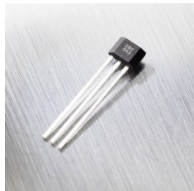


MLX91211 Medium Speed Current Sensor IC

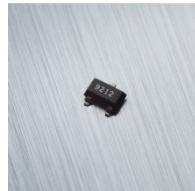
Datasheet

Features and Benefits

- Linear Hall sensor optimized for AC and DC current sensing applications
- Supply voltage of 3.3V or 5V
- Analog ratiometric output voltage
- Factory trimmed magnetic sensitivity and offset
- Medium speed sensing
 - DC to 40kHz bandwidth
 - <10 μ s response time
- Fast start-up time enabling power gating
- Miniature packages RoHS compliant & Green
 - SOT-23 3L surface mount
 - TO92 UA 3L through hole mount
- Suitable for lead free soldering profile up to 260°C, MSL3 (TSOT) and MSL1 (UA)
- AEC-Q100 Automotive Qualified



UA



TSOT23-3L

Applications

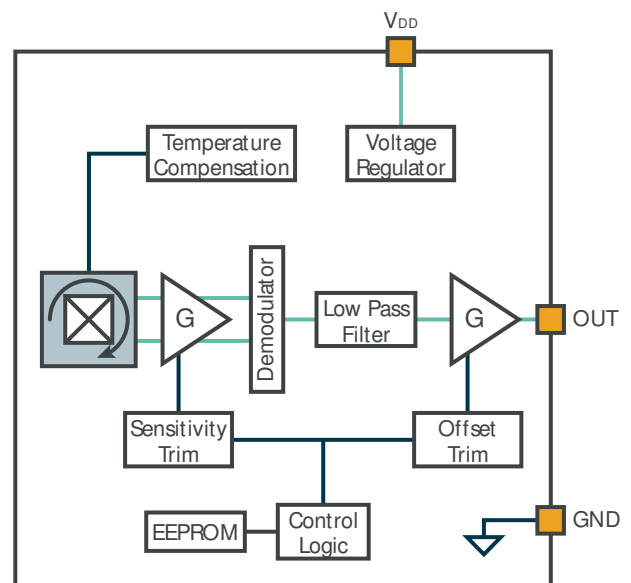
- 12V Starter-Generators
- 48V Inverters (BSG/ISG)
- E-scooter traction inverters
- Low-Speed EVs
- Forklifts

Description

The MLX91211 is a second generation medium speed Current Sensor that senses the magnetic field generated by the current flowing through a conductor, be it a cable, a bus bar or a PCB trace. For minimizing the susceptibility to external magnetic fields and maximizing the concentration of the magnetic field generated by the current flow, the sensor is typically placed inside a ferromagnetic core.

The sensor has an analog output ratiometric with varying supply voltage. The MLX91211 contains a voltage regulator for stable internal supply. The output is proportional to said magnetic field perpendicular to the package surface. The device is offered at different sensitivity settings as a function of different current sensing ranges and features a factory calibrated quiescent output voltage at 50% of the supply voltage.

The sensor is optimized for cost, and comes in 2 variants: the ABT version with multi-temperature trimming of the sensitivity, and the standard accuracy ABA version which has default trimming and wider specs.



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1. Ordering Information

| Product Code | Temperature Code | Package Code | Option Code | Packing Form Code |
|--------------|------------------|--------------|-------------|-------------------|
| MLX91211 | L | UA | ABA-500 | RE |
| MLX91211 | L | UA | ABA-510 | RE |
| MLX91211 | L | UA | ABA-520 | RE |
| MLX91211 | L | UA | ABA-530 | RE |
| MLX91211 | L | UA | ABA-540 | RE |
| MLX91211 | L | UA | ABT-500 | RE |
| MLX91211 | L | UA | ABT-510 | RE |
| MLX91211 | L | UA | ABT-520 | RE |
| MLX91211 | L | UA | ABT-530 | RE |
| MLX91211 | L | UA | ABT-540 | RE |
| MLX91211 | L | SE | ABA-510 | RE |
| MLX91211 | L | SE | ABA-310 | RE |

Legend:

| | |
|-------------------|--|
| Temperature Code: | L: from -40°C to 150°C ambient temperature |
| Package Code: | “SE” for TSOT23 3 leads surface mount package “UA” for TO-92 through hole package |
| Option Code: | ABx-xxx: die version xxA-xxx: “A” for standard accuracy variant and “T” for high accuracy over temperature xxx-3xx: “3” for 3.3V ratiometric supply and “5” for 5V ratiometric supply xxx-x0x: “0” for factory calibrated sensitivity |
| Packing Form: | “RE” for Plastic Tape on Reel “CR” for Carton Tape on Reel (UA package only) “BU” for Bulk |
| Ordering Example: | MLX91211LUA-ABT-510-RE |

Table 1 – Legend

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 output transfer characteristics, or trim&form options for the UA package, please contact your local Melexis Sales representative or distributor.

