MLX90637

Miniature Thermometer
Datasheet

Melexis
INNOVATION WITH HEART

General description

Features & benefits

- Small size of 3x3mm^2
- Factory calibrated
- Standard measurement resolution 0.02°C
- Sleep current less than 2.5µA
- I2C interface
- Software definable I2C address with 1 LSB bit external address pin
- Field of View of 50°
- Wide refresh rate range
- Integrated post-calibration option
- Ambient operating temperature range from -40°C to 125°C
- Package RoHS compliant SFN 5-pin
- AEC-Q100 qualified
- Diagnostics as Quality Management Device

Description

The MLX90637 is a non-contact infrared temperature sensor in a small SMD Chip-scale package. The device is factory calibrated with calibration constants stored in the EEPROM memory. The ambient and object temperature can be calculated externally based on these calibration constants and the measurement data.

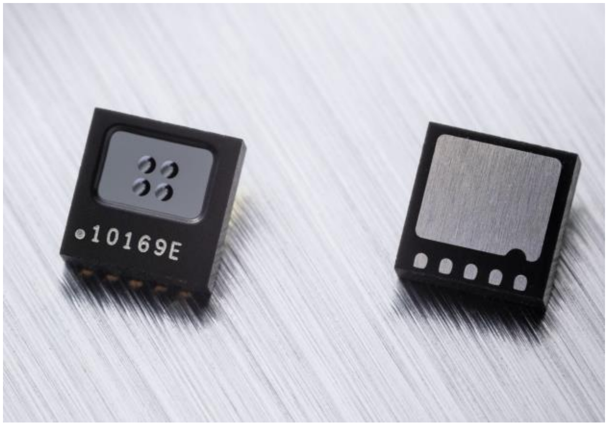
The MLX90637 is highly resistant to temperature fluctuations in its environment, ensuring accurate measurements. Localized thermal variations, such as air turbulence, will not affect the thermopile's output signal.
The supply voltage of the MLX90637 is 3.3V. For the I2C communication with the master microcontroller, the MLX90637 supports 3.3V I2C bus voltage.
An optical filter is integrated in the sensor to provide ambient light immunity. The wavelength pass band of this optical filter is from 2 to 20µm.

Applications examples

- High precision non-contact temperature measurements
- HVAC system
- EV inverter and motor temperature

Available support & tools

- www.melexis.com/technical-inquiry



Ordering information

Product code	Temperature	Package	Type	Output	Packing
MLX90637KLD-BCB-000-RE	-40 to 125 °C	SFN-5	Standard accuracy, FOV 50°	3.3V I2C bus	Reel

Table 1 – Product codes

MLX90637KLD-BCB-000-RE

- RE: Packing delivery form
- 000: Option code for variant
- BCB: Silicon & firmware version
- LD: Package code
- K: Temperature code
- 90637: Product name

CONTENTS

1 Pins description and block diagram

1.1 Pins description

1.1.1 Pins description for SFN-5 package

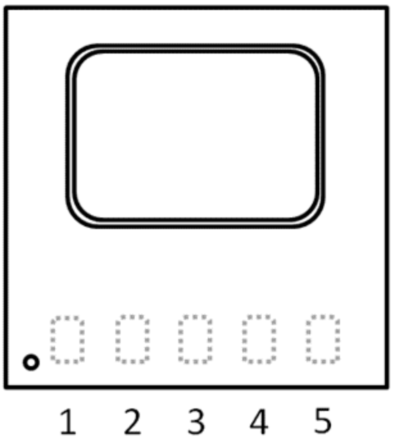


Figure 1 MLX90637 Front view

Pin #	Name	I/O [1]	Description
1	SDA	I/O	I2C Data line
2	VDD	S	Supply
3	GND	S	Ground
4	SCL	I	I2C Clock line
5	ADDR	I	LSB of I2C address

Table 2 – SFN-5 package pins description

For optimal EMC behaviour connect the unused pins (Not Used) to the ground (See section Recommended Application diagram).

[1] [S] Supply, [I] input, [O] output

1.2 Block diagram

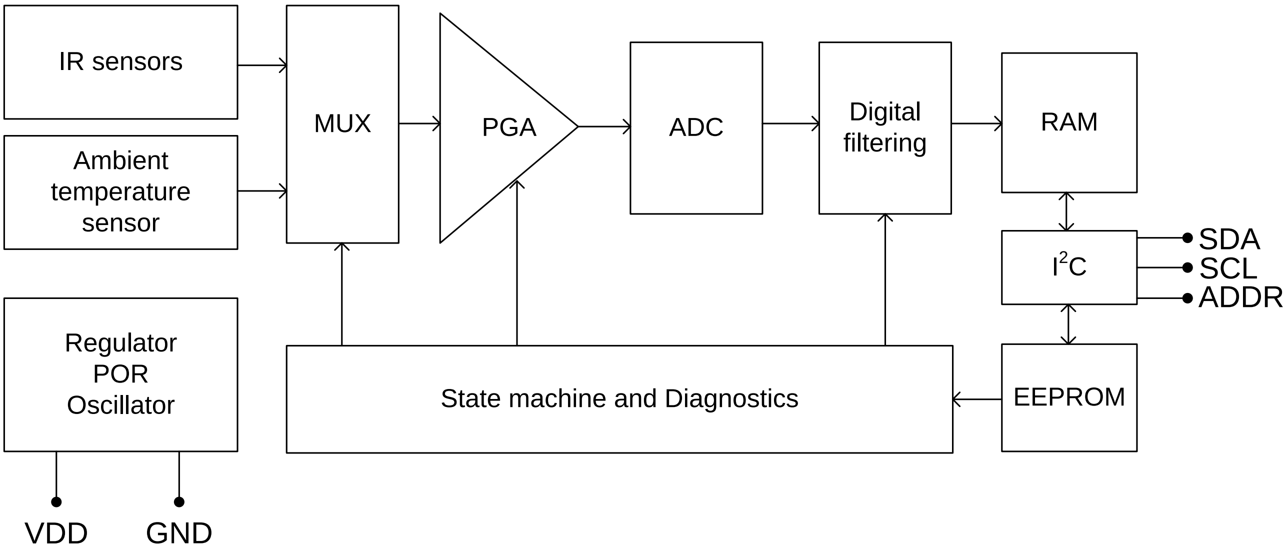


Figure 2 Block Diagram

2 Conditions and specifications

2.1 Absolute Maximum Ratings (AMR)

Parameter	Symbol	Min.	Max.	Unit	Condition
Supply Voltage (over voltage)	V_{DD}		5	V	
Reverse Voltage	V_R		-0.5	V	
Address-pin Voltage	V_{ADDR}		V_{DD} + 0.6	V	$V_{ADDR} < V_{DD} + 0.6$ & $V_{ADDR} < 5V$
Voltage at SDA pin	V_{SDA}		5	V	
Reverse SDA pin voltage	V_{SDA}	-0.5		V	
Voltage at SCL pin	V_{SCL}		5	V	
Reverse SCL pin voltage	V_{SCL}	-0.5		V	
DC current into SDA pin			25	mA	
ESD voltage	$V_{ESD\text{-}HBM}$		+/- 2	kV	HBM (AEC-Q100-002), all pins
	$V_{ESD\text{-}CDM}$		+/- 750	V	CDM (AEC-Q100-011)
	Air dis-charge		4	kV	IEC61000-4-2
	Contact discharge		2	kV	IEC61000-4-2
Operating Temperature Range		-40	+125	°C	Ambient temperature
Storage Temperature Range		-40	+125	°C	Ambient temperature
EEPROM re-writes			10		

Table 3 – Absolute Maximum Ratings

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

Maximum temperature for EEPROM writing is +85°C.

