# 1 Features and Benefits

- Wide operating voltage range: from 2.7V to 24V
- Accurate switching thresholds
- Reverse Supply Voltage Protection
- Output Current Limit with Auto-Shutoff
- Under-Voltage Lockout Protection
- Thermal Protection
- Traceability with integrated unique ID
- High ESD rating / Excellent EMC performance

# 2 Application Examples

- Automotive, Consumer and Industrial
- Solid-state switch
- Brake sensor
- Clutch sensor
- Sunroof/Tailgate opener
- Steering Column Lock
- Open/Close detection

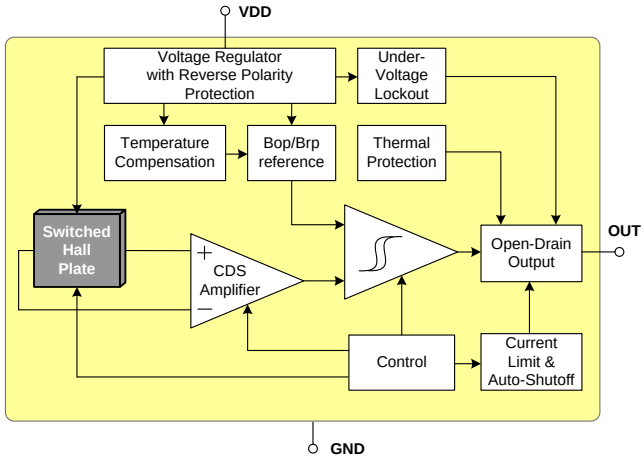
# 3 Ordering Information

| Product Code | Temperature Code | Package Code | Option Code | Packing from Code |
|---|---|---|---|---|
| MLX92231 | L | SE | AAA-0xx | RE |
| MLX92231 | L | UA | AAA-0xx | BU |
| MLX92231 | L | SE | AAA-2xx | RE |

**Legend:**

| | |
|---|---|
| Temperature Code: | L (-40°C to 150°C) |
| Package Code: | SE = TSOT-3L / UA = TO92-3L |
| Option Code: | 0xx => 3 wire Hall Effect Switch<br>2xx => IMC version |
| Packing Form: | RE = Reel \| BU=Bulk |
| Ordering Example: | MLX92231LSE-AAA-001-RE |

# 4 Functional Diagram




# 5 General Description

The Melexis MLX92231 is a Hall-effect unipolar switch designed in mixed signal CMOS technology.

The device integrates a voltage regulator, Hall sensor with advanced offset cancellation system, automotive qualified EEPROM and an open-drain output driver, all in a single package.

Based on the existing robust 922xx platform, the magnetic core has been equipped with a non-volatile memory that is used to accurately trim the switching thresholds and define the needed output magnetic characteristics (TC, $B_{OP}$, $B_{RP}$, Output pole functionality).

In addition to that an ID has been integrated on the IC to have a complete traceability throughout the process flow.

The included voltage regulator operates from 2.7 to 24V, hence covering a wide range of applications. With the built-in reverse voltage protection, a serial resistor or diode on the supply line is not required so that even remote sensors can be specified for low voltage operation down to 2.7V while being reverse voltage tolerant.

In the event of a drop below the minimum supply voltage during operation, the under-voltage lock-out protection will automatically freeze the device, preventing the electrical perturbation to affect the magnetic measurement circuitry. The output state is therefore only updated based on a proper and accurate magnetic measurement result.

The chopper-stabilized amplifier uses switched capacitor techniques to suppress the offset generally observed with Hall sensors and amplifiers. The CMOS technology makes this advanced technique possible and contributes to smaller chip size and lower current consumption than bipolar technology. The small chip size is also an important factor to minimize the effect of physical stress. This combination results in more stable magnetic characteristics and enables faster and more precise design.

The open drain output is fully protected against short-circuit with a built-in current limit. An additional automatic output shut-off is activated in case of a prolonged short-circuit condition. A self-check is then periodically performed to switch back to normal operation if the short-circuit condition is released. The on-chip thermal protection also switches off the output if the junction temperature increases above an abnormally high threshold. It will automatically recover once the temperature decreases below a safe value.

