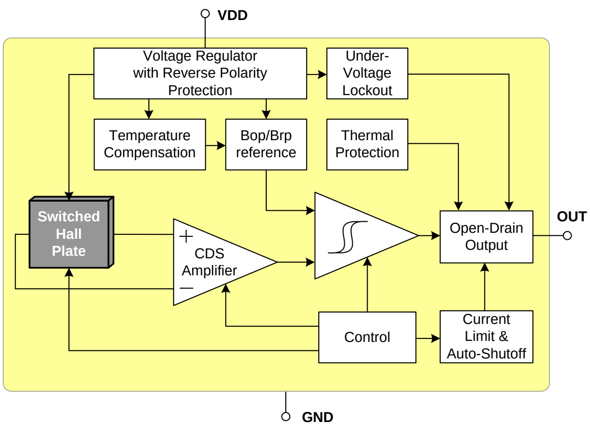
1. Features and Benefits

- Wide operating voltage range: from 2.7V to 24V
- Chopper-stabilized amplifier stage
- Built-in negative temperature coefficient
- Reverse Supply Voltage Protection
- Output Current Limit with Auto-Shutoff
- Under-Voltage Lockout Protection
- Thermal Protection
- High ESD rating (8kV) / Excellent EMC performance
- Dual supply chain and country of origin options

2. Application Examples

- Automotive, Consumer and Industrial
- Solid-state switch
- 3-phase BLDC motor commutation
- DC motors and index counting
- Window lifters & sunroof motors
- Cooling & expansion valves
- Power liftgate & power door motors
- Door handle & charge port motors
- Seat & steering motors
- Electronic park brake motors



3. General Description

The Melexis MLX92211 is the second generation Hall-effect latch 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. Based on a brand new platform, the magnetic core is using an improved offset cancellation system allowing faster and more accurate processing while being temperature insensitive and stress independent. In addition is implemented a negative temperature coefficient to compensate the natural behaviour of magnets becoming weaker with rise in temperature.

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.

With latching magnetic characteristics, the output is turned low or high respectively with a sufficiently strong South or North pole facing the package top side. When removing the magnetic field, the device keeps its previous state.

4. Ordering Information

Product Code	Temperature Code	Package Code	Magnetic option code	Country of Origin (COO)	Packing Form Code
MLX92211	L	UA	AA	A-000	BU
				C-000	
				Z-000	
MLX92211	L	SE	AA	A-000	RE
MLX92211	L	SE	AC	A-000	RE
MLX92211	L	UA	AD	A-000	BU
MLX92211	L	SE	AD	A-000	RE
MLX92211	L	UA	AE	A-000	BU
				C-000	
				Z-000	
MLX92211	L	SE	AE	A-000	RE

Legend:

Temperature Code: L (-40 to 150°C)
Package Code: SE = TSOT-3L
UA = UA (TO92-3L)
Magnetic Option Code: AA = B_{OP}/B_{RP}= ± 3mT, TC = -1100 ppm/°C
AC = B_{OP}/B_{RP}= ± 3mT, TC = -2000 ppm/°C
AD = B_{OP}/B_{RP}= ± 14mT, TC = -2000 ppm/°C
AE = B_{OP}/B_{RP}= ± 3mT, TC = -1100 ppm/°C, 8kV ESD HBM
COO Option Code: Z = Dual source from China & Non-China
C = China country of origin
A = Non-China country of origin
Packing Form: BU = Bulk
RE = Reel
Ordering Example: MLX92211LSE-AAC-000-RE: AA magnetic option code with China country of origin

5. Glossary of Terms

MilliTesla (mT), Gauss	Units of magnetic flux density: 1mT = 10 Gauss
RoHS	Restriction of Hazardous Substances
TSOT	Thin Small Outline Transistor (TSOT package) – also referred with the Melexis package code “SE”
ESD	Electro-Static Discharge
BLDC	Brush-Less Direct-Current
COO	Country of origin

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6. Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Supply Voltage [1, 2]	V_{DD}	+27	V
Supply Voltage (Load dump) [1, 3]	V_{DD}	+32	V
Supply Current [1, 2, 4]	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 (Load dump)[1, 3]	V_{DDREV}	-30	V
Reverse Supply Current [1, 2, 5]	I_{DDREV}	-20	mA
Reverse Supply Current [1, 3, 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, 3, 6, 9,10]	I_{OUT}	+75	mA
Output Current [1, 3, 6, 11]	I_{OUT}	+85	mA
Reverse Output Voltage [1]	V_{OUTREV}	-0.5	V
Reverse Output Current [1, 2]	I_{OUTREV}	-50	mA
Operating Temperature Range	T_A	-40 to +150	°C
Storage Temperature Range	T_S	-55 to +165	°C
Maximum Junction Temperature [7]	T_J	+165	°C
ESD Sensitivity – HBM [8, 9]	-	2000	V
ESD Sensitivity – HBM [8, 10]	-	4000	V
ESD Sensitivity – HBM [8, 11]	-	8000	V
ESD Sensitivity – CDM [12]	-	1000	V
Magnetic Flux Density	B	Unlimited	mT

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

[1] *The maximum junction temperature should not be exceeded*
[2] *For maximum 1 hour*
[3] *For maximum 0.5s*
[4] *Including current through protection device*
[5] *Through protection device*
[6] *For V_{OUT}≤27V.*
[7] *For 1000 hours.*
[8] *Human Model according AEC-Q100-002 standard*
[9] *valid for MLX92211ADx*
[10] *valid for MLX92211AAx/MLX92211ACx*
[11] *valid for MLX92211AEx*
[12] *Charged Device Model according AEC-Q100-011 standard*

