MLX92232

End of line programmable Hall-effect Latch / Switch

1. Features and Benefits

- Programmable parameters in the application
  - Wide magnetic Latch range: ±0.4mT to ±80mT
  - Wide magnetic Switch range: ±1.5mT to ±66mT
  - Programmable Hysteresis: 1mT to 36mT
  - Programmable field: North or South
  - Programmable Output polarity: Direct or Inverted
  - Built-in Negative TC coefficient: 0 to -2000 ppm/degC
  - Increased Traceability: 32 bits ID on chip
- Wide operating voltage rang : from 2.7V to 24V
- Reverse Supply Voltage Protection
- Output Current Limit with Auto-Shutoff
- Under-Voltage Lockout Protection
- Thermal Protection

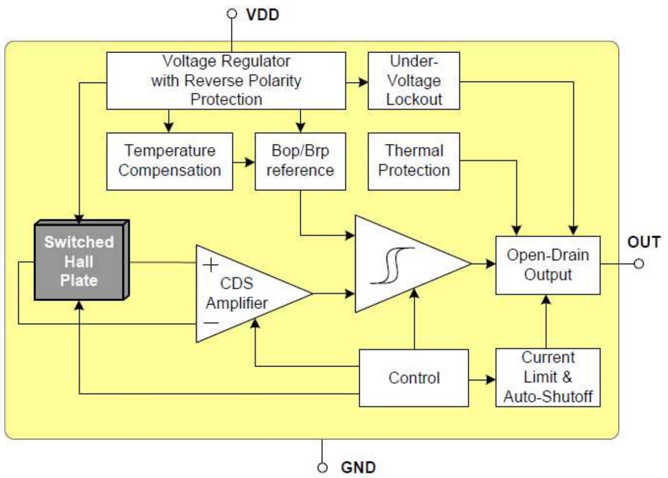
2. Application Examples

- Automotive, Consumer and Industrial
- Solid-state switch
- 3-phase BLDC motor commutation
- Wiper motor
- Window lifter
- Sunroof/Tailgate opener
- Seat motor adjuster
- Electrical power steering
- Brake Light switch

3. Ordering Information

Part No.	Temperature Code	Package Code	Comment
MLX92232LSE-AAA-000-RE	L (-40°C to 150°C)	SE (TSOT-3L)	3-wire Switch / Latch, TC = 0 ppm/°C
MLX92232LUA-AAA-000-BU	L (-40°C to 150°C)	UA (TO-92)	3-wire Switch / Latch, TC = 0 ppm/°C
MLX92232LSE-AAA-001-RE	L (-40°C to 150°C)	SE (TSOT-3L)	3-wire Switch / Latch, TC = -400 ppm/°C
MLX92232LUA-AAA-001-BU	L (-40°C to 150°C)	UA (TO-92)	3-wire Switch / Latch, TC = -400 ppm/°C
MLX92232LSE-AAA-002-RE	L (-40°C to 150°C)	SE (TSOT-3L)	3-wire Switch / Latch, TC = -1100 ppm/°C
MLX92232LUA-AAA-002-BU	L (-40°C to 150°C)	UA (TO-92)	3-wire Switch / Latch, TC = -1100 ppm/°C
MLX92232LSE-AAA-003-RE	L (-40°C to 150°C)	SE (TSOT-3L)	3-wire Switch / Latch, TC = -2000 ppm/°C
MLX92232LUA-AAA-003-BU	L (-40°C to 150°C)	UA (TO-92)	3-wire Switch / Latch, TC = -2000 ppm/°C

4. Functional Diagram



5. General description

The Melexis MLX92232 is the second generation programmable Hall-effect sensor designed in mixed signal CMOS technology. The device integrates a voltage regulator, Hall sensor with advanced offset cancellation system and an open-drain output driver, all in a single package.

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 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.

Furthermore the MLX92232 features a full set of programmable parameters that can be adjusted in the application in order to achieve the highest possible system accuracy by compensating the mechanical tolerances.

