MLX92231-AAA-xxx

3-Wire Hall Effect Switch

Datasheet

Features and Benefits

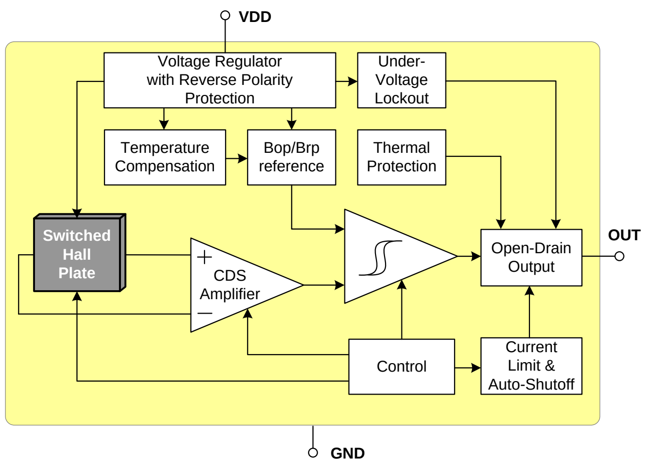
- Wide operating voltage range: from 2.7V to 24V
- Accurate switching thresholds
- Reverse Supply Voltage Protection
- Output Current Limit with Auto-Shutoff
- Under-Voltage Lockout Protection
- Thermal Protection
- Traceability with integrated unique ID
- High ESD rating / Excellent EMC performance
- Thin SOT23 3L Green Compliant package

Application Examples

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

Ordering Information			
Part No.	Temperature Code	Package Code	Comment
MLX92231LSE-AAA-xxx-RE	L (-40°C to 150°C)	SE (TSOT-3L)	RE (Reel)
MLX92231LUA-AAA-xxx-BU	L (-40°C to 150°C)	UA (TO-92)	BU (Bulk)

1. Functional Diagram



2. 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, Bop, Brp, 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 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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3. 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 Voltage (4)	V_{DDREV}	-30	V
Reverse Supply Voltage (Load Dump)(11)	V_{DDREV}	-35	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 – MM (9)	-	500	V
ESD Sensitivity – CDM (10)	-	1000	V
Magnetic Flux Density 11	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.

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[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] Machine Model according AEC-Q100-003 standard
[10] Charged Device Model according AEC-Q100-011 standard
[11] For maximum 100ms

4. 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 [2]	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 [1, 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 [1, 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) [1]	t_{JITTER}	Over 1000 successive switching events @1kHz square wave magnetic field, B > ±(B_{OPMAX} +20mT)	-	±4	-	µs
Maximum Switching Frequency [1, 5]	f_{SW}	B > ±3(B_{OPMAX} +1mT), square wave magnetic field	30	50	-	kHz
Under-voltage Lockout Threshold	V_{UVL}		-	-	2.7	V
Under-voltage Lockout Reaction time [1]	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 specifications

1 *Guaranteed by design and verified by characterization, not production tested*

2 *Typical values are defined at T_A = +25ºC and V_{DD} = 12V*

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 *$B > B_{opmax}$ +1mT for direct output sensors or $B < B_{rpmin}$ -1mT for inverted output sensors.*

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*

5. Magnetic Specifications[1]

5.1. MLX92231LSE-AAA-004

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	-8.4	-6	-3.6	-6.1	-3.6	-1.5	-1100	Direct	North pole
T_J = 25°C	-7.1	-5.5	-3.9	-5.3	-3.5	-2			
T_J = 150°C	-7.1	-4.8	-2	-6.7	-3.5	-1.3			

5.2. MLX92231LSE-AAA-007

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	20	26	33	14	20	25	0	Direct	South pole
T_J = 25°C	20	26	33	14	20	25			
T_J = 150°C	20	26	33	14	20	25			

5.3. MLX92231LSE-AAA-009

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ[10]	Max	Min	Typ[10]	Max	Typ[10]		
T_J = -40°C	2	3.5	5	1.4	2.5	3.3	0	Direct	South pole
T_J = 25°C	2.5	3.5	4.5	1.8	2.5	3.1			
T_J = 150°C	2	3.5	5	1.4	2.5	3.3			

