MLX90711
Position/movement Sensing Auto-Shutoff

Features and Benefits

Safety Auto shut off based on movement or position sensing.
Low cost – minimal external components.
Very reliable patented capacitive sensor,
    insensitive to erosion and dust.
On chip calibrated timer.
Pdip8 or sop8 package.
Drives different relay types, including low cost
    12V relays and most custom made relays.
Auto shut off status is indicated via a led.
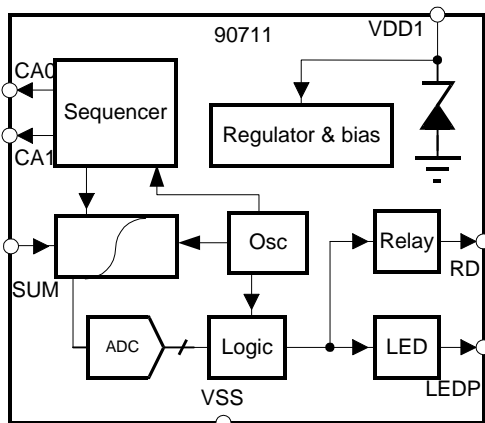Several timing options available.

Applications

Irons, fryers, ...

Ordering Information

Part No.	Temperature Suffix	Package	version	Temperature Range
MLX90711	S	A	-x	0C to 105C
MLX90711	S	L	-x	0C to 105C

The customer specific version code (defining the options) is indicated with 1 character at the end of the ordering number.

Functional Diagram

Description

The Automatic Shut-Off is a safety system which turns off the electrical power of a load based either on a movement detection or a position detection. This detection will be taken into account after a well defined time delay. A typical application is the safety feature in irons which will switch off the heating element when the iron is left immobile for a well defined period, which can be dependant on the position. The state of the Auto Shut-Off can be indicated with an led.

Introduction

The Automatic Shut-Off is a safety system which turns off the electrical power of a load based either on a movement detection or a position detection. This detection will be taken into account after a well defined time delay. A typical application is the safety feature in irons which will switch off the heating element:

if the iron is connected to the mains and left immobile in the ironing position for a time larger than TH;
OR

if the iron is connected to the mains and left vertically up on heel rest for a time larger than TV.
OR

if the iron is connected to the mains and left vertically down on heel rest for a time larger than TD. The heating of the iron is turned on again immediately after detecting a different position (or detecting a movement).

Sensing Principal

Melexis developed a new concept of Auto Shut-Off in which the position or movement detection is realized with a patented capacitive detection. This sensor uses the movement of a ball, but the detection is capacitive, and therefore, the system does not need a conductive contact. Consequently, the system is insensitive to erosion and dust.
The sensitivity of the asic is very high, and a ball with a diameter as small as 3 mm can be used.

This detection system described in the following section is protected by a patent (Patent European application Nr. EP0589092; US application Nr. US5627316).

General Description

The detection is done based on the ratio of two variable capacitors. These capacitors can be the parasitic capacitances of a small conductive ball placed on a cavity in the pcb. As the pcb is rotated in its lenghty direction, the ball is running forwards and backwards on the pcb. Copper tracks placed on the PCB at the edges of the hole will be used as the terminals of capacitors. We can define two capacitors made up of 2 copper tracks with a (conductive) ball in between. If the ball rolls just between 2 copper tracks, the distance between the copper tracks and the ball will decrease, thus increasing their capacitance. The circuitry on chip performs a measurement of the difference between these 2 caps. It controls the sense terminals (CA0, CA1, SUM), processes their data and drives 2 outputs: RD (to drive a relay) and LEDP (to drive an led). The information from the detection system results in a momentary down, up or horizontal position. This information can be used to generate a position detection or can be interpreted as a movement detection.