7. General Electrical Specifications

DC Operating Parameters T_A = -40 to 150°C, V_{DD} = 2.7V to 24V (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} = -18V	-1			mA
Output Leakage Current	I_{OFF}	V_{OUT} = 12V, V_{DD} = 12V, B < Brp		0.1	10	µA
Output Saturation Voltage	V_{DSon}	B > B_{OP}, V_{DD} = 3.8 to 18V, I_{OUT} = 20mA		0.2	0.5	V
Output Rise Time [2] (R_{PU} dependent)	t_R	V_{DD} = 12V, V_{PU}[3] = 5V, R_{PU} = 1kΩ C_{LOAD} = 50pF to GND	0.1	0.3	1	µs
Output Fall Time [2] (On-chip controlled)	t_F	V_{DD} = 12V, V_{PU} = 5V, R_{PU} = 1kΩ C_{LOAD} = 50pF to GND	0.1	0.3	1	µs
Output Current Limit [4]	I_{CL}	B > B_{OP}, V_{DD}=3.8 to 18V, V_{OUT} = 12V	22	40	70	mA
Output Current Limit [5]	I_{CL}	B > B_{OP}, V_{DD}=3.8 to 18V, V_{OUT} = 12V	30	50	80	mA
Output ON Time under Current Limit conditions [6]	t_{CLON}	B > B_{OP}, V_{PU} = 12V, R_{PU} = 100Ω	150	240		µs
Output OFF Time under Current Limit conditions [6]	t_{CLOFF}	B > B_{OP}, V_{PU} = 12V, R_{PU} = 100Ω		3.5		ms
Chopping Frequency	f_{CHOP}			340		kHz
Output Refresh Period [2]	t_{PER}			6		µs
Delay time [2,7]	t_D	Average over 1000 successive switching events @10kHz, square wave with B≥30mT, t_{RISE}=t_{FALL}≤20µs		6		µs
Output Jitter (p-p) [2, 8]	t_{JITTER}	Over 1000 successive switching events @1kHz, square wave with B≥30mT, t_{RISE}=t_{FALL} ≤100µs		±3		µs

---

[1] *Typical values are defined at T_A = +25°C and V_{DD} = 12V, unless otherwise specified*

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

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

[4] *Valid for MLX92211AAx, MLX92211ACx, MLX92211ADx*

[5] *Valid for MLX92211AEx*

[6] *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*

[7] *The Delay Time is the time from magnetic threshold reached to the start of the output switching*

[8] *Output jitter is the unpredictable deviation of the Delay time*

Parameter	Symbol	Test Conditions	Min	Typ[1]	Max	Units
Maximum Switching Frequency [2, 3]	f_{SW}	B≥30mT and square wave magnetic field	30	50		kHz
Power-On Time [4, 5]	t_{ON}	V_{DD} = 5V, dV_{DD}/dt > 2V/us		16	35	µs
Under-voltage Lockout Threshold	V_{UVL}		2.2	2.4	2.7	V
Under-voltage Lockout Reaction time	t_{UVL}			1		µs
Thermal Protection Threshold [6]	T_{PROT}	Junction temperature		185		°C
Thermal Protection Release [5]	T_{REL}	Junction temperature		170		°C
SE Package Thermal Resistance	R_{TH}	Single layer (1S) Jedec board		300		°C/W
UA Package Thermal Resistance	R_{TH}	Single layer (1S) Jedec board		200		°C/W

[1] *Typical values are defined at T_A = +25°C and V_{DD} = 12V, unless otherwise specified*

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

[3] *Maximum switching frequency corresponds to the maximum frequency of the applied magnetic field which is detected without loss of pulses.*

[4] *The power-On Time represents the time from reaching V_{DD} = V_{POR} to the first refresh of the output (first valid output state)*

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

[6] *T_{PROT} and T_{REL} are the corresponding junction temperature values*

8. Magnetic Specification

DC Operating Parameters V_{DD} = 3.8 to 24V, T_A = -40°C to 150°C

8.1. MLX92211LSE-AAx-000/ MLX92211LUA-AAx-000

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Active Pole
	Min	Typ [1]	Max	Min	Typ [1]	Max	Typ	mT
T_A = -40°C	1.4	3.2	4.7	-4.7	-3.2	-1.4	-1100 [2]	South Pole
T_A = 25°C	1.4	3	4.7	-4.7	-3.0	-1.4		
T_A = 150°C	0.7	2.6	5	-5	-2.6	-0.7		

8.2. MLX92211LSE-ACx-000

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Active Pole
	Min	Typ [1]	Max	Min	Typ [1]	Max	Typ	mT
T_A = -40°C	1.2	3.2	5.5	-5.5	-3.2	-1.2	-2000 [2]	North Pole
T_A = 25°C	1.0	2.8	4.7	-4.7	-2.8	-1.0		
T_A = 150°C	0.5	2.1	4.2	-4.2	-2.1	-0.5		

8.3. MLX92211LSE-ADx-000/ MLX92211LUA-ADx-000

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Active Pole
	Min	Typ [1]	Max	Min	Typ [1]	Max	Typ	mT
T_A = -40°C	9.2	15.1	21.0	-21.0	-15.1	-9.2	-2000 [2]	South Pole
T_A = 25°C	9.4	13.5	17.1	-17.1	-13.5	-9.4		
T_A = 150°C	6.7	10.3	14.7	-14.7	-10.3	-6.7		

8.4. MLX92211LSE-AEx-000/ MLX92211LUA-AEx-000

Test Condition	Operating Point B_{OP} (mT)			Release Point B_{RP} (mT)			TC (ppm/°C)	Active Pole
	Min	Typ [1]	Max	Min	Typ [1]	Max	Typ	mT
T_A = -40°C	1.4	3.2	4.7	-4.7	-3.2	-1.4	-1100 [2]	South Pole
T_A = 25°C	1.4	3.0	4.7	-4.7	-3.0	-1.4		
T_A = 150°C	0.7	2.6	5.0	-5.0	-2.6	-0.7		

[1] *Typical values are defined at TA = +25°C and VDD, unless otherwise specified*

[2] $\frac{B_{T2}-B_{T1}}{B_{25^oC}\times(T_2-T_1)} * 10^6, ppm/^oC\,; T_1 = -40^oC\,; T_2 = 150^oC$

value guaranteed by design and verified by characterization, not production tested

