

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 $\pm 350\text{mV/mT}$
- Measurement range up to 90 mT
- Wideband sensing: DC to 250kHz
- Very fast response time ($2\mu\text{s}$)
- High linearity down to $\pm 0.2\%$ full scale
- Very low thermal drift
 - Offset drift ($< 5\text{mV}$)
 - 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

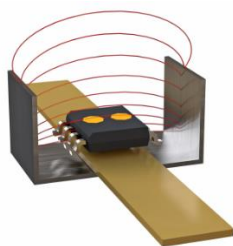


Figure 1. Typical IMC-Hall® Current Sensing Application

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.

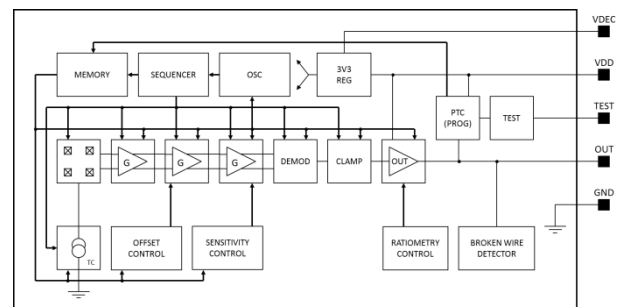


Figure 2. General Block Diagram

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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 | ACH – 002 ¹ | RE | 155 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.

¹ MLX91216LDC-ACH-002: customized offset, VOQ = 1V

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 ACH-002¹ ACV-000 ACV-001 ACV-002 ACX-000 ACX-001 ACX-002 | for sensitivity 100 mV/mT; (<i>programmable range: 50-350mV/mT</i>) for sensitivity 155 mV/mT; VOQ=1V (<i>programmable range: 50-350mV/mT</i>) for sensitivity 40 mV/mT; (<i>programmable range: 30-200mV/mT</i>) for sensitivity 60 mV/mT; (<i>programmable range: 30-200mV/mT</i>) for sensitivity 30 mV/mT; (<i>programmable range: 30-200mV/mT</i>) for sensitivity 25 mV/mT; (<i>programmable range: 20-125mV/mT</i>) for sensitivity 30 mV/mT; (<i>programmable range: 20-125mV/mT</i>) for sensitivity 20 mV/mT; (<i>programmable range: 20-125mV/mT</i>) |
| 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

