MLX91220 Integrated Current Sensor IC

Preliminary Datasheet

Features and Benefits

- Factory trimmed AC and DC current sensor
- Analog ratiometric or fixed output voltage
- Combining sensing element, signal conditioning & isolation in SOIC package
- No application programming required
- High speed sensing
  - DC to 300kHz bandwidth
  - 3µs response time
- Robust against external magnetic fields
- No magnetic hysteresis
- Double overcurrent detection (SOIC-16)
- Low ohmic losses of integrated conductor
  - 0.9mΩ SOIC-8 / 0.75mΩ SOIC-16
- SOIC-8 narrow body and SOIC-16 wide body package, RoHS compliant
- Lead free component, suitable for lead free soldering profile up to 260°C, MSL3
- Rated voltage isolation
  - 2.4kV_{RMS} for SOIC-8
  - 4.8kV_{RMS} for SOIC-16

SOIC-8

IEC60950-1:2005 + Am 1:2009 & 2:2013

pending

SOIC-16

IEC60950-1:2005 + Am 1:2009 & 2:2013

pending

Applications

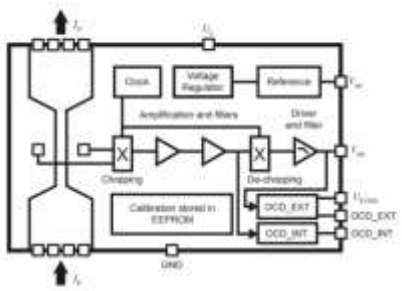
- On-board Chargers
- Electric Motor Control
- Inverters
- Maximum Power Point Tracking
- Switched Mode Power Supplies

Description

The MLX91220 is an Integrated Current Sensor that senses the current flowing through the leadframe of the SOIC package. The current conductor exhibits low power dissipation (0.75 - 0.9mΩ). By virtue of fixing the current conductor position with respect to the monolithic CMOS sensor, a fully integrated Hall-effect current sensor is obtained, that is factory calibrated.

Inside the package, the magnetic flux density generated by the current flow is sensed differentially by two sets of Hall plates. As a result the influence of external disturbing fields originating from the dense power electronics surrounding the IC is minimized in the fast analog front-end. The residual signal is amplified to provide a high-speed linear analog output voltage.

The close proximity of the Hall plates to the current conductor ensures a high signal-to-noise ratio and an accurate signal over temperature. With this miniaturization, high voltage isolation ratings are still maintained between the primary and their opposing secondary side leads of the package.



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1. Ordering Information

Product Code	Temperature Code	Package Code	Option Code	Packing Form Code	Availability
MLX91220	K	DC	ABF-025	RE	Sampling
MLX91220	K	DC	ABF-050	RE	Sampling
MLX91220	K	DC	ABR-025	RE	Development
MLX91220	K	DC	ABR-030	RE	Sampling
MLX91220	K	DC	ABR-050	RE	Sampling
MLX91220	K	DF	ABF-025	RE	Sampling
MLX91220	K	DF	ABF-050	RE	Sampling
MLX91220	K	DF	ABF-075	RE	Sampling
MLX91220	K	DF	ABR-025	RE	Development
MLX91220	K	DF	ABR-050	RE	Development

Legend:

Temperature Code:	K: from -40°C to 125°C
Package Code:	"DC" for SOIC-8 NB (Narrow Body – 150mils) package "DF" for SOIC-16 WB (Wide Body – 300mils) package
Option Code:	Axx-xxx: die version xBx-xxx: "B" for bipolar(1) and "U" for unipolar xxF-xxx: "F" for fixed mode output and "R" for ratiometric output xxx-0xx: "0" for default trimming xxx-x50: "50" for Full Scale current measurement (corresponding to 2V excursion from V_{OQ} in bipolar case)
Packing Form:	"RE" for Reel
Ordering Example:	MLX91220KDC-ABF-050-RE

Table 1 – Legend

(1) Bipolar output indicates that the sensor provides a symmetrical output around the 0A point which is set at half the output voltage (50% V_{DD}) in case of ratiometric mode, and V_{REF} equals 50%V_{DD} in case of fixed mode. Both designs imply sensing of positive and negative currents.

Melexis is continuously expanding its product portfolio by adding new option codes to better meet the needs of our customer's applications. This table is being updated frequently, please go to the [Melexis website]() to download the latest version of this datasheet. For custom transfer characteristics, please contact your local Melexis Sales representative or distributor.

2. Functional Diagram

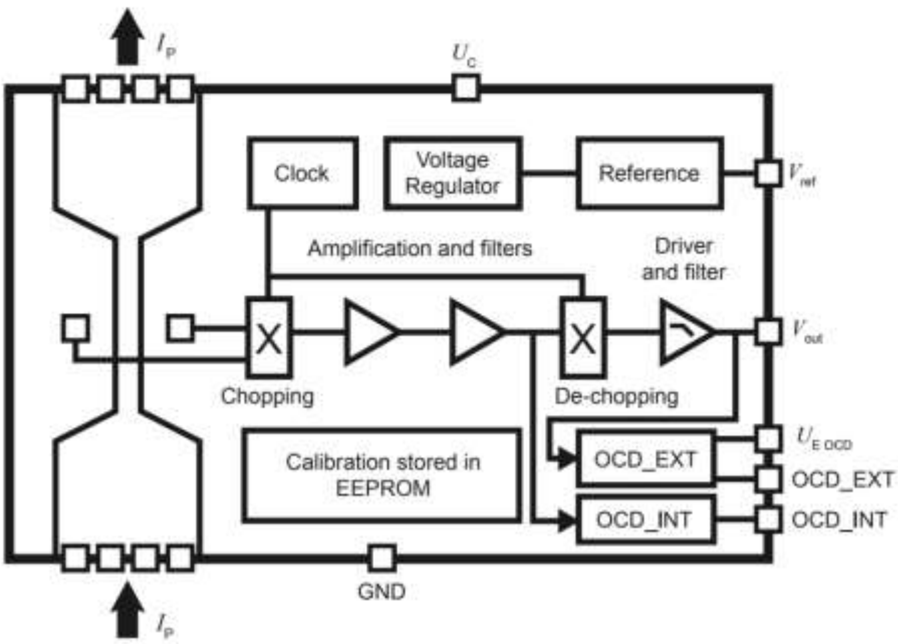
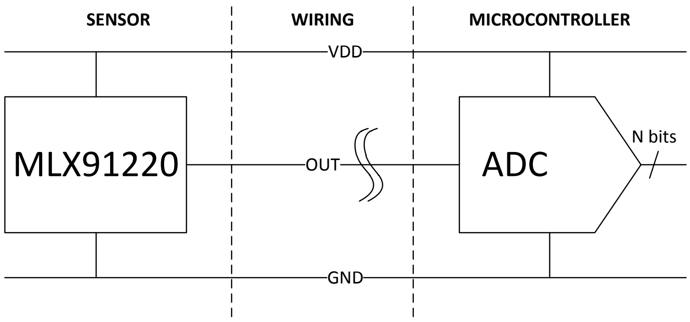