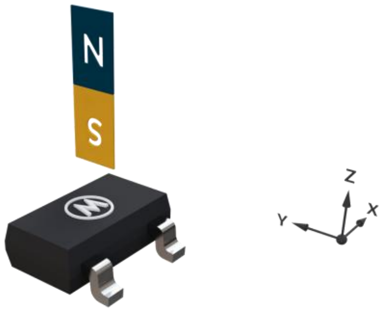
9. Output behaviour versus Magnetic Pole

Output behaviour versus magnetic pole (1)

9.1. South Pole Active

DC Operating Parameters T_A = -40°C to 150°C, V_{DD} = 2.7V to 24V

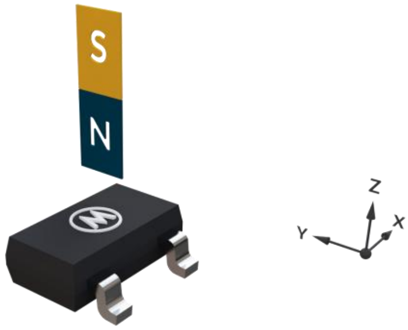
Parameter	Test Conditions	OUT
South pole	$B > B_{OP}$	Low (V_{DSon})
North pole	$B < B_{RP}$	High (V_{PU}) (2)



9.2. North Pole Active

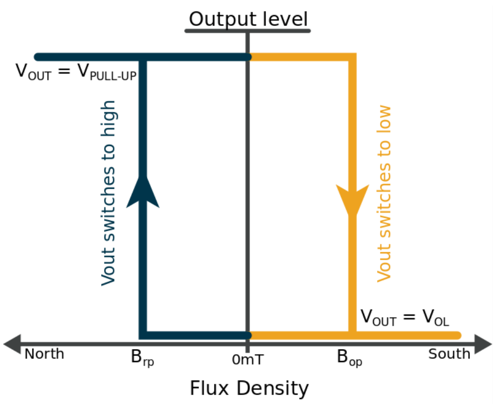
DC Operating Parameters T_A = -40°C to 150°C, V_{DD} = 2.7V to 24V

Parameter	Test Conditions	OUT
South pole	$B > B_{OP}$	High (V_{PU}) (2)
North pole	$B < B_{RP}$	Low (V_{DSon})



10. Latch characteristics

The MLX92211-Axx exhibits magnetic latching characteristics.



Typically, the device behaves as a latch with symmetric operating and release switching points (B_{OP}=|B_{RP}|). This means magnetic fields with equivalent strength and opposite direction drive the output high and low.

Removing the magnetic field ($B \rightarrow 0$) keeps the output in its previous state. This latching property defines the device as a magnetic memory.

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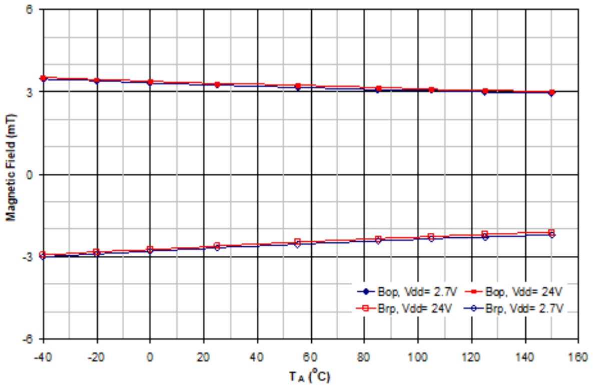
[1] *Magnetic pole facing the branded/top side of the package*

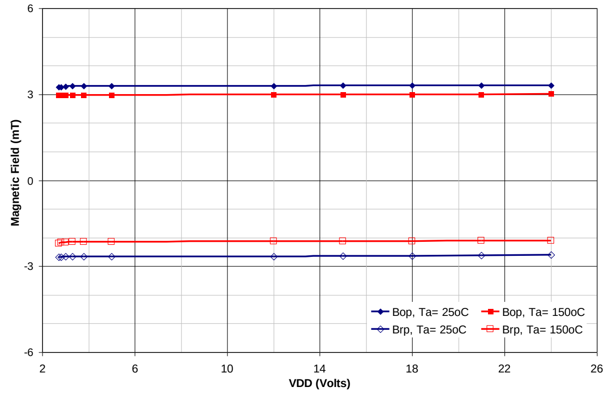
[2] *Default Output state during power-up*

