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Features and Benefits

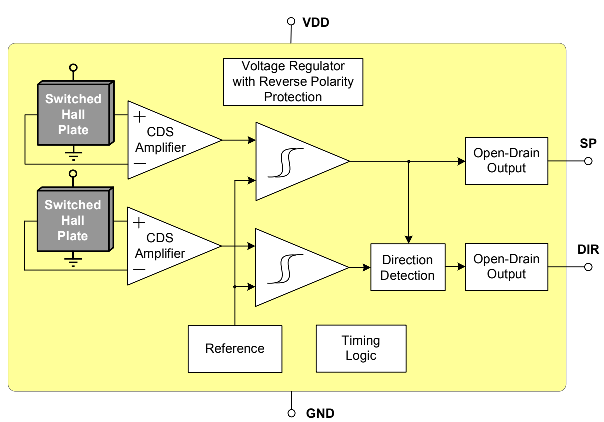
- Operating Voltage from 2.7V to 24V
- Two Integrated Hall plates for Direction Detection
- Latching Magnetic Characteristics
- Speed & Direction Open-Drain Outputs
- Direction Output updated prior Speed Output
- Excellent Temperature Stability
- Reverse Supply Voltage Protection
- Output Current Limitation and Auto-Shutoff
- Under-Voltage Lockout Protection

Application Examples

- Windows lifter with Anti-Pinch feature
- Rotation speed & direction detection
- Linear speed & direction detection
- Angular position detection
- Power closures with Anti-Pinch features

Ordering Information				
Part No.	**Temperature Code**	**Sensitivity**	**Package Code**	**Packing Form**
MLX92251LSE-AAA-000-RE	L (-40℃ to 150℃)	+- 7.5 mT	SE (TSOT-5L)	RE (Tape & Reel)
MLX92251LSE-ABA-000-RE	L (-40℃ to 150℃)	+- 2.5 mT	SE (TSOT-5L)	RE (Tape & Reel)

1 Functional Diagram



2 General Description

The Melexis MLX92251 is a second generation Hall-effect dual latch designed in mixed signal CMOS technology. The device integrates a voltage regulator, two Hall sensors with advanced offset cancellation system and two open-drain output drivers, all in a single package.

Two Hall plates are integrated on the same piece of silicon, thus using the high precision of the wafer fabrication process to ensure a fixed spacing of 1.45mm between the sensing elements. The first Hall plate signal is used to provide the speed signal output. The combination of both the first and second Hall plate signals is then internally processed to directly deliver a direction signal output.

The MLX92251 shares the MLX922xx-based platform, synonym of high performance in terms of electrical specification, magnetic specification and protection level.

With latching magnetic characteristics, the speed (SP) 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.

The direction (DIR) output is latched in Low or High state depending on the movement direction of the applied magnetic field, as a result of certain magnetic pulse sequence on both Hall sensors.

The MLX92251 is delivered in a Green compliant 5-pin Thin Small Outline Transistor (TSOT) for surface-mount process.

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3 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

4 Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Supply Voltage	V_{DD}	+27	V
Supply Current	I_{DD}	+20	mA
Reverse Supply Voltage	V_{DDREV}	-27	V
Reverse Supply Current	I_{DDREV}	-20	mA
Output Voltage	V_{OUT}	+27	V
Output Current	I_{OUT}	+20	mA
Reverse Output Voltage	V_{OUTREV}	-0.5	V
Reverse Output Current	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	T_J	+165	C
ESD Sensitivity – HBM (1)	-	2500	V
ESD Sensitivity – CDM (2)	-	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.