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# 6 Glossary of Terms

| | |
|---|---|
| Tesla | Units for the magnetic flux density, 1 mT = 10 Gauss |
| TC | Temperature Coefficient in ppm/°C |
| IMC | Integrated Magnetic Concentrator |
| POR | Power on Reset |

# 7 Absolute Maximum Ratings

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

| Parameter | Symbol | Value | Units |
|---|---|---|---|
| Supply Voltage (1, 2) | $V_{DD}$ | +27 | V |
| Supply Voltage (Load Dump) (1, 4) | $V_{DD}$ | +32 | V |
| Supply Current (1, 2, 3) | $I_{DD}$ | +20 | mA |
| Supply Current (1, 3, 4) | $I_{DD}$ | +50 | mA |
| Reverse Supply Voltage (1, 2) | $V_{DDREV}$ | -24 | V |
| Reverse Supply Voltage (1, 4) | $V_{DDREV}$ | -30 | V |
| Reverse Supply Current (1, 2, 5) | $I_{DDREV}$ | -20 | mA |
| Reverse Supply Current (1, 4, 5) | $I_{DDREV}$ | -50 | mA |
| Output Voltage (1, 2) | $V_{OUT}$ | +27 | V |
| Output Current (1, 2, 5) | $I_{OUT}$ | +20 | mA |
| Output Current (1, 4, 6) | $I_{OUT}$ | +75 | mA |
| Reverse Output Voltage (1) | $V_{OUTREV}$ | -0.5 | V |
| Reverse Output Current (1, 2) | $I_{OUTREV}$ | -100 | mA |
| Maximum Junction Temperature (7) | $T_J$ | +165 | °C |
| Storage Temperature Range | Ts | -55 to +165 | °C |
| ESD Sensitivity – HBM (8) | - | 4000 | V |
| ESD Sensitivity – CDM (9) | - | 1000 | V |
| Magnetic Flux Density | B | Unlimited | mT |

*Absolute maximum ratings*

*1 The maximum junction temperature should not be exceeded*

*2 For maximum 1 hour*

*3 Including current through protection device*

*4 For maximum 500ms*

*5 Through protection device*

*6 For $V_{OUT}$≤27V*

*7 For 1000 hours*

*8 Human Model according AEC-Q100-002 standard*

*9 Charged Device Model according AEC-Q100-011 standard*

# 8 General Electrical Specifications

DC Operating Parameters $V_{DD}$ = 2.7V to 24V, $T_A$ = -40°C to 150°C (unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | Typ[1] | Max | Units |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{DD}$ | Operating | 2.7 | - | 24 | V |
| Supply Current | $I_{DD}$ | | 1.5 | 3.0 | 4.5 | mA |
| Reverse supply current | $I_{DDREV}$ | $V_{DD}$ = -16V | -1 | - | - | mA |
| Output Saturation Voltage | $V_{DSON}$ | $V_{DD}$ = 3.5 to 24V, $I_{OUT}$ = 20mA | - | 0.3 | 0.5 | V |
| Output Leakage | $I_{OFF}$ | $V_{OUT}$ = 12V, $V_{DD}$ = 12V | - | - | 10 | µA |
| Output Rise Time [2, 6] ($R_{PU}$ dependent) | $t_R$ | $R_{PU}$ = 1kΩ, $V_{DD}$ = 12V, $V_{PU}$ = 5V $C_{LOAD}$ = 50pF to GND | 0.1 | 0.3 | 1 | µs |
| Output Fall Time [2, 6] (On-chip controlled) | $t_F$ | $R_{PU}$ = 1kΩ, $V_{DD}$ = 12V, $V_{PU}$ = 5V $C_{LOAD}$ = 50pF to GND | 0.1 | 0.3 | 1 | µs |
| Power-On Time [3,4,7] | $t_{ON}$ | $V_{DD}$ = 5V, $dV_{DD}/dt$ > 2V/us | - | 40 | 70 | µs |
| Power-On Output State | - | $t < t_{ON}$ | | High ($V_{PU}$) | | - |
| Output Current Limit | $I_{CL}$ | $V_{DD}$=3.5 to 24V, $V_{OUT}$ = 12V | 25 | 40 | 70 | mA |
| Output ON Time under Current Limit conditions[8] | $t_{CLON}$ | $V_{PU}$ = 12V, $R_{PU}$ = 100Ω | 150 | 240 | | µs |
| Output OFF Time under Current Limit conditions[8] | $t_{CLOFF}$ | $V_{PU}$ = 12V, $R_{PU}$ = 100Ω | - | 3.5 | - | ms |
| Chopping Frequency | $f_{CHOP}$ | | - | 340 | - | kHz |
| Refresh Period | $t_{PER}$ | | - | 6 | - | µs |
| Output Jitter (p-p) [2] | $t_{JITTER}$ | Over 1000 successive switching events @10kHz triangle wave magnetic field, B > ±($B_{OPMAX}$ +20mT) | - | ±3.2 | - | µs |
| Maximum Switching Frequency [2, 5] | $f_{SW}$ | B > ±3($B_{OPMAX}$ +1mT), triangle wave magnetic field | 30 | 65 | - | kHz |
| Under-voltage Lockout Threshold | $V_{UVL}$ | | - | - | 2.7 | V |
| Under-voltage Lockout Reaction time [2] | $t_{UVL}$ | | - | 1 | - | µs |
| Thermal Protection Threshold | $T_{PROT}$ | Junction temperature | - | 190[9] | - | °C |
| Thermal Protection Release | $T_{REL}$ | Junction temperature | - | 180[9] | - | °C |
| SE Package Thermal Resistance | $R_{THJA}$ | Single layer PCB, JEDEC standard test boards | | 300 | | °C/W |
| UA package Thermal Resistance | $R_{THJA}$ | Single layer PCB, JEDEC standard test boards | | 200 | | °C/W |

