordering information

Product code	Package	Die type	Supply Voltage	Sensitivity	Temperature
MLX91235HDC-BAA-500-RE	SOIC-8	Die up	5V	200 mV/mT	-40 to 165°C
MLX91235HDD-BAA-500-RE[1]	SOIC-8	Die down	5V	200 mV/mT	-40 to 165°C
MLX91235HDC-BAA-300-RE	SOIC-8	Die up	3V3	132 mV/mT	-40 to 165°C
MLX91235HDD-BAA-300-RE[1]	SOIC-8	Die down	3V3	132 mV/mT	-40 to 165°C

Table 1 – Product codes.

Different configurations available. This is an example, in the future this table will be updated reflecting the actual offer. Ordering code may change in the final version of the datasheet.



Product name:	MLX91235
Temperature Code:	H: from -40°C to 165°C ambient temperature
Package Code:	DC: for SOIC-8 die-up DD: for SOIC-8 die-down
Silicon and Firmware Version:	BAA: Release silicon version
Option code for variant:	500: 5V version for VDD 300: 3V3 version for VDD
Packing delivery form:	"RE" for Reel

Table 2 – Ordering information legend

Melexis is continuously expanding its product portfolio by adding new option codes to better meet the needs of our customers' applications.

[1] Die Down part numbers are only available as engineering samples, they are not released for production yet.

CONTENTS

1. Pins description and block diagram

1.1 Pins description

1.1.1 Pins description for SOIC-8 die up package (DC)

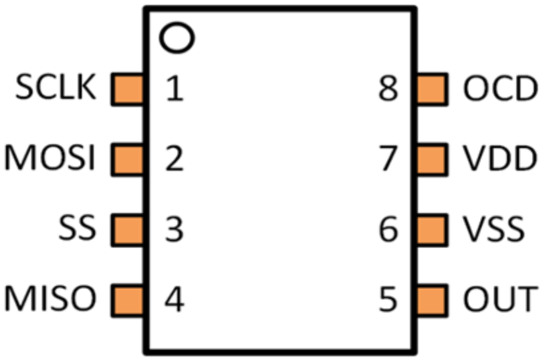


Figure 2: SOIC-8 die up pinout

Pin #	Name	I/O[2]	Description	Symbol of the pin voltage
1	SCLK	I	SPI interface clock pin	
2	MOSI	I	SPI interface input pin	
3	SS	I	SPI interface chip select pin	
4	MISO	O	SPI interface output pin	
5	OUT	O	Analog output pin	V_{OUT}
6	VSS	Ground	Ground pin	V_{SS}
7	VDD	Supply	Supply voltage pin	V_{DD}
8	OCD	O	Overcurrent detection pin	V_{OCD}

Table 3: SOIC-8 die up pin description

For optimal EMC behavior, it is recommended to connect the unused pins to the ground.

[2] I stands for input and O for output.

1.1.2 Pins description for SOIC-8 die down package (DD)

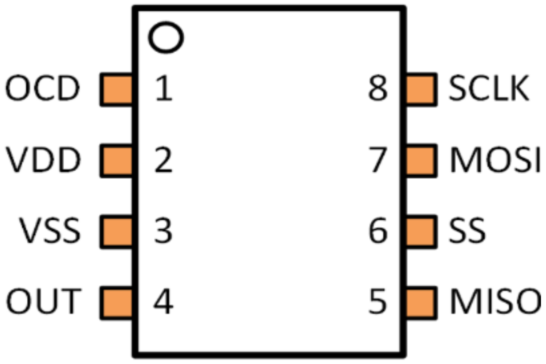


Figure 3: SOIC-8 die down pinout

Pin #	Name	I/O[3]	Description	Symbol of the pin voltage
1	OCD	O	Overcurrent detection pin	V_{OCD}
2	VDD	Supply	Supply voltage pin	V_{DD}
3	VSS	Ground	Ground pin	V_{SS}
4	OUT	O	Analog output pin	V_{OUT}
5	MISO	O	SPI interface output pin	
6	SS	I	SPI interface chip select pin	
7	MOSI	I	SPI interface input pin	
8	SCLK	I	SPI interface clock pin	

Table 4: SOIC-8 die down package pins description

For optimal EMC behavior, it is recommended to connect the unused pins to the ground.

1.2 Block Diagram

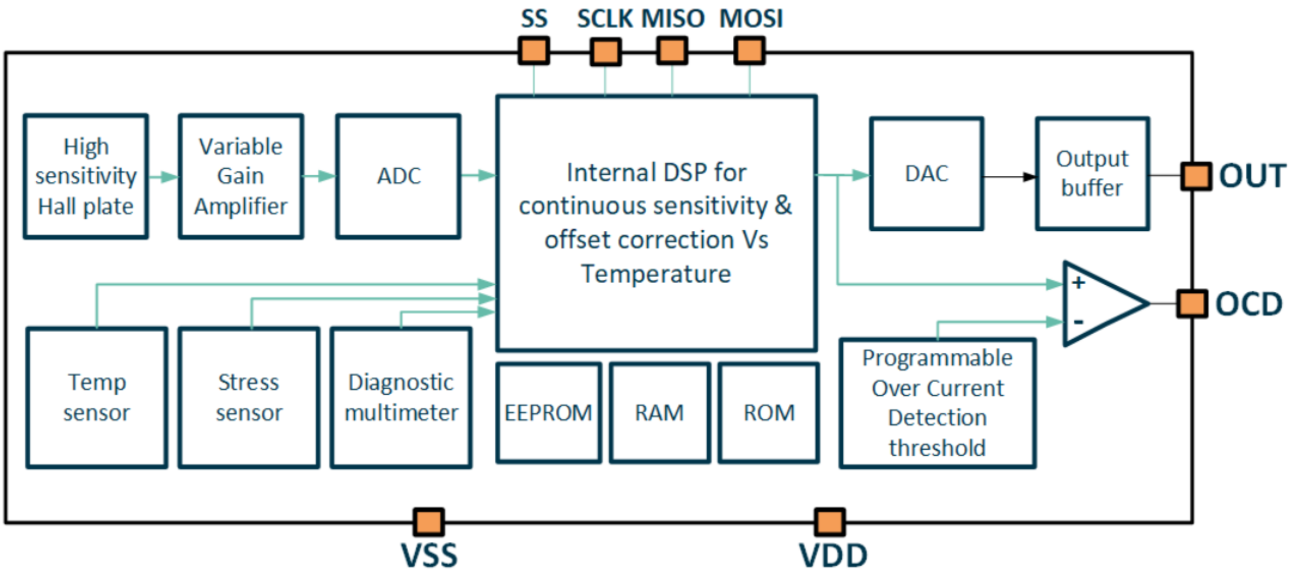


Figure 4: MLX91235 functional block diagram

[3] I stands for input and O for output.

2. Conditions and specifications

2.1 Absolute Maximum Ratings (AMR)

Parameter	Symbol	Min.	Max.	Unit	Condition
Positive Supply Voltage (non-destructive)	V_{DD-ABS_MAX}		7.0	V	
Maximum pin voltage	V_{MAX}		V_{DD} + 0.3V	V	
Reverse Supply Voltage	V_{DD-REV}	-0.5		V	
Voltage on pins other than V_{DD}[4]	V_{PIN}	-0.3		V	
Operating Ambient Temperature Range	T_A	-40	165	°C	Ambient temperature
Storage Temperature Range	T_S	-55	170	°C	
Junction Temperature	T_J		175	°C	
ESD voltage	$V_{ESD-HBM}$		± 2000	V	HBM (AEC-Q100-002), all pins
	$V_{ESD-CDM}$		± 500	V	CDM (AEC-Q100-011), internal pins
			± 750	V	CDM (AEC-Q100-011), corner pins

Table 5: Absolute maximum ratings

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

2.2 Electrical operating conditions & specifications

Unless otherwise specified, the electrical specifications are valid for a temperature range from -40 to 165°C, and a supply voltage range from 4.5V to 5.5V for 5V VDD mode or from 3.14V to 3.46V for 3.3V VDD mode.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply current	I_{DD}		27	30	mA	
Supply voltage	V_{DD}	4.5	5	5.5	V	V_{DD} = 5V
		3.14	3.3	3.46		V_{DD} = 3V3
Supply voltage rising speed	$V_{DD-rising}$	10		1000	mV/ µs	
Output current	I_{OUT}			15	mA	

Table 6: Electrical operating conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Output Capacitive Load[5]	C_L	0.22	0.47[6]	1.5	nF	500kHz bandwidth
Output Resistive Load[7]	R_L	10			kΩ	
SPI Output Capacitive Load	C_{L-SPI}		47	100	pF	Output load on MISO output
SPI Output Resistive Load	R_{L-SPI}	10	100		KΩ	
OCD Capacitive Load			47		pF	
OCD Resistive Load			10		kΩ	

Table 7: Electrical specifications

[4] Intended as maximum ratings to avoid damages to the sensor, in nonfunctional conditions.
[5] An output capacitive load is recommended to get a stable output.
[6] Recommended value.
[7] During Startup phase or in Safety mode, the output buffer is high impedance. It is strongly recommended to put an external pull-down resistor to control the node voltage.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Linear Output Range	VO_{LIN}	10		90	$\%V_{DD}$	
Diagnostic band	OUT_{DIAG}	0		4	$\%V_{DD}$	
High clamped output level	$CLAMP_{HIGH}$	90	93	96	$\%V_{DD}$	
Low clamped output level	$CLAMP_{LOW}$	4	7	10	$\%V_{DD}$	

Table 8: Analog output levels

As an illustration of the previous table, the MLX91235 fits the typical classification of the output span de-scribed on the Figure 5: Output range description below:

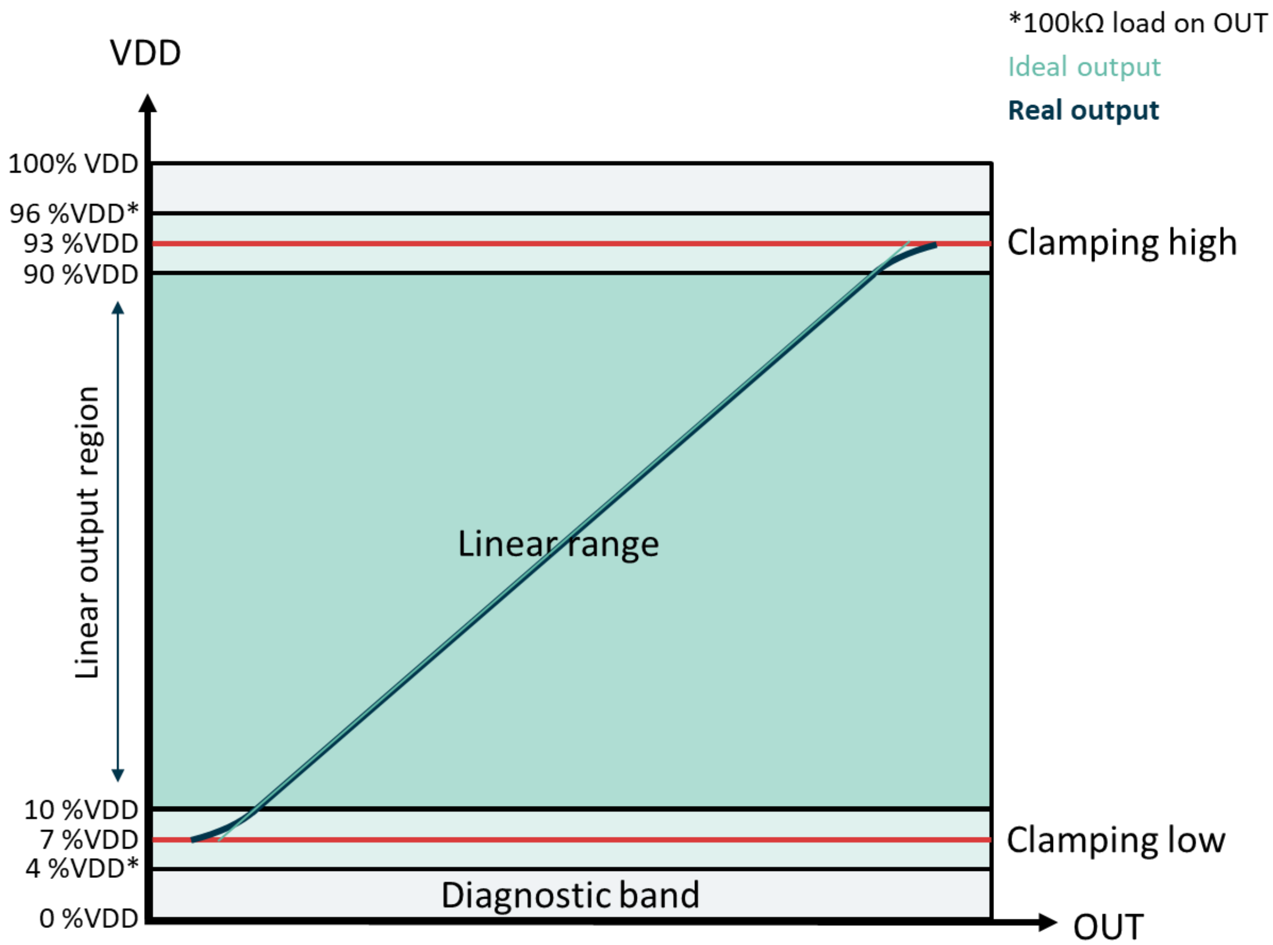


Figure 5: Output range description

2.3 Magnetic operating conditions and specifications

2.3.1 Definitions

2.3.1.1 Input differential magnetic field in Z direction (Magnetic density flux)

The gradient is measured thanks to 2 measurement points H_p and H_n with a 2.5mm-spacing.
The field amplitude is noted ΔBz.

$$\Delta B_z = \frac{1}{2}\left(B_{z,p} - B_{z,n}\right) = \frac{1}{2} Bz\left(x = \frac{-2.5mm}{2}\right) - \frac{1}{2} Bz\left(x = \frac{2.5mm}{2}\right) \text{ [mT]}$$

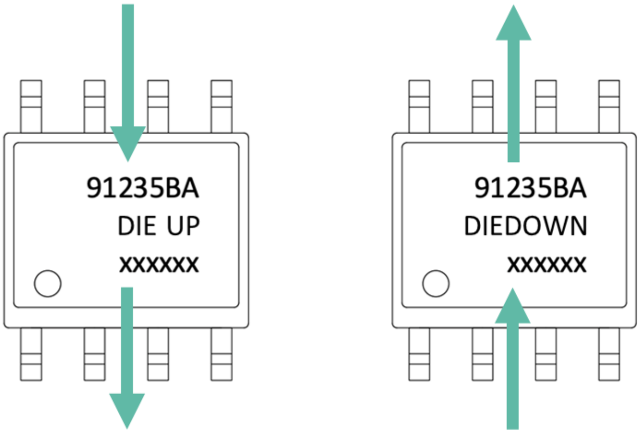


Figure 6: Current direction (indicated by the arrow) convention for die up and die down sensor's versions.

The current direction is opposite for die up and die down package versions. Similar magnetic fields will result in opposite output values for both versions.

2.3.1.2 Input common mode magnetic field in Z direction

$$B_z = \frac{1}{2}\left(B_{z,p} + B_{z,n}\right) = \frac{1}{2}\left[B_z\left(x = \frac{-2.5mm}{2}\right) + B_z\left(x = \frac{2.5mm}{2}\right)\right] \text{ [mT]}$$

2.3.1.3 Input referred noise

The input referred noise B_N is the ratio between the output standard deviation over 1ms in absence of magnetic field. It is normalized by the bandwidth.

$$B_N = \frac{\sigma(Vout)}{S}\frac{1}{\sqrt{BW}}(\Delta Bz = 0) \text{ [nT/}\sqrt{\text{Hz}}\text{]}$$

2.3.1.4 Sensitivity

The sensitivity S is the ratio between the output V_{OUT} of the MLX91235 and the applied differential magnetic flux density in z direction.

$$S = \frac{V_{OUT}}{\Delta B_Z} \text{ [mV/mT]}$$

The common-mode sensitivity S_{CM} is the ratio between the output V_{OUT} of the MLX91235 and the common-mode magnetic flux density in z direction.

$$S_{CM} = V_{OUT}/B_{Z,CM} \text{ [mV/mT]}$$

2.3.2 Specifications

Unless otherwise specified, the electrical specifications are valid for a temperature range from -40 to 165°C, and a supply voltage range from 4.5V to 5.5V for 5V VDD mode or from 3.14V to 3.46V for 3.3V VDD mode.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Differential Magnetic Flux Density in Z	ΔB_Z			±30	mT	Front-end saturation limit
Common-mode Magnetic Flux density in Z	$B_{Z\text{-}CM}$			±100	mT	Front-end saturation limit

Table 9: Magnetic operating conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Linearity error[8]	NLE			±0.3	%FS	V_{OUT} = [10, 90] %V_{DD} T_A = [-40, 150] °C
Input referred noise	B_N		115		nT/√Hz	T_A = -40°C
			135			T_A = 25°C
			165			T_A = 150 °C
Programmable sensitivity	S	75		300	mV/mT	V_{DD} = 5V
		50		200		V_{DD} = 3.3V
Sensitivity error from factory trimming	S_{ERR}		±1		%	Can be corrected by EOL calibration
Sensitivity programming resolution	S_{RES}			0.1	%	
Offset adjustment range		-25		25	mV	By EOL calibration, w.r.t Melexis factory trimming

Table 10: Magnetic specifications

2.4 General timing specifications

2.4.1 Timing definitions

2.4.1.1 Start-up time

The start-up time is the time between the power-on event and the time the first valid current measurement transmitted on the output. During start-up, the sensor output is in high-Z state, and the driver is only enabled when the sensor can transmit a valid output.

2.4.1.2 Step response

The step response is a suitable metric for the "delay" of the sensor in case of a step in the magnetic input, as illustrated in the figure below.

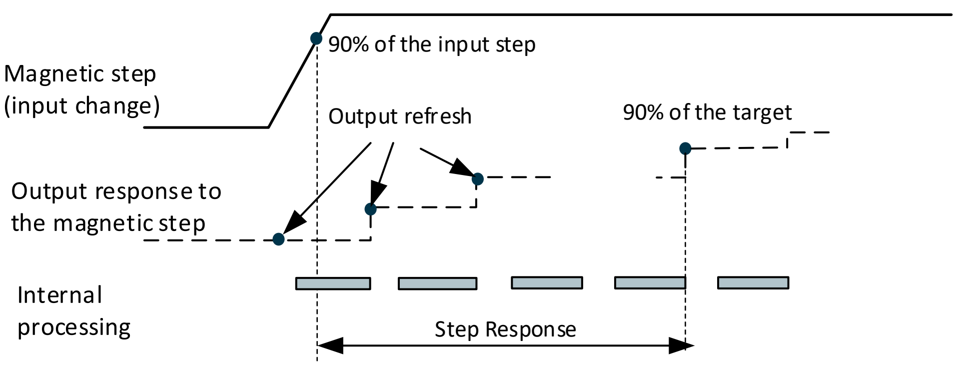


Figure 7: Step response description

[8] The linearity is tested dynamically with 2 superimposed sinewave and the inter-modulation is measured.