2. Functional Diagram

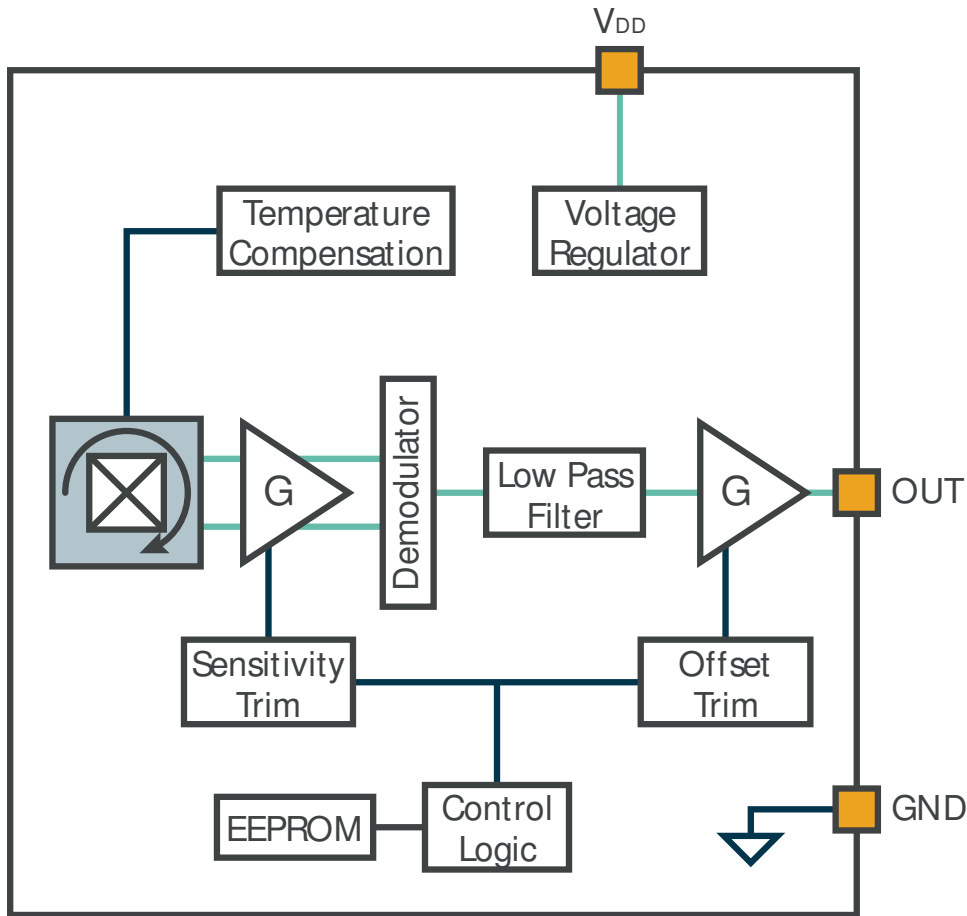


Figure 1 – Functional Diagram for MLX91211

No matter if the V_{DD} line is at nominal voltage or deviating within the supply voltage range, the ADC code for a given measured current and its associated magnetic field will remain the same as the ADC reference voltage is equal or proportional to the sensor supply voltage. The sensor sensitivity expressed in $\%V_{DD}/mT$ is kept constant over V_{DD} range. Please refer to Chapter 8 for the associated ratiometry accuracy.