*General Electrical parameters*

1 *Typical values are defined at $T_A$ = +25°C and $V_{DD}$ = 12V*
2 *Guaranteed by design and verified by characterization, not production tested*
3 *The Power-On Time represents the time from reaching $V_{DD}$ = 2.7V to the first refresh of the output*
4 *Power-On Slew Rate is not critical for the proper device start-up.*
5 *Maximum switching frequency corresponds to the maximum frequency of the applied magnetic field which is detected without loss of pulses*
6 *$R_{PU}$ and $V_{PU}$ are respectively the external pull-up resistor and pull-up power supply*
7 *Activated output with 1 mT overdrive*
8 *If the Output is in Current Limitation longer than $t_{CLON}$ the Output is switched off in high-impedance state. The Output returns back in active state at next reaching of $B_{OP}$ or after $t_{CLOFF}$ time interval*
9 *$T_{PROT}$ and $T_{REL}$ are the corresponding junction temperature values*

# 9 Magnetic Specifications

## 9.1 MLX92231LSE-AAA-004

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) | | | Release Point $B_{RP}$ (mT) | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | -7.7 | -5.9 | -4.3 | -5.6 | -4.0 | -2.3 | -1100[2] | Z-axis sensitive Direct Switch North Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | -6.8 | -5.5 | -4.2 | -5.0 | -3.7 | -2.3 | | | |
| $T_A$ = 150°C | -6.8 | -4.7 | -3.1 | -5.0 | -3.2 | -1.5 | | | |

## 9.2 MLX92231LSE-AAA-005

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | | | | | | | -1100[2] | Z-axis sensitive Direct Switch North Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | | -26 | | | -20 | | | | |
| $T_A$ = 150°C | | | | | | | | | |

## 9.3 MLX92231LSE-AAA-007

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 20.0 | 26.0 | 33.0 | 14.0 | 20.0 | 25.0 | 0[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 20.0 | 26.0 | 33.0 | 14.0 | 20.0 | 25.0 | | | |
| $T_A$ = 150°C | 20.0 | 26.0 | 33.0 | 14.0 | 20.0 | 25.0 | | | |

*1 Typical values are defined at $T_A$=+25°C and $V_{DD}$=12V*

*2 Temperature coefficient is calculated using the following formula:*

$$\frac{B_{OPT2} - B_{OPT1}}{B_{OP25^oC} \times (T_2 - T_1)} * 10^6, ppm/^oC; T_1 = -40^oC; T_2 = 150^oC$$

*3 Final magnetic parameters will be covered in the PPAP documentation set, the table below is based on theoretical calculations*

## 9.4 MLX92231LSE-AAA-009

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 2.0 | 3.5 | 5.0 | 1.4 | 2.5 | 3.3 | 0[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 2.5 | 3.5 | 4.5 | 1.8 | 2.5 | 3.1 | | | |
| $T_A$ = 150°C | 2.0 | 3.5 | 5.0 | 1.4 | 2.5 | 3.3 | | | |

## 9.5 MLX92231LSE-AAA-010

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) | | | Release Point $B_{RP}$ (mT) | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 8.7 | 10.7 | 13.4 | 6.8 | 9.0 | 11.5 | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 8.3 | 10.0 | 11.8 | 6.8 | 8.5 | 10.1 | | | |
| $T_A$ = 150°C | 6.1 | 8.6 | 11.4 | 4.9 | 7.3 | 9.8 | | | |

## 9.6 MLX92231LSE-AAA-013

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 2.0 | 3.5 | 5.0 | 1.4 | 2.5 | 3.3 | 0[2] | Z-axis sensitive Inverted Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 2.5 | 3.5 | 4.5 | 1.8 | 2.5 | 3.1 | | | |
| $T_A$ = 150°C | 2.0 | 3.5 | 5.0 | 1.4 | 2.5 | 3.3 | | | |

## 9.7 MLX92231LSE-AAA-014

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 3.6 | 6.0 | 8.4 | 1.5 | 3.6 | 6.1 | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 3.9 | 5.5 | 7.1 | 2.0 | 3.5 | 5.3 | | | |
| $T_A$ = 150°C | 2.0 | 4.8 | 7.1 | 1.3 | 3.5 | 6.7 | | | |

*1 Typical values are defined at $T_A$=+25°C and $V_{DD}$=12V*

*2 Temperature coefficient is calculated using the following formula:*

$$\frac{B_{OPT2} - B_{OPT1}}{B_{OP25^oC} \times (T_2 - T_1)} * 10^6, ppm/^oC; T_1 = -40^oC; T_2 = 150^oC$$