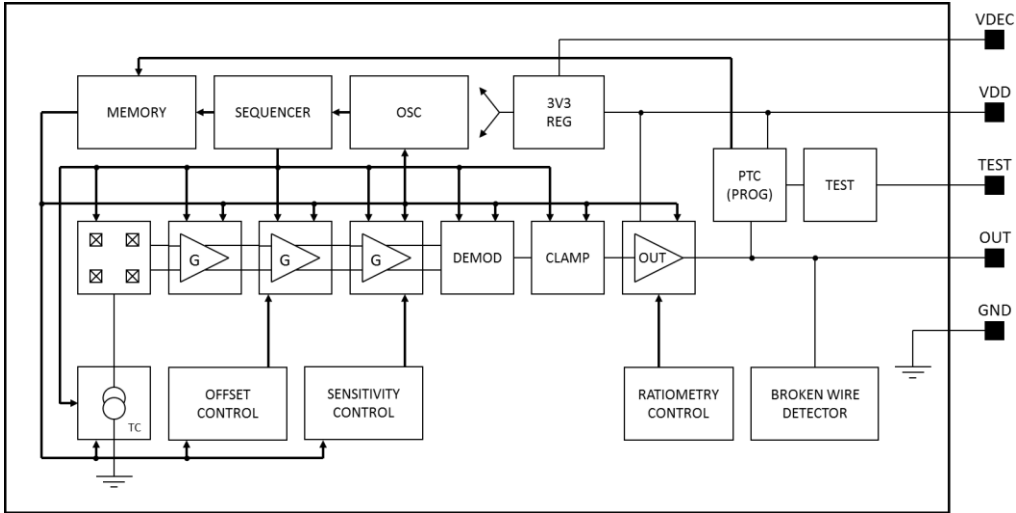


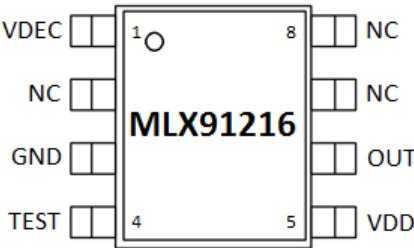
Figure 3: MLX91216 Block Diagram

6. Glossary of Terms

| Terms | Definition |
|-------|--|
| TC | Temperature Coefficient |
| FS | Full Scale, output referred. Corresponds to 2V excursion around 2.5V V_{OQ} point ¹ |
| 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 | V_{SREV} | -0.3 | V |
| Positive Output Voltage | V_{OUT} | +10 | V |
| Output Current | I_{OUT} | ±70 | mA |
| Reverse Output Voltage | V_{OREV} | -0.3 | V |
| Reverse Output Current | I_{OREV} | -50 | mA |
| Maximum Junction Temperature | $T_{j,max}$ | -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 (<i>junction-to-ambient</i>) 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 , $V_{DD} = 5\text{V} \pm 10\%$, 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 ² | | 12.5 | 15 | mA |
| | | LOW_POWER_MODE=1 | | 10 | 13 | mA |
| Output Impedance | R_{OUT} | $V_{out} = 50\% V_{DD}$, $R_L = 10\text{k}\Omega$ | | 1 | 5 | Ω |
| Output Capacitive Load | C_L | OUT_MODE=0 ¹ | 1 | | 10 | nF |
| | | OUT_MODE=1 | 10 | | 47 | nF |
| Output Resistive Load | R_L | Output resistive load for high linearity and diagnostic band. | 10 | 25 | 200 | $\text{k}\Omega$ |
| Output Short Circuit Current | I_{SHORT} | Output shorted permanent to VDD. Output shorted permanent to GND. | | Not Destroyed Not Destroyed | | |
| Linear Output Range | V_{OLIN} | pull-down $\geq 10\text{ k}\Omega$ | 10 | | 90 | %Vdd |
| Diagnostic Band ³ | DIAG | $R_L \geq 10\text{ k}\Omega$, $R_L \leq 200\text{ k}\Omega$, $V_{DD} = 5\text{V}$ | | | | |
| | | DIAG_LEVEL = 0 | 0 | | 4 | %Vdd |
| | | DIAG_LEVEL = 1 | 96 | | 100 | %Vdd |
| BrokenGND Output Level ³ | | $R_L \geq 10\text{ k}\Omega$, $V_{DD} = 5\text{V}$ | 96 | | 100 | %Vdd |
| BrokenVDD Output Level ³ | | $R_L \geq 10\text{ k}\Omega$, $V_{DD} = 5\text{V}$ | 0 | | 4 | %Vdd |
| Under-voltage detection ³ | V_{DD_UVL} | Detected Voltage (Low to High) | 4.0 | | 4.5 | V |
| | V_{DD_UVH} | Hysteresis | 0.01 | | 0.2 | V |
| Over-voltage detection 1 ³ | V_{DD_OVL1} | Detected Voltage (Low to High) | 6.7 | | 7.4 | V |
| | V_{DD_OVH1} | Hysteresis | 0.37 | | 0.66 | V |
| Over-voltage detection 2 ³ | V_{DD_OVL2} | 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

² Default Factory Calibration

³ Please refer to section 12 for more information on self-diagnostic modes.

10. Magnetic specification

Operating Parameters $T_A = -40$ to 150°C , $V_{DD} = 5V \pm 10\%$, 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} , $T_A = 25^{\circ}\text{C}$ | | | ± 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 |
| | | MLX91216LDC-ACH-002 | 50 | 155 | 350 | |
| 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} , $T_A = 25^{\circ}\text{C}$ | | | ± 0.5 | %FS |
| Hysteresis – Remanent Field | B_R | Measured after $B = B_{OP}$ | | | ± 60 | μT |
| Programmable Sensitivity | S | MLX91216LDC-ACV-000 | 30 | 40 | 200 | mV/mT |
| | | MLX91216LDC-ACV-001 | 30 | 60 | 200 | |
| 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} , $T_A = 25^{\circ}\text{C}$ | | | ± 0.5 | %FS |
| Hysteresis – Remanent Field | B_R | Measured after $B = B_{OP}$ | | | ± 90 | μT |
| Programmable Sensitivity | S | MLX91216LDC-ACX-000 | 20 | 25 | 125 | mV/mT |
| | | MLX91216LDC-ACX-001 | 20 | 30 | 125 | |
| | | MLX91216LDC-ACX-002 | 20 | 20 | 125 | |
| 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 , $V_{DD} = 5V \pm 10\%$, unless otherwise specified.

