

### Features and Benefits

- ❑ Wide operating voltage range: from 2.7V to 24V
- ❑ Integrated self-diagnostics
- ❑ Chopper-stabilized amplifier stage
- ❑ Programmable Built-in negative temperature coefficient
- ❑ Reverse Supply Voltage Protection
- ❑ Under-Voltage Lockout Protection
- ❑ Thermal Protection
- ❑ High ESD rating / Excellent EMC performance

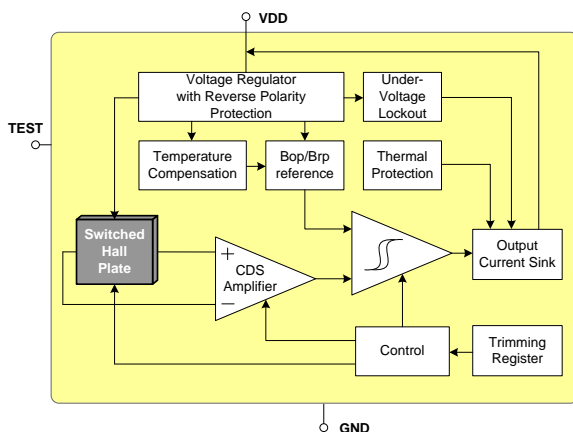
### Application Examples

- ❑ Automotive, Consumer and Industrial
- ❑ Wiper motor
- ❑ Window lifter
- ❑ Seatbelt buckle
- ❑ Seat positioning
- ❑ Sunroof/Tailgate opener
- ❑ Electrical power steering

### Ordering Information

Part No.	Temperature Code	Package Code	Comment
MLX92221LUA-AAA-xxx-BU	L (-40°C to 150°C)	UA (TO92-3L)	BU (Bulk)
MLX92221LSE-AAA-xxx-RE	L (-40°C to 150°C)	SE (TSOT-23)	RE (Reel)

## 1 Functional Diagram



## 2 General Description

The Melexis MLX92241 is a new generation of Hall-effect switches designed in mixed signal submicron CMOS technology.

The device integrates a voltage regulator, Hall sensor with advanced offset cancellation system and a current sink-configured 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 a temperature coefficient is implemented to compensate the natural behaviour of certain types 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 an 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 current state is therefore only updated based on a proper and accurate magnetic measurement result.

The two-wire interface not only saves one wire, but also allows implementation of diagnostic functions as reverse polarity connection and malfunction detection. 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 supply current state is turned high by a sufficiently strong South Pole facing the package branded side. Toggling the state of the supply current from high to low is possible by applying low or no magnetic field.

The MLX92221 is delivered in a Green and RoHS compliant Plastic Single-in-Line (TO-92 flat) for through-hole mount or PCB-less design or in 3-pin Thin Small Outline Transistor (TSOT) for surface mount process

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### 3 Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Supply Voltage <sup>(1, 2)</sup>	V <sub>DD</sub>	+27V	V
Supply Current <sup>(1, 2, 3)</sup>	I <sub>DD</sub>	+20	mA
Supply Current <sup>(1, 3, 4)</sup>	I <sub>DD</sub>	+50	mA
Reverse Supply Voltage <sup>(1, 2)</sup>	V <sub>DDREV</sub>	-24	V
Reverse Supply Current <sup>(1, 2, 5)</sup>	I <sub>DDREV</sub>	-20	mA
Reverse Supply Current <sup>(1, 4, 5)</sup>	I <sub>DDREV</sub>	-50	mA
Maximum Junction Temperature <sup>(6)</sup>	T <sub>J</sub>	+165	°C
Operating Temperature Range	T <sub>A</sub>	-40 to 150	°C
Storage Temperature Range	T <sub>S</sub>	-55 +165	°C
ESD Sensitivity – HBM <sup>(7)</sup>	-	3000	V
ESD Sensitivity – MM <sup>(8)</sup>	-	400	V
ESD Sensitivity – CDM <sup>(9)</sup>	-	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.