11. Performance graphs

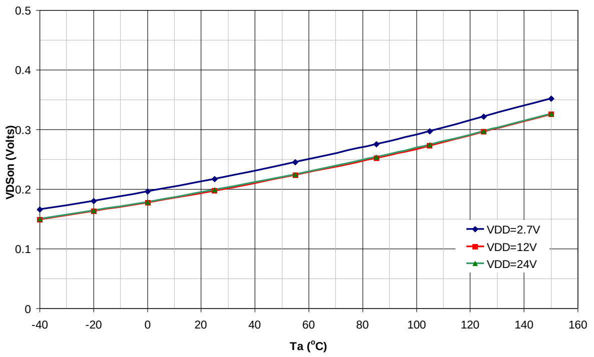
11.1. Magnetic parameters vs. T_A



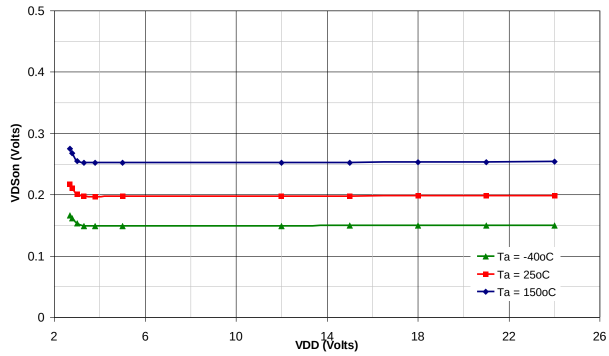
11.2. Magnetic parameters vs. V_{DD}



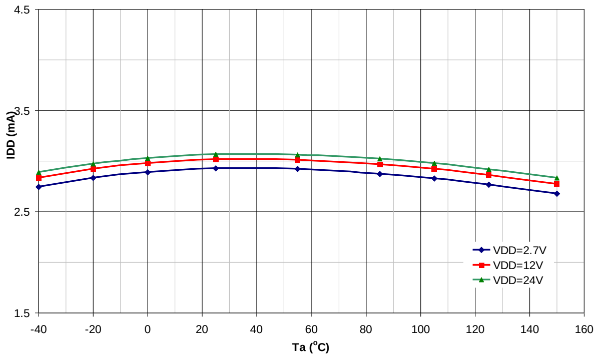
11.3. V_{DSon} vs. T_A



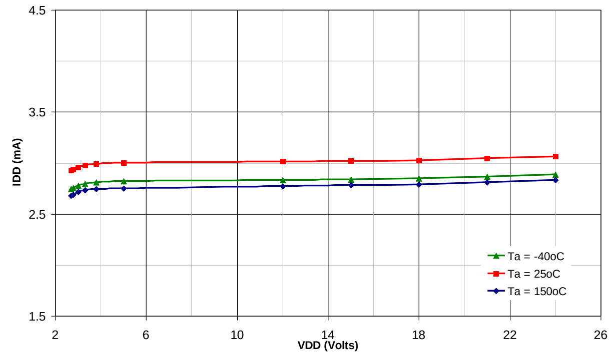
11.4. V_{DSon} vs. V_{DD}



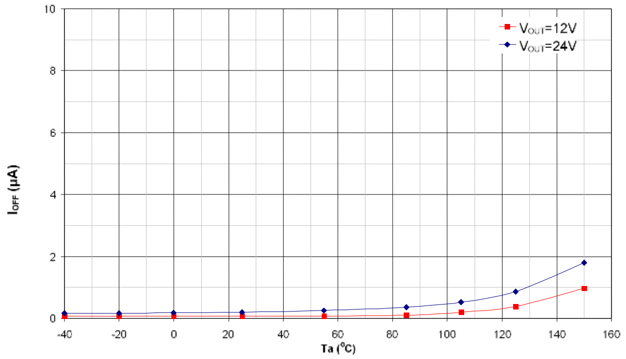
11.5. I_{DD} vs. T_A



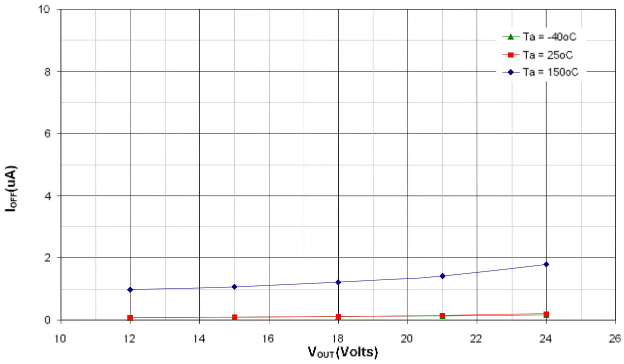
11.6. I_{DD} vs. V_{DD}



11.7. I_{OFF} vs. T_A

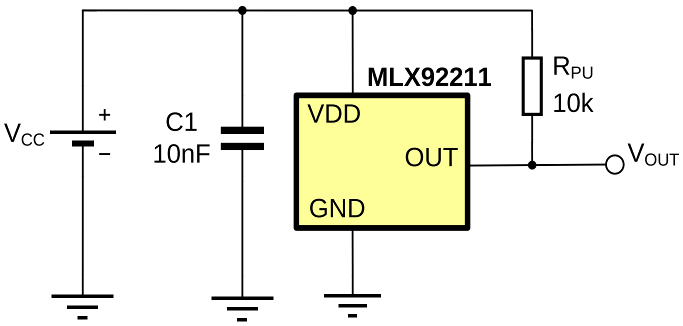


11.8. I_{OFF} vs. V_{DD}



12. Application Information

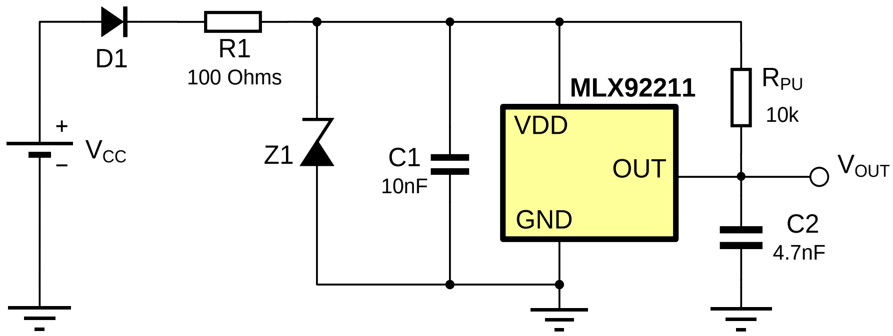
12.1. Typical Three-Wire Application Circuit



<u>Notes:</u>

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 obligatory, because the output slope is generated internally.

12.2. Automotive and Harsh, Noisy Environments Three-Wire Circuit



<u>Notes:</u>

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 -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:

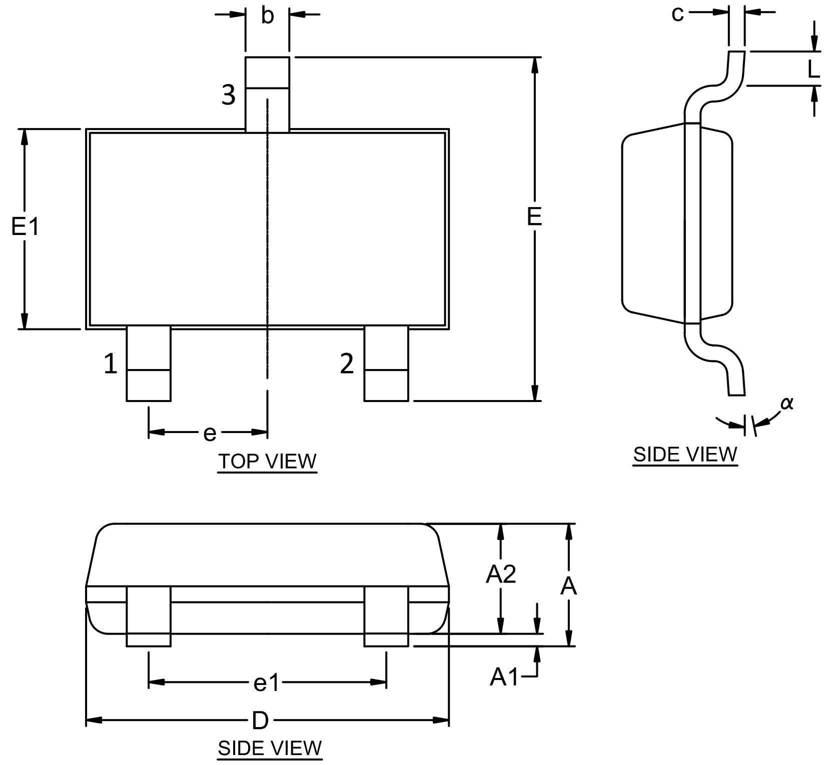
- the resistor has to limit I_{DD}/I_{DDREV} to 50mA maximum
- the resistor has to withstand the power dissipated in both over voltage conditions ($V_{R1}^2/R1$)
- the resulting device supply voltage V_{DD} has to be higher than V_{DD} min ($V_{DD} = V_{CC} – R1.I_{DD}$)

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.

14. Package Information

14.1. TSOT-3L (SE Package)

14.1.1. TSOT-3L – package dimensions

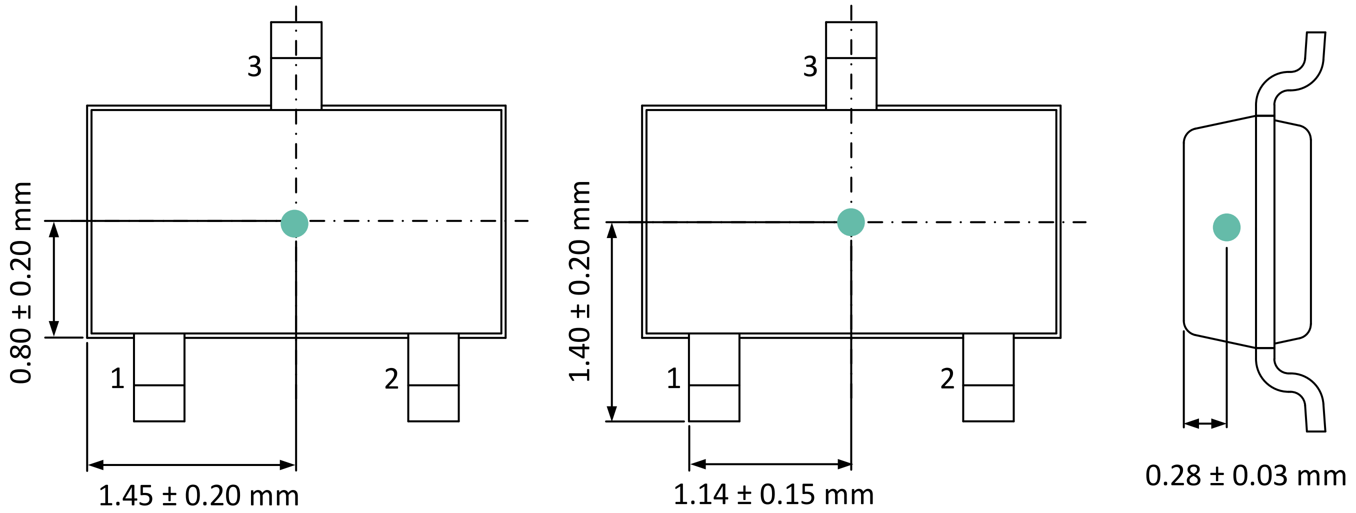


SYMBOL	MINIMUM	MAXIMUM
A	---	1.00
A1	0.025	0.10
A2	0.85	0.90
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
L	0.30	0.50
b	0.30	0.45
c	0.10	0.20
e	0.95 BSC	
e1	1.90 BSC	
α	0°	8°

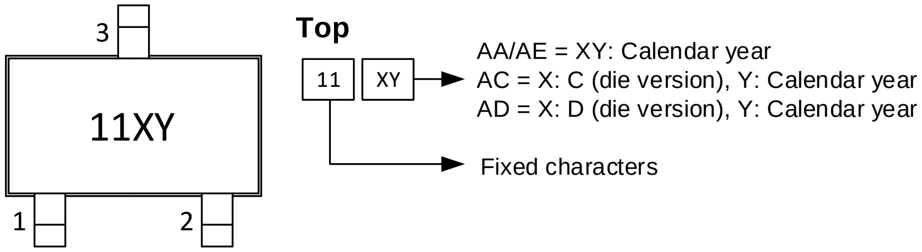
NOTE :

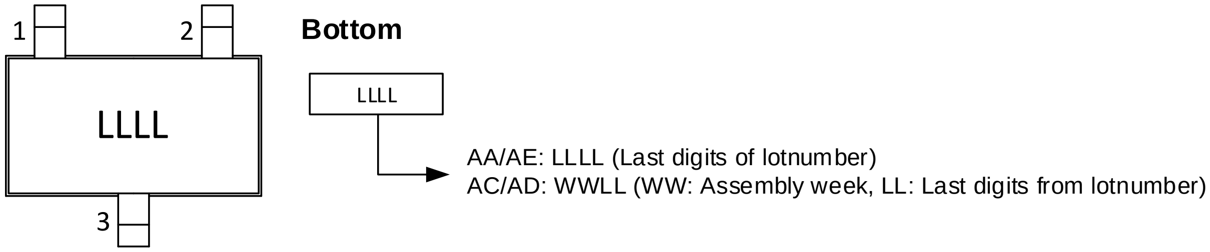
1. ALL DIMENSIONS IN MILLIMETERS (mm) UNLESS OTHERWISE STATED.
2. DIMENSION D DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS OF MAX 0.15 mm PER SIDE.
3. DIMENSION E1 DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS OF MAX 0.25 mm PER SIDE.
4. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION OF MAX 0.07 mm.
5. DIMENSION L IS THE LENGTH OF THE TERMINAL FOR SOLDERING TO A SUBTRATE.
6. FORMED LEAD SHALL BE PLANAR WITH RESPECT TO ONE ANOTHER WITH 0.076 mm SEATING PLANE.