Figure 1 – Functional Diagram for MLX91220

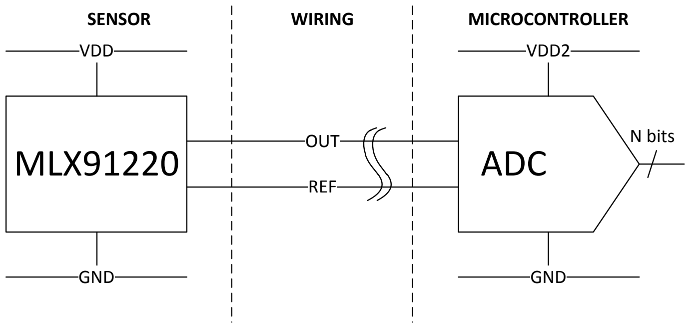
The sensor can be used in 2 different modes, depending on the application. Both modes rely on the output voltage of the sensor being proportional to the flow of current, but the difference resides in the signal reconstruction.

1. Ratiometric Mode



No matter if the VDD line is at 5V or deviating +/-10%, the ADC code for a given measured current will always be the same as the ADC is supplied by the same voltage as the sensor. The sensor has a sensitivity expressed in $\%V_{DD}/A$.

2. Differential or Fixed Mode



In this particular case the ADC does not necessarily share the same supply voltage with the sensor. For this reason , the sensor is calibrated with an absolute sensitivity regardless of the actual supply voltage. The output signal can be reconstructed by taking the difference between the output and the reference voltage from the IC. The ADC gets these two signals as inputs for establishing the sensed current accurately, and is not influenced by the supply voltage differences between both sensor and microcontroller, if applicable.

Parameter	Ratiometric Mode	Differential or Fixed Mode
Output Signal	V_{OUT} [%V_{DD}]	V_{OUT}-V_{REF} [V]
Offset	V_{OUT}[0A] = 50 [%V_{DD}] (programmable)	V_{REF} = 2.5 [V] (programmable) V_{OUT}[0A]-V_{REF} = 0 [V]
Offset ratiometric	Yes	No
Sensitivity	[%V_{DD}/A]	[mV/A]
Sensitivity ratiometric	Yes	No
Measured Current	(V_{OUT}-V_{OUT}[0A]) / Sensitivity	(V_{OUT}-V_{REF}) / Sensitivity

3. Glossary of Terms

Gauss (G), Tesla (T)	Units for the magnetic flux density - 1 mT = 10 G
TC	**T**emperature **C**oefficient (in ppm/°C)
NC	**N**ot **C**onnected
IP	**I**ntegrated **P**rimary
ASP	**A**nalog **S**ignal **P**rocessing
DSP	**D**igital **S**ignal **P**rocessing
AC	**A**lternate **C**urrent
DC	**D**irect **C**urrent
RAM	**R**andom **A**ccess **M**emory
EMC	**E**lectro-**M**agnetic **C**ompatibility
FS	**F**ull **S**cale
OCD	**O**ver**C**urrent **D**etection

Table 2 – Glossary of Terms

4. Pinout

PIN	SOIC-8		SOIC-16	
	Pin	Function	Pin	Function
1	IP+	Primary Current Path Input	IP+	Primary Current Path Input
2				
3	IP-	Primary Current Path Output		
4				
5	V_{SS}	Ground Voltage	IP-	Primary Current Path Output
6	V_{REF}	Reference Voltage		
7	V_{OUT}	Output Voltage		
8	V_{DD}	Supply Voltage		
9			V_{SS}	Ground Voltage
10			V_{REF}	Reference Voltage
11			*NC*	*Not connected*
12			V_{OUT}	Output Voltage
13			OCD_{EXT}	External Overcurrent detection
14			V_{DD}	Supply Voltage
15			VOC_{EXT}	External Overcurrent threshold voltage
16			OCD_{INT}	Internal Overcurrent Detection

For optimal EMC behavior, it is recommended to connect the unused pins (NC and TEST) to the Ground (see Chapter 12).

5. Absolute Maximum Ratings

Parameter	Value
Positive Supply Voltage (overvoltage)	+ 10 V
Reverse Supply Voltage	- 0.3 V
Positive Output Voltage	+ 10 V
Positive Output Current	+ 70 mA
Reverse Output Voltage	- 0.3 V
Reverse Output Current	- 50 mA
Operating Ambient Temperature Range, T_A	- 40°C to + 125°C
Storage Temperature Range, T_S	- 55°C to + 165°C
Maximum Junction Temperature, T_J	+ 165°C

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

For more information on how the junction temperature relates to the applied current and ambient temperature range, please refer to section 7.