When used as a position sensor, the output of the sensor consists of 3 digital signals, indicating the position of the sensor: the ball is in the middle (horizontal), is at the front side (down) or is at the end (up). The position of the ball is sensed every 15.6 msec. For this the analog output voltage of the sensor circuit is sent to 3 comparators with hysteresis. If the result is equal for 3 consecutive samples, the corresponding digital signal (DOWN, UP or HOR) becomes valid. This signal is used to evaluate the Auto Shut-Off function. The Auto Shut-Off is active only when UP remains high during a time period larger than TV or when HOR remains high during a time period larger than TH or when DOWN remains high during a time larger than TD. The signals UP, HOR and DOWN are debounced.
When the Auto Shut-Off is active the relay driver is activated. Using a NC (normally closed) type relay, this can switch off the power of the heating element.
When the module is moved, the ball can roll forwards and backwards in such a way that the states UP, HOR and DOWN never remain stable for a time more than TV, TH and TD respectively and the relay output is not activated.
As long as the vertical inclination is enough to keep the ball in the "vertical" area, the state UP remains active.

When used as a movement sensor the output of the sensor has only one signal which indicates that the position of the ball has changed. If this signal is inactive for the predefined time period TASO, the chip enters the Auto Shut-Off state. The position of the ball is sensed every 15.6 msec. When the Auto Shut-Off is active the relay driver is activated. Using a NC type relay, this can switch off the power of the heating element.
When the module is moved, the ball can roll forwards and backwards and due to this the chip continuously detects a change of state of the sensor.

Power On Reset

In the chip there is a block "Power On Reset" (POR), which tracks the level of the power supply voltage Vdd1 and defines the state of the chip.
If Vdd1 is less than the high POR level (PORHI) after initial plugging into the mains, the chip is in the "reset state". When Vdd1 becomes higher than the PORHI level, the operation of the chip starts: start up sequence, heating up and then the chip enters in "normal operation mode".
If Vdd1 becomes less than the low POR level (PORLO), (PORLO=PORHI-HYS), for more than 7.8msec the chip enters the "reset state".

