General description

1.1 Features & benefits

- Small size, low cost 32x24 pixels IR array
- Easy to integrate
- Industry standard four lead TO39 package
- Factory calibrated (reports temperature)
- Noise Equivalent Temperature Difference (NETD) 0.065K @2Hz refresh rate
- I2C compatible digital interface
- Programmable refresh rate 2Hz…16Hz
- 3.3V supply voltage
- Current consumption ≈ 28mA
- 2 FOV options – 45°x35° and 110°x75°
- Target temperature -40°C…260°C
- Pin compatible with MLX90640
- Ambient operating temperature range from -40°C to 85°C

1.2 Applications examples

- High precision non-contact temperature measurements
- Microwave ovens
- Intrusion / Movement detection
- Temperature sensing element for residential, commercial and industrial building air conditioning
- Busbar monitor
- Industrial temperature control of moving parts
- Visual IR thermometers

1.3 Description

The MLX90642 is a fully calibrated 32x24 pixels thermal IR array imager in an industry standard 4-lead TO39 package with digital interface.
The MLX90642 contains 768 FIR pixels. Also available is an integrated sensor to measure the cold junction temperature of the chip. The outputs of all pixels are linearized To, raw IR data and Ta are stored in internal RAM and are accessible through I^2C.

1.4 Available support & tools

- https://github.com/melexis/mlx90642-library.git
- www.melexis.com/technical-inquiry

Ordering information

Product code	Temperature	Package	Supply	TGC	FOV option	Packing
MLX90642ESF-BCA-000-TU	-40 to 85 °C	SF	Bxx – 3.3V	xCx - ON	xxA - Wide	Tube
MLX90642ESF-BCB-000-TU	-40 to 85 °C	SF	Bxx – 3.3V	xCx - ON	xxB - Narrow	Tube
MLX90642KSF-BCA-000-TU *	-40 to 125 °C	SF	Bxx – 3.3V	xCx - ON	xxA - Wide	Tube
MLX90642KSF-BCB-000-TU *	-40 to 125 °C	SF	Bxx – 3.3V	xCx - ON	xxB - Narrow	Tube

Table 1 – Product codes

* KSF product version not released yet, please contact Melexis for more information

MLX90642ESF-BCA-000-TU

- Packing delivery form – TU = tubes
- Option code for variant – 000 = standard product
- Supply / Gradient / FOV options
- Package code – SF = TO39
- Temperature code – E = -40°C...85°C, K = -40°C...125°C
- Product name

CONTENTS

1 Pins description and block diagram

1.1 Pins description

1.1.1 Pins description for TO39 package

Pin #	Name	I/O [1]	Description
1	SDA	I/O	I^2C serial data
2	VDD	S	Positive supply
3	GND	S	Negative supply (Ground)
4	SCL	I	I^2C serial clock

Table 2 – TO39 package pins description

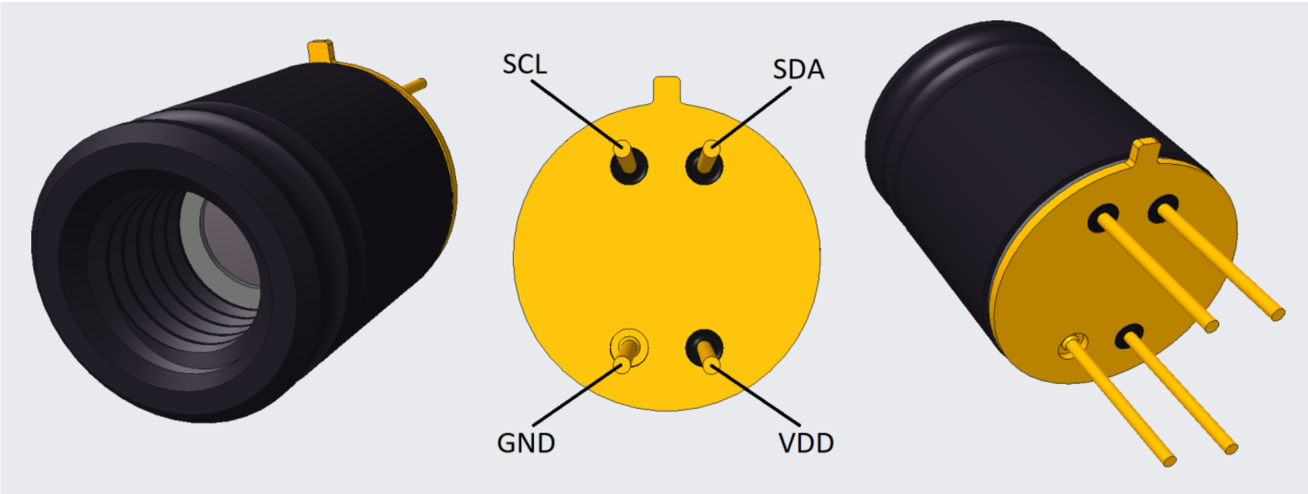


Figure 1 – MLX90642 overview and pin description (depicted narrow FOV device only)

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

2 Conditions and specifications

2.1 Absolute Maximum Ratings (AMR)

(T_A=25°C, unless otherwise specified)

Parameter	Symbol	Min.	Max.	Unit	Condition
Supply voltage	VDD		5	V	< 24 hours
SDA output (sink) current	$I_{\_SDA\_SINK}$		100	mA	< 24 hours
Reverse voltage (each pin)	$V_{REVERSE}$		-0.3	V	< 24 hours
ESD voltage	$V_{ESD-HBM}$		± 4	kV	HBM (AEC-Q100-002), all pins
	$V_{ESD-CDM}$		± 750	V	CDM (AEC-Q100-011)
Storage temperature	T_{STG}	-40	85	°C	
Operating temperature	T_O	-40	85	°C	Ambient temperature
Junction temperature	T_J		95	°C	

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.

2.2 Electrical operating conditions & specifications

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

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply voltage	V_{DD}	3.0	3.3	3.6	V	± 50mV
Supply voltage rising	$V_{DD\text{-rising}}$	0		1000	ms	
Supply voltage falling	$V_{DD\text{-falling}}$	0		1000	ms	

Table 4 – Electrical operating conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Current	I_{DD}	20	28	35	mA	
Sleep current	I_{SLEEP}		2	5	µA	
POR level up	V_{POR_UP}			2.8	V	VDD raising (over Ta)
POR level down	V_{POR_DOWN}	1			V	VDD falling (over Ta)
Input high voltage (SDA, SCL)	V_{IH}	0.7*V_{DD}			V	3.3V option (default)
Input low voltage (SDA, SCL)	V_{ILOW}			0.3*V_{DD}	V	3.3V option (default)
Input high voltage (SDA, SCL)	V_{IH}	1.26			V	1.8V option (up to Ta=85°C)
Input low voltage (SDA, SCL)	V_{ILOW}			0.54	V	1.8V option (up to Ta=85°C)
SDA output low voltage (FM mode)	V_{OL}			0.4	V	I_{SINK}=3mA (over Ta and V_{DD})
SDA output low voltage (FM mode)	V_{OL}			0.6	V	I_{SINK}=6mA (over Ta and V_{DD})
SDA output low voltage (FM+ mode)	V_{OL}			0.4	V	I_{SINK}=20mA (over Ta and V_{DD})
SDA leakage	I_{SDA_LEAK}			20	µA	V_{SDA}=3.6V, Ta=85°C
SCL leakage	I_{SCL_LEAK}			20	µA	V_{SCL}=3.6V, Ta=85°C
SDA capacitance	C_{SDA}			20	pF	
SCL capacitance	C_{SCL}			20	pF	
To output resolution	T_{O_RES}		0.02		°C	
I^2C clock frequency	F_{I2C}			1	MHz	FM+ mode
EEPROM write / erase cycles				100K	Times	Ta=25°C
Write cell time (EEPROM)	T_{WRITE}		10		ms	

Table 5 – Electrical specifications

<u>**NOTE 1**</u>: For best performance it is recommended to keep the supply voltage accurate and stable to 3.3V ± 0.05V

<u>**NOTE 2**</u>: In case the slave address in EEPROM is set to 0x00 the device will respond to SA=0x33.

3 Functional description & interfaces

3.1 Detailed description

3.1.1 Pixel position

The array consists of 768 IR sensors (also called pixels). Each pixel is identified with its row and column position as Pix(*i*,*j*) where ***i*** is its row number (from 1 to 24) and ***j*** is its column number (from 1 to 32).

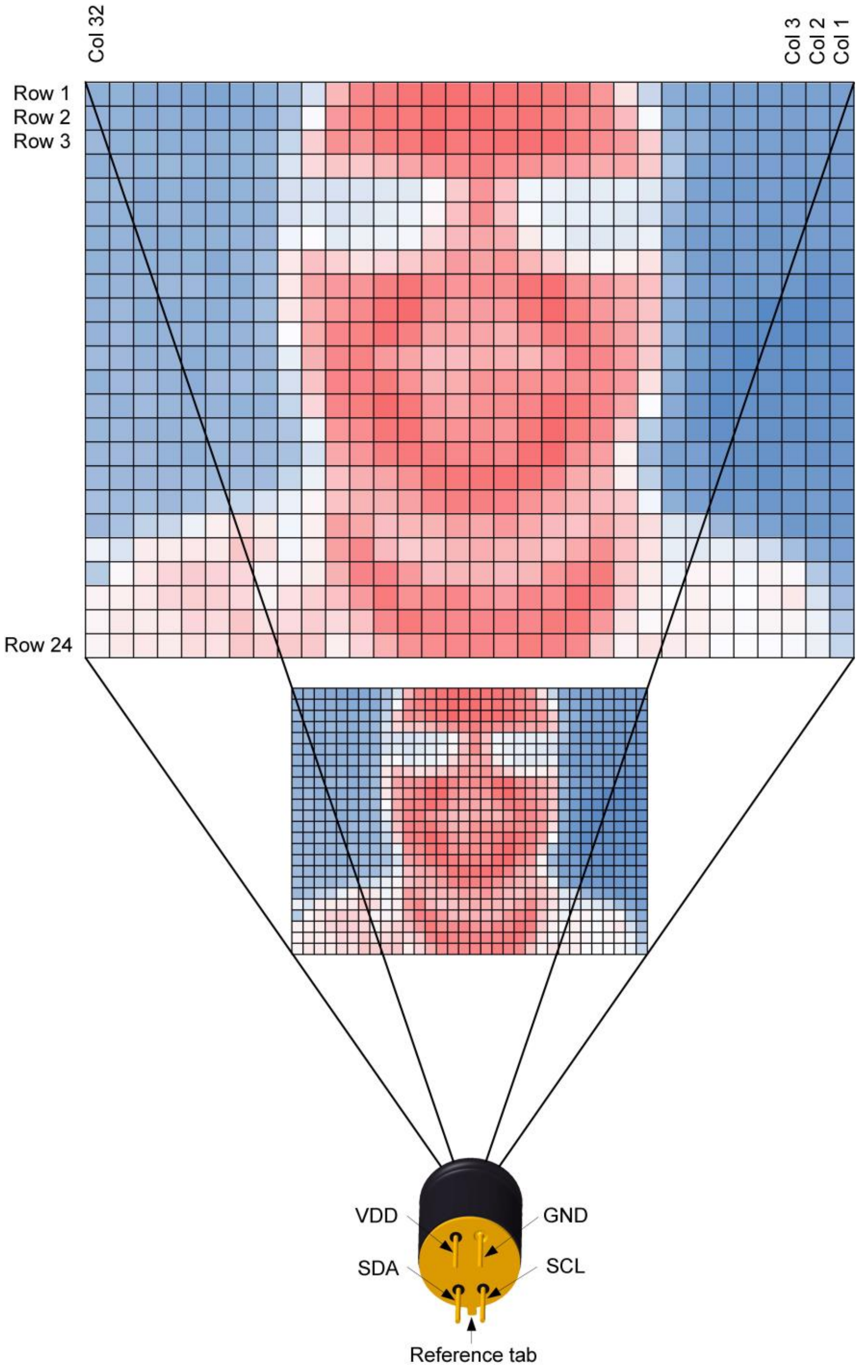


Figure 2 – Pixels arrangement in the FOV

3.1.2 Defective pixel identification and correction

The imager can have up to 4 defective pixels, with either no output or out of specification temperature reading.

No adjacent defective pixels are allowed.

These pixels are identified in dedicated memory cells in the sensor memory and can be read out through the I^{2}C. The defective pixels will be indicated as described in Tables 6 and 8 (X, Y notation) and Tables 7 and 9 (index notation - 0…767). The information about the X/Y coordinates and index will be filled out, else the content will be 0xFFFF. As the maximum number of defective pixels is 4 the same number of memory cells are dedicated at addresses 0xF070, 0xF072, 0xF074, and 0xF076 (X, Y notation) and 0xF078, 0xF07A, 0xF07C, and 0xF07E (index notation). The coordinates of the defective pixels are listed consecutively in the addresses. As a result, if 0xFFFF is read, that means no more defective pixels are listed.