2.2 Electrical operating conditions & specifications

Unless otherwise specified, the electrical specifications are valid for a temperature 25 °C, and a supply voltage 3.3 V.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply voltage	V_{DD}	3	3.3	3.6	V	
Supply voltage rising	T_{POR}			20	ms	10% to 90% of specified supply voltage

Table 4 – Electrical operating conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Current	I_{DD}	0.5	1	1.5	mA	No load
Sleep Current	I_{DDpr}		1.5	2.5	µA	No load, erase/write EEPROM operations
POR level						
POR level	V_{POR_up}	1.3		2.4	V	Power-up (full temp range)
POR level	V_{POR_down}	1.1		2.1	V	Power-down (full temp range)
POR hysteresis	V_{POR_hys}	200		500	mV	Full temp range
VDD rise time (10% to 90% of specified supply voltage)	T_{POR}[2]			20	ms	Ensure POR signal
Output valid	T_{valid}	160			ms	Results in RAM after POR
I2C interface (V_{I2C}=3.3V)						
Input high voltage	V_{IH}	0.7*V_{I2C}		V_{I2C}+0.5	V	Over temperature and supply
Input low voltage	V_{IL}	-0.5		0.3*V_{I2C}	V	Over temperature and supply
Output high voltage	V_{OH}	0.7*V_{I2C}		V_{I2C}	V	Over temperature and supply
Output low voltage	V_{OL}	0		0.4	V	Over temperature and supply, I_{SDA} =20mA
Address pin high voltage	$V_{ADDR,HI}$	2	V_{DD}	V_{DD}+0.5	V	
Address pin low voltage	$V_{ADDR,LO}$	0		0.4	V	
Address pin leakage	$I_{ADDR, leak}$			1	µA	
SDA pin leakage	$I_{SDA, leak}$			1	µA	V_{SDA}=3.6V, Ta=+125°C
SCL pin leakage	$I_{SCL, leak}$			1	µA	V_{SCL}=3.6V, Ta=+125°C
SDA pin capacitance				10	pF	
SCL pin capacitance				10	pF	
Slave address	SA		3A		hex	

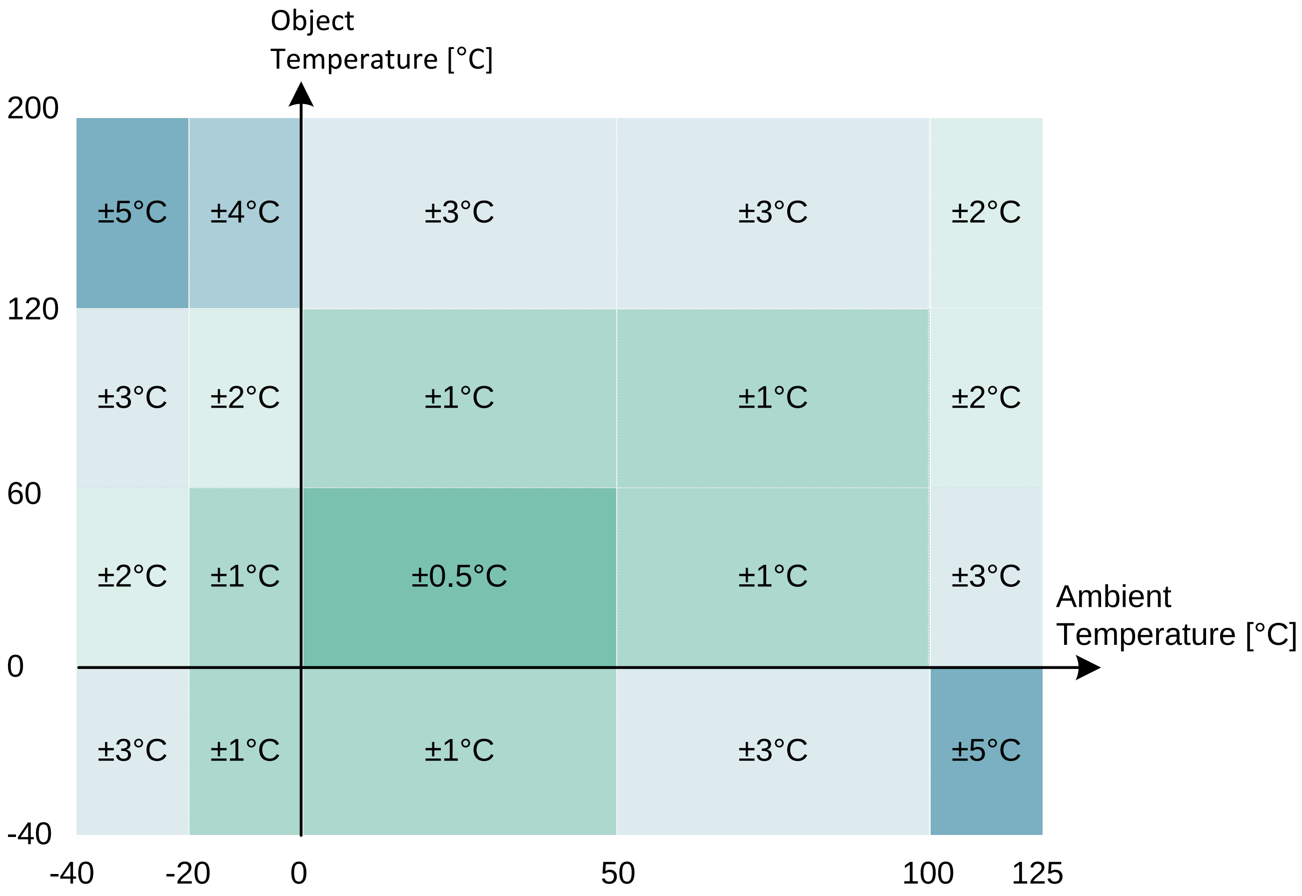
Table 5 – Electrical specifications

[2] During Tpor it is advised that I2C communication is not present. Failure to secure so may lead to increased current consumption. It can be minimized by adding a 10kOhm resistor at ADDR pin.

2.3 Accuracy specifications

The calculated ambient temperature has an accuracy of ±0.5˚C between 0˚C and 60˚C of ambient temperature and ±1˚C outside of this range.

All accuracy specifications apply under settled isothermal conditions only.



3 Functional description & interfaces

3.1 Detailed description

The MLX90637 is an AEC-Q100 qualified far infrared, non-contact temperature sensor in a small SMD Chip-scale package. The device is factory calibrated to a high accuracy with calibration constants stored in the EEPROM memory. The thermopile sensing element voltage signal is amplified and digitized. After digital filtering, the raw measurement result is stored in the RAM memory. Furthermore, the MLX90637 contains a sensor element to measure the temperature of the sensor itself. The raw information of this sensor is also stored in RAM after processing. All above functions are controlled by a state machine. The result of each measurement conversion is accessible via I2C. The ambient and object temperature can be calculated externally based on these calibration constants and the measurement data.

A major strength of the MLX90637 is that temperature differences around the sensor package will be reduced to a minimum. However, some extreme cases will influence the sensor.

The accuracy of the thermometer can be influenced by temperature differences in the package induced by causes like (among others): hot electronics behind the sensor, heaters/coolers behind or beside the sensor or by a hot/cold object very close to the sensor that not only heats the sensing element in the thermometer but also the thermometer package.

In the same way, localized thermal variations -like turbulence in the air- will not generate thermal noise in the output signal of the thermopile.

MLX90637 is calibrated in the ambient temperature range from -40 to 125˚C.

The object temperature range is limited from -40 to 200˚C. For more information, see Section 2.3.

It is very important for the application designer to understand that these accuracies are guaranteed and achievable when the sensor is in thermal equilibrium and under isothermal conditions (no temperature differences across the sensor package).

The typical supply voltage of the MLX90637 is 3.3V. For the I2C communication with the master microcontroller relies on 3.3V I2C bus voltage.

The communication to the chip is done by I2C up to fast mode plus (FM+).

- Control registers of internal state machines
- RAM for pixel and auxiliary measurement data
- EEPROM - used to store the trimming values, calibration constants and various device/measurement settings.

An optical filter (long-wave pass) that cuts off the visible and near infra-red radiant flux is integrated in the sensor to provide ambient light immunity. The wavelength pass band of this optical filter is from 2 to 20µm.

3.1.1 Memory map

Some bits in the registers below are Melexis reserved. Those bits need to be read and masked, prior to writing operation.

Access	Address	Name	Description
		EEPROM	
Read-only	0x2400		Beginning of Protected Part
Read-only	0x2405	ID0[15:0]	Chip version
Read-only	0x2406	ID1[15:0]	Chip version
Read-only	0x2407	ID2[15:0]	Chip version
Read-only	0x2408	ID_CRC16	CRC for 0x2405~0x2407
Read-only	0x2409	EE_PRODUCT_CODE	Sensor information
Read-only	0x240B	EE_VERSION	EEPROM version
Read-only	0x240C	EE_P_R [15:0]	P_R calibration constant (16-bit, Least Significant Word)
Read-only	0x240D	EE_P_R [31:16]	P_R calibration constant (16-bit, Most Significant Word)
Read-only	0x240E	EE_P_G [15:0]	P_G calibration constant (16-bit, Least Significant Word)
Read-only	0x240F	EE_P_G [31:16]	P_G calibration constant (16-bit, Most Significant Word)
Read-only	0x2410	EE_P_T [15:0]	P_T calibration constant (16-bit, Least Significant Word)
Read-only	0x2411	EE_P_T [31:16]	P_T calibration constant (16-bit, Most Significant Word)
Read-only	0x2412	EE_P_O [15:0]	P_O calibration constant (16-bit, Least Significant Word)
Read-only	0x2413	EE_P_O [31:16]	P_O calibration constant (16-bit, Most Significant Word)
Read-only	0x2414	EE_Ea [15:0]	Ea calibration constant (16-bit, Least Significant Word)
Read-only	0x2415	EE_Ea [31:16]	Ea calibration constant (16-bit, Most Significant Word)
Read-only	0x2416	EE_Eb [15:0]	Eb calibration constant (16-bit, Least Significant Word)
Read-only	0x2417	EE_Eb [31:16]	Eb calibration constant (16-bit, Most Significant Word)
Read-only	0x2418	EE_Fa [15:0]	Fa calibration constant (16-bit, Least Significant Word)
Read-only	0x2419	EE_Fa [31:16]	Fa calibration constant (16-bit, Most Significant Word)
Read-only	0x241A	EE_Fb [15:0]	Fb calibration constant (16-bit, Least Significant Word)
Read-only	0x241B	EE_Fb [31:16]	Fb calibration constant (16-bit, Most Significant Word)
Read-only	0x241C	EE_Ga [15:0]	Ga calibration constant (16-bit, Least Significant Word)
Read-only	0x241D	EE_Ga [31:16]	Ga calibration constant (16-bit, Most Significant Word)
Read-only	0x241E	EE_Gb [15:0]	Gb calibration constant (16-bit)
Read-only	0x241F	EE_Ka [15:0]	Ka calibration constant (16-bit)
Read-only	0x247F	MLX_CRC	Protected Part CRC – End of Protected EEPROM Part
R/W	0x2480	CUST_CRC	Customer Part CRC – Beginning of Unprotected Part
R/W	0x2481	EE_Ha [15:0]	Ha Customer calibration constant (16 bit)
R/W	0x2482	EE_Hb [15:0]	Hb Customer calibration constant (16 bit)
-	-	Melexis reserved	
R/W	0x24C0… 0x24CF	Customer data	Customer data storage area
-	-	Melexis reserved	
R/W	0x24D4	EE_CONTROL	EEPROM Control register, measurement control
R/W	0x24D5	EE_I2C_ADDRESS	I2C slave address >> 1 Example: standard address (= 0x003A) >> 1 = 0x001D
-	-	Melexis reserved	
R/W	0x24DE	EE_TCC1	Scaling Parameters
R/W	0x24DB	EE_TCC2	Scaling Parameters

