MLX92442

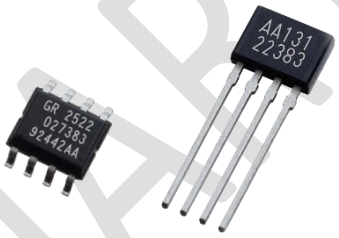
2-Wire Induxis® Switch
Preliminary Device Specification

1. Features and Benefits

- Stray-field immune sensor
- Innovative inductive sensing technology
- Wide operating voltage: 3.5 V to 18 V
- Operating temperature: -40°C to 150°C
- Airgap of up to 1.5 mm
- Current wire interface (2-wire) or open drain output (3-wire) [1]
- Packages, RoHS compliant
  - ❑ TO92-4L (VK), through hole
  - ❑ SOIC-8 (DC), surface mount
- Reverse supply voltage protection
- Under-voltage lockout protection
- Thermal protection
- Integrated self-diagnostic functions activating a dedicated Safe Mode
- ISO26262 ASIL A SEooC (Safety Element out of Context)

2. Application Examples

- Seatbelt buckle
- Seat positioning
- Door lock & handle
- On-board charging flap
- Brake light switch
- Transmission applications
- Gear tooth sensing
- Speed sensing (motorcycles)
- Bank angle sensor (motorcycles)
- Push-button / Radio-button [1]



3. Ordering Information

Product Code	Temperature Code	Package Code	Option Code	Packing Form Code
MLX92442	L	DC	AAA-000	RE
MLX92442	L	VK	AAA-100[2]	BU
MLX92442	L	VK	AAA-000	BU

Legend:

Temperature Code: L (-40°C to 150°C)
Package Code: VK = TO92-4L |DC= SOIC-8
Option Code: 000=> 2-wire inductive switch (right switch operation)
100 => Integrated capacitor (right switch operation, VK package only)

Packing Form: BU = Bulk | RE = Reel | CA=Papertape in Ammopack | CR=Papertape on Reel
Ordering example: MLX92442LVK-AAA-100-BU

Preliminary Device Specification: Melexis reserves the right to change the product and specifications without prior notice.

[1] *Contact our customer support for samples in such configuration.*

[2] *For additional information on EMC performance contact our customer support.*

4. Functional Diagram

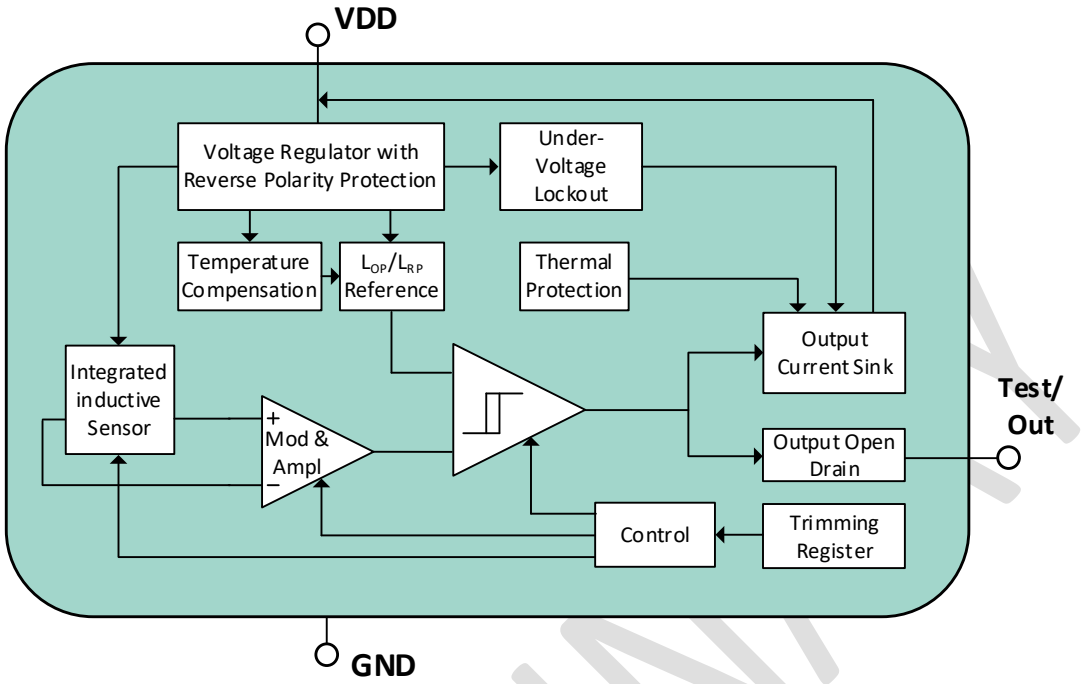


Figure 1 MLX92442 Block diagram

5. General Description

The MLX92442 is Melexis first inductive based switch, designed in mixed signal submicron CMOS technology. The chip is an integrated inductive latch / switch, designed to detect the presence of an electrically conductive target. The device integrates a voltage regulator, micro-transformer with advanced offset cancellation system, a current sink-configured or open drain output driver.

The included voltage regulator operates from 3.5V to 18V, 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 are usable for low voltage operation down to 3.5V 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 disable the device, preventing the electrical perturbation to affect the measurement circuitry. The output current state is therefore only updated based on a proper and accurate 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 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.

A selectable open drain output is also available in case of need.

MLX92442 is available in a Green and RoHS compliant Plastic Single-in-Line (TO-92 flat) for through-hole mount with integrated capacitor or in 8-pin Small Outline package (SO) for surface mount process.

Contents

6. Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Supply Voltage (1, 2)	V_{DD}	+28	V
Supply Voltage (Load Dump) (1, 4)	V_{DD}	+32	V
Supply Current (1, 2, 3)	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 (1, 4)	V_{DDREV}	-30	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}	+5	V
Output current(1, 4, 5)	I_{OUT}	+5	mA
Reverse output voltage(1)	V_{OUTREV}	-0.5	V
Reverse output current(1, 2)	I_{OUTREV}	-5	mA
Maximum Junction Temperature (6)	T_J	+165	°C
ESD Sensitivity – HBM (7) (VDD pin)	-	8	kV
ESD Sensitivity – System level (8) (VDD pin)	-	15	kV
ESD Sensitivity – CDM (9)	-	1000	V
ESD Sensitivity – HBM(7) (OUT pin)	-	500	V

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] Including current through protection device
[4] For maximum 500ms
[5] Through protection device
[6] For 1000 hours
[7] Human Model according AEC-Q100-002 standard
[8] Indirect discharge according VW TL82466 standard, typical value, only for option MLX92442LVA-AAA-100
[9] Charged Device Model according AEC-Q100-011 standard