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**0xF070, 0xF072, 0xF074, 0xF076**
Status	Y coordinate (row 1…24)							X coordinate (column 1…32)								**Broken / deviating pixel identification - X, Y notation**
																Column number of the deviating / failed pixel
																Row number of the deviating / failed pixel
0																Deviating pixel (some parameters are out of specification)
1																Broken pixel (integrity fail)

Table 6 – Broken / deviating pixel information (X, Y notation)

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**0xF078, 0xF07A, 0xF07C, 0xF07E**
Status	Pixel index (0…767)															**Broken / deviating pixel identification - index notation**
																Index number of the deviating / failed pixel
0																Deviating pixel (some parameters are out of specification)
1																Broken pixel (integrity fail)

Table 7 – Broken / deviating pixel information (index notation - 0…767)

Address	Content	Meaning
0xF070	0x0120	Deviating pixel – row=1, column=32
0xF072	0x8D05	Broken pixel – row=13, column=5
0xF074	0xFFFF	No more defective pixels
0xF076	0xFFFF	No more defective pixels

Table 8 – Defective pixel identification (X, Y notation)

Address	Content	Meaning
0xF078	0x001F	Deviating pixel – index = 31
0xF07A	0x8184	Broken pixel – index = 388
0xF07C	0xFFFF	No more defective pixels
0xF07E	0xFFFF	No more defective pixels

Table 9 – Defective pixel identification (index notation – 0…767)

3.1.3 Defective pixel correction

The defective pixel information (To or normalized data) is replaced by an interpolation of its neighboring pixels.
Implemented for devices with FW 1.18.0 and above.

3.1.4 Communication protocol – I²C

The device uses I²C protocol with support of FM+ mode (up to 1MHz clock frequency) and can only act as a slave on the bus.
The slave address is 7-bit programmable. This allows assigning any of the 127 different slave addresses to the device. Slave address 0x00 according to the I²C standard, is a general call address.

3.1.4.1 Low level description

3.1.4.1.1 Start / Stop and repeated Start conditions

Each communication session is initiated by a START condition and ends with a STOP condition. A START condition is generated by a 'HIGH' to 'LOW' transition of the SDA while a STOP is generated by a 'LOW' to 'HIGH' transition of the SDA. Both changes must be done while the SCL is 'HIGH'.
In case of read operation, special care **must** be taken in order to have properly generated repeated START condition ('HIGH' to 'LOW' transition of the SDA while SCL is "HIGH").

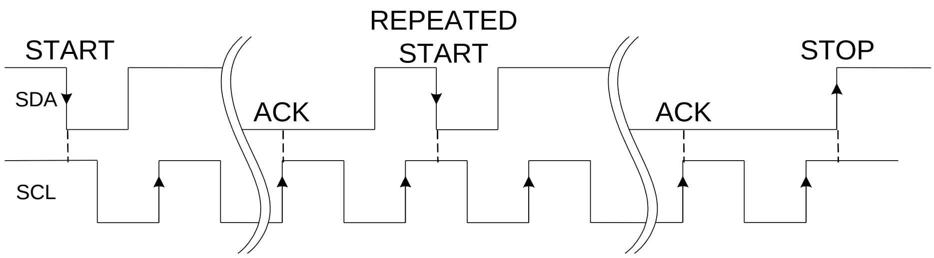


Figure 3 – START, Repeated START and STOP condition in read command only

3.1.4.1.2 Device addressing

The master is addressing the slave device by sending a 7-bit slave address after the START condition. The seven MSb bits are dedicated for the address and the LSb is the Read/Write (R/W) bit. This bit indicates the direction of the transfer:

- Read (HIGH) means that the master will read the data from the slave
- Write (LOW) means that the master will send data to the slave

3.1.4.1.3 Acknowledge

During the 9th clock following every byte transfer, the transmitter releases the SDA line. The receiver acknowledges (ACK) receiving the byte by pulling SDA line to 'LOW' or does not acknowledge (NoACK) by letting the SDA 'HIGH'.

3.1.4.1.4 I²C data read

There are three options to read data (Image data, raw data and Sensor temperature) from the device:

1. Image data (depending on end user configurable option selection) – starts at address 0x342C
    a. Object temperature
    b. Normalized data
2. Raw data (IR data) - starts at address 0x2E2A
3. Sensor temperature at address 0x3A2C (at normal operation in open air typically 8°C…10°C above ambient temperature) not to be confused with environment temperature.

3.1.4.1.5 General call RESET command

This is a generic I²C command and will reset all devices on the bus.
The first valid data will be available as after POR or regular power ON.

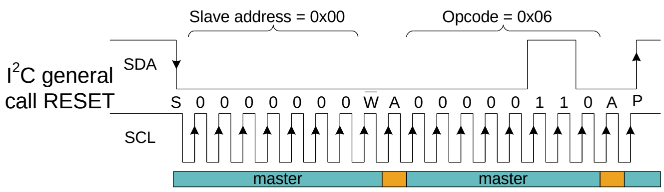


Figure 4 – I²C general call RESET command

3.1.4.1.6 RESET command

The command will reset the device.
The first valid data will be available as after POR or regular power ON.

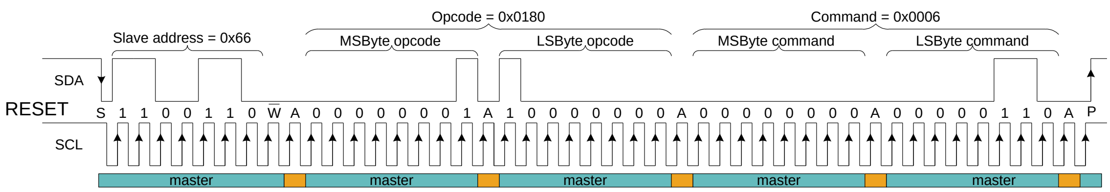


Figure 5 – RESET command (default SA=0x66 is used)

3.1.4.1.7 Single address write command

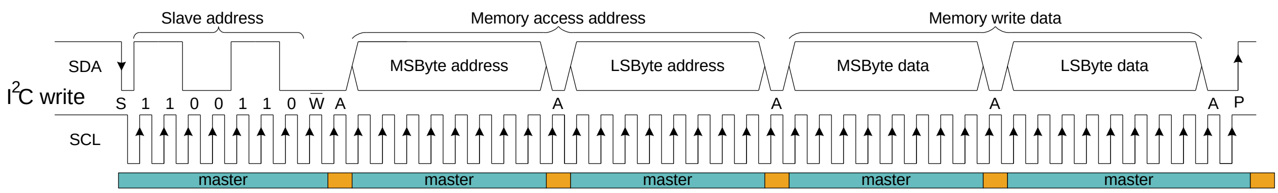


Figure 6 – I²C write command format (default SA=0x66 is used)

3.1.4.1.8 Block read command

In this mode more than one address can be read by adding additional clock pulses on the SCL line. The goal is to be able to read as much as possible data with minimal overhead for the shortest possible time. The communication is terminated by sending a STOP condition. Can be used as single word read as well.

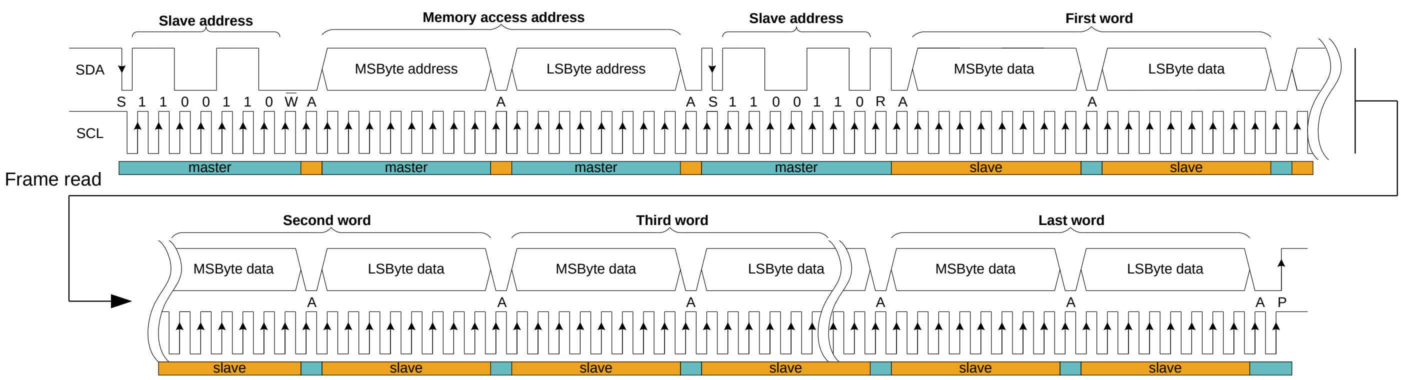


Figure 7 – I²C block read command format (default SA=0x66 is used)

3.1.4.1.9 Force start / Sync command

Writing 0x0001 at 0x0180 (please refer to 3.1.4.1.9)

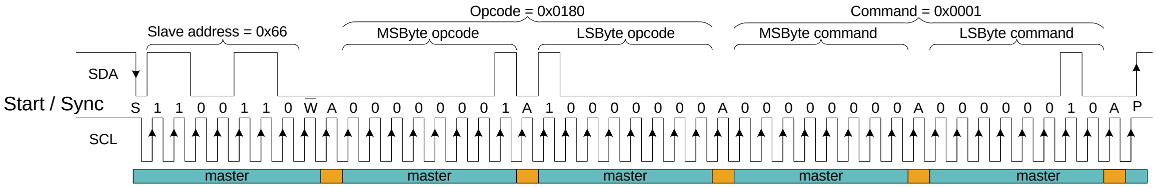


Figure 8 – Force start / sync command format (default SA=0x66 is used)

3.1.4.1.10 READY flag clear command

This command is effectively single memory cell read of only the first array address which automatically clears the READY flag. The read data is irrelevant.

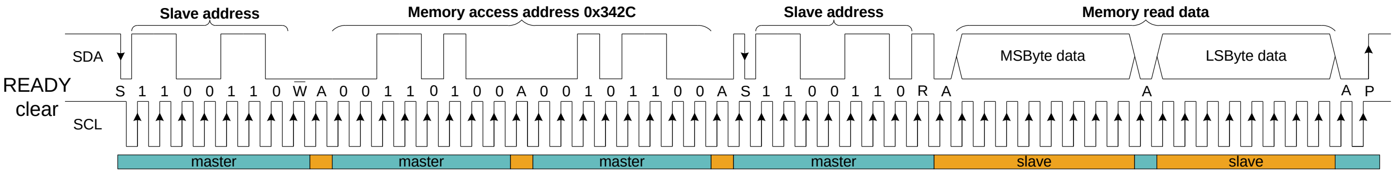


Figure 9 – READY flag clear command – single cell read at address 0x342C

3.1.4.1.11 Go to sleep command

Writing 0x0007 at 0x0180

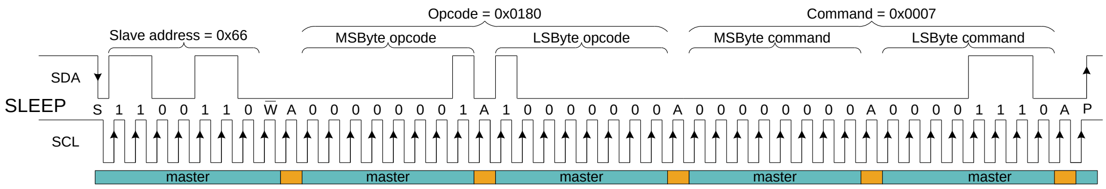


Figure 10 – Go to sleep command format (default SA=0x66 is used)

3.1.4.1.12 Wake up command

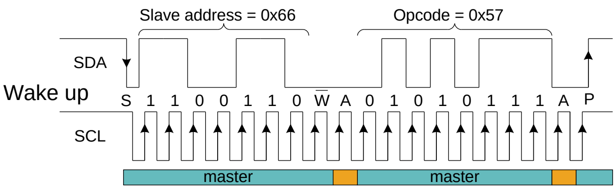


Figure 11 – Waking up command format (default SA=0x66 is used)

3.1.4.2 Operating modes

The device can operate in the following modes:

- Continuous mode
- Step mode – implemented for devices with FW 1.16.5 and above
- Sync request – implemented for devices with FW 1.16.5 and above
- Sleep mode

3.1.4.2.1 Continuous mode

In this mode the measurements are constantly running. Depending on the selected frame rate FPS, the data for IR pixels and To will be updated in the RAM each $\frac{1}{FPS}$ second.

3.1.4.2.2 Step mode

This mode is foreseen for single measurements triggered by an external device (microcontroller).
The measurement time is $\frac{1}{FPS}$ and the results remain in the RAM until the next measurement is triggered (using Force start / Sync command). Note that the overall consumption of the device remains the same although the device is in idle state.

3.1.4.2.3 Sync request

In this mode, the device is in continuous working mode and can be interrupted at any moment by the customer (using Force start / Sync command) and a new measurement will be initiated. In this way the customer can determine when the frame measurement starts. Once the initial frame is measured the device continues with the next frame.

