

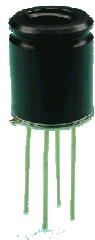
Features and Benefits

- Small size, low cost 16x4 pixels IR array
- Easy to integrate
- Industry standard four lead TO-39 package
- Factory calibrated infrared temperature measurement. Calibration parameters stored in EEPROM.
- Noise Equivalent Temperature Difference (NETD) 0.25K rms @4Hz refresh rate
- I²C compatible digital interface
- Programmable frame rate 0,5Hz...512Hz
- 2.6V supply voltage
- Current consumption less than 9mA
- Measurement start trigger for synchronization with external control unit
- 2 FOV options, 40° and 60°
- Ta -40 to 85°C
- To -50 to 300°C
- Complies with RoHS regulations

Applications Examples

- High precision non-contact temperature measurements;
- Temperature sensing element for residential, commercial and industrial building air conditioning;
- Microwave ovens
- Home appliances with temperature control;
- Thermal Comfort sensor in automotive Air Conditioning control system;
- Passenger classification
- Automotive blind angle detection;
- Industrial temperature control of moving parts;
- Identifying thermal leaks in homes
- Thermal scanners
- Security / safety gates
- Intrusion / Movement detection;
- Presence detection/ Person localization

Ordering Information



Part No.	Temperature Code	Package Code	Option Code	Standard part	Packing form
MLX90620	E (-40°C to 85°C)	SF (TO-39)	- X X X (1) (2) (3)	-000	-TU

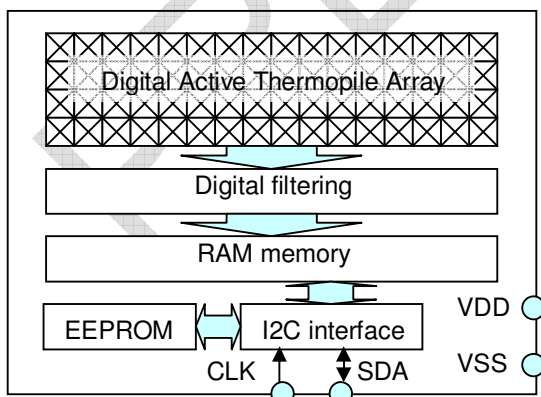
(1) Supply Voltage
B = 3V

(2) Number of thermopiles:
A = 16X4

(3) Package options:
A = reserved
B = 60° FOV
C = reserved
D = 40° FOV

Example:
MLX90620ESF-BAB-000-TU

Functional diagram



General Description

The MLX90620 is a fully calibrated 16x4 pixels IR array in an industry standard 4-lead TO-39 package. It contains 2 chips in one package: the MLX90670 (IR array with signal conditioning electronics) and the 24AA02 (256x8 EEPROM) chip.

The MLX90620 contains 64 IR pixels with dedicated low noise chopper stabilized amplifier and fast ADC integrated. A PTAT (Proportional To Absolute Temperature) sensor is integrated to measure the ambient temperature of the chip. The outputs of both IR and PTAT sensors are stored in internal RAM and are accessible through I²C.

General Description (continued)

The results of the infrared sensor measurements are stored in RAM:

- 16-bit result of IR measurement for each individual sensor (64 words)
- 16-bit result of PTAT sensor

Depending on the application, the external microcontroller can read the different RAM data and, based on the calibration data stored in the EEPROM memory, compensate for difference between sensors to build up a thermal image, or calculate the temperature at each spot of the imaged scene.

These constants are accessible by the user microcontroller through the I2C bus and have to be used for external post processing of the thermal data. This post processing includes:

- Ta calculation
- Pixel offset cancelling
- Pixel to pixel sensitivity difference compensation
- Object emissivity compensation
- Object temperature calculation

The result is an image with NETD better than 0.08K rms at 1Hz refresh rate.

The refresh rate of the array is programmable by means of register settings or directly via I2C command. Changes of the refresh rate have a direct impact on the integration time and noise bandwidth (faster refresh rate means higher noise level). The frame rate is programmable in the range 0,5Hz...512Hz and can be changed to achieve the desired trade off between speed and accuracy.

The MLX90620 requires a single 3V supply ($\pm 0,6V$) although the device is calibrated and performs best at $VDD=2.6V$.

The MLX90620 is factory calibrated in wide temperature ranges:

- -40...85°C for the ambient temperature sensor
- -50...300°C for the object temperature.

Each pixel of the array measures the average temperature of all objects in its own Field Of View (called nFOV).

It is very important for the application designer to understand that the accuracy of the temperature measurement is very sensitive to the thermal equilibrium isothermal conditions (there are 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.

This effect is especially relevant for thermometers with a small FOV as the energy received by the sensor from the object is reduced

1 Table of contents

1	Table of contents	3
2	Glossary of terms	5
3	Absolute Maximum ratings	5
4	Pin definition and description	6
5	Electrical characteristics	7
6	Block diagram	8
7	Principle of operation	9
7.1	Initialization	10
7.1.1	Reading configuration	11
7.2	Read measurement data	12
7.2.1	PTAT data read	12
7.2.2	IR data read	12
7.3	Calculation	14
7.3.1	Calculation of absolute chip temperature Ta (sensor temperature)	14
7.3.2	Example for Ta calculations	14
7.3.3	Calculation of To	16
7.3.4	Example for To calculations	18
8	Detailed description, Block description	20
8.1	Pixel position	20
8.2	MLX90620 address map	21
8.2.1	RAM	21
8.2.2	Internal registers	22
8.2.2.1	Configuration register (0x92)	22
8.2.2.2	Trimming register (0x93)	22
8.2.3	EEPROM	23
8.3	POR	24
8.4	ESD	24
9	Communication protocol	25
9.1	Communication pins	25
9.2	Low level communication protocol	26
9.2.1	Start / Stop condition	26
9.2.2	Device addressing	26
9.2.3	Acknowledge	26
9.2.4	Low level communication operation	26
9.3	Device modes	27
9.3.1	Normal mode	27
9.4	Communication to IR array	28
9.4.1	Read command	28
9.4.2	Write configuration register command	29
9.4.3	Write trimming command	29
9.5	Communication to EEPROM	30
10	Performance Graphs	31
10.1	Temperature accuracy of the MLX90620	31
10.2	Field Of View (FOV)	32
11	Applications Information	33
11.1	Use of the MLX90620 thermometer in SMBus configuration	33
12	Application Comments	33
13	Standard information regarding manufacturability of Melexis products with different soldering processes	35
14	ESD Precautions	35
15	FAQ	36
16	Mechanical specification	38
16.1	Package outline	38

16.2 Part marking.....	39
17 References.....	39
18 Disclaimer.....	39

PRELIMINARY

2 Glossary of terms

POR	P ower O n R eset
PTAT	P roportional T o A bsolute T emperature sensor (package temperature)
IR	I nfra R ed
IR_data	I nfrared d ata (raw data from ADC proportional to IR energy received by the sensor)
ADC	A nalog T o D igital C onverter
Ta	A mbient T emperature measured from the chip – (the package temperature)
To	O bject T emperature, 'seen' from IR sensor
TGC	T emperature G radient C oefficient
FOV	F ield O f V iew
ESD	E lectro- S tatic D ischarge
EMC	E lectro- M agnetic C ompatibility
I ² C	I nter- I ntegrated C ircuit communication protocol
SDA	S erial D ata
SCL	S erial C lock
DSP	D igital S ignal P rocessing
HFO	H igh F requency O scillator (RC type)
FpS	F rames p er S econd – data refresh rate
MD	M aster D evice
SD	S lave D evice
TBD	T o B e D efined
NA	N ot A pplicable

Table 1 Glossary of terms

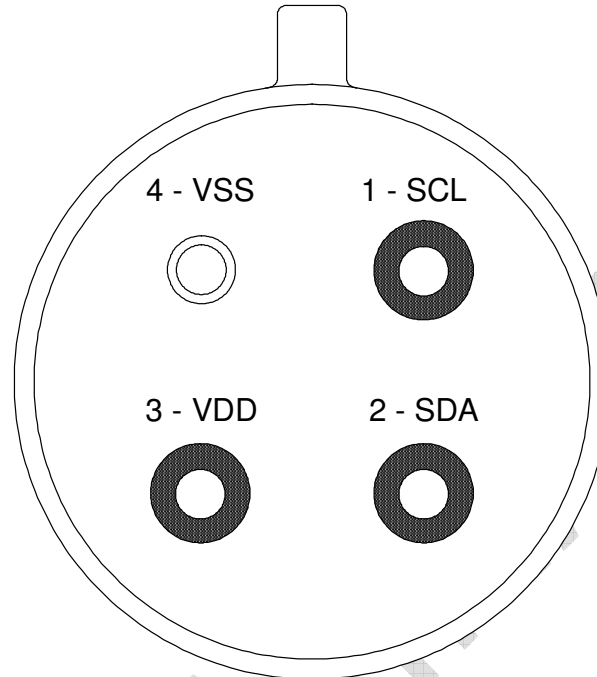
3 Absolute Maximum ratings

Parameter	MLX90620
Supply Voltage, V _{DD} (over voltage)	5V
Supply Voltage, V _{DD} (operating max)	3.6V
Reverse Voltage (each pin)	-0.3 V
Operating Temperature Range, T _A	-40...+85°C
Storage Temperature Range, T _S	-40...+125°C
ESD Sensitivity (AEC Q100 002)	2kV
DC sink current, SDA	25 mA
DC source current, SDA	NA
DC clamp current, SDA	NA
DC source current, SCL	NA (input only)
DC clamp current, SCL	NA