1 Human Body Model according AEC-Q100-002 standard.
2 Charged Device Model according AEC-Q100-011 standard.

5 General Electrical Specifications

DC Operating Parameters T_A = -40℃ to 150℃, 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}	V_{DD} = 12V	3	4.5	7	mA
Reverse Supply Current	I_{DDREV}	V_{DD} = -18V			1	mA
Output Leakage Current	I_{OFF}	V_{OUT} = 12V, V_{DD} = 12V, B < B_{RP}		0.1	10	µA
Output Saturation Voltage	V_{OUTS}	B > B_{OP}, I_{OUT} = 10mA		0.2	0.5	V
Output Rise/Fall Time [2,3]	t_R / t_F	V_{DD} = 12V, V_{PU} [4] = 5V, R_{PU} = 1kΩ, C_L = 50pF	0.1	0.3	1	µs
Output Current Limit	I_{CL}	B > B_{OP}, V_{OUT} = 12V	14	25	44	mA
Output ON Time under Current Limit conditions[5]	t_{CLON}	B > B_{OP}, V_{PU} = 12V, R_{PU} = 100Ω	150	230		µs
Output OFF Time under Current Limit conditions[5]	t_{CLOFF}	B > B_{OP}, V_{PU} = 12V, R_{PU} = 100Ω		3.5		ms
Chopping Frequency	f_{CHOP}			400		kHz
Speed Signal Delay [2,6]	t_{SPD}		0.4	0.85	1.6	µs
Output Refresh Period	t_{PER}		3.2	5	8.4	µs
Output Jitter (p-p value) [2]	t_{JITTER}	Over 1000 successive output switching events @1kHz square wave, B_{PEAK}= 50mT, t_{RISE}=t_{FALL} ≤100µs		±2.6		µs
Maximum Switching Frequency [2,7]	f_{SW}	≥30mT square wave magnetic field	40	66		kHz
Power-On Time [8]	t_{PON}	V_{DD}= 5V, dV_{DD}/dt > 2V/µs		16	35	µs
Under-voltage Lockout Threshold	V_{UVL}		2.2	2.4	2.7	V
Under-voltage Lockout Reaction time [2]	t_{UVL}			1		µs
SE Package Thermal Resistance	R_{TH}	Single layer (1S) JEDEC board		300		°C/W

Table 2: electrical specifications

1 Typical values are defined at T_A = +25ºC and V_{DD} = 12V
2 Based on device characterization results, not subject to production test
3 Measured between 0.1*V_{PU} and 0.9*V_{PU}
4 R_{PU} and V_{PU} are respectively the external pull-up resistor and pull-up power supply
5 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
6 Controlled delay between direction (DIR) signal update and speed (SP) signal update
7 Maximum switching frequency corresponds to the maximum frequency of the applied magnetic field which is detected without loss of pulses
8 The Power-On Time represents the time from reaching V_{DD} = 2.7V to the first refresh of the SP output

6 Magnetic Specifications

6.1 *MLX92251LSE-AAA-000*

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Operating Point	B_{OP}		5	7.5	10	mT
Release Point	B_{RP}		-10	-7.5	-5	mT
Magnetic Matching	B_{MATCH}	$B_{OP1} - B_{OP2}$ or $B_{RP1} - B_{RP2}$, T_A = 25°C	-2		2	mT
		$B_{OP1} - B_{OP2}$ or $B_{RP1} - B_{RP2}$	-3		3	mT
Magnetic Offset	B_{OFF}	$(B_{OP1} + B_{RP1}) / 2$, $(B_{OP2} + B_{RP2}) / 2$	-2		2	mT
Temperature Coefficient (1)	TC			0		ppm/°C
Hall Sensors Spacing	-			1.45		mm

Table 3: Magnetic specifications

6.2 *MLX92251LSE-ABA-000*

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Operating Point	B_{OP}		0.6	2.5	4.5	mT
Release Point	B_{RP}		-4.5	-2.5	-0.6	mT
Magnetic Matching	B_{MATCH}	$B_{OP1} - B_{OP2}$ or $B_{RP1} - B_{RP2}$, T_A = 25°C	-2		2	mT
		$B_{OP1} - B_{OP2}$ or $B_{RP1} - B_{RP2}$	-3		3	mT
Magnetic Offset	B_{OFF}	$(B_{OP1} + B_{RP1}) / 2$, $(B_{OP2} + B_{RP2}) / 2$	-2		2	mT
Temperature Coefficient (1)	TC			-1100		ppm/°C
Hall Sensors Spacing	-			1.45		mm