2.4.2 Timing specifications

Unless otherwise specified, the electrical specifications are valid for a temperature range from -40 to 165°C, and a supply voltage range from 4.5V to 5.5V for 5V VDD mode or from 3.14V to 3.46V for 3.3V VDD mode.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Start-up time	T_{SU}			5	ms	After supply ramp
Bandwidth	BW	396	440	484	kHz	500kHz mode
Step response time	T_{RESP}		1.5		µs	500kHz mode
Ratiometric bandwidth	BW_{RATIO}		70		kHz	

Table 11: General timing specifications

2.5 Accuracy specifications

2.5.1 Definitions

2.5.1.1 Thermal sensitivity drift

$\Delta^T S$ corresponds to the variation of S over temperature, always referred to 25°C.

2.5.1.2 Voltage output quiescent

V_{OQ} corresponds to the output when there is no differential magnetic field (ΔB_Z = 0 mT), at T_A=25°C.

2.5.1.3 Thermal offset drift

$\Delta^T V_{OQ}$ corresponds to the variation of V_{OQ} over temperature.

2.5.1.4 Total Sensitivity and offset drift

$\Delta^{TOT} S$ and $\Delta^{TOT} V_{OQ}$ corresponds to the variation of S and of V_{OQ} both over temperature (-40°C to 150°C) and over AEC-Q100 Grade 0 Automotive qualification of 1000h HTOL at T_A = 155°C with respect to after pre-conditioning at T_A = 35°C. Pre-conditioning is performed with MSL level 3 based on J-STD-020.

2.5.1.5 Ratiometric offset error

Although V_{OQ} scales linearly with the supply voltage, a residual error is defined as:

$$\Delta R_{VOQ} = V_{OQ}\left[V_{DDnom} \pm V_{DD_{var}}\right] \cdot \frac{V_{DDnom}}{V_{DDnom} \pm V_{DD_{var}}} - V_{OQ}\left[V_{DDnom}\right] \text{ [mV]}$$

Where V_{DDnom} is the nominal supply voltage and V_{DDvar} is the variation of the supply.

2.5.1.6 Ratiometric sensitivity error

Although S scales linearly with the supply voltage, a residual error is defined as:

$$\Delta R_S = 100 \cdot \left(\frac{S[V_{DDnom} \pm V_{DDvar}]}{S[V_{DDnom}]} \cdot \frac{V_{DDnom}}{V_{DDnom} \pm V_{DDvar}} - 1\right) \text{ [\%]}$$

Where V_{DDnom} is the nominal supply voltage and V_{DDvar} is the variation of the supply.

2.5.1.7 Common mode rejection

While the IC is designed to only measure ΔBZ with a sensitivity S, the common-mode field $B_{Z,CM}$ will leak into the measurement with a sensitivity S_{CM}.

$$V_{OUT} = S \cdot \Delta Bz + S_{CM} \cdot B_{Z,CM}$$

The common-mode field rejection ratio quantifies how much common-mode field is:

$$CMRR = \left(1 - \frac{S_{CM}}{S}\right) \cdot 100 \text{ [\%]}$$

2.5.2 Specifications

Unless otherwise specified, the electrical specifications are valid for a temperature range from -40 to 165°C, and a supply voltage range from 4.5V to 5.5V for 5V VDD mode or from 3.14V to 3.46V for 3.3V VDD mode. Only valid for sensitivity values smaller or equal to factory trimmed as listed inside Table 1.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Thermal sensitivity drift[9]	$\Delta^{T}S$	-0.5 - 0.7[10]		+0.5 +0.7[10]	%S	T_A = -40, 125°C T_A = 125, 150°C
Total sensitivity drift[11]	$\Delta^{TOT}S$		-0.3		%S	T_A = -40, 150°C
Thermal offset drift[8]	$\Delta^{T}VOQ$	-5		+5	mV	T_A = -40, 150°C
Total offset drift[11]	$\Delta^{TOT}VOQ$		-2.3		mV	T_A = -40, 150°C
Common-mode field rejection ratio	CMRR		99.9		%	Measured for $B_{Z,CM}$ = 40mT
			60		dB	
Thermal common-mode rejection ratio drift	$\Delta^{T}CMRR$		0.2		%	T_A = -40, 150°C
Ratiometric sensitivity error	$\Delta^{R}S$	-0.02		+0.02	%S/%VDD_{VAR}	
Ratiometric offset error	$\Delta^{R}VOQ$	-0.6		+0.6	mV/%VDD_{VAR}	
Junction temperature sensor error			±7		°C	

Table 12: Accuracy specifications

2.6 Overcurrent detection

2.6.1 OCD description

The MLX91235 provides an OCD feature that allows detection of an overcurrent event, i.e. measured current is above a programmable threshold. In case of OCD detection, the OCD pin is pulled to ground. During normal operation, the OCD voltage remains at VDD.
The OCD function can react to an overcurrent with a very short response time. To avoid false alarm, the overcurrent must be maintained during a programmable time for the detection to occur. After detection by the sensor, the output flag is maintained low during a programmable time window to allow the overcurrent to be easily detected at microcontroller level.
Figure 8 illustrates the OCD response (OCD) to the OCD event (OCD_INT), which can be filtered thanks to the programmable debounce time (OCD_DEB) and maintained during a programmable minimum time (OCD_LEN).

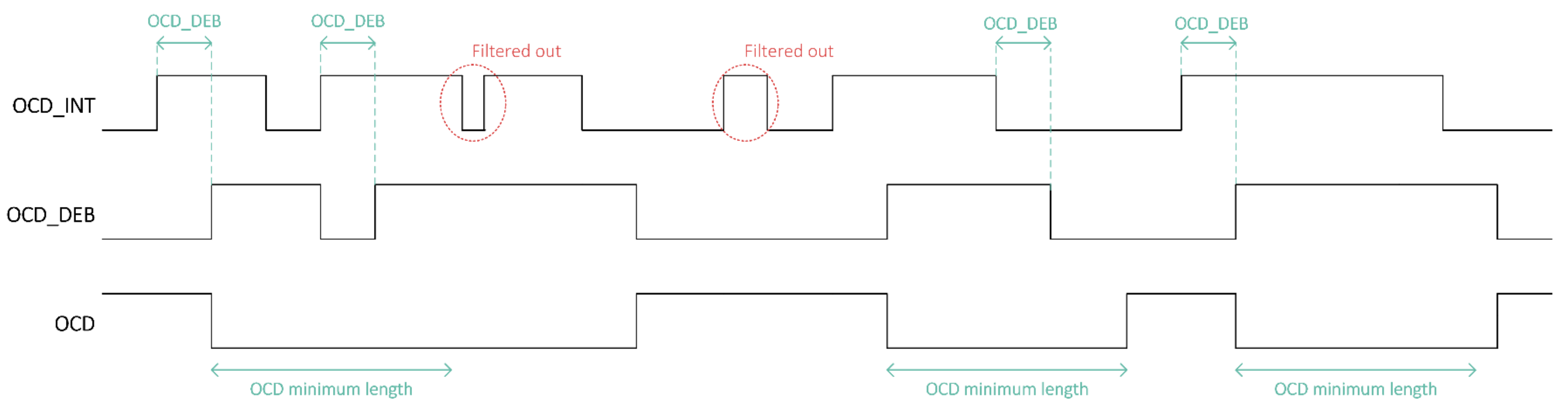


Figure 8: Illustration of OCD signals and OCD debounce time.

[9] Min. and Max. limits are defined as the worst case 5 sigma limits.
[10] The thermal drift with respect to 25degC in the range 125degC to 150degC is 0.7%.
[11] Typical total drift value corresponds to worse case average drift found during AEC-Q100 qualification.

Figure 9 illustrates the OCD_INT value with the OCD thresholds HIGH value set to the maximum value (+150%FS) as described in Table 13, and the LOW value set to -50%FS.