3.1.4.2.4 Sleep mode

In this mode the device is inactive with extremely small power consumption $I_{SLEEP} \approx 2\mu A$.
Please note that after waking up the device the absolute accuracy will be available after startup warming time (please refer to 3.2.3)

3.1.4.3 FW version

It is possible to check the device FW by reading addresses 0xFFF8 and 0xFFFA

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**FW version - 0xFFF8**
																Empty / not used
																FW version - Major version

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**FW version - 0xFFFA**
																FW version - Minor version
																FW version - Patch version

Table 10 – FW version

Example:
Reading FLASH address 0xFFF8 and 0xFFFA corresponding:

$$Major\ version = MSB(FLASH[0xFFF8]) = \mathrm{MSB}(0x0100) = 0x01 = 1$$

$$Minor\ version = LSB(FLASH[0xFFFA]) = \mathrm{LSB}(0x0510) = 0x10 = 16$$

$$Patch\ version = MSB(FLASH[0xFFFA]) = \mathrm{MSB}(0x0510) = 0x05 = 5$$

$$FW\ version = Major\ version.Minor\ version.Patch\ version = 1.16.5$$

3.1.4.4 Device ID

Each device has a unique ID stored in the device EEPROM at addresses: 0x1230, 0x1232, 0x1234 and 0x1236

3.1.5 Memory and end-user programmable items

All memories are organized in words and can **only** be addressed on even addresses.

Address	Memory
0x0040 – 0x0FFE	Registers MLX reserved
0x1000 – 0x11BE	EEPROM MLX reserved
0x11C0 – 0x11FE	EEPROM User accessible
0x1200 – 0x1244	EEPROM MLX reserved
0x2000 – 0x3DFE	RAM
0x6000 – 0x657E	ROM
0x7E68 – 0xFFFE	FLASH MLX reserved

Table 11 – MLX90642 memory map

3.1.5.1 Internal registers

The following information is available for monitoring the status and the measurement progress of the device:

- BUSY flag – If "1" this means that the device is calculating the temperatures (processing the data)
- READY flag – "1" if the data processing is finished. Cleared at first data reading by customer
- FRAME update flag – "1" if the frame update is ongoing. Safe to read frame data but overlapping of the frames may occur
- Progress bar – shows the progress of the measurement in % (resolution 1%). When BUSY = "1" progress stays at 0% although it is updated in the background. Once the BUSY = "0" the actual value is available for readout. Once the BUSY is cleared the "Progress bar" jumps to the actual value and continues updating till the end of the analog conversion

3.1.5.2 Progress bar (RAM)

The user can check the current state of conversion in percent. Immediately after a new conversion is started this value is **0**. During any conversion the value can be read by Addressed Read from address 0x3C10 and is in the range **0…100** with step 1 indicating the conversion progress. After the conversion is done, and between frames, this value is **100**, as indication that conversion is done and new one has not been launched yet.

3.1.5.3 RAM

0x2E0A 0x2E28	AUX
0x2E2A 0x3428	raw IR data
0x342A	MLX reserved
0x342C 0x3A2A	To
0x3A2C	T sensor
0x3C10	Progress bar

Table 12 – RAM memory map

All data in the RAM is stored in two's complement format (unless otherwise specified).
When reading To data, the resulting temperature is calculated as:

$$To_{(i:j)} = \frac{RAM[i:j]}{50}, °C$$

Examples:
Reading RAM address 0x342C corresponding to Pixel [1:1]:

$$RAM[0x342C] = 0x03B7 = 951$$

$$To_{(1:1)} = \frac{950}{50} = 19.02°C$$

Reading RAM address 0x3A2A corresponding to Pixel [24:32]:

$$RAM[0x3A2A] = 0xFA22 = 64034$$

$$To_{(24:32)} = \frac{-1502}{50} = -30.04°C$$

When reading T sensor data, the resulting temperature is calculated as:

$$T_{SENSOR} = \frac{RAM[0x3A2C]}{100}, °C$$

$$RAM[0x3A2C] = 0x0D1D = 3357$$

$$To_{(24:32)} = \frac{3357}{100} = 33.57°C$$

3.1.5.4 End user configurable options

There are several configurable parameters (such as refresh rate, emissivity etc.) which can be modified by the configuration command (opcode 0x3A2E). The customer can write to a certain EEPROM address the value that must be updated and the internal MCU takes care of the EEPROM write sequence and reconfiguring the device. It is recommended as a good practice to first read and store into an external memory the data from the target EEPROM address and modify only the parameter of interest before uploading the new values back to the device

Modifying each parameter is possible through a dedicated I^2C command – (Implemented for devices with FW 1.16.5 and above)

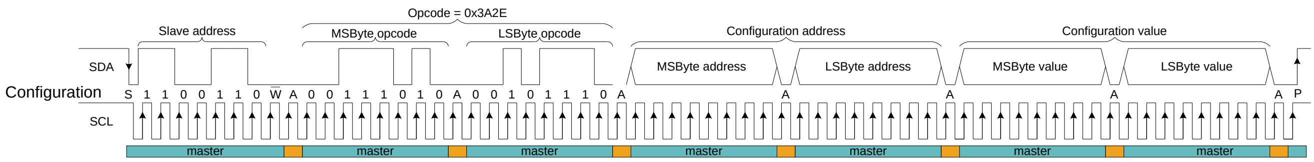


Figure 12 – Configuration command format (default SA=0x66 is used)

<u>**NOTE**</u>: As the measurement is with the highest priority, in order for the new configuration to be uploaded and take effect it can take up to 500ms (until the current measurement finishes) depending on the used refresh rate setting.

Address	Parameter	Range	Remark
0x11F0	Refresh rate – bits 0…2	2Hz…16Hz	Default – 8Hz
0x11F2	Emissivity – bits 0…15	-2.0...+1.99994	Default = 1 (0x4000)
0x11F4	Non-temperature image output – bit 8	0=Disable / 1=Enable	Normalized frame raw data
0x11F4	Step mode – bit 11	0=Disable / 1=Enable	Forced start measurement
0x11FC	FM+ mode – bit 0	0=Enable / 1=Disable	FM+ or FM only
0x11FC	SDA current limit – bit 1	0=Enable / 1=Disable	Current limit ≈ 40mA / <u>**no internal limit**</u>
0x11FC	I^2C threshold level reference (VDD or 1.8V)	0=VDD / 1=1.8V	
0x11FE	Device slave address – bits 0…6	1…127 (0X01…0X7F)	Default – 0x66 (hex)
0xEEEE	Background temperature x 100 – bits 0…15	± 327.67°C	Default – 0x8000 (disengaged, see 4.5)

Table 13 – Configurable option list

The parameters with customer access are as follows:

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	Refresh rate config - 0x11F0
													0	0	0	N/A
													0	0	1	N/A
													0	1	0	Refresh rate = 2 Hz
													0	1	1	Refresh rate = 4 Hz
													1	0	0	Refresh rate = 8 Hz (default)
													1	0	1	Refresh rate = 16 Hz
													1	1	0	N/A
													1	1	1	N/A
																Empty / not used
																Melexis reserved

Table 14 – Refresh rate

NOTE: If 16Hz refresh rate settings is selected, the actual refresh rate would be app 15.2Hz in absolute temperature mode and full 16Hz in normalized raw data mode

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	Emissivity - 0x11F2
																Emissivity: signed 16b value, default E=1 (0x4000)

Table 15 – Emissivity

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**Application config - 0x11F4**
																Melexis reserved
							0									Output data format - Absolute object temperature / 50
							1									Output data format - Normalized IR raw data
																Melexis reserved
				0												Step mode - disabled (default)
				1												Step mode - enabled
																Melexis reserved

Table 16 – Application configuration

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**Melexis reserved - 0x11F6**
																Melexis reserved

Table 17 – MLX reserved

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**I2C analog configuration - 0x11FC**
															0	FM+ mode enabled (default)
															1	FM+ mode disabled -> lower current limit, slower slopes, better EMC characteristics
														0		Current limit enabled (default), ≈40mA (FM+) / ≈15mA (FM), short to typ VDD
														1		Current limit disable - external pull-up resistor limited
													0			VDD referred threshold (normal mode) (default)
													1			1.8V referred threshold
																Melexis reserved

Table 18 – I²C analog parameter configuration

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**I2C configuration - 0x11FE**
																I2C ADDRESS - default SA = 0x66
																Melexis reserved

Table 19 – I²C configuration

<u>NOTE 1</u>: If the SA in the EEPRPOM is set to 0x00 the device will respond to SA=0x33.
<u>NOTE 2</u>: The new SA is effective immediately after successful write procedure (can take up to 500ms)

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	**Background temperature - 0xEEEE**
																Background Ta x 100 (two's complement) - (default = 0x8000, disabled)

Table 20 – Ta background (not an EEPROM address – valid only if set by customer)

There is a possibility to read back the set Background temperature using 3.1.4.1.8 Block read command single address at 0x2E1C.

3.2 Performance graphs

3.2.1 Accuracy

All accuracy specifications are valid under ***settled isothermal conditions only***.
Furthermore, the accuracy is only valid if the object fills the FOV of the sensor completely.

Parameter definitions:
Frame accuracy is defined as average value of the all (768) pixels in the frame or for frame n can be expressed as:

$$\overline{T_o\_frame(n)} = \frac{1}{768}\sum_{m=1}^{768} T_o(m,n)$$

$$Frame\ accuracy = \overline{T_o\_frame(n)} - T_{target}$$

Non-uniformity is defined as the maximum deviation of each individual pixel reading vs. the absolute accuracy.

$$Non\ Uniformity = MAX\left(\left|T_o(m) - \overline{T_o\_frame(n)}\right|\right)$$

Pixel absolute accuracy is defined as:

$$To_{accuracy(n)} = Frame\ accuracy + Non\ Uniformity$$

The pixels of the sensor are divided in 4 zones (BCA type) or 2 zones (BCB type). The accuracy depends on the zone of the pixel is in, as defined here after.

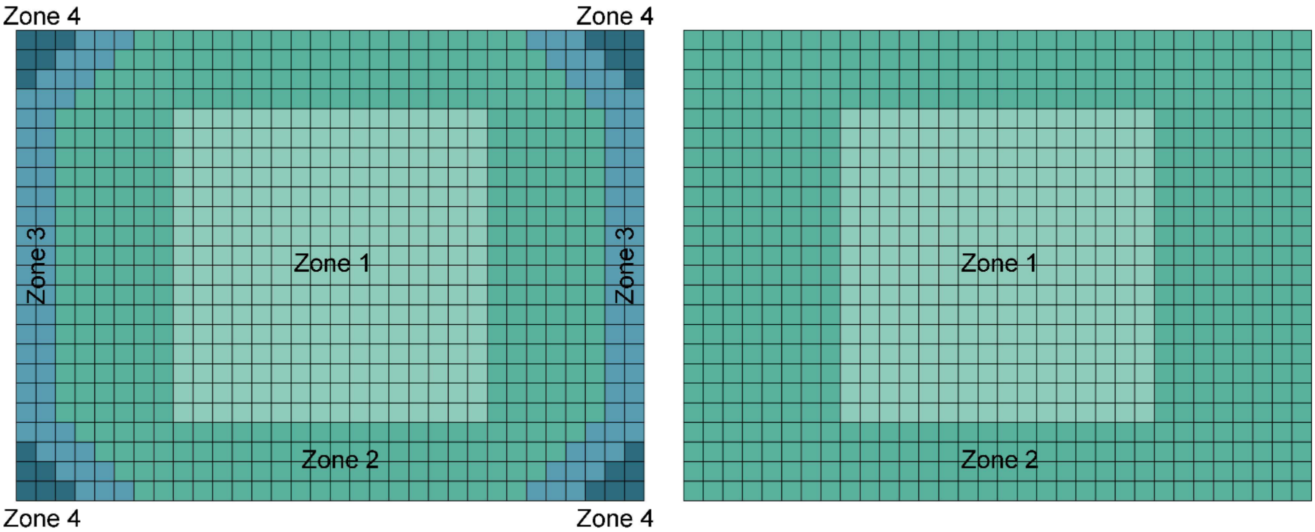


Figure 13 – Different accuracy zones depending on device type (BCA on the left and BCB on the right)