<sup>1</sup> The maximum junction temperature should not be exceeded

<sup>2</sup> For maximum 1 hour

<sup>3</sup> Including current through protection device

<sup>4</sup> For maximum 1000 ms

<sup>5</sup> Through protection device

<sup>6</sup> For 1000 hours.

<sup>7</sup> Human Model according AEC-Q100-002 standard

<sup>8</sup> Machine Model according AEC-Q100-003 standard

<sup>9</sup> Charged Device Model according AEC-Q100-011 standard

### 4 General Electrical Specifications

DC Operating Parameters  $V_{DD} = 2.7$  to  $24V$ ,  $T_J = -40^\circ C$  to  $165^\circ C$  (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ <sup>(1)</sup>	Max	Units
Supply Voltage	$V_{DD}$	Operating	2.7	-	24	V
Reverse Supply Current	$I_{DDREV}$	$V_{DD} = -16V$			1	mA
OFF Supply Current	$I_{OFFLow}$	$V_{DD} = 3.5$ to $24V$	2	3.3	5	mA
OFF Supply Current	$I_{OFFHigh}$	$V_{DD} = 3.5$ to $24V$	5	6	6.9	mA
ON Supply Current	$I_{ON}$	$V_{DD} = 3.5$ to $24V$	12	14.5	17	mA
Safe Mode Supply Current	$I_{TP}$	Thermal Protection activated	-	-	0.8	mA
Supply Current Rise/Fall Time <sup>(2)</sup>	$t_{RISE/FALL}$	$V_{DD} = 12V$ , $C_{LOAD} = 50pF$ to GND	0.1	0.3	1	$\mu s$
Power-On Time <sup>(3,4,5)</sup>	$t_{ON}$	$V_{DD} = 5V$ , $dV_{DD}/dt > 2V/\mu s$	-	40	70	$\mu s$
Chopping Frequency	$f_{CHOP}$		260	340	-	kHz
Delay time <sup>(2,6)</sup>	$t_D$	Average value for 1000 successive switching events @10kHz, Square wave with $B \geq 3 \cdot B_{OPMAX}$ , $t_{RISE} = t_{FALL} \leq 20\mu s$	-	7.5	-	$\mu s$
Output Jitter (p-p) <sup>(2,7)</sup>	$t_{JITTER}$	Square wave with $B \geq 3 \cdot B_{OPMAX}$ over 1000 successive switching events @1kHz	-	$\pm 3.3$	-	$\mu s$
Maximum Switching Frequency <sup>(2,8)</sup>	$f_{SW}$	$B \geq 3 \cdot B_{OPMAX}$ and square wave magnetic field	30	50	-	kHz
Under-voltage Lockout Threshold	$V_{UVL}$		-	2	2.7	V
Under-voltage Lockout Reaction time <sup>(2)</sup>	$t_{UVL}$		-	1	-	$\mu s$
Thermal Protection Threshold	$T_{PROT}$	Junction temperature	-	190 <sup>(9)</sup>	-	$^\circ C$
Thermal Protection Release	$T_{REL}$	Junction temperature	-	180 <sup>(9)</sup>	-	$^\circ C$
Safe Mode Supply Current	$I_{TP}$	Thermal Protection activated	-	-	0.8	mA
UA Package Thermal Resistance	$R_{TH}$	Single layer (1S) Jedec board, zero LFPM		200		$^\circ C/W$
TSOT Package Thermal Resistance	$R_{TH}$	Single layer (1S) Jedec board, zero LFPM		300		$^\circ C/W$

<sup>1</sup> Typical values are defined at  $T_A = +25^\circ C$  and  $V_{DD} = 12V$

<sup>2</sup> Guaranteed by design and verified by characterization, not production tested

<sup>3</sup> The Power-On Time represents the time from reaching  $V_{DD} = V_{POR}$  to the first refresh of the supply current state.

<sup>4</sup> Power-On Slew Rate is not critical for the proper device start-up.

<sup>5</sup>  $B > B_{OPmax} + 1$  mT for direct output sensors, or  $B < B_{RPmin} - 1$  mT.

<sup>6</sup> Delay Time is the time from magnetic threshold reached to the start of the supply current switching.

