

# MLX90632 FIR sensor

## Datasheet

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### Features and Benefits

- Small size
- Easy to integrate
- Factory calibrated
- External ambient and object temperature calculation
- Measurement resolution of 0.02°C
- Supply voltage of 3.3V, supply current 1mA (sleep current less than 2.5uA)
- I<sup>2</sup>C compatible digital interface
- Software definable I<sup>2</sup>C address with 1 LSB bit external address pin
- Field of View of 50°
- Default refresh rate 0.5s, configurable between 16ms and 2s
- Integrated post-calibration option

### Application Examples

- Non-contact temperature measurements
- Temperature sensing element for residential, commercial and industrial building air conditioning
- Industrial temperature control of moving parts
- Home appliances with temperature control



*Figure 1: Image of MLX90632*

# MLX90632 FIR sensor

## Datasheet

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### Description

The MLX90632 is a non-contact infrared temperature sensor in a small SMD SFN package. The device is factory calibrated with calibration constants stored in the EEPROM memory. The ambient and object temperature can be calculated based on these calibration constants and the measurement data.

The MLX90632 is factory calibrated in the ambient temperature range from -20 to 85°C and from -20 to 200°C for the object temperature range. The measured value is the average temperature of all objects in the Field Of View of the sensor.

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 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.

A major strength of the MLX90632 is that the measured effect of these temperature differences around the sensor package is reduced to a minimum by the internal measurement algorithm.

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

However, some extreme cases will influence the sensor.

The typical supply voltage of the MLX90632 is 3.3V. The communication with the chip is done by I<sup>2</sup>C in fast mode plus (FM+). Through I<sup>2</sup>C the external microcontroller has access to the following blocks:

- RAM memory used for measurement data
- EEPROM used to store the trimming values, calibration constants and device/measurement settings
- Register to control the sensor

Based on this data, the external microcontroller can calculate the object temperature and if needed the sensor temperature.

An optical filter (long-wave pass) that cuts off the visible and near infrared radiant flux is integrated in the sensor to provide ambient light immunity. The wavelength pass band of this optical filter is from 2 till 14µm.

## Contents

|   |    |
|---|----|
| Features and Benefits.....                    | 1  |
| Application Examples .....                    | 1  |
| Description.....                              | 2  |
| 2. Ordering Information .....                 | 5  |
| 3. Glossary of Terms.....                     | 6  |
| 4. Absolute Maximum ratings.....              | 7  |
| 5. Pin definitions and descriptions.....      | 8  |
| 6. Electrical characteristics .....           | 9  |
| 7. Product Description.....                   | 10 |
| 7.1. Block diagram.....                       | 10 |
| 7.2. Description .....                        | 10 |
| 8. Memory map.....                            | 11 |
| 9. Control and configuration registers .....  | 13 |
| 9.1. REG_CONTROL .....                        | 13 |
| 9.2. REG_STATUS .....                         | 14 |
| 10. I <sup>2</sup> C commands .....           | 15 |
| 10.1. Addressed read .....                    | 16 |
| 10.2. Addressed write .....                   | 16 |
| 10.3. Global reset.....                       | 17 |
| 10.4. Addressed reset .....                   | 17 |
| 10.5. EEPROM unlock for customer access ..... | 17 |
| 10.6. Direct read .....                       | 18 |
| 11. Operating Modes.....                      | 19 |
| 12. Temperature calculation .....             | 20 |
| 12.1. Pre-calculations.....                   | 21 |
| 12.1.1. Ambient.....                          | 21 |
| 12.1.2. Object .....                          | 21 |
| 12.2. Ambient temperature .....               | 22 |
| 12.3. Object temperature.....                 | 22 |
| 12.4. Example Temperature Calculation .....   | 23 |
| 12.4.1. Ambient temperature calculation ..... | 24 |

12.4.2. Object temperature calculation.....25

**13. Performance characteristics ..... 27**

13.1. Accuracy .....27

13.2. Field of View (FoV).....28

**14. Mechanical Drawing ..... 29**

14.1. Package dimensions .....29

14.2. PCB footprint.....30

**15. Application schematic..... 31**

**16. Standard information regarding manufacturability of Melexis products with different soldering processes..... 32**

**17. ESD Precautions..... 33**

**18. FAQ ..... 33**

**19. Table of figures..... 34**

**20. Disclaimer..... 34**

**21. Contact Information ..... 35**

## 2. Ordering Information

| Product  | Temperature Code | Package | Option Code | Packing Form |
|----------|------------------|---------|-------------|--------------|
| MLX90632 | S                | LD      | BCB-000     | RE/SP        |

Table 1 : Ordering codes for MLX90632

### Legend:

|                   |  |
|-------------------|--|
| Temperature Code: | S: from -20°C to 85°C sensor temperature   |
| Package Code:     | “LD” for SFN 3x3 package   |
| Option Code:      | <p>XYZ-123</p> <p>X: Accuracy</p> <ul style="list-style-type: none"> <li>B: standard accuracy</li> </ul> <p>Y: Pixel type</p> <ul style="list-style-type: none"> <li>C: high stability version</li> </ul> <p>Z: Field Of View</p> <ul style="list-style-type: none"> <li>B: 50 degrees</li> </ul> <p>1: I<sup>2</sup>C level</p> <ul style="list-style-type: none"> <li>0: 3V3</li> </ul> <p>2-3:</p> <ul style="list-style-type: none"> <li>00: Standard configuration</li> <li>xx: Reserved</li> </ul> |
| Packing Form:     | <p>“RE” for Reel</p> <p>“SP” for sampling quantities in tubes</p>  |
| Ordering Example: | <p>“MLX90632SLD-BCB-000-RE”</p> <p>For a non-contact thermometer in SFN 3x3 package with standard accuracy and a Field Of View of 50 degrees, delivered in Reel.</p>   |

Table 2: Coding legend

### 3. Glossary of Terms

|                  |  |
|------------------|--|
| POR              | <b>P</b> ower <b>O</b> n <b>R</b> eset   |
| IR               | <b>I</b> nfra <b>R</b> ed  |
| I <sup>2</sup> C | <b>I</b> nter- <b>I</b> ntegrated <b>C</b> ircuit                                      |
| SDA              | <b>S</b> erial <b>D</b> Ata – I <sup>2</sup> C compatible communication pins           |
| SCL              | <b>S</b> erial <b>C</b> Lock – I <sup>2</sup> C compatible communication pins          |
| ACK / NACK       | <b>A</b> cknowledge / <b>N</b> ot <b>A</b> cknowledge                                  |
| SOC              | <b>S</b> tart <b>O</b> f <b>C</b> onversion  |
| EOC              | <b>E</b> nd <b>O</b> f <b>C</b> onversion  |
| FOV              | <b>F</b> ield <b>O</b> f <b>V</b> iew  |
| Ta               | <b>A</b> mbient <b>T</b> emperature measured from the chip – (the package temperature) |
| To               | <b>O</b> bject <b>T</b> emperature, ‘seen’ from IR sensor                              |
| SFN              | <b>S</b> ingle <b>F</b> lat pack <b>N</b> o-lead                                       |
| TBD              | <b>T</b> o <b>B</b> e <b>D</b> efined  |
| LSB              | <b>L</b> east <b>S</b> ignificant <b>B</b> it  |
| MSB              | <b>M</b> ost <b>S</b> ignificant <b>B</b> it   |
| EMC              | <b>E</b> lectro- <b>M</b> agnetic <b>C</b> ompatib <b>i</b> lity                       |
| ESD              | <b>E</b> lectro- <b>S</b> tatic <b>D</b> ischarge                                      |
| HBM              | <b>H</b> uman <b>B</b> ody <b>M</b> odel   |
| CDM              | <b>C</b> harged <b>D</b> evice <b>M</b> odel   |

*Table 3: List of abbreviations*

## 4. Absolute Maximum ratings

| Parameter                      | Symbol     | Min. | Max.           | Unit |
|--------------------------------|------------|------|----------------|------|
| Supply Voltage, (over voltage) | $V_{DD}$   |      | 5              | V    |
| Supply Voltage, (operating)    | $V_{DD}$   |      | 3.6            | V    |
| Reverse Voltage                | $V_R$      |      | -1.5           | V    |
| Address-pin Voltage            | $V_{ADDR}$ |      | $V_{DD} + 0.6$ | V    |
| Operating Temperature Range    | $T_A$      | -20  | +85            | °C   |
| Storage Temperature Range      | $T_S$      | -40  | +105           | °C   |
| ESD Sensitivity (AEC Q100 002) |            |      |                |      |
| - HBM                          |            |      | 2              | kV   |
| - CDM                          |            |      | 750            | V    |
| - Air discharge                |            |      | +4             | kV   |
| - Contact discharge            |            |      | +2             | kV   |
| DC current into SCL            |            |      | 10             | μA   |
| DC sink current, SDA pin       |            | 20   |                | mA   |
| DC clamp current, SDA pin      |            |      | 25             | mA   |
| DC clamp current, SCL pin      |            |      | 25             | mA   |