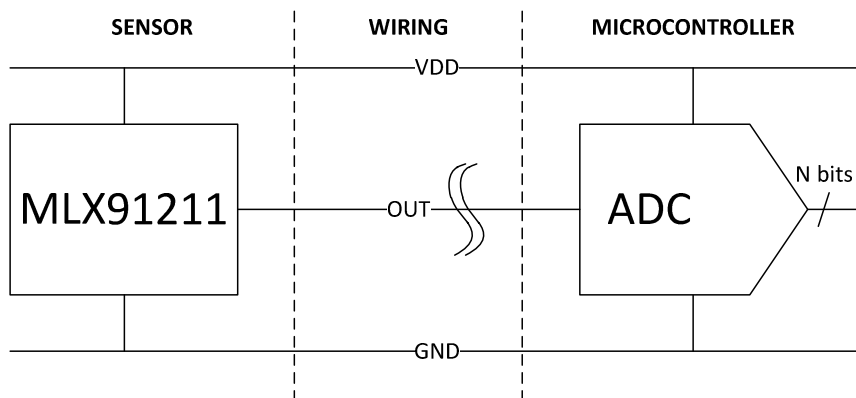


Figure 2 Ratiometry Application

3. Glossary of Terms

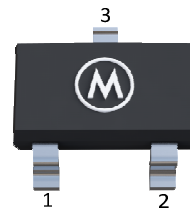
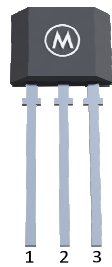
| | |
|----------------------|--|
| Gauss (G), Tesla (T) | Units for the magnetic flux density - 1 mT = 10 G |
| TC | Temperature Coefficient (in ppm/°C) |
| TSOT | Thin Small Outline Transistor package |
| PSRR | Power Supply Rejection Ratio |
| ASP | Analog Signal Processing |
| ECU | Electronic Control Unit |
| BSG | Belt Starter-Generator (P0 architecture) |
| ISG | Integrated Starter-Generator (P2 architecture or higher) |
| AC | Alternate Current |
| DC | Direct Current |
| SMD | Surface Mounted Device |
| EMC | Electro-Magnetic Compatibility |
| FS | Full Scale |
| RoHS | Restriction of Hazardous Substances |

Table 2 – Glossary of Terms

4. Pinout

| PIN | UA | | TSOT23 | |
|-----|-----------------|---------------|-----------------|---------------|
| | Pin | Function | Pin | Function |
| 1 | V _{DD} | Supply | V _{DD} | Supply |
| 2 | GND | Ground | OUT | Analog Output |
| 3 | OUT | Analog Output | GND | Ground |

Visualization of package pin numbers



For optimal EMC behavior, please follow the recommended application diagram (see Chapter 10).

5. Absolute Maximum Ratings

| Parameter | Value |
|--|-------------------------|
| Positive Supply Voltage (technology limitation) | + 7 V |
| Positive Supply Voltage (maintaining application mode) | + 6.5 V |
| Reverse Supply Voltage | - 0.3 V |
| Positive Output Voltage | V _{DD} + 0.3 V |
| Output Current | ± 20% mA |
| Reverse Output Voltage | -0.3 V |
| Operating Ambient Temperature Range, T _A | - 40°C to + 150°C |
| Storage Temperature Range, T _S | - 55°C to + 165°C |
| Maximum Junction Temperature, T _J | + 165°C |
| Maximum Flux Density | >1000 mT |

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

6. MLX91211 Electrical Specification

Operating Parameters at $V_{DD} = 3.135V$ to $5.5V$ (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|------------------------------|-------------|--|-------|---------------------------------|---------------------------|------------|
| Supply Voltage | V_{DD} | Option code ABx-3xx | 3.135 | 3.3 (V_{DDNOM}) | 5.5 | V |
| | | Option code ABx-5xx | 3.135 | 5 (V_{DDNOM}) | 5.5 | V |
| Supply Current | I_{DD} | Without R_{LOAD} , within V_{DD} range | 3 | 5 | 8 | mA |
| Reset Voltage | V_{POR} | OUT to high impedance | | 2.7 | 2.95 | V |
| DC Load Current | I_{OUT} | | -1 | | 1 | mA |
| Output Resistance | R_{OUT} | $-1mA < I_{OUT} < 1mA$ | | 1 | 5 | Ω |
| Output Capacitive Load | C_{LOAD} | Between OUT and GND | 0 | 10 | 100 ($R_S=50\Omega$) | nF |
| Output Resistive Load | R_{LOAD} | Between OUT and GND | 5 | | | k Ω |
| Output Saturation Voltage | V_{SATLO} | $-1mA < I_{OUT} < 1mA$ $-0.1mA < I_{OUT} < 0.1mA$ | 0 | | 0.25 0.1 | V |
| | V_{SATHI} | $-1mA < I_{OUT} < 1mA$ $-0.1mA < I_{OUT} < 0.1mA$ | | $V_{DD}-0.25V$ $V_{DD}-0.1V$ | V_{DD} | V |
| Power Supply Rejection Ratio | PSRR | From 80kHz to 200kHz | 20 | | | dB |

7. MLX91211 Timing Specification

Operating Parameters at $V_{DD} = 3.135V$ to $5.5V$ (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|--------------------|------------|--|-----|-----|-----|---------|
| Refresh rate | T_{RR} | $1/f_{CHOP}$ | | 1.1 | | μs |
| Chopping frequency | f_{CHOP} | | | 900 | | kHz |
| Step Response Time | T_{RESP} | From 90% input to 90% output (see Figure 3) | | 8 | 10 | μs |
| Signal Bandwidth | BW | -3dB, $T_A = 25^\circ C$ | | 40 | | kHz |
| Power on Delay | T_{POD} | $V_{DD} = 3.3V$ or $5V$, 400mV output referred signal applied | | 40 | 70 | μs |