*3 Final magnetic parameters will be covered in the PPAP documentation set, the table below is based on theoretical calculations*

## 9.8 MLX92231LSE-AAA-019

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 21.5 | 26.0 | 31.0 | 19.0 | 24.0 | 28.5 | -2000[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 20.0 | 23.0 | 26.0 | 17.5 | 21.0 | 24.0 | | | |
| $T_A$ = 150°C | 13.0 | 17.0 | 22.0 | 12.0 | 15.0 | 20.0 | | | |

## 9.9 MLX92231LSE-AAA-021

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 4.3 | 5.9 | 7.7 | 2.1 | 3.8 | 5.4 | -1100[2] | Z-axis sensitive Inverted Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 3.8 | 5.5 | 7.2 | 2.0 | 3.5 | 5.0 | | | |
| $T_A$ = 150°C | 3.2 | 4.8 | 6.8 | 1.7 | 3.0 | 5.2 | | | |

## 9.10 MLX92231LSE-AAA-023

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 39.0 | 46.1 | 53.9 | 36.3 | 44.1 | 52.5 | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 38.5 | 43.0 | 47.5 | 35.9 | 41.0 | 46 | | | |
| $T_A$ = 150°C | 28.8 | 37.1 | 46.5 | 25.6 | 35.0 | 45.1 | | | |

## 9.11 MLX92231LSE-AAA-026

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 21.5 | 26.0 | 31.0 | 19.0 | 24.0 | 28.5 | -2000[2] | Z-axis sensitive Inverted Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 20.0 | 23.0 | 26.0 | 17.5 | 21.0 | 24.0 | | | |
| $T_A$ = 150°C | 13.0 | 17.0 | 22.0 | 12.0 | 15.0 | 20.0 | | | |

*1 Typical values are defined at $T_A$=+25°C and $V_{DD}$=12V*

*2 Temperature coefficient is calculated using the following formula:*

$$\frac{B_{OPT2} - B_{OPT1}}{B_{OP25^oC} \times (T_2 - T_1)} * 10^6, ppm/^oC; T_1 = -40^oC; T_2 = 150^oC$$

*3 Final magnetic parameters will be covered in the PPAP documentation set, the table below is based on theoretical calculations*

## 9.12 MLX92231LSE-AAA-029

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) | | | Release Point $B_{RP}$ (mT) | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 13.5 | 16.0 | 18.8 | 12.5 | 15.0 | 17.9 | -1100[2] | Z-axis sensitive Inverted Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 13.3 | 15.0 | 16.7 | 12.3 | 14.0 | 15.7 | | | |
| $T_A$ = 150°C | 10.2 | 13.0 | 16.0 | 9.1 | 12.0 | 15.0 | | | |

## 9.13 MLX92231LSE-AAA-031

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) | | | Release Point $B_{RP}$ (mT) | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | -17.5 | -13.5 | -10.0 | -12.0 | -8.5 | -5.7 | 0[2] | Z-axis sensitive Direct Switch North Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | -17.5 | -13.5 | -10.0 | -12.0 | -8.5 | -5.7 | | | |
| $T_A$ = 150°C | -17.5 | -13.5 | -10.0 | -12.0 | -8.5 | -5.7 | | | |

## 9.14 MLX92231LSE-AAA-032

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 20.4 | 24.6 | 29.4 | 17.7 | 22.6 | 27.9 | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 20.2 | 23.0 | 25.9 | 17.6 | 21.0 | 24.4 | | | |
| $T_A$ = 150°C | 15.4 | 19.8 | 25 | 12.6 | 17.7 | 23.5 | | | |

## 9.15 MLX92231LSE-AAA-033

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | | | | | | | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | | 18 | | | 12.5 | | | | |
| $T_A$ = 150°C | | | | | | | | | |

*1 Typical values are defined at $T_A$=+25°C and $V_{DD}$=12V*

*2 Temperature coefficient is calculated using the following formula:*

$$\frac{B_{OPT2} - B_{OPT1}}{B_{OP25^oC} \times (T_2 - T_1)} * 10^6, ppm/^oC; T_1 = -40^oC; T_2 = 150^oC$$

*3 Final magnetic parameters will be covered in the PPAP documentation set, the table below is based on theoretical calculations*

## 9.16 MLX92231LUA-AAA-034

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 4.3 | 5.9 | 7.7 | 2.1 | 3.8 | 5.4 | -1100[2] | Z-axis sensitive Direct Switch South Pole | UA (TO92-3) |
| $T_A$ = 25°C | 3.8 | 5.5 | 7.2 | 2 | 3.5 | 5 | | | |
| $T_A$ = 150°C | 3.2 | 4.8 | 6.8 | 1.7 | 3 | 5.2 | | | |