Table 4: Absolute maximum ratings

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

## 5. Pin definitions and descriptions

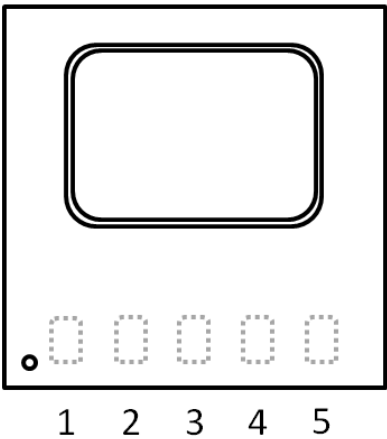


Figure 2: MLX90632 pinout, TOP view

| Pin # | Name | Direction | Description                     |
|-------|------|-----------|---------------------------------|
| 1     | SDA  | In/Out    | I <sup>2</sup> C Data line      |
| 2     | VDD  | POWER     | Supply                          |
| 3     | GND  | GND       | Ground                          |
| 4     | SCL  | In        | I <sup>2</sup> C Clock line     |
| 5     | ADDR | In        | LSB of I <sup>2</sup> C address |

Table 5: Pin definition



## 6. Electrical characteristics

All parameters are valid for  $T_A = 25\text{ }^{\circ}\text{C}$ ,  $V_{DD} = 3.3\text{V}$  (unless otherwise specified)

| Parameter   | Symbol           | Test Conditions                                       | Min                 | Typical  | Max                 | Units         |
|---|------------------|---|---------------------|----------|---------------------|---------------|
| <b>Supplies</b>   |                  |   |                     |          |                     |               |
| External supply   | $V_{DD}$         |   | 3                   | 3.3      | 3.6                 | V             |
| Supply current  | $I_{DD}$         | No load   | 0.5                 | 1        | 1.4                 | mA            |
| Sleep current   | $I_{DDpr}$       | No load, erase/write EEPROM operations                |                     | 1.5      | 2.5                 | $\mu\text{A}$ |
| <b>Power On Reset</b>                                       |                  |   |                     |          |                     |               |
| POR level   | $V_{POR\ up}$    | Power-up (full temp range)                            | 1.3                 |          | 2.4                 | V             |
| POR level   | $V_{POR\ down}$  | Power-down (full temp range)                          | 1.1                 |          | 2.1                 | V             |
| POR hysteresis  | $V_{POR\ hys}$   | Full temperature range                                | 200                 |          | 500                 | mV            |
| $V_{DD}$ rise time (10% to 90% of specified supply voltage) | $T_{POR}$        | Ensure POR signal                                     |                     |          | 20                  | ms            |
| Output valid (result in RAM)                                | $T_{valid}$      | After POR   | 64                  |          |                     | ms            |
| <b>I<sup>2</sup>C compatible 2-wire interface</b>           |                  |   |                     |          |                     |               |
| I <sup>2</sup> C Voltage                                    | $V_{I2C}$        |   | 3                   | $V_{DD}$ | 3.6                 | V             |
| Input high voltage  | $V_{IH}$         | Over temperature and supply                           | $0.7 \cdot V_{I2C}$ |          | $V_{I2C} + 0.5$     | V             |
| Input low voltage   | $V_{IL}$         | Over temperature and supply                           | -0.5                |          | $0.3 \cdot V_{I2C}$ | V             |
| Output low voltage  | $V_{OL}$         | Over temperature and supply                           | 0                   |          | 0.4                 | V             |
| Address pin voltage ("1")                                   | $V_{ADDR,HI}$    |   | 2                   | $V_{DD}$ | $V_{DD} + 0.5$      | V             |
| Address pin voltage ("0")                                   | $V_{ADDR,LO}$    |   | 0                   |          | 0.5                 | V             |
| ADDR leakage  | $I_{ADDR, leak}$ |   |                     |          | 1                   | $\mu\text{A}$ |
| SCL leakage   | $I_{SCL, leak}$  | $V_{SCL} = 3.6\text{V}$ , $T_A = +85^{\circ}\text{C}$ |                     |          | 1                   | $\mu\text{A}$ |
| SDA leakage   | $I_{SDA, leak}$  | $V_{SDA} = 3.6\text{V}$ , $T_A = +85^{\circ}\text{C}$ |                     |          | 1                   | $\mu\text{A}$ |
| SCL capacitance   | $C_{SCL}$        |   |                     |          | 10                  | pF            |
| SDA capacitance   | $C_{SDA}$        |   |                     |          | 10                  | pF            |
| Slave address   | SA               | Factory default, ADDR-pin grounded                    |                     | 3A       |                     | hex           |

Table 6: Electrical characteristics

## 7. Product Description

### 7.1. Block diagram

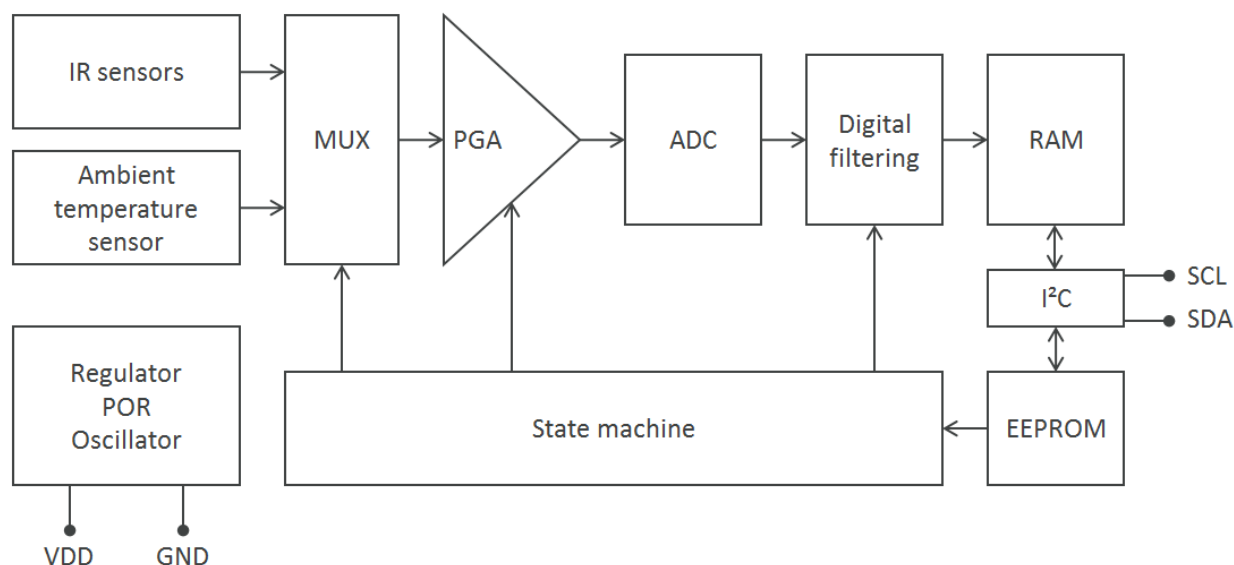


Figure 3: Block diagram

### 7.2. Description

The MLX90632 is a far infrared, non-contact temperature sensor which is factory calibrated to a high accuracy. Internally, electrical and thermal precautions are taken to compensate for thermally harsh external conditions. 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 MLX90632 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 I<sup>2</sup>C.

The communication to the chip is done by I<sup>2</sup>C in fast mode plus (FM+). The requirement of the standard is to run at frequencies up to 1MHz. Through I<sup>2</sup>C the external unit can have access to the following blocks:

- Control registers of internal state machines
- RAM (96bit x 16bit) for pixel and auxiliary measurement data, in this document mainly referred to as 'storage memory'.
- EEPROM (256bit x 16bit) used to store the trimming values, calibration constants and various device/measurement settings.

From the measurement data and the calibration data the external unit can calculate both the sensor temperature and the object temperature. The calculation allows the customer to adjust the calibration for his own application in case an optical window or obstructions are present.