Access	Address	Name	Description
R/W	0x24E2	EE_MEAS_2	Measurement settings 3 (see section Measurement settings)
R/W	0x24E3	EE_MEAS_3	Measurement settings 4 (see section Measurement settings)
R/W	0x24FF		End of Unprotected EEPROM Part
			REGISTER
R/W	0x3000	REG_I2C_ADDRESS	I2C slave address >> 1
R/W	0x3001	REG_CONTROL	Control register, measurement mode
-	-	Melexis reserved	
R/W	0x3FFF	REG_STATUS	Status register: data available
			RAM
Read-only	0x4000	RAM_1	Raw data 1
Read-only	0x4001	RAM_2	Raw data 2
..	..	..	..
Read-only	0x403A	RAM_59	Raw data 59
Read-only	0x403B	RAM_60	Raw data 60

Table 6 Memory organization

Important! The width of the EEPROM is 16 bit.
Some calibration parameters are 32 bit and split up into two 16 bit numbers in EEPROM.

Important! The EEPROM needs to be unlocked before each write command, e.g. all addresses with R/W access need the customer key for modification.
(Section EEPROM unlock for customer access)

3.1.2 Customer Data storage Area (0x24C0 to 0x24CF)

The EEPROM area dedicated for customer data storage consists of 16 EEPROM cell of 16-bit words in the address range from 0x24C0 to 0x24CF.

The customer data area in the MLX90637 EEPROM is not meant for storing intermittent data during production, calibration or normal application use. The purpose of having such an area is to enable the customer to store additional MLX90637 related calibration or tracing information. It is important that only the final data is written to the MLX90637 EEPROM in one go. In order to verify that the writing process was successful, the whole EEPROM data should be read-out prior to writing and compared to the EEPROM content after writing - only the customer data values should be different.

Important note: The maximum number of EEPROM re-writes is 10. Therefore, it is highly recommended that the writing of the data is done 1 time only. The maximum ambient temperature for EERPOM write operations is +85degC.

3.1.2.1 Product Code (0x2409)

15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	FOV		Package			Accuracy range				

- FOV
  - 0: 50°

- Package
  - 0: -
  - 1: SFN 3x3
- Accuracy range
  - 0: -
  - 1: -
  - 2: -
  - 3: -
  - 4: Automotive

3.1.2.2 Product ID

A unique 48-bit product ID is stored in the EEPROM.
Addresses 0x2405 (ID0), 0x2406 (ID1) and 0x2407 (ID2) should be readout to know the ID of the product.
ProductID[47:0] = ID2[15:0] << 32 | ID1[15:0] << 16 | ID0[15:0]

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ProductID[15:0]															

Figure 3 ID0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ProductID[31:16]															

Figure 4 ID1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ProductID[47:32]															

Figure 5 ID2

3.1.3 Control and configuration

Several bits in the EEPROM or register are available to control and configure the measurements:

3.1.3.1 Measurement

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Melexis reserved	*Melexis reserved*	*Melexis reserved*	*Melexis reserved*	*sob*	*Melexis reserved*	*Melexis reserved*	*Melexis reserved*					*soc*	*mode*		*Melexis reserved*

Figure 6 Register REG_CONTROL bitmap

Note that register REG_ CONTROL is initialized during POR by the EEPROM word EE_CONTROL.

REG_CONTROL controls the measurement handling and data storage.
Changes will take immediate effect.

Bits	Parameter	Description	See section
11	sob	starts a full measurement when being in (sleeping) step mode	Operating Modes
3	soc	starts a single measurement when being in (sleeping) step mode	Operating Modes
2:1	mode [1:0]	defines the operating mode (step mode or continuous mode)	Operating Modes

Figure 7 REG_CONTROL explained

Several measurement modes exist. These modes are controlled by bits mode [1:0] in register REG_CONTROL. In continuous mode the measurements are constantly running while in step mode the state machine will execute only one measurement which is initiated by soc bit. After finishing the measurement, it will go in wait state until the next measurement is initiated by soc. The measurements are following the measurement sequence as defined in the measurement table.

The different possible measurement modes are:

- mode [1:0] = 01: Enables the sleeping step mode. In this mode the device will be in sleep. On request (soc bit), the device will power-on, the state machine will do one measurement, will go into sleep and will wait for next command.
- mode [1:0] = 10: Enables the step mode. In this mode the state machine will do one measurement upon request (soc bit) and will wait for next command. The device remains powered all time in this mode.
- mode [1:0] = 11: Device is in continuous mode. Measurements are executed continuously. The device remains powered all time in this mode.

Switching between the step modes and continuous mode has only effect after the current measurement has finished (not waiting till end of measurement table was reached).

By default, the device is in continuous mode.

8.2. Device status

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	device_busy	eeprom_busy	brown_out	Melexis reserved	cycle_position					Melexis reserved	new_data

Figure 8 Register Device status settings

REG_STATUS allows checking in which state the device is and indicates when measurements are finished.
Changes will take immediate effect.

Bits	Parameter	Description	See section
10	device_busy	Read-only Flag indicating that a measurement is being executed (1 = meas-urement ongoing) In sleep mode, this flag is always low. In continuous mode, this flag is always high. In soc-step mode, this flag is high during one measurement. In sob-step mode, this flag is high till all measurements are finished.	Operating Modes
9	eeprom_busy	Read-only Flag indicating that the eeprom is busy (0: not busy) Eeprom being busy is defined as follows: - at start-up, the eeprom is busy and remains busy till initialization phase (eeprom copy) has finished - during eeprom write/erase, the eeprom is busy	
8	brown_out	Bit is set to 0 Customer should set bit to 1 When device is reset, the bit is set to 0 and reset can be detected	
6:2	cycle_position	Read-only Indicates from which measurement (in the measurement table) the last written data is coming: - cycle_position[4:0]=x, corresponds to measurement x, x=0->31	Temperature calculation
0	new_data	Customer should set bit to 0 When a measurement is done, the bit is set to 1 Customer can readout the data and reset the bit to 0	Operating Modes

Table 7 Register REG_STATUS explained

3.1.4 Measurement settings

3.1.4.1 Refresh rate

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Refresh rate			Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved

Figure 9 EEPROM measurement settings

The refresh rate is the speed that the RAM will be updated with results and is configurable with 3 bits and in EEPROM addresses 0x24E2 and 0x24E3.
Changing the refresh rate will take immediate effect.
It is important to know that the refresh rate should be kept the same for both measurements.
The table below shows the available refresh rates and the corresponding result to be written in EEPROM addresses EE_MEAS_2 and EE_MEAS_3.

EE_MEAS_2[10:8] EE_MEAS_3[10:8]	Refresh rate [Hz]	Time [s]	Burst meas time [s]	EE_MEAS_2 (0x24E2)	EE_MEAS_3 (0x24E3)
0	0.460	2.176	4.224	0x800D	0x801D
1	0.868	1.152	2.176	0x810D	0x811D
2	**1.563**	**0.64**	**1.152**	**0x820D**	**0x821D**
3	2.604	0.384	0.64	0x830D	0x831D
4	3.906	0.256	0.384	0x840D	0x841D
5	5.208	0.192	0.256	0x850D	0x851D
6	6.250	0.16	0.192	0x860D	0x861D
7	6.944	0.144	0.16	0x870D	0x871D

Table 8 EEPROM refresh rate

3.1.5 CRC Fields and coverage

There are three CRC(Cyclic Redundancy Check) values, calculated on the following EEPROM ranges:

- ID_CRC16 - calculated on ID0; ID1 and ID2 ;
- MLX_CRC – covers the entire Protected area: 0x2400 till 0x247E;

Note: it is important to first compute the ID_CRC16 of the IDs, and then MLX_CRC.