## 9.17 MLX92231LUA-AAA-039

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 10.0 | 13.5 | 17.4 | 5.7 | 8.5 | 12.0 | 0[2] | Z-axis sensitive Direct Switch South Pole | UA (TO92-3) |
| $T_A$ = 25°C | 10.0 | 13.5 | 17.4 | 5.7 | 8.5 | 12.0 | | | |
| $T_A$ = 150°C | 10.0 | 13.5 | 17.4 | 5.7 | 8.5 | 12.0 | | | |

## 9.18 MLX92231LSE-AAA-040

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | | | | | | | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | | 66.0 | | | 50.0 | | | | |
| $T_A$ = 150°C | | | | | | | | | |

## 9.19 MLX92231LSE-AAA-041

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | | | | | | | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | | 10.2 | | | 8.4 | | | | |
| $T_A$ = 150°C | | | | | | | | | |

*1 Typical values are defined at $T_A$=+25°C and $V_{DD}$=12V*

*2 Temperature coefficient is calculated using the following formula:*

$$\frac{B_{OPT2} - B_{OPT1}}{B_{OP25^oC} \times (T_2 - T_1)} * 10^6, ppm/^oC; T_1 = -40^oC; T_2 = 150^oC$$

*3 Final magnetic parameters will be covered in the PPAP documentation set, the table below is based on theoretical calculations*

## 9.20 MLX92231LSE-AAA-042

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | | | | | | | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | | 51.2 | | | 41 | | | | |
| $T_A$ = 150°C | | | | | | | | | |

## 9.21 MLX92231LSE-AAA-049

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

| Test Condition | Operating Point $B_{OP}$ (mT) [3] | | | Release Point $B_{RP}$ (mT) [3] | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 13.5 | 16.0 | 18.8 | 12.5 | 15.0 | 17.9 | -1100[2] | Z-axis sensitive Direct Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 13.3 | 15.0 | 16.7 | 12.3 | 14.0 | 15.7 | | | |
| $T_A$ = 150°C | 10.2 | 13.0 | 16.0 | 9.1 | 12.0 | 15.0 | | | |

## 9.22 MLX92231LSE-AAA-204

DC Operating Parameters $V_{DD}$ = 3.5V to 24V, $T_A$ = -40°C to 150°C

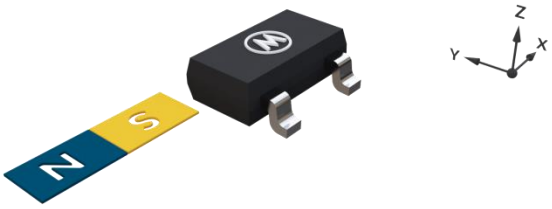
| Test Condition | Operating Point $B_{OP}$ (mT) | | | Release Point $B_{RP}$ (mT) | | | TC (ppm/°C) | Output Polarity Active Pole | Package Information |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Typ[1] | Max | Min | Typ[1] | Max | Typ[1] | | |
| $T_A$ = -40°C | 4.7 | 7.0 | 9.4 | 3.5 | 6.2 | 9.0 | -1100[2] | X-axis sensitive Inverted Switch South Pole | SE (TSOT-3L) |
| $T_A$ = 25°C | 4.4 | 6.5 | 8.7 | 3.2 | 5.6 | 8.1 | | | |
| $T_A$ = 150°C | 3.4 | 5.5 | 7.8 | 2.2 | 4.6 | 7.3 | | | |

*1 Typical values are defined at $T_A$=+25°C and $V_{DD}$=12V*

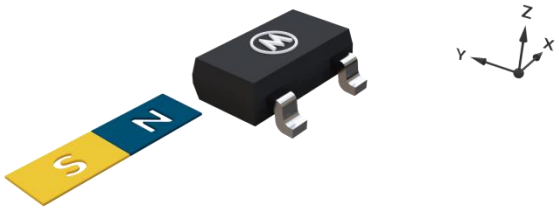
*2 Temperature coefficient is calculated using the following formula:*

$$\frac{B_{OPT2} - B_{OPT1}}{B_{OP25^oC} \times (T_2 - T_1)} * 10^6, ppm/^oC; T_1 = -40^oC; T_2 = 150^oC$$

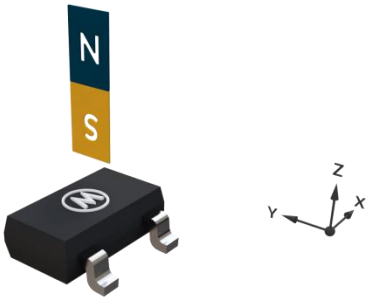
*3 Final magnetic parameters will be covered in the PPAP documentation set, the table below is based on theoretical calculations*