7. General Electrical Specification

DC Operating Parameters V_{DD} = 3.5V to 18V, T_J = -40°C to 165°C (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ[1]	Max	Units
OFF Supply Current (selectable by a dedicated bit)	I_{OFF}		2	-	5	mA
			5	-	6.9	mA
ON Supply Current	I_{ON}		12	-	17	mA
Reverse Supply current	I_{DDREV}	V_{DD} = -16V	-1	-	-	mA
Safe Mode Supply Current	I_{SAFE}		0.8	-	1.4	mA
Supply Current Rise/Fall Time [2]	t_R/t_F	V_{DD} = 12V, C_{LOAD} = 50pF to GND	0.1	0.3	1	µs
Power-On Time [3, 4]	t_{ON}	V_{DD} = 5V, dV_{DD}/dt > 2V/us, activated output	-	40	70	µs
Delay Time [2, 5]	t_D		-	8	16	µs
Jitter (pk-pk) [2, 6]	t_j				13	µs
Switching Frequency	F_{SW}				20	kHz
Under-voltage Lockout Threshold	V_{UVL}	With respect to VDD	2.5	-	3.4	V
Output leakage [7]	I_{OFF1}	During operation VOUT =3.6V			1	µA
Output ON Resistance	R_{OUTON}			15	30	Ω
OUT pin pull up voltage	V_{PU}				3.6	V
Integrated bypass capacitor	C_{BP}	Only for options MLX92442LVA-AAA-100	-	68	-	nF
Thermal Protection Activation	T_{PROT}		-	190[8]	-	°C
Thermal Protection Release	T_{REL}		-	180[8]	-	°C
Default output state at power up	-	Direct Switch or Latch		OFF		

1 Typical values are defined at T_A = +25°C and V_{DD} = 12V.

2 Guaranteed by design and verified by characterization, not production tested.

3 The Power-On Time represents the time from reaching V_{DD} = 2.7V to the first refresh of the supply current state / output update.

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

5 The Delay Time is the time from the moment the target is brought over the package as described to the start of the output switching.

6 Jitter is the timing uncertainty of t_D.

7 In this design. During Power-on and VOUT =3.6V the leakage can reach 1mA for 1ms.

8 T_{PROT} and T_{REL} are the corresponding junction temperature values.

8. Application Specification

8.1. MLX92442LVK-AAA-100 & MLX92442LDC-AAA-000

DC Operating Parameters V_{DD} = 3.5V to 18V, T_J = -40°C to 125°C (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ[1]	Max	Units
Airgap detection range latch [2]	A_{DRL}	MLX92442LVK-AAA-100 σ_{TARGET} = 2.32x10^6 S/m			1.2	mm
Airgap detection range switch [2]	A_{DRS}	MLX92442LVK-AAA-100 σ_{TARGET} = 2.32x10^6 S/m			1	mm
Target positioning tolerance – Latch [3]	ΔD_{OVL}	A_{DRL} = 1.2mm	-0.3	0	0.3	mm
		A_{DRL} = 1mm	-0.5	0	0.5	mm
		A_{DRL} = 0.75mm	-0.6	0	0.6	mm
Target positioning tolerance – Switch [3]	ΔD_{OVS}	A_{DRS} = 1mm	-0.3	0	0.3	mm
		A_{DRS} = 0.75mm	-0.5	0	0.5	mm
		A_{DRS} = 0.5mm	-0.6	0	0.6	mm
Target thickness	d_{TARGET}		0.1			mm
Target electrical conductivity	σ_{TARGET}	DIN1614 (St24)	2.32x10^6			S/m
Target Overlap or clearance	D_{OV}		3			mm
Cut-out separation	D_{SC}	Latch in Figure 4 and Figure 5	0.81	0.88	0.95	mm
Output Polarity Selection		"0" -> Direct Output "1" -> Inverted Output	-	1	-	bit
Push-button functionality selection		"0"-> Disable push button mode "1"-> Enable push button mode	-	1	-	bit
VDD Programming Lock		"0"-> EEPROM unlocked "1" -> EEPROM Locked	-	1	-	bit
OFF Current Selection		"0" -> 2mA to 5mA "1" -> 5mA to 6.9mA	-	1	-	bit
Cust ID			-	8	-	bit

[1] Typical values are defined at T_A = +25°C and V_{DD} = 5V. The values (ADR) are still under evaluation.

[2] Defined distance from top of the package (see package drawing). The tilt and rotation of the target are assumed to be 0°. Both the sensor and the target are subjected to the specified temperature range. High target temperature lead to increased target resistance and low signal level.

[3] Target must be aligned as IC pin #2 or #3 – For reference see Figure 2 and Figure 3.

9. Target Positioning

The airgap, measured from the top of the package, and the target material selection will be crucial for the application. Therefore, it is strongly advised to consider the parameters from the inductive specification when designing the full sensor module (see Figure 2). It is advised to use a target with a minimum conductivity of $2.32x10^6$ S/m with minimum thickness of 100µm.

MLX92442 can work either as a switch or as a latch. In a switch operation mode, only one side of the chip needs to be covered by the target for ON state and when removing the target (or the target covers the whole package with at least 2mm overlap on each side) the state is OFF. For latch operation – the left and right sides are covered alternatively in order to achieve an ON and OFF state. An illustration of a switch and a latch target configuration is shown in Figure 2 and Figure 3. See also Section 10 for complete description of latch and switch working modes.

