MLX91216

High Speed Current Sensor IC

Datasheet

1. Features and Benefits

- IMC-Hall® Technology
- High Field, Very High Field and Extra High Field variants
- End-of-line programmable sensor
- Selectable analog ratiometric output
- Programmable sensitivity from ±20 to ±350mV/mT
- Measurement range up to 90 mT
- Wideband sensing: DC to 250kHz
- Very fast response time (2µs)
- High linearity down to ±0.2% full scale
- Very low thermal drift
    - Offset drift (<5mV)
    - Sensitivity drift (<1%)
- Programmable output clamping levels
- Broken wire detection and diagnostics
- AEC-Q100 – Grade 0 Automotive Qualified
- RoHS compliant
- SOIC-8 package
- MSL-3

2. Application Examples

- High Voltage Traction Motor Inverter
- 48V Boost Recuperation Inverter
- DCDC Converter
- Smart Battery Junction Boxes
- Smart Fuse Overcurrent Detection

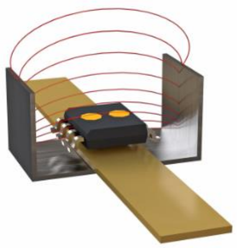


Figure 1. Typical IMC-Hall® Current Sensing Application

3. Description

The MLX91216 is a monolithic Hall-effect sensor utilizing the IMC-Hall® technology. The sensor provides an analog output voltage proportional to the applied magnetic flux density parallel to the IC surface.

The transfer characteristic of the MLX91216 is factory trimmed over temperature, and is programmable (offset, sensitivity, clamping, filtering) during end-of-line customer calibration. The output clamping levels and on-chip filtering are also programmable as a function of application needs. With the 250kHz bandwidth and fast response time, it is particularly adapted for high speed applications such as inverters and converters where fast response time due to fast switching is required.

In a typical current sensing application, the sensor is used in combination with a U-shaped shield which facilitates the mechanical assembly of the current sensor over traditional ferromagnetic cores. This shield is recommended to be laminated for high bandwidth applications. The MLX91216 can then be mounted over the bus bar and separated from it by the PCB. As the shield does not serve the primary purpose of concentration, it can be made smaller and lighter than ferromagnetic cores without losing signal thanks to the integrated magnetic concentrator (IMC) depicted also in Figure 1. Typical IMC-Hall® Current Sensing Application. As a result, dense power electronics can be achieved enabling system savings and surface mount assembly.

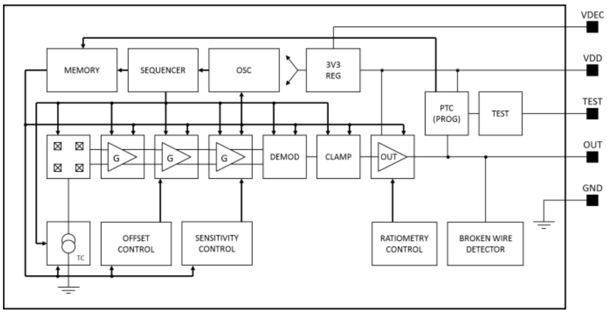


Figure 2. General Block Diagram

Contents

4. Ordering Information

Product	Temperature	Package	Option Code	Packing Form	Typical Sensitivity
MLX91216	L	DC	ACH – 000	RE	100 mV/mT *(prog: 50..350mV/mT)*
MLX91216	L	DC	ACV – 000	RE	40 mV/mT *(prog: 30..200mV/mT)*
MLX91216	L	DC	ACV – 001	RE	60 mV/mT *(prog: 30..200mV/mT)*
MLX91216	L	DC	ACV – 002	RE	30 mV/mT *(prog: 30..200mV/mT)*
MLX91216	L	DC	ACX – 000	RE	25 mV/mT *(prog: 20..125mV/mT)*
MLX91216	L	DC	ACX – 001	RE	30 mV/mT *(prog: 20..125mV/mT)*
MLX91216	L	DC	ACX – 002	RE	20 mV/mT *(prog: 20..125mV/mT)*

Table 1: Available ordering codes.