6. MLX91220 Electrical Specification

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Nominal Supply Voltage	V_{DD}		4.5	5	5.5	V
Supply Current	I_{DD}	Without RLOAD, in application mode	14	17	21	mA
DC Load Current	I_{OUT}	R_{LOAD} in range [6kΩ, 100kΩ]	-2		2	mA
Maximum Output Current (driving capability)	I_{MAX}	V_{OUT} can cover 3%Vdd to 97%Vdd span	-2		2	mA
Output Resistance	R_{OUT}	V_{OUT} = 50%V_{DD}, R_{LOAD} = 10kΩ		1	5	Ω
Output Capacitive Load	C_{LOAD}	Output amplifier stability is optimized for this typical value	0	4.7	6	nF
Output Resistive Load	R_{LOAD_PU} R_{LOAD_PD}	Output resistive load for high linearity (pull-up or pull-down)	6			kΩ
Output Short Circuit Current	I_{SHORT}	Output shorted to V_{DD} or V_{SS} - Permanent	35		180	mA
Output Leakage current	I_{LEAK}	High impedance mode, T_A=150°C	0.5	1.5	20	µA
Output Voltage Linear Swing	V_{OUT_LSW}	Pull-down or pull-up ≥ 10 kΩ	10		90	%V_{DD}
High-impedance Mode Levels	$V_{OUT\_HIZ\_PU}$	R_{LOAD_PU} ≤ 25kΩ, T_A ≤ 125°C	95			%V_{DD}
	$V_{OUT\_HIZ\_PD}$	R_{LOAD_PD} ≤ 25kΩ, T_A ≤ 125°C			5	%V_{DD}

7. MLX91220 Current Specification

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Electrical Resistance of the Primary Current Path	R_{IP_SOIC8} R_{IP_SOIC16}	T_A=25°C		0.9 0.75		mΩ mΩ
Measurement Range	IP_{MAX}	Option Code ABx-025 Option Code ABx-030 Option Code ABx-050 Option Code ABx-075		25 30 50 75		A A A A
Linearity Error	NL	Current in range IP_{MAX}, T_A=25°C		±0.6		%FS
Current Capability[(2)] (see also Figure 2 & Figure 3)	IP_{C85_SOIC8} IP_{C25_SOIC8} IP_{T25_SOIC8}	Continuous, T_A=-40 to 85°C Continuous, T_A=25°C Transient, 1ms pulse, T_A=25°C		 ±100	±25 ±35 	A A A
	IP_{C85_SOIC16} IP_{C25_SOIC16} IP_{T25_SOIC16}	Continuous, T_A=-40 to 85°C Continuous, T_A=25°C Transient, 1ms pulse, T_A=25°C		 ±100	±30 ±40 	A A A

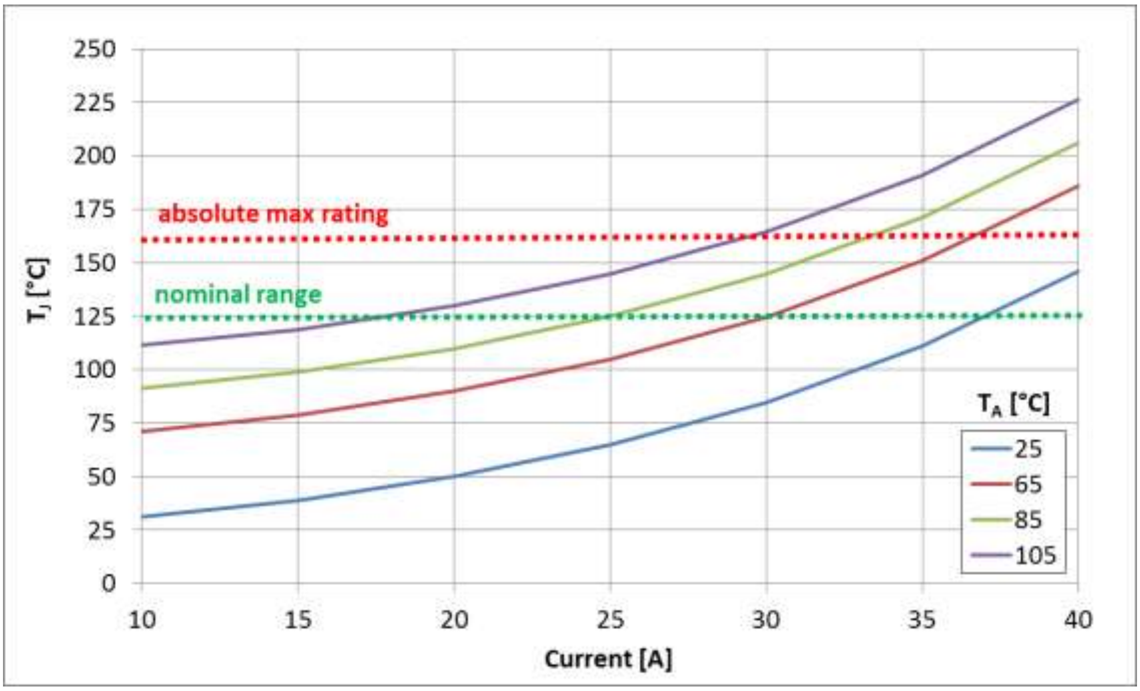


Figure 2 – Typical junction temperature [°C] on SOIC8 vs applied current [A] and ambient temperature [°C].