5.4. MLX92231LSE-AAA-010

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	8.7	10.7	13.4	6.8	9.0	11.5	-1100	Direct	South pole
T_J = 25°C	8.3	10	11.8	6.8	8.5	10.1			
T_J = 150°C	6.1	8.6	11.4	4.9	7.3	9.8			

[1] *Final magnetic parameters will be covered in the ppap documentation set, the tables below are based on estimations and simulations*

5.5. MLX92231LSE-AAA-013

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	2	3.5	5	1.4	2.5	3.3	0	Inverted	South pole
T_J = 25°C	2.5	3.5	4.5	1.8	2.5	3.1			
T_J = 150°C	2	3.5	5	1.4	2.5	3.3			

5.6. MLX92231LSE-AAA-014

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	3.6	6	8.4	1.5	3.6	6.1	-1100	Direct	South pole
T_J = 25°C	3.9	5.5	7.1	2	3.5	5.3			
T_J = 150°C	2	4.8	7.1	1.3	3.5	6.7			

5.7. MLX92231LSE-AAA-019

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	21.5	26	31	19	24	28.5	-2000	Direct	South pole
T_J = 25°C	20	23	26	17.5	21	24			
T_J = 150°C	13	17	22	12	15	20			

5.8. MLX92231LSE-AAA-021

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	4.3	5.9	7.7	2.1	3.8	5.4	-1100	Inverted	South pole
T_J = 25°C	3.8	5.5	7.2	2	3.5	5			
T_J = 150°C	3.2	4.8	6.8	1.7	3	5.2			

5.9. MLX92231LSE-AAA-023

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	39	46.1	53.9	36.3	44.1	52.5	-1100	Direct	South pole
T_J = 25°C	38.5	43	47.5	35.9	41	46			
T_J = 150°C	28.8	37.1	46.5	25.6	35	45.1			

5.10. MLX92231LSE-AAA-026

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	21.5	26	31	19	24	28.5	-2000	Inverted	South pole
T_J = 25°C	20	23	26	17.5	21	24			
T_J = 150°C	13	17	22	12	15	20			

5.11. MLX92231LSE-AAA-029

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	13.5	16	18.8	12.5	15	17.9	0	Inverted	South pole
T_J = 25°C	13.3	15	16.7	12.3	14	15.7			
T_J = 150°C	10.2	13	16	9.1	12	15			

5.12. MLX92231LSE-AAA-031

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	-10	-13.5	-17.4	-12	-8.5	-5.7	0	Direct	North pole
T_J = 25°C	-10	-13.5	-17.4	-12	-8.5	-5.7			
T_J = 150°C	-10	-13.5	-17.4	-12	-8.5	-5.7			

5.13. MLX92231LSE-AAA-032

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	20.4	24.6	29.4	17.7	22.6	27.9	-1100	Direct	South pole
T_J = 25°C	20.2	23	25.9	17.6	21	24.4			
T_J = 150°C	15.4	19.8	25	12.6	17.7	23.5			

5.14. MLX92231LSE-AAA-033

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C							-1100	Direct	South pole
T_J = 25°C		18			12.5				
T_J = 150°C									

5.15. MLX92231LUA-AAA-034

DC Operating Parameters V_{DD} = 3.5V to 24V, T_J = -40°C to 165°C

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Output behaviour	Active Pole
VDD = 12 V	Min	Typ	Max	Min	Typ	Max	Typ		
T_J = -40°C	4.3	5.9	7.7	2.1	3.8	5.4	-1100	Direct	South pole
T_J = 25°C	3.8	5.5	7.2	2	3.5	5			
T_J = 150°C	3.2	4.8	6.8	1.7	3	5.2			

6. Magnetic Behaviour

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, $B_{HYS} = B_{OP} - B_{RP}$