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6. Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Supply Voltage [1, 2]	V_{DD}	+27V	V
Supply Voltage (Load Dump) [1, 4]	V_{DD}	+32V	V
Supply Current [1, 2, 3]	I_{DD}	+20	mA
Supply Current [1, 4, 3]	I_{DD}	+50	mA
Reverse Supply Voltage [1, 2]	V_{DDREV}	-24	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}	-50	mA
Maximum Junction Temperature [7]	T_J	+165	°C
ESD Sensitivity – HBM [8]	-	4500	V
ESD Sensitivity – MM [9]	-	500	V

[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 $V_{OUT} \leq 27V$.*
[7] *For 1000 hours.*
[8] *Human Model according AEC-Q100-002 standard*
[9] *Machine Model according AEC-Q100-003 standard*

ESD Sensitivity – CDM [10]	-	1000	V
Magnetic Flux Density	B	Unlimited	mT

Table 1 - 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.

[10] *Charged Device Model according AEC-Q100-011 standard*

7. General Electrical Specifications

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

Parameter	Symbol	Test Conditions	Min	Typ[11]	Max	Units
Supply Voltage	V_{DD}	Operating	2.7	-	24	V
Supply Current	I_{DD}		1.9	3.0	3.9	mA
Reverse supply current	I_{DDREV}	V_{DD} = -16V	-1	-	-	mA
Output Saturation Voltage	V_{OL}	V_{DD} = 3.5 to 24V, I_{OUT} = 20mA	-	0.25	0.5	V
Output Leakage	I_{OFF}	V_{OUT} = 12V, V_{DD} = 12V	-	-	10	µA
Output Rise Time [12, 15] (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 [12, 15] (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 [13, 14]	t_{ON}	V_{DD} = 5V, dV_{DD}/dt > 2V/us, activated output with >1mT overdrive	-	40	70	µs
Power-On Output State	-	t < t_{ON}	High (VPU)			-
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 [15, 16]	t_{CLON}	V_{PU} = 12V, R_{PU} = 100Ω	180	240	-	µs
Output OFF Time under Current Limit conditions [15, 16]	t_{CLOFF}	V_{PU} = 12V, R_{PU} = 100Ω	-	3.5	-	ms
Chopping Frequency	f_{CHOP}			350	-	kHz
Refresh Period	t_{PER}		-	6	-	µs
Delay Time [12, 17]	t_D	Average over 1000 successive	-	7.5	-	µs

[11] *Typical values are defined at TA = +25°C and VDD = 12V*

[12] *Guaranteed by design and verified by characterization, not production tested*

[13] *The Power-On Time represents the time from reaching V_{DD} = 2.7V to the first refresh of the output*

[14] *Power-On Slew Rate is not critical for the proper device start-up.*

[15] *R_{PU} and V_{PU} are respectively the external pull-up resistor and pull-up power supply*

[16] *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*

Parameter	Symbol	Test Conditions	Min	Typ[11]	Max	Units
		switching events @10kHz, Latch, B_{OP} set to 5mT, square wave magnetic field with B > ±20mT, $t_{RISE} = t_{FALL} \leq 20\mu s$				
Output Jitter (p-p) [12, 18]	t_{JITTER}	Over 1000 successive switching events @ 1kHz, Latch, B_{OP} set to 5mT, square wave magnetic field with B > ±20mT, $t_{RISE} = t_{FALL} \leq 20\mu s$	-	±4	-	µs
Maximum Switching Frequency [12, 19]	f_{SW}	Latch, B_{OP} set to 5mT, square wave magnetic field with B > ±20mT	30	50	-	kHz
Under-voltage Lockout Threshold	V_{UVL}		-	-	2.7	V
Under-voltage Lockout Reaction time [12]	t_{UVL}		-	1	-	µs
Thermal Protection Threshold	T_{PROT}	Junction temperature	-	190	-	°C
Thermal Protection Release	T_{REL}	Junction temperature	-	180	-	°C

Table 2 - General Electrical Specifications

[17] *The Delay Time is the time from magnetic threshold reached to the start of the output switching*
[18] *Output jitter is the unpredictable deviation of the Delay Time*
[19] *Maximum switching frequency corresponds to the maximum frequency of the applied magnetic field which is detected without loss of pulses*