Table 2 Absolute maximum ratings for MLX90620

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

4 Pin definition and description



Bottom view

Figure 1 Pin description

Pin Name	Function
SCL	Serial clock input for 2 wire communications protocol
SDA	Digital input / output 2 wire communications protocol.
VDD	External supply voltage
VSS	Ground (case)

Table 3 Pin description for MLX90620

5 Electrical characteristics

All parameters are valid for $T_A = 25^\circ\text{C}$, $V_{DD} = 2.6\text{V}$ (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supplies						
External supply ¹	V_{DD}		2.5	2.6	2.7	V
Supply current	I_{DD}	No load		5	7	mA
Power On Reset						
POR level	V_{POR_up}	Power-up (full temp range)	2	2.2	2.4	V
POR level	V_{POR_down}	Power –down (full temp range)	1.9	2.1	2.3	V
POR hysteresis	V_{POR_hys}	Full temp range		0.1		V
V_{DD} rise time (10% to 90% of specified supply voltage)	T_{POR}	Ensure POR signal	100			μs
I²C compatible 2-wire interface Sensor chip						
Slave address	SA	Factory default		60		hex
Input high voltage	$V_{IH}(Ta, V)$	Over temperature and supply	0.7VDD			V
Input low voltage	$V_{IL}(Ta, V)$	Over temperature and supply			0.3VDD	V
Output low voltage	V_{OL}	SDA over temperature and supply, $I_{sink} = 6\text{mA}$ (FM mode)			0.6	V
Output low voltage	V_{OL}	SDA over temperature and supply, $I_{sink} = 20\text{mA}$ (FM+ mode)			0.4	V
SCL leakage	$I_{SCL, leak}$	$V_{SCL}=4\text{V}$, $T_a=+85^\circ\text{C}$			2	μA
SDA leakage	$I_{SDA, leak}$	$V_{SDA}=4\text{V}$, $T_a=+85^\circ\text{C}$			2	μA
SCL capacitance	C_{SCL}	Two dies MLX90670 + EEPROM			20	pF
I ² C clock frequency	SCL_{IR}	MLX90620			1	MHz
Acknowledge setup time	$T_{suac}(MD)$	8-th SCL falling edge, Master			0.45	μs
Acknowledge hold time	$T_{hdac}(MD)$	9-th SCL falling edge, Master			0.45	μs
Acknowledge setup time	$T_{suac}(SD)$	8-th SCL falling edge, Slave			0.45	μs
Acknowledge hold time	$T_{hdac}(SD)$	9-th SCL falling edge, Slave			0.45	μs
EEPROM						
Slave address	SA	Factory default		50		hex
I ² C clock frequency	SCL_{EEPROM}	EEPROM			400	kHz
Data retention		$T_a = +85^\circ\text{C}$	200			years
Erase/write cycles		$T_a = +25^\circ\text{C}$	1M			Times
Erase/write cycles		$T_a = +125^\circ\text{C}$	100K			Times
Erase cell time	T_{erase}				5	ms
Write cell time	T_{write}				5	ms

Table 4 Electrical specification parameters of MLX90620

1) The device can be supplied with $V_{DD} = 2.6\dots 3.3\text{V}$ but the best performance is at $V_{DD}=2.6\text{V}$

6 Block diagram

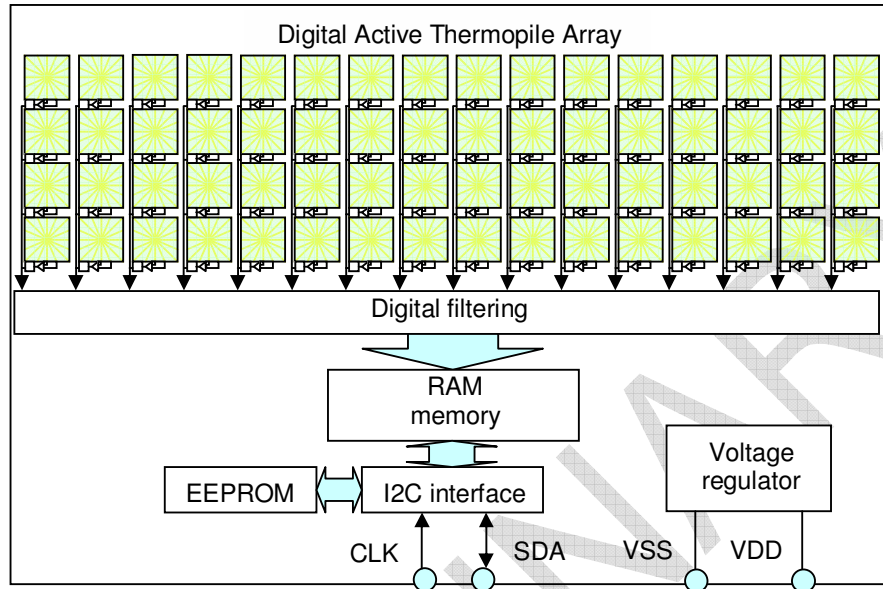


Figure 2 Block diagram

The device consists of 2 chips packed in single TO-39 package

- IR array and processing electronics
- EEPROM chip

7 Principle of operation

The output of all IR sensors and absolute temperature sensors is scanned according to the programmed refresh rate. Using their output data as well as calibration constants written in EEPROM the absolute chip temperature and object temperature, 'seen' by each pixel can be calculated. For this goal several sequential calculations must be done according to the Figure 3 Operation block diagram