<sup>7</sup> Output jitter is the unpredictable deviation of the Delay time

<sup>8</sup> Maximum switching frequency corresponds to the maximum frequency of the applied magnetic field which is detected without loss of pulses

<sup>9</sup>  $T_{PROT}$  and  $T_{REL}$  are the corresponding junction temperature values.

### 5 Specifications

#### 5.1 MLX92221LSE-AAA-001

DC Operating Parameters  $V_{DD} = 3.5V$  to  $24V$ ,  $T_J = -40^{\circ}C$  to  $165^{\circ}C$

Test Condition	Operating Point $B_{OP}$ (mT)			Release Point $B_{RP}$ (mT)			TC (ppm/ $^{\circ}C$ )	$I_{off}$ (mA)	Active Pole
	Min	Typ <sup>(10)</sup>	Max	Min	Typ <sup>(10)</sup>	Max			
$T_J = -40^{\circ}C$	7.4	11.8	16.3	-7.4	-11.8	-16.3	0	6	South pole
$T_J = 25^{\circ}C$	7.4	11.8	16.3	-7.4	-11.8	-16.3			
$T_J = 150^{\circ}C$	7.4	11.8	16.3	-7.4	-11.8	-16.3			

#### 5.2 MLX92221LSE-AAA-002

DC Operating Parameters  $V_{DD} = 3.5V$  to  $24V$ ,  $T_J = -40^{\circ}C$  to  $165^{\circ}C$

Test Condition	Operating Point $B_{OP}$ (mT)			Release Point $B_{RP}$ (mT)			TC (ppm/ $^{\circ}C$ )	$I_{off}$ (mA)	Active Pole
	Min	Typ <sup>(10)</sup>	Max	Min	Typ <sup>(10)</sup>	Max			
$T_J = -40^{\circ}C$	4.1	6.8	9.6	-9.6	-6.8	-4.1	-2000	6	South pole
$T_J = 25^{\circ}C$	4.1	6	7.9	-7.9	-6	-4.1			
$T_J = 150^{\circ}C$	1.8	4.5	7.1	-7.1	-4.5	-1.8			

#### 5.3 MLX92221LSE-AAA-003

DC Operating Parameters  $V_{DD} = 3.5V$  to  $24V$ ,  $T_J = -40^{\circ}C$  to  $165^{\circ}C$

Test Condition	Operating Point $B_{OP}$ (mT)			Release Point $B_{RP}$ (mT)			TC (ppm/ $^{\circ}C$ )	$I_{off}$ (mA)	Active Pole
	Min	Typ <sup>(10)</sup>	Max	Min	Typ <sup>(10)</sup>	Max			
$T_J = -40^{\circ}C$	0.5	2	3.2	-3.2	-2	-0.5	0	6	South pole
$T_J = 25^{\circ}C$	0.8	1.8	2.8	-2.8	-1.8	-0.8			
$T_J = 150^{\circ}C$	0.3	1.8	3.3	-3.3	-1.8	-0.3			

#### 5.4 MLX92221LUA-AAA-004

DC Operating Parameters  $V_{DD} = 3.5V$  to  $24V$ ,  $T_J = -40^{\circ}C$  to  $165^{\circ}C$

Test Condition	Operating Point $B_{OP}$ (mT)			Release Point $B_{RP}$ (mT)			TC (ppm/ $^{\circ}C$ )	$I_{off}$ (mA)	Active Pole
	Min	Typ <sup>(10)</sup>	Max	Min	Typ <sup>(10)</sup>	Max			
$T_J = -40^{\circ}C$	4.1	6.8	9.6	-9.6	-6.8	-4.1	-1100	6	South pole
$T_J = 25^{\circ}C$	4.1	6	7.9	-7.9	-6	-4.1			
$T_J = 150^{\circ}C$	1.8	4.5	7.1	-7.1	-4.5	-1.8			

### 5.5 MLX92221LUA-AAA-005

DC Operating Parameters  $V_{DD} = 3.5V$  to  $24V$ ,  $T_J = -40^{\circ}C$  to  $165^{\circ}C$