8. Magnetic Specifications

DC Operating Parameters V_{DD} = 3.5V to 24V, T_A = -40°C to 150°C (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ[1]	Max	Units
Latch Threshold Programming Range (2, 6)	B_{LTH}	V_{DD}=12V, T_A=25°C	±0.4		±80	mT
Switch Operating Point Programming Range (3, 6)	B_{OP}	V_{DD} =12V, T_A =25°C	±1.5		±66	mT
Proportional Hysteresis Ratio Programming Range HYS_{RATIO} (4, 7)	HYS_{RATIO}	V_{DD}=12V, T_A=25°C	0.10		0.55	
Fixed Hysteresis Value 0 (5)	B_{FHYS0}			0		mT
Fixed Hysteresis Value 1 (5, 8)	B_{FHYS1}			1		mT
Fixed Hysteresis Value 2 (5)	B_{FHYS2}			1.2		mT
Fixed Hysteresis Value 3 (5)	B_{FHYS3}			1.4		mT
Fixed Hysteresis Value 4 (5)	B_{FHYS4}			1.8		mT
Fixed Hysteresis Value 5 (5)	B_{FHYS5}			2.2		
Latch sensor Magnetic Offset (B_{OP} + B_{RP})/2	B_{OFFSET}	T_A = 25°C	-0.5		+0.5	mT
	B_{OFFSET} (8)	T_A = -40°C to 150°C	-0.9		+0.9	mT
Temperature Coefficient (9)	TC	Flat		0		ppm/ºC
		SmCo,		- 400		
		NdFeB,		- 1100		
		Hard Ferrite,		- 2000		
Factory Programmed B_{OP}, Switch	B_{OP}	V_{DD} = 12V, T_A = 25°C, programming target 28mT	26	28	30	mT
Factory Programmed B_{RP}, Switch	B_{RP}	V_{DD} = 12V, T_A = 25°C, programming target 28mT, HYS_{RATIO} = 0.75	19	21	23	mT

Table 3: Magnetic specifications

The hysteresis is programmable for each Bop point with a fixed value or proportional (ratiometric) to B_{OP} :

1) Ratiometric hysteresis example: B_{OP} = 10mT ➔ 4.5mT ≤ B_{RP} ≤ 9mT 2)
Fixed hysteresis example: B_{OP} = 10mT ➔ 7.8mT ≤ B_{RP} ≤ 9mT

1. The typical values are defined at T_A = 25ºC and V_{DD} = 12V
2. For Latch sensor B_{LTH} = (B_{OP} - B_{RP})/2. The Latch programming step is typically between 0.7% and 1.5% of the programmed B_{LTH} value for $|B_{LTH}|$ ≥ 1.2mT and 0.018mT for $|B_{LTH}|$ ≤ 1.2mT
3. For Switch sensor the B_{OP} programming step is typically between 0.7% and 1.5% of the programmed B_{OP} value for $|B_{OP}|$ ≥ 4.8mT and 0.072mT for $|B_{OP}|$ ≤ 4.8mT
4. For Switch sensor with proportional hysteresis HYS_{RATIO} = B_{HYS} / B_{OP}. The HYS_{RATIO} programming step is 0.05
5. For Switch sensor with fixed hysteresis value
6. Guaranteed by design and verified by characterization. The programming ranges for B_{LTH} and B_{OP} include some margin for process deviations
7. The given min/max limits are typical values
8. Guaranteed by design and verified by characterization
9. The Temperature Coefficient is calculated using following formula:

$$TC = \frac{B_{150} - B_{-40}}{190 * B_{25}} * 10^6, \text{ppm/°C}$$

9. Programming parameters

Parameter	Symbol	Comments	Value	Units
B_{OP} programming resolution	B_{OPFINE}	Fine programming of thresholds B_{OP} (Switch) and B_{LTH} (Latch)	7	Bit
B_{OP} sub-range	$B_{OPRANGE}$	Selection of the appropriate Switch sensor sub-range	2	Bit
B_{LTH} sub-range	$B_{OPRANGE}$	Selection of the appropriate Latch sensor sub-range	3	Bit
Programmable Hysteresis	B_{HYST}	Hysteresis can be fixed or proportional (ratiometric)	4	Bit
Active Pole Selection	B_{POLE}	Part can be programmed for South (default) or North magnetic pole active	1	Bit
Output Polarity Selection	Pol_{OUT}	Selects Direct or Inverted sensor Output Polarity	1	Bit
Switch/Latch Function Selection		Selects Latch (default) or Switch sensor function	1	Bit
Melexis programmed ID	ID	A unique fixed ID is implemented for device traceability, no overwriting allowed	32	Bit

Table 4: Programmable Parameters

10. Magnetic Behaviour

10.1. Definitions:

Operation Point B_{OP} – magnetic threshold for activation of the device output, turning in ON (low) state.