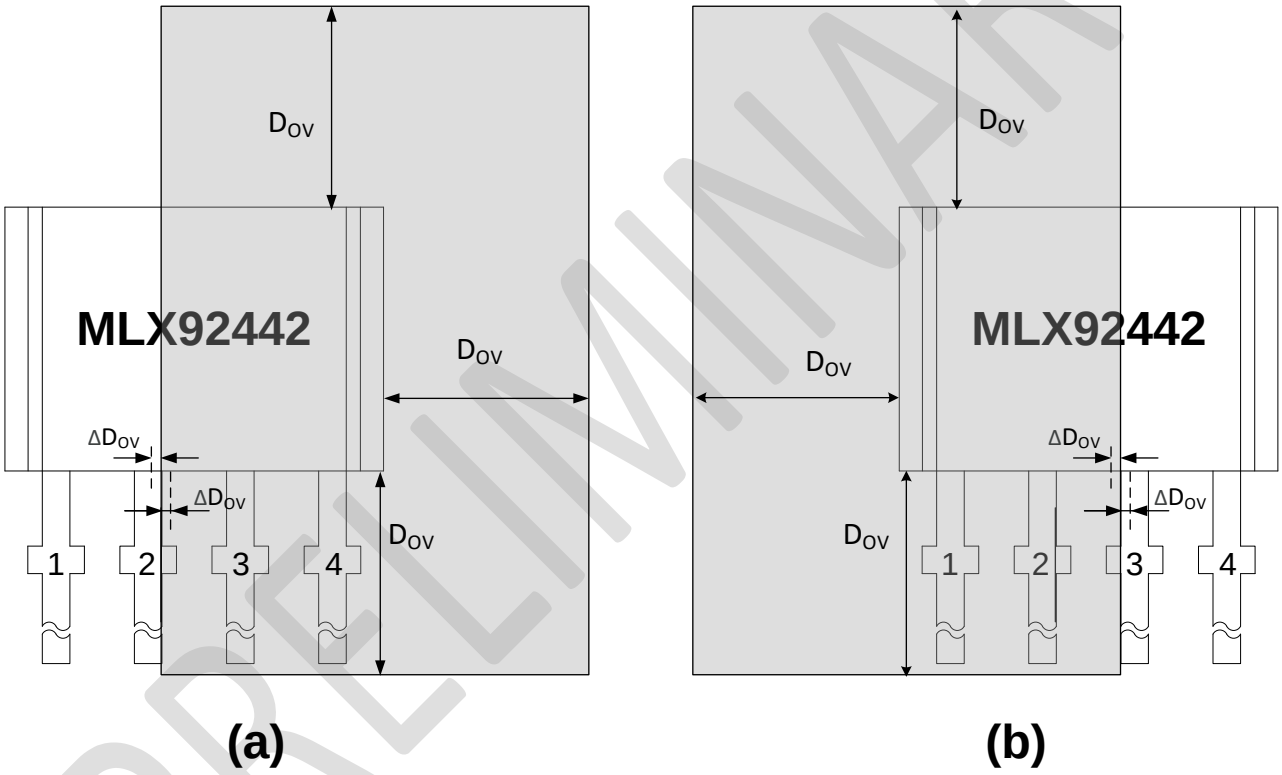


Figure 2 Target position over a packaged in VK MLX92442, switch-right (a) and switch-left (b) application, illustrating a proper target position over the package of the IC for ON state (Direct Output). Alternatively, for latch programming (a) is the ON state, while (b) is the OFF state

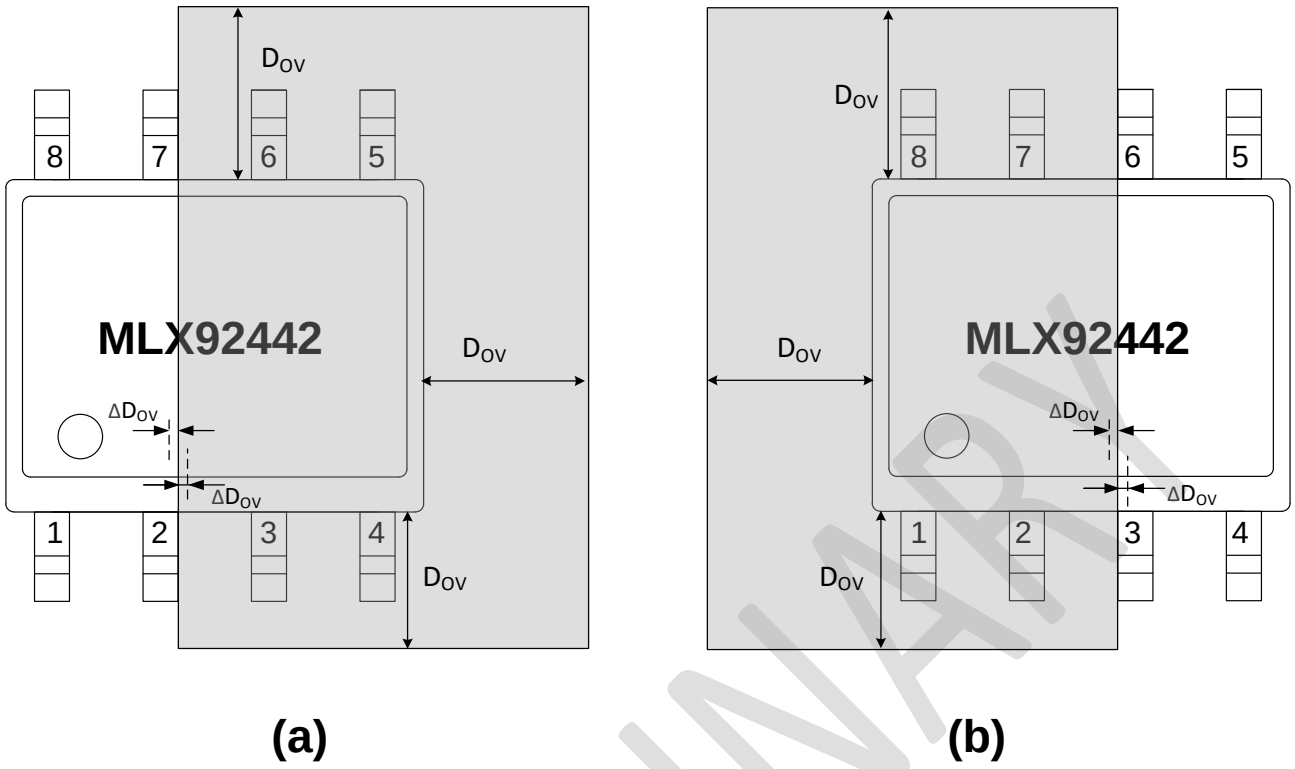


Figure 3 Target position over a packaged in SOIC8 MLX92442, switch-right (a) and switch-left (b) application, illustrating a proper target position over the package of the IC for ON state (Direct Output). Alternatively, for latch programming (a) is the ON state, while (b) is the OFF state

10. Modes of Operation

10.1. Latch operation

When MLX92442 is configured to work in latch mode, it is needed that the target covers one part of the package for ON state and the other part of the package for an OFF state as shown in Figure 4.