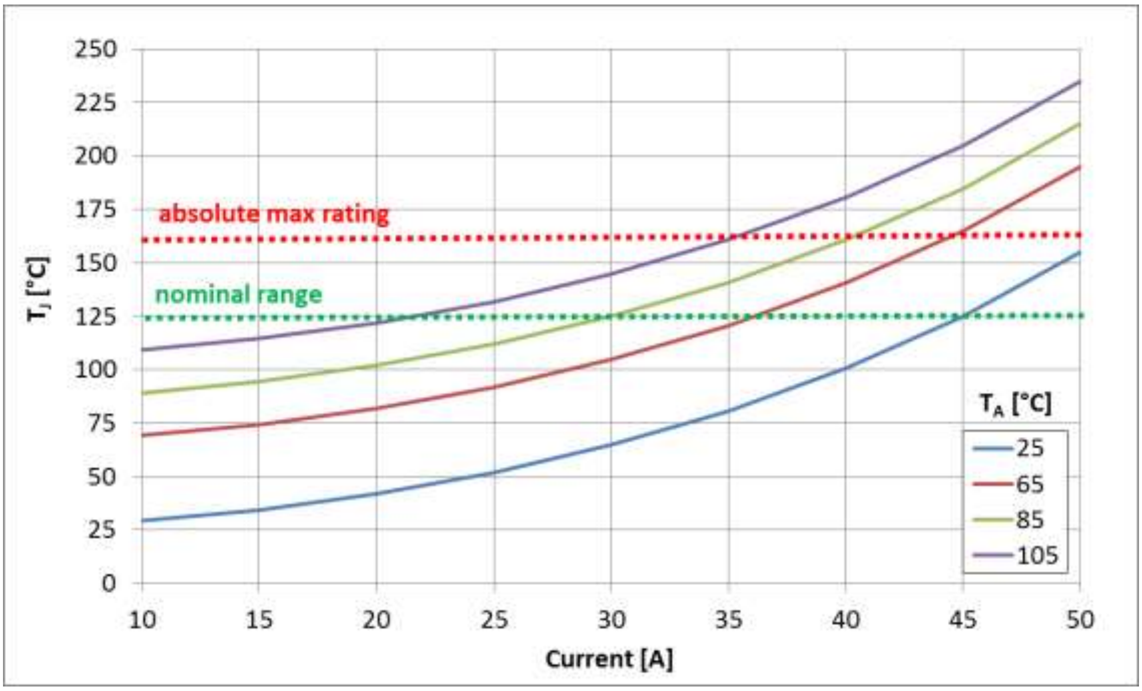


Figure 3 – Typical junction temperature [°C] on SOIC16 vs applied current [A] and ambient temperature [°C].

(2) Current capability has been assessed on a Melexis evaluation board with 2oz of Copper on 2 layers, and is the steady state thermal situation after several minutes of settling time. Although the linear measurement range is wider, the steady-state DC current or RMS current should be chosen such that it does not bring the junction temperature above the operating temperature range. Having the heatsink designed such that it can extract the heat generated inside the IC will extend the maximum current capability. Please contact Melexis for further information about the thermal aspects of your design.

8. MLX91220 Voltage Isolation Specification

Parameter	Symbol	Test Conditions	Rating	Units
Dielectric Strength Test Voltage (3) (4)	V_{ISO_SOIC8}	IEC/UL60950-1:2005 + Am 1:2009 + Am 2:2013	2400	V_{RMS}
	V_{ISO_SOIC16}		4800	

(3) Agency type tested, measured between IP (pin 1-4 on SOIC8, pin 1-8 on SOIC16) and Secondary side (pin 5-8 on SOIC8, pin 9-16 on SOIC16).
(4) Melexis performs routine production-line tests, for all SOIC8 & SOIC16 devices produced.

9. MLX91220 Timing Specification

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Refresh rate	T_{RR}		0.4	0.5	0.6	µs
Step Response Time	T_{RESP}	Delay between the input signal reaching 90% and the output reaching 90% (see Figure 4)			2	µs
Bandwidth	BW	-3dB, T_A =25°C		300		kHz
Power on Delay(5)	T_{POD}	V_{OUT} = 100% of FS, $R_{LOAD\_PD} \leq 100k\Omega$			1	ms

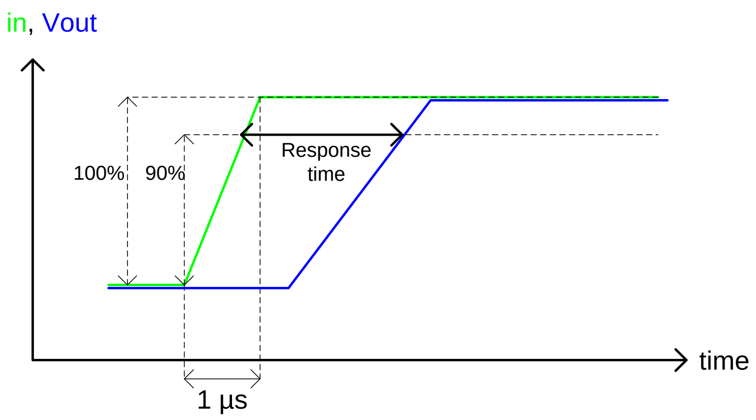


Figure 4 – Response Time definition

(5) During the Power-on delay, the output will remain within the 10% fault band at all time.

10. MLX91220 Accuracy Specification

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Voltage Reference	V_{REF}	T_A=25°C, ABF-xxx versions T_A=25°C, AUF-xxx versions		2.5 0.5		V V
Thermal Reference Drift	ΔT_{VREF}	Variation versus 25°C			±200	ppm/°C
Voltage Output Quiescent	V_{OQ}	No current flowing through IP, V_{OUT} –V_{DD}/2 (ratiometric) or V_{OUT}-V_{REF} (fixed), T_A=25°C Option Code : ABx-025 Option Code : ABx-030 Option Code : ABx-050 Option Code : ABx-075	-5 -63 -75 -125 -188	0	5 63 75 125 188	mV mA mA mA mA
Thermal Offset Drift	ΔT_{VOQ}	Referred to T_A=25°C, IP = 0A Option Code : ABx-025 Option Code : ABx-030 Option Code : ABx-050 Option Code : ABx-075		±5 ±63 ±75 ±125 ±188	±7.5 ±94 ±113 ±188 ±282	mV mA mA mA mA
Sensitivity	S	At T_A=25°C Option Code : ABx-025 Option Code : ABx-030 Option Code : ABx-050 Option Code : ABx-075	 79.2 66.0 39.6 26.4	±1 80 66.7 40 26.7	 80.8 67.4 40.4 27.0	% mV/A mV/A mV/A mV/A
Thermal Sensitivity Drift	ΔT_S	Current range IP_{MAX}		±1	±1.5	%S
Output Noise Spectral Density(6)	N_{SD}	within BW = 1 .. 100kHz Option Code : ABx-025 Option Code : ABx-030 Option Code : ABx-050 Option Code : ABx-075		 169 171 175 188		 $\mu A_{RMS}/\sqrt{Hz}$ $\mu A_{RMS}/\sqrt{Hz}$ $\mu A_{RMS}/\sqrt{Hz}$ $\mu A_{RMS}/\sqrt{Hz}$
Output RMS Noise	N_{RMS}	BW = 300kHz Option Code : ABx-025 Option Code : ABx-030 Option Code : ABx-050 Option Code : ABx-075		 92 93 96 103		 mA_{RMS} mA_{RMS} mA_{RMS} mA_{RMS}

(6) Further output filtering possible with RC load circuitry on the output pin, impacting response time.