Release Point B_{RP} – magnetic threshold for release of the device output, turning in OFF (high) state.

Hysteresis B_{HYS} – magnetic hysteresis, $B_{HYS} = B_{OP} - B_{RP}$

United Latch Threshold B_{LTH} – used for Latch sensor programming:

$B_{LTH} = (B_{OP} - B_{RP})/2 = B_{HYS}/2$, targeting symmetrical placement of both Latch sensor thresholds vs. zero $B_{RP} \approx -B_{OP}$

Proportional Hysteresis to Operation Point Ratio – used for Switch sensor with proportional hysteresis:

$HYS_{RATIO} = B_{HYS} / B_{OP}$

10.2. Latch sensor

Parameter	Pole Active	Remark
Option 1	South	Fig.1
Option 3	North	Fig.2

Note: Latch sensors are inherently Direct South or Direct North Pole Active only.

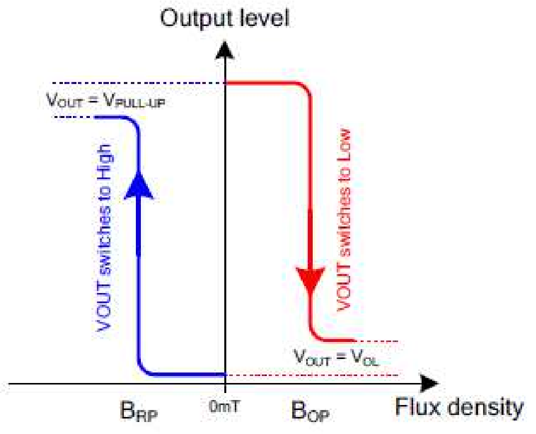


Fig.1 –South Pole Active

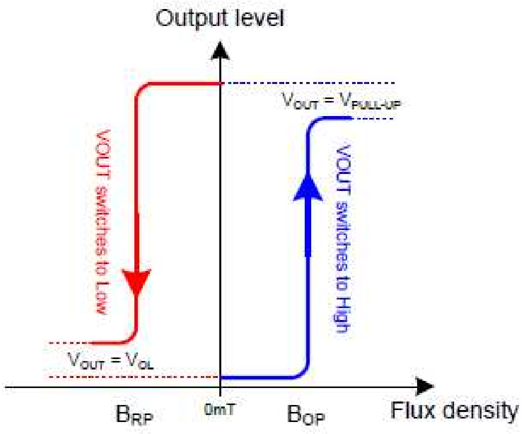


Fig.2 –North Pole Active

10.3. Unipolar Switch Sensor

Parameter	Pole Active	Magnetic Polarity	Remark
Option 1	South	Direct	Fig.1
Option 2	South	Inverted	Fig.2
Option 3	North	Direct	Fig.3
Option 4	North	Inverted	Fig.4