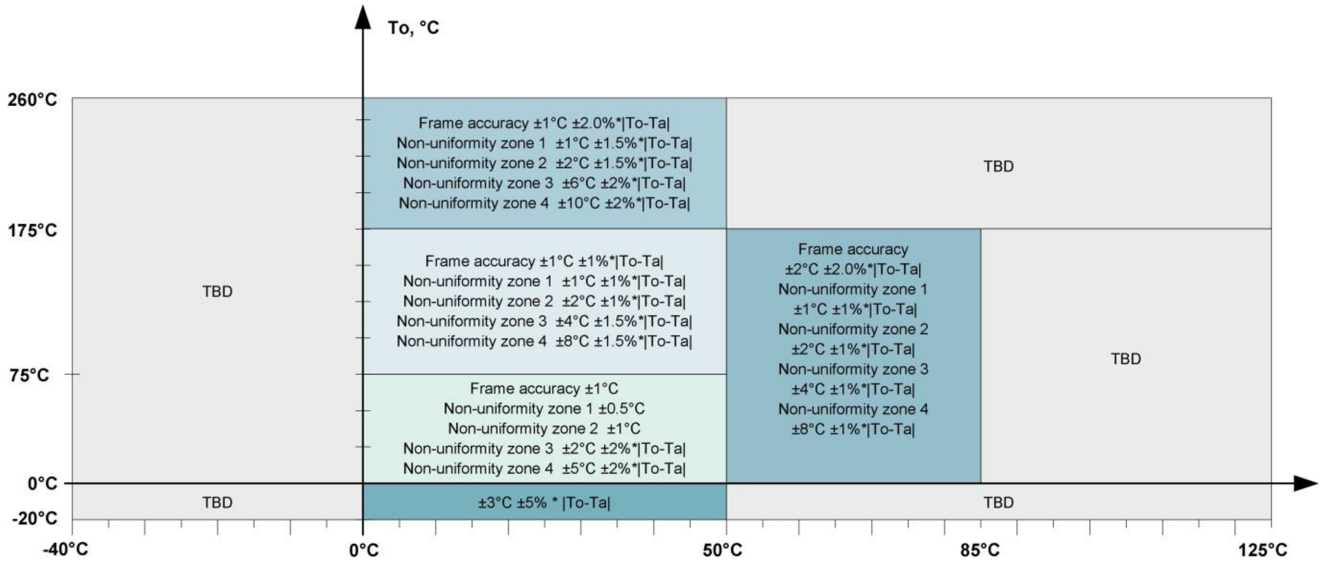


Figure 14 – Absolute temperature accuracy MLX90642BCA

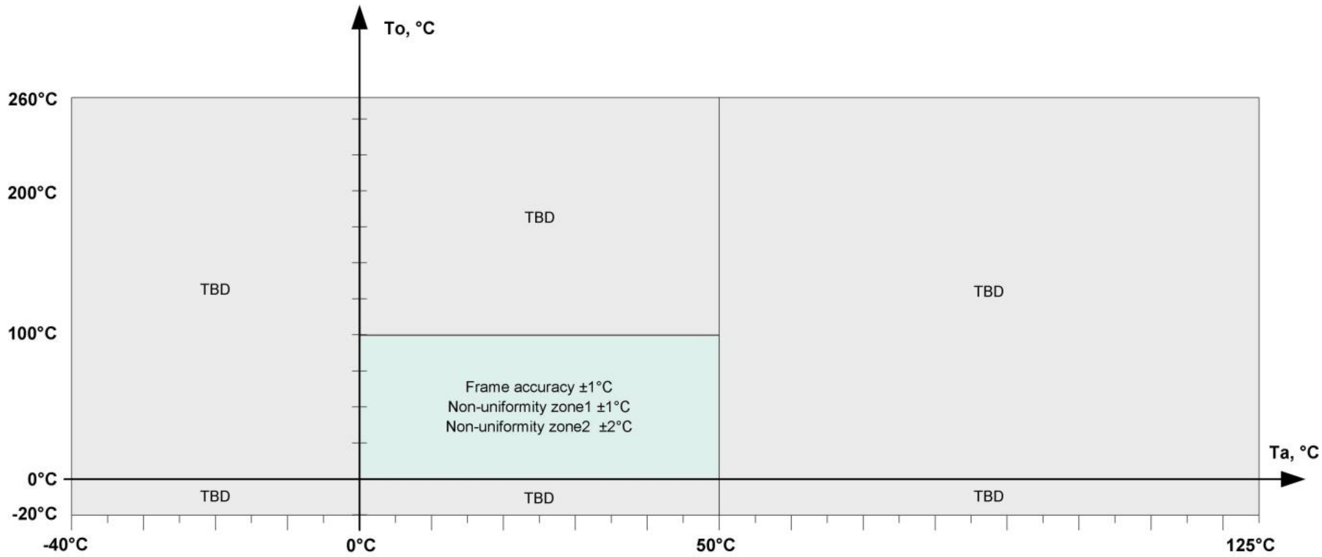


Figure 15 – Absolute temperature accuracy MLX90642BCB

Example: If we assume that the sensor (at room temperature, BCA type, zone 1) is measuring a target at 80°C that would mean that there should be no pixel with error bigger than:

$$T_{O_{accuracy(n)}} = Frame\ accuracy + \ Non\ Uniformity = \pm 1 \pm 0.5 = \pm 1.5°C$$

<u>**NOTE 1**</u>: For best performance it is recommended to keep the supply voltage accurate and stable to 3.3V ± 0.05V

3.2.2 First valid data

Very first data before data ready is set will correspond to -273.16°C (0xCAA6).
After POR the first valid data is available after no more than T_{valid_data} , calculated as:

$T_{valid\_data} = 10(Init) + 70\ (\max) + RT$, ms (RT is Refresh Time depending on the Refresh Rate settings)

NOTE: In case of changing the refresh rate on the fly (by writing new values into address 0x11F0) the new setting will take place only after the current frame under measurement is finished. Changing the refresh rate during initialization will be ignored.

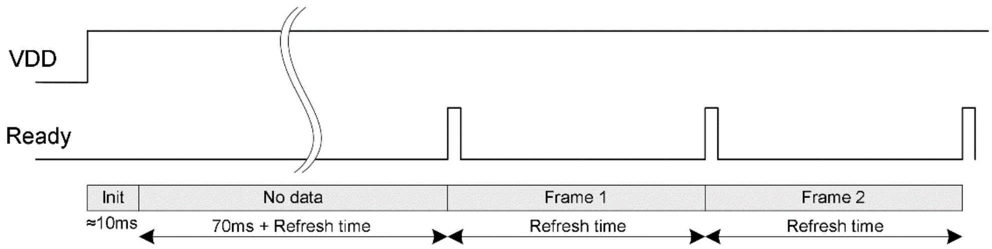


Figure 16 – Start up behavior

3.2.3 Thermal behaviour at power ON

After power ON, although the device is electrically set and running, there is thermal stabilization time necessary before the device can reach the specified accuracy – up to 180 sec.

3.2.4 Noise performance

Noise measurement condition T_O=30°C (Black Body as IR source), T_A=25°C (room)

NOTE: Due to the nature of the thermal infrared radiation, it is normal that the noise will decrease for higher object temperatures and increase for lower object temperatures

NETD(K)	2Hz RMS noise (temperature equivalent), all pixels	
MLX90642	Average RMS noise of all pixels	Minimum (for the 4x4 central pixels)
BCA	0.08	0.06
BCB	0.11	0.10

Table 21 – Typical noise levels

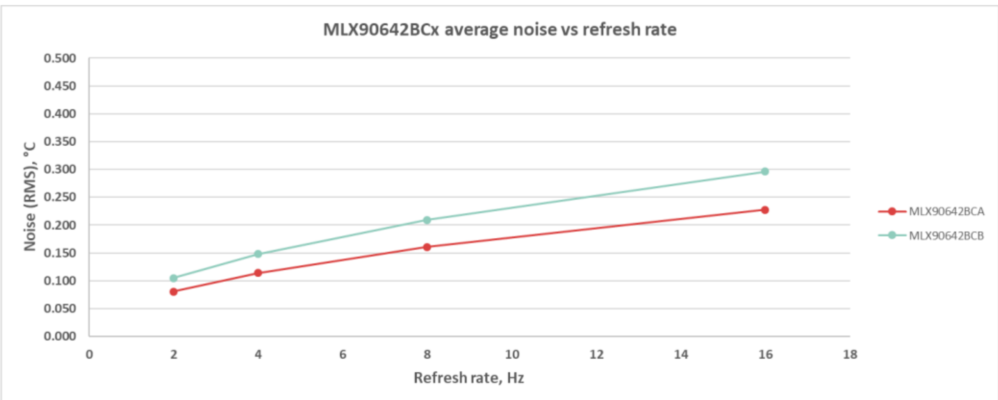


Figure 17 – MLX90642BCx noise vs refresh rate

Not all pixels have the same noise performance. Because of the optical performance of the integrated lens, it is normal that the pixels in the corner of the frame are noisier in comparison with the pixels in the middle. The graphs bellow shows the distribution of the noise density versus the pixel position in the frame (pixel number)

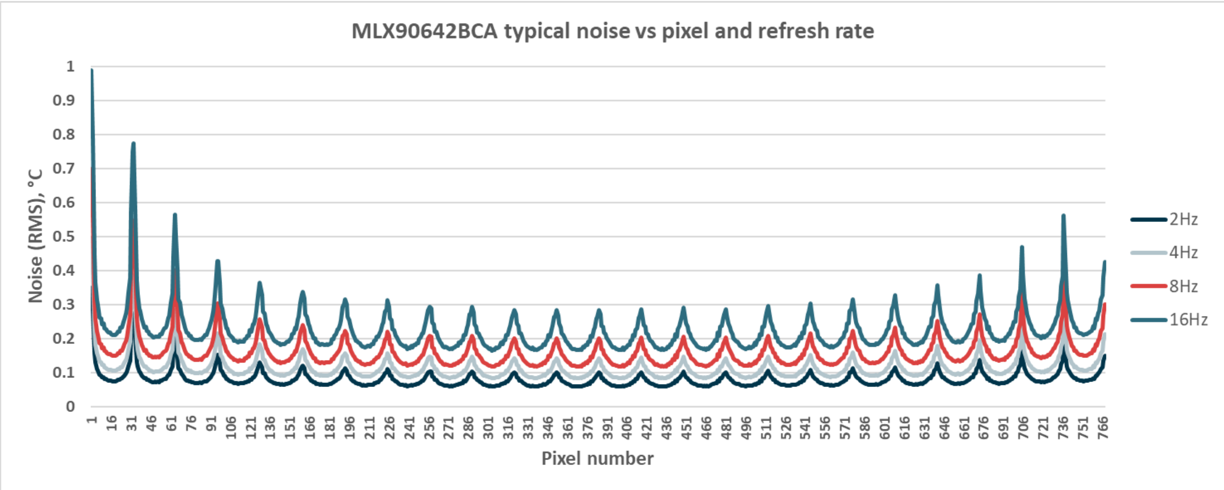


Figure 18 – Typical noise performance MLX90642BCA vs pixel index and refresh rate