Legend:

Temperature Code:	**L**	from -40°C to 150°C ambient temperature
Package Code:	**DC**	for SOIC8 package, refer to Chapter 17 for detailed drawings
Option Code:	**ACH-000**	for sensitivity 100 mV/mT; *(programmable range: 50-350mV/mT)*
	ACV-000	for sensitivity 40 mV/mT; *(programmable range: 30-200mV/mT)*
	ACV-001	for sensitivity 60 mV/mT; *(programmable range: 30-200mV/mT)*
	ACV-002	for sensitivity 30 mV/mT; *(programmable range: 30-200mV/mT)*
	ACX-000	for sensitivity 25 mV/mT; *(programmable range: 20-125mV/mT)*
	ACX-001	for sensitivity 30 mV/mT; *(programmable range: 20-125mV/mT)*
	ACX-002	for sensitivity 20 mV/mT; *(programmable range: 20-125mV/mT)*
Packing Form:	**RE**	for Plastic Reel.
Ordering Example:	“**MLX91216LDC-ACV-001-RE**” MLX91216 IMC-Hall® current sensor in SOIC8 package, temperature range -40°C to 150°C. Sensitivity 60mV/mT. Parts delivered in Plastic Reel.	

5. Functional Diagram

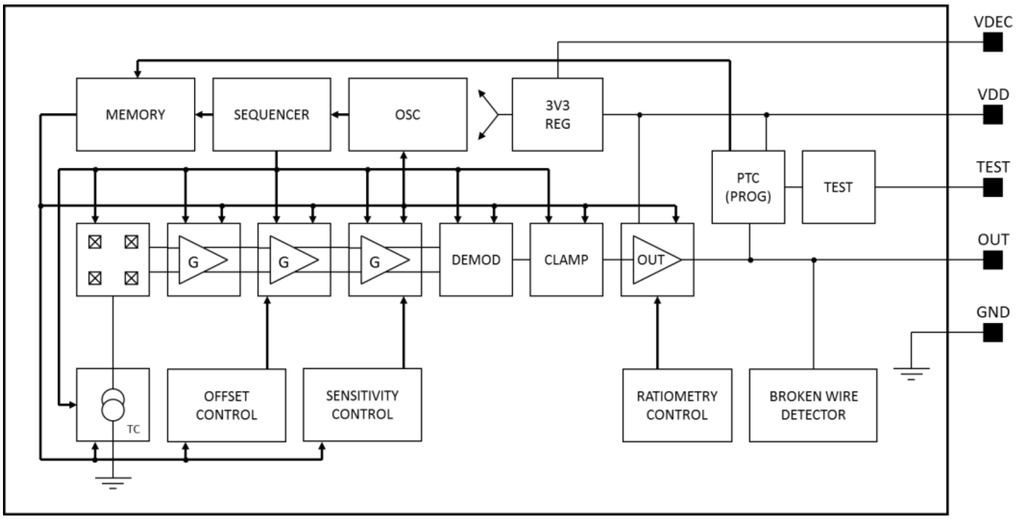


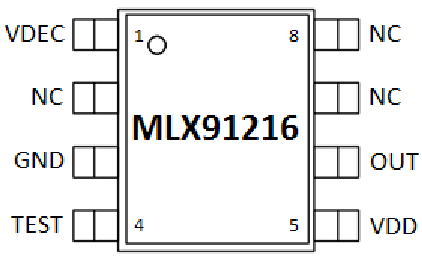
Figure 3: MLX91216 Block Diagram

6. Glossary of Terms

Terms	Definition
TC	Temperature Coefficient
FS	Full Scale, output referred. Corresponds to 2V excursion around 2.5V V_{OQ} point
T, mT	Tesla, milliTesla = units for the magnetic flux density
G	Gauss = unit for the magnetic flux density [1mT = 10G]
PTC	Programming Through Connector
IMC	Integrated Magnetic Concentrator

Table 2: Glossary of Terms

7. Pin Definitions and Descriptions



Pin #	Name	Type	Description
1	VDEC	Digital	Digital Supply Voltage
2	NC	-	Not Connected
3	GND	Ground	Supply Voltage
4	TEST	Digital	Test and Factory Calibration
5	VDD	Supply	Supply Voltage
6	OUT	Analog	Current Sensor Output
7,8	NC	-	Not Connected

Table 3: Pin definitions and descriptions (MLX91216 is pin-to-pin compatible with MLX91208)

For optimal EMC performance, it is recommended to connect the unused (NC) pins to the Ground.

8. Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Positive Supply Voltage (overvoltage)	V_{DD}	+10	V
Reverse Voltage Protection	VS_{REV}	-0.3	V
Positive Output Voltage	V_{OUT}	+10	V
Output Current	I_{OUT}	±70	mA
Reverse Output Voltage	VO_{REV}	-0.3	V
Reverse Output Current	IO_{REV}	-50	mA
Maximum Junction Temperature	Tj,max	-55 to 155	°C
Operating Ambient Temperature Range	T_A	-40 to +150	°C
Storage Temperature Range	T_S	-55 to +165	°C
Package Thermal Resistance *(junction-to-ambient)* θ_{ja} *is defined according to JEDEC 1s0p board*	θ_{ja}	174	°C/W
ESD – Human Body Model *(Applicable for all pins)*	ESD_{HBM}	2	kV
Magnetic Flux Density	B_{MAX}	±3	T

Table 4: Absolute maximum ratings

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

9. General Electrical Specifications

Operating Parameters T_A = -40 to 150°C, V_{DD} = 5V±10%, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Nominal Supply Voltage	V_{DD}		4.5	5	5.5	V
Supply Current	I_{DD}	No OUT load LOW_POWER_MODE=0[1] LOW_POWER_MODE=1		 12.5 10	 15 13	 mA mA
Output Impedance	R_{OUT}	Vout = 50% Vdd, RL = 10kΩ		1	5	Ω
Output Capacitive Load	C_L	OUT_MODE=0[1] OUT_MODE=1	1 10		10 47	nF nF
Output Resistive Load	R_L	Output resistive load for high linearity and diagnostic band.	10	25	200	kΩ
Output Short Circuit Current	I_{SHORT}	Output shorted permanent to VDD. Output shorted permanent to GND.		Not Destroyed Not Destroyed		
Linear Output Range	VO_{LIN}	pull-down ≥ 10 kΩ	10		90	%Vdd
Diagnostic Band[2]	DIAG	R_L ≥ 10kΩ, R_L ≤ 200 kΩ, V_{DD} =5V DIAG_LEVEL = 0 DIAG_LEVEL = 1	 0 96		 4 100	 %Vdd %Vdd
BrokenGND Output Level[2]		R_L ≥ 10kΩ, V_{DD} = 5V	96		100	%Vdd
BrokenVDD Output Level[2]		R_L ≥ 10kΩ, V_{DD} = 5V	0		4	%Vdd
Under-voltage detection[2]	V_{DD_UVD}	Detected Voltage (Low to High)	4.0		4.5	V
	V_{DD_UVH}	Hysteresis	0.01		0.2	V
Over-voltage detection 1[2]	V_{DD_OVD1}	Detected Voltage (Low to High)	6.7		7.4	V
	V_{DD_OVH1}	Hysteresis	0.37		0.66	V
Over-voltage detection 2[2]	V_{DD_OVD2}	Detected Voltage (Low to High)	8.3		9.5	V
	V_{DD_OVH2}	Hysteresis	0.2		0.8	V
Clamped Output Level	Clamp_lo0	CLAMP_LEVEL=0	5	6	7	%Vdd
	Clamp_hi0	CLAMP_LEVEL=0	92	93	94	%Vdd
	Clamp_lo1	CLAMP_LEVEL=1	5	6	7	%Vdd
	Clamp_hi1	CLAMP_LEVEL=1	93	94	95	%Vdd
	Clamp_lo2	CLAMP_LEVEL=2	7	8	9	%Vdd
	Clamp_hi2	CLAMP_LEVEL=2	91	92	93	%Vdd
	Clamp_lo3	CLAMP_LEVEL=3	9	10	11	%Vdd
	Clamp_hi3	CLAMP_LEVEL=3	89	90	91	%Vdd

Table 5: General electrical parameters

[1] *Default Factory Calibration*
[2] *Please refer to section 12 for more information on self-diagnostic modes.*

10. Magnetic specification

Operating Parameters T_A = -40 to 150°C, V_{DD} = 5V±10%, unless otherwise specified.