Table 3: Magnetic specifications

1 Temperature coefficient value is guaranteed by design and verified by characterization and is calculated using the following formula

$$\frac{B_{T2} - B_{T1}}{B_{25^\circ C} \times (T_2 - T_1)} * 10^6,\ ppm/^\circ C;\quad T_1 = -40^\circ C;\quad T_2 = 150^\circ C$$

7 Output Behaviour versus Magnetic Pole

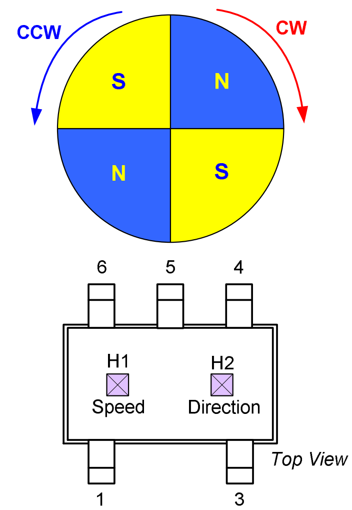
DC Operating Parameters T_A = -40°C to 150°C, V_{DD} = 2.7V to 24V (unless otherwise specified)

Parameter	Test Conditions	SP Output State
South pole	$B > B_{OP}$	Low
North pole	$B < B_{RP}$	High [(2)]

Table 4: Output behaviour versus magnetic pole [(3)]

Direction	Step	H1	H2	DIR Output State
CCW	n_x	N	S	Low
	$n_{(x+1)}$	N	N	
	$n_{(x+2)}$	S	N	
	$n_{(x+3)}$	S	S	
	$n_{(x+4)} \equiv n_x$	N	S	

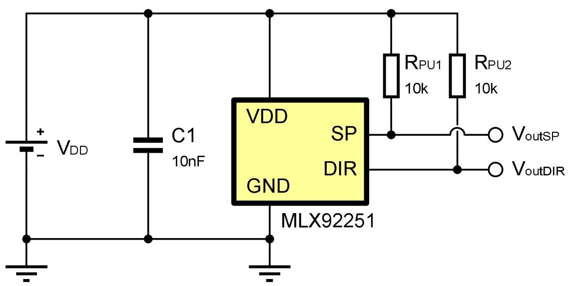
Direction	Step	H1	H2	DIR Output State
CW	n_x	N	S	High [(4)]
	$n_{(x+1)}$	S	S	
	$n_{(x+2)}$	S	N	
	$n_{(x+3)}$	N[(4)]	N[(4)]	
	$n_{(x+4)} \equiv n_x$	N	S	



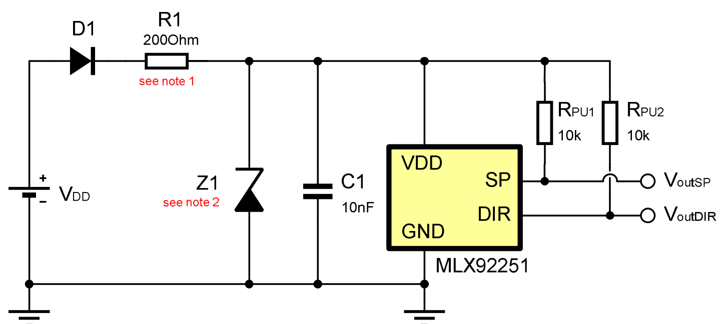
2 Default SP output state during power-up
3 Magnetic pole applied perpendicularly to Hall plate "H1", facing the branded/top side of the package
4 Default magnetic and DIR output state during power-up