## 8. Memory map

| Access<br>(Write key<br>required) | Address | Name           | Description   |
|-----------------------------------|---------|----------------|---|
| <b>EEPROM</b>                     |         |                |   |
| 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_Aa [15:0]   | Aa calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x2415  | EE_Aa [31:16]  | Aa calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x2416  | EE_Ab [15:0]   | Ab calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x2417  | EE_Ab [31:16]  | Ab calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x2418  | EE_Ba [15:0]   | Ba calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x2419  | EE_Ba [31:16]  | Ba calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x241A  | EE_Bb [15:0]   | Bb calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x241B  | EE_Bb [31:16]  | Bb calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x241C  | EE_Ca [15:0]   | Ca calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x241D  | EE_Ca [31:16]  | Ca calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x241E  | EE_Cb [15:0]   | Cb calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x241F  | EE_Cb [31:16]  | Cb calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x2420  | EE_Da [15:0]   | Da calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x2421  | EE_Da [31:16]  | Da calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x2422  | EE_Db [15:0]   | Db calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x2423  | EE_Db [31:16]  | Db calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x2424  | EE_Ea [15:0]   | Ea calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x2425  | EE_Ea [31:16]  | Ea calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x2426  | EE_Eb [15:0]   | Eb calibration constant (16-bit, Least Significant Word)  |
| Read-only                         | 0x2427  | EE_Eb [31:16]  | Eb calibration constant (16-bit, Most Significant Word)   |
| Read-only                         | 0x2428  | EE_Fa [15:0]   | Fa calibration constant (16-bit, Least Significant Word)  |

|                 |        |                  |  |
|-----------------|--------|------------------|--|
| Read-only       | 0x2429 | EE_Fa [31:16]    | Fa calibration constant (16-bit, Most Significant Word)  |
| Read-only       | 0x242A | EE_Fb [15:0]     | Fb calibration constant (16-bit, Least Significant Word)   |
| Read-only       | 0x242B | EE_Fb [31:16]    | Fb calibration constant (16-bit, Most Significant Word)  |
| Read-only       | 0x242C | EE_Ga [15:0]     | Ga calibration constant (16-bit, Least Significant Word)   |
| Read-only       | 0x242D | EE_Ga [31:16]    | Ga calibration constant (16-bit, Most Significant Word)  |
| Read-only       | 0x242E | EE_Gb [15:0]     | Gb calibration constant (16-bit)   |
| Read-only       | 0x242F | EE_Ka [15:0]     | Ka calibration constant (16-bit)   |
| Read-only       | 0x2430 | EE_Kb [15:0]     | Kb calibration constant (16-bit)   |
| -               | -      | Melexis reserved |  |
| 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             | 0x24D4 | EE_CONTROL       | EEPROM Control register, measurement control   |
| R/W             | 0x24D5 | EE_I2C_ADDRESS   | I <sup>2</sup> C slave address >> 1<br><u>Example:</u> standard address (= 0x003A) >> 1 = 0x001D |
| <b>REGISTER</b> |        |                  |  |
| R/W             | 0x3000 | REG_I2C_ADDRESS  | I <sup>2</sup> C slave address >> 1  |
| R/W             | 0x3001 | REG_CONTROL      | Control register, measurement mode   |
| -               | -      | Melexis reserved |  |
| R/W             | 0x3FFF | REG_STATUS       | Status register: data available  |
| <b>RAM</b>      |        |                  |  |
| Read-only       | 0x4000 | RAM_1            | Raw data 1   |
| Read-only       | 0x4001 | RAM_2            | Raw data 2   |
| Read-only       | 0x4002 | RAM_3            | Raw data 3   |
| Read-only       | 0x4003 | RAM_4            | Raw data 4   |
| Read-only       | 0x4004 | RAM_5            | Raw data 5   |
| Read-only       | 0x4005 | RAM_6            | Raw data 6   |
| Read-only       | 0x4006 | RAM_7            | Raw data 7   |
| Read-only       | 0x4007 | RAM_8            | Raw data 8   |
| Read-only       | 0x4008 | RAM_9            | Raw data 9   |

*Table 7: Memory table*

**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.

The least significant 16 bits of the parameter starts on the address shown in the Memory table.

Example: To retrieve value EE\_Aa (32bit) = EE\_Aa\_MS (at 0x2415) << 16 | EE\_Aa\_LS (at 0x2414)

## 9. Control and configuration registers

Several registers are available to control and configure the measurements:

### 9.1. REG\_CONTROL

REG\_CONTROL controls the measurement handling and data storage.

| Bits  | Parameter    | Description   | See section |
|-------|--------------|---|-------------|
| 15:12 | MLX internal |   |             |
| 10    | MLX internal |   |             |
| 9     | MLX internal |   |             |
| 8:4   | MLX internal |   |             |
| 3     | soc          | starts a measurement when being in (sleeping) step mode   | 11          |
| 2:1   | mode[1:0]    | defines the operating mode (step mode or continuous mode) | 11          |
| 0     | MLX internal |   |             |

Table 8: REG\_CONTROL register

Note that this register is initialized during POR by the EEPROM word EE\_CONTROL.

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 by default 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).

## 9.2. REG\_STATUS

REG\_STATUS allows checking in which state the device is and indicates when measurements are finished.

| Bits | Parameter   | Description  | See section        |
|------|-------------|--|--------------------|
| 10   | device_busy | Read-only<br>Flag indicating that a measurement is being executed (1: measurement ongoing)<br>In sleep mode, this flag is always low.<br>In continuous mode, this flag is always high.<br>In step mode, this flag is high during one measurement.                            |                    |
| 9    | eprom_busy  | Read-only<br>Flag indicating that the eeprom is busy (0: not busy)<br>Eeprom being busy is defined as follows:<br>- at start-up, the eeprom is busy and remains busy till initialization phase (eeprom copy) has finished<br>- during eeprom write/erase, the eeprom is busy |                    |
| 8    | brown_out   | Bit is set to 0<br>Customer should set bit to 1<br>When device is reset, the bit is set to 0 and reset can be detected   |                    |
| 6:2  | cycle_pos   | Read-only<br>Cycle_pos returns the current position of the measurement defined by the measurement table (number from 0 to 31)  |                    |
| 0    | new_data    | Customer should set bit to 0<br>When a measurement is done, the bit is set to 1<br>Customer can readout the data and reset the bit to 0  | <a href="#">11</a> |

Table 9: REG\_STATUS register

## 10. I<sup>2</sup>C commands

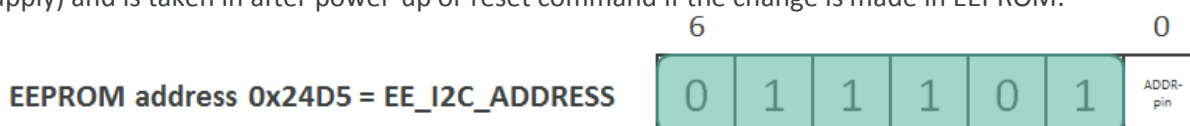
This device is based on I<sup>2</sup>C specification Rev.5 – October 9<sup>th</sup> 2012. I<sup>2</sup>C FM+ mode is supported.

The sensor implements following I<sup>2</sup>C features:

- Slave mode only
- 7-bits addressing
- Modes: Standard-mode, Fast-mode, Fast-mode Plus
- Incremental addressing – allowing a block of addresses to be accessed inside one I<sup>2</sup>C sequence

As a standard, the device responds to the 7-bit slave address: 0x3A.

The least significant bit 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.



Part that is written in EEPROM  
= 0x1D



7-bit slave address  
= 0x3A if ADDR-pin is pulled low  
= 0x3B if ADDR-pin is pulled high

**Important!** The device will not respond if the I<sup>2</sup>C 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.

The following I<sup>2</sup>C commands are implemented:

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

**Important!** The device shall not execute measurements when performing EEPROM memory operations (I<sup>2</sup>C 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.

## 10.1. Addressed read

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

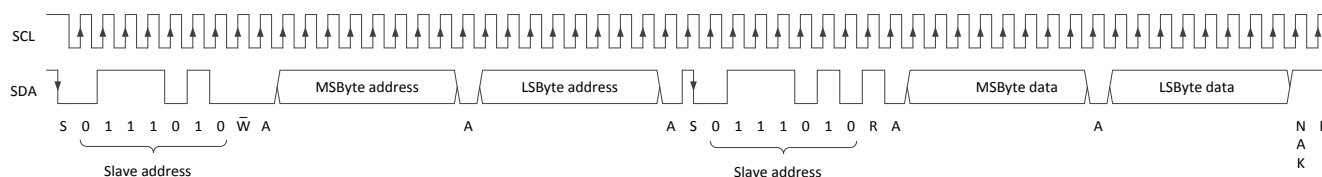


Figure 4: Addressed read

### **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.

## 10.2. Addressed write

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

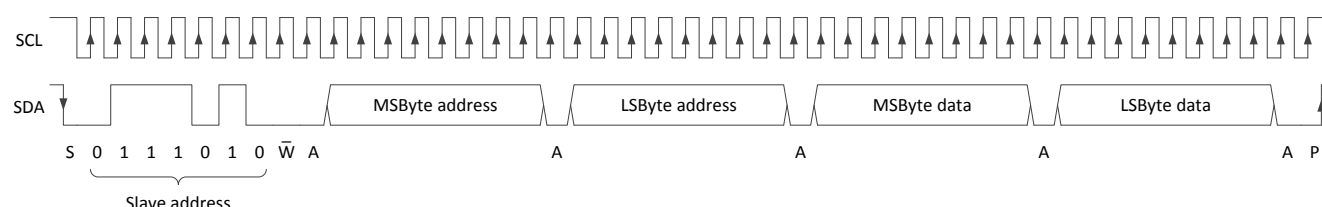


Figure 5: Addressed write

### **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`.



## 10.3. Global reset

This command resets all devices on the I<sup>2</sup>C bus (based on the general call address 0x00).