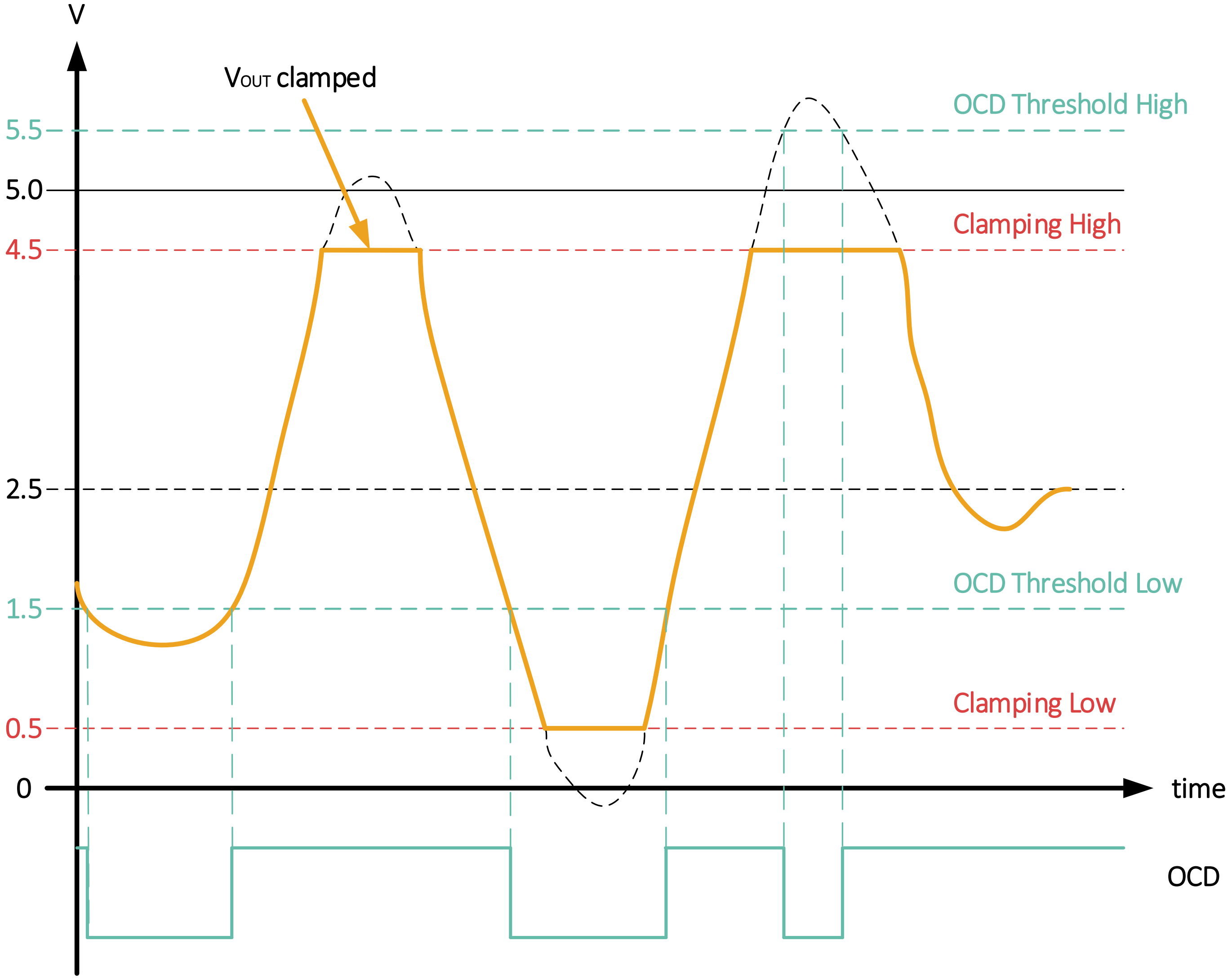


Figure 9: Illustration of OCD with thresholds at maximum values.

2.6.2 OCD specifications

Unless otherwise specified, the electrical specifications are valid for a temperature range from -40 to 165°C, and a supply voltage range from 4.5V to 5.5V for 5V V_{DD} mode or from 3.14V to 3.46V for 3.3V V_{DD} mode. Only valid for sensitivity values of part numbers listed inside Table 1. Accuracy performances over lifetime and temperature are the same as the magnetic sensitivity.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
OCD threshold	OCD_{THRESH}	-150		150	%FS	Programmable in EEPROM, ΔB_Z < 30mT
OCD programing resolution	OCD_{RES}		0.1		%FS	
OCD response time[12]	$T_{RESP,OCD}$		1.33		µs	500kHz mode
OCD debounce time	OCD_{DEB}			10	µs	Programmable in EEPROM
OCD output time	OCD_{LEN}	1		25	µs	Programmable in EEPROM

Table 13: Overcurrent specifications

[12] OCD response time is programmable between 1.0µs and 3.3µs using the OCD_DEB parameter (see Table 16). Value in Table 13 corresponds to OCD_DEB = 4.

3. Functional description & interfaces

3.1 SPI Interface

The MLX91235 serial interface allows a Master device to operate the current sensor. The MLX91235 inter-face allows multi-slave applications and synchronous start of the data acquisition among the Slaves. The serial protocol ensures efficient communication, with the ability to reprogram the customer CEE area in 150ms. It operates in half-duplex mode.
Data integrity is guaranteed in both directions by an 8-bit CRC covering the content of the incoming and outgoing messages.

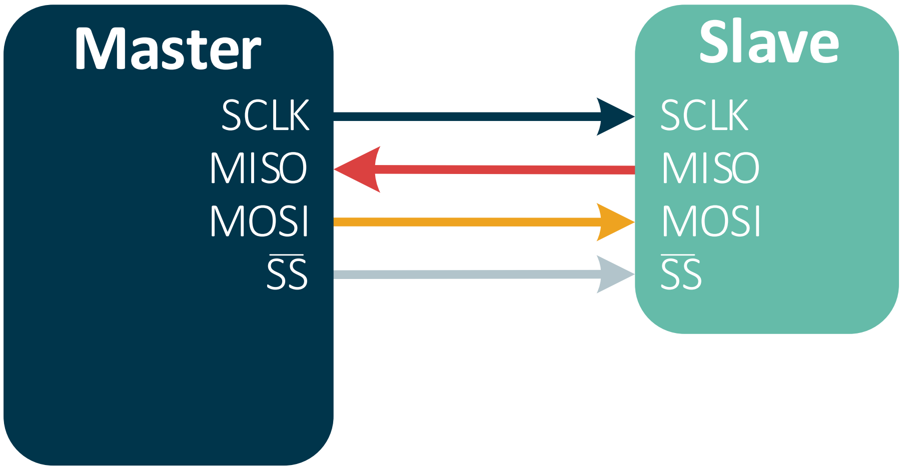


Figure 10: SPI communication master-slave application diagram.

3.1.1 General frame structure

SPI communication starts with a falling edge on the SS line and ends with a rising edge on it. A command byte (CMD) is first sent by the master (only frame with the size of one byte only). In response to this command, several frames are then exchanged on MOSI or MISO line depending on the communication direction. The CPU is not able to handle the incoming command bytes within less than one clock pulse. Therefore, a short time interval (WAIT) is needed between the received command and the response. This gives the CPU time to switch the SPI direction if needed, to prepare the response and to configure/activate the DMA.

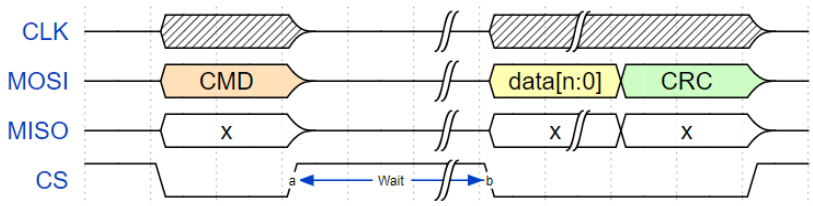


Figure 11: SPI RX Communication

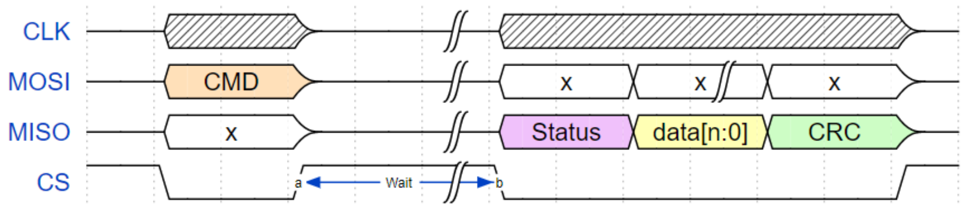


Figure 12: SPI TX Communication

The hardware provides support to ensure that the WAIT time is respected
The communication handling by the software is time critical for the CPU (as the main application should not be disturbed) therefore a maximum frame rate at which the MCU/ECU is allowed to send to the chip must be defined. To achieve this maximum frame-rate, each response is followed by a dead time (BLOCKING). During this timeframe the chip blocks all incoming SPI frames.

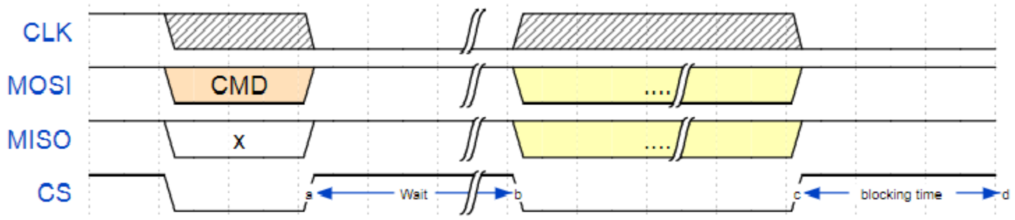


Figure 13: SPI blocking time illustration

The MLX91235 User manual provides more detailed information about the SPI communication and is available on request.

3.1.2 SPI Signal levels

Unless otherwise specified, the electrical specifications are valid for a temperature range from -40 to 165°C, and a supply voltage range from 4.5V to 5.5V for 5V VDD mode or from 3.14V to 3.46V for 3.3V VDD mode.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Input high threshold				75	%VDD	For MOSI/SCLK/SS
Input low threshold		25			%VDD	For MOSI/SCLK/SS
Input hysteresis		15	25		%VDD	For MOSI/SCLK/SS
Output level high		90			%VDD	For MISO/OCD
Output level low				10	%VDD	For MISO/OCD

Table 14 – SPI levels

3.1.3 SPI interface timing specifications

Unless otherwise specified, the electrical specifications are valid for a temperature range from -40 to 165°C, and a supply voltage range from 4.5V to 5.5V for 5V VDD mode or from 3.14V to 3.46V for 3.3V VDD mode.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
EEPROM programming time			200		ms	
Diagnostic call time			10		ms	
SPI clock frequency	F_{SCLK}			4	MHz	
SPI MOSI rise/fall time	$T_{rise,MOSI}$ $T_{fall,MOSI}$		25	50	ns	Nominal capacitance load
SPI MISO rise/fall time	$T_{rise,MISO}$ $T_{fall,MISO}$		25	50	ns	Nominal capacitance load
SPI SCLK rise/fall time	$T_{rise,SCLK}$ $T_{fall,SCLK}$		25	50	ns	Nominal capacitance load
SPI SS rise/fall time	$T_{rise,SS}$ $T_{fall,SS}$		25	50	ns	Nominal capacitance load

Table 15 – SPI interface timing specifications

3.1.4 Memory access

3.1.4.1 Introduction

The serial protocol of MLX91235 allows customizing the calibration of the sensor, when needed, at the end-of-line, through EEPROM programming.