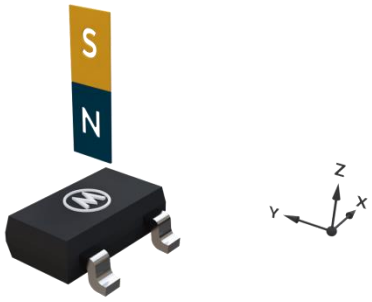

*South active pole (IMC version)*



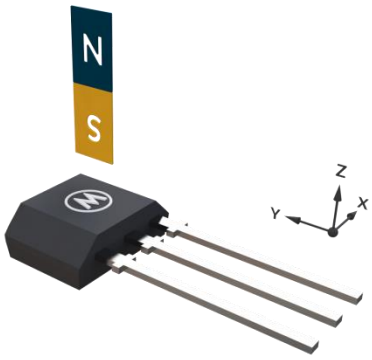

*North active pole (IMC version)*



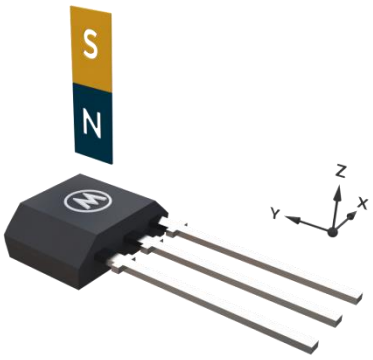

*South active pole*




*North active pole*

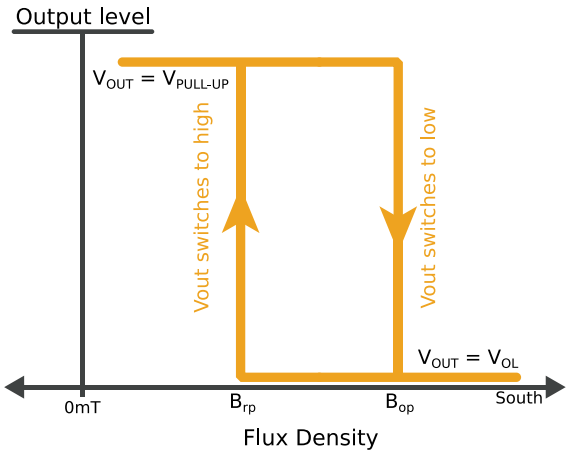



*South active pole*

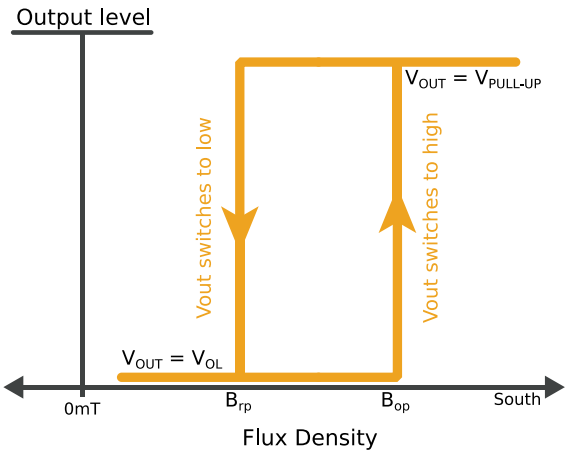



*North active pole*

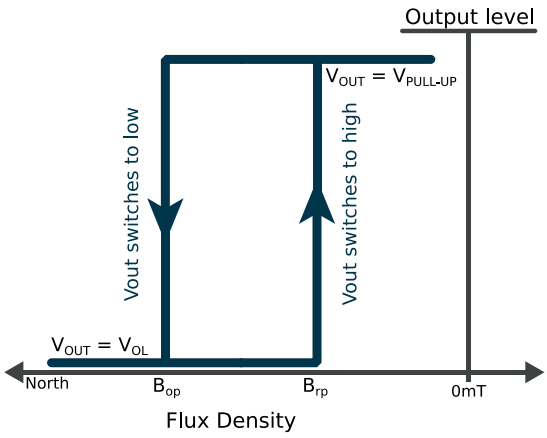
# 10 Magnetic Behaviour



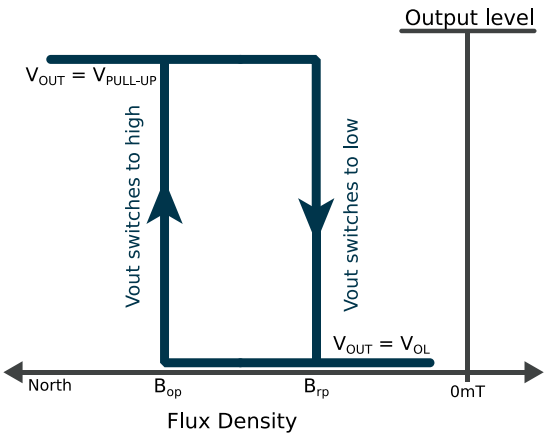

*Direct South Active Pole*




*Inverted South Active Pole*



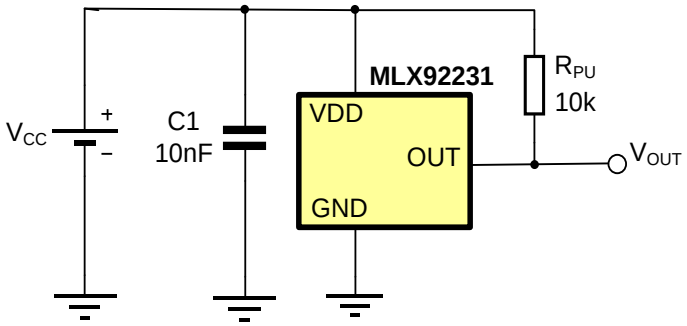

*Direct North Active Pole*




*Inverted North Active Pole*

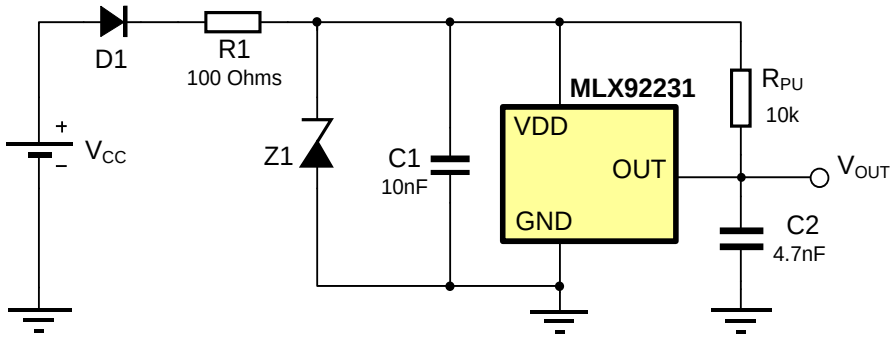
# 11 Application Information

## 11.1 Typical Three-Wire Application Circuit




Notes:
1. For proper operation, a 10nF to 100nF bypass capacitor should be placed as close as possible to the $V_{DD}$ and ground pin.
2. The pull-up resistor $R_{PU}$ value should be chosen in to limit the current through the output pin below the maximum allowed continuous current for the device.
3. A capacitor connected to the output is not needed, because the output slope is generated internally.

## 11.2 Automotive and Harsh, Noisy Environments Three-Wire Circuit




Notes:
1. For proper operation, a 10nF to 100nF bypass capacitor should be placed as close as possible to the $V_{DD}$ and ground pin.