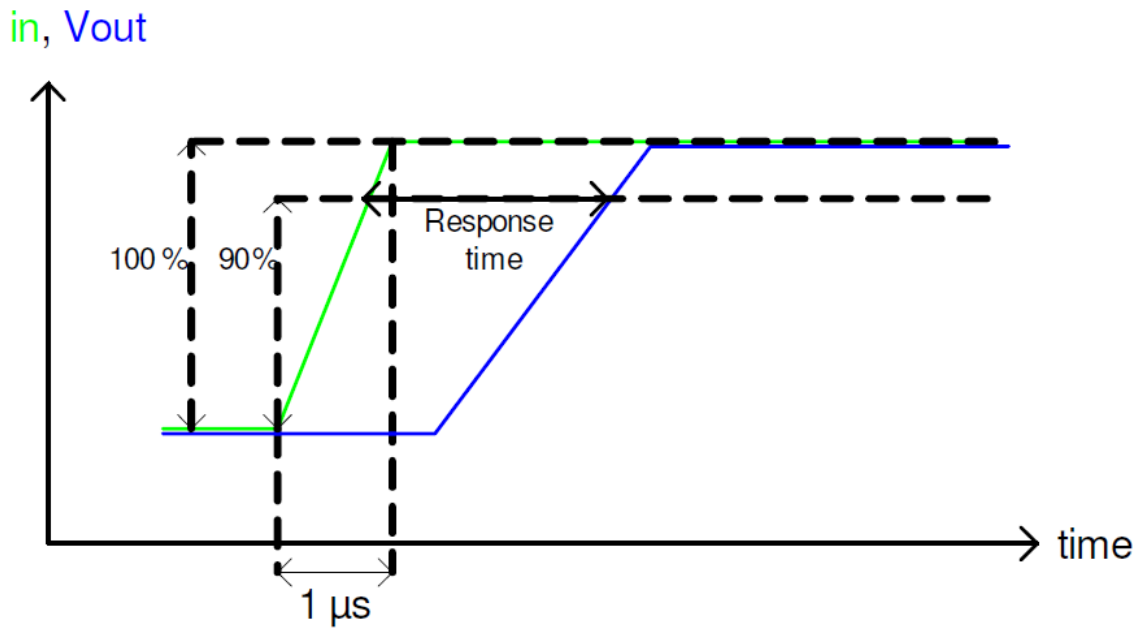


Figure 3: Response time definition

8. MLX91211 Accuracy Specification

Operating Parameters at $V_{DD} = 3.135V$ to $5.5V$ (unless otherwise specified) and for T_A as specified by the Temperature suffix (L).

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|--------------------|---|------|-----------|------|------------|
| Linear Magnetic Field Range | B | $T_A=25^{\circ}C$ | | | | |
| | | Option Code: ABx-x00 | | ± 106 | | mT |
| | | Option Code: ABx-x10 | | ± 80 | | mT |
| | | Option Code: ABx-x20 | | ± 64 | | mT |
| | | Option Code: ABx-x30 | | ± 40 | | mT |
| Option Code: ABx-x40 | | ± 20 | | mT | | |
| Linearity Error | NL | Option Code: ABT-xx0 | -0.9 | | 0.9 | % |
| | | Option Code: ABA-xx0 | -1.5 | | 1.5 | % |
| Quiescent Output Voltage ⁽²⁾ | V_{OQ} | $B=0mT, T_A=25^{\circ}C, V_{DD}=V_{DDNOM}$ | 49.5 | 50 | 50.5 | $\%V_{DD}$ |
| Thermal Offset Drift Hot ABT variant ⁽²⁾ | ΔT_{VOQHT} | $B=0mT$, Referred to $T_A=25^{\circ}C$, $V_{DD}=V_{DDNOM}$ | | | | |
| | | Option Code: ABT-500 | -33 | | 28 | mV |
| | | Option Code: ABT-510 | -34 | | 27 | mV |
| | | Option Code: ABT-520 | -36 | | 27 | mV |
| | | Option Code: ABT-530 | -44 | | 30 | mV |
| Option Code: ABT-540 | -61 | | 26 | mV | | |