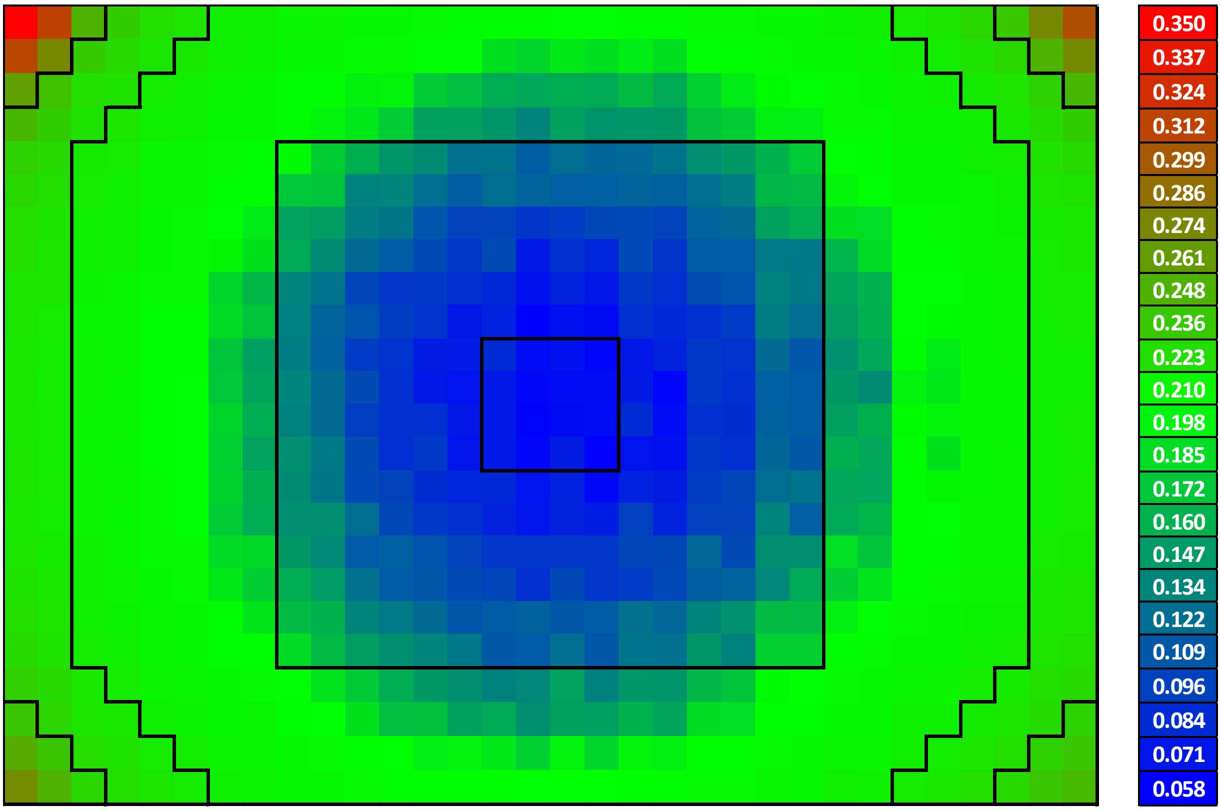


Figure 19 – Typical noise level over the array distribution – MLX90642BCA at 2Hz

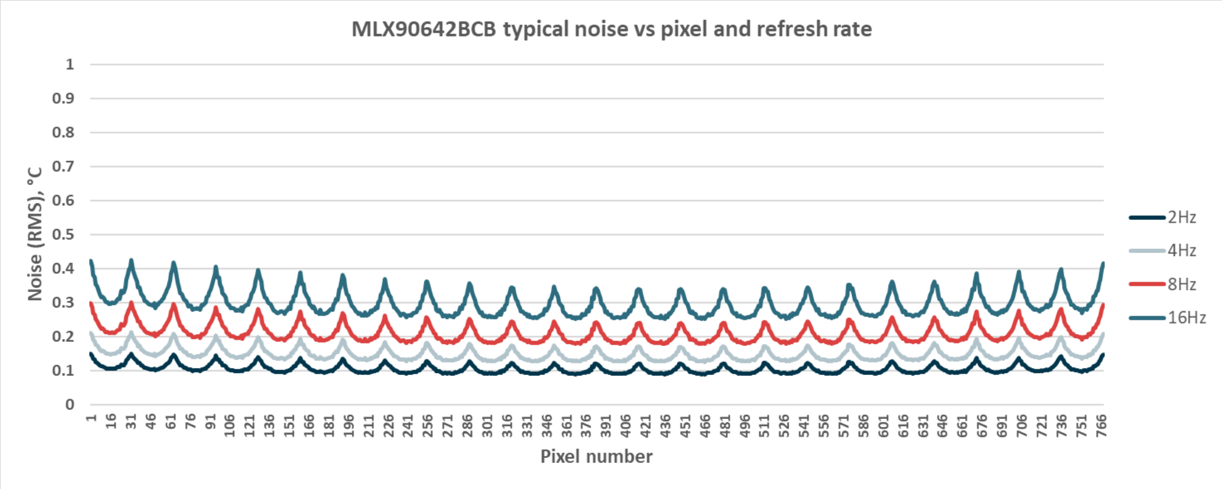


Figure 20 – typical noise performance MLX90642BCB vs pixel index and refresh rate

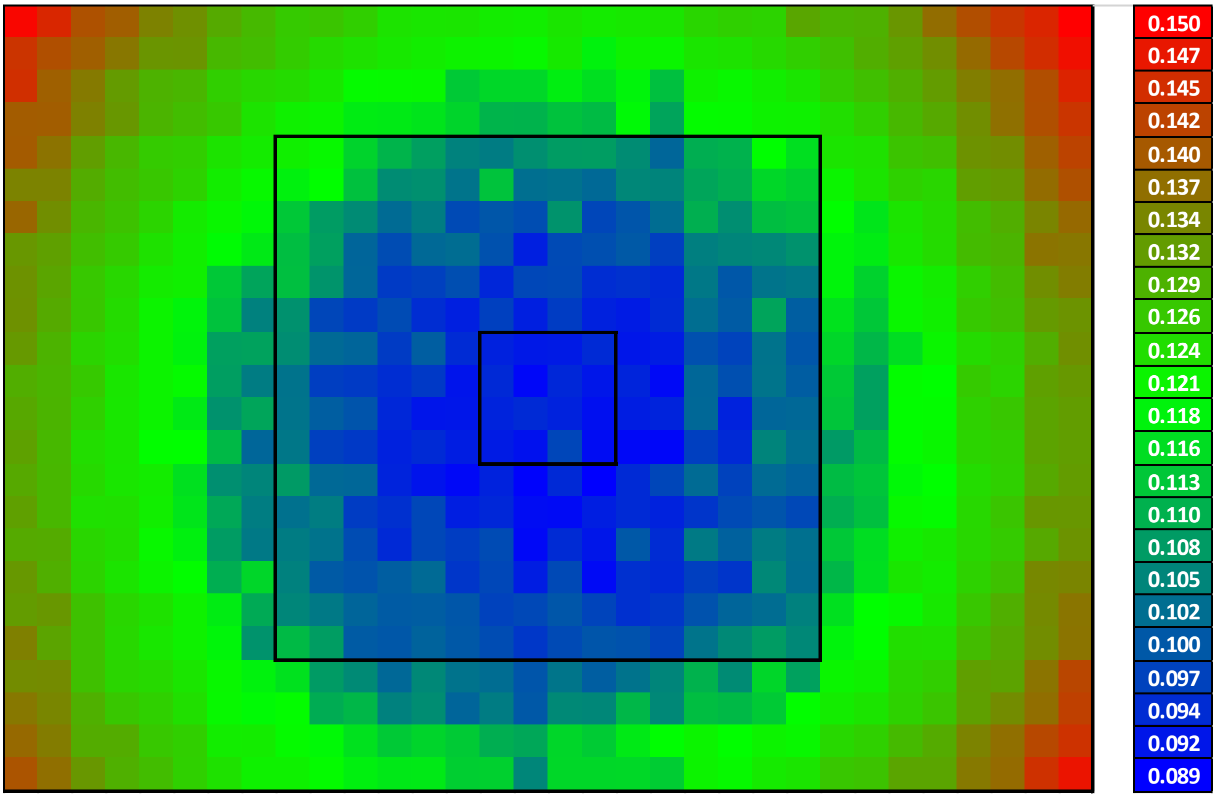


Figure 21 – Typical noise level over the array distribution – MLX90642BCB at 2Hz

3.2.5 Field of view (FOV)

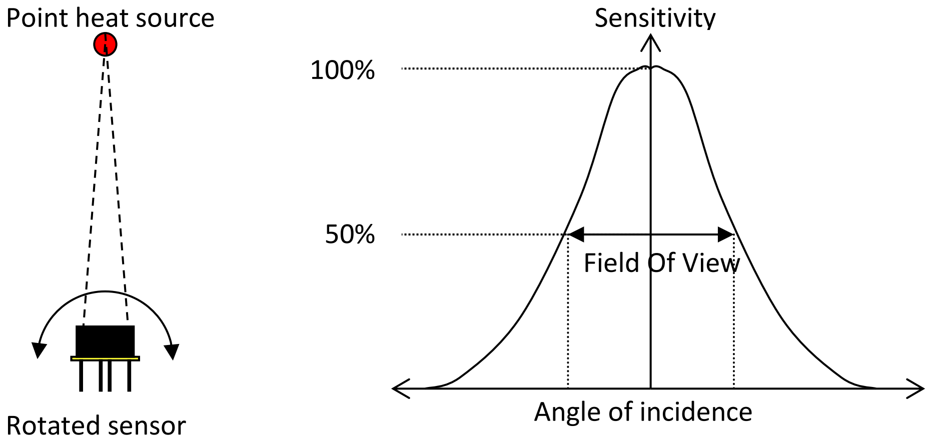


Figure 22 – Field Of View measurement concept

FOV	X direction TYP	Y direction TYP	Central pointing from normal (X & Y direction) MAX
BCA	110°	75°	± 6°
BCB	45°	35°	± 4°

Table 22 – FOV options

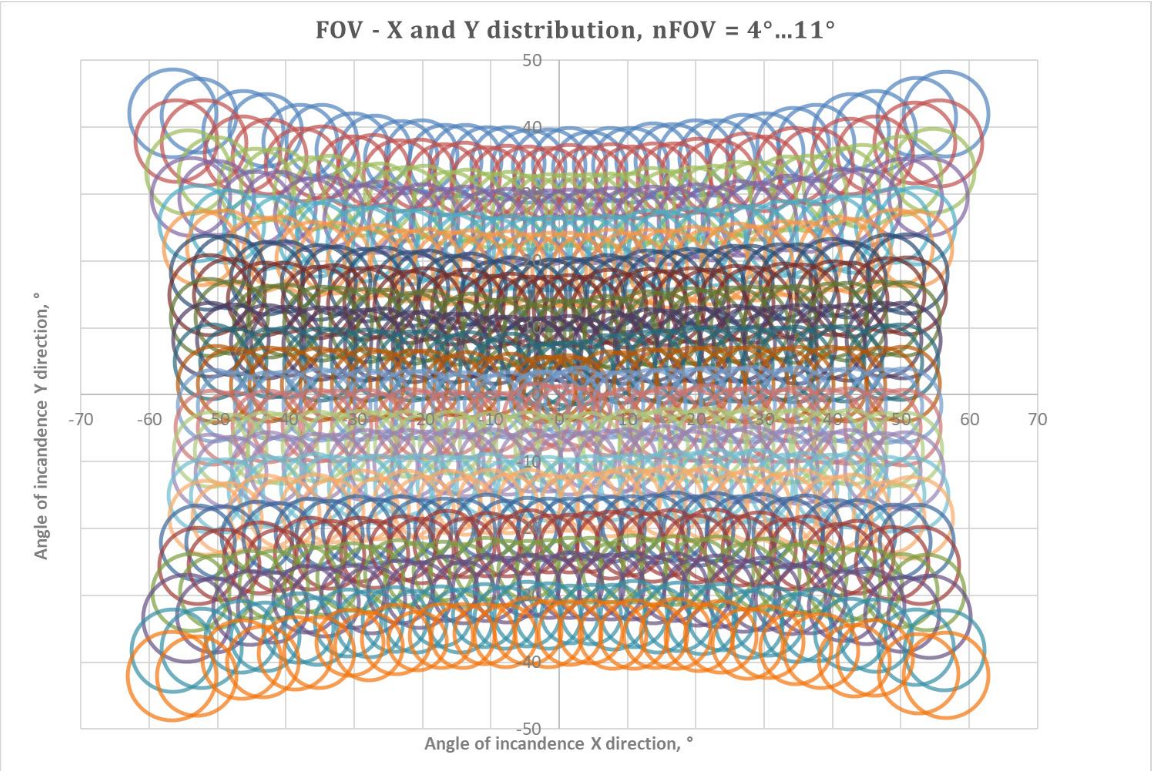


Figure 23 – MLX90642BCA (wide FOV) typical nFOV bubble diagram

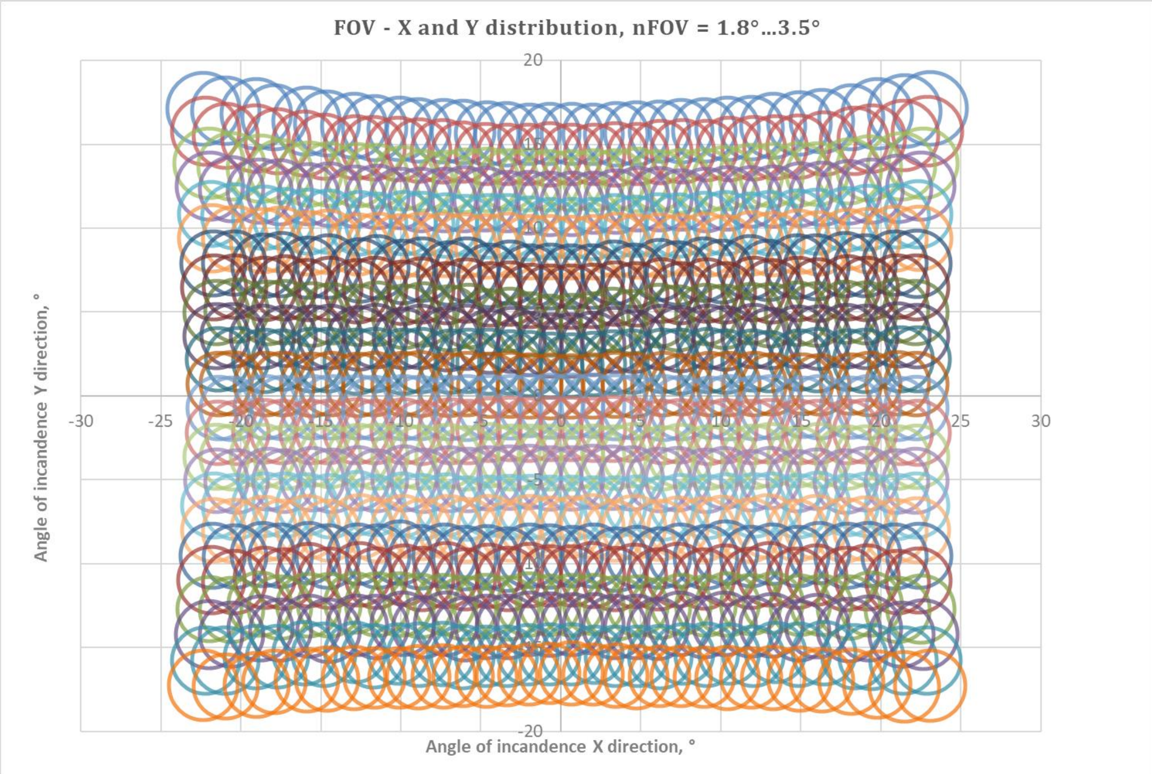


Figure 24 – MLX90642BCB (narrow FOV) typical nFOV bubble diagram

NOTE: The above Figures 23 and 24 show the nFOV of each individual pixel. These figures show the distortion due the lens. In the field of view figures this looks like pincushion distortion, but the resulting image distortion is actually a barrel distortion.