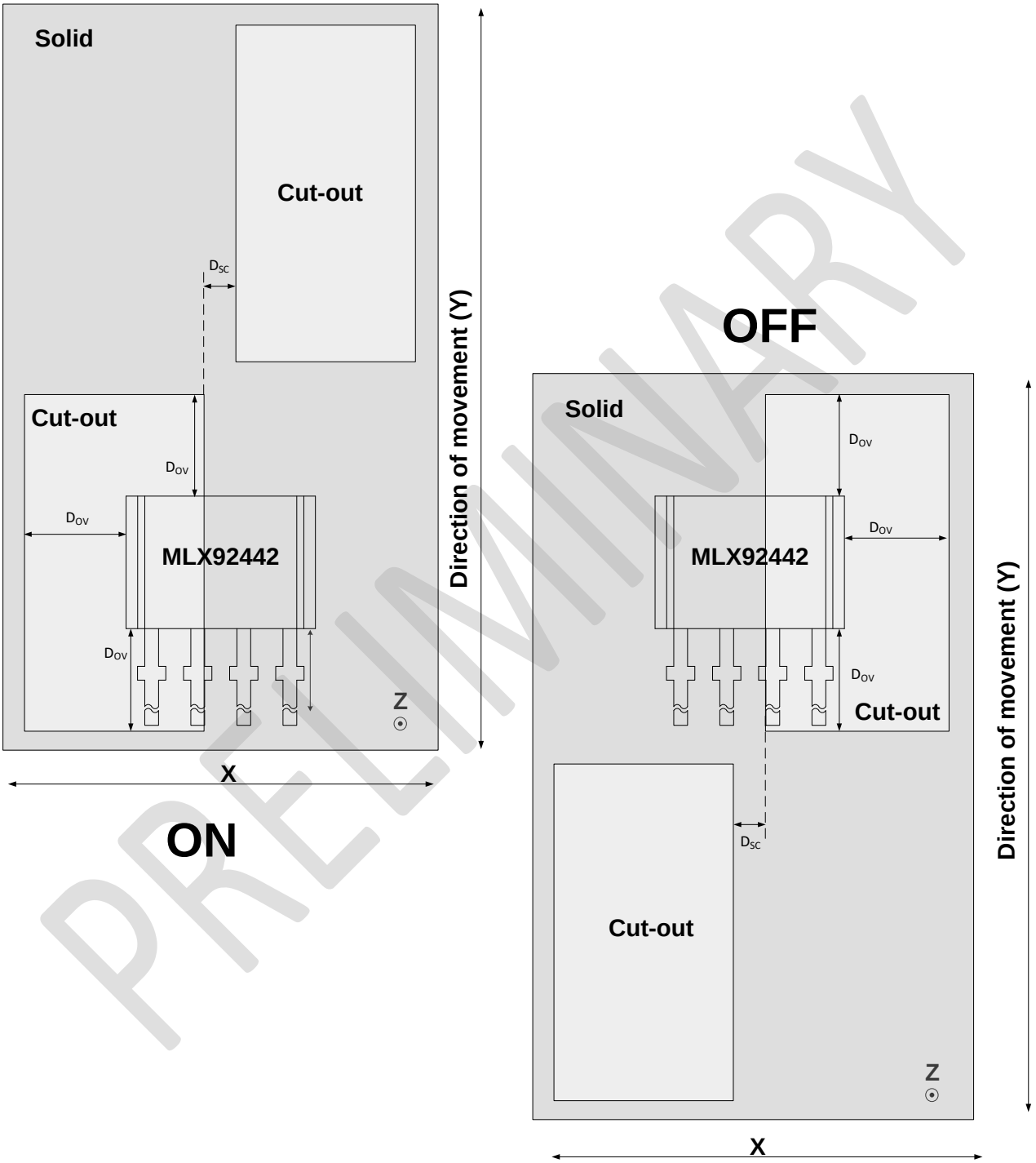


Figure 4 Latch operation for VK package. Direct Output

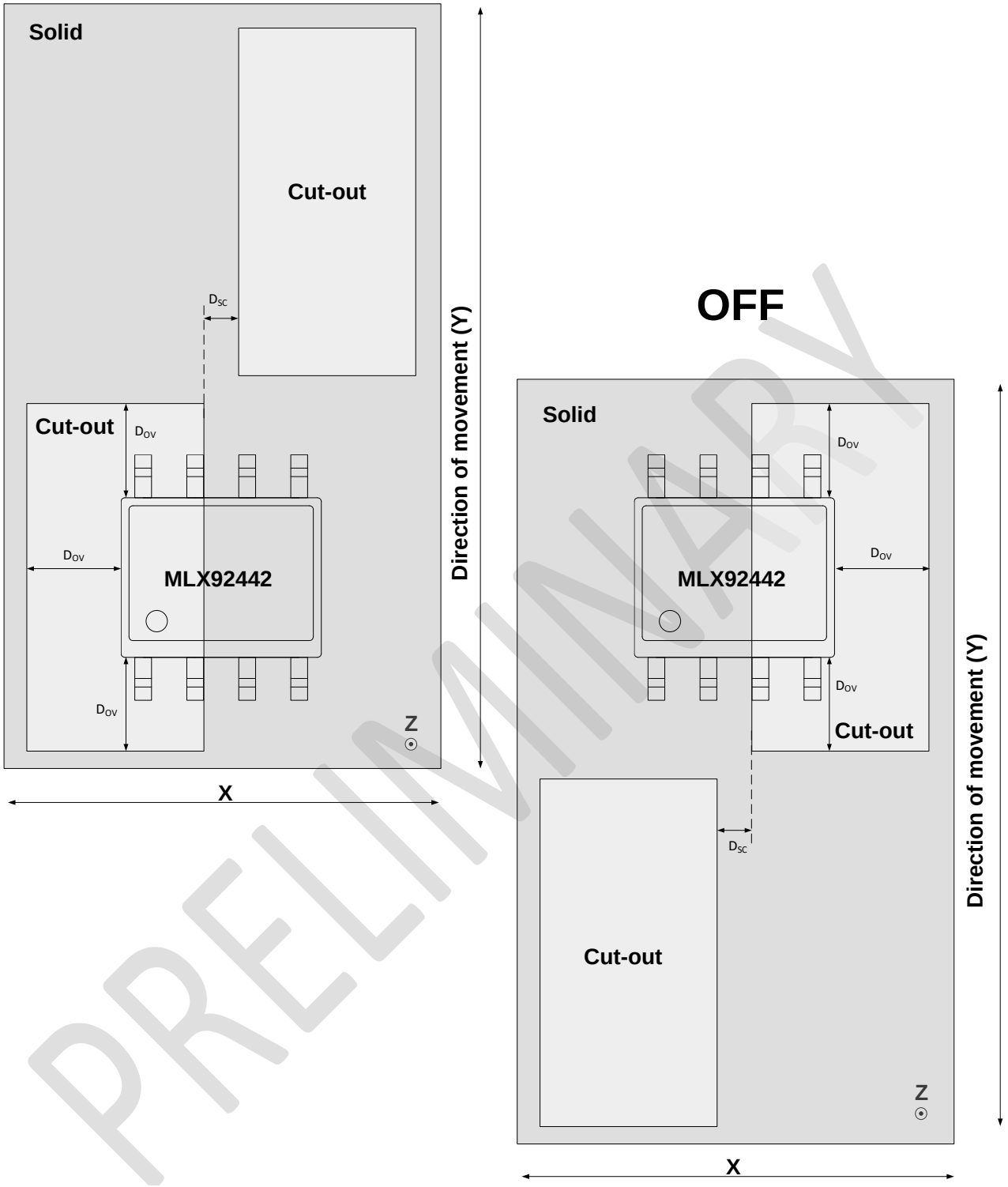


Figure 5 Latch operation for SOIC8 package. Direct Output

10.2. Switch operation

The switch operation is achieved by proper positioning of the target on top of the package as shown in Figure 6. This position provides for an ON state of the switch[1]. In order to switch OFF, the target needs to be removed from the chip surface or the target needs to cover the whole package. For turning OFF, uncovering of the device is preferable as tilt might still create differential signal if the device is fully covered. The switch operation can be achieved either coming from the right of the package (as shown in Figure 2 and Figure 6 → switch-right), or from the left (switch-left). Different thresholds need to be programmed for left or right switch operation.