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|--------------------|---|----------------|------------------------|------------------------------|----------------|
| Thermal Offset Drift Cold ABT variant ⁽²⁾ | ΔT_{VOQLT} | B=0mT, Referred to $T_A=25^\circ\text{C}$, $V_{DD}=V_{DDNOM}$ | | | | |
| | | Option Code: ABT-500 | -16 | | 19 | mV |
| | | Option Code: ABT-510 | -16 | | 20 | mV |
| | | Option Code: ABT-520 | -16 | | 21 | mV |
| | | Option Code: ABT-530 | -16 | | 26 | mV |
| Option Code: ABT-540 | -16 | | 33 | mV | | |
| Thermal Offset Drift ABA variant ⁽¹⁾ | ΔT_{VOQ} | B=0mT, Referred to $T_A=25^\circ\text{C}$, $V_{DD}=V_{DDNOM}$ Option Code: ABA-xxx | | ± 15 | $\pm(35+0.40$ $*S_{NOM})$ | mV |
| Lifetime Offset Drift ⁽³⁾ | ΔL_{VOQ} | B=0mT, $T_A=25^\circ\text{C}$, $V_{DD}=V_{DDNOM}$ | | | | |
| | | Option Code: ABx-520 Option Code: ABx-320 | | ± 1.7 ± 1.5 | | mV |
| Sensitivity ⁽²⁾ | S_{NOM} | $T_A=25^\circ\text{C}$, $B=0.4*V_{DDNOM}/S_{NOM}$ $V_{DD}=V_{DDNOM}$ | | | | |
| | | Option Code: ABT-500 | 18.42 | 18.8 | 19.18 | mV/mT |
| | | Option Code: ABT-510 | 24.5 | 25 | 25.5 | mV/mT |
| | | Option Code: ABT-520 | 30.6 | 31.25 | 31.88 | mV/mT |
| | | Option Code: ABT-530 | 49 | 50 | 51 | mV/mT |
| | | Option Code: ABT-540 | 98 | 100 | 102 | mV/mT |
| | | Option Code: ABA-310 Option Code: ABA-520 | 15.68 29.69 | 16.5 31.25 | 17.32 32.81 | mV/mT mV/mT |
| Thermal Sensitivity Drift | ΔT_S | Referred to $T_A=25^\circ\text{C}$ Option Code: ABT-xx0 ⁽²⁾ | -1.5 | ± 1 | 1.5 | % |
| | | Referred to $T_A=25^\circ\text{C}$ Option Code: ABA-xx0 ⁽¹⁾ | -10 | ± 5 | 10 | % |
| Lifetime Sensitivity Drift ⁽⁴⁾ | ΔL_S | $T_A=25^\circ\text{C}$, $V_{DD}=V_{DDNOM}$ Option Code: ABx-xx0 | | -5 | | % |
| Package Thermal Hysteresis ⁽¹⁾ | ΔT_{PKG} | $T_A=25^\circ\text{C}$, $V_{DD}=V_{DDNOM}$ Option Code: ABx-xx0 | | ± 1 | | % |
| Ratiometry Error ⁽²⁾ | ΔR_{VOQ} | Ref. to V_{DDNOM} , $T_A=25^\circ\text{C}$, B=0mT | -1.5 | | 1.5 | %/V |
| | ΔR_S | Referred to V_{DDNOM} , $T_A=25^\circ\text{C}$ | 0 | | 2 | %/V |
| RMS Input Referred Noise ⁽¹⁾ | N_{RMS} | $T_A=25^\circ\text{C}$, Bandwidth = 40kHz Option Code: 520 ⁽¹⁾ | | 770 | | nT/VHz |

(1) Guaranteed by design and characterization

(2) Guaranteed limits by 100% production test at Melexis. No aging effects included.

(3) The typical value is specified as one standard deviation of the measured Quiescent Output Voltage drift after 1000h HTOL qualification performed at $T_A=150^\circ\text{C}$.

(4) The typical value is specified as average value of the change in sensitivity (expressed in %) after 1000h HTOL qualification performed at $T_A=150^\circ\text{C}$ compared to the value after preconditioning.

9. Characteristic Definitions

- The Sensor DC Output Voltage is defined by:

$$V_{OUT} = V_{OQ} + S \cdot B, \text{ expressed in [V]}$$

- where V_{OQ} is the measured quiescent output voltage at $B = 0$
 - where $S = \frac{\Delta V_{OUT}}{\Delta B}$, $\left[\frac{V}{T}\right]$ or $\left[\frac{mV}{mT}\right]$ is the magnetic sensitivity at given supply voltage V_{DD}
- Magnetic Sensitivity Ratiometry is defined by:

$$\Delta R_{VOQ} = \frac{V_{OQ}(V_{DD}) - V_{OQ}(V_{DDNOM})}{V_{OQ}(V_{DDNOM}) \cdot (V_{DD} - V_{DDNOM})} \cdot 100\%, \left[\frac{\%}{V}\right] \text{ and}$$

$$\Delta R_S = \frac{S(V_{DD}) - S(V_{DDNOM})}{S(V_{DDNOM}) \cdot (V_{DD} - V_{DDNOM})} \cdot 100\%, \left[\frac{\%}{V}\right]$$

- Linearity for both positive and negative magnetic fields is defined by:**

$$NL = \frac{S(B_2) - S(B_1)}{S(B_1)} \cdot 100\%, \text{ expressed in [\%]}$$

- where $B_1 = \pm \frac{0.2 V_{DDNOM}}{S}$, $B_2 = \pm \frac{0.4 V_{DDNOM}}{S}$
- Linear Magnetic Field Range** is defined for V_{OUT} varying from 10% to 90% of V_{DD} . This can be ensured if the applied magnetic field B is not exceeding $\pm \frac{0.4 V_{DDNOM}}{S}$ at any T_A .