Table 5: Unipolar switch sensor

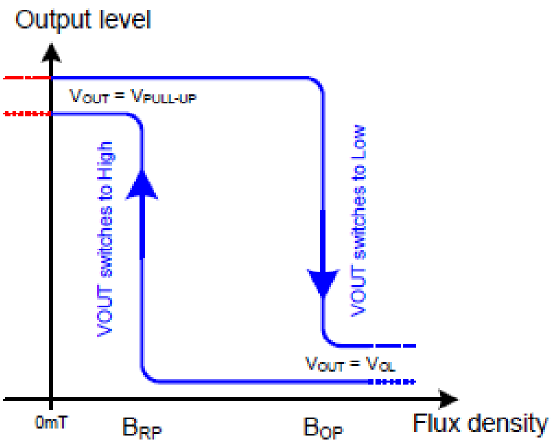


Fig.1 – Direct South Pole Active

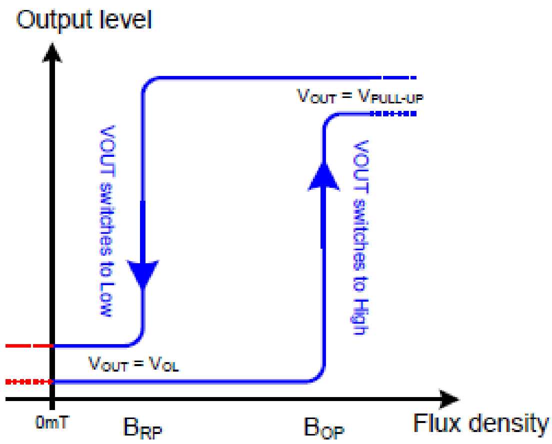


Fig.2 – Inverted South Pole Active

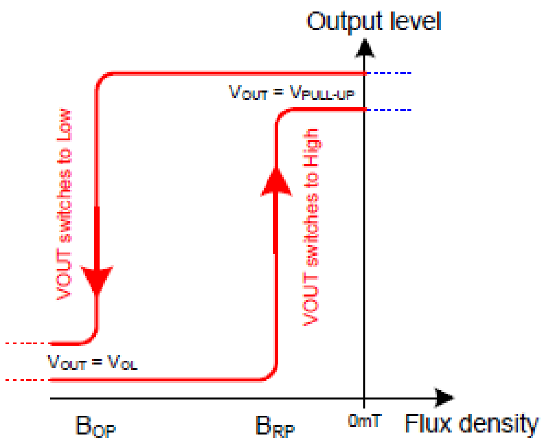


Fig.3 – Direct North Pole Active

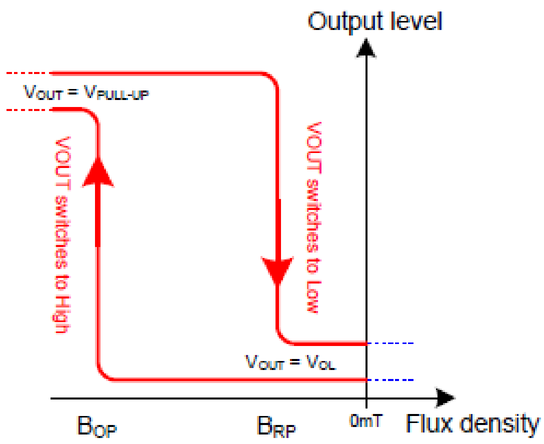
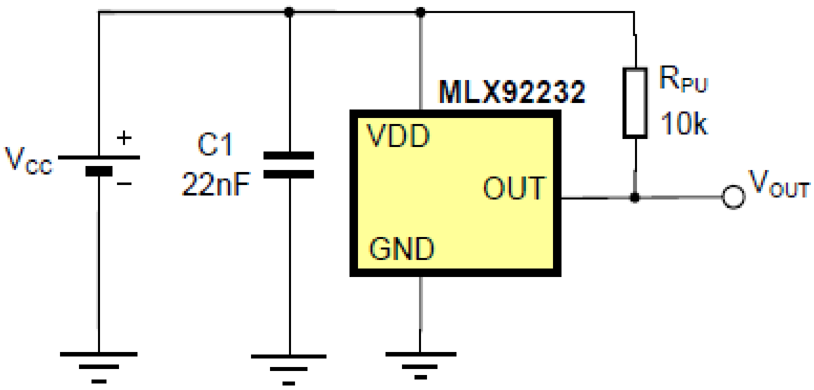