2. The device could tolerate negative voltage down to -24V, so if negative transients over supply line $V_{PEAK}$< -30V are expected, usage of the diode D1 is recommended. Otherwise only R1 is sufficient.
When selecting the resistor R1, three points are important:
   - the resistor has to limit $I_{DD}/I_{DDREV}$ to 50mA maximum
   - the resistor has to withstand the power dissipated in both over voltage conditions ($V_{R1}^2/R1$)
   - the resulting device supply voltage $V_{DD}$ has to be higher than $V_{DD}$ min ($V_{DD} = V_{CC} – R1.I_{DD}$)
3. The device could tolerate positive supply voltage up to +27V (until the maximum power dissipation is not exceeded), so if positive transients over supply line with $V_{PEAK}$> 32V are expected, usage a zener diode Z1 is recommended. The R1-Z1 network should be sized to limit the voltage over the device below the maximum allowed.

# 12 Standard information regarding manufacturability of Melexis products 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.

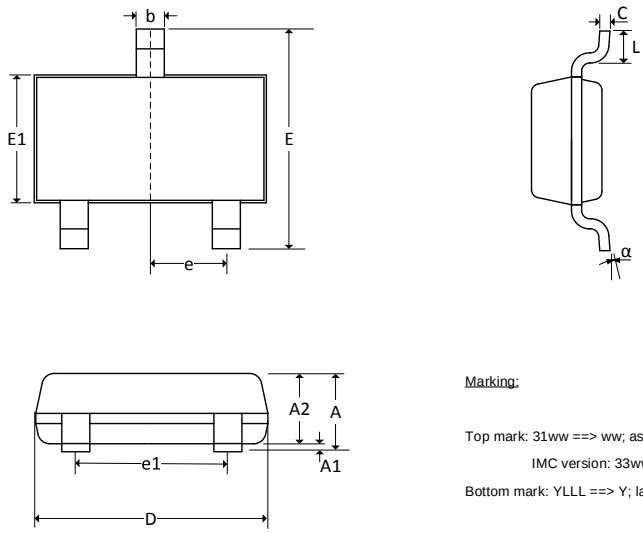
Melexis is contributing to global environmental conservation by promoting **lead free** solutions. For more information on qualifications of **RoHS** compliant products (RoHS = European directive on the Restriction Of the use of certain Hazardous Substances) please visit the quality page on our website: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