- Thermal Offset Drift is defined by:**

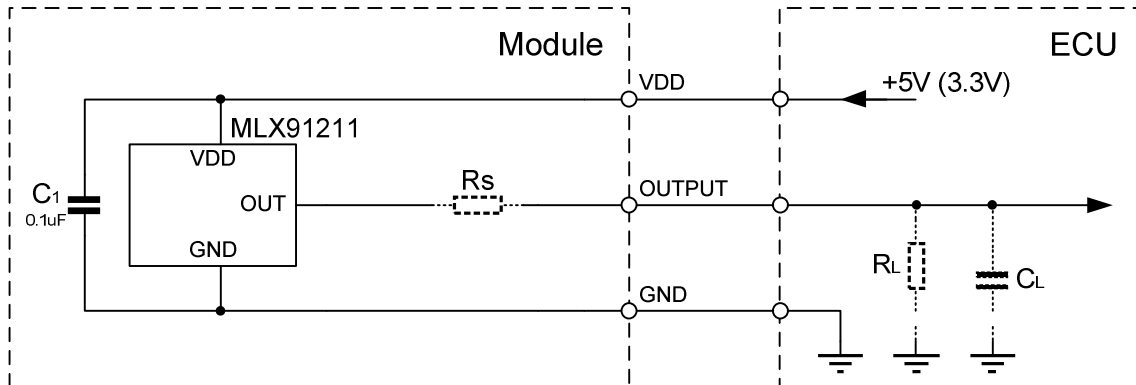
$$\Delta T_{VOQ} = V_{OQ}(T_A) - V_{OQ}(25^\circ C), \text{ expressed in [mV]}$$

- Thermal Sensitivity Drift is defined by:**

$$\Delta T_S = \left(\frac{S(T_A)}{S(25^\circ C)} - 1 \right) \cdot 100, [\%] \text{ at } T_A = -40^\circ C \text{ or } 150^\circ C$$

10. Recommended Application Diagrams

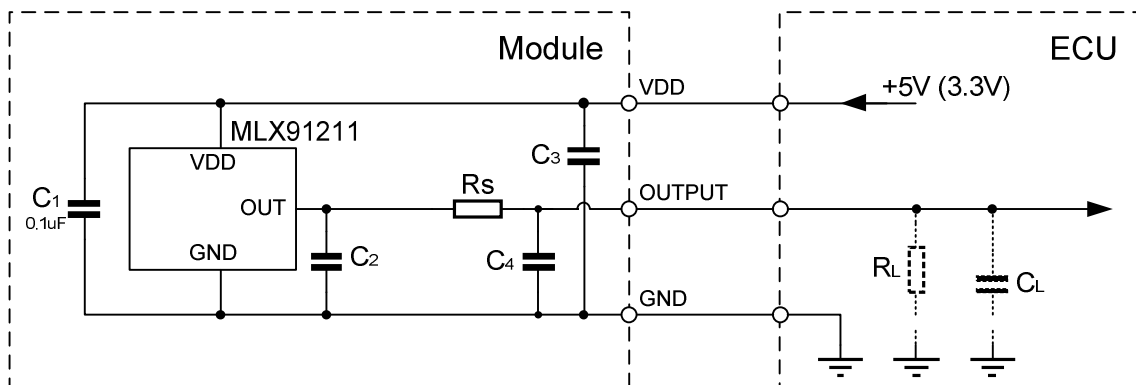
10.1. Typical Application Diagram



Notes:

For proper operation a 100nF or bigger bypass capacitor C1 should be placed as close as possible to the VDD and GND pins of MLX91211. For embedded applications the components R_s , R_L and C_L are not required.

10.2. Application Diagram for harsh and noisy environment



Notes:

For proper operation a 100nF or bigger bypass capacitor C1 should be placed as close as possible to the VDD and GND pins of MLX91211. For harsh and noisy environment, a bypass capacitor C2 of 1nF to 10nF can be placed on the output. For improved EMC performance an additional resistance, R_s and capacitors, C3 and C4 placed close to the connector of the module are recommended. Recommended values for: $R_s \geq 50\Omega$, $1\text{nF} \geq C3 \leq 4.7\text{nF}$, $1\text{nF} \geq C4 \leq 10\text{nF}$. For embedded applications the components R_L and C_L are not required.

11. 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>).

12. 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 | 8 | kV |
| Charged Device Model ESD Protection | ESD_{CDM} | AEC-Q100-011 Rev B | 500 | V |