- CUST_CRC– covers the entire customer area: 0x2481 till 0x24FF.

The CRC use the 16-bit algorithm, with seed value 0x0637, polynomial 1021 (X^16 + X^12 + X^5 + 1).
Example code:

```
/*
  Optimized implementation of CRC16 using the CCITT polynomial 1021
  (X^16 + X^12 + X^5 + 1)
  See e.g. http://www.ccsinfo.com/forum/viewtopic.php?t=24977 and others
*/

uint16_t m_crcCCITT (uint8_t c, uint16_t seed)
{
   uint16_t crc = seed;

   crc  = (uint8_t)(crc >> 8u) | (crc << 8u);
   crc ^= c;
   crc ^= (crc >> 4u) & 0x000Fu;
   crc ^= (crc << 8u) << 4u;
   crc ^= ((crc & 0xffu) << 4u) << 1u;

   return crc;
}

void example_crc_calculation()
{
  uint16_t data[32];
  for (int i=0; i<32; i++)  {
   data[i] = i*i; // dummy data
```

```
 }
 uint16_t seed = 90637 & 0xFFFF;
 uint16_t crc = seed;
 for (int i=0; i<32; i++)  {
  crc = m_crcCCITT (data[i] & 0xFF, crc);
  crc = m_crcCCITT ((data[i] >> 8u) & 0xFF, crc);
 }
 printf ("crc = %d\n", crc);
}
```

3.1.6 I2C commands

This device is based on I2C specification Rev.5 – October 9th 2012. I2C FM+ mode is supported.

The sensor uses the following I2C features:

- Slave mode only
- 7-bits addressing
- Modes: Standard-mode, Fast-mode – Standard-mode, Fast-mode, Fast-mode Plus
- Incremental addressing – allowing a block of addresses to be accessed inside one I2C sequence

The following I2C commands are implemented:

- Read/write access to internal memories and registers
  - Addressed write
  - Addressed read
- Global reset
- Addressed reset
- EEPROM unlock for CUST access
- Direct read

3.1.6.1 I2C address

The 7-bit address is for slave recognition on I2C bus. By default, the device responds to the 7-bit slave address 0x3A.
Configuration of the 7-bit slave address is possible at EEPROM address 0x24D5.

The least significant bit (bit0) of the address is determined by the status of the ADDR-pin (either connected to ground or supply) and is taken in after power-up or reset command if the change is made in EEPROM.
- Bit0 = '0' if ADDR-pin is connected to GND
- Bit0 = '1' if ADDR-pin is connected to VDD
The remaining 6-bits can be used to configure the I2C address of the device.

15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Melexis reserved	Configurable 6-bit slave address (0x1D)						External status of ADDR-pin
									I2C slave address(7-bit) = 0x3A if ADDR-pin=0(GND) = 0x3B if ADDR-pin=1(VDD)						

Figure 10 EEPROM I2C address configuration

Important! The device will not respond if the I2C address is changed to 0 (and ADDR pin is low).
The only way to get the device to respond is to pull the ADDR pin high.
The slave address will be changed to 1 and communication is possible.

Important! The device shall not execute measurements when performing EEPROM memory operations (I2C read/write instructions in EEPROM address range)! Hence, the device shall be put in halt mode or in a stepping mode before doing EEPROM read/write operations.

3.1.6.2 Slave Address change flow

- ⇨ Put device in Halt mode, use current slave address
- ⇨ Read Control Register
- ⇨ Mask Control register value – change only the power mode bits
- ⇨ Write the new value to Control register
- ⇨ Write Slave address to EERPOM, use current slave address
- ⇨ Send EEPROM unlock key
- ⇨ Write 0x0000 to address 0x24D5

Important! Do not power down the device at this point

- ⇨ Wait at least 5ms
- ⇨ Send EERPOM unlock key
- ⇨ Write New slave address [6:1] to address 0x24D5
- ⇨ Wait at least 5ms

It is advised to read back and verify the written address value at this point

It is now safe to power-down the device

After power-down of the device the new slave address will be in operation.

3.1.6.3 Addressed read

The addressed read command allows doing an incremental read-out, starting from any given address within the memory space.

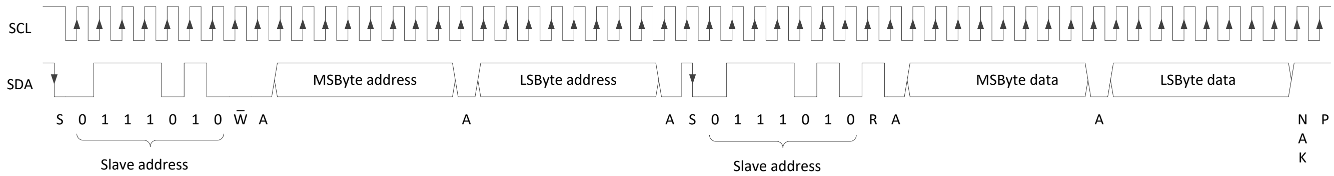


Figure 11 Addressed read

Important! An addressed read is only valid when combining directly an addressed write and a direct read through a repeated START condition. In case the read and write part are separated by a STOP condition, or in case the read is not directly following the write, or in case the slave address is not identical for both, the command will not be seen as an addressed read. As a result, the second read will in practice act as a direct read.

As soon as incremental addressing leaves the address space, the slave will respond with all 8'hFF.

3.1.6.4 Addressed write

The addressed write command allows doing an incremental write, starting from any given address within the memory space.

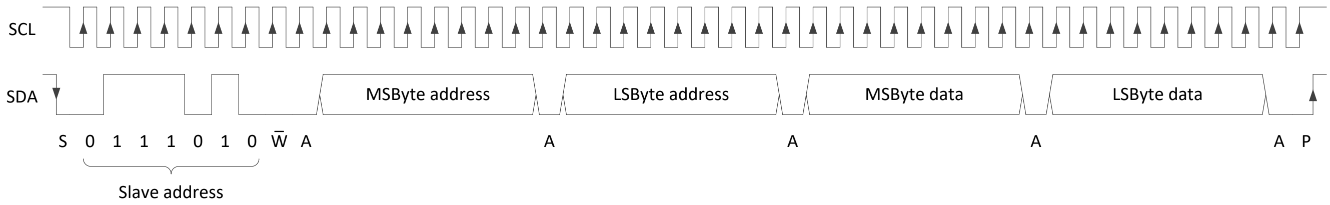


Figure 12 Addressed write

Important! The slave is sending ACK/NACK based on the fact whether it was able to write data (timing, end of register space, access rights).

The slave will automatically increment the address of the write byte, independent if it gave an ACK or a NACK to the master. It is up to the master to re-write the byte afterwards.

Before writing to EEPROM it is necessary to erase the specific address location in EEPROM. This is done by first writing 0x0000. Then the new data can be written.

When the device is busy with the write operation to EEPROM, new write commands will be ignored. A read operation will return invalid data. The fact that the device is busy is indicated via the bit device_busy in REG_STATUS.

3.1.6.5 Reset commands

When the device is in sleeping step mode there is a requirement for the last SCL transitions. The time t_P between the last falling edge of the SCL and the last rising edge of the SCL must not exceed 1.8µs, as indicated on Figure 15 below. In case this timing cannot be ensured, the command will not be executed properly.

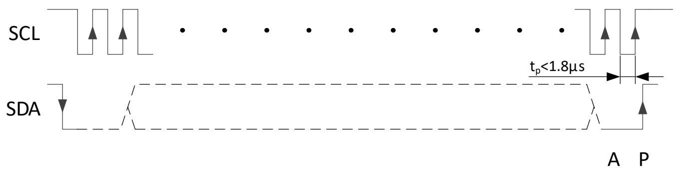


Figure 13 Reset command timing requirements

3.1.6.5.1 Global reset

This command resets all devices on the I2C bus (based on the general call address 0x00).

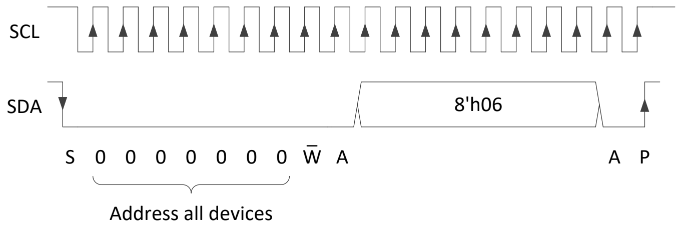


Figure 14 Global reset

Note: After this command, the device reloads all control parameters from the EEPROM and a delay of at least 150µs is needed before the next communication with the device.