# 13 ESD Precautions

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

# 14 Package Information

## 14.1 SE (TSOT-3L) Package Information

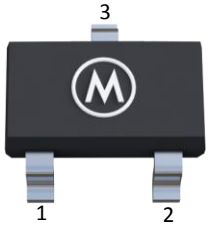



| | A | A1 | A2 | D | E | E1 | L | b | c | e | e1 | α |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| min | – | 0.025 | 0.85 | 2.80 | 2.60 | 1.50 | 0.30 | 0.30 | 0.10 | 0.95 | 1.90 | 0° |
| max | 1.00 | 0.10 | 0.90 | 3.00 | 3.00 | 1.70 | 0.50 | 0.45 | 0.20 | BSC | BSC | 8° |

Notes:

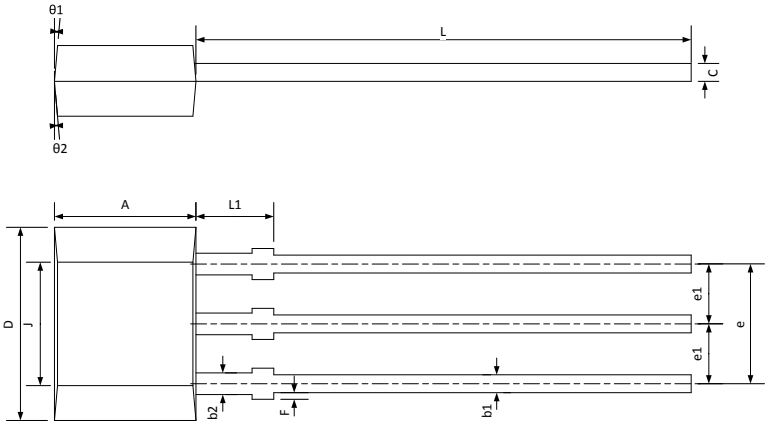
1. All dimensions are in millimetres.
2. Dimension “D” and “E1” do not include mold flash or protrusions. Mold flash or protrusion shall not exceed 0.15mm on “D” and 0.25mm on “E” per side.
3. Dimension “b” does not include dambar protrusion.

| SE Pin № | Name | Type | Function |
|---|---|---|---|
| 1 | VDD | Supply | Supply Voltage pin |
| 2 | OUT | Output | Open Drain output |
| 3 | GND | Ground | Ground pin |



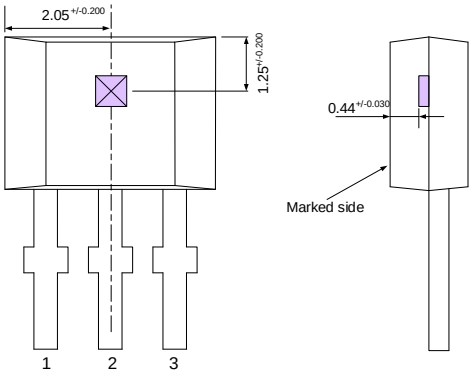

*SE Package pinout*

## 14.2 UA (TO92-3L) Package Information




Marking:
1st Line : 31WW → WW - calendar week
2nd Line : YLLL: → Y - last digit of year
LLL- Lot number (3 digits)

**Hall plate location**




Notes:
1. All dimensions are in millimeters

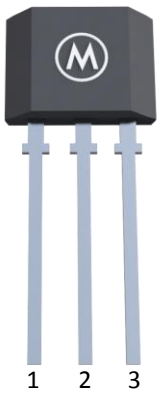
| | A | D | E | F | J | L | L1 | S | b1 | b2 | c | e | e1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| min | 2.80 | 3.90 | 1.40 | 0.00 | 2.51 | 14.0 | 0.90 | 0.63 | 0.35 | 0.43 | 0.35 | 2.51 | 1.24 |
| max | 3.20 | 4.30 | 1.60 | 0.20 | 2.72 | 15.0 | 1.10 | 0.84 | 0.44 | 0.52 | 0.44 | 2.57 | 1.30 |

| | θ1 | θ2 | θ3 | θ4 |
|---|---|---|---|---|
| min | 7° REF | 7° REF | 45° REF | 7° REF |
| max | | | | |

Notes:
1. All dimensions are in millimetres
2. Mold flashes and protrusion are not included.
3. Gate burrs shall not exceed 0.127mm on the top side.

| UA Pin № | Name | Type | Function |
|---|---|---|---|
| 1 | VDD | Supply | Supply Voltage pin |
| 2 | GND | Ground | Ground pin |
| 3 | OUT | Output | Open Drain output |

*UA Package pinout*



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For the latest version of this document, go to our website at www.melexis.com.

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

| | |
|---|---|
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| | Email : sales_europe@melexis.com |
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| | Email : sales_usa@melexis.com |
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