13. Package Information

13.1. UA (TO92-3L) Package Dimensions

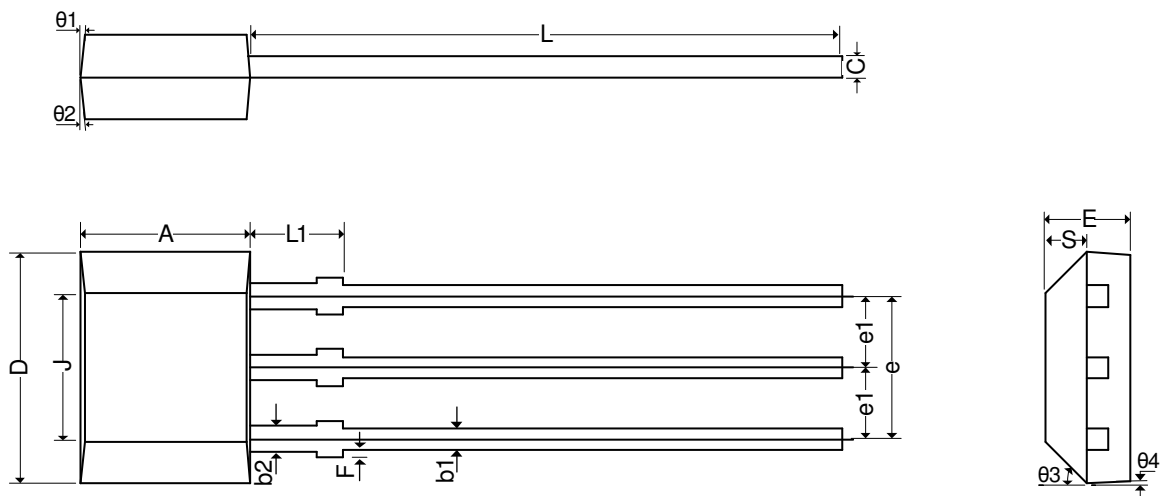


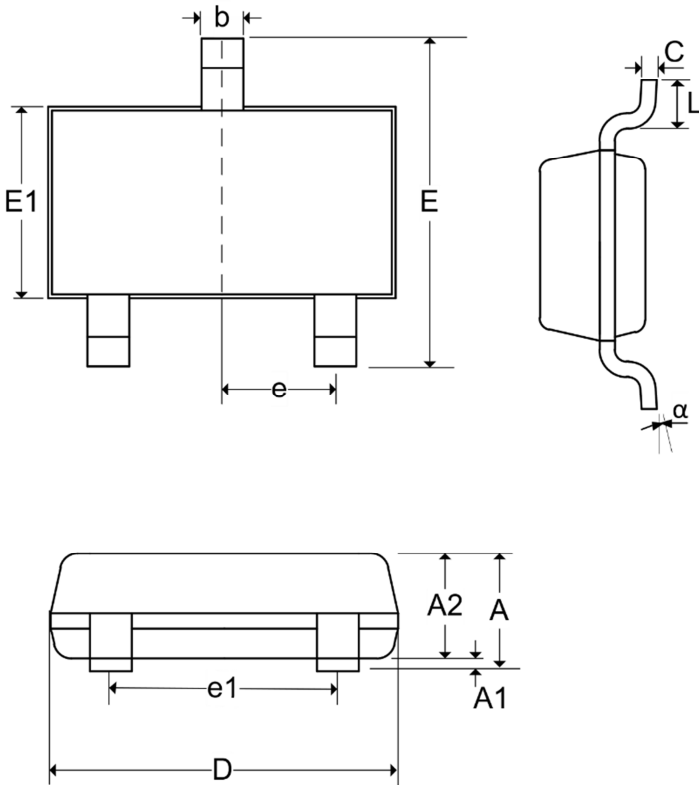
Figure 4 – UA (TO92-3L) Package Dimensions

| | A | D | E | F | J | L | L1 | S | b1 | b2 | c | e | e1 |
|-----|------------|------------|------------|------------|------|------|------|------|------|------|------|------|------|
| min | 2.80 | 3.90 | 1.40 | 0.00 | 2.51 | 14.0 | 0.90 | 0.63 | 0.35 | 0.43 | 0.35 | 2.51 | 1.24 |
| max | 3.20 | 4.30 | 1.60 | 0.15 | 2.72 | 15.0 | 1.10 | 0.84 | 0.44 | 0.52 | 0.44 | 2.57 | 1.30 |
| | $\theta 1$ | $\theta 2$ | $\theta 3$ | $\theta 4$ | | | | | | | | | |
| min | 7° REF | 7° REF | 45° REF | 7° REF | | | | | | | | | |
| max | | | | | | | | | | | | | |

Notes:

- All dimensions are in millimeters.
- Mold flashes, gate burrs and dambar protrusion are not included.
- Gate burrs shall not exceed 0.127mm on the top side.

13.2. SE (TSOT-3L) Package Dimensions



Notes:

1. All dimensions are in millimeters
2. Outermost plastic extreme width does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 0.15mm per side.
3. Outermost plastic extreme length does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 0.25mm per side.
4. The lead width dimension does not include dambar protrusion. Allowable dambar protrusion shall be 0.07mm total in excess of the lead width dimension at maximum material condition.
5. Dimension α is the length of terminal for soldering to a substrate.
6. Formed lead shall be planar with respect to one another with 0.076mm at seating plane.