3.1.6.5.2 Addressed reset

This command resets the addressed device only (based on the I2C address).

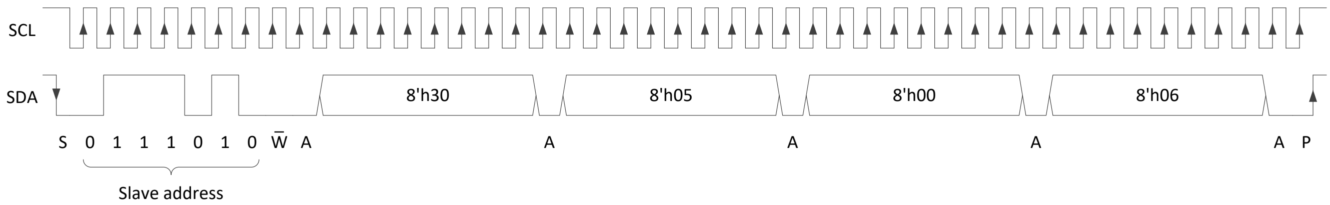


Figure 15 Addressed reset

Note: After this command, the device reloads all control parameters from the EEPROM and a delay of at least 150µs is needed before the next communication with the device.

3.1.6.6 EEPROM unlock for customer access

This command unlocks the EEPROM allowing only one write operation to an EEPROM word in the customer part of the EEPROM.

After the EEPROM write, the EEPROM access goes back to the "NoKey" access mode.

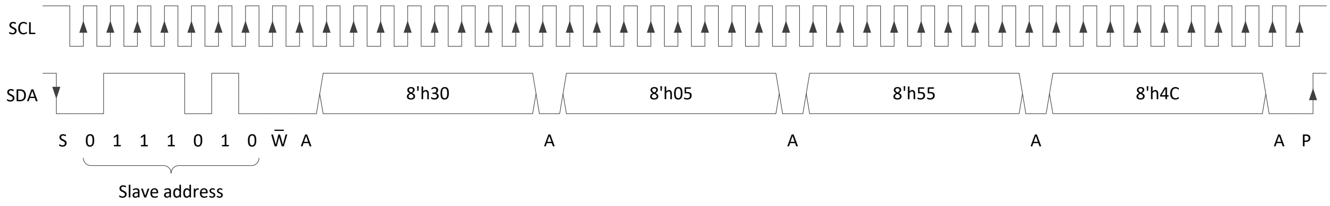


Figure 16 EEPROM unlock

3.1.6.7 *Direct read*

The direct read command allows an incremental read out at a default start address.
This default start address is fixed to the register location REG_STATUS (0x3FFF).
According to the I2C specification, the master will keep sending an acknowledge (A) until it want to stop. This is indicated by sending a NAK. As a result, the slave will stop driving the SDA-bus as soon as a NAK is received by the master.

As soon as the incremental addressing leaves the address space, the slave will respond with all 8'hFF.

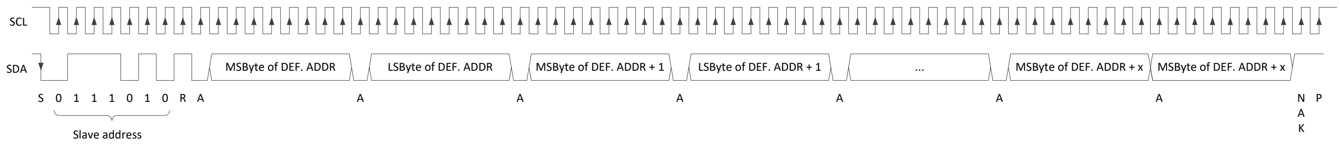


Figure 17 Direct read

3.2 Operating Modes

The device has 2 states of operation: sleep state and active state.

- Sleep state

In this state, most of the circuitry is disabled to limit the current consumption to a few uA.

- Active state

In this state, the sensor is active.

Several measurement modes exist.
These modes are controlled by bits mode[1:0] in register REG_CONTROL[2:1].
In continuous mode the measurements are constantly running while in step mode the state machine will execute only one measurement which is initiated by the soc bit or a whole set of measurements initiated by the sob bit. After finishing the measurement(s) it will go in wait state until the next measurement is initiated by the **soc** or **sob** bit. If **soc** is used to initiate a measurement, the measurements are following the measurement sequence as defined in the measurement table.

The different possible measurement modes are:

- mode[1:0] = 01: Enables the sleeping step mode.

The device will be in sleep mode. On request (soc or sob bit), the device will power-on, the state machine will perform one measurement(**soc**) or the full measurement table (**sob**), will go into sleep and wait for the next command.

In the sleeping step mode all the measurements from the measurement table will be performed so that all data necessary for the calculations is refreshed. The two ways of using the device in this mode are:

- **sob** bit

The **sob** bit initiates a full measurement table measurement. Once the measurement is started, the **sob** bit is cleared and the **device_busy** bit is set internally in the MLX90637. When all the measurements from the measurement table are performed, the **device_busy** bit is cleared indicating the end of measurements – the new data can be read. The flow should be:

1. Set **sob** bit
2. Wait for all the measurements from the measurement table to finish - depending on the refresh rates (see Table 8)
3. Make sure that the **device_busy** bit is cleared
4. Read out the data
5. Calculate the temperatures

- **soc** bit

The **soc** bit initiates a single measurement from the measurement table. The measurements are being performed consecutively as set in the measurement table. Once the measurement is started, the SOC bit is cleared internally in the MLX90637 and could be set again so that the next measurement from the measurement table is started right after the current one is done. When the current measurement is done, the **new_data** bit is set – the new data can be read and the bit should be cleared. The flow should be:

1. Set **soc** bit
2. Wait for the 1st measurement from the measurement table to finish - depending on the refresh rate (see Table 8)
3. Make sure that the **new_data** bit is set and clear it
4. Set **soc** bit
5. Wait for the 2nd measurement from the measurement table to finish - depending on the refresh rate (see Table 8)
6. Make sure that the **new_data** bit is set and clear it
8. Set **soc** bit
9. Wait for the 3rd measurement from the measurement table to finish - depending on the refresh rate (see Table 8)
10. Make sure that the **new_data** bit is set and clear it
11. Read out the data
12. Calculate the temperatures

- mode[1:0] = 10: Enables the step mode.

The state machine will do one measurement upon request (**soc** bit) and will wait for the next command. The device remains powered all the time in this mode.

- mode[1:0] = 11: Device is in continuous mode.

Measurements are executed continuously. The device remains powered all time in this mode.

By default, the device is in continuous mode.

Switching between the step modes and continuous mode has only effect after the current measurement has finished (not waiting until the end of the measurement table was reached).

3.3 Temperature calculation

Note: In this section only Ta/To calculation is described. For diagnostics RAM_1, RAM_2, RAM_4 and RAM_5 will be needed.

To calculate the ambient and object temperature, multiple measurements are required:

- Measurement 1: RAM_3;
- Measurement 2: RAM_6;
- Measurement 3: RAM_7, RAM_8, RAM_9;
- Measurement 4: RAM_10, RAM_11, RAM_12;

One should notice this requires double the measurement time than specified (= 2 * 500ms) for the very first calculation.

After the first calculation, TA and TO can be calculated with the next measurement.

Example:

t0: (cycle_pos = 0)	Measurement 1=>	no calculation of TA or TO possible because not all parameters are known		
t1: (cycle_pos = 1)	Measurement 2=>	no calculation of TA or TO possible because not all parameters are known		
t2: (cycle_pos = 2)	Measurement 3=>	no calculation of TA or TO possible	=>	0.5s.
t3: (cycle_pos = 3)	Measurement 4=>	calculate TA (RAM_9, RAM_12) calculate TO	=>	0.5s.
t4:	…			

To calculate a new ambient temperature RAM_9 and RAM_12 have to be used.

To calculate a new object temperature RAM_7 and RAM_8 or RAM_10 and RAM_11, or all 4 of them, have to be used. The choice between [RAM_7 and RAM_8] or [RAM_10 and RAM_11] depends on the current measurement. REG_STATUS [6:2] (= “cycle_pos”) returns the current position of the measurement defined in the measurement table.

Using the current data and the data from measurement (x-1), TA and TO can be calculated every 500ms.

The complete measurement sequence can be automated by using the new_data bit in combination with cycle_pos bits.