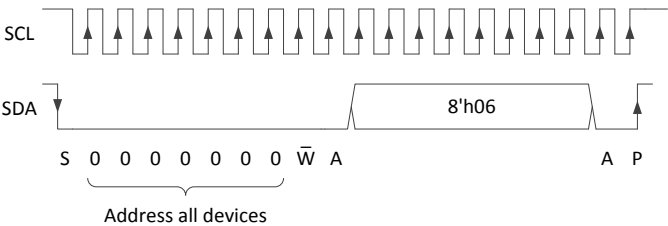


Figure 6: Global reset

## 10.4. Addressed reset

This command resets the addressed device only (based on the I<sup>2</sup>C address).

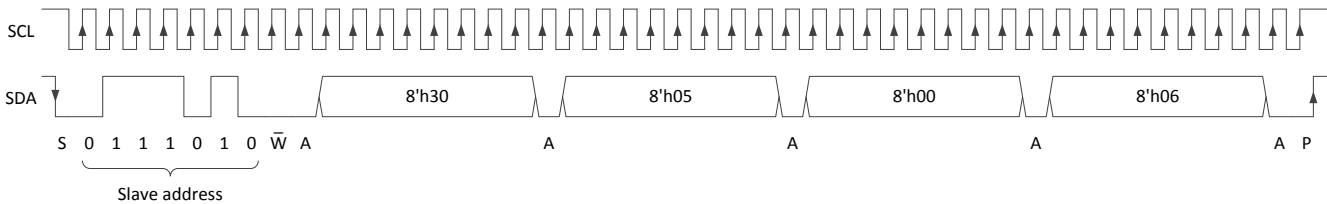


Figure 7: Addressed reset

## 10.5. 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.

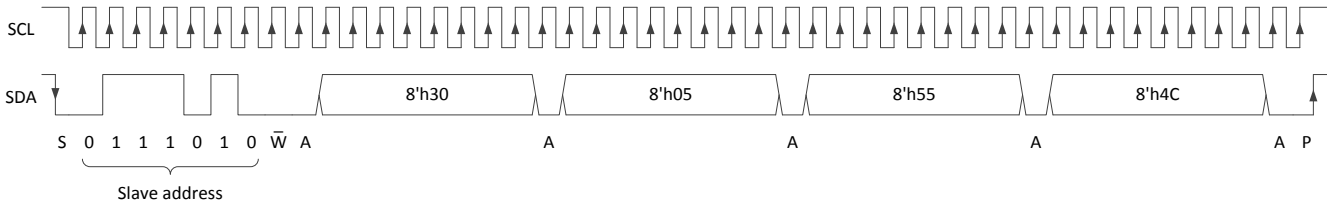


Figure 8: EEPROM unlock

## 10.6. 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 I<sup>2</sup>C specification, the master will keep sending an acknowledge (A) until it want to stop. This is indicated by sending a NACK. As a result, the slave will stop driving the SDA-bus as soon as a NACK is received by the master.

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

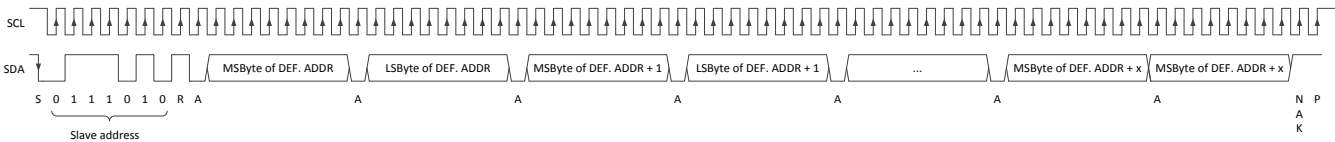


Figure 9: Direct read

## 11. Operating Modes

The device has two 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  $\mu\text{A}$ .

- **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 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.

The device will be by default in sleep mode. 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.

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).

## 12. Temperature calculation

To calculate the ambient and object temperature, a set of 2 measurements is required:

- Measurement 1: RAM\_4, RAM\_5, RAM\_6;
- Measurement 2: RAM\_7, RAM\_8, RAM\_9;

One should notice this requires double the measurement time than specified ( $= 2 * 512\text{ms}$ ).

However, this is only valid for the very first calculation.

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

### Example:

|     |  |    |   |    |          |
|-----|--|----|---|----|----------|
| t0: | Measurement 1<br>(cycle_pos = 1)       | => | no calculation of TA or TO possible<br>because not all parameters are known |    |          |
| t1: | Measurement 2<br>(cycle_pos = 2)       | => | calculate TA (RAM_6, RAM_9)<br>calculate TO (RAM_7, RAM_8, RAM_6, RAM_9)    | => | 1 s.     |
| t2: | Measurement 3 (= 1)<br>(cycle_pos = 1) | => | calculate TA (RAM_6, RAM_9)<br>calculate TO (RAM_4, RAM_5, RAM_6, RAM_9)    | => | 0.512 s. |
| t3: | Measurement 4 (= 2)<br>(cycle_pos = 2) | => | calculate TA (RAM_6, RAM_9)<br>calculate TO (RAM_7, RAM_8, RAM_6, RAM_9)    | => | 0.512 s. |
| t4: | ...                                    |    |   |    |          |

To calculate the new ambient and object temperature RAM\_6 and RAM\_9 have to be used.

The choice between [RAM\_4 and RAM\_5] or [RAM\_7 and RAM\_8] 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 and the data from measurement (x-1), TA and TO can be calculated every 512ms.

The complete measurement sequence can be automated by using the new\_data bit in combination with cycle\_pos bits.

The sequence should look like the following:

- Write new\_data = 0
- Check when new\_data = 1
- Read cycle\_pos to get measurement pointer
  - ❑ If cycle\_pos = 1
    - Calculate TA and TO based on RAM\_4, RAM\_5, RAM\_6, RAM\_9
  - ❑ If cycle\_pos = 2
    - Calculate TA and TO based on RAM\_7, RAM\_8, RAM\_6, RAM\_9
- Return to top

## 12.1. Pre-calculations

### 12.1.1. Ambient

$$VR_{TA} = RAM\_9 + Gb * \frac{RAM\_6}{12}$$

$$Gb = EE\_Gb * 2^{-10}$$

$$AMB = \left\lceil \frac{RAM\_6}{12} \right\rceil / VR_{TA} * 2^{19}$$

The parameter EE\_Gb is a signed 16-bit number.

### 12.1.2. Object

$$S = \frac{RAM\_4 + RAM\_5}{2}$$

OR

$$S = \frac{RAM\_7 + RAM\_8}{2}$$

$$VR_{TO} = RAM\_9 + Ka * \frac{RAM\_6}{12}$$

$$Ka = EE\_Ka * 2^{-10}$$

$$S_{TO} = \left\lceil \frac{S}{12} \right\rceil / VR_{TO} * 2^{19}$$

The parameter EE\_Ka is a signed 16-bit number.

## 12.2. Ambient temperature

$$Ta \text{ (sensor temperature in } ^\circ\text{C)} = P\_O + \frac{AMB - P\_R}{P\_G} + P\_T * (AMB - P\_R)^2$$

**With:**

Ta in degrees Celsius

$$\begin{aligned} P\_R &= EE\_P\_R * 2^{-8} \\ P\_O &= EE\_P\_O * 2^{-8} \\ P\_G &= EE\_P\_G * 2^{-20} \\ P\_T &= EE\_P\_T * 2^{-44} \end{aligned}$$

The parameters EE\_P\_R, EE\_P\_O, EE\_P\_G and EE\_P\_T are signed 32-bit numbers.