10.1. High Field version (option code ACH)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Operational Magnetic Field Range	B_{OP}				±25	mT
Linearity Error (Magnetic)	NL	B within B_{OP}, T_A = 25°C			±0.5	%FS
Hysteresis – Remanent Field	B_R	Measured after B = B_{OP}			±25	µT
Programmable Sensitivity	S	MLX91216LDC-ACH-000	50	100	350	mV/mT
Sensitivity Programming Resolution	S_{RES}	B = B_{OP}		0.1		%

Table 6: Magnetic specification High Field version

10.2. Very High Field version (option code ACV)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Operational Magnetic Field Range	B_{OP}				±60	mT
Linearity Error (Magnetic)	NL	B within B_{OP}, T_A = 25°C			±0.5	%FS
Hysteresis – Remanent Field	B_R	Measured after B = B_{OP}			±60	µT
Programmable Sensitivity	S	MLX91216LDC-ACV-000 MLX91216LDC-ACV-001	30 30	40 60	200 200	mV/mT
Sensitivity Programming Resolution	S_{RES}	B = B_{OP}		0.1		%

Table 7: Magnetic specification Very High Field version

10.3. Extra High Field version (option code ACX)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Operational Magnetic Field Range	B_{OP}				±90	mT
Linearity Error (Magnetic)	NL	B within B_{OP}, T_A = 25°C			±0.5	%FS
Hysteresis – Remanent Field	B_R	Measured after B = B_{OP}			±90	µT
Programmable Sensitivity	S	MLX91216LDC-ACX-000 MLX91216LDC-ACX-001 MLX91216LDC-ACX-002	20 20 20	25 30 20	125 125 125	mV/mT
Sensitivity Programming Resolution	S_{RES}	B = B_{OP}		0.1		%

Table 8: Magnetic specification Extra High Field version

11. Analog output specification

11.1. Accuracy specifications

Operating Parameters T_A = -40 to 150°C, V_{DD} = 5V±10%, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Thermal Offset Drift	$\Delta^T V_{OQ}$	T_A = -40 to 125°C T_A = -40 to 150°C			±5 ±8	mV mV
Thermal Sensitivity Drift	$\Delta^T S$	T_A = -40 to 125°C T_A = -40 to 150°C			±1.0 ±1.2	%S %S
RMS Output Noise	N_{RMS}	Scales with typical sensitivity of Table 1 for given IMC type (HF, VHF, XHF) MLX91216LDC-AC**H**-000 MLX91216LDC-AC**V**-000 MLX91216LDC-AC**V**-002 (NOISE_FILTER 1) MLX91216LDC-AC**X**-000		8 6.5 4.5 6.5		mV_{RMS} mV_{RMS} mV_{RMS} mV_{RMS}
V_{OQ} Ratiometry	$\Delta^R V_{OQ}$	V_{DD} = 5V±5%, V_{OQ} = 50%V_{DDx}			±0.4	%V_{OQ}
Sensitivity Ratiometry	$\Delta^R S$	V_{DD} = 5V±5%, B = B_{OP}			±0.4	%S
Clamped output accuracy	CL_{ACC}				±1	%Vdd

Table 9: Accuracy specifications – analog parameters

The accuracy specifications are defined for the factory calibrated sensitivity. The achievable accuracy is dependent on the user's end-of-line calibration. Resolution for offset and offset drift calibration is better than 0.02%V_{DD}. Trimming capability is higher than measurement accuracy. End-user calibration can therefore increase the accuracy of the system.