3.3.1 Object temperature measurement

There is a list of parameters stored in EEPROM, needed for the calculations:

Parameter name	EEPROM name	Scaling	Resolution	Signed
CP	EE_TCC1[1:0]	-	-	-
CV	EE_TCC1[3:2]	-	-	-
CH	EE_TCC1[5:4]	-	-	-
CL	EE_TCC1[7:6]	-	-	-
CI	EE_TCC2[11:10]	-	-	-
P_R	EE_P_R	-8	32-bit	no
P_G	EE_P_G	-20	32-bit	no
P_T	EE_P_T	-44	32-bit	yes
P_O	EE_P_O	-8	32-bit	yes
Ea	EE_Ea	-16	32-bit	no
Eb	EE_Eb	-8	32-bit	no
Fa	EE_Fa	-46	32-bit	no
Fb	EE_Fb	-36	32-bit	yes
Ga	EE_Ga	-36	32-bit	yes
Gb	EE_Gb	-10	16-bit	no
Ka	EE_Ka	-10	16-bit	no
Ha	EE_Ha	-14	16-bit	no
Hb	EE_Hb	-10	16-bit	yes

Table 9 List of parameters used in the calculations below.

Note: Conversion formula: <Parameter name> = <EEPROM name>*2^<Scaling>

CB = 0

3.3.1.1 Pre-calculations

- Calculate the ratio

$$\mathrm{GR} = \frac{\mathrm{RAM\_6}/2^{CL}}{\mathrm{RAM\_3}/2^{CH}}$$

- Signal:

$$\mathrm{S} = \frac{\mathrm{RAM\_7} + \mathrm{RAM\_8} + \mathrm{RAM\_10} + \mathrm{RAM\_11}}{4}$$

- Parameter VRO:

$$VRO = \frac{\mathrm{RAM\_12}}{2^{CB}} + \frac{\mathrm{Ka} * \mathrm{RAM\_9}}{3 * 2^{CP}}$$

- Modified Signal

$$\boldsymbol{S_{TO}} = \frac{\boldsymbol{S}}{\boldsymbol{VRO} * \mathbf{3} * \mathbf{2^{CI}}} * \mathbf{2^{19}}$$

- Parameter AMB

$$AMB = \frac{\text{RAM\_9} * 2^{19}}{VRO * 3 * 2^{CP}}$$

3.3.1.2 Ambient Temperature

$$\text{Ta} = \frac{\frac{\text{RAM\_9} * 2^{19}}{\text{RAM\_12} * \text{GR} * 2^{\text{CP}-\text{CV}} + \text{Gb} * \text{RAM\_9}} - \text{P\_R}}{P\_G} + 30, [oC]$$

Note: The Ta calculated in 3.3.1.2 is different that the TA_{DUT} used in the next section 3.3.2.

3.3.2 Object temperature

$$\mathbf{TO}\ (\textbf{object temperature in }°\mathbf{C}) = \sqrt[4]{\frac{\mathbf{S_{TO}}}{\boldsymbol{\varepsilon} * \mathbf{Fa} * \mathbf{Ha} * \left(\mathbf{1} + \mathbf{Ga} * (\mathbf{To} - \mathbf{TO_0}) + \mathbf{Fb} * (\mathbf{TA_{DUT}} - \mathbf{TA_0})\right)} + \mathbf{Ta_{[K]}}^{4}} - \mathbf{273.15} - \mathbf{Hb}$$

where
TO_0 = 60°C;
TA_0 = 30°C;

$$\text{TA}_{\text{DUT}} = \frac{(\text{AMB} - \text{Eb})}{\text{Ea}} + 30$$

$Ta_{[K]}$ = TA_{DUT} + 273.15 in Kelvin
ε = 1 = Object Emissivity parameter (not stored in EEPROM, but part of the 'app')
Note:
One can see that to compute "To (object temperature)", "To" already needs to be known.
"To (object temperature)" is computed in an iterative manner. In the first iteration "To" is assumed to be 25°C. In the 2nd iteration the result of first iteration is used, and in the 3rd iteration the end result is obtained.

4 Diagnostics

The MLX90637 is a Quality Management device, developed prior to the existence of ISO26262. Hence the Melexis-Ready program has not been followed for this product (product is not developed according to ISO26262 flow). However, the product could still be integrated into a safety-related application, with the support of external safety mechanisms. The MLX90637 is intended to be used with an external microcontroller, which processes the measurements and calculates the temperature. The product is providing the possibility to the integrator to detect the faults, by implementing the diagnostics in the ECU/microcontroller by using the mechanisms implemented in the dedicated device driver, provided by Melexis. There is no internal safety mechanism implemented in MLX90637, hence the system, integrating this product, is responsible for implementing the appropriate reaction based on the technical safety concept.

For more information contact Melexis.

5 Application

5.1 Application description

5.2 Recommended Application diagram

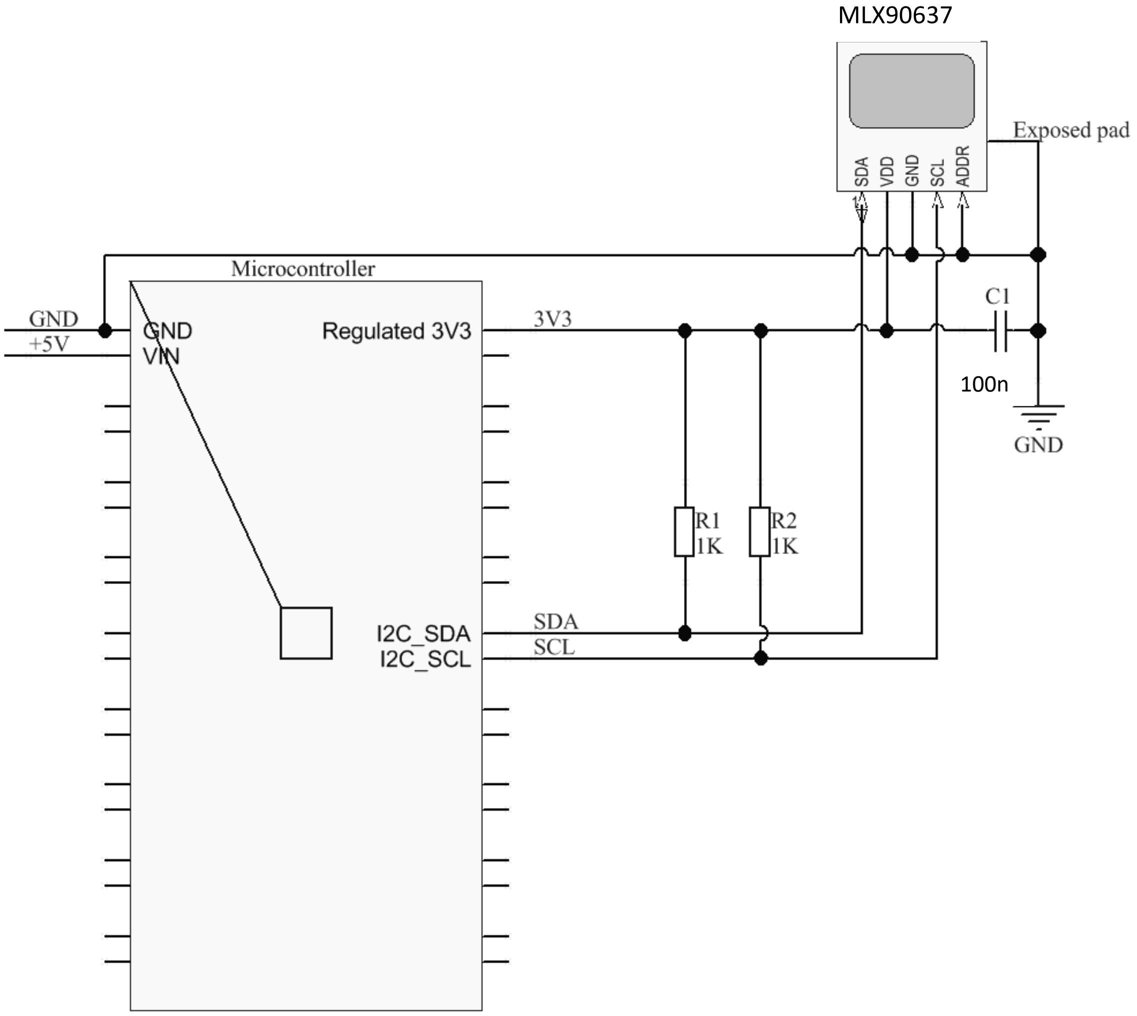


Figure 18 Typical application schematic

Note: C1 should be placed within 10mm from the device

5.3 Application comments

- Significant contamination at the optical input side (sensor filter) might cause unknown additional filtering/distortion of the optical signal and therefore results in unspecified errors.

- IR sensors are inherently susceptible to errors caused by thermal gradients. There are physical reasons for these phenomena and, in spite of the careful design of the MLX90637, it is recommended not to subject the MLX90637 to heat transfer and especially transient conditions.
- The MLX90637 is designed and calibrated to operate as a non-contact thermometer in settled conditions.
- Upon power-up the MLX90637 passes embedded checking and calibration routines. During these routines the output is not defined and it is recommended to wait for the specified POR time before reading the module. Very slow power-up may cause the embedded POR circuitry to trigger on inappropriate levels, resulting in unspecified operation which is not recommended.
- The ADDR pin should be always connected to either VDD, or GND.
- Capacitive loading on an I2C bus can degrade the communication. Improvement is possible with use of current sources compared to resistors in the pull-up circuitry. Further improvement is possible with specialized commercially available bus accelerators.
- A sleep mode is available in the MLX90637. This mode is entered and exited via the I2C compatible 2-wire communication.
- A power supply and decoupling capacitor is needed as with most integrated circuits. The MLX90637 is a mixed-signal device with sensors, small analog signals, digital parts and I/O circuitry. In order to keep the noise low, power supply switching noise needs to be decoupled. High noise from external circuitry can also affect the noise performance of the device. In many applications a 100nF SMD ceramic capacitor close to the VDD and GND pins would be a good choice. It should be noted that not only the trace to the VDD pin needs to be short, but also the one to the GND pin.
- Do not perform measurements in oily or helium environments.