4 Application

4.1 Application description – optical consideration

It is paramount that the FOV in the optical path is kept clear. The external aperture is designed to a specific shape to have a certain FOV of the device, and is installed prior to the calibration process. Thus, it can be considered as a part of the device which does not impact the performance but may be used as a reference for the "Obstacle free zone".

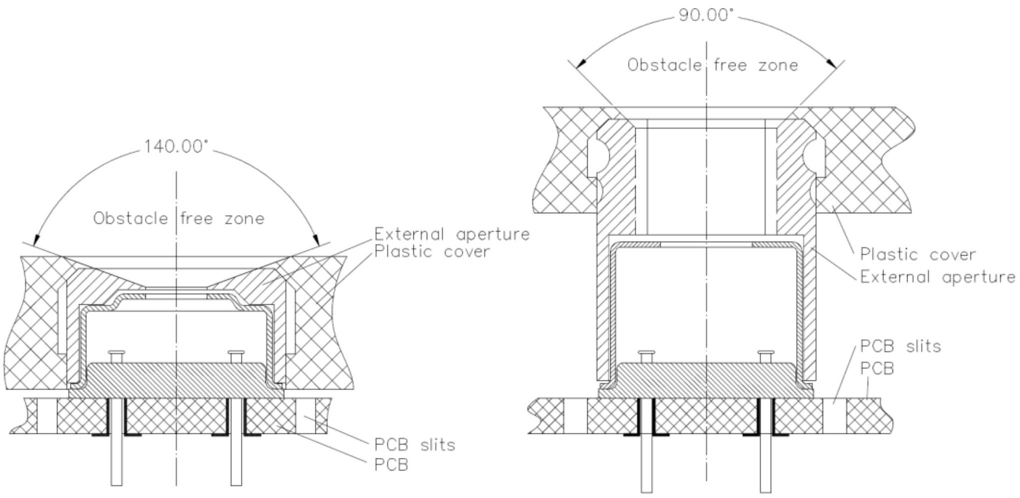


Figure 25 – Application examples concerning the optical consideration

4.2 Recommended Application diagram

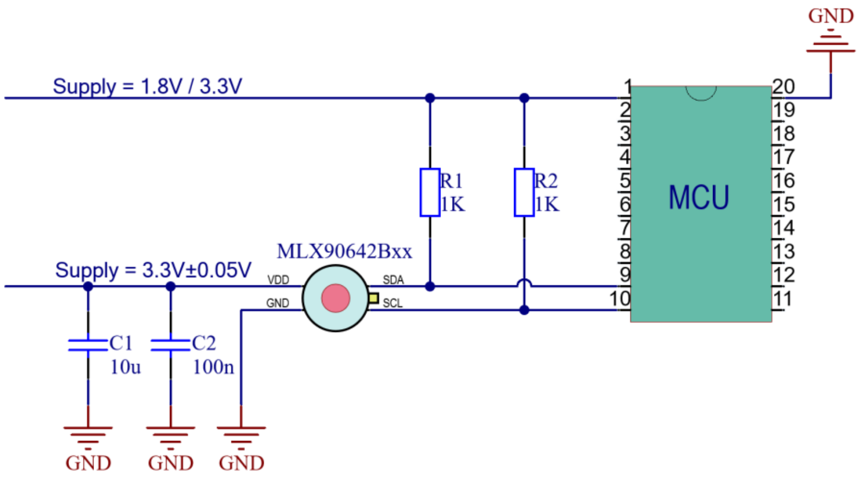


Figure 26 – MLX90642 electrical connections

The MLX90642Bxx is fully I^{2}C compatible and for better flexibility the communication inputs (SDA and SCL) are designed with two threshold options, namely VDD referred (3.3V) and 1.8V internal reference. This allows to build a system in which the MCU may be supplied with different supply voltages such as VDD=1.8V or VDD=3.3V while the sensor itself is supplied from separate supply =3.3V (or left with no supply i.e. VDD=0V). In case of lower supply voltage of the MCU is used, please configure the corresponding I^{2}C settings (0x11FC)

4.3 Data synchronization and readout

As described in 3.1.5.1 (Internal registers) in order to check the status of the measurement process following two flags and a “Progress bar” are available for the customer to monitor.

1. BUSY flag – is set when the DSP has started and cleared when all To values are calculated
2. READY flag – is set when all To values are available for readout, and cleared ***only*** if the customer reads data starting from the beginning of the array (0x342C). If the data read is not starting from the beginning of the array, the READY flag remains set. It is recommended to read the data right after READY flag is set to “1” (this will avoid overlapping of frame data).
3. FRAME update flag is set when the frame data update is ongoing. Safe to read data but frame overlap may occur
4. “Progress bar” – shows the current status of the analog conversion in %. Please note that when BUSY is set to “1”, in order to save processing time, the progress bar is not updated. Once the BUSY is cleared, the “Progress bar” jumps to the actual value, and continues updating until the end of the analog conversion (please see timing diagrams below for more details).

Examples:
Reading RAM address 0x3C10 corresponding to Progress bar:

$RAM[0x3C10] = 0x003A = 58$ → Progress is 58%

$RAM[0x3C10] = 0x004E = 78$ → Progress is 78%

$RAM[0x3C10] = 0x0064 = 100$ → Progress is 100%

Bits	Progress bar - 0x3C10
B7 … B0	Progress of measurement in %. When BUSY = "1" the progress stays "0".
B15 … B8	Melexis reserved

Table 23 – Analog conversion progress bar

Bits	Data flags - 0x3C14
B0	BUSY flag - high "1" when data is being processed
B7 … B1	Melexis reserved
B8	READY flag - "1" when data processing is done. Cleared automatically at first read
B9	FRAME update flag - "1" when frame data being updated - safe to read data
B15 … B10	Melexis reserved

Table 24 – DSP status flags (BUSY, READY and FRAME update flag)

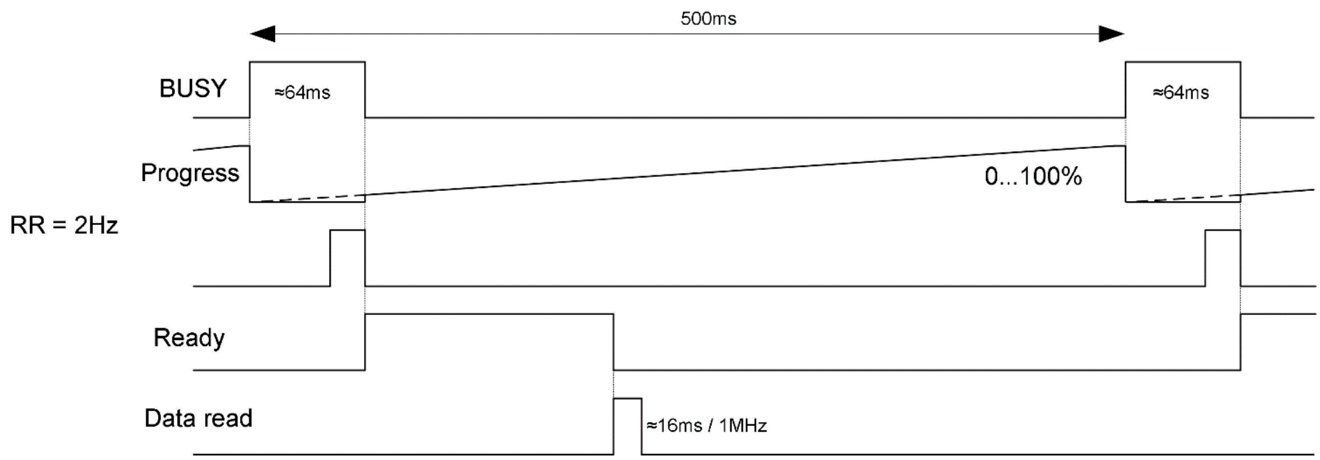


Figure 27 – Typical timing diagram at RR=2Hz

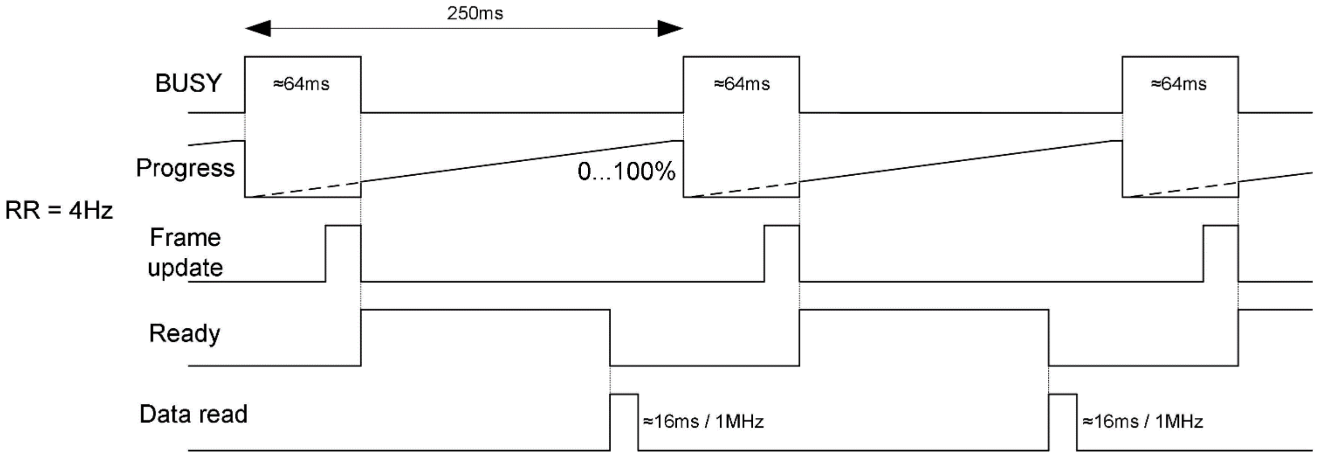


Figure 28 – Typical timing diagram at RR=4Hz

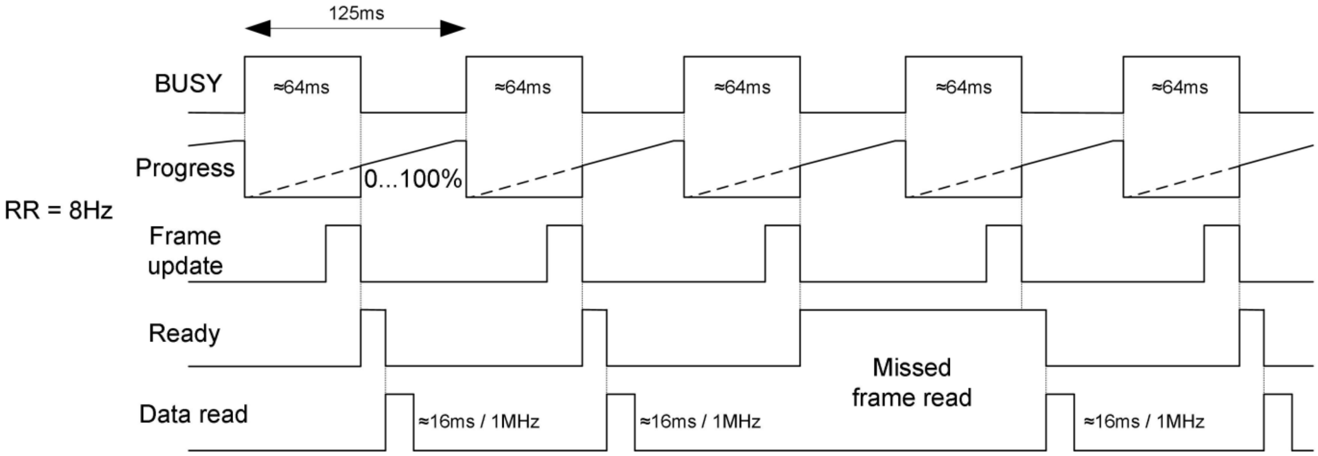


Figure 29 – Typical timing diagram at RR=8Hz

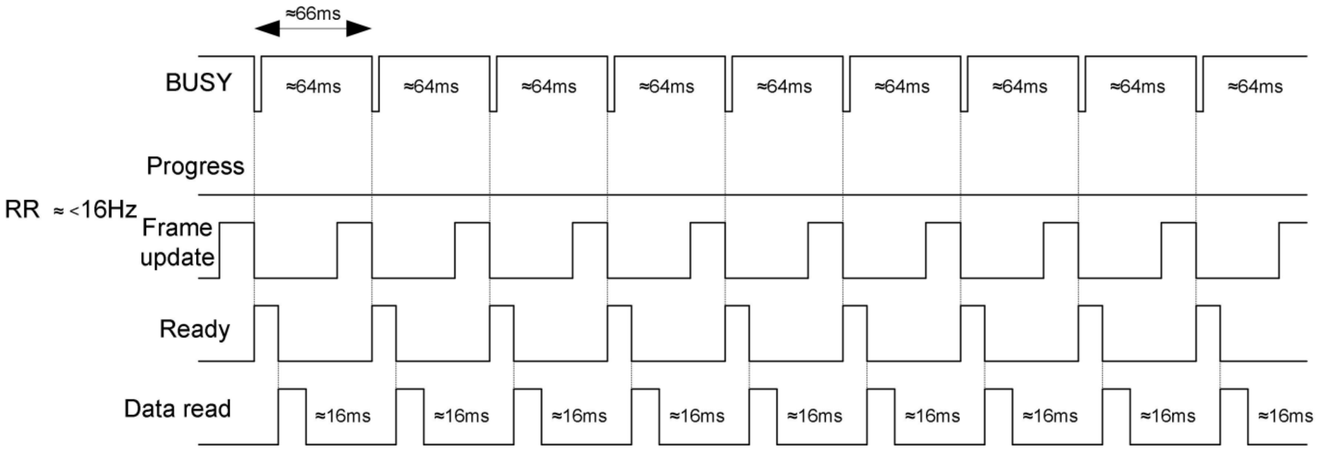


Figure 30 – Typical timing diagram at RR=16Hz (effective ≈15.2Hz)