11. MLX91220 Overcurrent Detection

11.1. General

The MLX91220 provides two OCD features that allow detecting overcurrent applied on the integrated sensor primary. In case of OCD detection, the OCD_{INT} or OCD_{EXT} is pulled to ground. During normal operation the OCD voltage remains at V_{DD}. This OCD feature is available for SOIC16 version only.

The two OCD functions are able to react to an overcurrent event within few us of response time. To avoid false alarm, the overcurrent has to be maintained at least 1µs for the detection to occur. After detection by the sensor the output flag is maintained for 10µs of dwell time. This allows the overcurrent to be easily detected at microcontroller level.

The following table offers a comparison between OCD_{INT} and OCD_{EXT}:

	OCD_{INT}		OCD_{EXT}	
	Min	Max	Min	Max
Typical Application	Short-circuit detection		Out-of-range detection	
Overcurrent effect	OCD_{INT} pin to V_{SS}		OCD_{EXT} pin to V_{SS}	
Detection mode	Bidirectional		Unidirectional / bidirectional	
Accuracy	Lower		Higher	
Threshold trimming	EEPROM		Voltage divider on VOC_{EXT}	
Response time	1.4µs	2.1µs	10µs typical	
Required Input holding time	1µs		1µs	
OCD output dwell time	10µs		10µs	

Table 5 – Comparison between OCD_{INT} and OCD_{EXT} performances

11.2. Internal Overcurrent Detection Principle

The internal OCD takes fixed threshold voltage values predefined in the EEPROM and do not require any extra components. The OCD_{INT} implementation allows detecting overcurrent outside of the output measurement range of the sensor and is therefore suitable for large current peaks as occurring during short-circuit. If the theoretical sensor output overcomes the OCD_{INT} voltage threshold, the overcurrent event is flagged on OCD_{INT} pin. The internal OCD offers a faster response than OCD_{EXT} but the threshold is defined less accurately. The default OCD threshold voltages are defined as follow, but other values can be set on request. The overcurrent threshold in ampere is deduced from the sensitivity of the sensor [mV/A] and the OCD_{INT} threshold voltage.

	Sensor configuration	Min.	Default	Max.
OCD_{INT} Threshold Voltage	V_{DD} = 5V / V_{REF} = 2.5V	V_{REF} ±0.54V	V_{REF} ±2.34V	V_{REF} ±4.61V
	V_{DD} = 3.3V / V_{REF} = 1.65V or 1.5V		V_{REF} ±1.53V	
	V_{DD} = 5V / V_{REF} = 0.5V		V_{REF} ±4.61V	

Table 4: OCD_{INT} factory programmable threshold voltages

11.3. External Overcurrent Detection Principle

The external OCD uses the voltage applied on VOC_{EXT} pin as threshold voltage. This translates into an overcurrent threshold in ampere depending on the sensitivity of the sensor. A voltage divider on VOC_{EXT} allows defining the threshold voltage in a custom way. Depending on the voltage divider configuration, the OCD_{EXT} can be used either in bidirectional or unidirectional mode. The External OCD threshold is defined within the measurement range of the sensor output. This feature is then suitable for out-of-range detection where the OCD threshold remains close to the nominal current. It offers a better accuracy than OCD_{INT} but the response is slower. The below table presents the unidirectional and bidirectional external OCD configurations. Please refer to section 13.1 and 13.3 for more details about the application diagram and the recommended resistances.

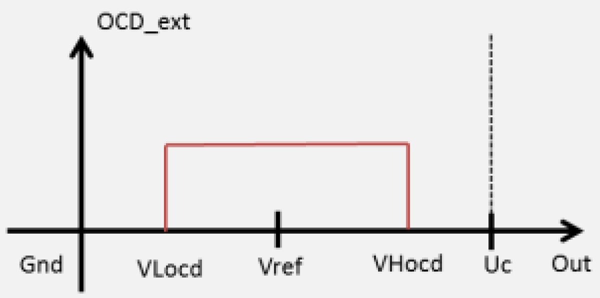
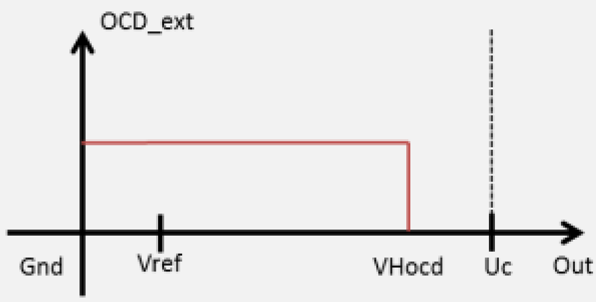
Bidirectional configuration	Unidirectional configuration
	
	
$VOC_{EXT} = V_{REF} * \frac{R_{ext}}{R_{ext} + R_{ext\_bi}}$ $VLocd = VOC_{EXT}$ $VHocd = Uc - VLocd$	$VOC_{EXT} = V_{REF} + (V_{DD} - V_{REF}) * \frac{R_{ext\_uni}}{R_{ext} + R_{ext\_uni}}$ $VHocd = VOC_{EXT}$

Table 5: External OCD, bidirectionnal and unidirectional configurations

12. Recommended Application Diagrams

12.1. Resistor and Capacitor Values

Part	Description	Value	Unit
C_1	Supply capacitor, EMI, ESD	47	nF
C_2	Decoupling, EMI, ESD	47	nF
C_3	Decoupling, EMI, ESD	4.7	nF
R_{EXT} + R_{EXT_BI} / R_{EXT_UNI}	External OCD Resistor	~200	kΩ
R_{EXT_BI} or R_{EXT_UNI}	External OCD Resistor	custom	-