## 12.3. Object temperature

$$\begin{aligned} &TO \text{ (object temperature in } ^\circ\text{C)} \\ &= \sqrt[4]{\frac{S_{TO}}{\epsilon * Fa * Ha * (1 + Ga * (TO_{DUT} - TO_0) + Fb * (TA_{DUT} - TA_0))}} + Ta_{[K]}^4 \\ &- 273.15 - Hb \end{aligned}$$

**With:**

$$\begin{aligned} Fa &= EE\_Fa * 2^{-46} \\ Fb &= EE\_Fb * 2^{-36} \\ Ga &= EE\_Ga * 2^{-36} \\ Ha &= EE\_Ha * 2^{-14} \\ Hb &= EE\_Hb * 2^{-14} \\ TO_0 &= 25^\circ\text{C} \\ TA_0 &= 25^\circ\text{C} \\ TA_{DUT} &= \frac{(AMB - Eb)}{Ea} + 25 \\ Ea &= EE\_Ea * 2^{-16} \\ Eb &= EE\_Eb * 2^{-8} \\ Ta_{[K]} &= TA_{DUT} + 273.15 \text{ in Kelvin} \\ TO_{DUT} &= \text{Object temperature in } 25^\circ\text{C} \\ \epsilon &= 1 = \text{Object Emissivity parameter (not stored in EEPROM, but part of the 'app')} \end{aligned}$$

The parameters EE\_Ea, EE\_Eb, EE\_Fa, EE\_Fb, EE\_Ga are signed 32-bit numbers.

The parameters EE\_Gb, EE\_Ka, EE\_Ha and EE\_Hb are signed 16-bit numbers.

**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 2<sup>nd</sup> iteration the result of first iteration is used, and in the 3<sup>rd</sup> iteration the end result is obtained.

(See example on next page).

## 12.4. Example Temperature Calculation

Assumed are the following calibration parameters read from EEPROM:

| ADDR   | PARAM          | DATA (hex) | hex to dec   | Conversion to use in formula                               |
|--------|----------------|------------|--|--|
| 0x240C | EE_P_R [15:0]  | 0103       | EE_P_R = 005D0103 <sub>hex</sub> = 6095107 <sub>dec</sub>  | <b>P_R</b> = 6095107 * 2 <sup>-8</sup> = <b>23809.01</b>   |
| 0x240D | EE_P_R [31:16] | 005D       |  |  |
| 0x240E | EE_P_G [15:0]  | FAE5       | EE_P_G = 051CFAE5 <sub>hex</sub> = 85785317 <sub>dec</sub> | <b>P_G</b> = 85785317 * 2 <sup>-20</sup> = <b>81.81125</b> |
| 0x240F | EE_P_G [31:16] | 051C       |  |  |
| 0x2410 | EE_P_T [15:0]  | 0000       | EE_P_T = 00000000 <sub>hex</sub> = 0 <sub>dec</sub>        | <b>P_T</b> = 0 * 2 <sup>-44</sup> = <b>0</b>               |
| 0x2411 | EE_P_T [31:16] | 0000       |  |  |
| 0x2412 | EE_P_O [15:0]  | 1900       | EE_P_O = 00001900 <sub>hex</sub> = 6400 <sub>dec</sub>     | <b>P_O</b> = 6400 * 2 <sup>-8</sup> = <b>25</b>            |
| 0x2413 | EE_P_O [31:16] | 0000       |  |  |
| 0x2424 | EE_Ea [15:0]   | CFAE       | EE_Ea = 0051CFAE <sub>hex</sub> = 5361582 <sub>dec</sub>   | <b>Ea</b> = 5361582 * 2 <sup>-16</sup> = <b>81.81125</b>   |
| 0x2425 | EE_Ea [31:16]  | 0051       |  |  |
| 0x2426 | EE_Eb [15:0]   | 0103       | EE_Eb = 005D0103 <sub>hex</sub> = 6095107 <sub>dec</sub>   | <b>Eb</b> = 6095107 * 2 <sup>-8</sup> = <b>23809.01</b>    |
| 0x2427 | EE_Eb [31:16]  | 005D       |  |  |
| 0x2428 | EE_Fa [15:0]   | 6351       | EE_Fa = 03506351 <sub>hex</sub> = 5559995 <sub>dec</sub>   | <b>Fa</b> = 55599953 * 2 <sup>-46</sup> = <b>7.9E-07</b>   |
| 0x2429 | EE_Fa [31:16]  | 0350       |  |  |
| 0x242A | EE_Fb [15:0]   | 71F1       | EE_Fb = FE2571F1 <sub>hex</sub> = -31100431 <sub>dec</sub> | <b>Fb</b> = -31100431 * 2 <sup>-36</sup> = <b>-0.00045</b> |
| 0x242B | EE_Fb [31:16]  | FE25       |  |  |
| 0x242C | EE_Ga [15:0]   | A7A4       | EE_Ga = FDFFA7A5 <sub>hex</sub> = -33577052 <sub>dec</sub> | <b>Ga</b> = -33577052 * 2 <sup>-36</sup> = <b>-0.00049</b> |
| 0x242D | EE_Ga [31:16]  | FDFF       |  |  |
| 0x242E | EE_Gb [15:0]   | 2600       | EE_Gb = 2600 <sub>hex</sub> = 9728 <sub>dec</sub>          | <b>Gb</b> = 9728 * 2 <sup>-10</sup> = <b>9.5</b>           |
| 0x242F | EE_Ka [15:0]   | 2A00       | EE_Ka = 2A00 <sub>hex</sub> = 10752 <sub>dec</sub>         | <b>Ka</b> = 10752 * 2 <sup>-10</sup> = <b>10.5</b>         |
| 0x2481 | EE_Ha [15:0]   | 4000       | EE_Ha = 4000 <sub>hex</sub> = 16384 <sub>dec</sub>         | <b>Ha</b> = 16384 * 2 <sup>-14</sup> = <b>1</b>            |
| 0x2482 | EE_Hb [15:0]   | 0000       | EE_Hb = 0000 <sub>hex</sub> = 0 <sub>dec</sub>             | <b>Hb</b> = 0 * 2 <sup>-14</sup> = <b>0</b>                |

The returned values from the RAM (0x4000 to 0x4008):

| ADDR   | PARAM | DATA (hex) | DATA (dec) |
|--------|-------|------------|------------|
| 0x4003 | RAM_4 | FF9B       | -101       |
| 0x4004 | RAM_5 | FF9D       | -99        |
| 0x4005 | RAM_6 | 57E4       | 22500      |
| 0x4006 | RAM_7 | FF97       | -105       |
| 0x4007 | RAM_8 | FF99       | -103       |
| 0x4008 | RAM_9 | 59D8       | 23000      |

### 12.4.1. Ambient temperature calculation

$$VR_{TA} = RAM_9 + Gb * \frac{RAM_6}{12} = 23000 + 9.5 * \frac{22500}{12}$$

$$VR_{TA} = 40812.5$$

$$AMB = \left[ \frac{RAM_6}{12} \right] / VR_{TA} * 2^{19} = \left[ \frac{22500}{12} \right] / 40812.5 * 2^{19}$$

$$AMB = 24086.73813$$

$$Ta \text{ (sensor temperature in } ^\circ\text{C)} = P_O + \frac{AMB - P_R}{P_G} + P_T * (AMB - P_R)^2$$

$$Ta = 25 + \frac{24086.73813 - 23809.01}{81.81125} + 0 * (24086.73813 - 23809.01)^2$$

$$Ta = 28.395^\circ\text{C}$$

$$Ta = 28.4^\circ\text{C}$$



## 12.4.2. Object temperature calculation

$$S = \frac{RAM\_4 + RAM\_5}{2} = \frac{(-101) + (-99)}{2}$$

$$S = -100$$

OR

$$S = \frac{RAM\_7 + RAM\_8}{2} = \frac{(-105) + (-103)}{2}$$

$$S = -104$$

Assumed is that RAM\_4 and RAM\_5 are updated lastly by the device (cycle\_pos = 1)

$$VR_{TO} = RAM\_9 + Ka * \frac{RAM\_6}{12} = 23000 + 10.5 * \frac{22500}{12}$$

$$VR_{TO} = 42687.5$$

$$S_{TO} = \left[ \frac{S}{12} \right] / VR_{TO} * 2^{19} = \left[ \frac{-100}{12} \right] / 42687.5 * 2^{19}$$

$$S_{TO} = -102.35$$

$$TO_0 = 25^{\circ}\text{C}$$

$$TA_0 = 25^{\circ}\text{C}$$

$$TA_{DUT} = \frac{(AMB - Eb)}{Ea} + 25 = \frac{(24086.73813 - 23809.01)}{81.81125} + 25 = 28.3947$$

$$Ta_{[K]} = TA_{DUT} + 273.15 = 28.3947 + 273.15 = 301.5447$$

$T_o$  (object temperature in °C)

$$= \sqrt[4]{\frac{S_{TO}}{\varepsilon * Fa * Ha * (1 + Ga * (T_{O_{DUT}} - T_{O_0}) + Fb * (T_{A_{DUT}} - T_{A_0}))}} + T_{a[K]}^4 - 273.15 - Hb$$

The emissivity parameter ( $\varepsilon$ ) is controlled by the user and is assumed in this example equal to 1.