14.1.2. TSOT-3L – Sensitive spot



14.1.3. TSOT-3L – Package marking / pin definition

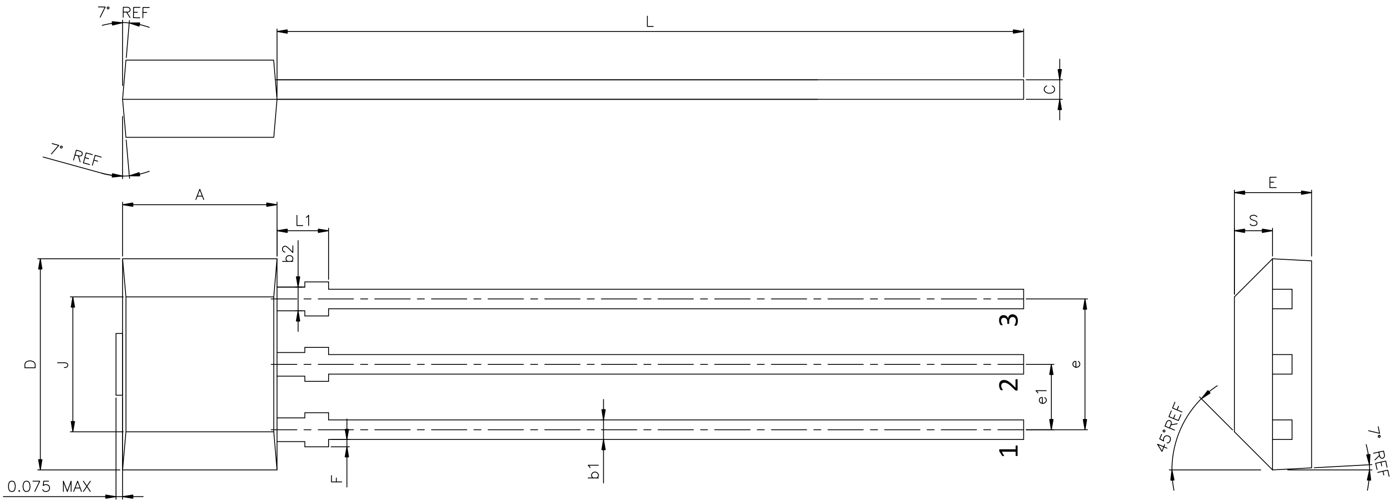




Pin #	Name	Type	Function
1	VDD	Supply	Supply Voltage pin
2	OUT	Out	Open drain output pin
3	GND	Ground	Ground pin

14.2. TO92-3L (UA Package) – Non-China COO

14.2.1. TO92-3L – Non-China COO – package dimensions

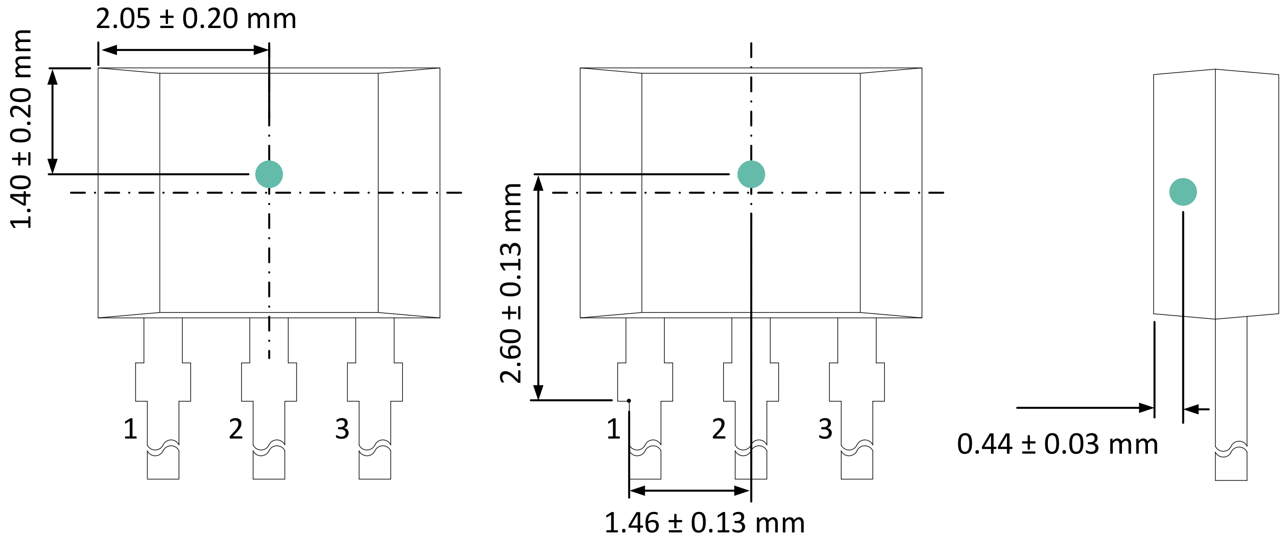


SYMBOL	MINIMUM	MAXIMUM
A	2.90	3.10
D	4.00	4.20
E	1.40	1.60
F	0.00	0.15
J	2.51	2.72
L	14.00	15.00
L1	0.90	1.10
S	0.63	0.84
b1	0.35	0.44
b2	0.43	0.52
c	0.35	0.44
e	2.51	2.57
e1	1.24	1.30