Applications Example
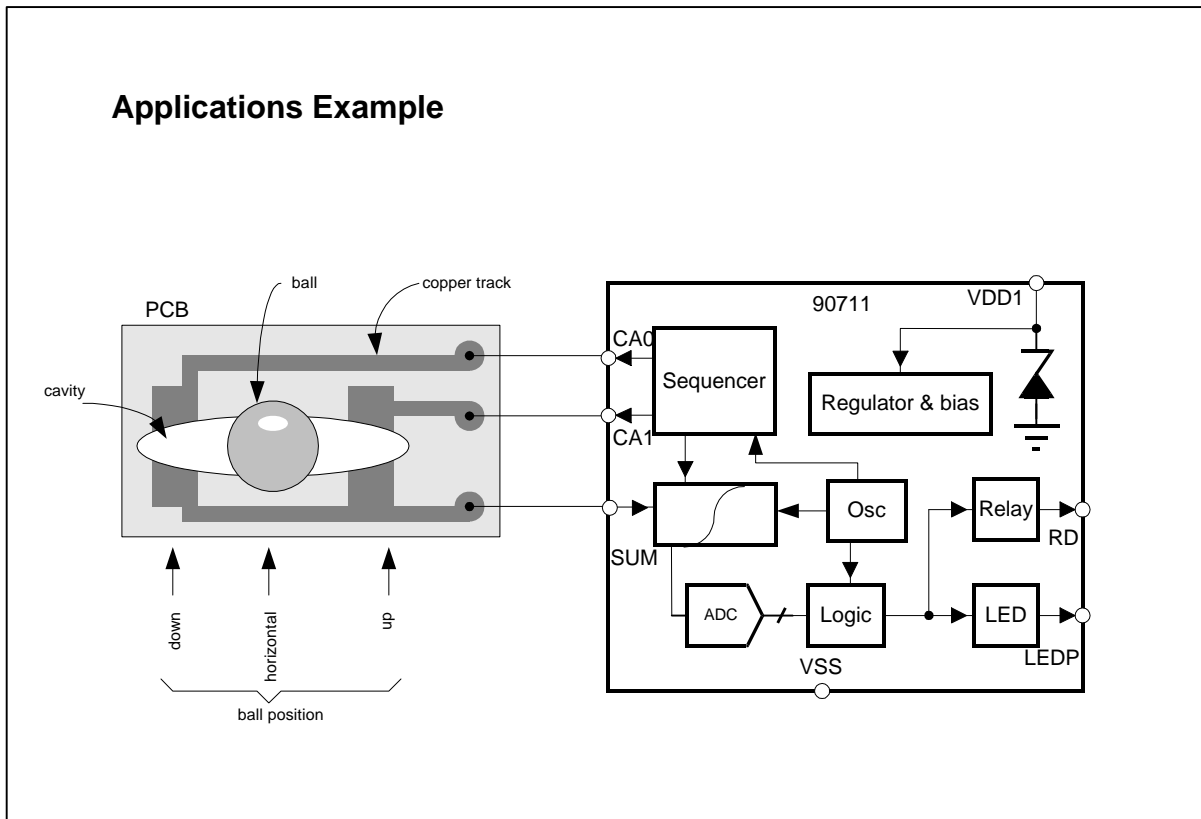
Power down timing

After disconnecting the mains , the chip will reset:
- within typical 0.25sec when the coil is not activated (iron is heating)
- within typical 2.5sec when the coil is activated (iron is in ASO)

Relay and led driver options

The relay is driven by a pulsed signal instead of a continuous signal. Consequently, the power consumption is reduced.

The relay driver performs this feature. There are four duty cycles available: 14.4%,16%, 28% and 31%. During 7.8 ms after the switching time , the duty cycle is increased. This will give an increased energy to the relay for a short time at the moment the relay coil must change the state of the contact. The switching time starts by applying the control voltage on the coil of the relay. The values of the duty cycles

for the first 7.8 ms are in the table in brackets. The switching frequency of relay and led are the same and are typically 20.48KHz.

Relay - Led output configuration
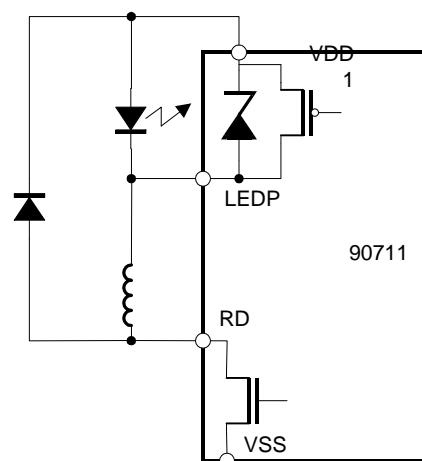
The type of relay should be normally closed (NC). A NC relay is opened by applying the control voltage on its coil and in this case the module is in Auto Shut-Off mode.

SRD1	SRD2	Relay DC	Led DC
0	0	14.4%(28%)	14.4%(28%)
0	1	28%(43%)	28%(43%)
1	0	16%(31%)	16%(31%)
1	1	31%(48%)	31%(48%)

Movement Auto Shut-Off time

When used as a movement Auto Shut-Off module, several timing options are available. All timings are derived from the on chip oscillator and have thus the same tolerance.

If the module is left immobile for a time longer than TASO the auto shut-off function becomes active. There is also an additional time period TADI. This time is valid only in the vertical state and determines the time between shut-off and the start of the led blinking.

Movement sensor options		
version	TASO	TADI
V1	30 sec	0
V2	30 sec	4 min
V3	4 min	0
V4	1 min	0
V5	10 min	0
V6	2 min	0
V7	8 min	0
V8	30 sec	8 min

Position Auto Shut-Off

When used as a position Auto Shut-Off module, several timing options are available. All timings are derived from the on chip oscillator and have thus the same tolerance.

Three different time delays can be defined: the horizontal shut-off (TH), the vertical shut-off (TV) and the down shut-off (TD).

position sensor options			
version	TD	TH	TV
V1	30″	30″	4′
V2	30″	30″	infinity
V3	30″	5″	8′
V4	30″	30″	8′

Start up sequence

When connecting the asic to the AC line the asic first passes through a startup sequence. The duration of this sequence is 1.25 or 3.75 seconds depending on the duration of phase 1. After the start up test the normal function of the chip begins. This sequence

involves the following phases :

PHASE 0: The duration is a time period "TS", which incorporates the Power On Reset time period. This time 'TS" is typically 0.2 sec.