$T_{O_{DUT}} = 25$  for the first calculation

$$T_o = \sqrt[4]{\frac{-102.35}{1 * (7.9E - 07) * 1 * (1 + (-0.00049) * (25 - 25) + (-0.00045) * (28.3947 - 25))}} + (301.5447)^4 - 273.15 - 0$$

$$T_o = 27.2048027^\circ\text{C}$$

The object temperature needs to be calculated 3 times in order to get the end result.

Next object temperature calculation uses previous obtained object temperature.

$$T_o = \sqrt[4]{\frac{-102.35}{1 * (7.9E - 07) * 1 * (1 + (-0.00049) * (27.2048027 - 25) + (-0.00045) * (28.3947 - 25))}} + (301.5447)^4 - 273.15 - 0$$

$$T_o = 27.2035098^\circ\text{C}$$

$$T_o = \sqrt[4]{\frac{-102.35}{1 * (7.9E - 07) * 1 * (1 + (-0.00049) * (27.2035098 - 25) + (-0.00045) * (28.3947 - 25))}} + (301.5447)^4 - 273.15 - 0$$

$$T_o = 27.20351053^\circ\text{C}$$

$$T_o = 27.2^\circ\text{C}$$

# 13. Performance characteristics

## 13.1. Accuracy

The MLX90632 is factory calibrated in the temperature range of -20...85°C for the ambient temperature and -20...200°C for the object temperature. The measured value is the average temperature of all objects in the Field Of View of the sensor. The accuracy of the MLX90632 is  $\pm 1^\circ\text{C}$  within the object temperature range of 0 to 50°C for consumer applications.

The calculated ambient temperature has an accuracy of  $\pm 3^\circ\text{C}$  between -20°C and 85°C of ambient temperature. Between 15°C and 45°C the accuracy is  $\pm 1^\circ\text{C}$ .

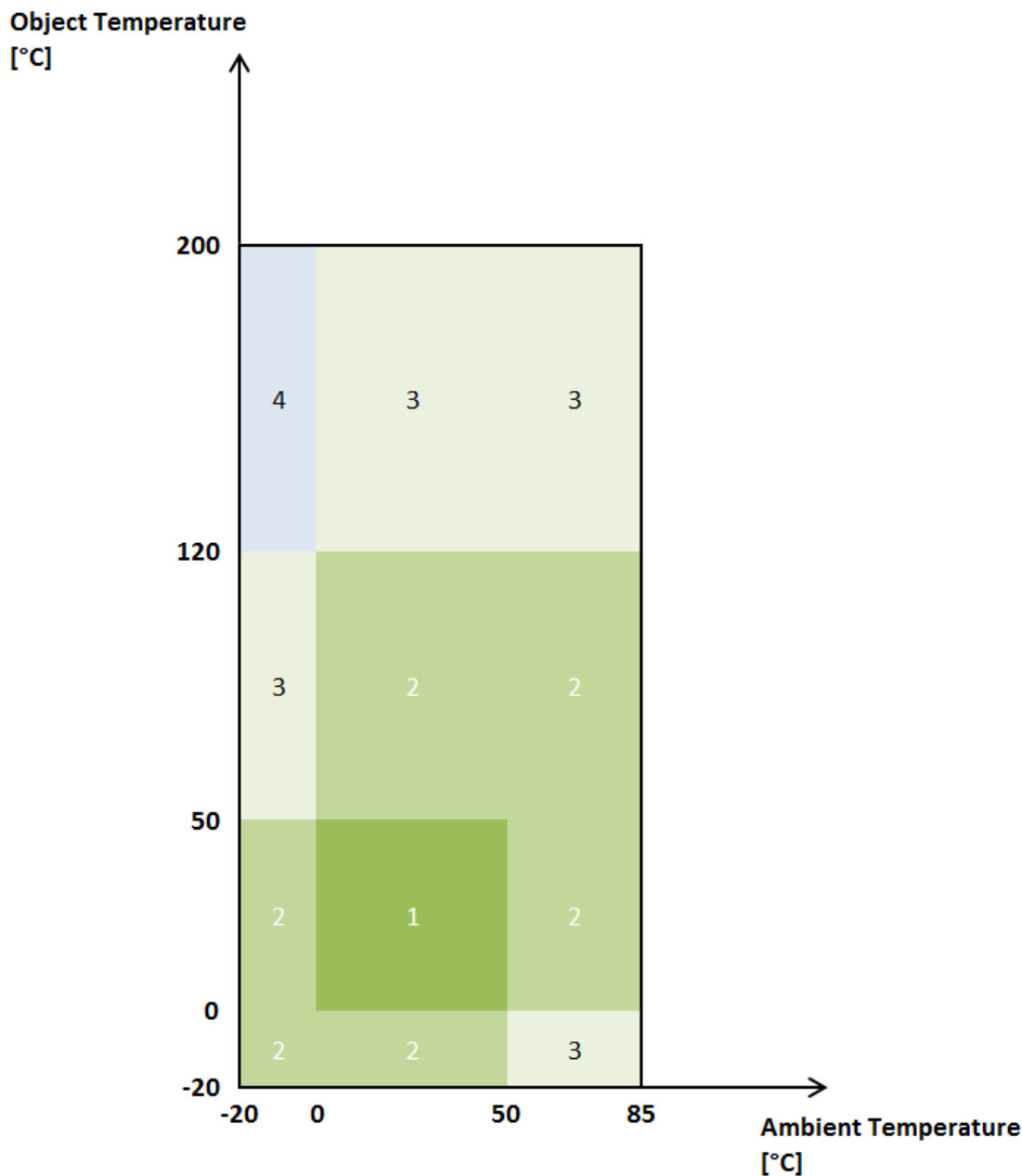


Figure 10 : Accuracy table for VDD = 3.3V

All accuracy specifications apply under settled isothermal conditions only.