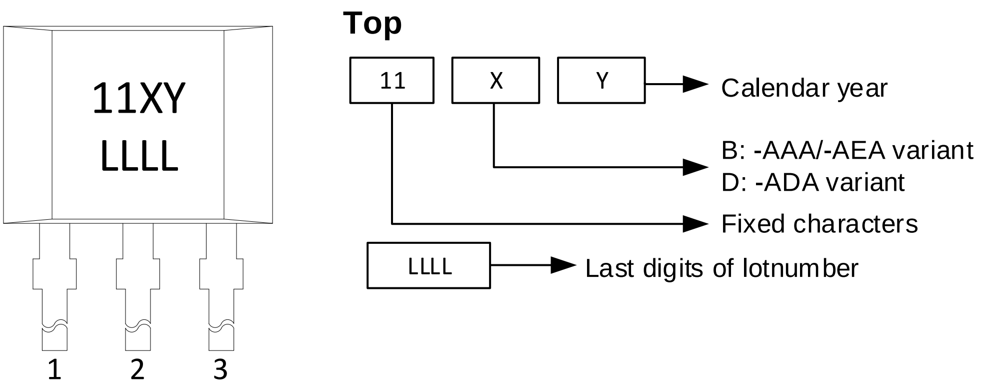
NOTES :

1. DIMENSIONS IN MILLIMETERS (mm) UNLESS NOTED OTHERWISE.
2. PACKAGE DIMENSIONS DO NOT INCLUDE MOLD FLASHES AND PROTRUSIONS.
3. DIMENSION A AND D DO NOT INCLUDE MOLD GATE AND SIDE FLASH (PROTRUSION) of MAXIMUM 0.127 mm PER SIDE.
4. THE LEADS MAY BE SLIGHTLY DEFORMED DURING TRANSPORTATION IF PACKED IN BULK (BAG), AFFECTING e1 DIMENSION. IT IS RECOMMENDED TO ORDER RADIAL TAPE (REEL OR AMMOPACK) IF SUCH DEFORMATION IS CRITICAL FOR THE LEAD FORMING PROCESS, EVEN IF MANUAL LOADING INTO THE TOOL IS FORESEEN.

14.2.2. TO92-3L – Non-China COO – Sensitive spot



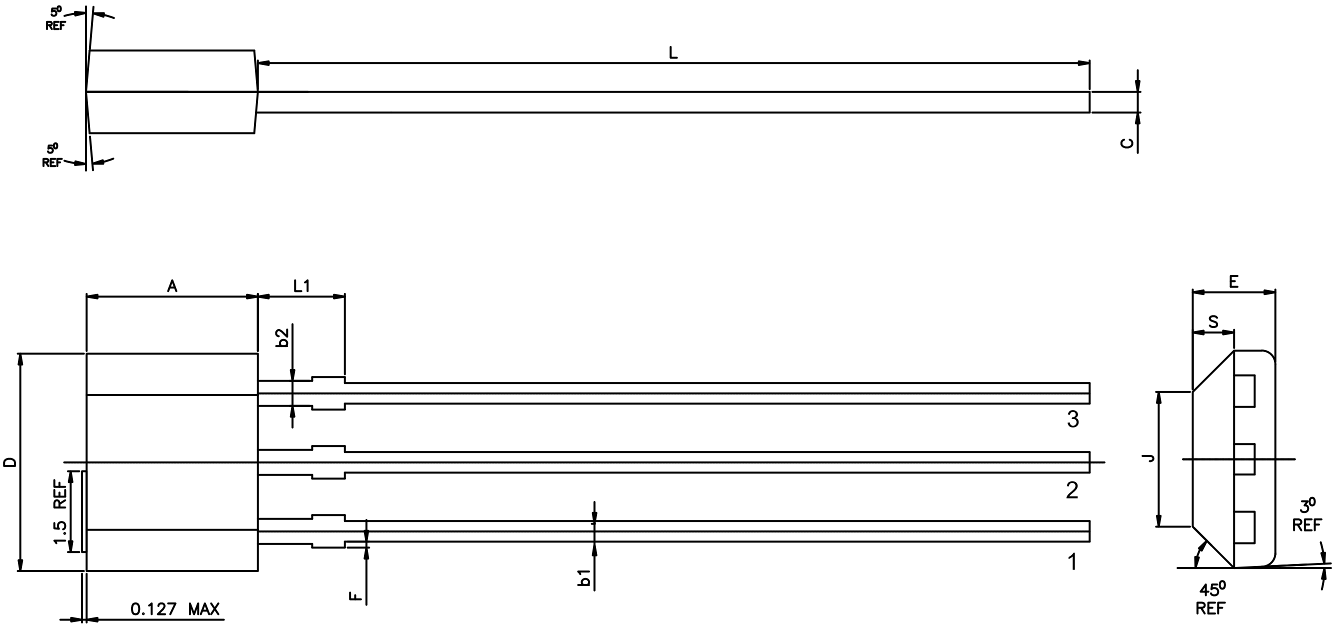
14.2.3. TO92-3L – Non-China COO – Package marking / pin definition



Pin #	Name	Type	Function
1	VDD	Supply	Supply Voltage pin
2	GND	Ground	Ground pin
3	OUT	Out	Open drain output pin