The memory access procedure is the following:

- Enter Memory Access mode after start-up.
- Set address pointer.
- Write all required bytes.
- Read status byte after each write command to detect write is done. Status bit returned from 4 ('Write in progress') to 3 ('Memory Access Mode').
- Alternatively wait appropriate time until write process has been completed.
- Leave Memory Access Mode. This will execute a reset after current write process is done.

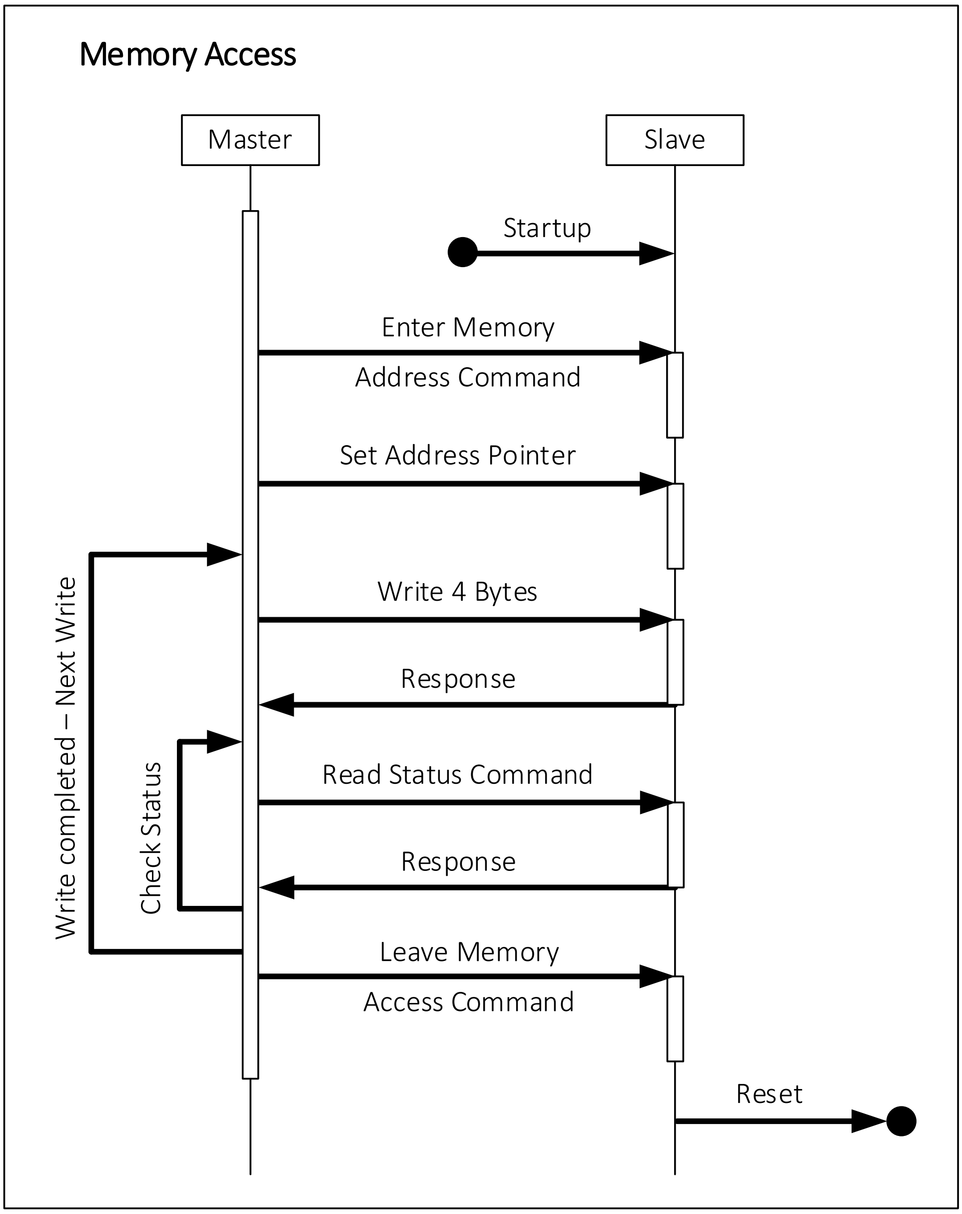


Figure 14: Memory access procedure diagram.

3.1.4.2 Detailed procedure

Only the user configuration bits, stored in EEPROM, are programmable with this protocol for end of line programming at a temperature below 120°C. Memory access is allowed after the programming mode has been enabled, which is done with following command:

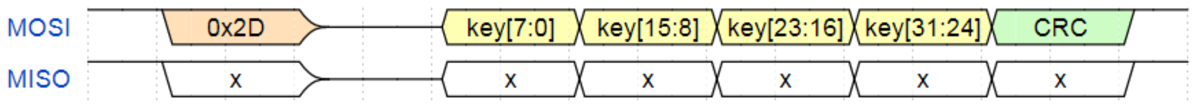


Figure 15: Memory access mode entry command

The command frame is followed by a frame with a unique key and CRC.
Closing the programming mode is needed to complete programming procedure and run the main application or force a reset.

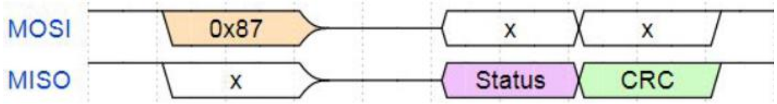


Figure 16: Memory access mode exit command

The command frame is followed by a status byte and CRC.
The memory access always takes place on the current internal address pointer position. The address pointer is 4byte aligned. After Read/Write command, the address pointer will increase by 4 bytes.
Single 4-byte or burst read/write of a multiple of 4 bytes is supported.

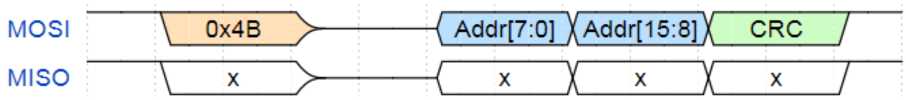


Figure 17: Memory access mode address command

Read command to be used to read 4 bytes from the current address pointer position. The frame content is secured by a CRC.

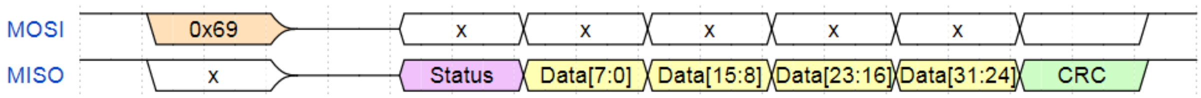


Figure 18: Read command

The following write command can be used to write 4 bytes to the current address pointer position. The frame content is secured by a CRC.

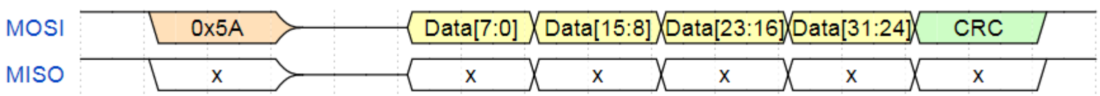


Figure 19: Write command

3.1.5 Memory and end-user programmable items

Parameter	Description	bits
GAIN_CORR	Hall Plate Sensitivity correction fractional part	13
OUT_OFFS_CUST	Output offset programmability	11
OCD_THR_POS	Positive threshold for Overcurrent detection	16
OCD_THR_NEG	Negative threshold for Overcurrent detection	16
OCD_LEN_MIN	OCD pulse minimum length	5
OCD_DEB	OCD debounce time	4
GAIN	Fast DSP gain before compensation	5
STEP_LOW	DAC low code for Step response	5
STEP_HIGH	DAC high code for Step response	5
CUST_CRC	Customer CRC	8
CUST_INFO	Customer Information	16
CUST_ID	Customer ID	32
LOCK[13]	Customer Area Lock bit	1

Table 16: Customer EEPROM parameters and description.

The MLX91235 User manual provides more detailed information about the EEPROM content and parameters and is available on request.

3.1.6 Diagnostics

The MLX91235 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 status on-demand thanks to the SPI interface.
The status of analog diagnostics is erased after each request. To access to the status of the safety diagnostics which can be reported on demand via the SPI interface, a special 'Read diagnostic' command has to be used:

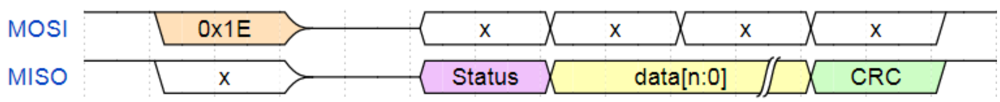


Figure 20: SPI diagnostics reading command

The MLX91235 User manual provides more detailed information about the diagnostics information provided by the sensor and is available on request.
The self-diagnostics with characteristics are displayed in the following tables, the reporting modes being:

- SPI: status of the safety mechanism reported on request via the SPI interface
- DIG: digital hardware failure reporting, described in the safety manual.

[13] Changing the value of CUST_LOCK will permanently lock the IC EEPROM.