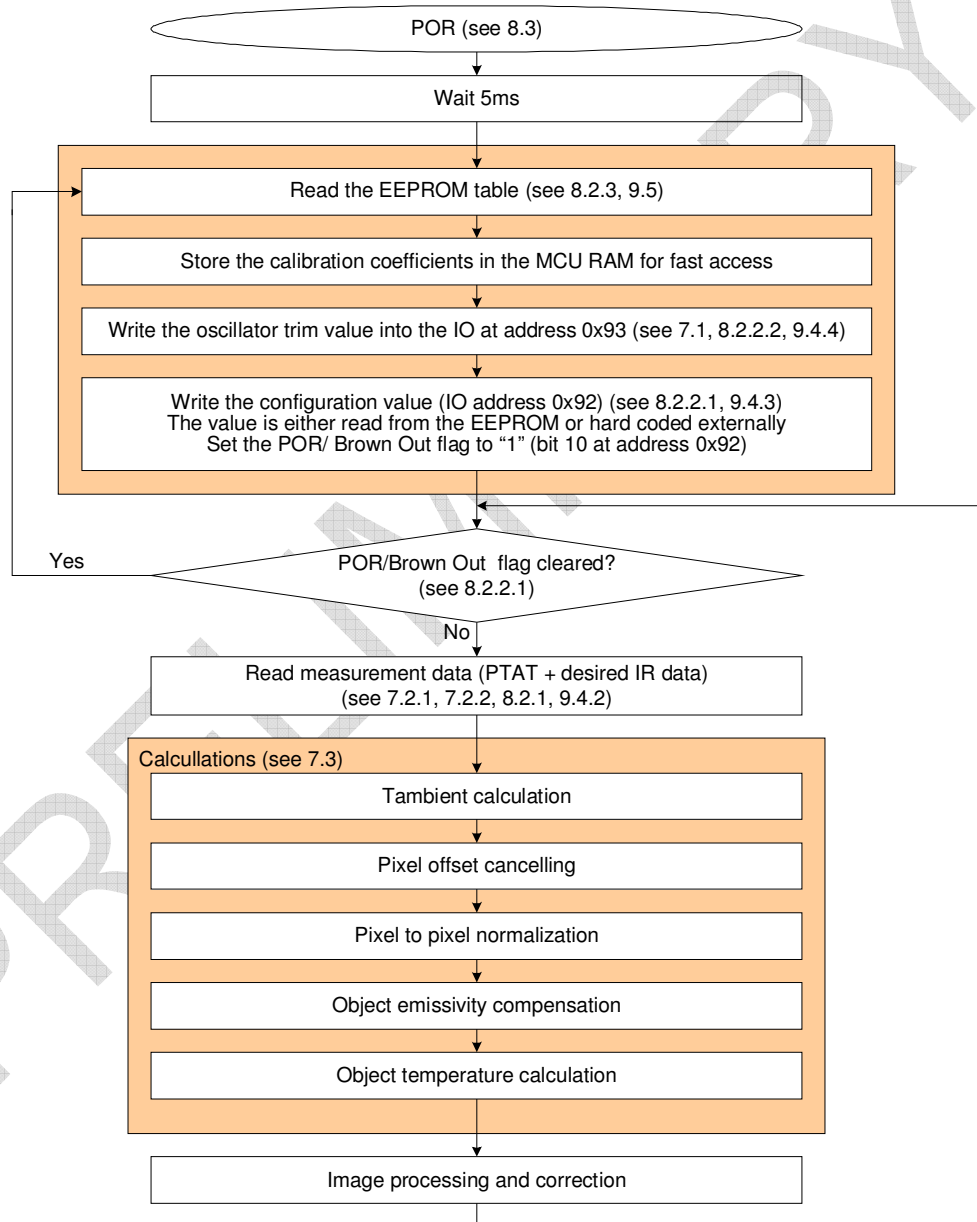


Figure 3 Operation block diagram

7.1 Initialization

After the POR is released the external MCU must execute an initialization procedure. This procedure must start at least 5ms after POR release.

- **Read the whole EEPROM** (see Figure 4). For maximum speed performance MELEXIS recommends that the whole calibration data is stored into the client MCU RAM. However it is possible to read the calibration data from the EEPROM only when needed. This will result in increased time for temperature calculation i.e. low refresh rate.

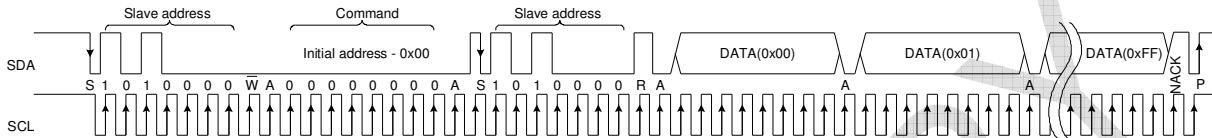


Figure 4 Whole EEPROM dump (SA = 0x50, command = 0x00)

- **Store the EEPROM content into customer MCU RAM** – This step could be omitted resulting in more data processing time because calibration data needs to be reread for each calculation
- **Write the oscillator trimming value** (extracted from EEPROM content at address 0xF7) into the corresponding register (0x93).

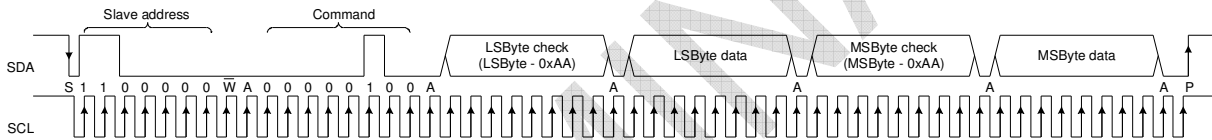


Figure 5 Write oscillator trimming (SA = 0x60, command = 0x04)

Example: If the value that has to be uploaded is 0x0052 the following sequence must be

sent:

1. Start condition (Falling edge of SDA while SCL is high)
2. Slave address (SA=0x60) plus write bit = 0xC0
3. Command = 0x04
4. LSB check = LSByte – 0xAA = 0x52 – 0xAA = 0xA8
5. LSbyte = 0x52
6. MSByte check = MSByte – 0xAA = 0x00 – 0xAA = 0x56
7. MSbyte = 0x00
8. Stop condition (Rising edge of SDA while SCL is high)

- **Write device configuration value.** In EEPROM addresses (0xF5 and 0xF6) MELEXIS provides a typical value of the configuration register (0x740E). So it is up to the user to copy that value or hardcode a new value to be loaded into the configuration register. If the EEPROM value is to be used the 16 bits are combined as follows:

For example: if EEPROM 0xF5 = 0x0E and 0xF6 = 0x74, the Configuration register value is:

$$\text{Configuration_register_value} = \{0xF6 : 0xF5\} = 0x740E$$

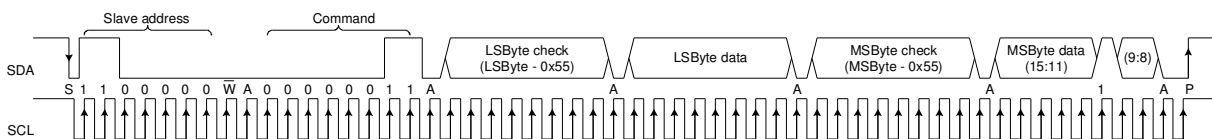


Figure 6 Write configuration register (SA = 0x60, command = 0x03)

– **Single line read**

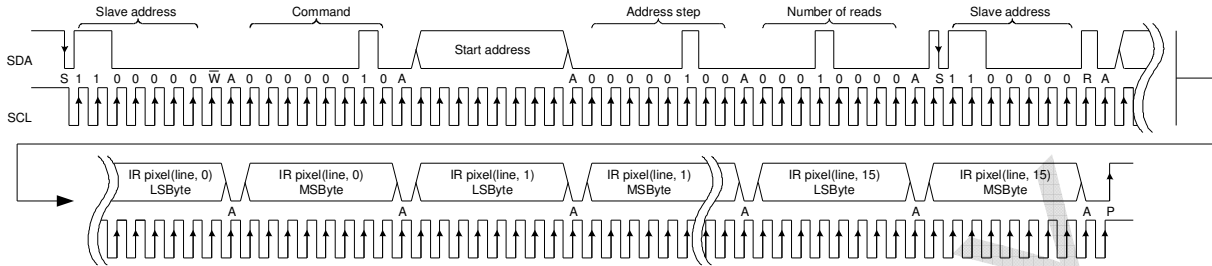


Figure 12 Single line (SA = 0x60, command = 0x02, Start address = 0x00...0x03 (step 0x01), Address step = 0x04, Number of reads = 0x10) measurement result read

– **Single pixel read**

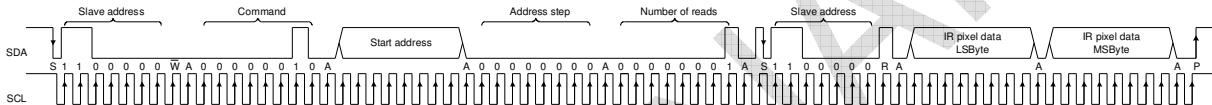


Figure 13 Single pixel (SA = 0x60, command = 0x02, Start address = 0x00...0x3F, Address step = 0x00, Number of reads = 0x01) measurement result read

– **Compensation pixel read**

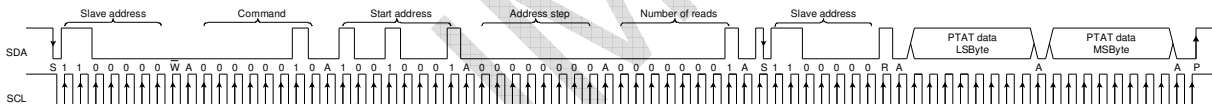


Figure 14 Compensation pixel (SA = 0x60, command = 0x02, Start address = 0x91, Address step = 0x00, Number of reads = 0x01) measurement result read

The 16bit data for each pixel is:

$$IR(i, j)_{data} = \{IR(i, j)_{data_MSbyte}: IR(i, j)_{data_LSbyte}\}$$

7.3 Calculation

7.3.1 Calculation of absolute chip temperature T_a (sensor temperature)

The output signal of the IR sensors is relative to the cold junction temperature. That is why we need to know the temperature of the die in order to be able to calculate the object temperature 'seen' by each pixel.