14.3. TO92-3L (UA Package) – China COO

14.3.1. TO92-3L – China COO – package dimensions

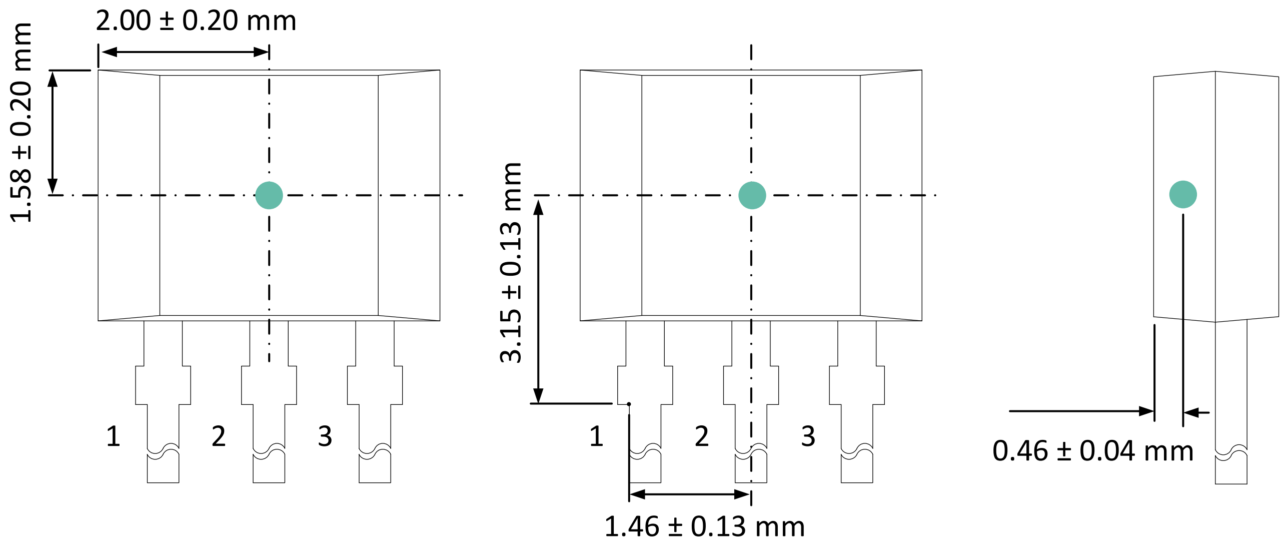


SYMBOL	MINIMUM	MAXIMUM
A	3.05	3.25
D	3.90	4.10
E	1.42	1.62
F	---	0.15
J	2.48 REF	
L	15.10	15.50
L1	---	1.75
S	0.66	0.86
b1	0.33	0.48
b2	0.40	0.53
c	0.38	0.43
e	2.54 BSC	
e1	1.27 BSC	

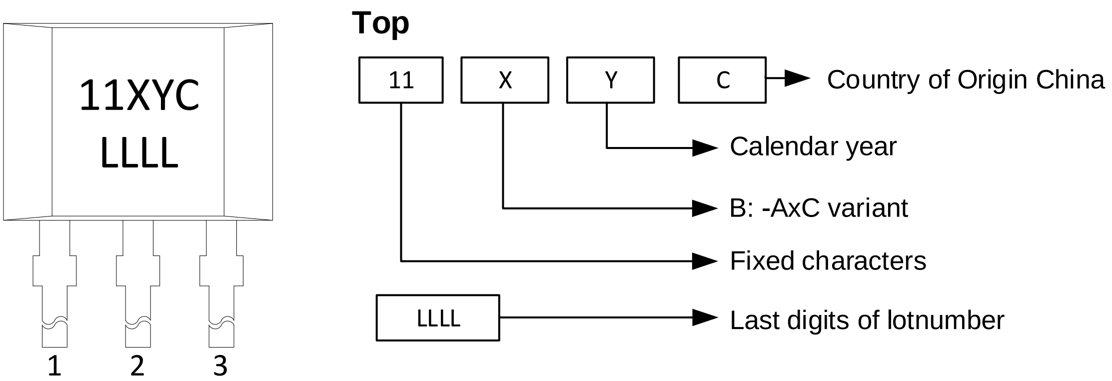
NOTE :

1. DIMENSIONS IN MILLIMETERS (mm) UNLESS NOTED OTHERWISE.
2. PACKAGE DIMENSIONS DO NOT INCLUDE MOLD FLASHES AND PROTRUSIONS.
3. DIMENSION A AND D DO NOT INCLUDE MOLD GATE AND SIDE FLASH (PROTRUSION) of MAXIMUM 0.127 mm PER SIDE.
4. THE LEADS MAY BE SLIGHTLY DEFORMED DURING TRANSPORTATION IF PACKED IN BULK (BAG), AFFECTING e1 DIMENSION. IT IS RECOMMENDED TO ORDER RADIAL TAPE (REEL OR AMMOPACK) IF SUCH DEFORMATION IS CRITICAL FOR THE LEAD FORMING PROCESS, EVEN IF MANUAL LOADING INTO THE TOOL. IS FORESEEN

14.3.2. TO92-3L – China COO – Sensitive spot



14.3.3. TO92-3L – China COO – Package marking / pin definition



Pin #	Name	Type	Function
1	VDD	Supply	Supply Voltage pin
2	GND	Ground	Ground pin
3	OUT	Out	Open drain output pin

15. IC handling and assembly

15.1. Storage and handling of plastic encapsulated ICs

Plastic encapsulated ICs shall be stored and handled according to their MSL categorization level (specified in the packing label) as per J-STD-033.

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). The component assembly shall be handled in EPA (Electrostatic Protected Area) as per ANSI S20.20

For more information refer to Melexis *Guidelines for storage and handling of plastic encapsulated ICs*[(1)]

15.2. Assembly of encapsulated ICs

For Surface Mounted Devices (SMD, as defined according to JEDEC norms), the only applicable soldering method is reflow.

For Through Hole Devices (THD), the applicable soldering methods are reflow, wave, selective wave and robot point-to-point. THD lead pre-forming (cutting and/or bending) is applicable under strict compliance with Melexis *Guidelines for lead forming of SIP Hall Sensors*[(1)].

Melexis products soldering on PCB should be conducted according to the requirements of IPC/JEDEC and J-STD-001. Solder quality acceptance should follow the requirements of IPC-A-610.

For PCB-less assembly refer to the relevant application notes [(1)] or contact Melexis.

Electrical resistance welding or laser welding can be applied to Melexis products in THD and specific PCB-less packages following the *Guidelines for welding of PCB-less devices*[(1)].

Environmental protection of customer assembly with Melexis products for harsh media application, is applicable by means of coating, potting or overmolding considering restrictions listed in the relevant application notes [(1)]

For other specific process, contact Melexis via www.melexis.com/technical-inquiry

15.3. Environment and sustainability

Melexis is contributing to global environmental conservation by promoting non-hazardous solutions. For more information on our environmental policy and declarations (RoHS, REACH…) visit www.melexis.com/environmental-forms-and-declarations

[1] *www.melexis.com/ic-handling-and-assembly*

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