Category and safety mechanism name	Reporting mode
Sensing element connection check	SPI
External supply monitor	SPI
Temperature monitor	SPI
Bandgap and auxiliary A/D converter monitor	SPI
Internal supplies monitor	SPI
Current bias monitor	SPI
Internal thermometer monitor	SPI
Sensitivity accuracy check	SPI
Offset accuracy check	SPI

Table 17: Analog diagnostics

Category and safety mechanism name	Reporting mode
RAM Parity	DIG
ROM Parity	DIG
RAM bist	DIG
EEPROM configuration Data Integrity Check	DIG
EEPROM double error detection	DIG
Software flow control	DIG
CPU errors “invalid address”, “wrong opcode”	DIG
Critical ports monitoring	DIG
State Machine safety (no locked state)	DIG
Invalid mechanical stress or thermal compensation	DIG

Table 18: Digital-circuit diagnostics

Category and safety mechanism name	Reporting mode
Data and command protection with checksum	DIG

Table 19: SPI interface diagnostics

Category and safety mechanism name	Reporting mode
Verification of Temperature range before programming	DIG
Verification of EEPROM bits strength	DIG
Memlock feature	DIG

Table 20: EEPROM programmability diagnostics

3.2 Functional Safety

The MLX91235 is an ASSP developed as a Safety Element out of Context (SEooC) with assumed technical safety requirements. As per ISO 26262 the MLX91235 Automotive Safety Integrity Levels is ASIL B. The technical safety concept is described in the MLX91235 Safety manual.

The safety manual contains:

- 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:
    - Assumption 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.
- The description and the result of the functional safety assessment process; list of confirmation measures and description of the independency level.

3.2.1 Safety Mechanism: On-demand step response

The MLX91235 includes an On-demand Step Response function that allows evaluating the main performances of the sensor (response time, sensitivity, offset) and flag any critical deviations. The On-demand Step Response is triggered by the customer microcontroller by SPI communication. During the Step Response period, the Hall plates are disconnected, and the current monitoring function is then stopped. A step response lasts between typically 20µs (short) and 100µs (long) and is programmable.

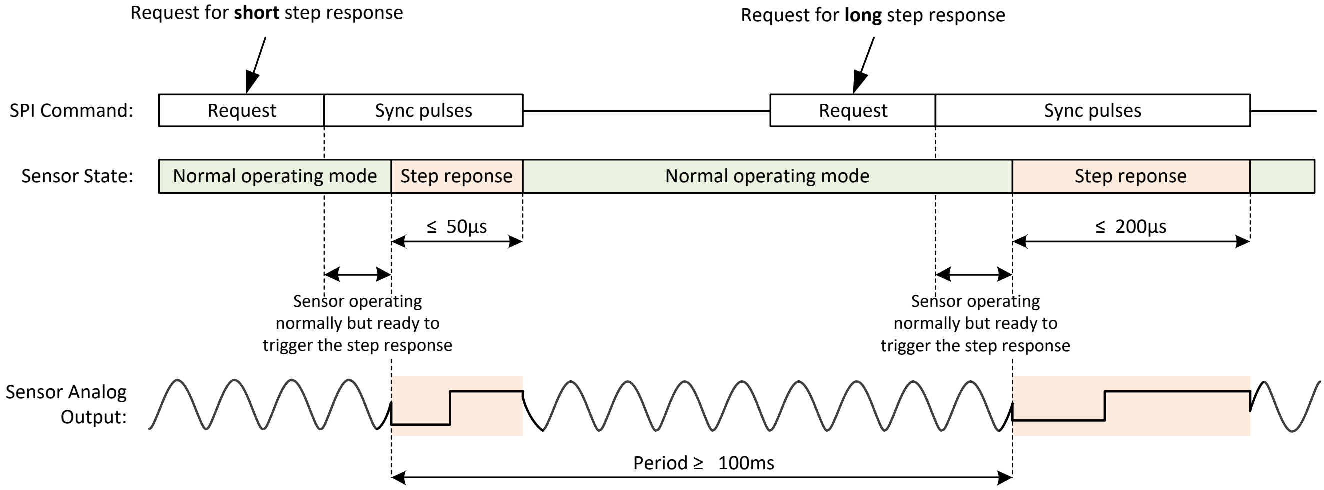


Figure 21: On-demand step response timing diagrams

Minimum diagnosable error	Typical value	Unit	Description
Sensitivity error[14]	2	%	Repeatability per chip
Offset error	5	mV	Repeatability per chip
Response time error	500	ns	Repeatability per chip

Table 21 – Detectable errors with the self-test response

Parameter	Typical Value	Unit	Description
Step response DAC resolution	5	bit	
Max step response output swing	±60	mT	
Short step-response time	15	µs	Programmable with SPI
Long step-response time	100	µs	Programmable with SPI
Step-response minimum period	100	ms	Between two step responses

Table 22 – Self-test response specifications

[14] For a sensitivity S smaller than 150mV/mT

4. Application

4.1 Recommended application diagram

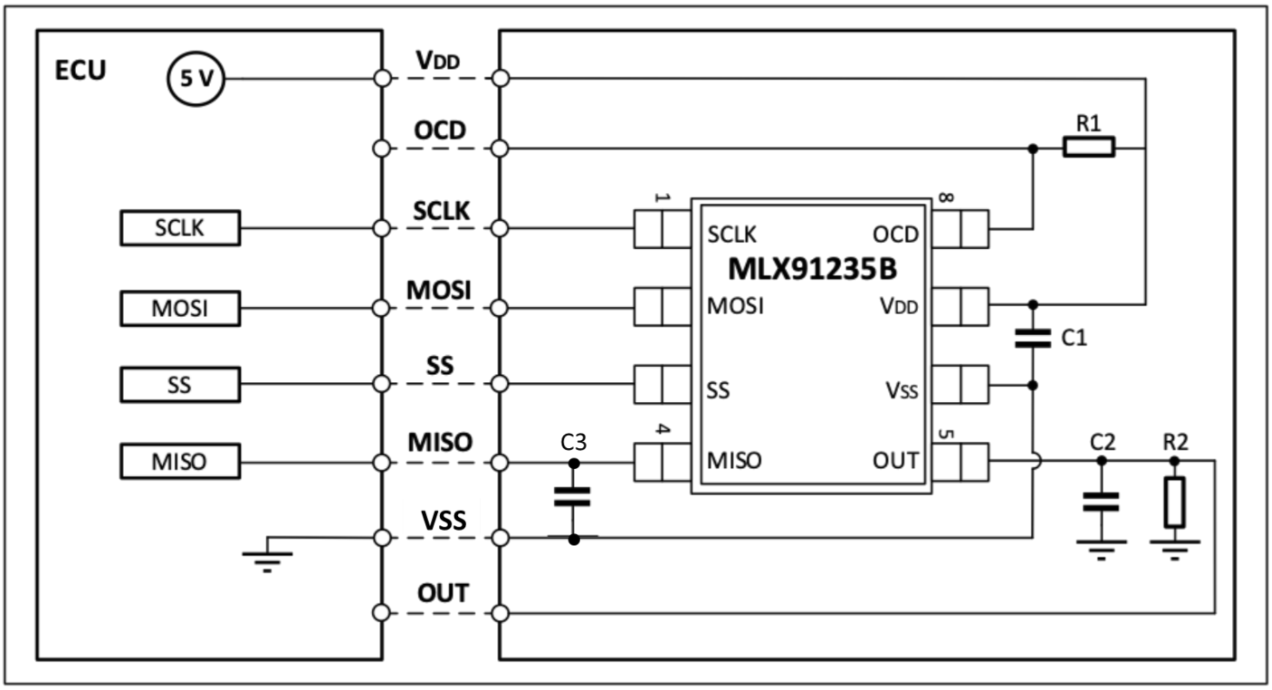


Figure 22: Application diagram with external pull-down resistance

Part	Description	Value	Unit
C1	Supply capacitor, EMC	220	nF
C2 (C_L)	Capacitive Load, for optimal noise management	470	pF
C3[15]	Decoupling capacitance on MISO	47	pF
R1	OCD pull-up	100	kΩ
R2	Recommended pull-down to VSS	100	kΩ

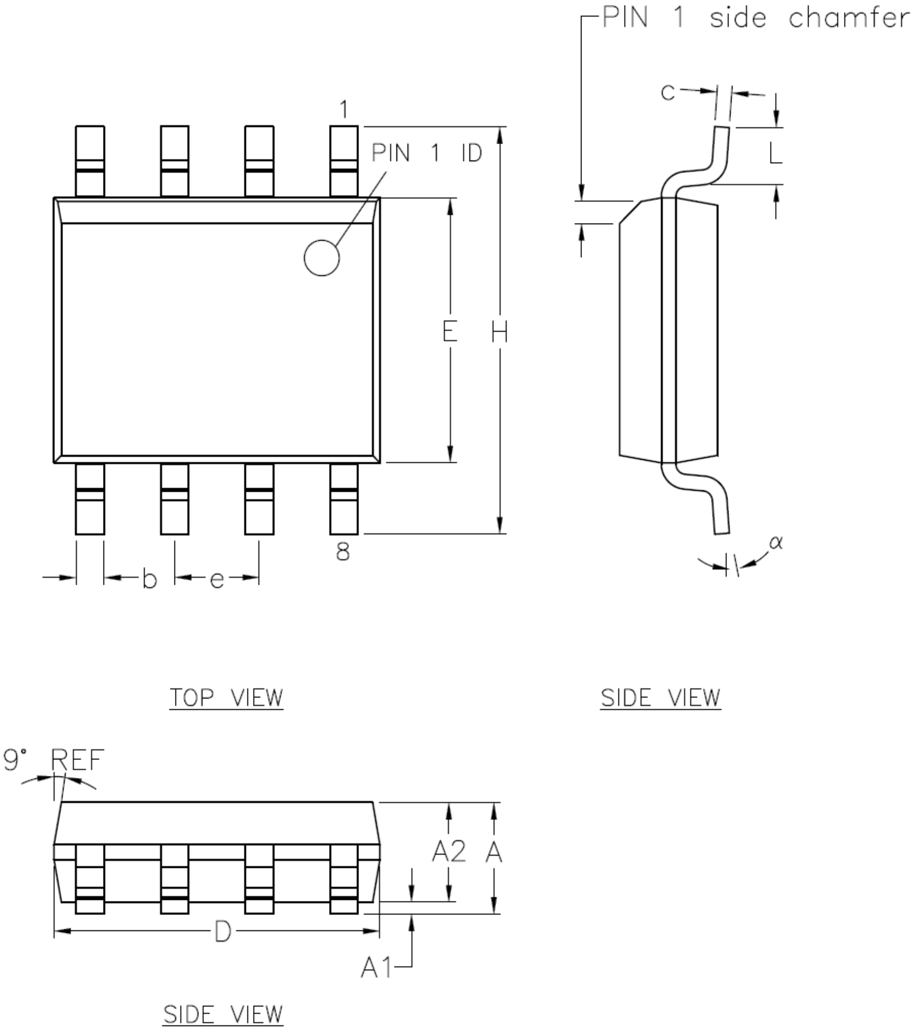
Table 23 – Recommended passive components values[16]

[15] Additional parasitic capacitance load (due to line connexion and input load of the MISO driver) shall be below kept below 10pF.
[16] The IC performance and output stability are not guaranteed unless the recommended values are used.