PHASE 1: The duration is 0.5 second or 3 seconds. This can be defined by the mask option SPH1. During this phase the iron heats. The ASO function is not active. The LED is off. The relay is NC and the control voltage is not applied to its coil during this phase.

PHASE 2: The duration is 0.75 second. The ASO function is active. The iron is not heating. The control voltage is applied to the coil of the relay during this phase. The LED indicates that the ASO function is active. Some additional information is sent out by the led driver during this phase. This information involves three frequency codes.

- the first code is the highest digital clock (20.48kHz). The duration is 250ms.

- the second code is the information of the position sensor. The frequency depends on the position of the module:

- the third code is the information of the metal mask where the customer specific options are defined. It is coded using one of five frequencies (20kHz, 10kHz, 5kHz, 2.5kHz, 1.25kHz).

position	LED frequency (KHz)
UP	1.28
Between UP and HOR	2.56
HOR	5.12
Between HOR and DO	10.24
DO	20.48

EMC

Thanks to a special algorithm the sensor is made very insensitive to noise and AC line coupling.
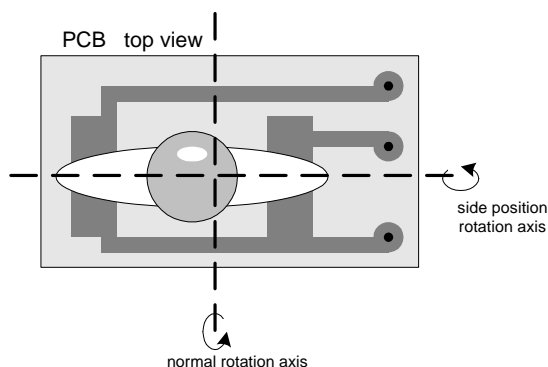
ESD Precautions

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

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

Side Position Shut-Off

The design of the cavity in the pcb, on which the ball of the sensor is moving, as well as the design of the protective cover important aspects. When designed properly the function of the Auto Shut-Off module can also be defined when the module is rotated around the axis perpendicular to the normal axis, even when the ball tends to fall off of the pcb. In the application of an iron this can be useful for defining the functionality when the iron is put at his side.

PCB   top view

side position rotation axis

normal rotation axis

Heating Up feature

If the heating up feature is present, it inhibits the Auto Shut-Off function for 1 minute and 30 seconds after the start up sequence regardless of the position or the movement of the iron. If the iron is left immobile the asic will activate the relay output after 1 min and 30 sec added to the time TH (or TV or TD depending on the position).

If the heating up feature not present, the Auto Shut-Off function is available as soon as the iron is plugged: so the relay contacts will switch off after a time TH if it is left in the ironing position without movement , or after time TV if it is left vertically up, or after time TD if it is left vertically down.

Sensor test mode

To measure the performance of the sensor in the module, a sensor test mode is implemented. This test mode is activated via the test pin TEST1, which is normally left open. When connecting the pin TEST1 to an external 12V supply (with respect to the asic ground VSS) via a resistor of 220 Kohm the test mode is activated and the output of the on chip integrator is now available at the pin TEST1.

Depending on the position of the sensor the voltage at the TEST1 output will change.
The pin TEST1 is also used as digital I/O during the asic production test.

Options

Following is a summary of the options that can be

parameter	value	option
POSMOV	0	Position sensing
	1	Movement sensing
V1—V8	Select timing options	
SPH1	0	Phase 1 of startup sequence is 0.5 sec.
	1	Phase 1 of startup sequence is 3 sec.
HEATUPM	0	No heatup feature
	1	Heatup feature present
SRD1 + SRD2	Select relay and led driver options	

changed with the metal mask:

Pinout

Standard package is 8-pin dual inline package or 8-pin sop package.