6.1. 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

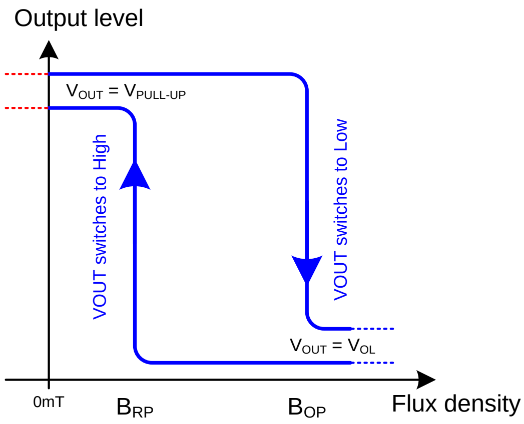


Fig.1 – Direct South Pole Active

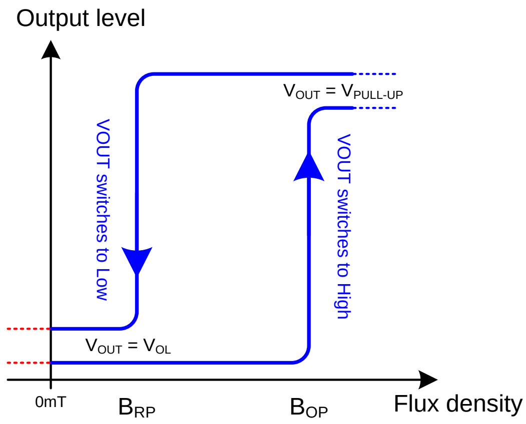


Fig.2 – Inverted South Pole Active

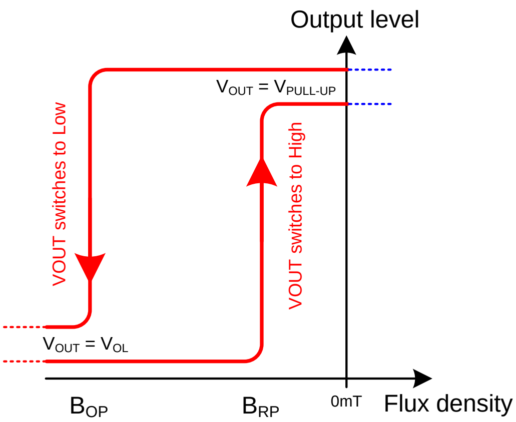


Fig.3 – Direct North Pole Active

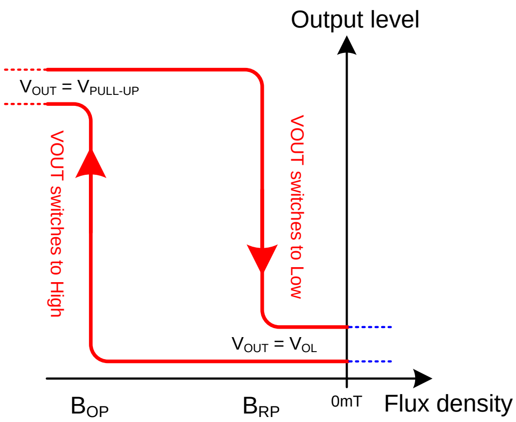


Fig.4 – Inverted North Pole Active

7. Detailed General Description

Based on mixed signal CMOS technology, Melexis MLX92231 is a Hall-effect device with a pre-programmed magnetic threshold. It allows using generic magnets, weak magnets or larger air gap.

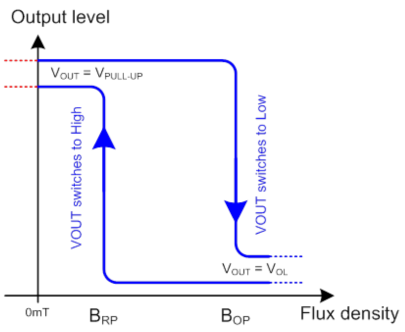
The chopper-stabilized amplifier uses switched capacitor techniques to suppress the offset generally observed with Hall sensors and amplifiers. The CMOS technology makes this advanced technique possible and contributes to smaller chip size and lower current consumption than bipolar technology. The small 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 operating voltage from 2.7V to 24V, pre-programmed tc and an operating temperature range according to “L” specification make this device suitable for automotive, industrial and consumer low voltage applications.

The output signal is open-drain type. Such output allows simple connectivity with TTL or CMOS logic by using a pull-up resistor tied between a pull-up voltage and the device output

8. Magnetic Characteristic

The MLX92231-AAA exhibits magnetic switching characteristics.