5.4 Field of View (FoV)

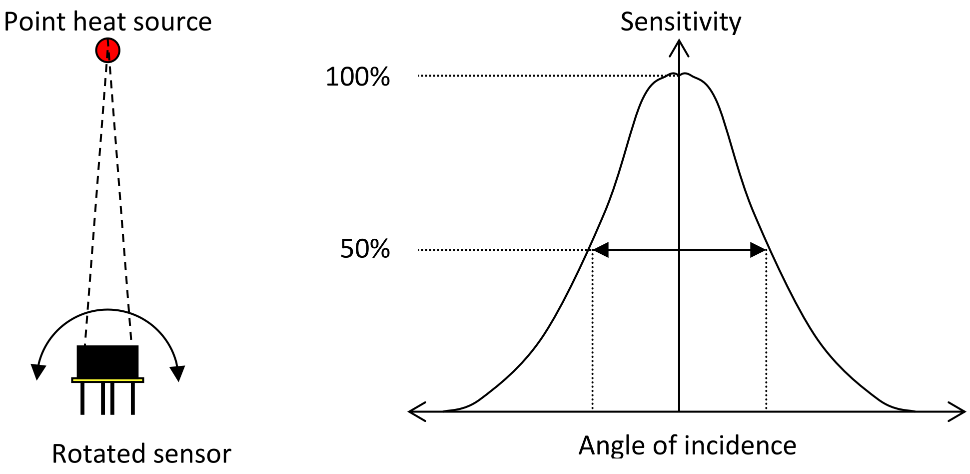


Figure 19 Field of View measurement principle

Parameter	50% of maximum	10% of maximum	Unit
Field Of View	50	70	° (angular degrees)

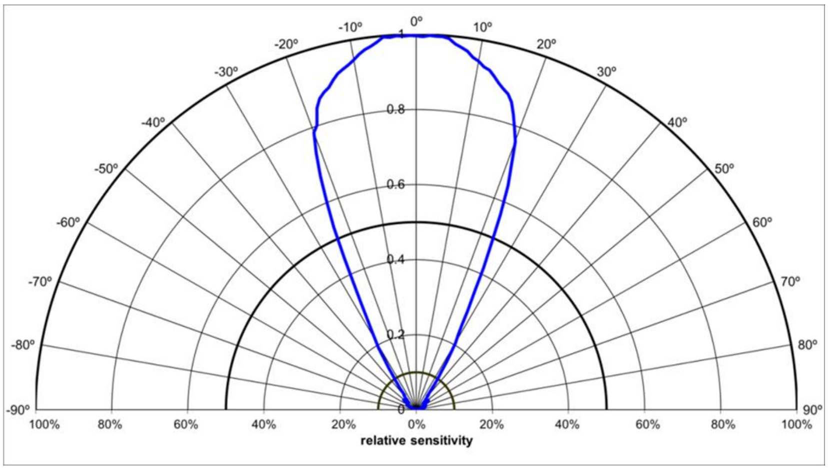


Table 10 Field Of View of the MLX90637

The 50° is measured at the 50% level of sensitivity.

5.5 Noise

Measurement conditions for noise performance are To = Ta = 25°C.
Note: Due to the nature of thermal infrared radiation, it is normal that the noise will decrease for high temperature and increase for lower temperatures.