Marking:

Top side :

90XXX

XXX: Last three digits of the lot

Bottom side:

WWYY

WW: Calendar Week

YY: Calendar Year

Figure 5 – SE (TSOT-3L) Hall Plate Location

| | A | A1 | A2 | D | E | E1 | L | b | c | e | e1 | α |
|-----|------|-------|------|------|------|------|------|------|------|------|------|----------|
| min | – | 0.025 | 0.85 | 2.80 | 2.60 | 1.50 | 0.30 | 0.30 | 0.10 | 0.95 | 1.90 | 0° |
| max | 1.00 | 0.10 | 0.90 | 3.00 | 3.00 | 1.70 | 0.50 | 0.45 | 0.20 | BSC | BSC | 8° |

Notes:

1. All dimensions are in millimeters.
2. Dimension “D” and “E1” do not include mold flash or protrusions. Mold flash or protrusion shall not exceed 0.15mm on “D” and 0.25mm on “E” per side.
3. Dimension “b” does not include dambar protrusion.

13.3. UA (TO92-3L) Hall Plate Location

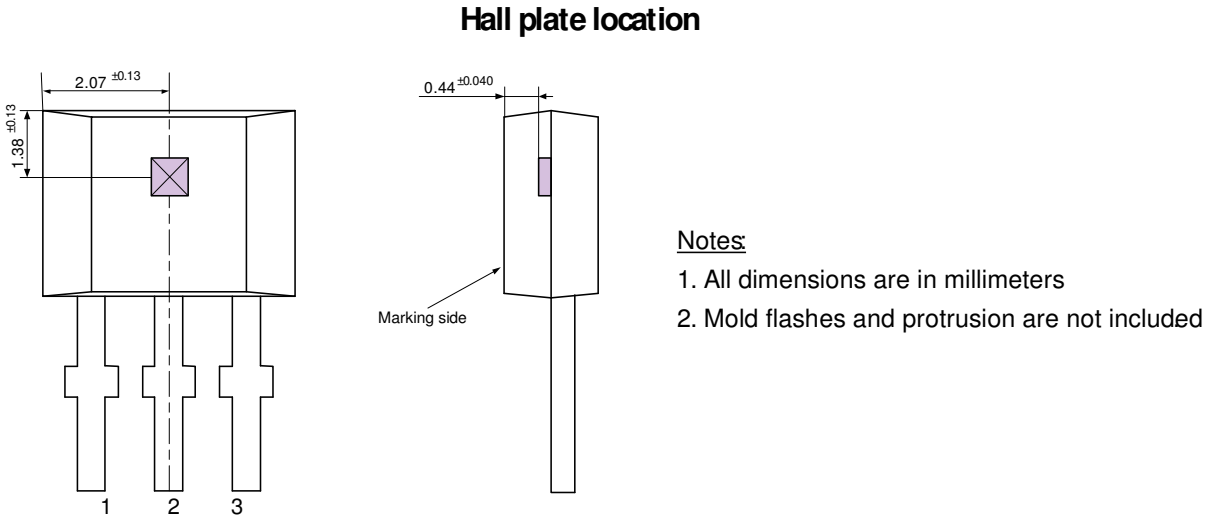


Figure 6 – UA (TO92-3L) Nominal Hall Plate Location

13.4. SE (TSOT-3L) Hall Plate Location

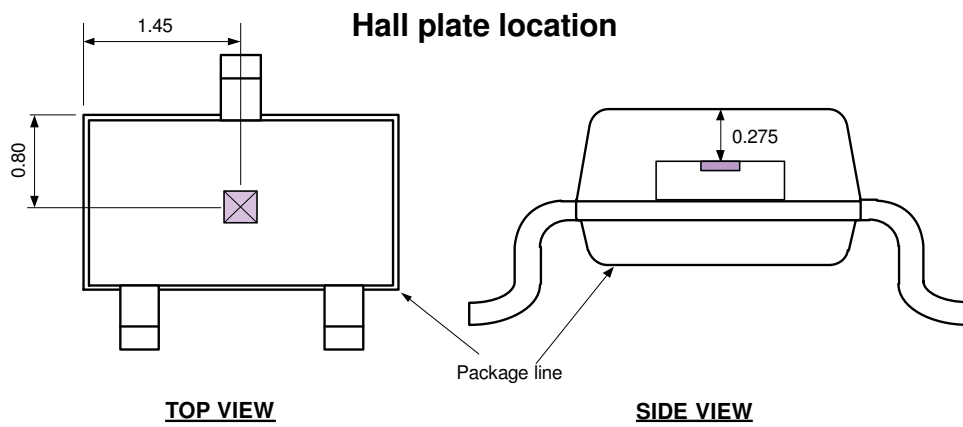


Figure 7 – SE (TSOT-3L) Nominal Hall Plate Location

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Or for additional information contact Melexis Direct:

Europe, Africa, Asia:

Phone: +32 1367 0495

E-mail: sales_europe@melexis.com

Americas:

Phone: +1 603 223 2362

E-mail: sales_usa@melexis.com

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