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---------------------------|-------------------|--|-----|----------|-----------|-------------------|
| Thermal Offset Drift | $\Delta^T V_{OQ}$ | $T_A = -40$ to 125°C | | | ± 5 | mV |
| | | $T_A = -40$ to 150°C | | | ± 8 | mV |
| | | MLX91216LDC-ACH-002, $T_A = -40$ to 125°C | | ± 20 | | mV |
| Thermal Sensitivity Drift | $\Delta^T S$ | $T_A = -40$ to 125°C | | | ± 1.0 | %S |
| | | $T_A = -40$ to 150°C | | | ± 1.2 | %S |
| | | MLX91216LDC-ACH-002, $T_A = -40$ to 125°C | | | ± 1.2 | %S |
| RMS Output Noise | N_{RMS} | Scales with typical sensitivity of Table 1 for given IMC type (HF, VHF, XHF) | | | | |
| | | MLX91216LDC-ACH-000 | | 8 | | mV _{RMS} |
| | | MLX91216LDC-ACV-000 | | 6.5 | | mV _{RMS} |
| | | MLX91216LDC-ACV-002 (NOISE_FILTER 1) | | 4.5 | | mV _{RMS} |
| | | MLX91216LDC-ACX-000 | | 6.5 | | mV _{RMS} |
| V_{OQ} Ratiometry | $\Delta^R V_{OQ}$ | $V_{DD} = 5V \pm 5\%$, $V_{OQ} = 50\%V_{DDx}$ | | | ± 10 | mV |
| | | $V_{DD} = 5V \pm 5\%$, $V_{OQ} = 20\%V_{DDx}$ | | | | |
| Sensitivity Ratiometry | $\Delta^R S$ | $V_{DD} = 5V \pm 5\%$, $B = B_{OP}$ | | | ± 0.4 | %S |
| Clamped output accuracy | CL_{ACC} | | | | ± 1 | %V _{dd} |

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 , $V_{DD} = 5V \pm 10\%$, unless otherwise specified.

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|------------------------------|-----------|----------------------------------|-----|-----|-----|---------|
| Refresh rate | T_{rr} | LOW_POWER_MODE=0 | 0.8 | 1 | 2 | μs |
| Step Response Time | T_R | $C_L=10nF$ | | | | |
| | | NOISE_FILTER=0, LOW_POWER_MODE=0 | | 2 | 3 | μs |
| | | NOISE_FILTER=0, LOW_POWER_MODE=1 | | 3 | 4 | μs |
| | | NOISE_FILTER=1, LOW_POWER_MODE=0 | | 3 | 4 | μs |
| | | NOISE_FILTER=1, LOW_POWER_MODE=1 | | 5 | 6 | μs |
| | | NOISE_FILTER=2, LOW_POWER_MODE=0 | | 4 | 5 | μs |
| | | NOISE_FILTER=2, LOW_POWER_MODE=1 | | 6 | 7 | μs |
| | | NOISE_FILTER=3, LOW_POWER_MODE=0 | | 8 | 9 | μs |
| | | NOISE_FILTER=3, LOW_POWER_MODE=1 | | 10 | 11 | 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

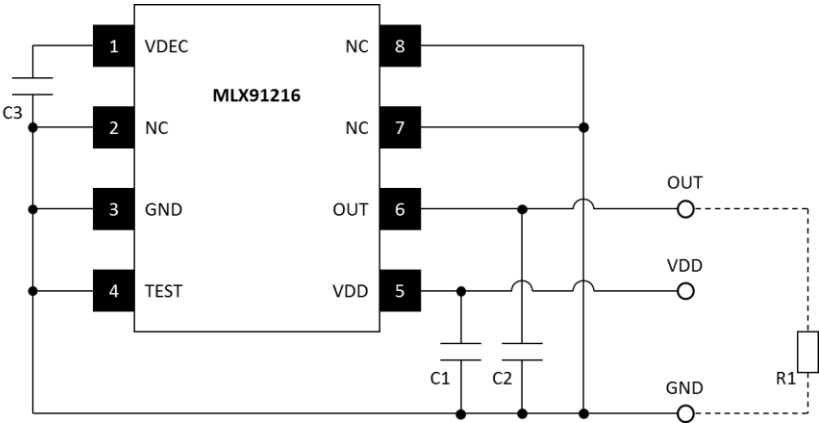


Figure 4: Application Diagram with external Pull-Down resistance

| Part | Description | Value | Unit |
|------|----------------------------------|--------|------|
| C1 | Supply capacitor, EMI, ESD | 100 | nF |
| C2 | Decoupling, EMI, ESD, OUT_MODE=0 | 1-10 | nF |
| | Decoupling, EMI, ESD, OUT_MODE=1 | 10-47 | 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 (<i>see section 13</i>) 1: high capacitive load (<i>see section 13</i>) |
| 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 ⁴ | 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