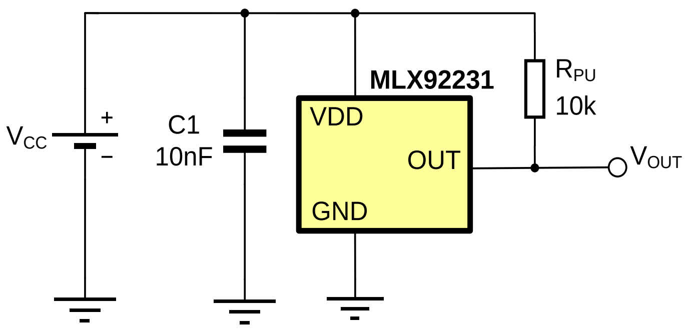
switch characteristic

The device is south or north pole active:
Applying a sufficient magnetic pole greater than BOP facing the branded side of the package switches the output low for direct or high for inverted.

Removing the magnetic field (B=0) switches the output high for direct or low for inverted selection. The use of the opposite magnetic pole facing the branded side does not affect the output state.

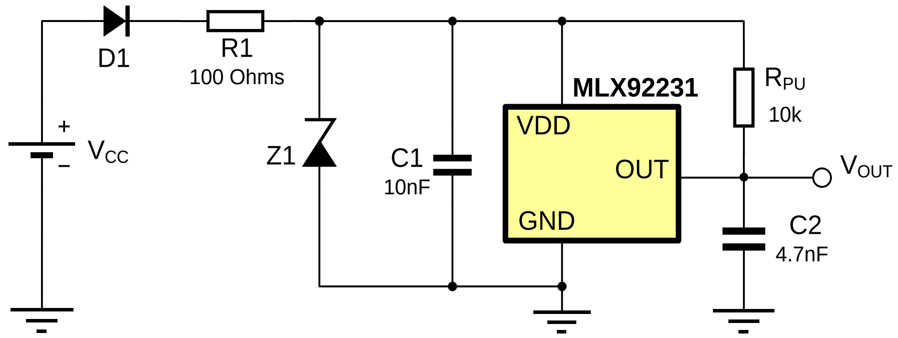
9. Application Information

9.1. 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.

9.2. 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.

10. 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.

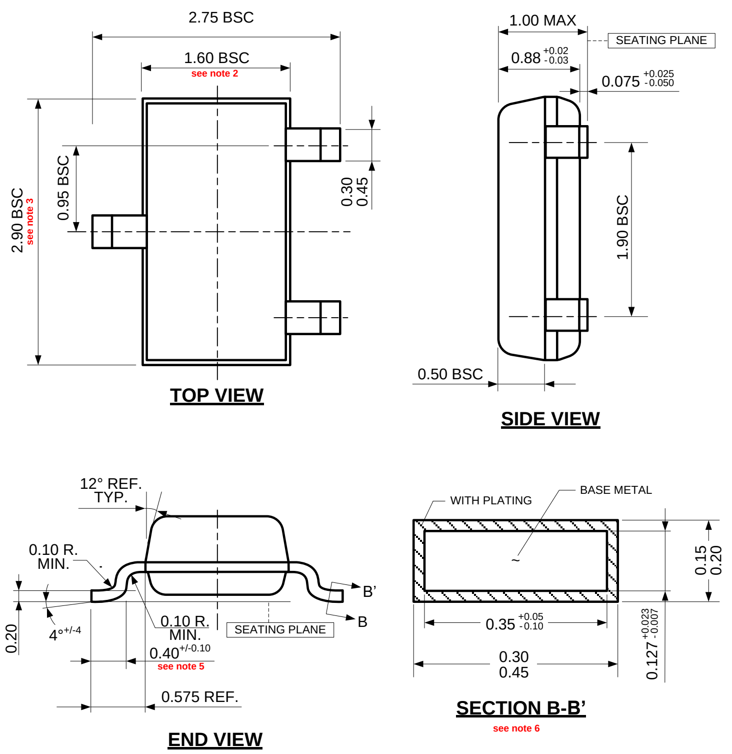
Melexis is contributing to global environmental conservation by promoting **lead free** solutions. For more information on qualifications of **RoHS** compliant products (RoHS = European directive on the Restriction Of the use of certain Hazardous Substances) please visit the quality page on our website: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