The T_a can be calculated using the formula:

$$T_a = \frac{-K_{T1} + \sqrt{K_{T1}^2 - 4K_{T2}[V_{TH}(25) - PTAT_data]}}{2K_{T2}} + 25, [^{\circ}C]$$

Constants $V_{TH}(25)$, **Error! Objects cannot be created from editing field codes.** and K_{T2} are stored in EEPROM at following addresses as two's complement values:

EEPROM address	Cell name	Stored as	Parameter
0xDA	V_{TH_L}	2's complement	V_{TH0} of absolute temperature sensor
0xDB	V_{TH_H}		
0xDC	K_{T1_L}	2's complement	K_{T1} of absolute temperature sensor
0xDD	K_{T1_H}		
0xDE	K_{T2_L}	2's complement	K_{T2} of absolute temperature sensor
0xDF	K_{T2_H}		

Table 5 EEPROM parameters for T_a calculations

$$V_{TH}(25) = 256.V_{TH_H} + V_{TH_L}$$

$$K_{T1} = \frac{256.K_{T1_H} + K_{T1_L}}{2^{10}}$$

$$K_{T2} = \frac{256.K_{T2_H} + K_{T2_L}}{2^{20}}$$

7.3.2 Example for T_a calculations

Let's assume that the values in EEPROM are as follows:

EEPROM address	Cell name	Cell values (hex)
0xDA	V_{TH_L}	0x78
0xDB	V_{TH_H}	0x1A
0xDC	K_{T1_L}	0x33
0xDD	K_{T1_H}	0x5B
0xDE	K_{T2_L}	0xCC
0xDF	K_{T2_H}	0xED

Table 6 EXAMPLE for T_a calibration values

$$V_{TH}(25) = 256.V_{TH_H} + V_{TH_L} = 256.26 + 120 = 6776, \text{ decimal value}$$

$$\text{Sign check } 6776 < 32767 \rightarrow V_{TH}(25) = 6776$$

$$K_{T1} = \frac{256.K_{T1_H} + K_{T1_L}}{2^{10}} = \frac{256.91 + 51}{1024} = \frac{23347}{1024}$$

$$\text{Sign check } 23347 < 32767 \rightarrow K_{T1} = \frac{23347}{1024} \approx 22.7998$$

$$K_{T2} = \frac{256.K_{T2_H} + K_{T2_L}}{2^{20}} = \frac{256.237 + 204}{1048576} = \frac{60876}{1048576}$$

$$\text{Sign check } 60876 > 32767 \rightarrow K_{T2} = \frac{60876 - 65536}{1048576} = \frac{-4660}{1048576} \approx -0.0044441$$

Let's assume that the input data is:

$$PTAT_data = 0x1AC0 = 6848 \text{ dec}$$

Thus the ambient temperature is:

$$Ta = \frac{-K_{T1} + \sqrt{K_{T1}^2 - 4K_{T2}[V_{TH}(25) - PTAT_data]}}{2K_{T2}}$$

$$Ta \approx \frac{-22.7998 + \sqrt{519.8309 - 4(-0.0044441)[6776 - 6848]}}{-0.0088882} + 25$$

$$Ta \approx \frac{-22.7998 + \sqrt{519.8309 + 0.0177764(-72)}}{-0.0088882} + 25$$

$$Ta \approx \frac{-22.7998 + \sqrt{518.551}}{-0.0088882} + 25 \approx \frac{-22.7998 + 22.7717}{-0.0088882} + 25 \approx 3.16 + 25$$

$$Ta \approx 28.16^\circ\text{C}$$

7.3.3 Calculation of T_o

Following formula is used to calculate the temperature seen by specific pixel in the matrix:

$$T_{O(i,j)} = 4 \sqrt[4]{\frac{V_{IR(i,j)_COMPENSATED}}{\alpha_{(i,j)}} + (T_a + 273.15)^4} - 273.15, [^{\circ}C]$$

Where:

$V_{IR(i,j)_COMPENSATED}$ is the parasitic free IR compensated signal as calculated in 7.3.3.1

$\alpha_{(i,j)}$ is a individual pixel sensitivity coefficient stored in EEPROM as calculated in 7.3.3.2

T_a is the ambient temperature calculated in 7.3.1

7.3.3.1 Calculating $V_{IR(i,j)_COMPENSATED}$

1. Offset compensation

$$V_{IR(i,j)_OFF_COMP} = V_{IR(i,j)} - \left(A_{i(i,j)} + \frac{B_{i(i,j)}}{2^{B_{i_scale}}} (T_a - T_{a_0}) \right)$$

Where:

$V_{IR(i,j)}$ is a individual pixel IR_data readout (RAM read)

$A_{i(i,j)}$ is a individual pixel offset stored in EEPROM as two's complement value

$B_{i(i,j)}$ is a individual pixel offset slope coefficient stored in EEPROM as two's complements value

B_{i_SCALE} is a scaling coefficient for slope of IR pixels offset and is stored in the EEPROM as unsigned value

T_a is ambient temperature calculated in 7.3.2

$T_{a_0} = 25^{\circ}C$ is a constant

NOTE: This applies to the compensation pixel as well (A_{CP} and B_{CP} while B_{i_SCALE} is the same)

2. Thermal Gradient Compensation (TGC)

$$V_{IR(i,j)_TGC_COMP} = V_{IR(i,j)_OFF_COMP} - \frac{TGC}{32} \cdot V_{IR_CP_OFF_COMP}$$

Where:

$V_{IR_CP_OFF_COMP}$ is offset compensated IR signal of the thermal gradient compensation pixel

TGC is a coefficient stored at EEPROM address 0xD8 as two's complement value

3. Emissivity compensation

$$V_{IR(i,j)_COMPENSATED} = \frac{V_{IR(i,j)_TGC_COMP}}{\varepsilon}$$

Where:

ε is emissivity coefficient. The scaled value is stored into EEPROM as unsigned value

$$\varepsilon = \frac{256 \cdot \varepsilon_H + \varepsilon_L}{32768}$$

7.3.3.2 Calculating $\alpha_{(i,j)}$

$$\alpha_{(i,j)} = \frac{(256 \cdot \alpha_{0_H} + \alpha_{0_L})}{2^{\alpha_{0_SCALE}}} + \frac{\Delta\alpha_{(i,j)}}{2^{\Delta\alpha_{SCALE}}}$$

Where:

α_{0_H} , α_{0_L} , $\Delta\alpha_{(i,j)}$, α_{0_SCALE} and $\Delta\alpha_{SCALE}$ are stored in the EEPROM as unsigned values

All parameters necessary to calculate T_o are stored into EEPROM at following addresses:

EEPROM address	Cell name	Stored as	Parameter
0x00...0x3F	$A_{i(i,j)}$	2's complement	IR pixel individual offset coefficient
0x40...0x7F	$B_{i(i,j)}$	2's complement	Individual T_a dependence (slope) of IR pixels offset
0x80...0xBF	$\Delta\alpha_{(i,j)}$	unsigned	Individual sensitivity coefficient
0xD4	A_{CP}	2's complement	Compensation pixel individual offset coefficients
0xD5	B_{CP}	2's complement	Individual T_a dependence (slope) of the compensation pixel offset
0xD6	α_{CP_L}	unsigned	Sensitivity coefficient of the compensation pixel
0xD7	α_{CP_H}		
0xD8	TGC	2's complement	Thermal gradient coefficient
0xD9	B_{i_SCALE}	unsigned	Scaling coefficient for slope of IR pixels offset
0xE0	α_{0_L}	unsigned	Common sensitivity coefficient of IR pixels
0xE1	α_{0_H}		
0xE2	α_{0_SCALE}	unsigned	Scaling coefficient for common sensitivity
0xE3	$\Delta\alpha_{SCALE}$	unsigned	Scaling coefficient for individual sensitivity
0xE4	ε_L	unsigned	Emissivity
0xE5	ε_H		

Table 7 EEPROM parameters for T_o calculations

7.3.4 Example for T_o calculations

Let's assume that we have following EEPROM data for pixel $i=2, j=8$:

EEPROM address	Cell name	Stored as	Cell values (hex)
0x22	$A_{i(2,8)}$	2's complement	0xD6
0x62	$B_{i(2,8)}$	2's complement	0xC1
0xA2	$\Delta\alpha_{(2,8)}$	unsigned	0x8F
0xD4	A_{CP}	2's complement	0xD0
0xD5	B_{CP}	2's complement	0xCA
0xD6	α_{CP_L}	unsigned	0x00
0xD7	α_{CP_H}	unsigned	0x00
0xD8	TGC	2's complement	0x23
0xD9	B_{i_SCALE}	unsigned	0x08
0xE0	α_{0_L}	unsigned	0xE4
0xE1	α_{0_H}	unsigned	0xD5
0xE2	α_{0_SCALE}	unsigned	0x2A
0xE3	$\Delta\alpha_{SCALE}$	unsigned	0x21
0xE4	ε_L	unsigned	0x99
0xE5	ε_H	unsigned	0x79