DIP8	SOP8	Name	Type	Description
1	2	CA1	Output	Sensor output CA1
2	3	VSS	Supply	Ground
3	4	SUM	Input	Sensor input
4	5	TEST1	Output	Test output
5	6	VDD1	Supply	Power supply
6	7	LEDP	Output	Led driver
7	8	RD	Output	Relay driver
8	1	CA0	Output	Sensor output CA0

MLX90711 Electrical Specifications

DC Operating Parameters T_A = 0°C to 105°C

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Power supply range	VDD1		60		70	V
Zener protection	IVZ1	VDD1 = 68V	10			mA
	IVZ2	VDD1 = 60V			1	mA
Current consumption	Idd1	VDD1 = 50V			0.8	mA

MLX90711 Internal clock

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Clock period	Tcl			48.9		usec
Initial deviation	Erri		-8		8	%
Deviation over temperature	Errt		-4		4	%
Deviation over Vdd1	Errv		-3		3	%

MLX90711 Auto shut-off timing tolerance

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
DO auto shut-off time	td		-15		15	%
HOR auto shut-off time	th		-15		15	%
VERT auto shut-off time	tv		-15		15	%

MLX90711 Relay driver

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Leakage current	Irdlk	Vrd = Vdd1			10	uA
On resistance	Rrdon	At 30mA			90	ohm

MLX90711 Led driver

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Leakage current	Iledlk	Vledp = Vdd1—5V			10	uA
On resistance	Rledon	At 30mA			50	ohm

MLX90711 Power on reset

| Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Upper level	PORHI		30		40	V
hysteresis	PORHYS		5		10	V

Application Example
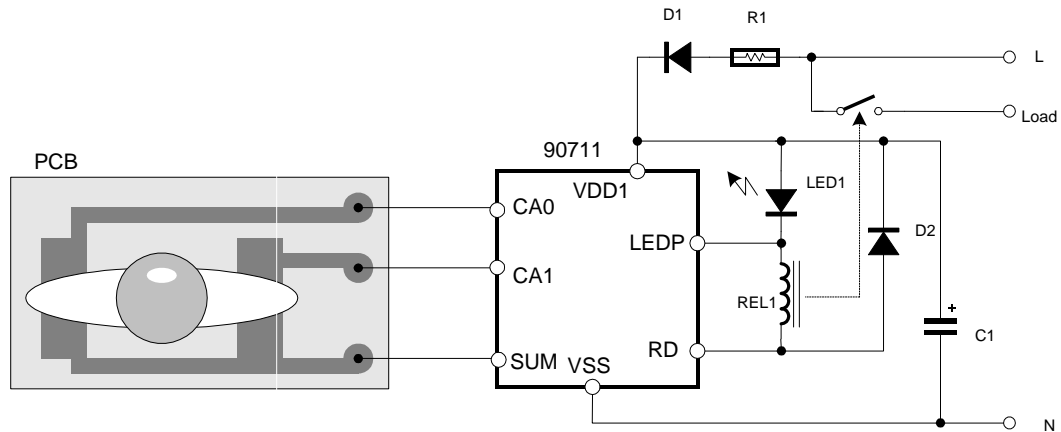
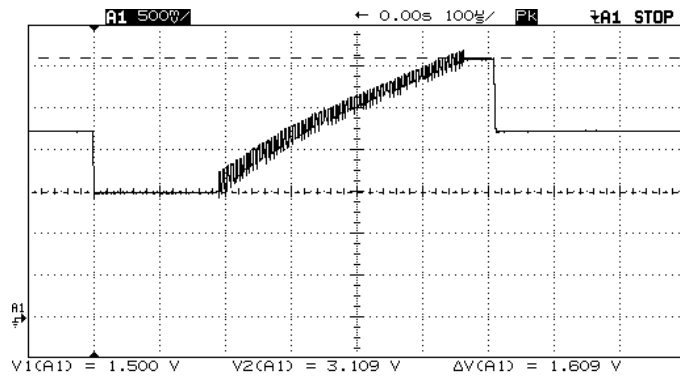The above drawing shows the electrical schematic of a typical application.