8 Application Information

8.1 *Default Application Schematic*

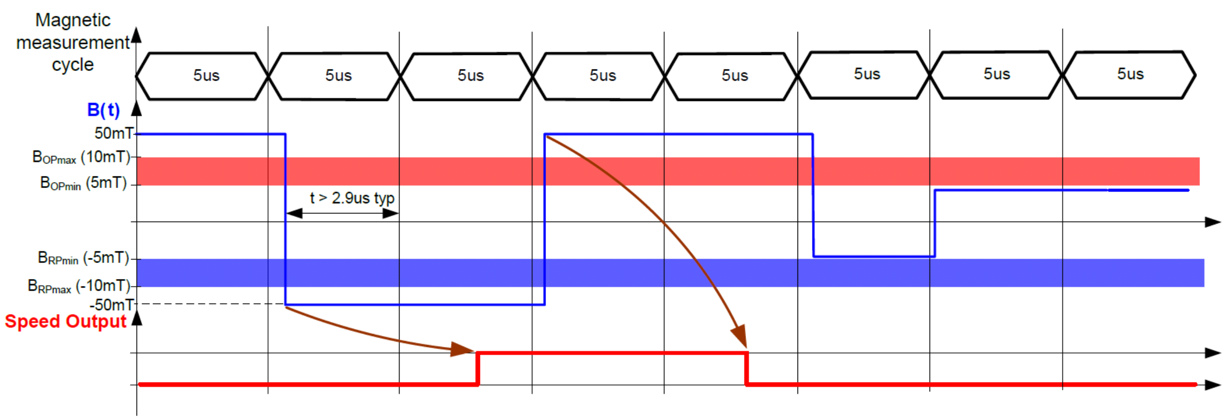


8.2 *Recommended Application Schematic for ISO7637-2 (pulses 5a and 5b)*



Notes:
1. Recommended for conducted transients on supply line above 32V with duration above 500ms.
2. Recommended for conducted transients on supply line above 36V.
3. Recommended zener diode Z1 is BZX55C27 or equivalent.

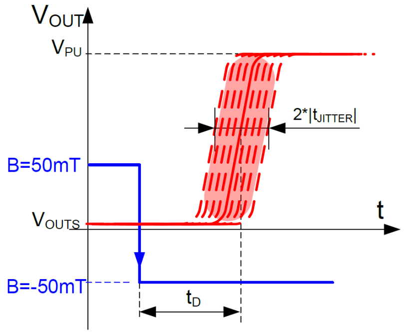
8.3 *Speed (SP) Output Behavior vs. B_{OP}/B_{RP}*



Note: The decision for output update is taken at the end of each magnetic measurement cycle

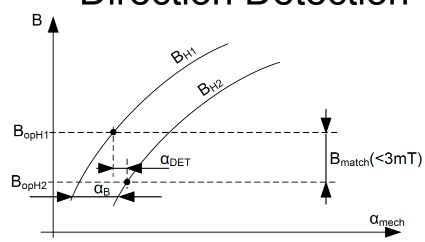
8.4 *Output Jitter, Speed Signal Delay and Direction Detection*

Output Jitter



Note: t_D=8us typ for DIR output and t_D=8.85us typ for SP output, based on simulation

Direction Detection



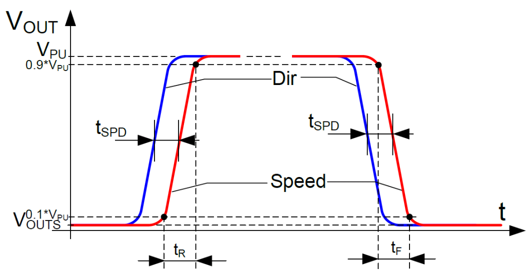
$$\alpha_{DET} = \alpha_B - \frac{B_{match}}{dB/d\alpha}$$