Table 8

Let's assume that we have the following input data:

$$V_{CP} = 0xFFD8 = 65496, \text{ decimal value (compensation pixel readings)}$$

$$\text{Sign check } 65496 > 32767 \rightarrow V_{CP} = 65496 - 65536 = -40$$

$$V_{IR(2,8)} = 0x0090 = 144, \text{ decimal value}$$

$$\text{Sign check } 144 < 32767 \rightarrow V_{IR(2,8)} = 144$$

$$T_a \approx 28.16^\circ\text{C (as calculated in 7.3.2)}$$

Reference routine for T_o computation:

$$A_{CP} = 0xD0 = 208, \text{ decimal value}$$

$$\text{Sign check } 208 > 127 \rightarrow A_{CP} = 208 - 256 = -48$$

$$B_{CP} = 0xCA = 202, \text{ decimal value}$$

$$\text{Sign check } 202 > 127 \rightarrow B_{CP} = 202 - 256 = -54$$

$$V_{CP_OFF_COMP} = V_{CP} - \left(A_{CP} + \frac{B_{CP}}{2^{B_{i_scale}}} (T_a - T_{a_0}) \right) = -40 - \left(-48 + \frac{-54}{2^8} (28.16 - 25) \right) \approx 8.67$$

$$A_{i(2,8)} = 0xD6 = 214, \text{ decimal value}$$

$$\text{Sign check } 214 > 127 \rightarrow A_{i(2,8)} = 214 - 256 = -42$$

$$B_{i(2,8)} = 0xC1 = 193, \text{ decimal value}$$

$$\text{Sign check } 193 > 127 \rightarrow B_{i(2,8)} = 193 - 256 = -63$$

$$V_{IR(2,8)_OFF_COMP} = V_{IR(2,8)} - \left(A_{i(2,8)} + \frac{B_{i(2,8)}}{2^{b_{i_scale}}} (T_a - T_{a_0}) \right) = 144 - \left(-42 + \frac{-63}{2^8} (28.16 - 25) \right) \approx 186.78$$

$$TGC = 0x23 = 35, \text{ decimal value}$$

$$\text{Sign check } 35 < 127 \rightarrow TGC = 35$$

$$V_{IR(i,j)_TGC_COMP} = V_{IR(i,j)_OFF_COMP} - \frac{TGC}{32} \cdot V_{IR_CP_OFF_COMP} = 186.78 - \frac{35}{32} \cdot 8.67 \approx 177.30$$

$$\varepsilon = \frac{256 \cdot \varepsilon_H + \varepsilon_L}{32768} = \frac{256 \cdot 121 + 153}{32768} = \frac{31129}{32768} \approx 0.949981$$

$$V_{IR(i,j)_COMPENSATED} = \frac{V_{IR(i,j)_TGC_COMP}}{\varepsilon} = \frac{177.30}{0.949981} \approx 186.63$$

$$\alpha_{(2,8)} = \frac{\left(256 \cdot \alpha_{0_H} + \alpha_{0_L} - \frac{TGC}{32} (256 \cdot \alpha_{CP_H} + \alpha_{CP_L}) \right)}{2^{\alpha_{0_SCALE}}} + \frac{\Delta \alpha_{(2,8)}}{2^{\Delta \alpha_{SCALE}}}$$

$$\alpha_{(2,8)} = \frac{\left(256 \cdot 213 + 228 - \frac{35}{32} (256 \times 0 + 0) \right)}{2^{42}} + \frac{143}{2^{33}} \approx 2.9097 \cdot 10^{-8}$$

$$T_{O(2,8)} = \sqrt[4]{\frac{V_{IR(2,8)_COMPENSATED}}{\alpha_{(2,8)}} + (T_a + 273.15)^4} - 273.15$$

$$T_{O(2,8)} = \sqrt[4]{\frac{186.63}{2.9097 \cdot 10^{-8}} + (28.16 + 273.15)^4} - 273.15 \approx 74.79^\circ\text{C}$$

8 Detailed description, Block description

8.1 Pixel position

The array consists of 64 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 0 to 3) and j is its column number (from 0 to 15)

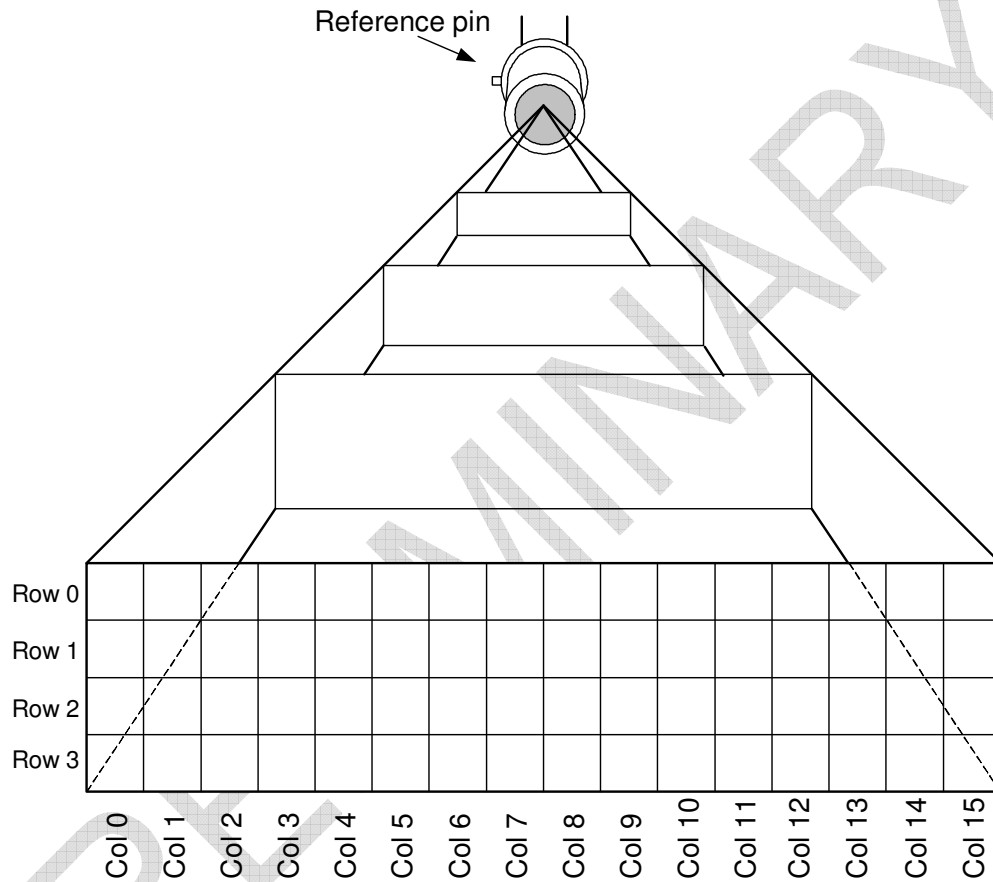


Figure 15 Pixel position in the whole FOV

8.2 MLX90620 address map

The MLX90620 address map is shown below:

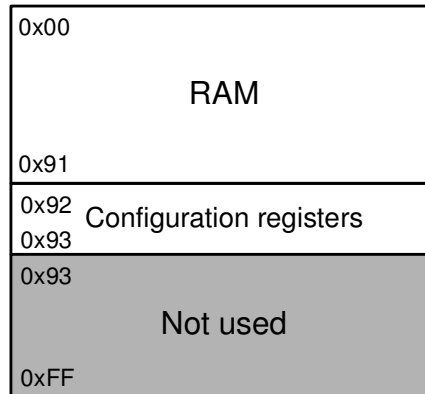


Figure 16 Address map

8.2.1 RAM

The on chip 146x16 RAM is accessible for reading via I²C. The RAM is used for storing the results of measurements of pixels and Ta sensor and is distributed as follows:

- 64 words for IR sensors. The data is in 2's complement format (see 7.2.2)
- 1 word for measurement result of PTAT sensor. The data is 16 bit without sign. (see 7.2.1)

The memory map of the RAM is shown below:

RAM Address	RAM variable description
0x00	IR sensor (0,0) result
0x01	IR sensor (1,0) result
0x02	IR sensor (2,0) result
0x03	IR sensor (3,0) result
0x04	IR sensor (0,1) result
0x05	IR sensor (1,1) result
...	...
0x3B	IR sensor (3,14) result
0x3C	IR sensor (0,15) result
0x3D	IR sensor (1,15) result
0x3E	IR sensor (2,15) result
0x3F	IR sensor (3,15) result
0x40	NA
...	...
0x8F	NA
0x90	PTAT sensor result
0x91	TGC sensor result