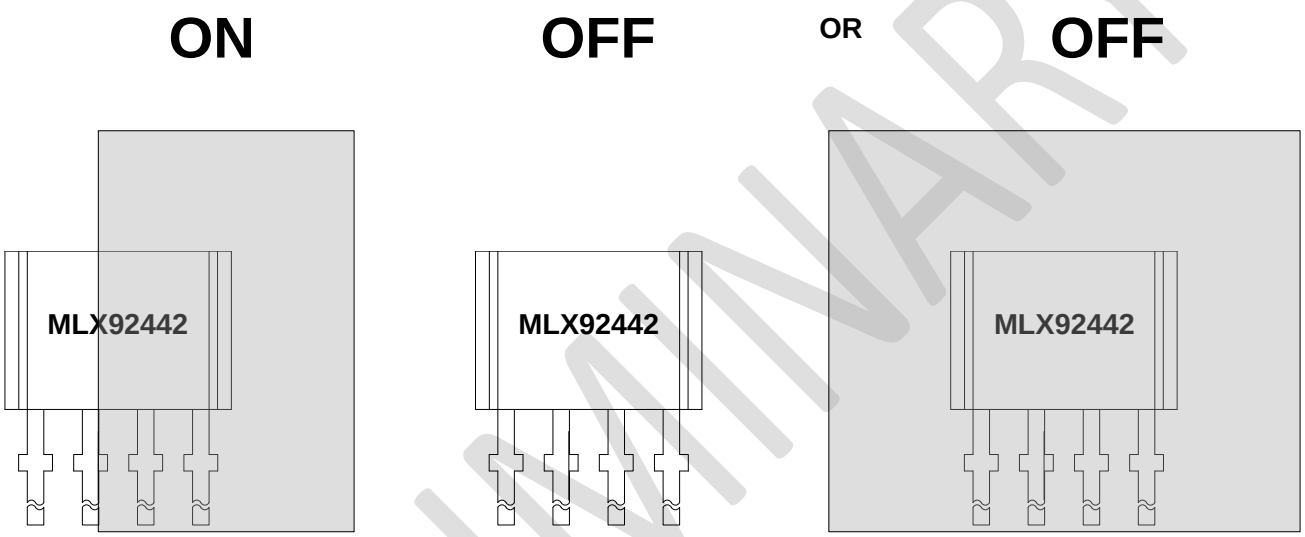


Figure 6 Switch-right operation for VK package. Direct Output

[1] *Depending on the setting of the output polarity, it could be alternatively OFF*

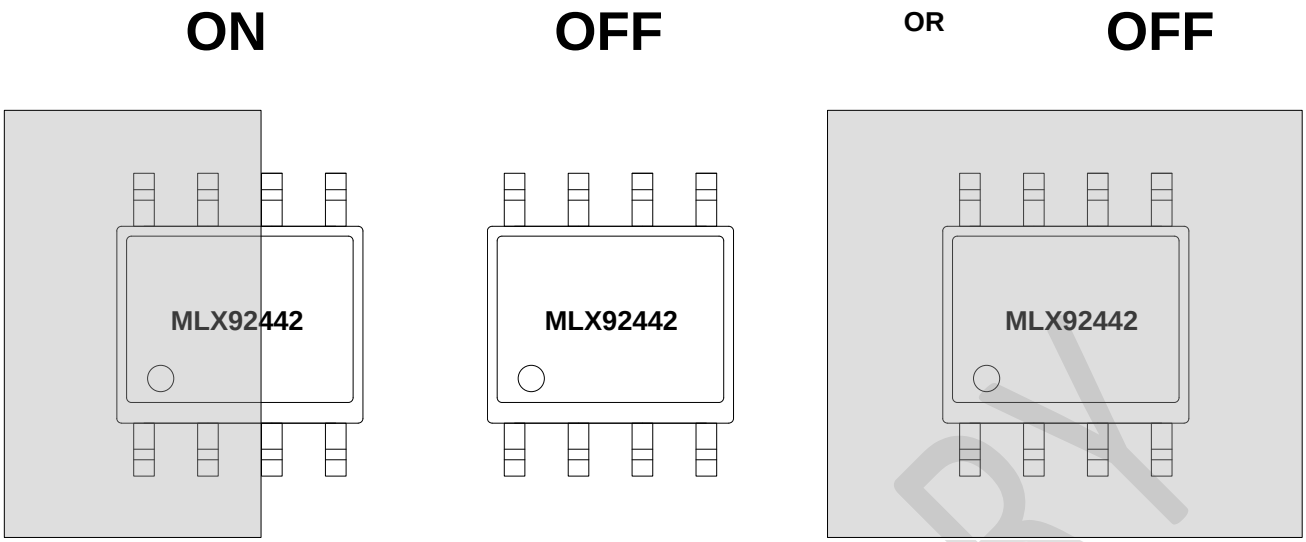


Figure 7 Switch-left operation for SOIC8 package. Direct Output

10.3. Switch operation (push button)

The push button operation is a functionality with memory about its previous state. Figure 8 shows an example, where the initial state is OFF (step 1) and MLX92442 does not see a target. Bringing a target as shown will produce an ON state of the output current (step 2). Removing the target will keep this state (step 3). In order to obtain an OFF state, the target needs to be brought again over the package (step 4) and then removed (step 5).

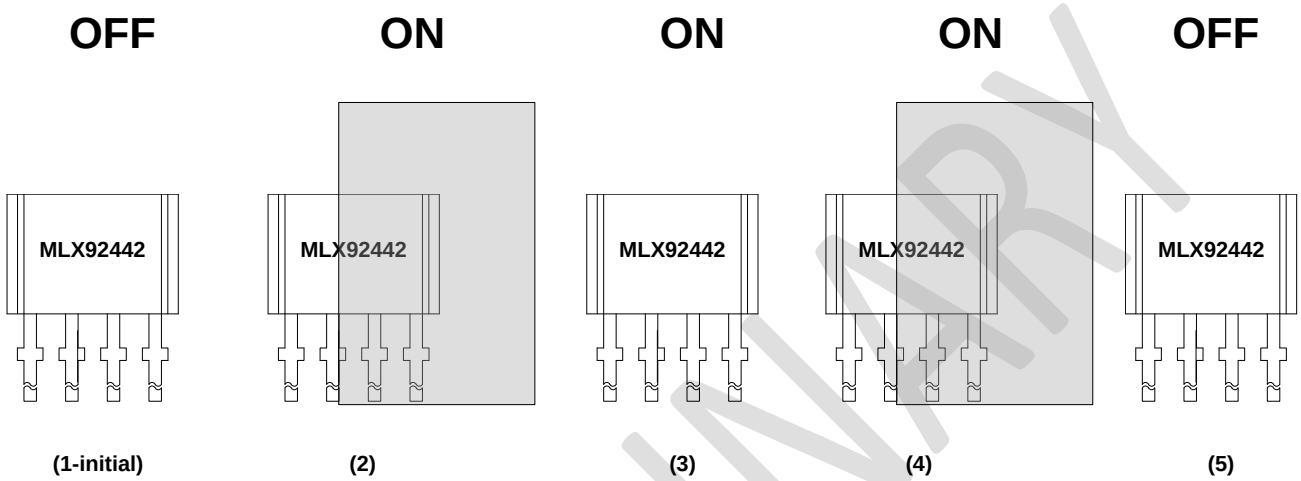


Figure 8 Switch-right push button for VK package. Direct Output

11. Top Safety requirements

Mission: The MLX92442 shall not be in supply current state corresponding to wrong detection of target presence / absence at $V_{DD} \geq V_{DDMIN}$ (3.5V).