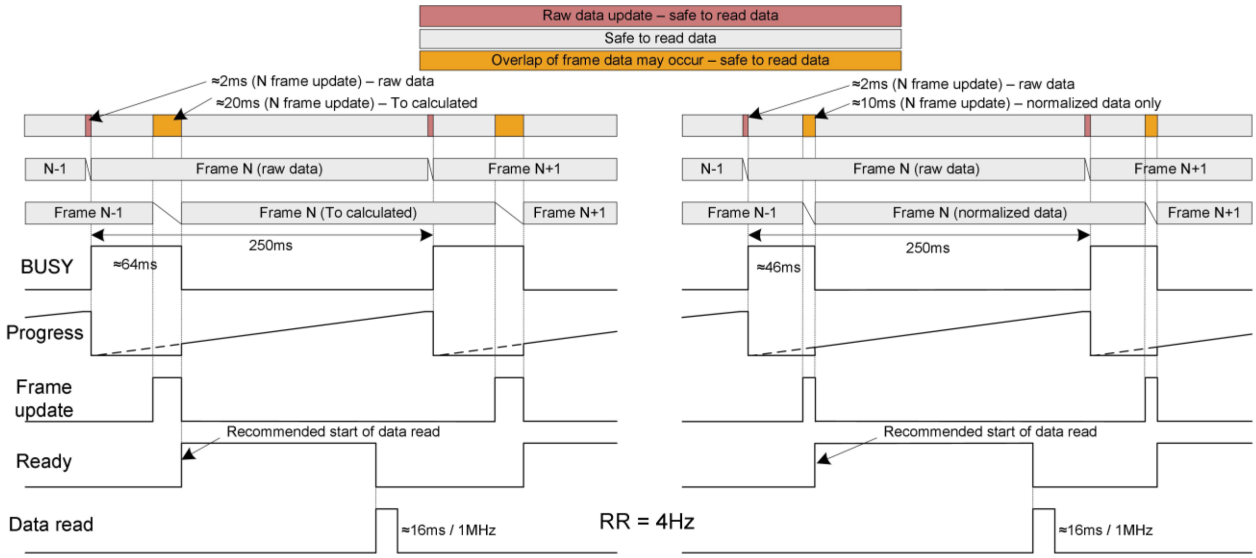


Figure 31 – Detailed timing diagram of internal data handling, To calculated frame (Left) and Normalized data (Right) at 4Hz

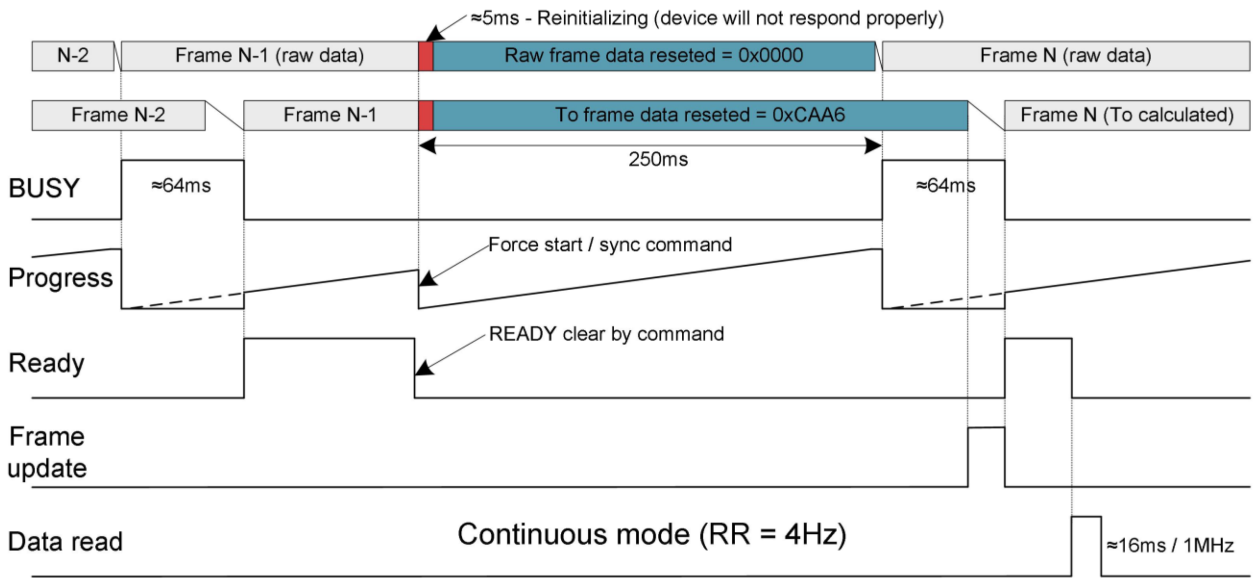


Figure 32 – Typical timing when using Force / Sync command in continuous mode

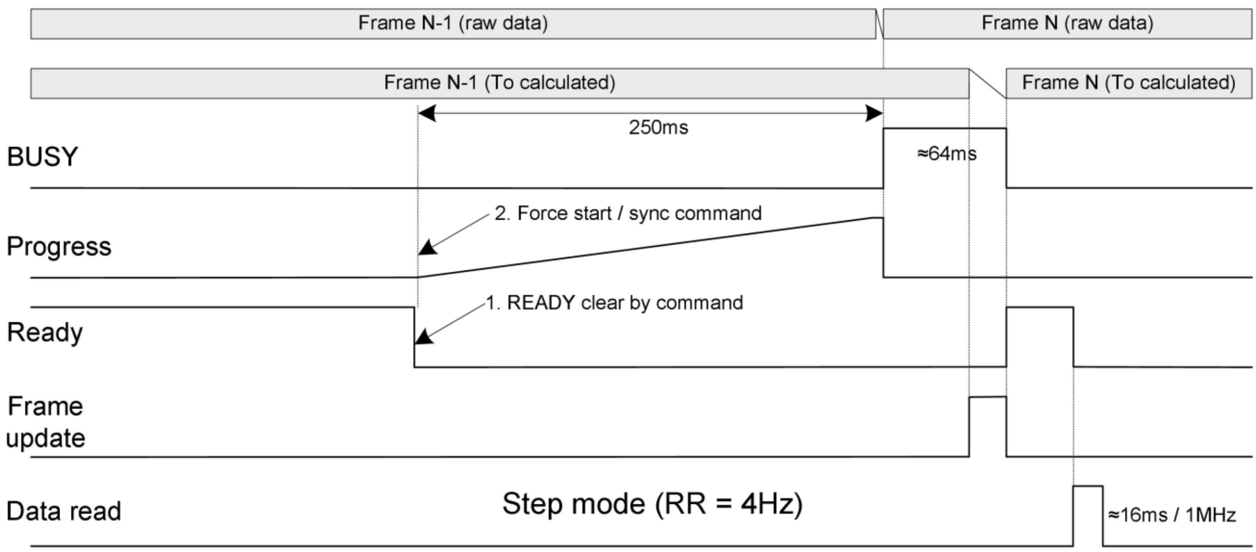


Figure 33 – Typical timing when using Force / Sync command in step mode

4.4 I²C speed limitations

MLX90642 supports I²C speed up to 1MHz. In case lower I²C is used some practical limitations are valid due to the volume of data that must be transmitted. The necessary time to dump a frame of calculated temperatures at 1MHz is app 16ms, thus lowering the communication speed will limit the data throughput resulting in missed or overlapped frames.

I²C speed \ Refresh rate	2 Hz	4 Hz	8 Hz	16 Hz	32 Hz
100kHz	OK	OK	NOK	NOK	NOK
400kHz	OK	OK	OK	OK	NOK
1MHz	OK	OK	OK	OK	OK

Table 25 – Limitation due to I²C speed – ability to read full frame without missing or overlapping

4.5 Emissivity and background temperature

The device is factory configured with default emissivity = 1, but in most cases, the measured object has a lower emissivity, for instance almost all paints (regardless of the visible color) have emissivity ≈ 0.95. In some extreme cases, if the object is for instance polished Aluminum, the emissivity coefficient can be as low as 15…20%.
The MLX90642 has built-in emissivity compensation. The emissivity factor can be configured in the device EEPROM (address 0x11F2) and the device FW will take care of the compensation using information from the sensor temperature sensor. In this case the device assumes the background temperature is T_{sensor} -9°C.
In challenging conditions, for better compensation of the emissivity, an additional coefficient is foreseen – namely “background temperature” (configuration address 0xEEEE).
The background temperature should be the temperature behind and surrounding the measured object, which is most likely to be reflected by the object towards the sensor. The goal is to provide the sensor with as accurate information as possible regarding the surrounding temperature such that when the emissivity compensation is done it will be more precise.
The default behaviour after POR is to use the sensor temperature for emissivity compensation. The extra background temperature compensation needs to be enabled by the user after every start up.
If the background temperature differs more than ±10°C from the sensor temperature, the emissivity compensation can be improved by writing the actual background temperature in configuration (RAM) address 0xEEEE. Once the value is written, the compensation will be enabled until POR or writing the default value of 0x8000. Data format is two’s complement in °C x 100.

Examples:

Let’s assume the surrounding temperature is:

1. T_A=58.6°C

As 58.6 > 0 → $RAM[0xEEEE] = 58.6 * 100 = 5860 = 0x16E4$

2. T_A=-25.2°C

As -25.2 < 0 → $RAM[0x\text{EEEE}] = -25.2 * 100 + 65536 = 63016 = 0\text{xF628}$

It is possible to check the value of the “background temperature” by reading 0x2E1C:

Examples:

Reading RAM address 0x2E1C:

$RAM[0x2E1C] = 0x8000 = 32768 \rightarrow T_A = T_{sensor} - 9°C$ (default after POR)

$RAM[0x2E1C] = 0x16E4 = 5860 \rightarrow T_A = \frac{5860}{100} = 58.6°C$

$RAM[0x2E1C] = 0xF628 = 63016 \rightarrow T_A = \frac{63015-65536}{100} = \frac{-2520}{100} = -25.2°C$

4.6 General application comments

Significant **contamination** at the optical input side (sensor filter) might cause unknown additional filtering and/or distortion of the optical signal and therefore result 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 MLX90642Bxx, it is recommended not to subject the MLX90642Bxx to heat transfer and especially transient conditions.

The MLX90642Bxx is designed and calibrated to operate as a non-contact thermometer in **settled conditions**. Using the thermometer in a very different way will result in unknown results.
Capacitive loading on an I^2C 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. With the MLX90642Bxx additional improvement is possible by increasing the pull-up current (decreasing the pull-up resistor values). Input levels for I^2C compatible mode have higher overall tolerance than the I^2C specification, but the output low level is rather low even with the high-power I^2C specification for pull-up currents. Another option might be to go for a slower communication (clock speed), as the MLX90642Bxx implements Schmidt triggers on its inputs in I^2C compatible mode and is therefore not really sensitive to rise time of the bus (it is more likely the rise time to be an issue than the fall time, as far as the I^2C systems are open drain with pull-up).
Power dissipation within the package may affect performance in two ways: by heating the “ambient” sensitive element significantly beyond the actual ambient temperature, as well as by causing gradients over the package that will inherently cause thermal gradient over the cap

Power supply decoupling capacitors are needed as with most integrated circuits. MLX90642Bxx is a mixed-signal device with 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 100nF SMD plus 10µF ceramic capacitors 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. Using MLX90642Bxx with short pins improves the effect of the power supply decoupling.