Test Condition	Operating Point $B_{OP}$ (mT)			Release Point $B_{RP}$ (mT)			TC (ppm/ $^{\circ}C$ )	$I_{off}$ (mA)	Active Pole
	Min	Typ <sup>(10)</sup>	Max	Min	Typ <sup>(10)</sup>	Max			
$T_J = -40^{\circ}C$	0.5	2	3.2	-3.2	-2	-0.5	0	6	South pole
$T_J = 25^{\circ}C$	0.8	1.8	2.8	-2.8	-1.8	-0.8			
$T_J = 150^{\circ}C$	0.3	1.8	3.3	-3.3	-1.8	-0.3			

### 5.6 MLX92221LUA-AAA-006

DC Operating Parameters  $V_{DD} = 3.5V$  to  $9.3V$ ,  $T_J = -40^{\circ}C$  to  $165^{\circ}C$

Test Condition	Operating Point $B_{OP}$ (mT)			Release Point $B_{RP}$ (mT)			TC (ppm/ $^{\circ}C$ )	$I_{off}$ (mA)	Active Pole
	Min	Typ <sup>(10)</sup>	Max	Min	Typ <sup>(10)</sup>	Max			
$T_J = -40^{\circ}C$	-0.5	1.25	2	-2	-1.25	0.5	0	6	South pole
$T_J = 25^{\circ}C$	0	0.8	1.6	-1.6	-0.8	0			
$T_J = 150^{\circ}C$	-0.5	1.25	2	-2	-1.25	0.5			

### 6 Magnetic Behaviour

#### 6.1 Latch sensor

Pole Active	Remark
South	Fig.1
North	Fig.2

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

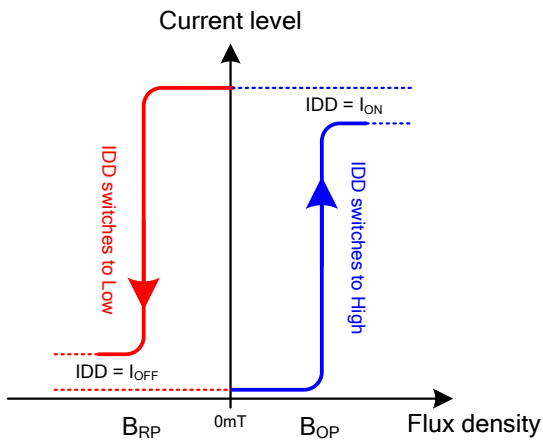


Fig.1 –South Pole Active

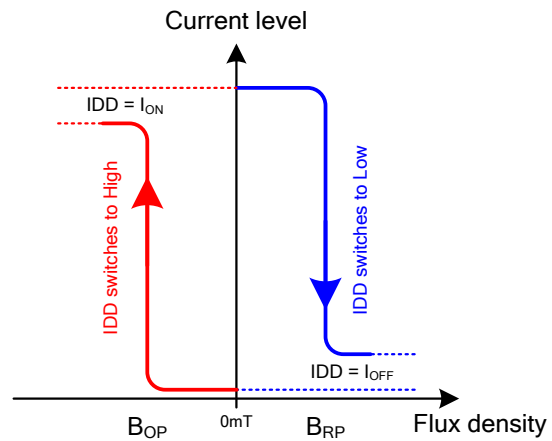
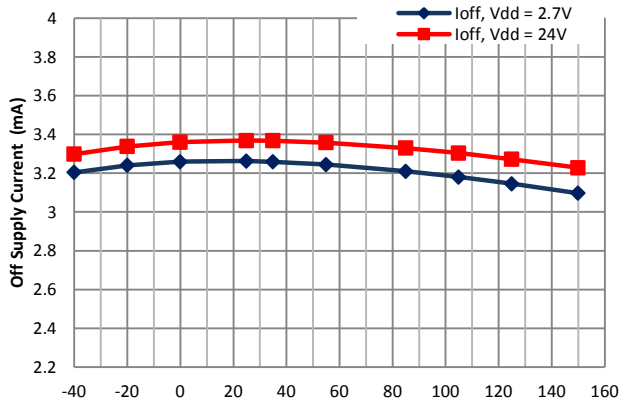