Assumed safe state 1: supply current state corresponding to correct detection of Target presence / absence.

Assumed safe state 2: supply current ≤ $I_{SAFEMAX}$ (1.4mA) & ≥ $I_{SAFEMIN}$ (0.8mA)

Assumed external diagnostics: The user, shall check the Safe States at the item-level (e.g. in the ECU)

Assumed FHTI: 0.5ms

Assumed metrics: SPFM ≥60, LFM = N/A, PMHF = 3FIT [1]

Assumed supply current first read out time: >70us after power-up

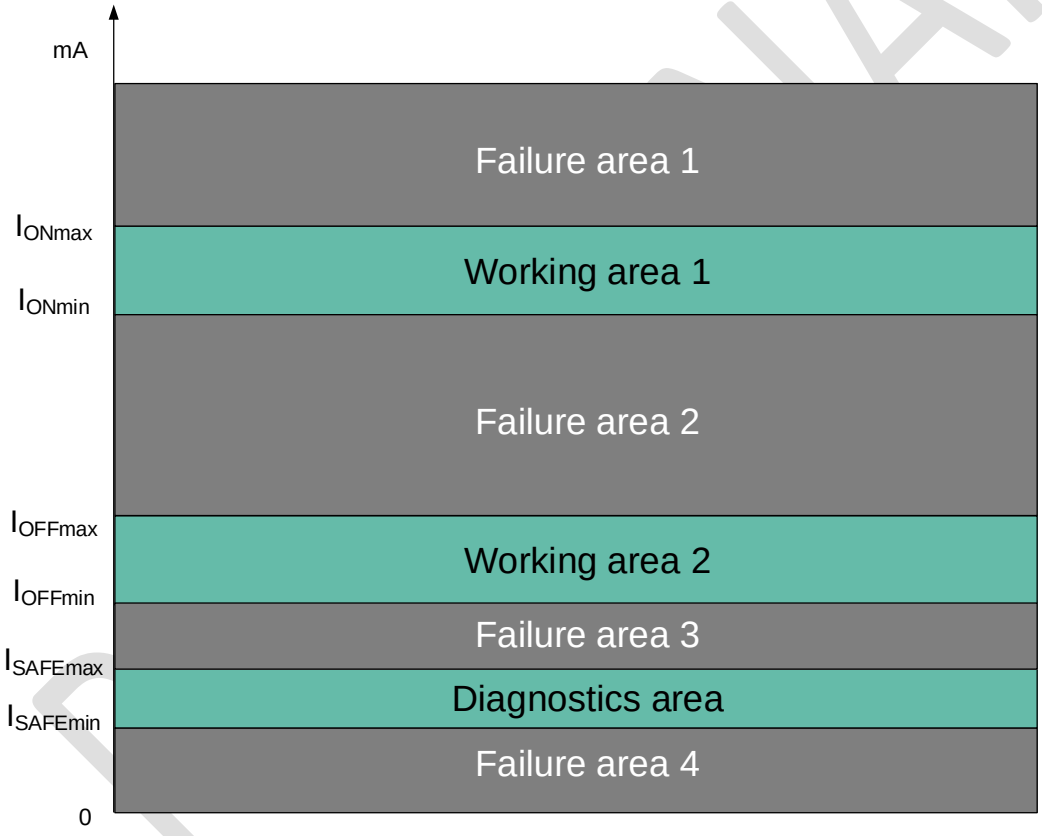
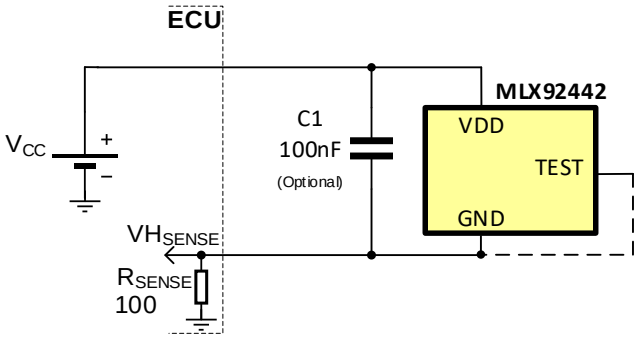


Figure 9 Working, failure and diagnostic areas of the output current

[1] *The failure rates for HW parts used in this analysis are estimated using statistics based on Melexis internal qualification tests according to ISO 26262-5, 8.4.3*

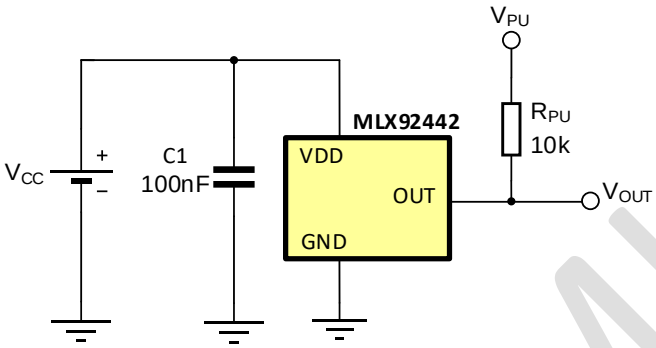
12. Application Information

12.1. Typical 2-wire Application Circuit



Notes:
1. For proper operation, 100nF bypass capacitor should be placed as close as possible to the V_{DD} and ground (GND) pin.
For MLX92442LVK-AAA-100 C1 is not required.
2. The TEST pin is to be connected to GND or left open.