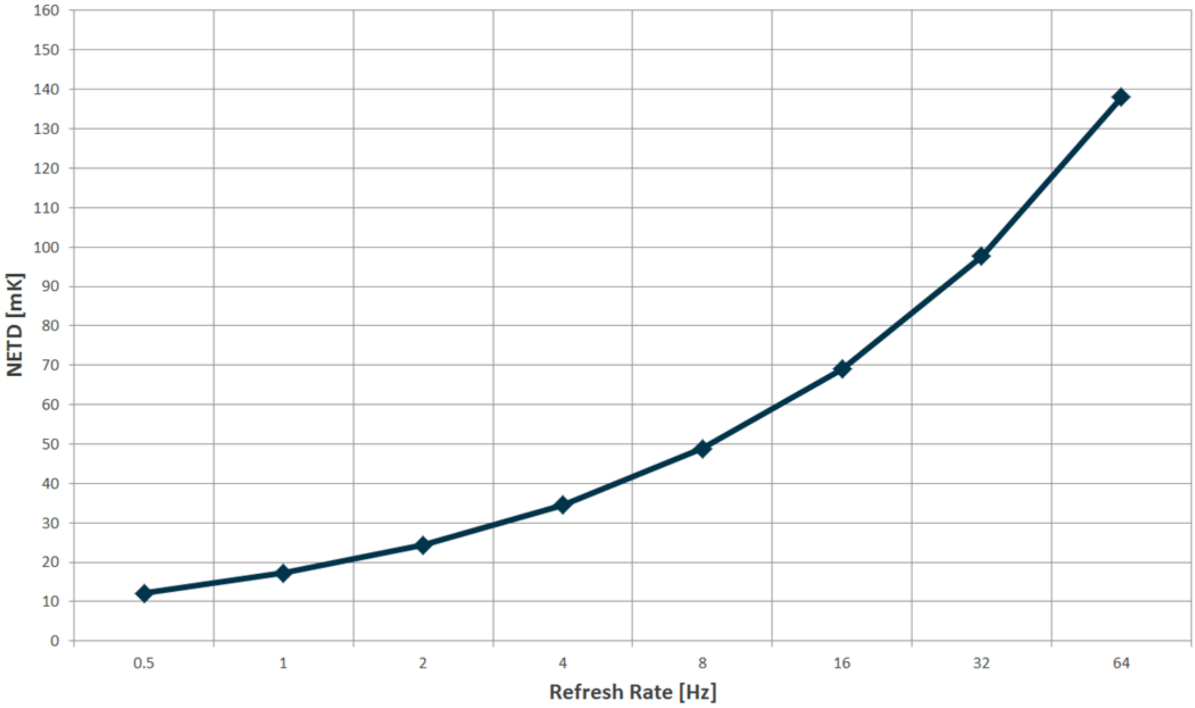


Figure 20 Noise

6 Package, IC handling and assembly

6.1 Package information

6.1.1 Package dimensions SFN-5

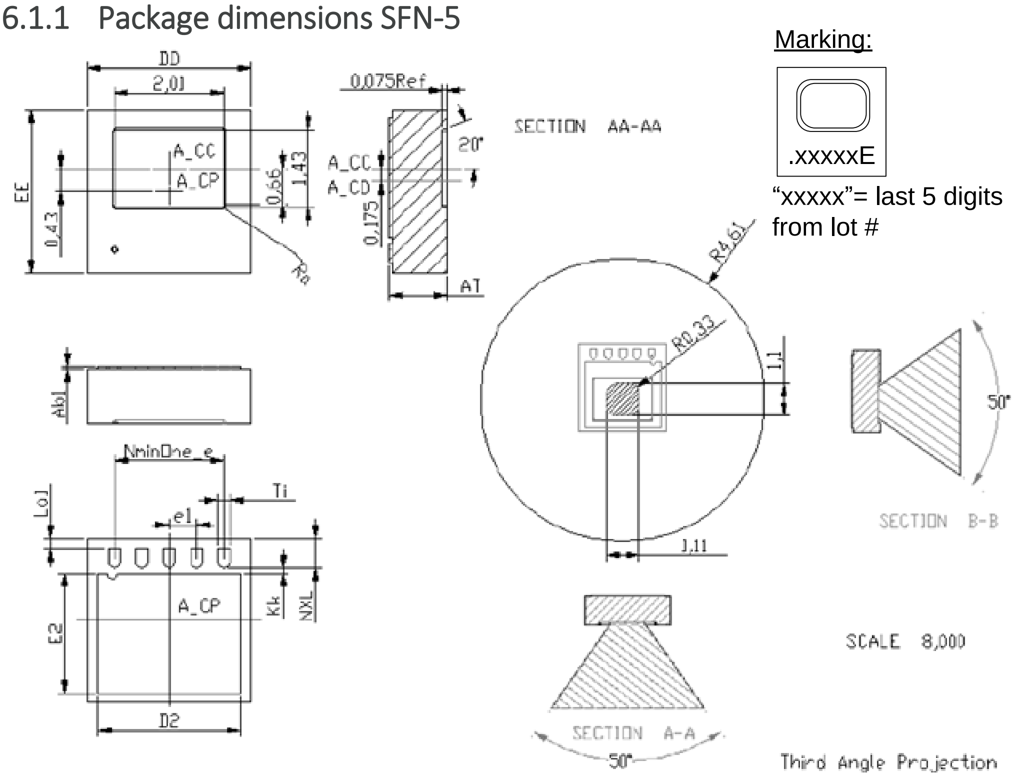


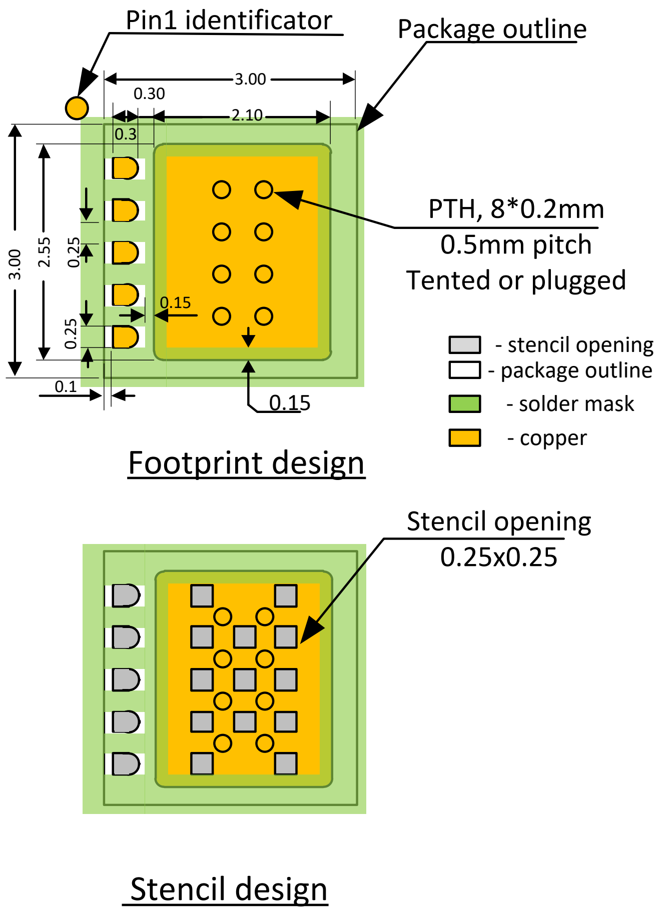
Figure 21 Package dimensions for MLX90637. All linear dimensions are in [mm]

Symbol	Min	Nom	Max
DD=EE	2.9	3.0 BSC	3.1
AT	0.90	0.95	1.00
Ra		0.05	
D2	2.40	2.50	2.60
E2	2.00	2.10	2.20
Lo1			0.15 Max
Kk	0.20	0.30	
NXL	0.35	0.40	0.45
e1		0.50 BSC	
NminOne_e		4e1	
Ti	0.18	0.25	0.30
Tolerance (A_CC – A_CP)	-0.15		0.15
Tolerance (A_CC – A_CD)	-0.1		0.1

Table 11 Package dimensions list for MLX90637, SFN-5

*BSC Ξ basic dimension *A_CC = Center of silicon Cap *A_CD = Center of Die frame *A_CP = Center of Package

6.1.2 PCB footprint



Recommended 1)PCB finish: OSP, ENIG, ENEPIG
2)Stencil thickness max 100um
3)Solderpaste – noclean , halogen free

Figure 22 Example PCB footprint for MLX90637 (not to scale)

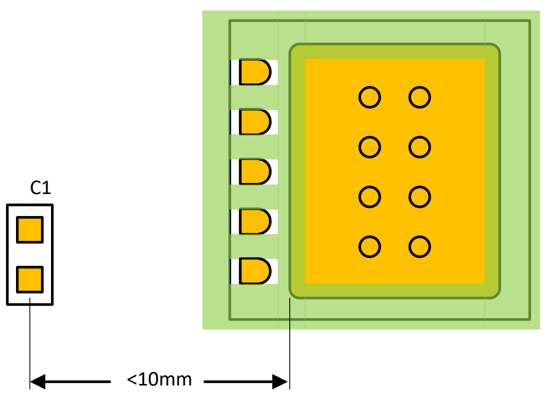


Figure 23 Decoupling capacitor C1 placement

6.2 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* [(3)]

6.3 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* [(3)].

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 [(3)] 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*[(3)].

Environmental protection of customer assembly with Melexis products for harsh media application, is applicable by means of coating, potting or over molding considering restrictions listed in the relevant application notes [(3)]

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

6.4 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

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

7 Glossary of terms & references

7.1 Glossary

Term	Description
POR	Power On Reset
IR	InfraRed
I2C	Inter-Integrated Circuit
SDA	Serial DAta – I2C communication pins
SCL	Serial CLock – I2C communication pins
ACK / NACK	Acknowledge / Not Acknowledge
SOC	Start Of Conversion
EOC	End Of Conversion
FOV	Field Of View
Ta	Ambient Temperature measured from the chip – (the package temperature)
To	Object Temperature, 'seen' from IR sensor
LGA	Land Grid Array
TBD	To Be Defined
LSB	Least Significant Bit
MSB	Most Significant Bit
EMC	Electro-Magnetic Compatibility
ESD	Electro-Static Discharge
HBM	Human Body Model
CDM	Charged Device Model

7.2 List of tables

Revision	Date	Change history
Preliminary	11-Nov-24	Creation
001	28-Mar-25	Memory map; Electrical and AMR specifications;
002	20-Oct-25	Product launch version: AMR; Refresh rates; Memory map; DSP; Diagnostics;

Table 12 – Revision history

8 Disclaimer

The content of this document is believed to be correct and accurate. However, the content of this document is furnished "as is" for informational use only and no representation, nor warranty is provided by Melexis about its accuracy, nor about the results of its implementation. Melexis assumes no responsibility or liability for any errors or inaccuracies that may appear in this document. Customer will follow the practices contained in this document under its sole responsibility. This documentation is in fact provided without warranty, term, or condition of any kind, either implied or expressed, including but not limited to warranties of merchantability, satisfactory quality, non-infringement, and fitness for purpose. Melexis, its employees and agents and its affiliates' and their employees and agents will not be responsible for any loss, however arising, from the use of, or reliance on this document. Notwithstanding the foregoing, contractual obligations expressly undertaken in writing by Melexis prevail over this disclaimer.

This document is subject to change without notice, and should not be construed as a commitment by Melexis. Therefore, before placing orders or prior to designing the product into a system, users or any third party should obtain the latest version of the relevant information.
Users or any third party must determine the suitability of the product described in this document for its application, including the level of reliability required and determine whether it is fit for a particular purpose.

This document as well as the product here described may be subject to export control regulations. Be aware that export might require a prior authorization from competent authorities. The product is not designed, authorized or warranted to be suitable in applications requiring extended temperature range and/or unusual environmental requirements. High reliability applications, such as medical life-support or life-sustaining equipment or avionics application are specifically excluded by Melexis. The product may not be used for the following applications subject to export control regulations: the development, production, processing, operation, maintenance, storage, recognition or proliferation of:
1. chemical, biological or nuclear weapons, or for the development, production, maintenance or storage of missiles for such weapons;
2. civil firearms, including spare parts or ammunition for such arms;
3. defense related products, or other material for military use or for law enforcement;
4. any applications that, alone or in combination with other goods, substances or organisms could cause serious harm to persons or goods and that can be used as a means of violence in an armed conflict or any similar violent situation.

No license nor any other right or interest is granted to any of Melexis' or third party's intellectual property rights.

If this document is marked “restricted” or with similar words, or if in any case the content of this document is to be reasonably understood as being confidential, the recipient of this document shall not communicate, nor disclose to any third party, any part of the document without Melexis’ express written consent. The recipient shall take all necessary measures to apply and preserve the confidential character of the document. In particular, the recipient shall (i) hold document in confidence with at least the same degree of care by which it maintains the confidentiality of its own proprietary and confidential information, but no less than reasonable care; (ii) restrict the disclosure of the document solely to its employees for the purpose for which this document was received, on a strictly need to know basis and providing that such persons to whom the document is disclosed are bound by confidentiality terms substantially similar to those in this disclaimer; (iii) use the document only in connection with the purpose for which this document was received, and reproduce document only to the extent necessary for such purposes; (iv) not use the document for commercial purposes or to the detriment of Melexis or its customers. The confidentiality obligations set forth in this disclaimer will have indefinite duration and in any case they will be effective for no less than 10 years from the receipt of this document.

This disclaimer will be governed by and construed in accordance with Belgian law and any disputes relating to this disclaimer will be subject to the exclusive jurisdiction of the courts of Brussels, Belgium.

The invalidity or ineffectiveness of any of the provisions of this disclaimer does not affect the validity or effectiveness of the other provisions.
The previous versions of this document are repealed.

IATF 16949 and ISO 14001 Certified