5. Package, IC handling and assembly

5.1 Package information

5.1.1 General SOIC-8 package dimensions



SYMBOL	MINIMUM	MAXIMUM
A	---	1.75
A1	0.10	0.25
A2	1.32	1.57
D	4.80	5.00
E	3.81	3.99
H	5.80	6.20
L	0.41	1.27
b	0.33	0.51
c	0.19	0.25
e	1.27 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.

Figure 23: SOIC-8 package dimensions

5.1.2 Package SOIC-8 Die up

5.1.2.1 SOIC-8 package die up marking

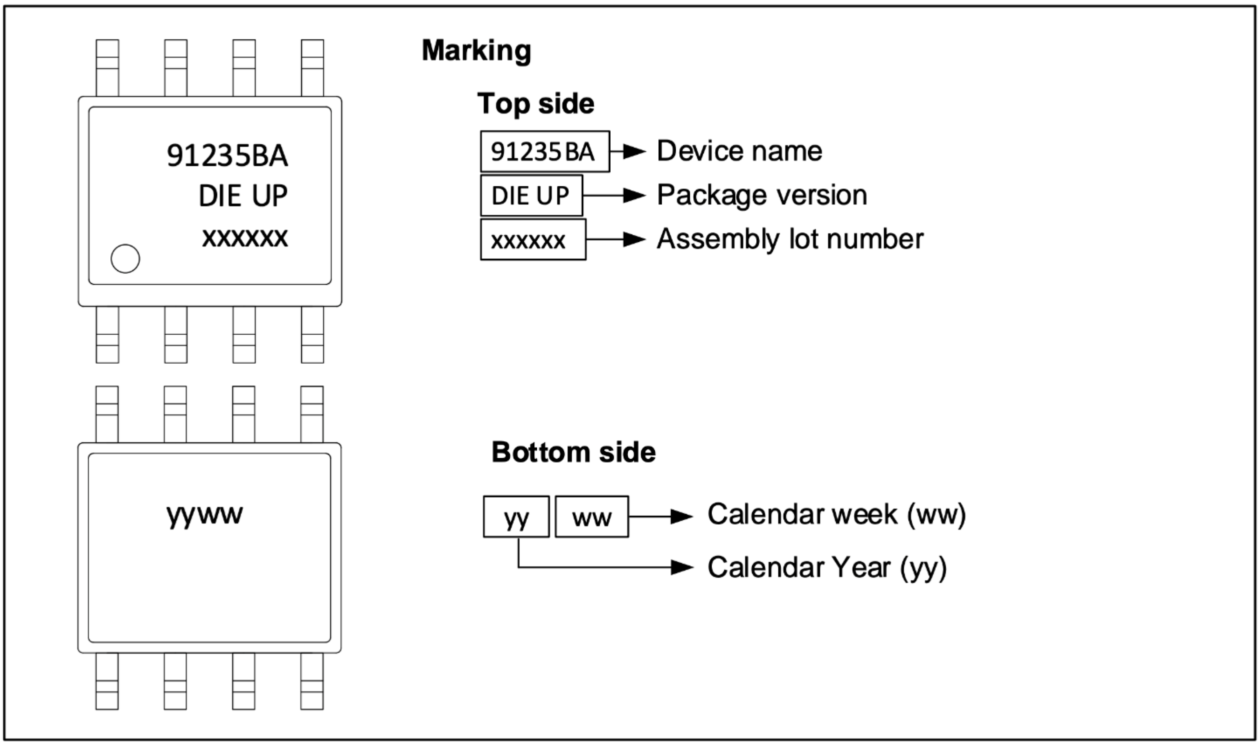


Figure 24: SOIC-8 die up marking

5.1.2.2 SOIC-8 package die up sensing element position

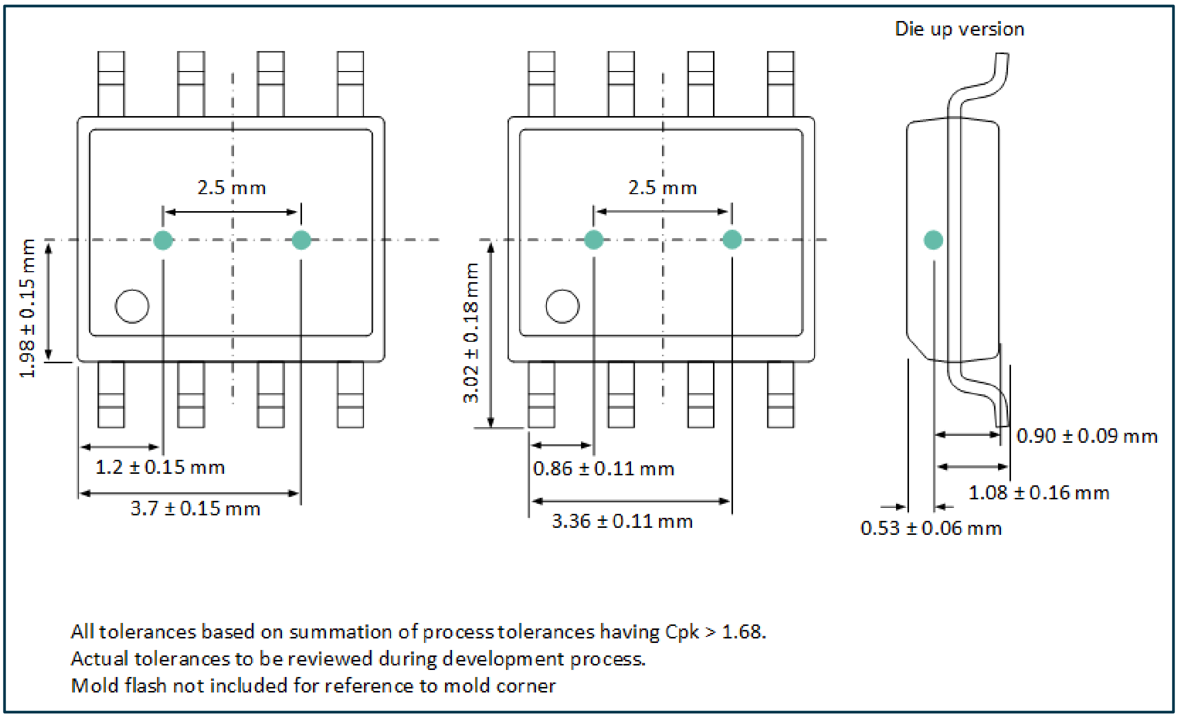


Figure 25: SOIC-8 die up sensing element position

5.1.3 Package die down

5.1.3.1 SOIC-8 die down marking

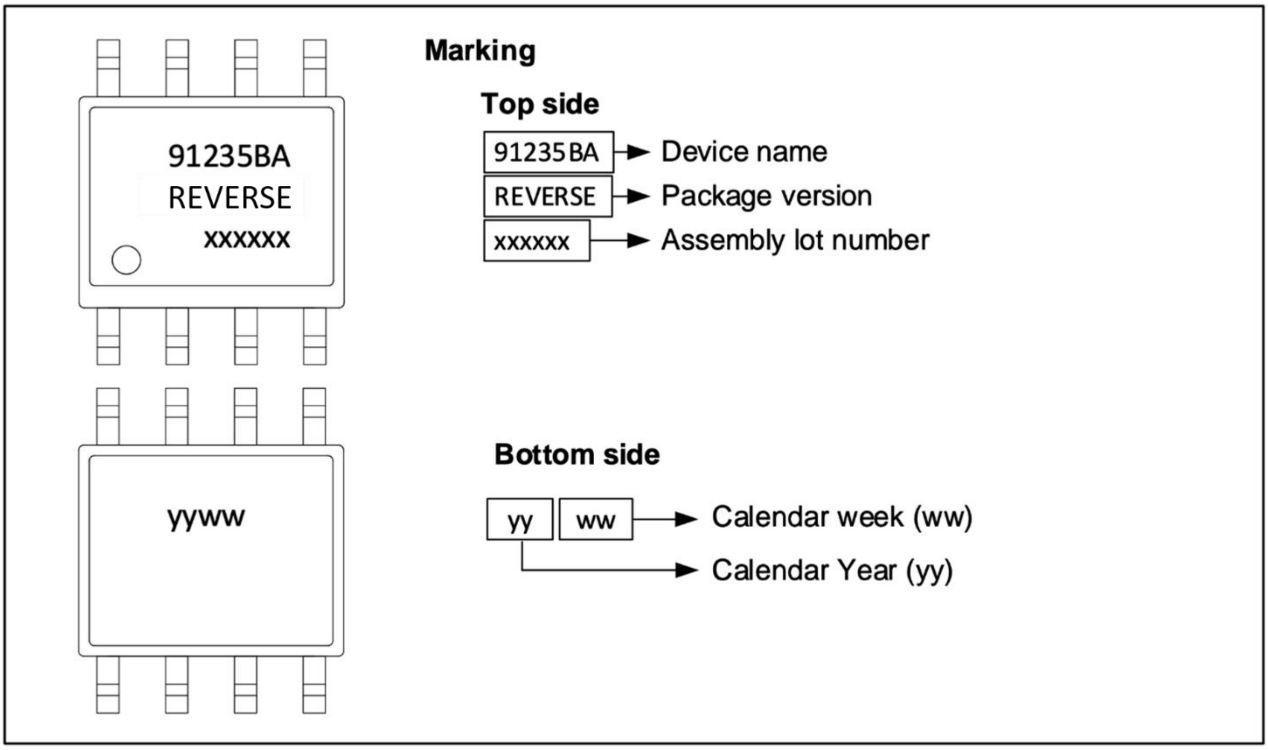


Figure 26: SOIC-8 die down marking

5.1.3.2 SOIC-8 die down package sensing element position

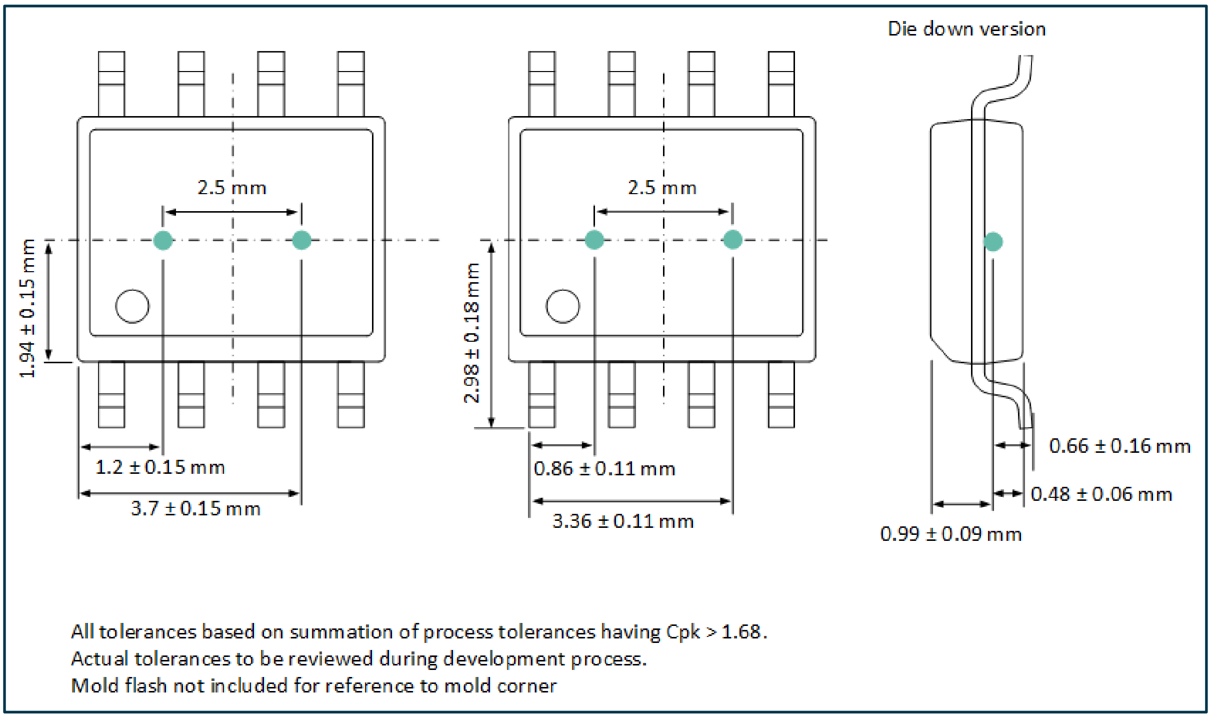


Figure 27: SOIC-8 die down sensing element position

5.2 Storage and handling of plastic encapsulated ICs

Plastic encapsulated ICs shall be stored and handled according to their MSL categorization level (specified in the packing label) as per J-STD-033.
Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). The component assembly shall be handled in EPA (Electrostatic Protected Area) as per ANSI S20.20
For more information refer to Melexis *Guidelines for storage and handling of plastic encapsulated ICs* [17]

5.3 Assembly of encapsulated ICs

For Surface Mounted Devices (SMD, as defined according to JEDEC norms), the only applicable soldering method is reflow.
For Through Hole Devices (THD), the applicable soldering methods are reflow, wave, selective wave and robot point-to-point. THD lead pre-forming (cutting and/or bending) is applicable under strict compliance with Melexis *Guidelines for lead forming of SIP Hall Sensors* [17].
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 [17] 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*[17].
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 [17]
For other specific process, contact Melexis via www.melexis.com/technical-inquiry

5.4 Environment and sustainability

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

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

6. Glossary of terms & references

6.1 Glossary

Term	Description
Gauss (G), Tesla (T)	Units for the magnetic flux density – 1 mT – 10G
HE	Hall Element
TC	Temperature Coefficient (in ppm/Deg.C.)
NC	Not Connected
PWM	Pulse Width Modulation
%DC	Duty Cycle of the output signal i.e. $T_{ON}/(T_{ON}+T_{OFF})$
ADC	Analog-to-Digital Converter
DAC	Digital-to-Analog Converter
LSB/MSB	Least Significant Bit / Most Significant Bit
FIR	Finite Impulse Response
INL/DNL	Integral Non-Linearity / Differential Non-Linearity
CPU	Central Processing Units
CRC	Cycle Redundancy Check
EOL	End of Line
EMC	Electro-Magnetic Compatibility
DSP	Digital Signal Processing
FS	Output Full Scale (linear range) FS = ±40%VDD. VDD=5V ⇒ FS=±2V – VDD=3.3V ⇒ FS=±1.32V

Table 24: Glossary of terms

6.2 List of tables

6.3 List of figures

7. Revision history

Revision	Date	Change history
001	14-Nov-2025	First release version.
002	20-Nov-2025	Updated Die-Down package markings (fig. 26) and ratiometric sensitivity error value.
003	27-Apr-2026	Updated ESD voltage values for corner pins and die down availability.

Table 25 – Revision history

8. Disclaimer

The content of this document is believed to be correct and accurate. However, the content of this document is furnished "as is" for informational use only and no representation, nor warranty is provided by Melexis about its accuracy, nor about the results of its implementation. Melexis assumes no responsibility or liability for any errors or inaccuracies that may appear in this document. Customer will follow the practices contained in this document under its sole responsibility. This documentation is in fact provided without warranty, term, or condition of any kind, either implied or expressed, including but not limited to warranties of merchantability, satisfactory quality, non-infringement, and fitness for purpose. Melexis, its employees and agents and its affiliates' and their employees and agents will not be responsible for any loss, however arising, from the use of, or reliance on this document. Notwithstanding the foregoing, contractual obligations expressly undertaken in writing by Melexis prevail over this disclaimer.