12.2. Typical 3-wire Application Circuit

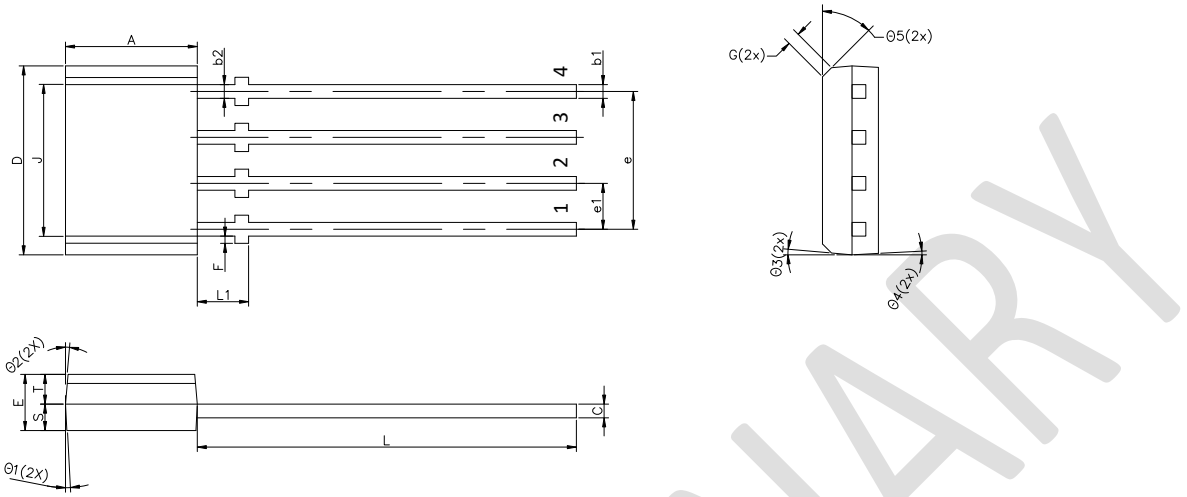


Notes:
1. For proper operation, 100nF bypass capacitor should be placed as close as possible to the V_{DD} and ground pin.
2. The pull-up resistor R_{PU} value should be chosen in to limit the current through the output pin below the maximum allowed continuous current for the device.
3. A capacitor connected to the output is not needed, because the output slope is generated internally.

13. Package Information

13.1. TO92-4L (VK package)

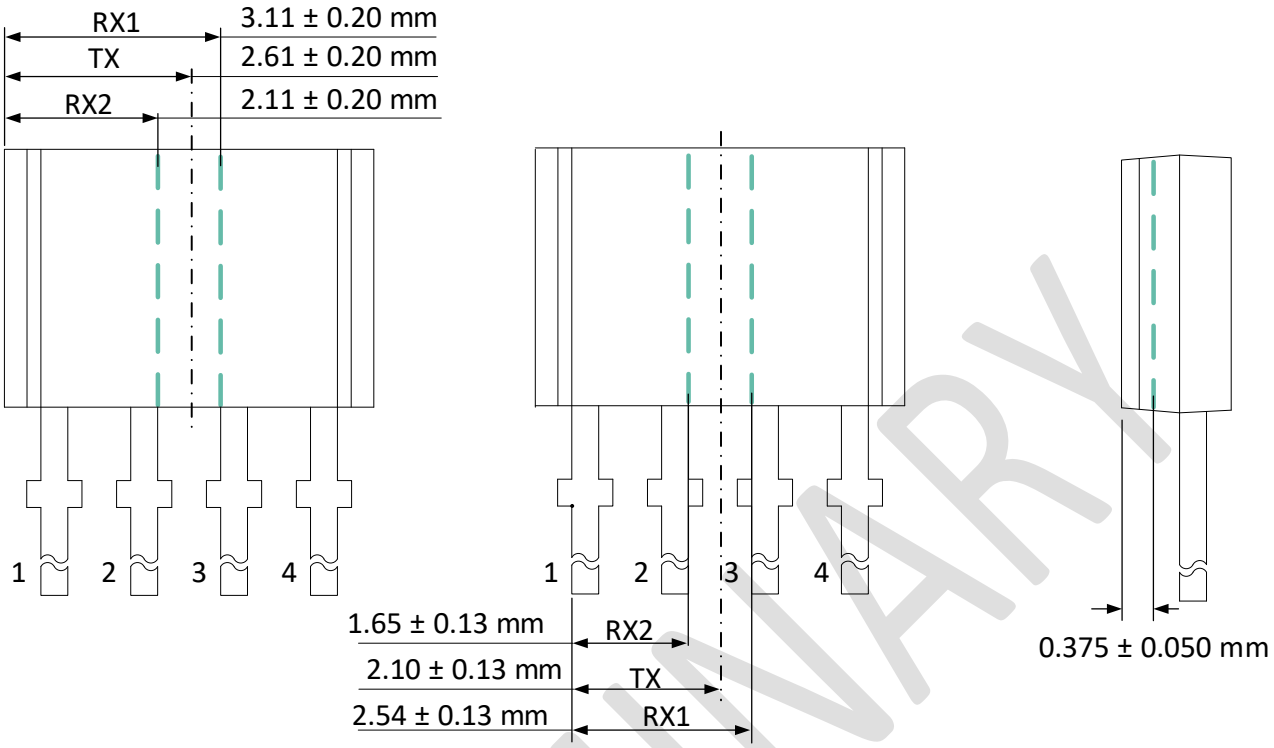
13.1.1. TO92-4L – Package dimensions



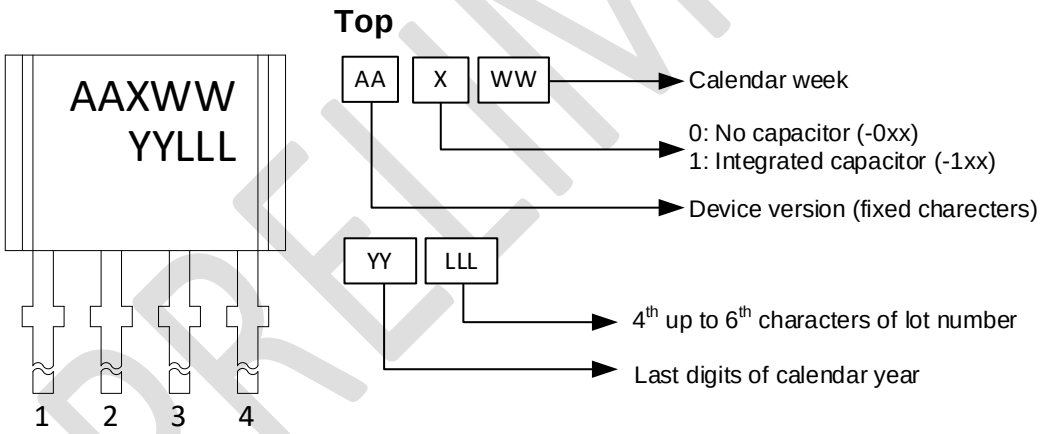
SYMBOLS	MIN	NOM	MAX
A	3.55	3.65	3.75
D	5.12	5.22	5.32
E	1.45	1.55	1.65
J	4.10	4.20	4.30
F	0.00	---	0.20
L	10.2	10.5	10.8
L1	1.32	1.42	1.52
S	0.63	0.73	0.83
T	0.72	0.82	0.92
b1	0.35	---	0.44
b2	0.43	---	0.52
c	0.35	---	0.41
e	3.78	---	3.84
e1	1.24	1.27	1.30
G	0.20	0.30	0.40
θ1	3° REF		
θ2	5° REF		
θ3	5° REF		
θ4	3° REF		
θ5	45° REF		

Note:
1. ALL DIMENSIONS IN MILLIMETERS (mm) UNLESS NOTED OTHERWISE.
2. DIMENSIONS "A" AND "D" DO NOT INCLUDE MOLD FLASH, PROTRUSIONS AND GATE BURRS.
3. MOLD GATE BURRS SHALL NOT EXCEED 0.15 mm MEASURED FROM EDGE OF MOLD FLASH (FLANGE).
4. LEAD PLATING; MATTE TIN PLATING THICKNESS 7.62 – 15.42 um.
5. THE LEADS MAY BE SLIGHTLY DEFORMED DURING TRANSPORTATION IF PACKAGE 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.