⁴ 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

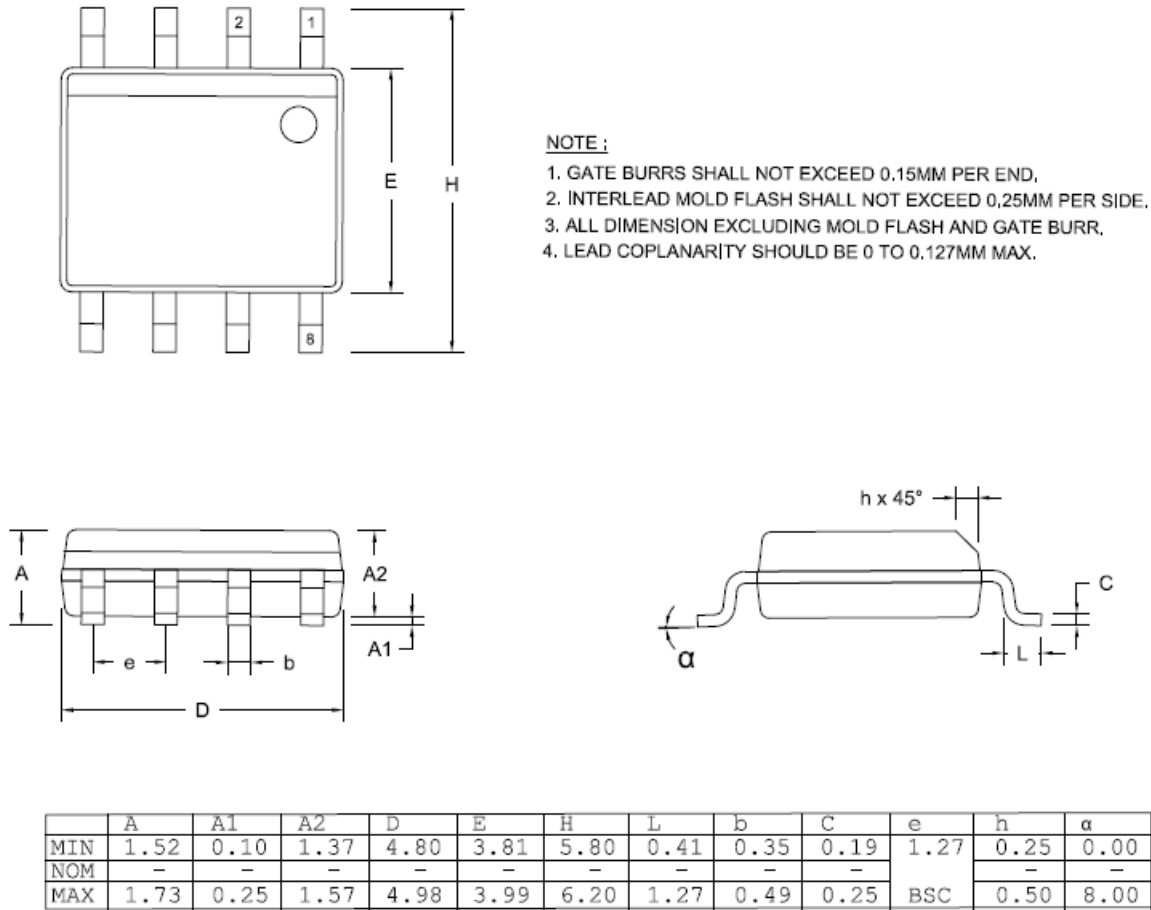


Figure 5: SOIC8 - Package Information

17.1. SOIC-8 Pinout and Marking

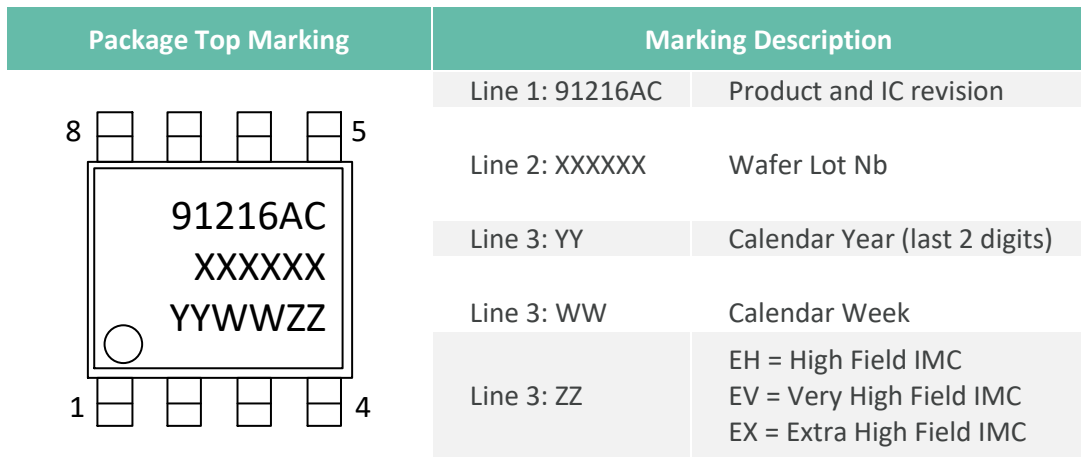


Figure 6: SOIC8 - Pinout and marking

17.2. Hall plate position

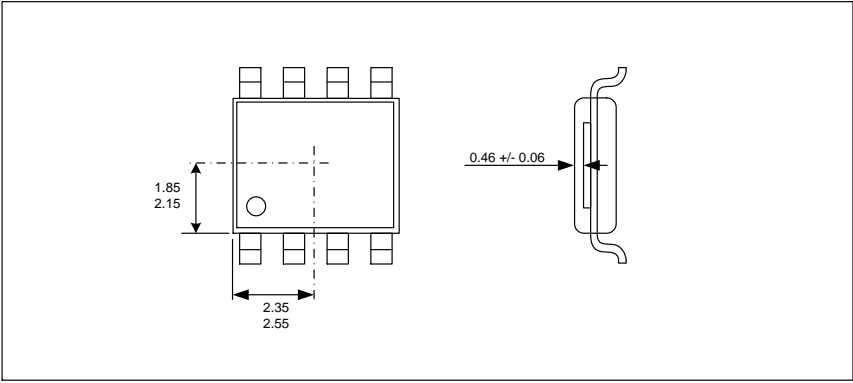


Figure 7: Hall plate position

17.3. IMC Position and Sensing Direction

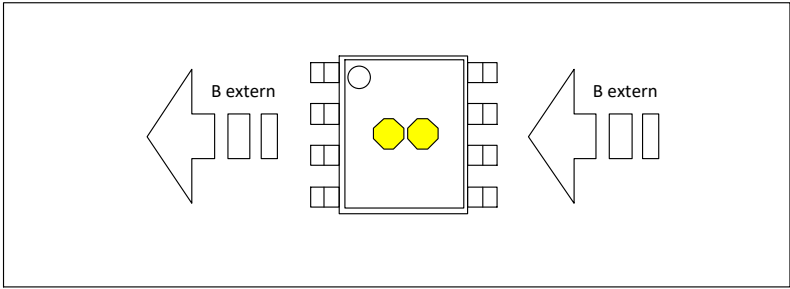


Figure 8 IMC position and geometry high field (HF) version

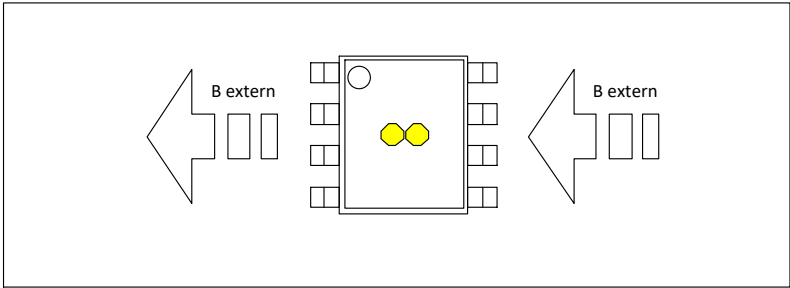


Figure 9 IMC position and geometry very high field (VHF) version

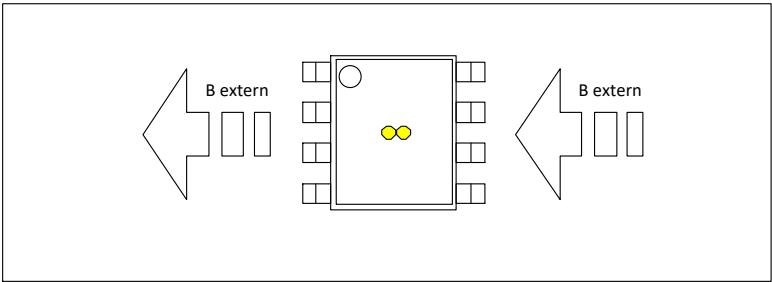


Figure 10 IMC position and geometry extra high field (XHF) version

18. Contact

For the latest version of this document, go to our website at <http://www.melexis.com/MLX91216>.

For additional information, please contact our Direct Sales team and get help for your specific needs:

| | |
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19. Disclaimer

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