11. ESD Precautions

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

12. Package Information

12.1. SE (TSOT-3L) Package Information



Notes:

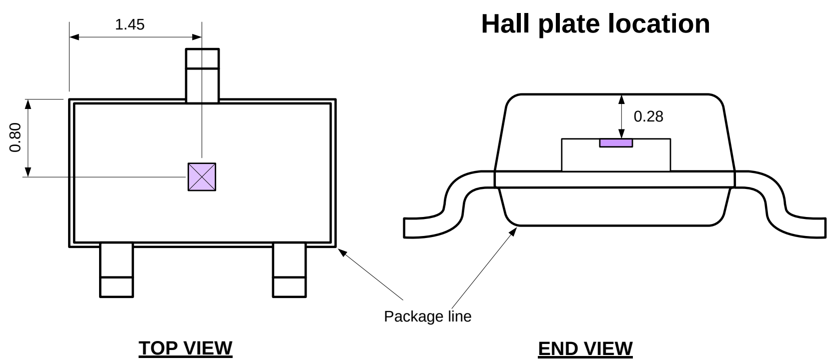
1. All dimensions are in millimeters
2. Outermost plastic extreme width does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 0.15mm per side.
3. Outermost plastic extreme length does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 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 Voltage pin
2	OUT	Output	Open Drain output
3	GND	Ground	Ground pin

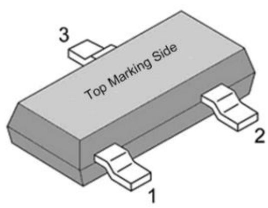
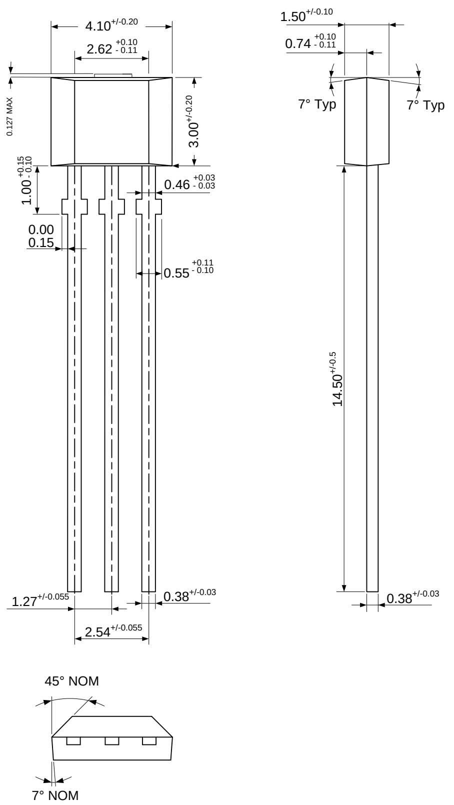


Table 1: SE Package pinout

12.2. UA (TO92-3L) Package Information



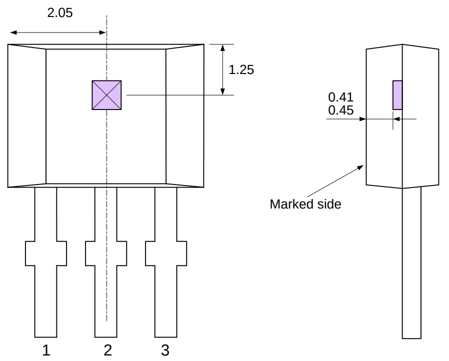
Notes:

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:

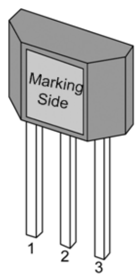
1st Line : 31WW → WW - calendar week
2nd Line : YLLL: → Y - last digit of year
LLL- Lot nr (3 digits)

Hall plate location



Notes:

1. All dimensions are in millimeters



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

Table 2: UA Package pinout

13. Contact

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:

Europe, Africa	Telephone: +32 13 67 04 95
	Email : sales_europe@melexis.com
Americas	Telephone: +1 603 223 2362
	Email : sales_usa@melexis.com
Asia	Email : sales_asia@melexis.com

14. Disclaimer