Table 9: Result address map

For IR sensors results, the addressing can be summarized:
IR(x,y) is on address:

$$IR(x, y)address = x + 4.y$$

8.2.2 Internal registers

8.2.2.1 Configuration register (0x92)

The configuration register defines the chip operating modes. It can be read and written by the I²C MD.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Configuration register bit meaning (0x92)
												0	0	0	0	- IR Refresh rate = 512Hz
												0	0	0	1	- IR Refresh rate = 512Hz
												0	0	1	0	- IR Refresh rate = 512Hz
												0	0	1	1	- IR Refresh rate = 512Hz
												0	1	0	0	- IR Refresh rate = 512Hz
												0	1	0	1	- IR Refresh rate = 512Hz
												0	1	1	0	- IR Refresh rate = 256Hz
												0	1	1	1	- IR Refresh rate = 128Hz
												1	0	0	0	- IR Refresh rate = 64Hz
												1	0	0	1	- IR Refresh rate = 32Hz
												1	0	1	0	- IR Refresh rate = 16Hz
												1	0	1	1	- IR Refresh rate = 8Hz
												1	1	0	0	- IR Refresh rate = 4Hz
												1	1	0	1	- IR Refresh rate = 2Hz
												1	1	1	0	- IR Refresh rate = 1Hz (default)
												1	1	1	1	- IR Refresh rate = 0.5Hz
												x	x		NA	
																0 - Continuous measurement mode (default)
																1 - Melexis reserved
																0 - Normal operation mode (default)
																1 - Sleep mode
																0 - No Ta measurement running (flag only can not be written)
																1 - Ta measurement running (flag only can not be written)
																0 - No IR measurement running (flag only can not be written)
																1 - IR measurement running (flag only can not be written)
																0 - POR or Brown-out occurred - Need to reload Configuration register
																1 - MD must write "1" during uploading Configuration register (default)
																0 - I ² C FM+ mode enabled (max bit transfer rates up to 1000 kbit/s) (default)
																1 - I ² C FM+ mode disabled (max bit transfer rates up to 400 kbit/s)
																0 0 - Ta Refresh rate = 16Hz
																0 1 - Ta Refresh rate = 8Hz
																1 0 - Ta Refresh rate = 4Hz
																1 1 - Ta Refresh rate = 2Hz (default)
																0 - ADC high reference enabled
																1 - ADC low reference enabled (default)
																x NA

Table 10: Configuration register bit meaning

8.2.2.2 Trimming register (0x93)

It can be read and written by the I²C MD.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Trimming register bit meaning (0x93)
																7 bit value - Oscillator trim value
x	x	x	x	x	x	x	x	x	NA							

Table 11: Oscillator trimming bit meaning

8.2.3 EEPROM

A 2kbit, organized as 256x8 EEPROM is built in the Mlx90620. The EEPROM has a separate I2C address SA = 0x50 and is used to store the calibration constants and the configuration of the device.

Address	0	1	2	3	4	5	6	7
00	Ai (0,0)	Ai (1,0)	Ai (2,0)	Ai (3,0)	Ai (0,1)	Ai (1,1)	Ai (2,1)	Ai (3,1)
08	...							
10								
18								
20	Ai - IR pixels individual offset coefficients							
28								
30								
38	Ai (0,14)	Ai (1,14)	Ai (2,14)	Ai (3,14)	Ai (0,15)	Ai (1,15)	Ai (2,15)	Ai (3,15)
40	Bi (0,0)	Bi (1,0)	Bi (2,0)	Bi (3,0)	Bi (0,1)	Bi (1,1)	Bi (2,1)	Bi (3,1)
48	...							
50								
58	Bi - Individual Ta dependence (slope) of IR pixels offset							
60								
68								
70	...							
78	Bi (0,14)	Bi (1,14)	Bi (2,14)	Bi (3,14)	Bi (0,15)	Bi (1,15)	Bi (2,15)	Bi (3,15)
80	$\Delta\alpha$ (0,0)	$\Delta\alpha$ (1,0)	$\Delta\alpha$ (2,0)	$\Delta\alpha$ (3,0)	$\Delta\alpha$ (0,1)	$\Delta\alpha$ (1,1)	$\Delta\alpha$ (2,1)	$\Delta\alpha$ (3,1)
88	...							
90								
98	Individual sensitivity coefficients							
A0								
A8								
B0								
B8	$\Delta\alpha$ (0,14)	$\Delta\alpha$ (1,14)	$\Delta\alpha$ (2,14)	$\Delta\alpha$ (3,14)	$\Delta\alpha$ (0,15)	$\Delta\alpha$ (1,15)	$\Delta\alpha$ (2,15)	$\Delta\alpha$ (3,15)
C0	MELEXIS reserved							
C8	MELEXIS reserved							
D0	MELEXIS reserved				Compensation pixel coefficients			
D8	TGC	Scale offset			PTAT			
E0	Common sensitivity coefficients				Emissivity		KsTa	
E8	MELEXIS reserved							
F0	MELEXIS reserved				Config register		OSC trim	
F8	Chip ID							

Table 12: EEPROM map

Detailed descriptions of some of the EEPROM addresses are described here after:

D7	D6	D5	D4	D3	D2	D1	D0	EEPROM cell meaning
				MELEXIS reserved				MELEXIS reserved
				A _{CP}				- Compensation pixel individual offset
				B _{CP}				- Individual Ta dependence (slope) of the compensation pixel offset
$\Delta\alpha_{CP_H}$	$\Delta\alpha_{CP_L}$							- Sensitivity coefficient of the compensation pixel

Table 13: D0...D7 EEPROM cell meaning

DF	DE	DD	DC	DB	DA	D9	D8	EEPROM cell meaning
							TGC	- Thermal Gradient Coefficient
							B _{scale}	- Scaling coefficient of slope of IR pixels offset
				V _{th_H}	V _{th_L}			- Vth0 of absolute temperature sensor
K _{T2_H}	K _{T2_L}	K _{T1_H}	K _{T1_L}					- K _{T1} of absolute temperature sensor
								- K _{T2} of absolute temperature sensor

Table 14: DF...D8 EEPROM cell meaning

E7	E6	E5	E4	E3	E2	E1	E0	EEPROM cell meaning	
						α_{0_H}	α_{0_L}	- Common sensitivity coefficient	
						α_{0_scale}		- Common sensitivity scaling coefficient	
						$\Delta\alpha_{scale}$		- Individual sensitivity scaling coefficient	
		ϵ_H	ϵ_L						- Emissivity coefficient
MELEXIS reserved		- MELEXIS reserved							

Table 15: E7...E0 EEPROM cell meaning

F7	F6	F5	F4	F3	F2	F1	F0	EEPROM cell meaning	
								MELEXIS reserved	
								- MELEXIS reserved	
		CFG_H	CFG_L						- Config register value
OSC_trim		- Oscillator trimming value							

Table 16: F7...F0 EEPROM cell meaning

8.3 POR

The Power On Reset (POR) is connected to the Vdd supply. The on-chip POR circuit provides an active level of the POR signal when the Vdd voltage rises above approximately 0.5V and holds the entire MLx90620 in reset until the Vdd is higher than 2.4V. The device will start approximately 5 ms after the POR release.

8.4 ESD

ESD, 2KV Human Body Model

9 Communication protocol

The device supports Fast Mode Plus I²C FM+ (IR array only up to 1Mbps) and will work in slave mode only.

The master device is providing the clock signal (SCL) for the communication. The data line SDA is bidirectional and is driven by the master or the slave depending on the command. The selection of the SDA occupant is done according to the I²C specification. As the SDA is an open-drain IO, '0' is transmitted by forcing the line 'LOW' and a '1' just by releasing it. During data transfer, the data line could be changed only while SCL is low. Other wise, it would be interpreted as a start/stop condition

9.1 Communication pins

There are two communication pins SCL and SDA. SCL is an input only for the MLX90620 while the SDA pin is a bidirectional one. The SDA line should be wired in an open-drain configuration.