$$f_{Bmax} = \frac{\alpha_{DET}}{360^\circ * \Delta t}$$, where

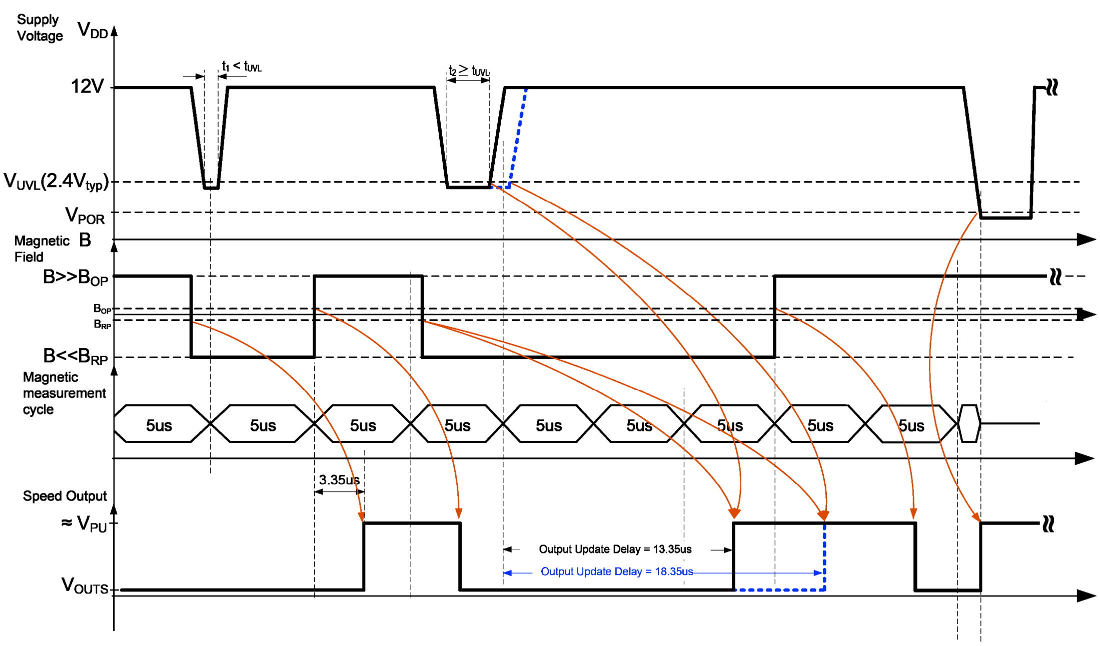
α_{DET} is the angular difference between H1 and H2 magnetic threshold crossing points;
B_{H1} (B_{H2}) is the magnetic field facing Hall plate H1(H2) as a function of the mechanical angle α_{mech};
α_B is the angular difference between B_{H1} and B_{H2};
B_{match}< 3mT is the magnetic matching (see Magnetic Specifications section)
dB/dα is the magnetic field gradient
f_{Bmax} is the maximum magnetic field frequency at which the direction will be detected without error
Δt is the time difference between H1 and H2 magnetic threshold crossing points;

For example, if α_B = 5° and dB/dα > 1mT/°;
for MLX92251 Δt = 10us (definitely > 2*|t_{JITTER}|) could be assumed;
The calculated f_{Bmax} = 555Hz.