Table 6 – Resistor and Capacitor Values for Recommended Application Diagrams

12.2. SOIC8 Application Diagram

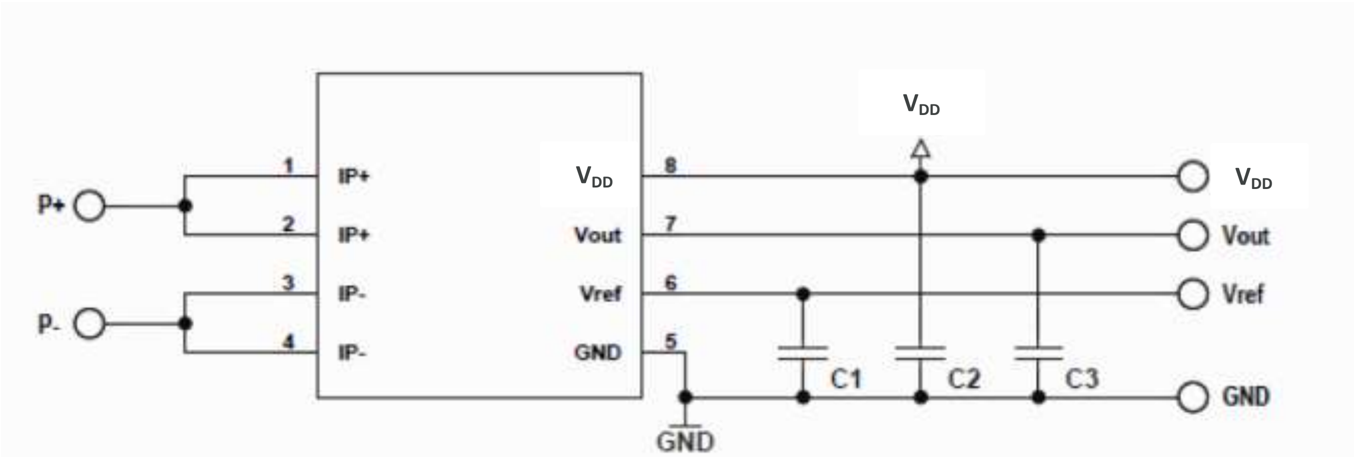


Figure 5 – Recommended wiring for the MLX91220 in SOIC-8 package

12.3. SOIC16 Application Diagram

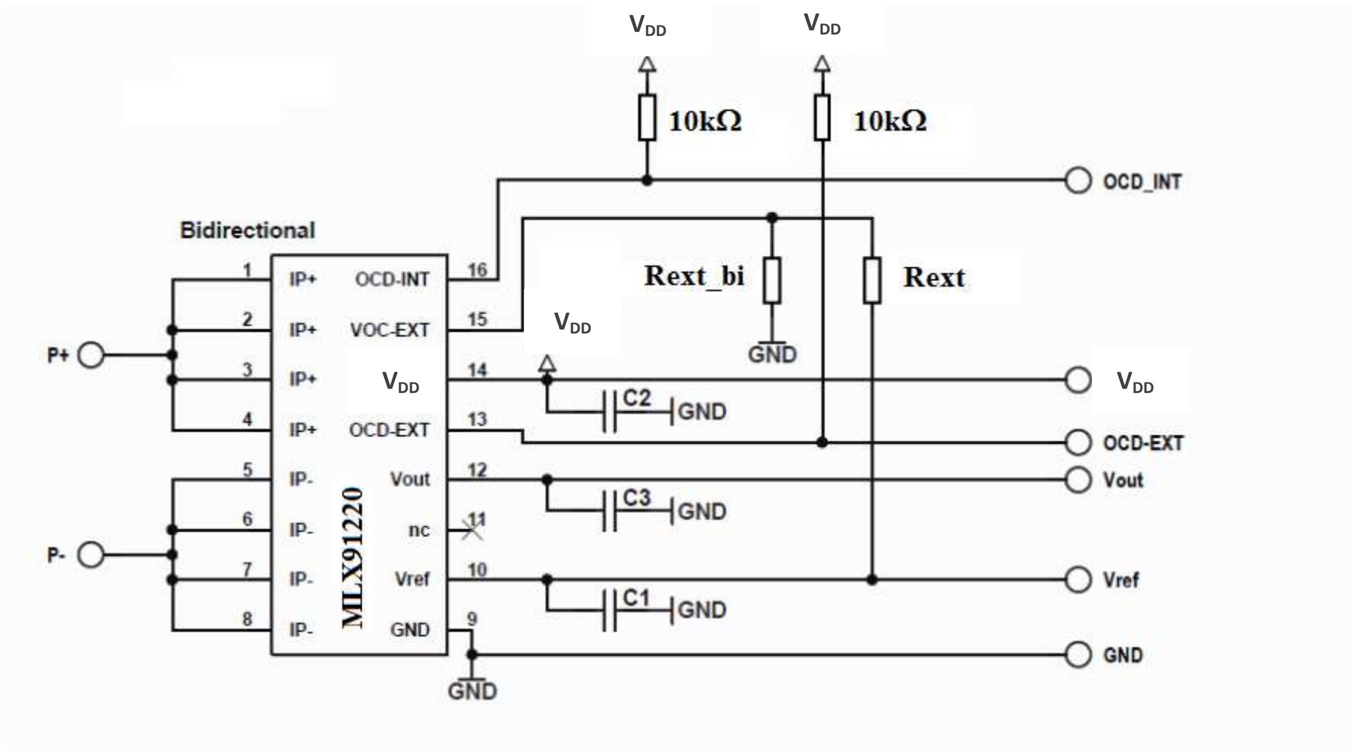


Figure 6 – Recommended wiring for the MLX91220 with Bidirectionnal External OCD

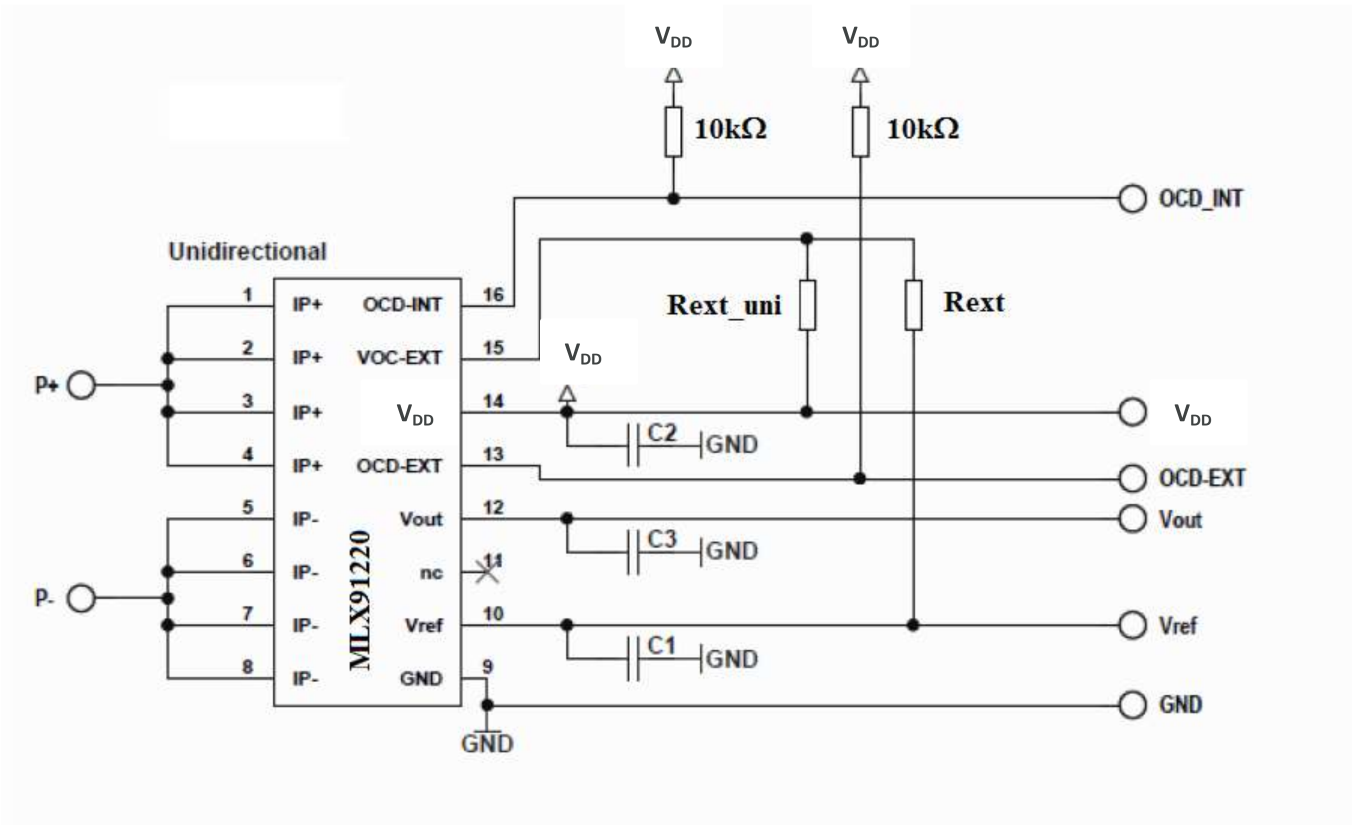


Figure 7 – Recommended wiring for the MLX91220 with Unidirectionnal External OCD

13. Standard information regarding manufacturability with different soldering processes

Our products are classified and qualified regarding soldering technology, solderability and moisture sensitivity level according to following test methods:

Reflow Soldering SMD's (Surface Mount Devices)

- IPC/JEDEC J-STD-020

  Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices (classification reflow profiles according to table 5-2)

- EIA/JEDEC JESD22-A113

  Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing (reflow profiles according to table 2)

Wave Soldering SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

- EN60749-20

  Resistance of plastic- encapsulated SMD's to combined effect of moisture and soldering heat

- EIA/JEDEC JESD22-B106 and EN60749-15

  Resistance to soldering temperature for through-hole mounted devices

Iron Soldering THD's (Through Hole Devices)

- EN60749-15

  Resistance to soldering temperature for through-hole mounted devices

Solderability SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

- EIA/JEDEC JESD22-B102 and EN60749-21

  Solderability

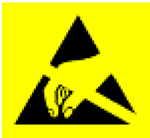
For all soldering technologies deviating from above mentioned standard conditions (regarding peak temperature, temperature gradient, temperature profile etc) additional classification and qualification tests have to be agreed upon with Melexis.

The application of Wave Soldering for SMD's is allowed only after consulting Melexis regarding assurance of adhesive strength between device and board.

Melexis recommends reviewing on our web site the General Guidelines soldering recommendation (https://www.melexis.com/en/quality-environment/soldering).

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

14. ESD Precautions



Electronic semiconductor products are sensitive to Electro Static Discharge (ESD).

Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

Parameter	Symbol	Test Method	Value	Unit
Human Body ESD Protection	ESD_{HBM}	AEC-Q100-002 Rev D	2	kV
Charged Device Model ESD Protection	ESD_{CDM}	AEC-Q100-011 Rev B	500	V