## 13.2. Field of View (FoV)

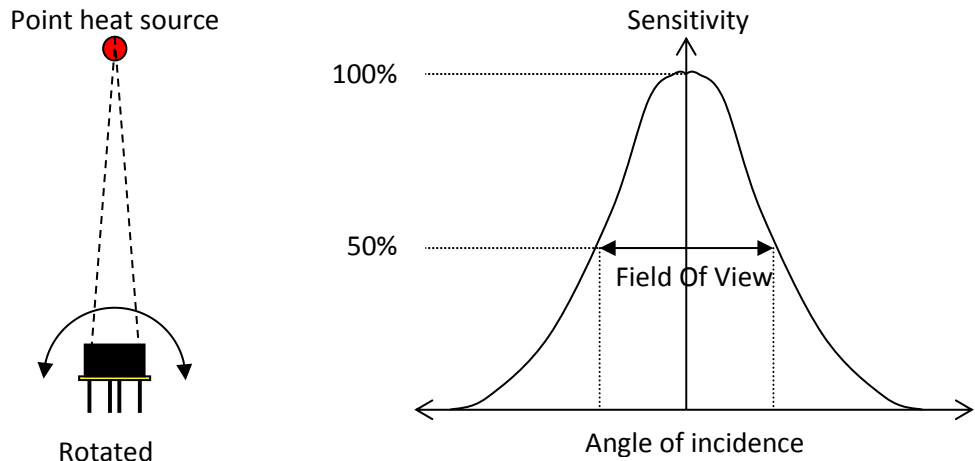


Figure 11: Field of View measurement principle

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

Table 10 : Field Of View of the MLX90632

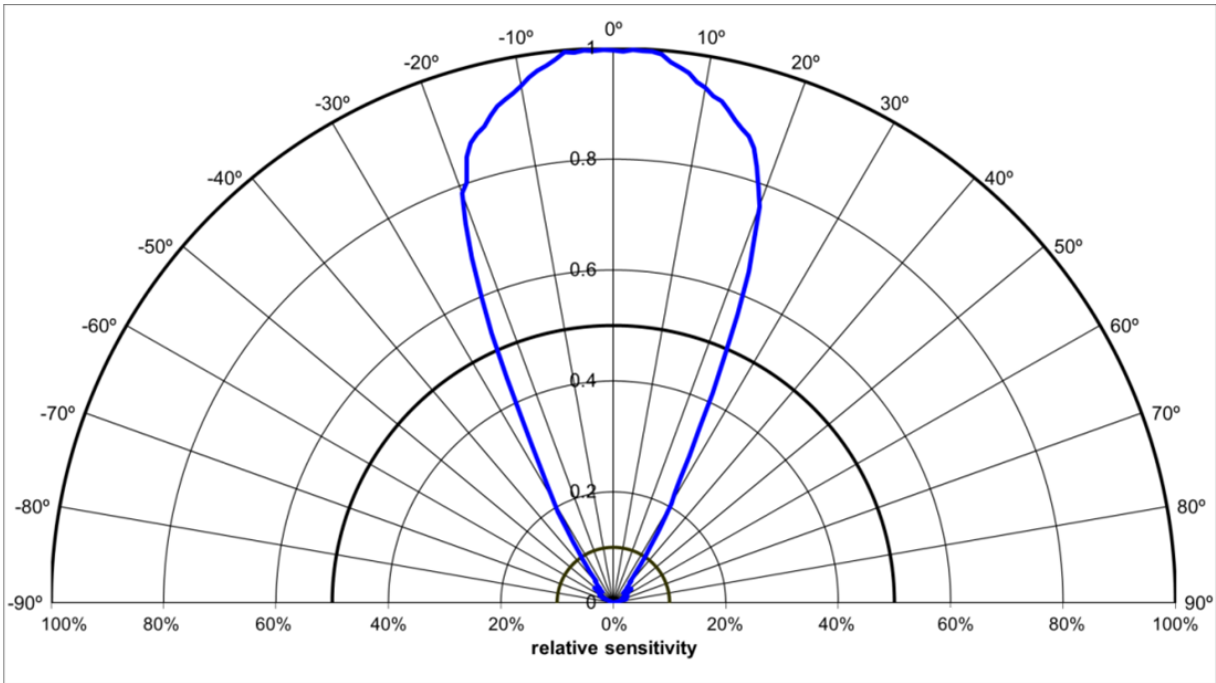


Figure 12: Field of View of MLX90632

## 14. Mechanical Drawing

### 14.1. Package dimensions

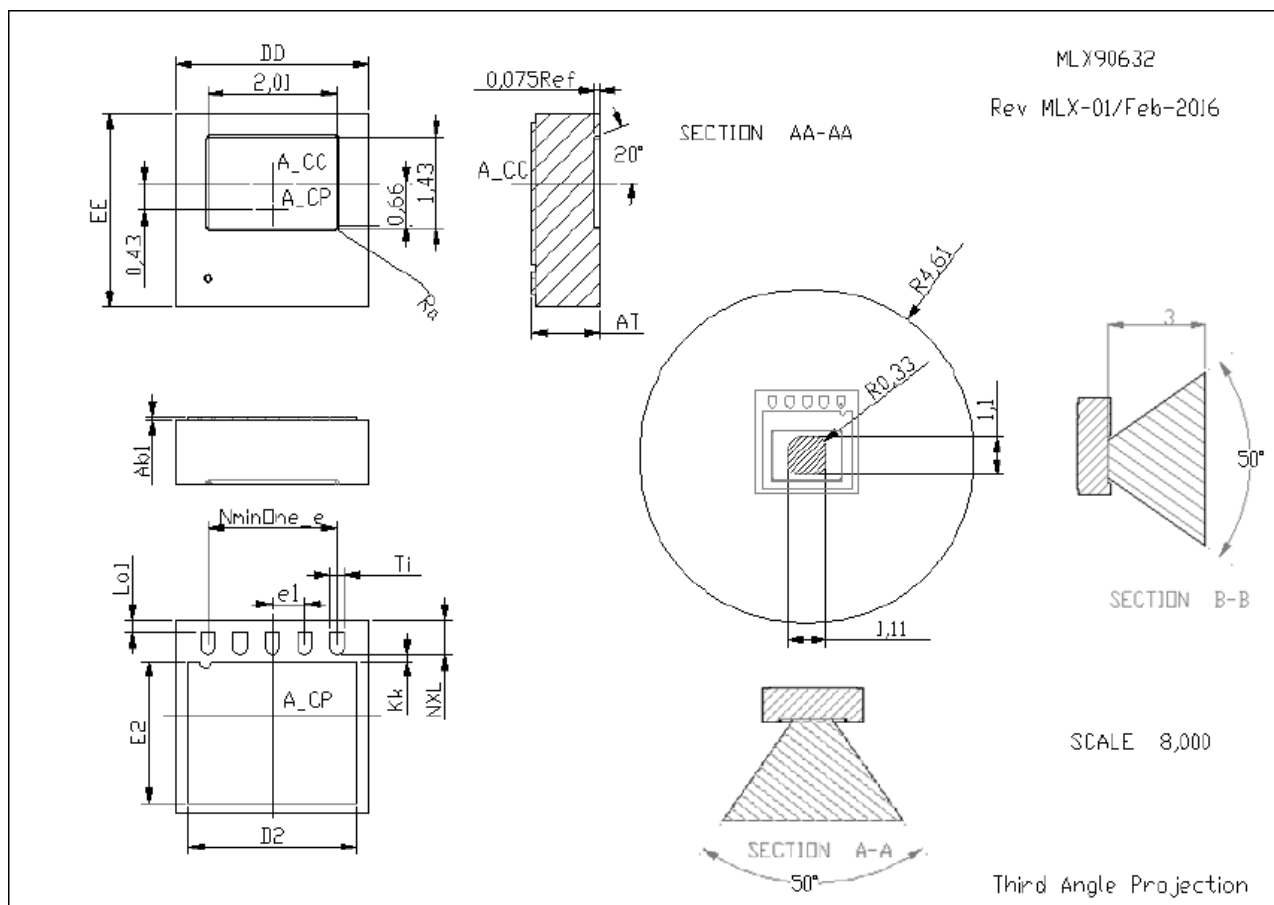


Figure 13: Package dimensions for MLX90632 (FoV = 50°)

| Symbol    | Min      | Nom  | Max  |
|-----------|----------|------|------|
| DD        | 3.00 BSC |      |      |
| EE        | 3.00 BSC |      |      |
| 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 | (5-1)*e1 |      |      |
| Ti        | 0.18     | 0.25 | 0.30 |

Table 11: Package dimensions for MLX90632 (FoV = 50°)

\*BSC ≡ basic dimension

\*A\_CC = Center of silicon Cap

\*A\_CP = Center of Package

## 14.2. PCB footprint

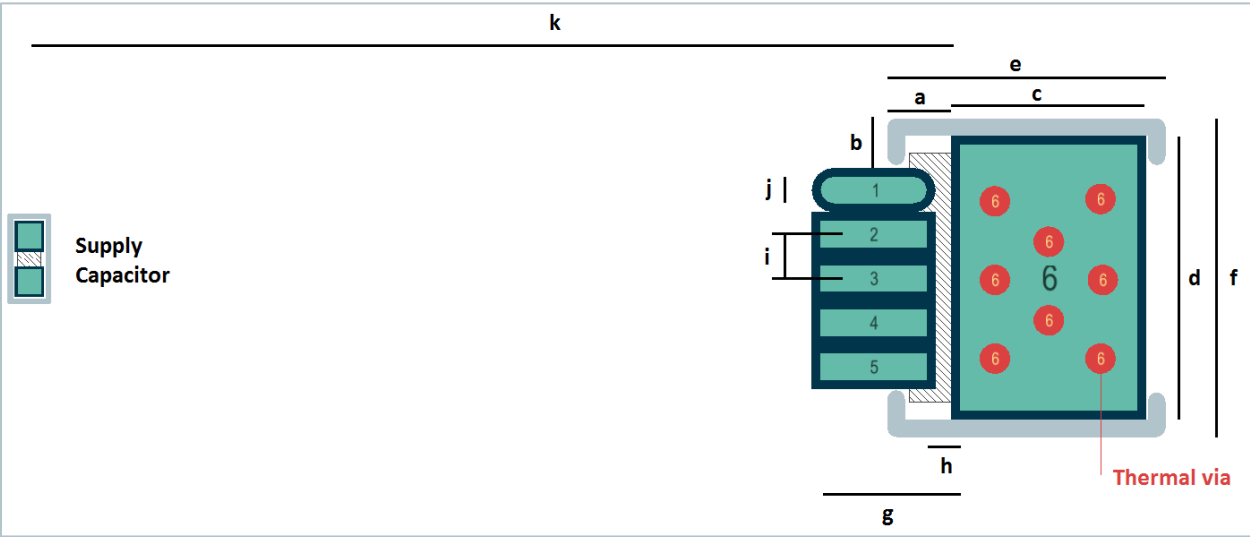


Figure 14: PCB footprint for MLX90632

| Symbol | Distance [mm]  |
|--------|----------------|
| a      | 0.60           |
| b      | 0.25           |
| c      | 2.10           |
| d      | 2.50           |
| e      | 3.00           |
| f      | 3.00           |
| g      | 0.60/0.80/1.00 |
| h      | 0.20           |
| i      | 0.50           |
| j      | 0.30           |
| k      | 10 (max.)      |