This document is subject to change without notice, and should not be construed as a commitment by Melexis. Therefore, before placing orders or prior to designing the product into a system, users or any third party should obtain the latest version of the relevant information.
Users or any third party must determine the suitability of the product described in this document for its application, including the level of reliability required and determine whether it is fit for a particular purpose.

This document as well as the product here described may be subject to export control regulations. Be aware that export might require a prior authorization from competent authorities. The product is not designed, authorized or warranted to be suitable in applications requiring extended temperature range and/or unusual environmental requirements. High reliability applications, such as medical life-support or life-sustaining equipment or avionics application are specifically excluded by Melexis. The product may not be used for the following applications subject to export control regulations: the development, production, processing, operation, maintenance, storage, recognition or proliferation of:
1. chemical, biological or nuclear weapons, or for the development, production, maintenance or storage of missiles for such weapons;
2. civil firearms, including spare parts or ammunition for such arms;
3. defense related products, or other material for military use or for law enforcement;
4. any applications that, alone or in combination with other goods, substances or organisms could cause serious harm to persons or goods and that can be used as a means of violence in an armed conflict or any similar violent situation.

No license nor any other right or interest is granted to any of Melexis' or third party's intellectual property rights.

If this document is marked "restricted" or with similar words, or if in any case the content of this document is to be reasonably understood as being confidential, the recipient of this document shall not communicate, nor disclose to any third party, any part of the document without Melexis' express written consent. The recipient shall take all necessary measures to apply and preserve the confidential character of the document. In particular, the recipient shall (i) hold document in confidence with at least the same degree of care by which it maintains the confidentiality of its own proprietary and confidential information, but no less than reasonable care; (ii) restrict the disclosure of the document solely to its employees for the purpose for which this document was received, on a strictly need to know basis and providing that such persons to whom the document is disclosed are bound by confidentiality terms substantially similar to those in this disclaimer; (iii) use the document only in connection with the purpose for which this document was received, and reproduce document only to the extent necessary for such purposes; (iv) not use the document for commercial purposes or to the detriment of Melexis or its customers. The confidentiality obligations set forth in this disclaimer will have indefinite duration and, in any case, they will be effective for no less than 10 years from the receipt of this document.

This disclaimer will be governed by and construed in accordance with Belgian law and any disputes relating to this disclaimer will be subject to the exclusive jurisdiction of the courts of Brussels, Belgium.

The invalidity or ineffectiveness of any of the provisions of this disclaimer does not affect the validity or effectiveness of the other provisions.
The previous versions of this document are repealed.

IATF 16949 and ISO 14001 Certified

For the latest revision of this document, visit www.melexis.com/MLX91235
Happy to help you! www.melexis.com/contact