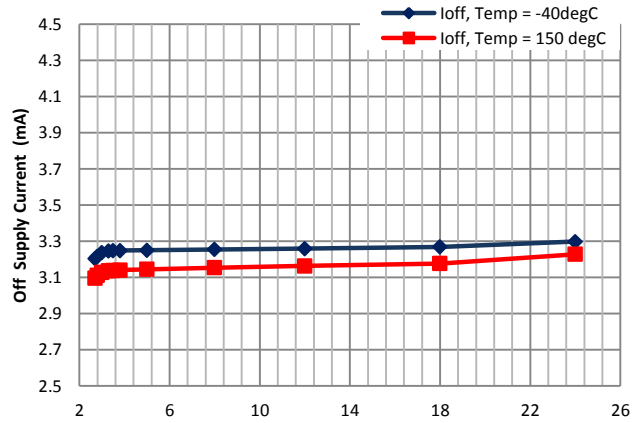
Fig.2 –North Pole Active

## 7 Performance Graphs

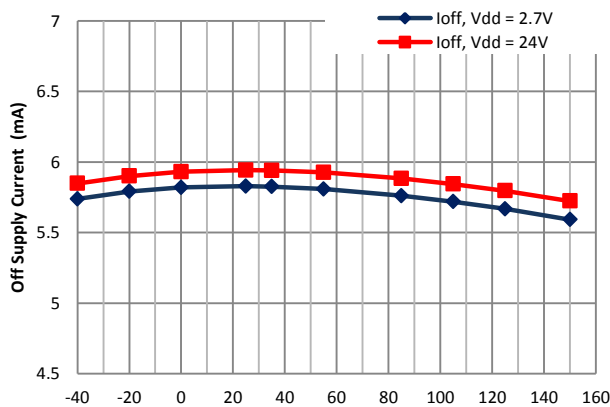
7.1  $I_{OFFLow}$  vs.  $T_J$



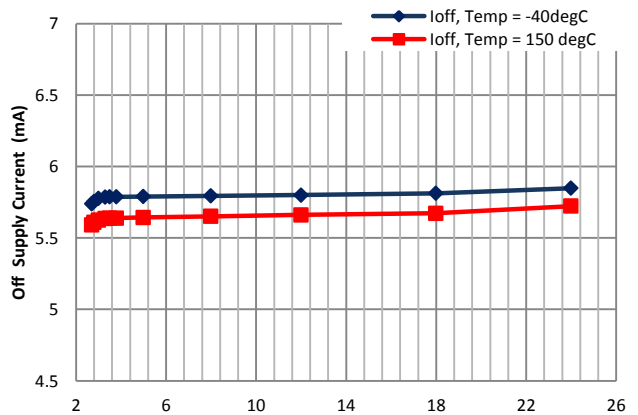
7.4  $I_{OFFLow}$  vs.  $V_{DD}$



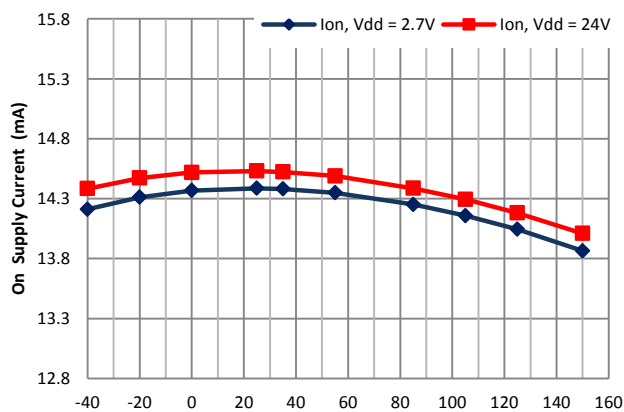
7.2  $I_{OFFHigh}$  vs.  $T_J$



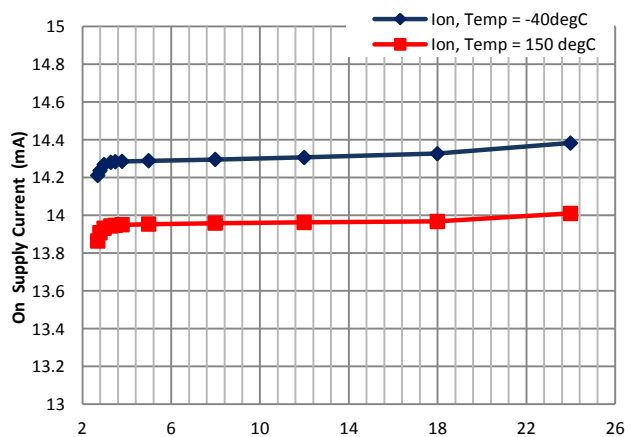
7.5  $I_{OFFHigh}$  vs.  $V_{DD}$



7.5  $I_{ON}$  vs.  $T_J$

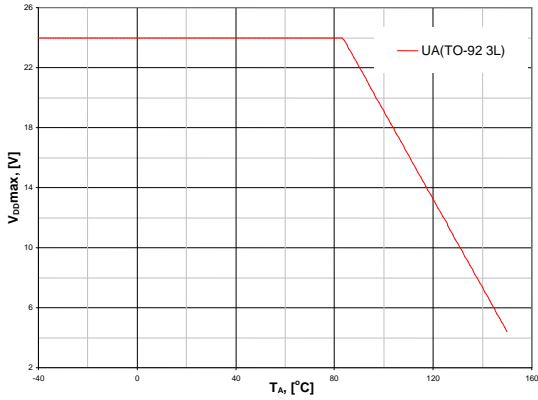


7.6  $I_{ON}$  vs.  $V_{DD}$

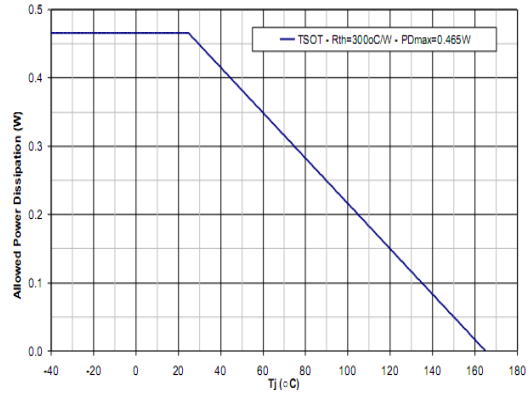