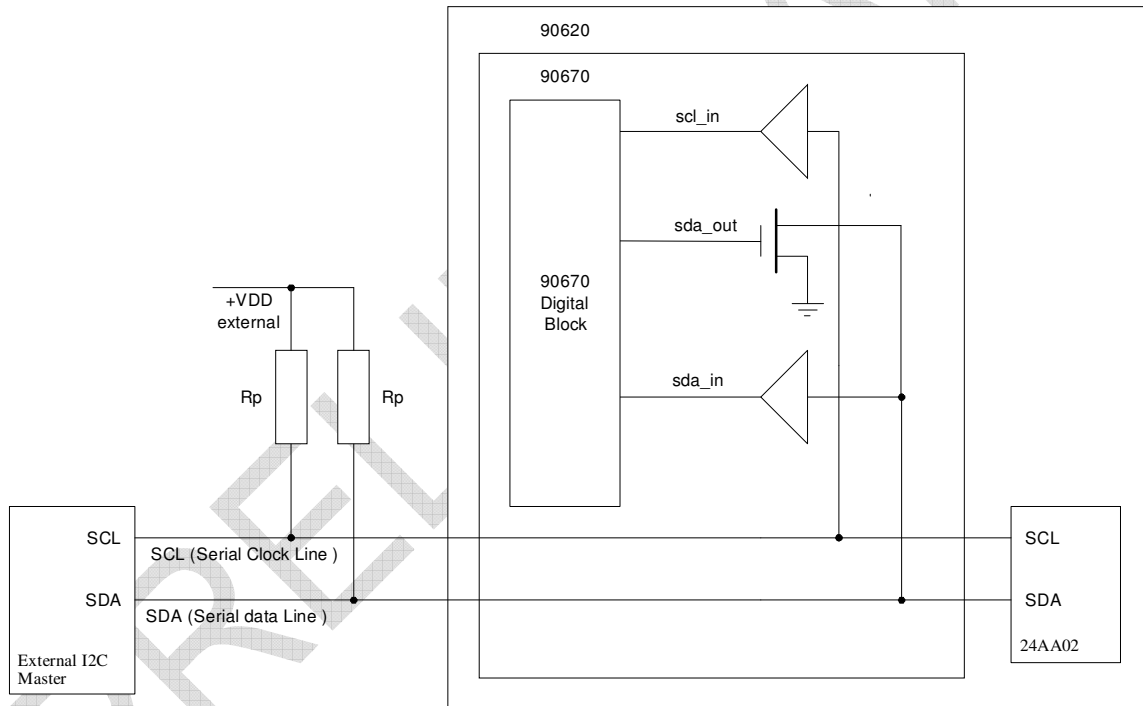


Figure 17 Communication pin diagram

9.2 Low level communication protocol

9.2.1 Start / Stop condition

Each communication session is initiated by a START condition and ends with a STOP condition. A START condition is initiated by a HIGH to LOW transition of the SDA while a STOP is generated by a LOW to HIGH transition. Both changes must be done while the SCL is HIGH (see the figure)

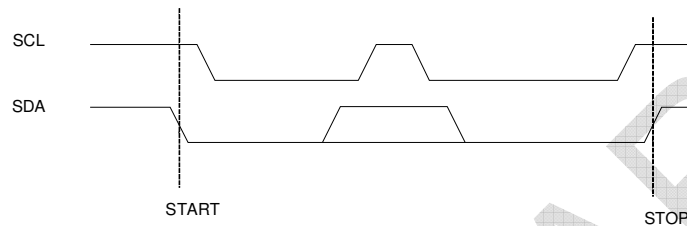


Figure 18: Start / Stop conditions of I²C

9.2.2 Device addressing

The master is addressing the slave device by sending an 7-bit slave address after the START condition. The first seven bits are dedicated for the address and the 8th is 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

Mlx90620 is responding to 2 different slave addresses:

1	0	1	0	0	0	0	R/W	for access to internal EEPROM
1	1	0	0	0	0	0	R/W	For access to IR array data

Figure 19: I²C addresses

9.2.3 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'.

9.2.4 Low level communication operation

The low level operation communication is based on 8bits (1byte) transmissions. This includes start/stop event, acknowledgement and errors detection.

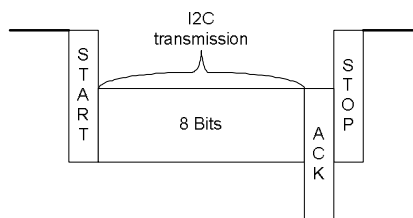


Figure 20: I²C communication

9.3 Device modes

The device can operate in following modes:

- Normal mode

9.3.1 Normal mode

In this mode the measurements are constantly running. Depending on the selected frame rate Fps in ConfReg, the data for IR pixels and Ta will be updated in the RAM each 1/Fps seconds. In this mode the external microcontroller has full access to the internal registers and memories of the device (both for 90670 and EEPROM chip).

PRELIMINARY

9.4 Communication to IR array

9.4.1 Read command

Opcode – 0x02.

The read command is used to read measurement, configuration and other data from the chip to the external master.

The read command has the following parameters:

- Start address – 8bits. Address in the chip address space (0 to 255). It is the address of the first word read.
- Address step – 8bits. On every read word the next address is formed by adding the address step to the current address.
- Number of reads – 8bits. Number of the words to be read.

Different combinations are possible in order to read all, one line, one column, one exact pixel of the IR or Ta sensors. They are summarized in the table below:

Sensors read	Start address	Address step	Number of reads
All IR	0x00	0x01	0x40
One line IR(i)	i	0x04	0x10
One column IR(j)	j*0x04	0x01	0x04
One pixel IR(i,j)	i + j*0x04	0x00	0x01

Table 17 RAM readout options

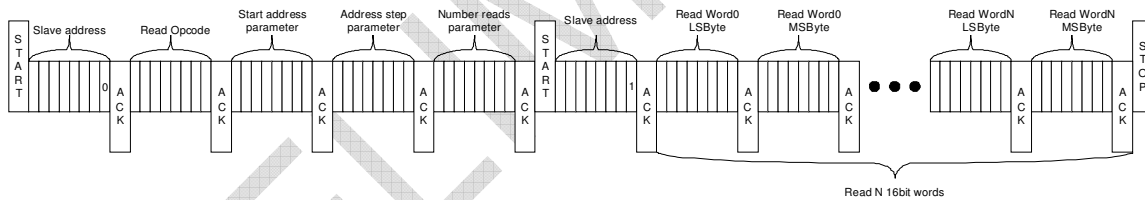


Figure 21: RAM readout command structure

9.4.2 Write configuration register command

Opcode – 0x03.

This command is used to set the configuration register (16bits) value – all configuration settings.

Each data byte is transmitted in two stages:

- First stage → Data byte - 0x55
- Second stage → Data byte

This way of transmitting the data is done in order to have a simple error check. The chip adds 0x55 to the first byte and compares the result with the second one. If both match the configuration register is updated.

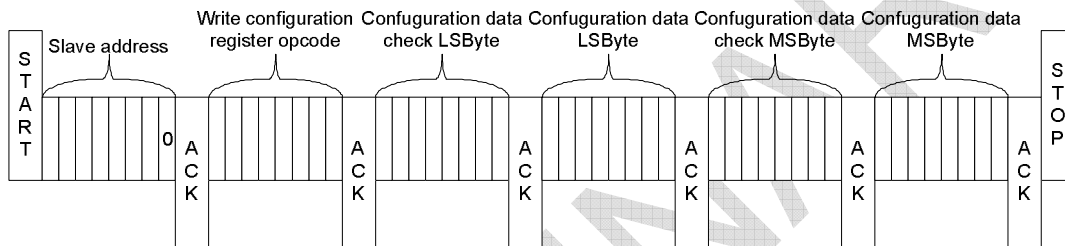


Figure 22: Configuration register update command structure

9.4.3 Write trimming command

Opcode – 0x04.

This command is used to set the oscillator trimming oscillator trimming value.

This command is used to set the oscillator trimming register (16bits) value.

Each data byte is transmitted in two stages:

- First stage → Data byte - 0xAA
- Second stage → Data byte

This way of transmitting the data is done in order to have a simple error check. The chip adds 0xAA to the first byte and compares the result with the second one. If both match the oscillator trimming register is updated.

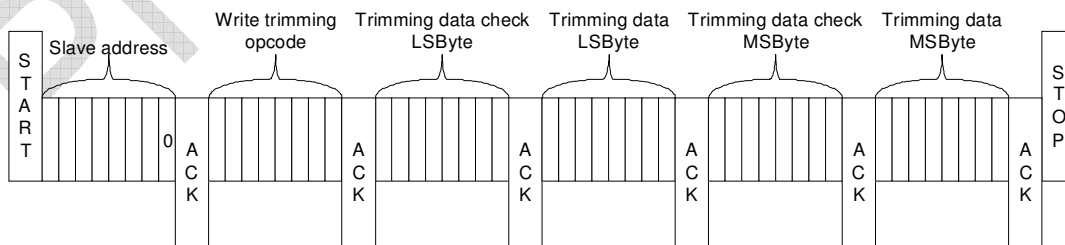


Figure 23: Oscillator trimming register update command structure

9.5 Communication to EEPROM

See datasheet of 24AA02. This can be found at
<http://www.melexis.com/Assets/Datasheet-MLX90620-EEPROM-6088.aspx>