Table 12 : PCB footprint dimensions for MLX90632

# 15. Application schematic

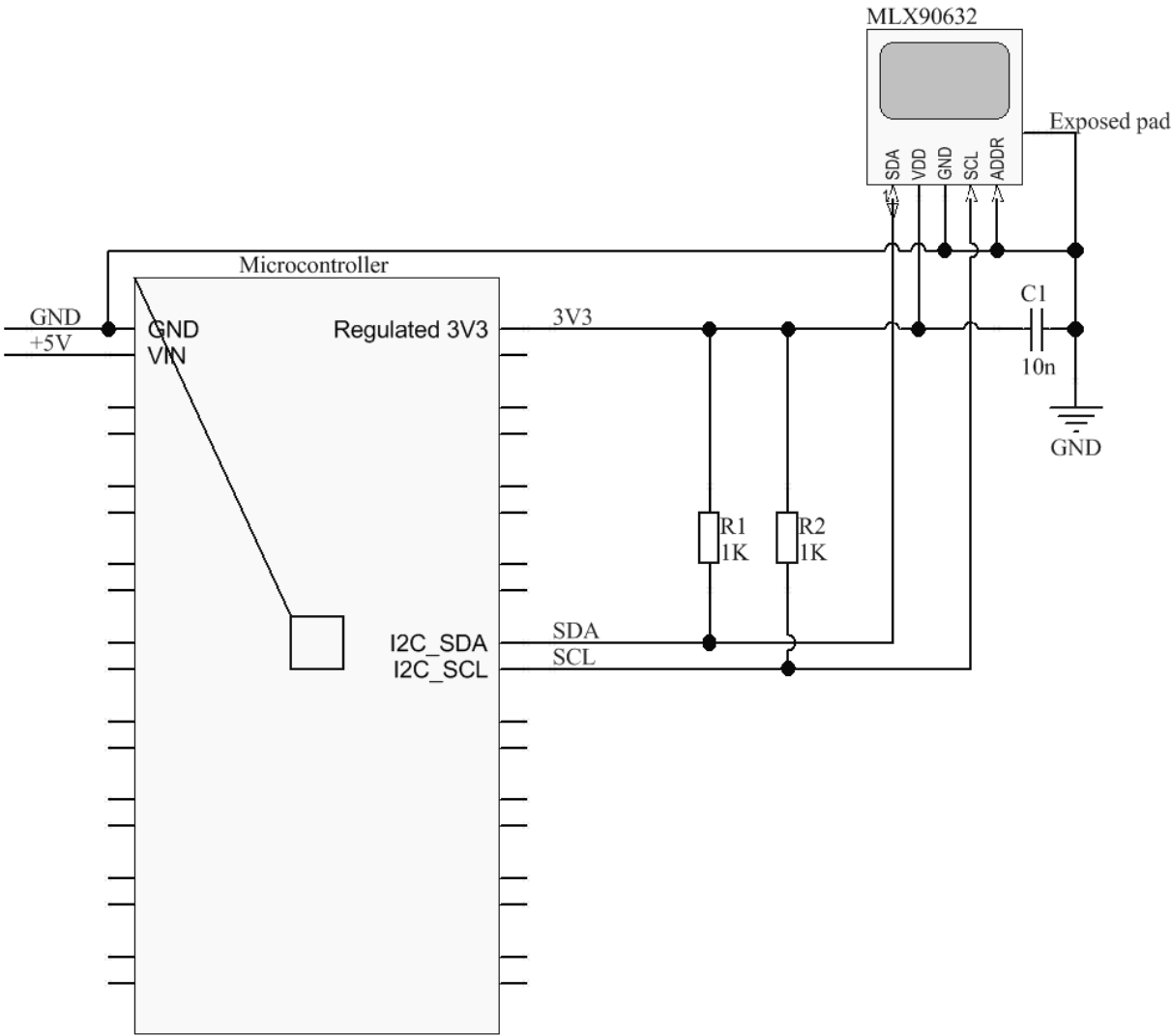


Figure 15: Typical application schematic for I<sup>2</sup>C communication with MLX90632

## 16. Standard information regarding manufacturability of Melexis products with different soldering processes

The MLX90632 is a MSL-3 device.

Our products are classified and qualified regarding soldering technology, solderability and moisture sensitivity level according to following test methods:

### **Reflow Soldering SMD's (Surface Mount Devices)**

- IPC/JEDEC J-STD-020  
Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices  
(Classification reflow profiles according to table 5-2)
- EIA/JEDEC JESD22-A113  
Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing  
(Reflow profiles according to table 2)

### **Wave Soldering SMD's (Surface Mount Devices) and THD's (Through Hole Devices)**

- EN60749-20  
Resistance of plastic- encapsulated SMD's to combined effect of moisture and soldering heat
- EIA/JEDEC JESD22-B106 and EN60749-15  
Resistance to soldering temperature for through-hole mounted devices

### **Iron Soldering THD's (Through Hole Devices)**

- EN60749-15  
Resistance to soldering temperature for through-hole mounted devices

### **Solderability SMD's (Surface Mount Devices) and THD's (Through Hole Devices)**

- EIA/JEDEC JESD22-B102 and EN60749-21  
Solderability

For all soldering technologies deviating from above mentioned standard conditions (regarding peak temperature, temperature gradient, temperature profile etc.) additional classification and qualification tests have to be agreed upon with Melexis.

The application of Wave Soldering for SMD's is allowed only after consulting Melexis regarding assurance of adhesive strength between device and board.

Melexis recommends reviewing on our web site the General Guidelines [soldering recommendation](http://www.melexis.com/Quality_soldering.aspx) ([http://www.melexis.com/Quality\\_soldering.aspx](http://www.melexis.com/Quality_soldering.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>



## 17. ESD Precautions

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

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

## 18. FAQ

1. Significant contamination at the optical input side (sensor filter) might cause unknown additional filtering/distortion of the optical signal and therefore result in unspecified errors.
2. 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 MLX90632, it is recommended not to subject the MLX90632 to strong heat transfer and especially transient conditions.
3. The MLX90632 are designed and calibrated to operate as a non-contact thermometer in settled conditions.
4. Upon power-up the MLX90632 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 and this is not recommended.
5. Capacitive loading on an I<sup>2</sup>C bus can degrade the communication. Some improvement is possible with use of current sources compared to resistors in pull-up circuitry. Further improvement is possible with specialized commercially available bus accelerators.
6. A sleep mode is available in the MLX90632. This mode is entered and exited via the I<sup>2</sup>C compatible 2-wire communication.
7. A power supply decoupling capacitor is needed as with most integrated circuits. The MLX90632 is a mixed-signal device with integrated sensors, small signal analog part, digital part 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 noise performance of the device. In many applications a 10nF SMD ceramic capacitor close to the Vdd and Vss 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 Vss pin.

## 19. Table of figures

|  |    |
|--|----|
| Figure 1: Image of MLX90632.....   | 1  |
| Figure 2: MLX90632 pinout, TOP view .....  | 8  |
| Figure 3: Block diagram .....  | 10 |
| Figure 4: Addressed read .....   | 16 |
| Figure 5: Addressed write .....  | 16 |
| Figure 6: Global reset .....   | 17 |
| Figure 7: Addressed reset .....  | 17 |
| Figure 8: EEPROM unlock.....   | 17 |
| Figure 9: Direct read .....  | 18 |
| Figure 10 : Accuracy table for VDD = 3.3V .....  | 27 |
| Figure 11: Field of View measurement principle .....   | 28 |
| Figure 12: Field of View of MLX90632 .....   | 28 |
| Figure 13: Package dimensions for MLX90632 (FoV = 50°) .....                                   | 29 |
| Figure 14: PCB footprint for MLX90632 .....  | 30 |
| Figure 15: Typical application schematic for I <sup>2</sup> C communication with MLX90632..... | 31 |

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*The information furnished by Melexis is believed to be correct and accurate. However, this User Manual is intended as an aid to enable a user to install engineering parts of the MLX90632 into his own application for evaluation. While Melexis intends for the final production part of the MLX90632 to be comparable to the engineering parts, it is highly probable that changes will still be implemented.*

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## 21. Contact Information

For the latest version of this document, go to our website at  
[www.melexis.com](http://www.melexis.com)

Or for additional information contact Melexis Direct:

**Europe, Africa, Asia:**

Phone: +32 1367 0495

E-mail: [sales\\_europe@melexis.com](mailto:sales_europe@melexis.com)

**America:**

Phone: +1 248 306 5400

E-mail: [sales\\_usa@melexis.com](mailto:sales_usa@melexis.com)

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