### 7.7 $V_{DD}$ de-rating UA package

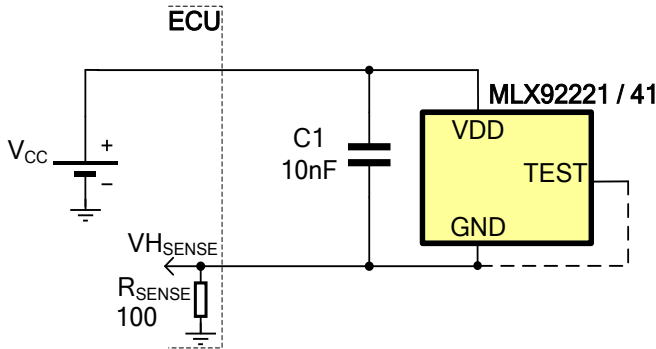


### 7.8 $V_{DD}$ de-rating TSOT package



### 8 Application Information

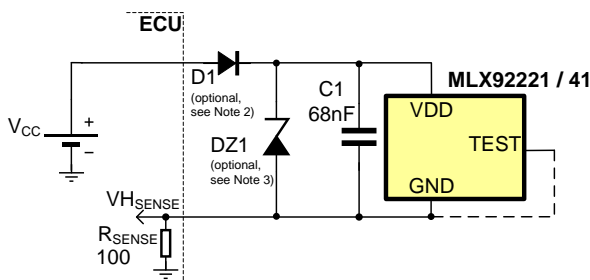
#### 8.1 Typical Automotive Application Circuit



**Notes:**

1. For proper operation, a 10nF bypass capacitor should be placed as close as possible to the V<sub>DD</sub> and ground(GND) pin. For complete emissions protection a C1 = 68nF is recommended.
2. The TEST pin is to be left open or connected to GND.