Speed Signal Delay



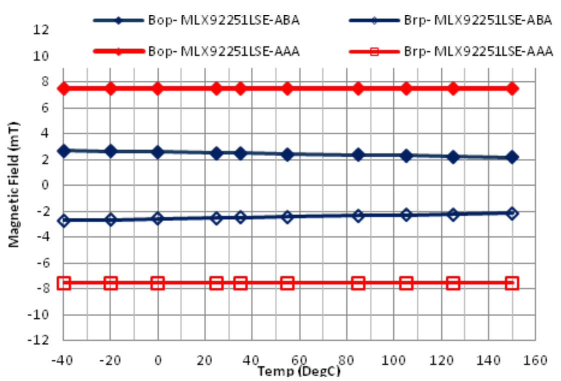
8.5 *UV lockout and POR behaviour*



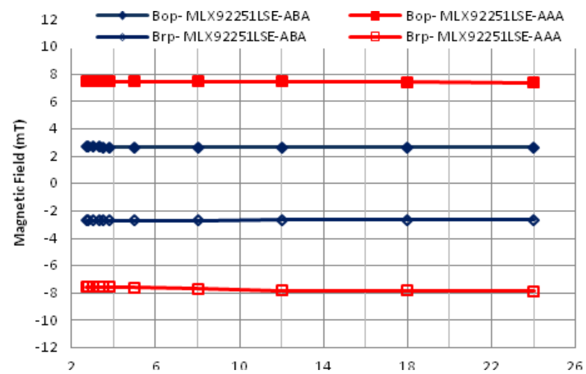
NOTE: Start-up behaviour feature does not occur after under-voltage lockout. $V_{POR} \leq$ 2V (based on device characterization results).