11.2. Timing specifications

Operating Parameters T_A = -40 to 150°C, Vdd = 5V±10%, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Refresh rate	T_{rr}	LOW_POWER_MODE=0	0.8	1	1	µs
Step Response Time	T_R	C_L=10nF NOISE_FILTER=0, LOW_POWER_MODE=0 NOISE_FILTER=0, LOW_POWER_MODE=1 NOISE_FILTER=1, LOW_POWER_MODE=0 NOISE_FILTER=1, LOW_POWER_MODE=1 NOISE_FILTER=2, LOW_POWER_MODE=0 NOISE_FILTER=2, LOW_POWER_MODE=1 NOISE_FILTER=3, LOW_POWER_MODE=0 NOISE_FILTER=3, LOW_POWER_MODE=1		2 3 3 5 4 6 8 10	3 4 4 6 5 7 9 11	µs µs µs µs µs µs µs µs
Power on Delay	T_{POD}	Vout =100% of F.S.			1	ms
Ratiometry Cut-off Frequency	F_{RAT}			250		Hz

Table 10: Timing specifications of the high-speed analog output

12. Self-diagnostic

MLX91216 provides several self-diagnostic features, which prevent the IC from providing erroneous output signal in case of internal or external failure modes.

Error	Effect on Output	Remarks
Calibration data CRC Error	DIAG_LEVEL=0 → active pull-down to GND DIAG_LEVEL=1 → active pull-up to VDD	At power up and in normal mode
Power-On Delay	Pull-down to GND	1ms max followed by settling
Over-voltage Mode 1	Active pull-down to GND	
Over-voltage Mode 2	DIAG_LEVEL=0 → active pull-down to GND DIAG_LEVEL=1 → active pull-up to VDD	
Under-voltage Mode	DIAG_LEVEL=0 → active pull-down to GND DIAG_LEVEL=1 → active pull-up to VDD	Valid with enabled ratiometry (Default: RATIOEN = 1)
Broken OUT	Active pull-down to GND	
Broken GND	Output pulled up to VDD	IC is switched off
Broken VDD	Output pulled down to GND	IC is switched off

Table 11: Description of the self-diagnostic modes in MLX91216

13. Recommended Application Diagram

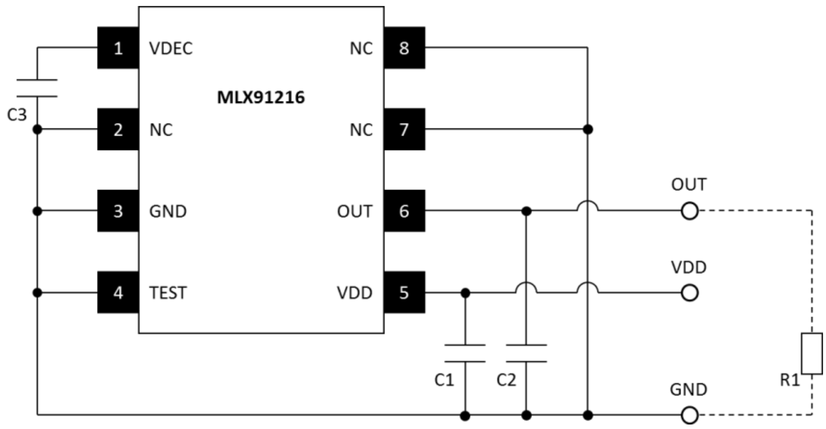


Figure 4: Application Diagram with external Pull-Down resistance

Part	Description	Value	Unit
C1	Supply capacitor, EMI, ESD	100	nF
C2	Decoupling, EMI, ESD, OUT_MODE=0 Decoupling, EMI, ESD, OUT_MODE=1	1-10 10-47	nF nF
C3	Decoupling, EMI, ESD	47	nF
R1	Pull down resistor	10-200	kΩ

Table 12: Resistor and capacitor values

14. Programmable items

Customers can re-program the parameters described in the table below by using the PTC-04 hardware and the Product Specific Functions (PSF) libraries provided by Melexis. We recommend using the latest version of the PSF and the firmware, with a communication speed of 10kbps (maximum output capacitor of 47nF). Please contact your sales representative to get access to Melexis SoftDist platform and download the latest software.