13.1.2. TO92-4L – Sensitive area



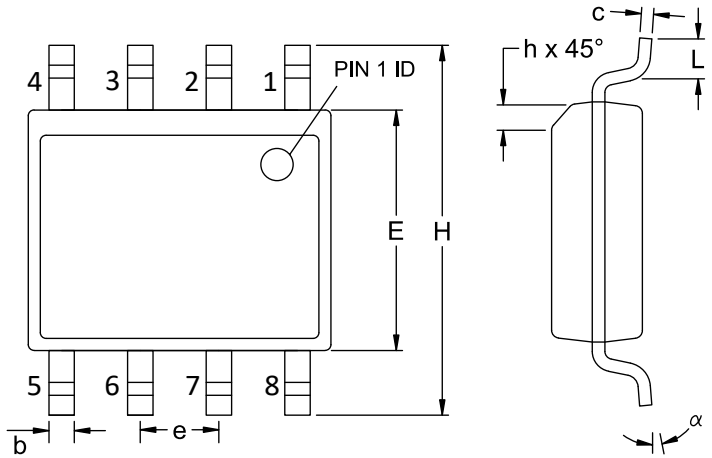
13.1.3. TO92-4L – Package marking / Pin definition

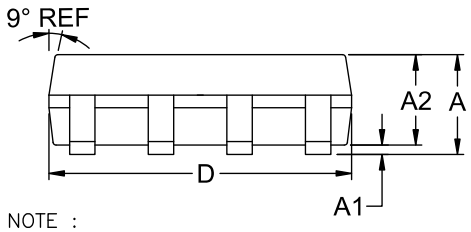


Pin #	Name	Type	Function
1	OUT	Out	Open drain output pin
2	GND	Ground	Ground pin
3	VDD	Supply	Supply voltage pin
4	VDD	Suppy	Supply voltage pin

13.2. SOIC-8 Package Information (DC package)

13.2.1. SOIC8 – Package dimensions



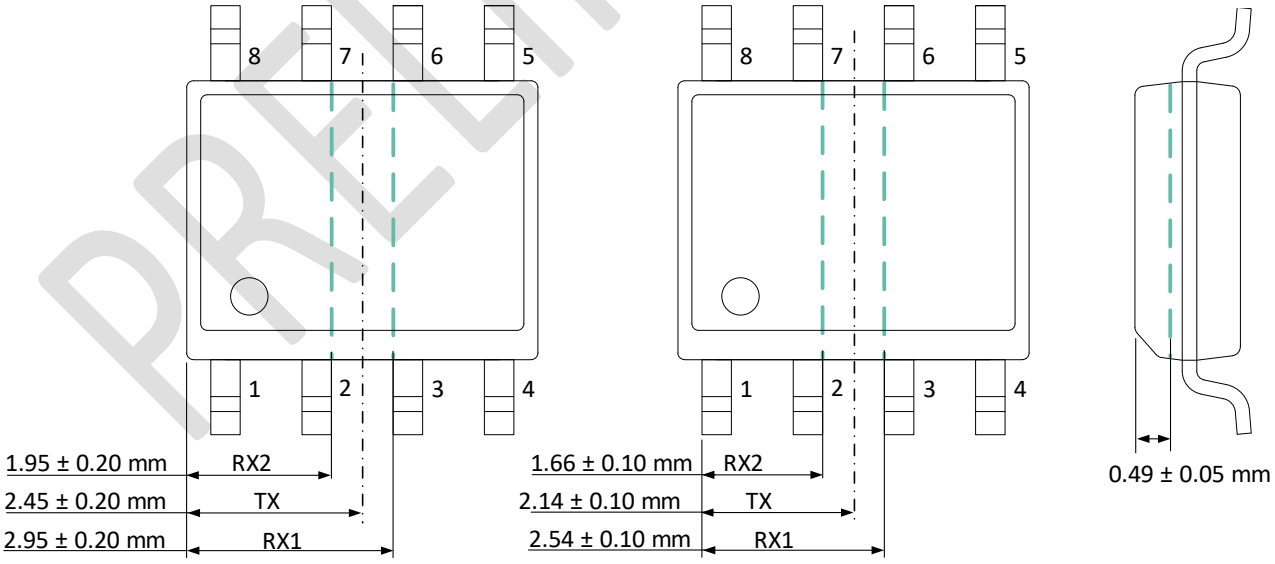


SYMBOL	MINIMUM	MAXIMUM
A	1.52	1.73
A1	0.10	0.25
A2	1.37	1.57
D	4.80	4.98
E	3.81	3.99
H	5.80	6.20
L	0.41	1.27
b	0.35	0.49
c	0.19	0.25
h	0.25	0.50
e	1.27 BSC	
α	0°	8°

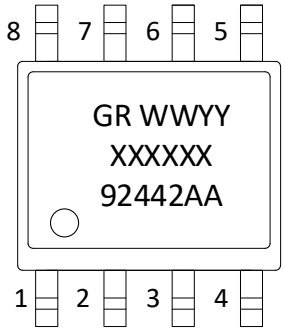
NOTE :

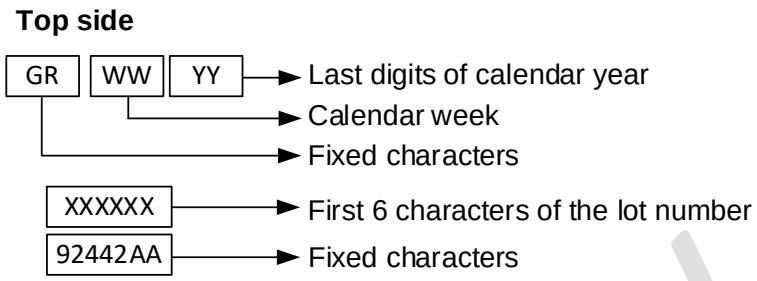
1. ALL DIMENSIONS IN MILLIMETERS (mm) UNLESS OTHERWISE STATED.
2. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS OF MAX 0.15 mm PER SIDE.
3. DIMENSION E DOES NOT INCLUDE INTERLEADS FLASH OR PROTRUSIONS OF MAX 0.25 mm PER SIDE.
4. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION OF MAX 0.08 mm.

13.2.2. SOIC8 – Sensitive area



13.2.3. SOIC8 – Package marking / Pin definition





Pin #	Name	Type	Function
1	OUT	Output	Open drain output
2	GND	Ground	Ground pin
3	VDD	Supply	Supply voltage pin
4-8	/	N.C.	Not connected

14. IC handling and assembly

14.1. 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]

14.2. 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

14.3. 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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