#### 8.2 Automotive and Harsh, Noisy Environments Application Circuit



**Notes:**

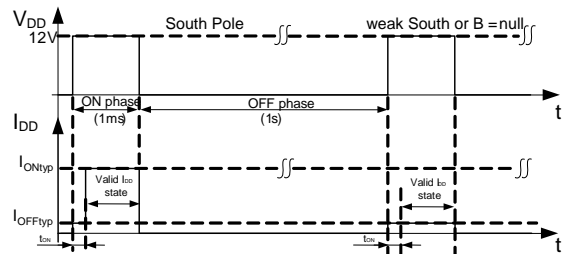
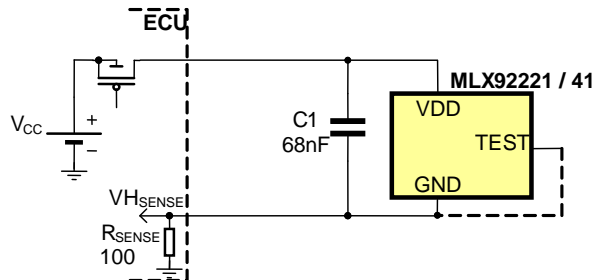
1. For proper operation, a 10nF to 100nF bypass capacitor should be placed as close as possible to the V<sub>DD</sub> and ground pin.
2. The device could tolerate negative voltage down to -24V, so if negative transients over supply line V<sub>PEAK</sub> < -29V are expected, usage of the diode D1 is recommended. Otherwise only R<sub>SENSE</sub> is sufficient.

When selecting the resistor R<sub>SENSE</sub>, three points are important:

- the resistor has to limit I<sub>DD</sub>/I<sub>DDREV</sub> to 50mA maximum
- the resistor has to withstand the power dissipated in both over voltage conditions ( $V_{RSENSE}^2/R_{SENSE}$ )
- the resulting device supply voltage V<sub>DD</sub> has to be higher than V<sub>DD min</sub> ( $V_{DD} = V_{CC} - R_{SENSE} \cdot I_{DD}$ )

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<sub>PEAK</sub> > 32V are expected, usage a zener diode DZ1 is recommended. The R<sub>SENSE</sub>-DZ1 network should be sized to limit the voltage over the device below the maximum allowed.

#### 8.3 Strobing V<sub>DD</sub> application (used for reduced self-heating)



**Notes:**

1. Given strobe timing is exemplary only.
2. For proper operation, a 10nF to 100nF bypass capacitor should be placed as close as possible to the V<sub>DD</sub> and ground pin.

### **9 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.

<http://www.melexis.com/Assets/Soldering-Application-Note-and-Recommendations-5446.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>

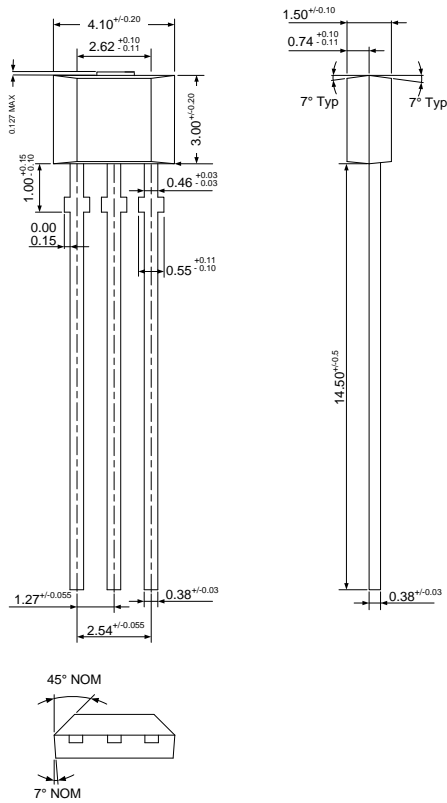
### **10 ESD Precautions**

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD).

Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

### 11 Package Information

#### 11.1 UA (TO92 - 3L)



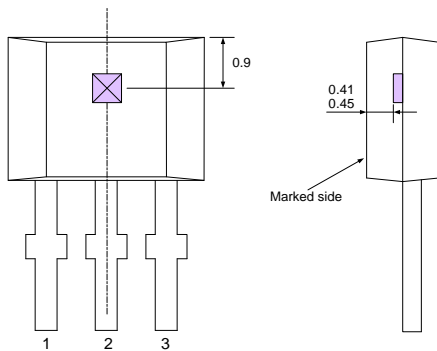
#### Notes:

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:

- 1<sup>st</sup> Line : xxx – last three digits from lot number  
 2<sup>nd</sup> Line : yww  
 y - last digit of year  
 ww - calendar week

#### Hall plate location

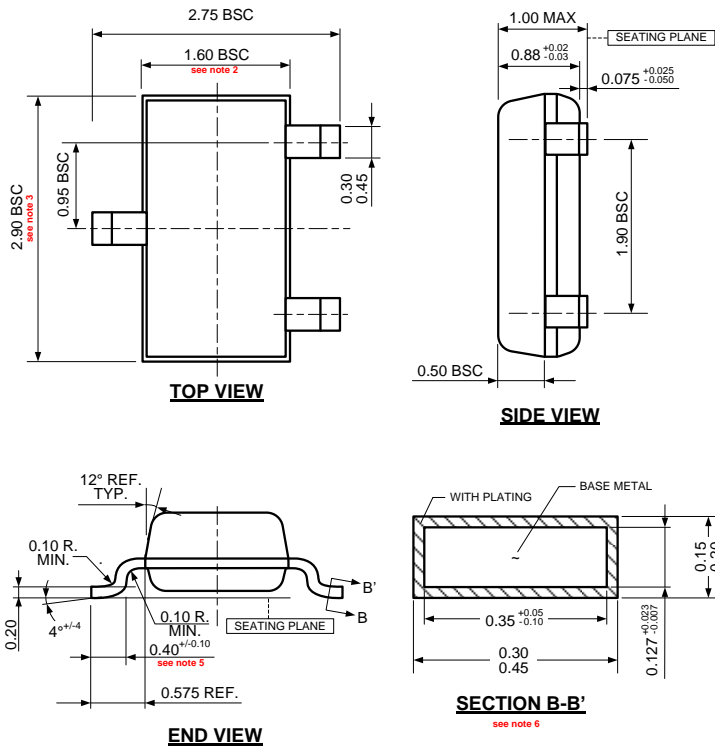


#### Notes:

1. All dimensions are in millimeters

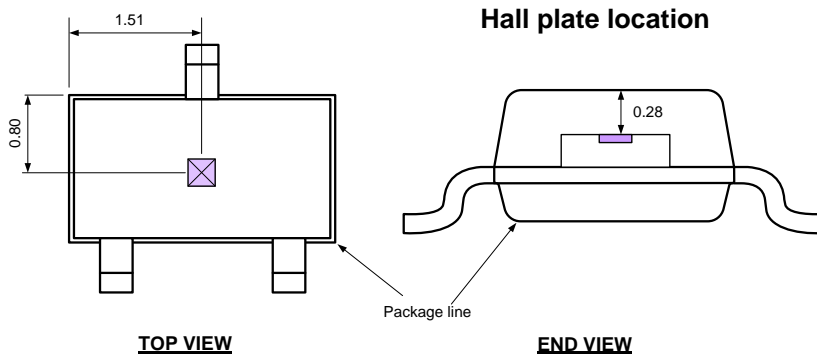
Pin №	Name	Type	Function
1	VDD	Supply	Supply Voltage pin
2	GND	Ground	Ground pin
3	TEST	I/O	Analog & Digital I/O

### 11.2 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.



**Notes:**

1. All dimensions are in millimeters

SE Pin №	Name	Type	Function
1	VDD	Supply	Supply Voltage pin
2	TEST	I/O	Analog & Digital I/O
3	GND	Ground	Ground pin

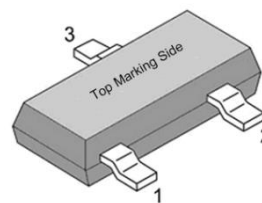


Table 1: SE Package pinout

Note: Test pin to be left open or connected to GND in the application

### 12 Disclaimer

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