Parameter	Bits	Factory Setting	Function
ROUGHGAIN	3	Trimmed	Rough gain trimming
FINEGAIN	10	Trimmed	Fine gain trimming
VOQ	12	Trimmed	Offset trimming
OUT_MODE	1	0	0: low capacitive load (*see section 13*) 1: high capacitive load (*see section 13*)
DIAG_LEVEL	1	0	0: in diagnostic, output is pulled down to GND 1: in diagnostic, output is pulled up to Vdd
LOW_POWER_MODE	1	0	0: normal mode 1: low power mode with slower response time
CLAMP_LEVEL	2	1	Select clamping level (%VDD) 0: 6%/93%, 1: 6%/94%, 2: 8%/92%, 3: 10%/90%
NOISE FILTER	2	0/1[3]	0: Noise filter: deactivated 1: Noise filter: 120kHz 2: Noise filter: 60kHz 3: Noise filter: 15kHz
CSTID	17	N/A	Customer ID

Table 12: Customer Programmable Items

[3] *The Noise Filter parameter is set to 1 for MLX91216LDC-ACV-002 IC version. The Noise Filter is deactivated for all other option codes.*

15. Standard Information

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

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 further details about test method references and for compliance verification of selected soldering method for product integration, Melexis recommends reviewing on our web site the General Guidelines soldering recommendation. For all soldering technologies deviating from the one mentioned in above document (regarding peak temperature, temperature gradient, temperature profile etc), additional classification and qualification tests have to be agreed upon with Melexis.

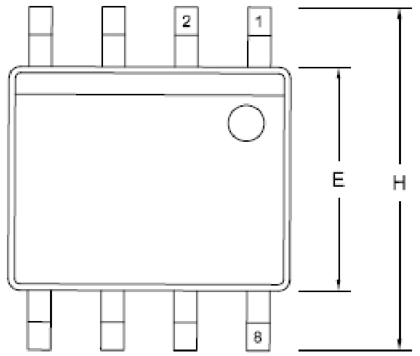
For package technology embedding trim and form post-delivery capability, Melexis recommends to consult the dedicated trim&form recommendation application note: lead trimming and forming recommendations.

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

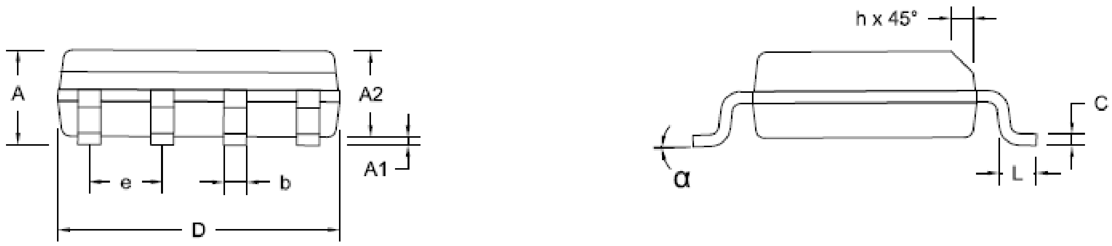
16. ESD Precautions

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

17. Packaging information



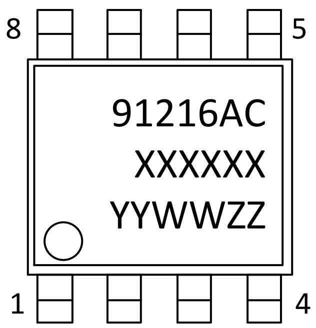
NOTE :
1. GATE BURRS SHALL NOT EXCEED 0.15MM PER END.
2. INTERLEAD MOLD FLASH SHALL NOT EXCEED 0.25MM PER SIDE.
3. ALL DIMENSION EXCLUDING MOLD FLASH AND GATE BURR.
4. LEAD COPLANARITY SHOULD BE 0 TO 0.127MM MAX.



	A	A1	A2	D	E	H	L	b	C	e	h	α
MIN	1.52	0.10	1.37	4.80	3.81	5.80	0.41	0.35	0.19	1.27	0.25	0.00
NOM	–	–	–	–	–	–	–	–	–		–	–
MAX	1.73	0.25	1.57	4.98	3.99	6.20	1.27	0.49	0.25	BSC	0.50	8.00

Figure 5: SOIC8 - Package Information

17.1. SOIC-8 Pinout and Marking



Package Top Marking	Marking Description	
	Line 1: 91216AC	Product and IC revision
	Line 2: XXXXXX	Wafer Lot Nb
	Line 3: YY	Calendar Year (last 2 digits)
	Line 3: WW	Calendar Week
	Line 3: ZZ	HB = High Field IMC EV = Very High Field IMC EX = Extra High Field IMC