9 Performance Graphs

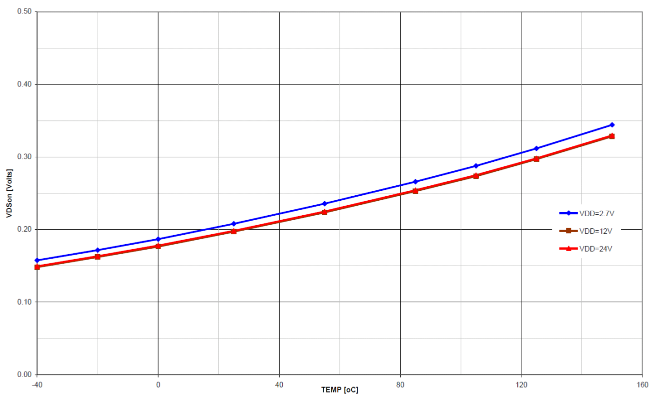
9.1 *Magnetic parameters vs. T_A*



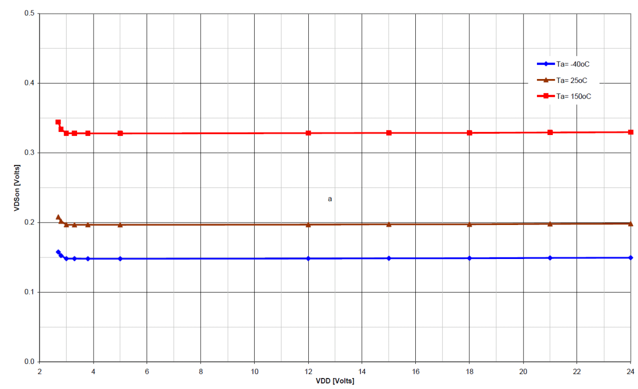
9.2 *Magnetic parameters vs. V_{DD}*



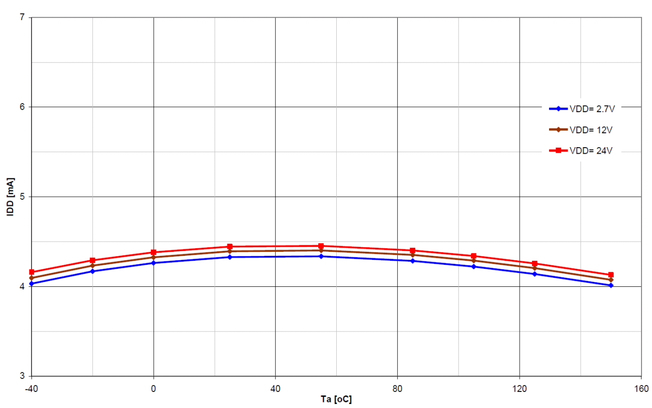
9.3 *V_{DSON} vs. T_A*



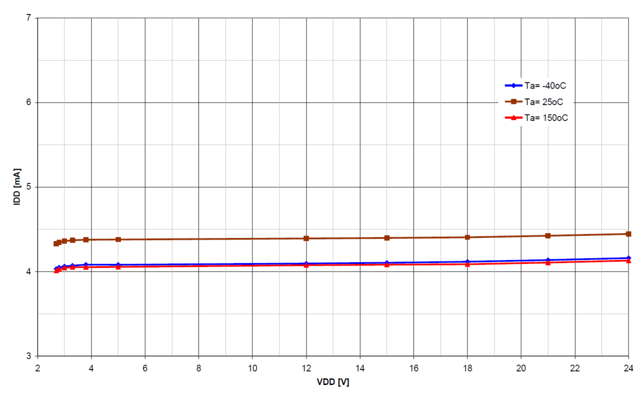
9.4 *V_{DSON} vs. V_{DD}*



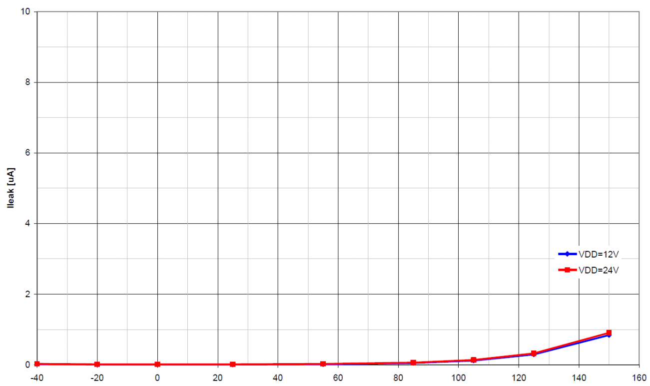
9.5 *I_{DD} vs. T_A*



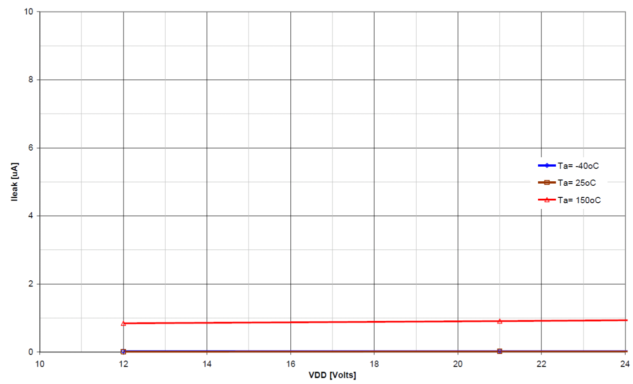
9.6 *I_{DD} vs. V_{DD}*



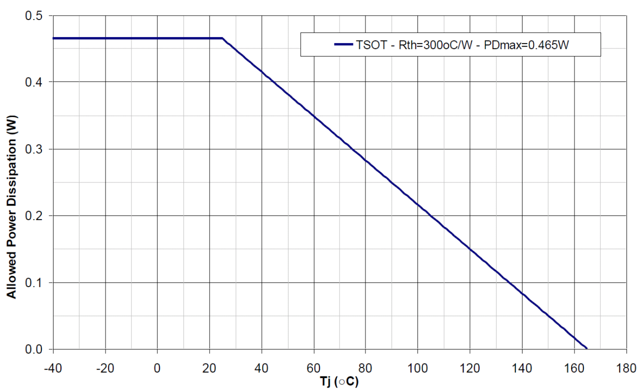
9.7 I_{LEAK} vs. T_A



9.8 I_{LEAK} vs. V_{DD}



9.9 Power Derating vs. T_A



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.