The asic is directly connected to the AC line via a resistor R1 and diode D1, thus supplying the asic during only the positive cycle of the AC line voltage. A capacitor C1 is therefore added between VDD1 and VSS to smooth the asic supply voltage. The asic will limit the voltage at VDD1 at approximately 60V. A 12V relay REL1 can be used to load the pin RD. The relay is driven with a well defined duty cycle to ensure that the relay is driven with the right energy. The relay driver needs a flyback diode D2. A led LED1 can be added to indicate the state of the asic. If no led is used, it must be replaced by a short circuit.

Special care must be paid to the layout of the sensor on the pcb and to the connections between sensor and asic. The asic is designed to detect very small variations in capacitance in the sensor. Therefore parasitic capacitances must be kept as small as possible, and injection of noise must be avoided.
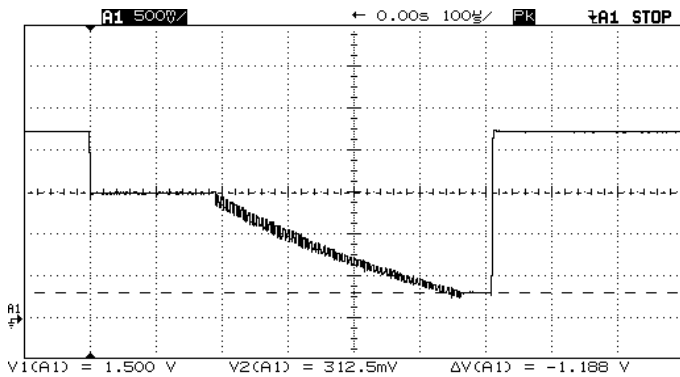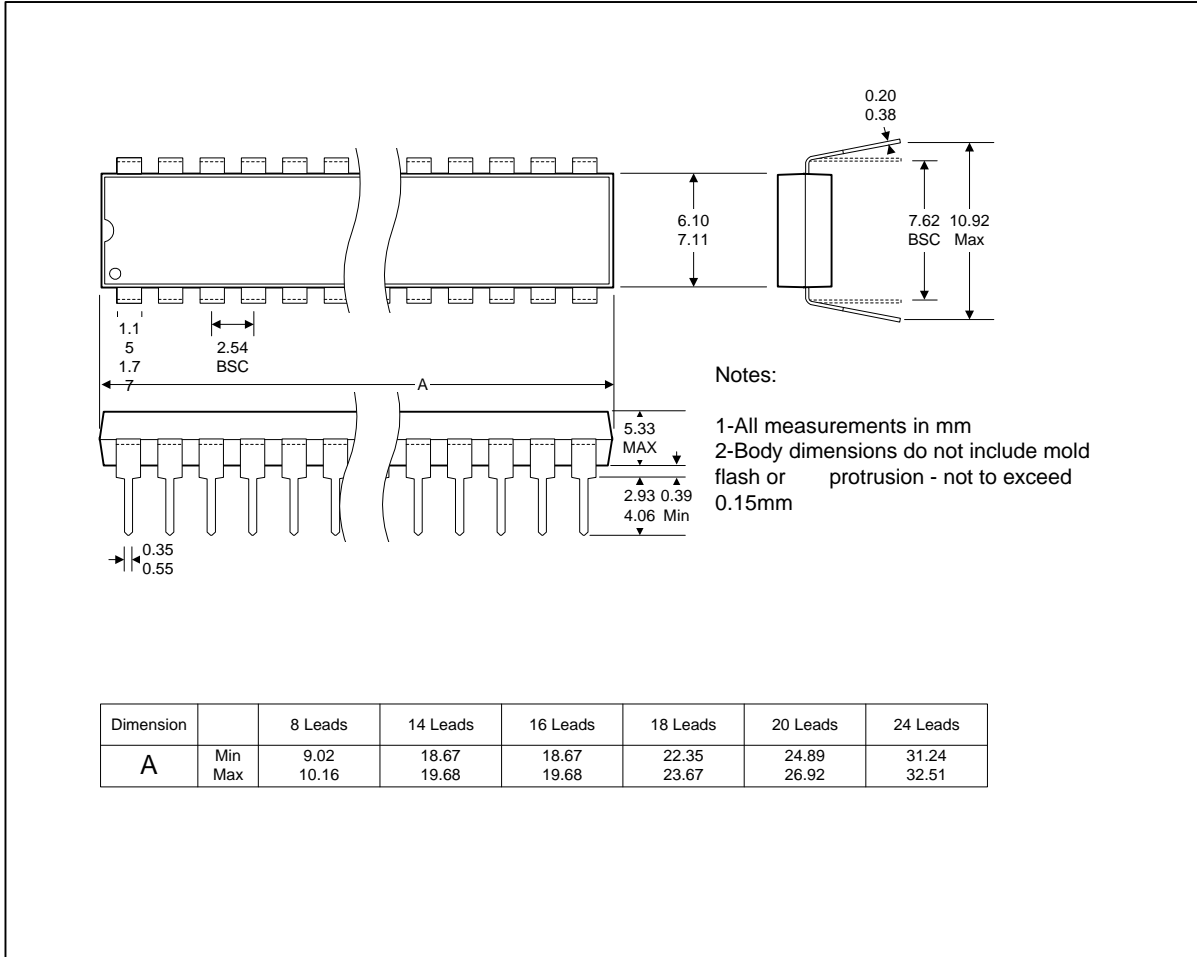
sensor output measurement
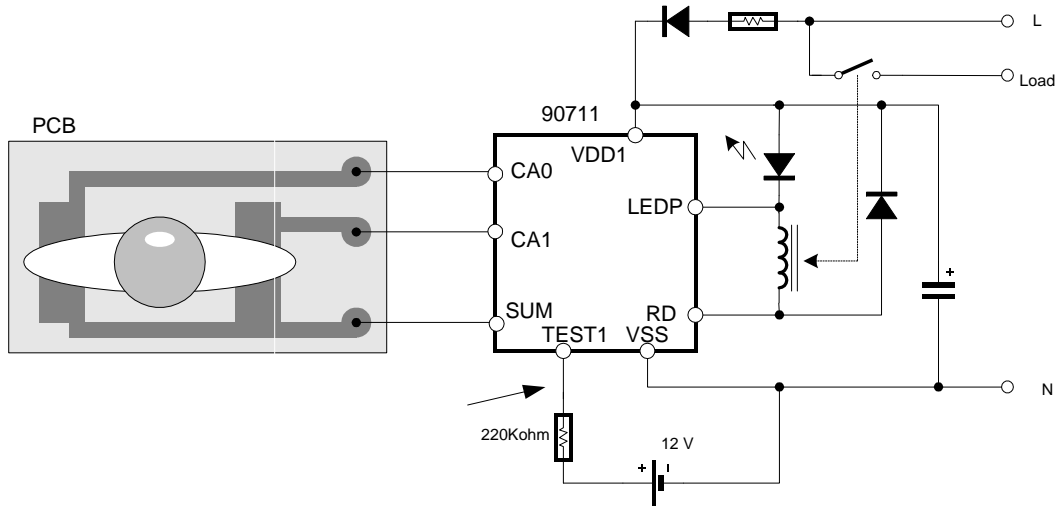
signal at TEST1 output