Check www.melexis.com for most recent application notes about MLX90642Bxx

5 Package, IC handling and assembly

5.1 Package information

5.1.1 Package MLX90642BCA

5.1.1.1 Package MLX90642BCA dimensions

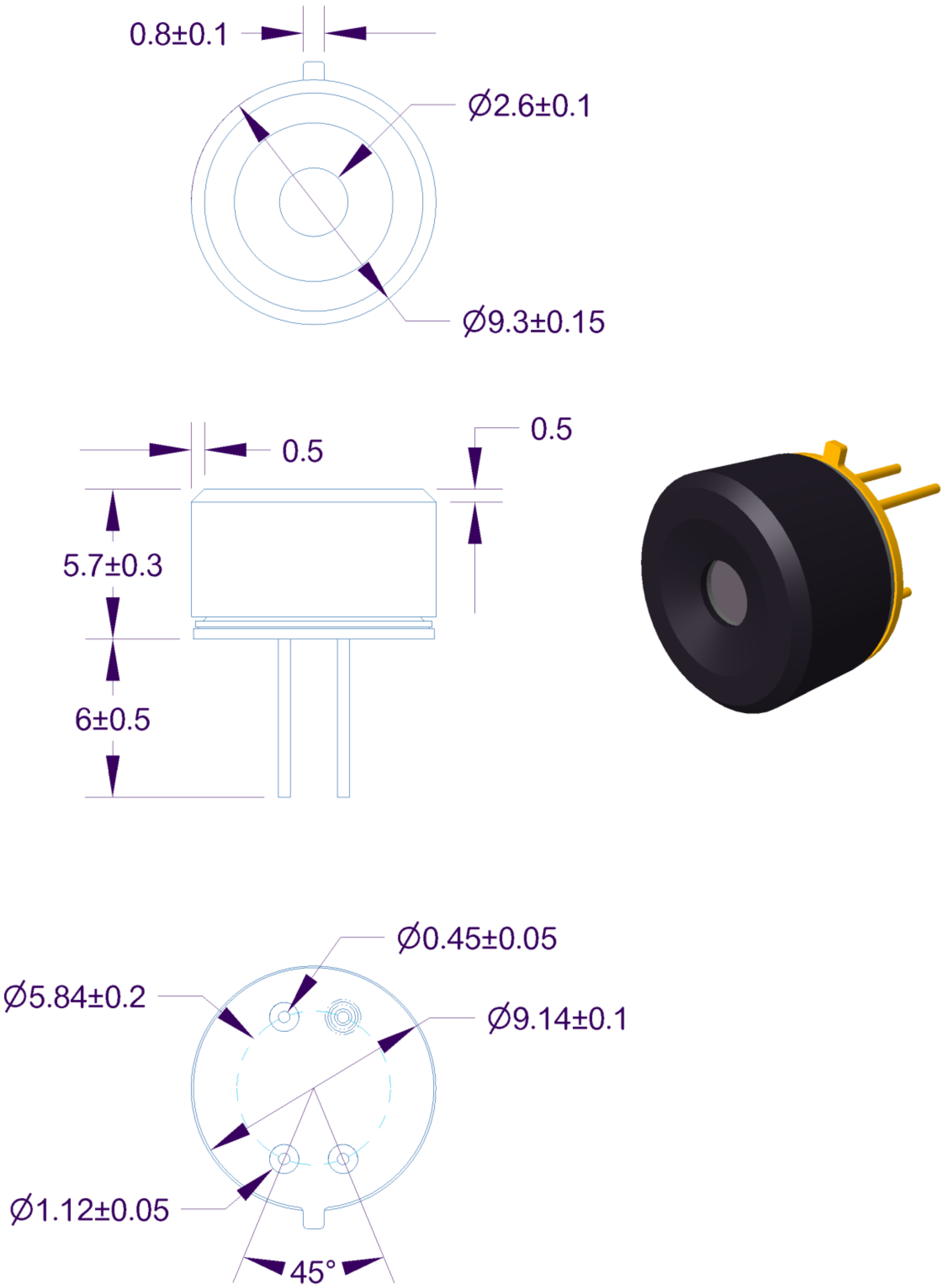


Figure 34 – Mechanical drawing MLX90642BCA

5.1.2 Package MLX90642BCB

5.1.2.1 Package MLX90642BCB dimensions

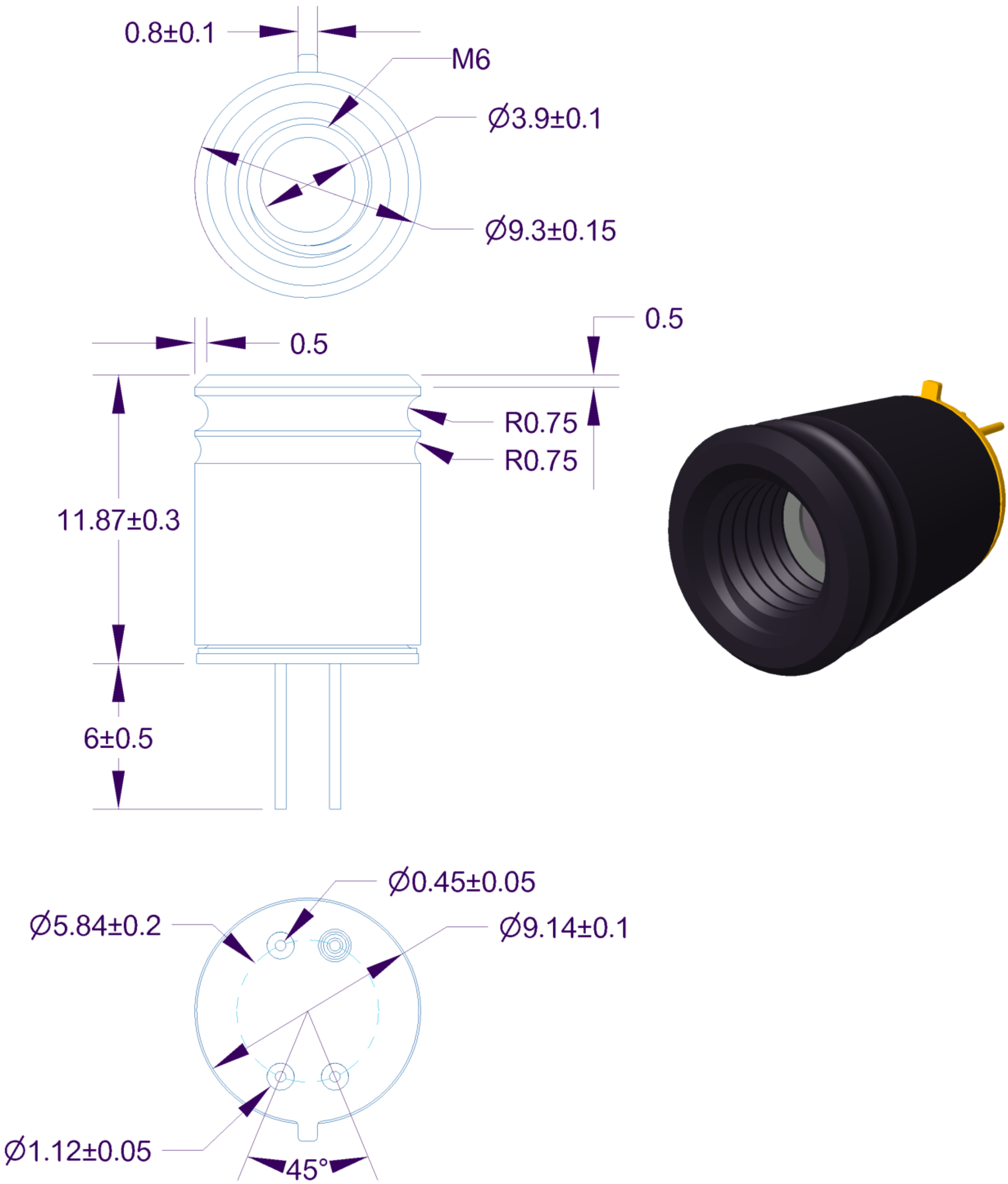


Figure 35 – Mechanical drawing MLX90642BCB

5.1.2.2 Package marking

The MLX90642 is laser marked with 10 symbols as follows.

2	A	A	xxxxx	xx	**Laser marking**
					2 digits Split number
				5 digits LOT number	
		A	FOV = 110° x 75°		
		B	FOV = 45° x 35°		
	C	Device with thermal gradient compensation (TGC ≠ 0)			
2	MLX90642				

Table 26 – Laser marking convention

Example: “2CA1010218” – Device type MLX90642BCA from lot 10102, sub LOT split 18 with Thermal Gradient Compensation activated.

5.2 Storage and handling of ICs

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* [(2)]

5.3 Assembly of TO packaged ICs

Pin handling: According to MIL STD 883-2 Method 2009.4 / 3.3.5 Leads / b. :
Terminal leads must be:

- Intact
- Aligned in their normal location
- Free of sharp or unspecified bends
- Twisted no more than 20° from the normal lead plane.

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* [(2)].

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.

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

Wave Soldering THD’s (Through Hole Devices)

- EIA/JEDEC JESD22-B106 and EN60749-15
  Resistance to soldering temperature for through-hole mounted devices

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

Iron Soldering THD's (Through Hole Devices)

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

Solderability 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.

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

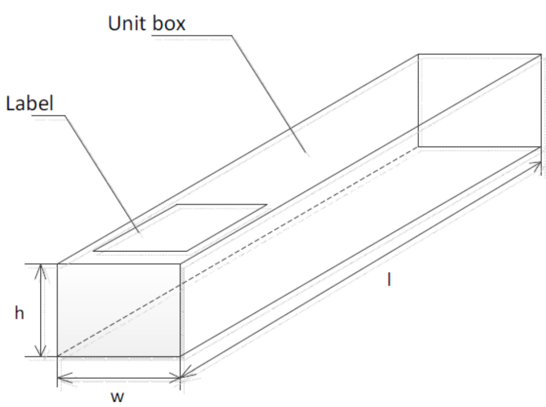
5.4 Environment and sustainability

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

5.5 Packing information

5.5.1 Packing method

Sensors are stored in tubes and the tubes are put in the box



Item	w, mm	h, mm	l, mm
Small Unit Box	85	60	600
Big Unit Box	155	75	570
Shipping box	360	230	600

Figure 36 – Box for tubes – 11 tubes or less per box (small or big)

5.5.2 Packing style

There are two variants for packing style depending on the used packing method boxes

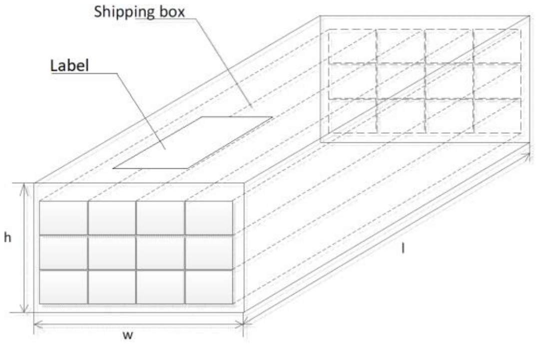


Figure 37 – Variant 1: 12 small boxes in one shipping box

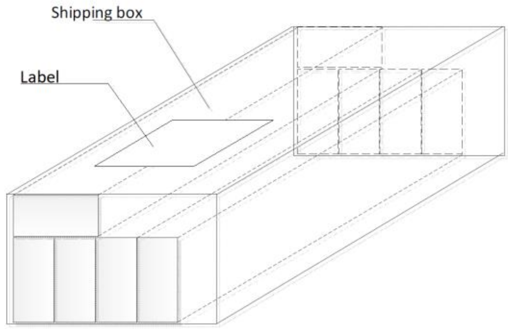


Figure 38 – Variant 2: 5 big boxes in one shipping box

Figure 39 – Shipping (carton) box label

6 Glossary of terms & references

6.1 Glossary

Term	Description
ADC	**A**nalog to **D**igital **C**onverter
DSP	**D**igital **S**ignal **P**rocessing
EMC	**E**lectro **M**agnetic **C**ompatibility
ESD	**E**lectro **S**tatic **D**ischarge
FIR	**F**ar **I**nfra-**R**ed
FOV	**F**ield **O**f **V**iew
FPS	**F**rames per **S**econd – data refresh rate
I2C	**I**nter-**I**ntegrated **C**ircuit communication protocol
IR data	**I**nfra**R**ed data (raw data from ADC proportional to IR energy received by the sensor)
LSb	**L**east **S**ignificant **b**it
LSB	**L**east **S**ignificant **B**yte
MD	**M**aster **D**evice
MSb	**M**ost **S**ignificant bit
MSB	**M**ost **S**ignificant Byte
N/A	**N**ot **A**pplicable
NC	**N**ot **C**onnected
nFOV	**F**ield **O**f **V**iew of the N-th pixel
POR	**P**ower **O**n **R**eset
RR	**R**efresh **R**ate
RT	**R**efresh **T**ime
SCL	**S**erial **C**lock
SD	**S**lave **D**evice
SDA	**S**erial **D**ata
Ta	**A**mbient **T**emperature – the temperature of the TO39 package
TGC	**T**emperature **G**radient **C**oefficient / Compensation

Table 27 – Glossary

6.2 List of tables

6.3 List of figures

6.4 References

[1] I²C-bus specification and user manual Rev. 06 – 04 April 2014 according to the document UM10204 (NXP Semiconductor)

7 Disclaimer

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