Fig.4 – Inverted North Pole Active

11. Application Information

11.1. Typical Three-Wire Application Circuit



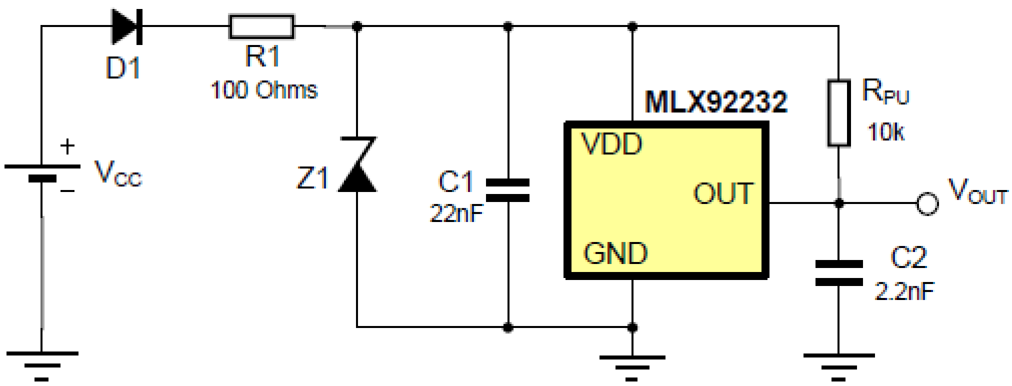
Notes:

1. For proper operation, a 10nF to 22nF bypass capacitor should be placed as close as possible to the VDD and ground pin.

2. The pull-up resistor RPU 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. Harsh, Noisy Environments Three-Wire Circuit



Notes:
1. For proper operation, a 10nF to 22nF 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 -27V, so if negative transients over supply line V_{PEAK}< -32V 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.
4. Limit C1 to max. 22nF and C2 to 2.2nF in case end of line programming is requested.

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 recommends reviewing on our web site the General Guidelines soldering recommendation (http://www.melexis.com/Quality_soldering.aspx) as well as trim&form recommendations (http://www.melexis.com/Assets/Trim-and-form-recommendations-5565.aspx).

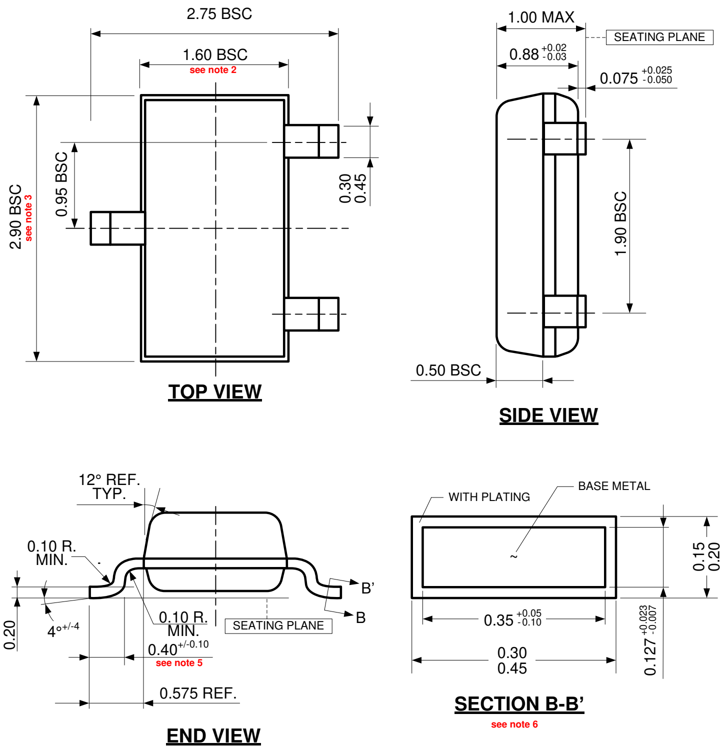
Melexis is contributing to global environmental conservation by promoting **lead free** solutions. For more information on qualifications of **RoHS** compliant products (RoHS = European directive on the Restriction Of the use of certain Hazardous Substances) please visit the quality page on our website: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

14.1. (TSOT-3L) Package Information



Notes:

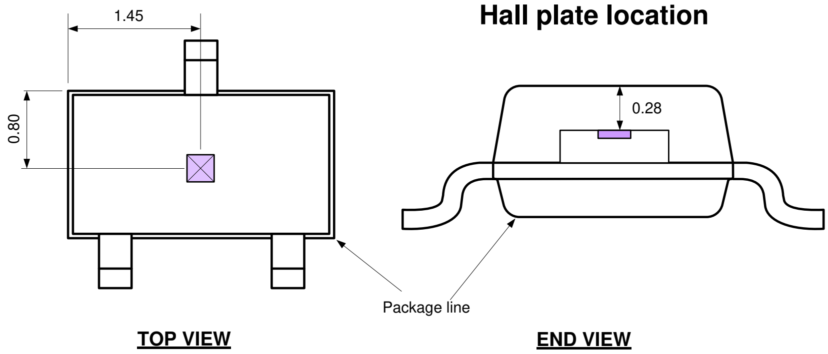
1. All dimensions are in millimeters
2. Outermost plastic extreme width does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 0.15mm per side.
3. Outermost plastic extreme length does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 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 is the length of terminal for soldering to a substrate.
6. Dimension on SECTION B-B' applies to the flat section of the lead between 0.08mm and 0.15mm from the lead tip.
7. Formed lead shall be planar with respect to one another with 0.076mm at seating plane.

Marking:

Top mark: 31ww ==> ww; assembly week

Bottom mark: YLLL ==> Y; year LLL= last 3 digits of lotnr

Hall plate location



Notes:

1. All dimensions are in millimeters

SE Pin №	Name	Type	Function
1	VDD	Supply	Supply
2	OUT	Outpu	Open Drain
3	GND	Groun	Ground pin

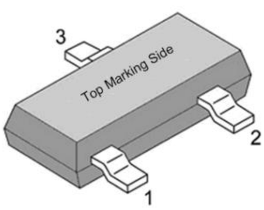
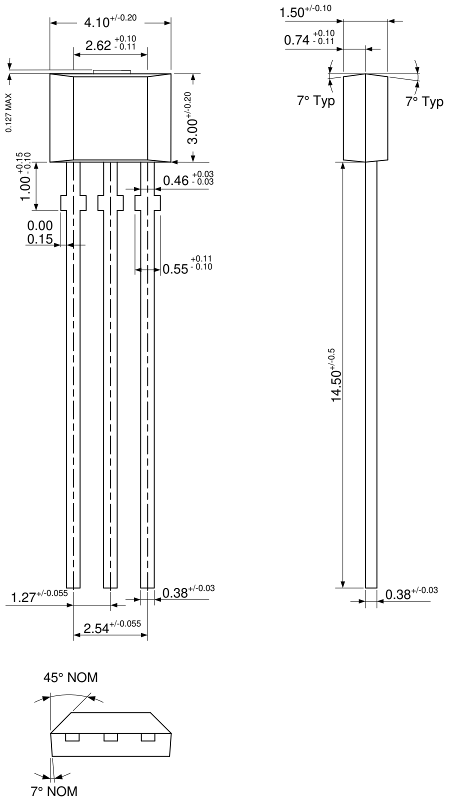


Table 3: SE Package pinout

14.2. UA (TO92-3L) Package Information



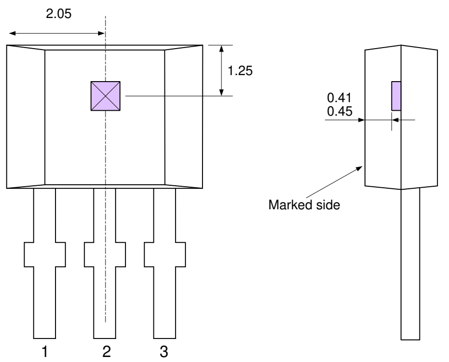
Notes:

1. All dimensions are in millimeters
2. Package dimension exclusive molding flash.
3. The end flash shall not exceed 0.127 mm on the top side.

Marking:

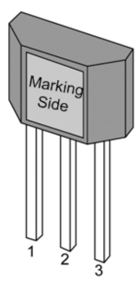
1st Line : 31WW → WW - calendar week
2nd Line : YLLL: → Y - last digit of year
LLL- Lot nr (3 digits)

Hall plate location



Notes:

1. All dimensions are in millimeters



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

Table 4: UA Package pinout

15. Contact

For the latest version of this document, go to our website at [www.melexis.com.](http://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_usa@melexis.com
Asia	Email : sales_asia@melexis.com

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