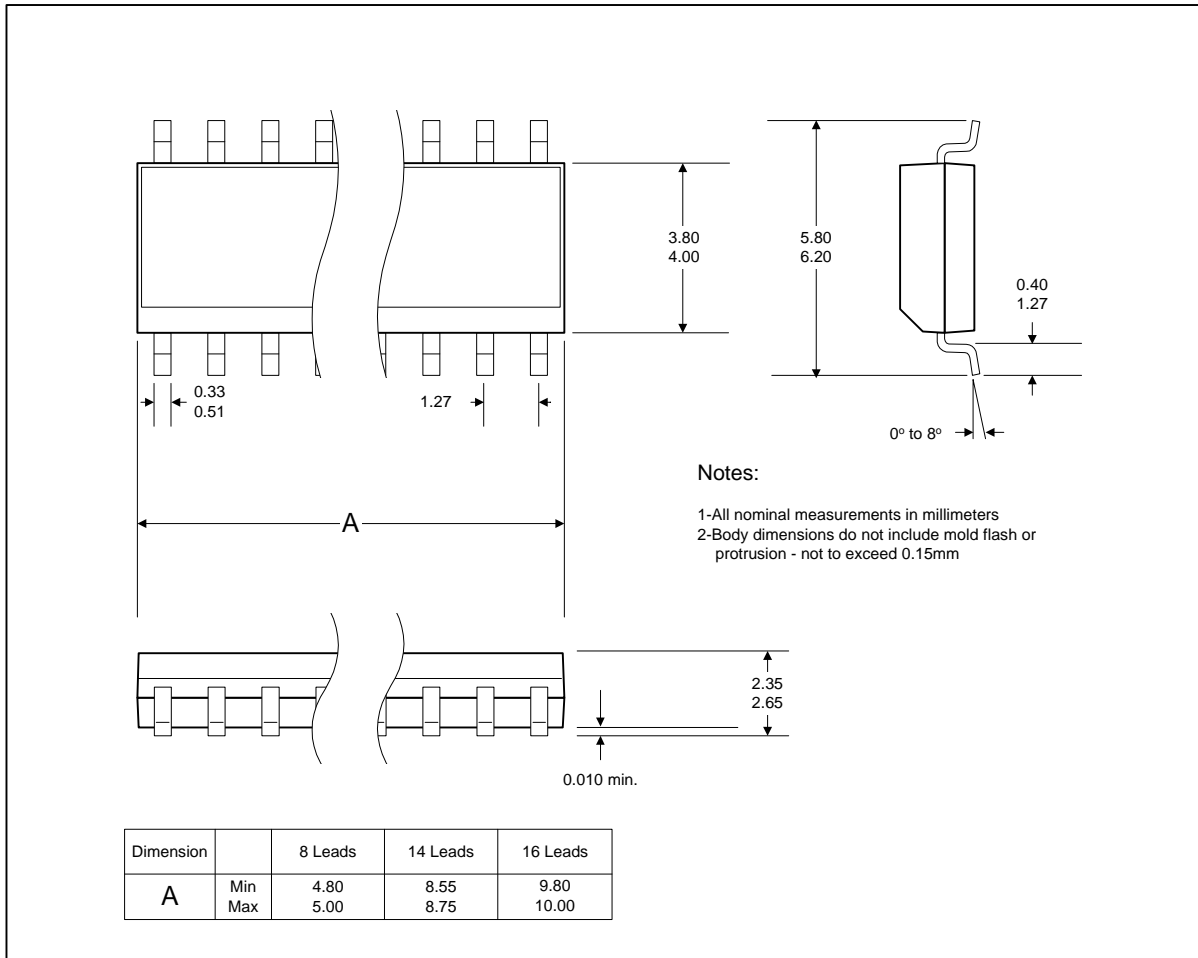**detecting UP state**

signal at TEST1 output

detecting DOWN state

"A" Package Dimensions

0.20
0.38

6.10
7.11

7.62   10.92
BSC   Max

1.1
5   2.54
1.7   BSC
7

A

5.33
MAX

2.93 0.39
4.06 Min

0.35
0.55

Notes:

1-All measurements in mm
2-Body dimensions do not include mold
flash or   protrusion - not to exceed
0.15mm

Dimension		8 Leads	14 Leads	16 Leads	18 Leads	20 Leads	24 Leads
A	Min	9.02	18.67	18.67	22.35	24.89	31.24
	Max	10.16	19.68	19.68	23.67	26.92	32.51

Disclaimer

Melexis reserves the right to periodically make modifications to product specifications. The information included herein is believed to be accurate and reliable. However, Melexis assumes no responsibility for its use; nor for any infringements of patents or other rights of third parties which may result from its use.

"L" Package Dimensions

Notes:

1-All nominal measurements in millimeters
2-Body dimensions do not include mold flash or
  protrusion - not to exceed 0.15mm

Dimension		8 Leads	14 Leads	16 Leads
A	Min	4.80	8.55	9.80
	Max	5.00	8.75	10.00

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