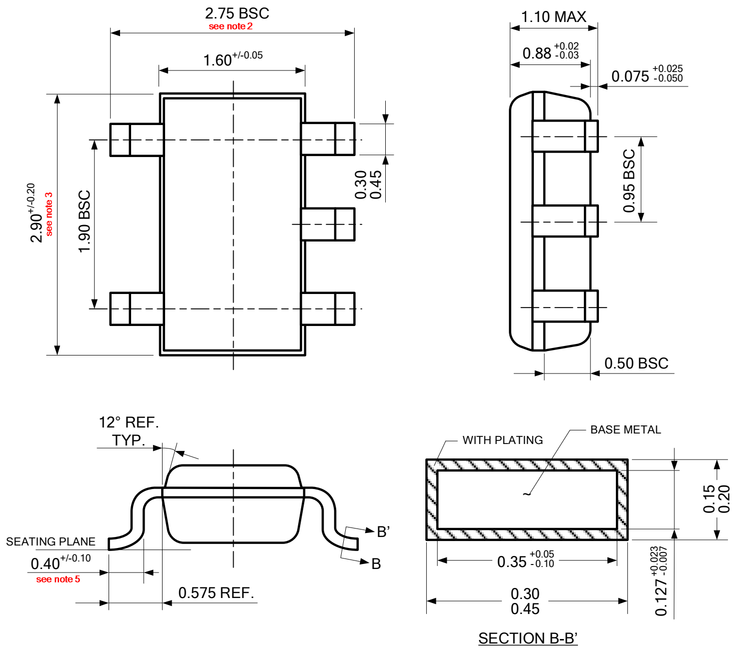
Melexis recommends reviewing on our web site the General Guidelines soldering recommendation (http://www.melexis.com/Quality_soldering.aspx) as well as trim&form recommendations (http://www.melexis.com/Assets/Trim-and-form-recommendations-5565.aspx).

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

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 SE Package Information



Notes:

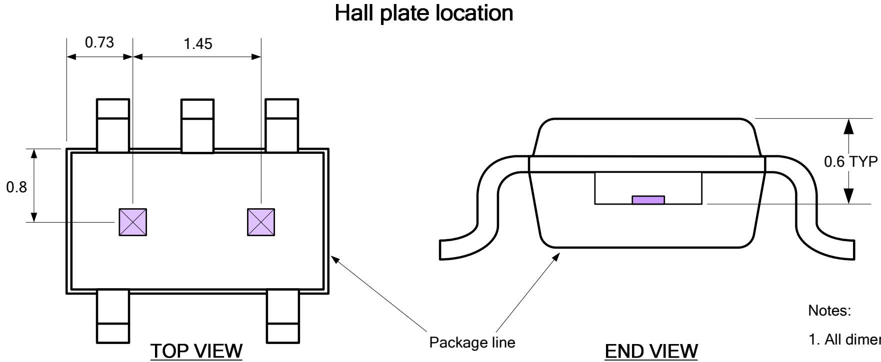
1. All dimensions are in millimeters
2. Outermost plastic extreme width does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 0.15mm per side.
3. Outermost plastic extreme length does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 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. Formed lead shall be planar with respect to one another with 0.076mm at seating plane.
7. This part is compliant with JEDEC specification MO-193. This part is full compliance to EIAJ specification SC-74.

Marking:

Top Side: ●51A - Name of the Device (MLX92251AA)

Bottom Side: xyww x = last digit of lot number
y = last digit of year
ww = week

Hall plate location

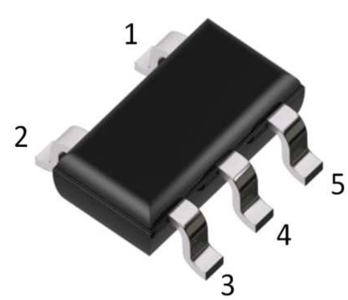


Notes:

1. All dimensions are in millimeters

12.1 *Pin Definitions and Descriptions*

SE Pin №	Name	Type	Function
1	SP	Output	Speed Open-Drain Output
2	DIR	Output	Direction Open-Drain Output
3	VDD	Supply	Power Supply
4	GND	Ground	Ground pin
5	GND	Ground	Ground pin



13 Disclaimer

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

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