Figure 6: SOIC8 - Pinout and marking

17.2. Hall plate position

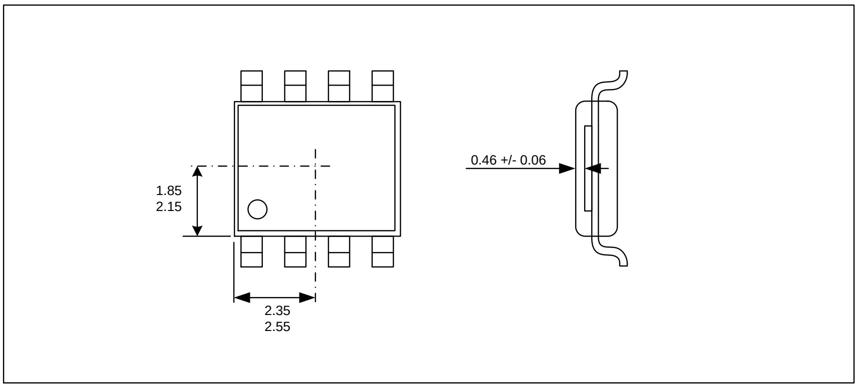


Figure 7: Hall plate position

17.3. IMC Position and Sensing Direction

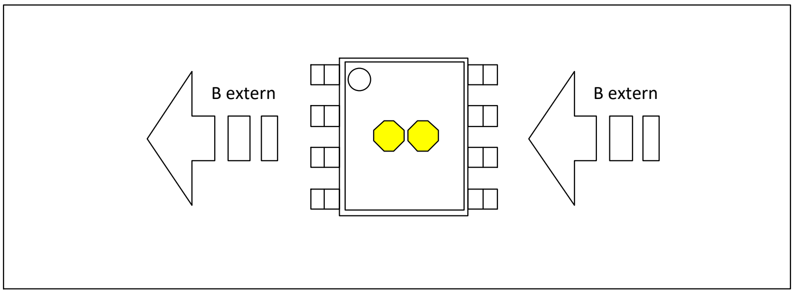


Figure 8 IMC position and geometry high field (HF) version

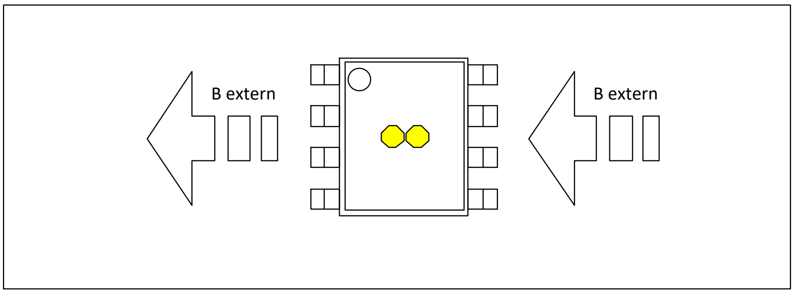


Figure 9 IMC position and geometry very high field (VHF) version

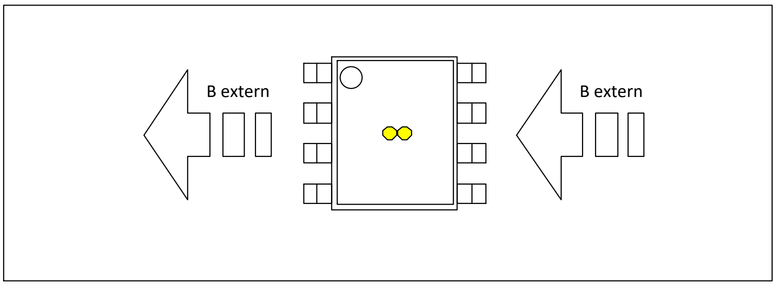


Figure 10 IMC position and geometry extra high field (XHF) version

18. Contact

For the latest version of this document, go to our website at [www.melexis.com.](http://www.melexis.com)

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19. Disclaimer

IATF 16949 and ISO 14001 Certified