Table 7 – Electrostatic Discharge Ratings

15. Package Information

15.1. SOIC-8 150mils - Package Dimensions

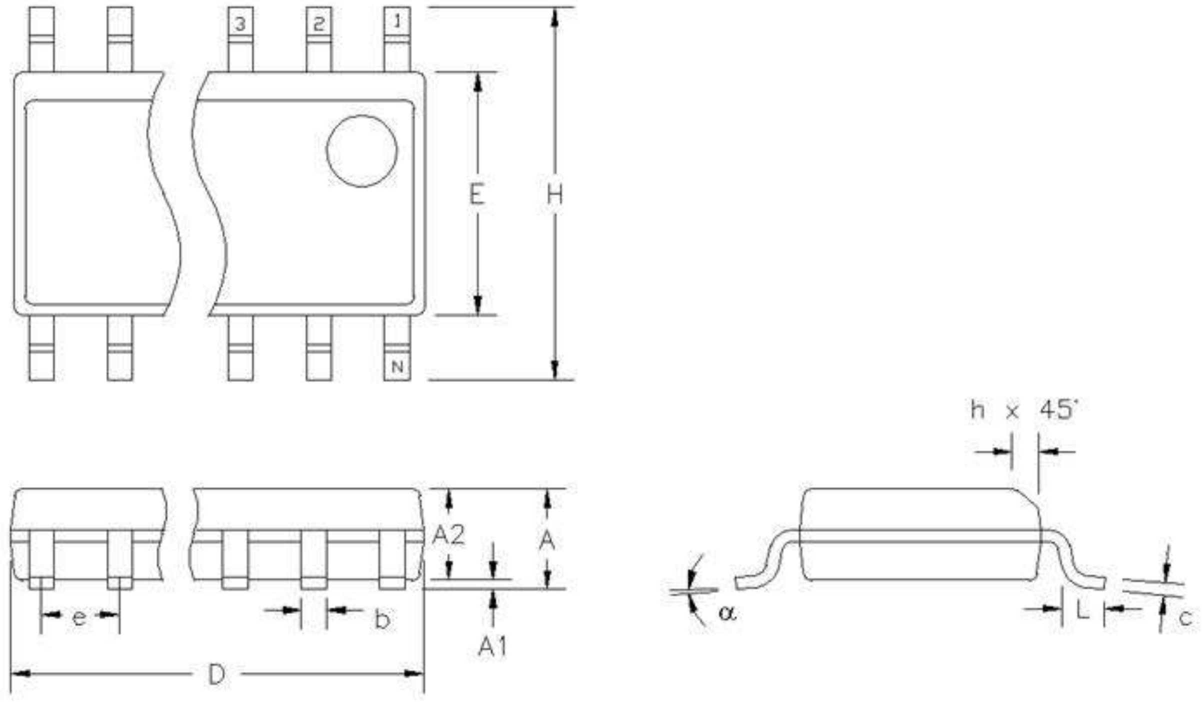


Figure 7 – SOIC8 Package Dimensions [inches]

[mm]	A	A1	A2	D	E	H	L	b	c	e	h	⍰
min	1.52	0.10	1.37	4.80	3.81	5.80	0.41	0.35	0.19	1.27 BSC	0.25	0°
max	1.73	0.25	1.57	4.98	3.99	6.20	1.27	0.49	0.25		0.50	8°

[inch]	A	A1	A2	D	E	H	L	b	c	e	h	⍰
min	.060	.004	.054	.189	.150	.228	.016	.014	.008	.050 BSC	.010	0°
max	.068	.010	.062	.196	.157	.244	.050	.019	.010		.020	8°

15.2. SOIC-16 300mils - Package Dimensions

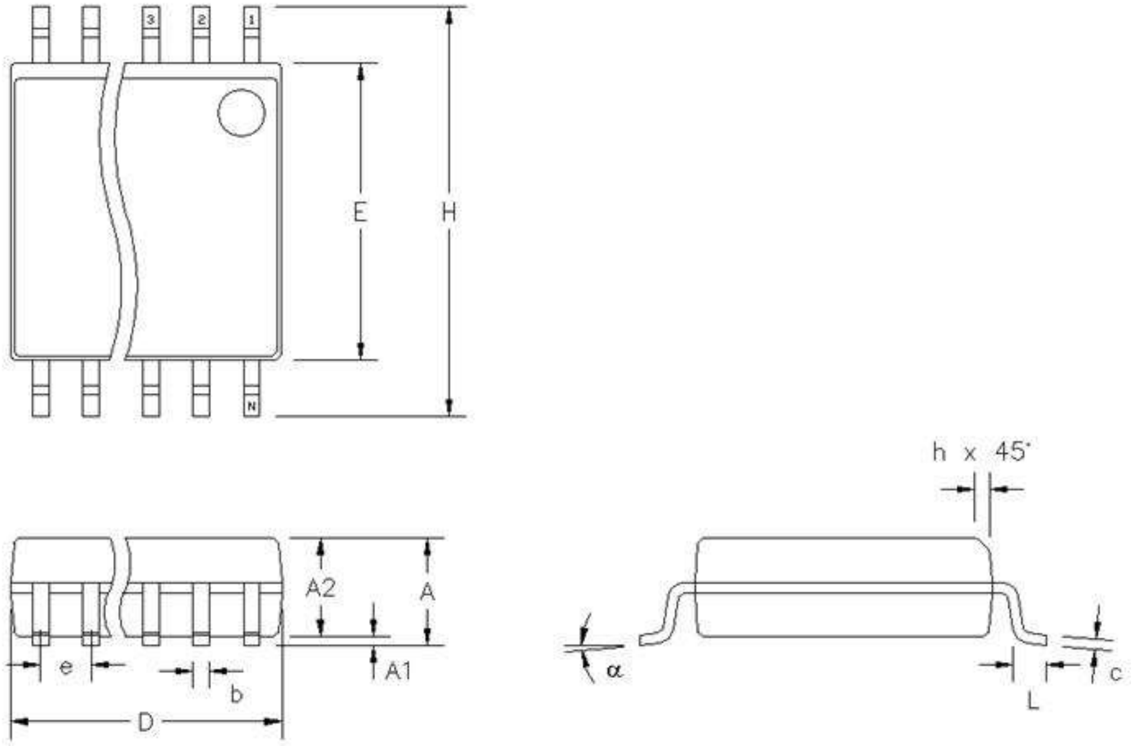


Figure 8 – SOIC16 Package Dimensions [inches]

[mm]	A	A1	A2	D	E	H	L	b	c	e	h	⍰
min	2.44	0.10	2.24	10.11	7.40	10.11	0.51	0.35	0.23	1.27 BSC	0.25	0°
max	2.64	0.30	2.44	10.46	7.60	10.51	1.02	0.48	0.32		0.71	8°

[inch]	A	A1	A2	D	E	H	L	b	c	e	h	⍰
min	.096	.004	.088	.398	.291	.398	.020	.014	.009	.050 BSC	.010	0°
max	.104	.012	.096	.412	.299	.414	.040	.019	.013		.028	8°

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