PRELIMINARY

10 Performance Graphs

10.1 Temperature accuracy of the MLX90620

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

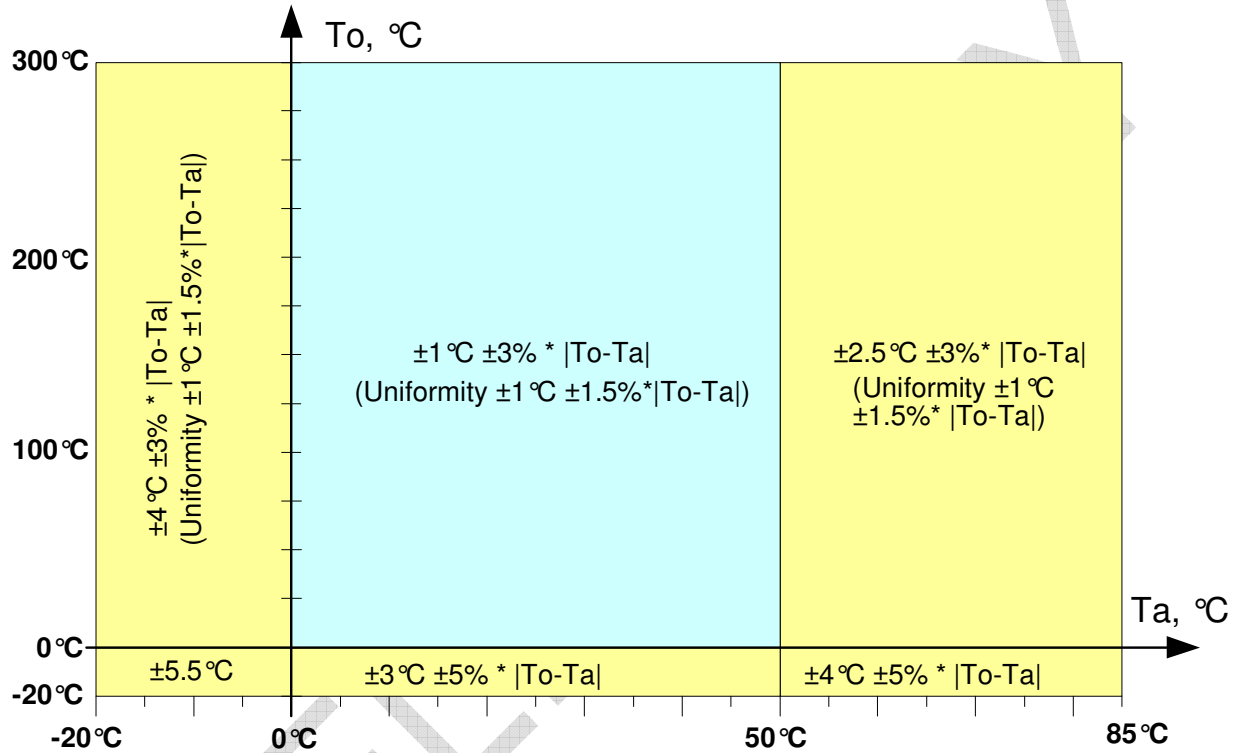


Figure 24: Absolute temperature accuracy for the central four pixels

NOTE: The accuracy is specified for the four central pixels. The accuracy of the rest of the pixels is according to the uniformity statement

NOTE: For certain combinations of Tambient and Tobject, there can be an additional measurement deviation of $\pm 3^\circ\text{C}$ for object temperatures around room temperature, lowering to 1°C for object temperatures around 200°C . This higher deviation occurs in limited, localised temperature regions.

All accuracy specifications apply under settled isothermal conditions only.

10.2 Field Of View (FOV)

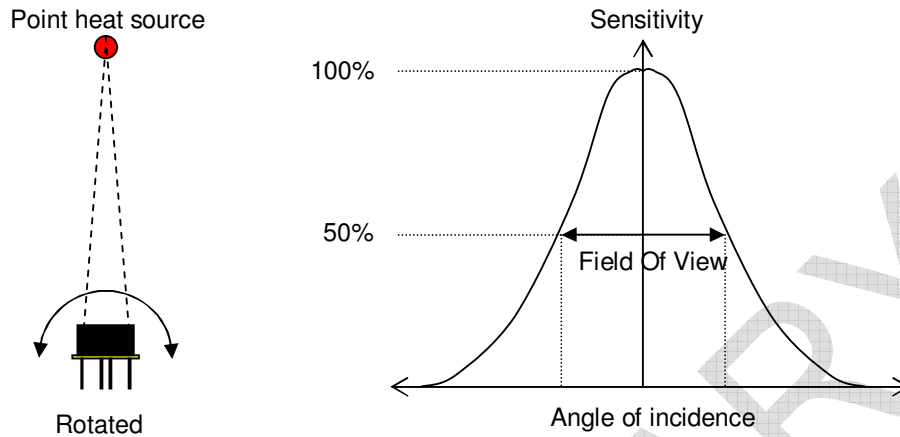


Figure 25: Field Of View measurement

The specified FOV is calculated for the wider direction, in this case for the 16 pixels. Angular alignment must be 5% of specified FOV and will be valid for both directions. For example for the 60 deg FOV in wider direction will come with 16.4 deg in shorter direction.

FOV	X direction	Y direction
	Typ	Typ
Wide	60	16.4
Medium	40	10.4

Table 18 Available FOV options

11 Applications Information

11.1 Use of the MLX90620 thermometer in SMBus configuration

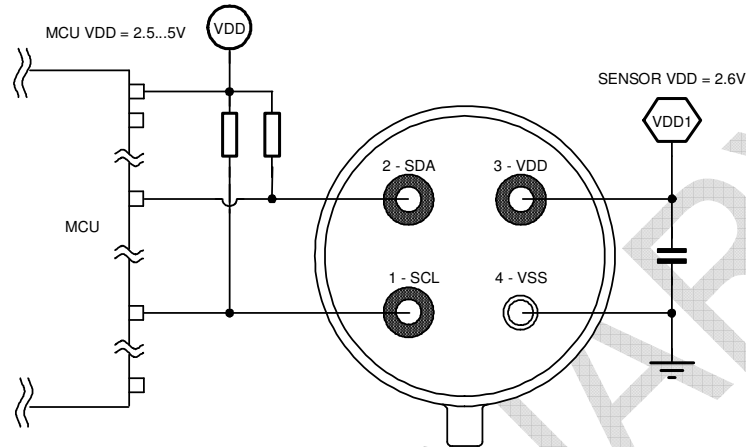


Figure 26: MLX90620 SMBus connection

Figure 26 shows the connection of a MLX90620 to a SMBus with 3.3V power supply. The MLX90620 has diode clamps SDA/SCL to Vdd so it is necessary to provide MLX90620 with power in order not to load the SMBus lines.

12 Application Comments

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.

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 MLX90620xxx, it is recommended not to subject the MLX90620 to heat transfer and especially transient conditions.

The MLX90620 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 a I²C 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 MLX90620 additional improvement is possible by increasing the pull-up current (decreasing the pull-up resistor values). Input levels for I²C compatible mode have higher overall tolerance than the I²C specification, but the output low level is rather low even with the high-power I²C specification for pull-up currents. Another option might be to go for a slower communication (clock speed), as the MLX90620 implements Schmidt triggers on its inputs in I²C 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 I²C 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 capacitor is needed as with most integrated circuits. MLX90620 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 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. Using MLX90620 with short pins improves the effect of the power supply decoupling.

Check www.melexis.com for most recent application notes about MLX90620.

PRELIMINARY

13 Standard information regarding manufacturability of Melexis products with different soldering processes

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

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.

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>

The MLX90620 is RoHS compliant

14 ESD Precautions

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD).
Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

15 FAQ

When I measure aluminum and plastic parts settled at the same conditions I get significant errors on aluminum. Why?

Different materials have different **emissivity**. A typical value for aluminum (roughly polished) is 0.18 and for plastics values of 0.84...0.95 are typical. IR thermometers use the radiation flux between the sensitive element in the sensor and the object of interest, given by the equation

$$q = \varepsilon_1 \cdot \alpha_1 \cdot (T_1^4) \cdot \sigma \cdot A_1 \cdot F_{a-b} - \varepsilon_2 \cdot (T_2^4) \cdot \sigma \cdot A_2,$$

Where:

ε_1 and ε_2 are the emissivities of the two objects,
 α_1 is the absorptivity of the sensor (in this case),

σ is the Stefan-Boltzmann constant,

A_1 and A_2 are the surface areas involved in the radiation heat transfer,

F_{a-b} is the shape factor,

T_1 and T_2 are known temperature of the sensor die (measured with specially integrated and calibrated element) and the object temperature that we need.

Note that these are all in Kelvin, heat exchange knows only physics.

When a body with low emissivity (such as aluminum) is involved in this heat transfer, the portion of the radiation incident to the sensor element that really comes from the object of interest decreases – and the reflected environmental IR emissions take place. (This is all for bodies with zero transparency in the IR band.) The IR thermometer is calibrated to stay within specified accuracy – but it has no way to separate the incoming IR radiation into real object and reflected environmental part. Therefore, measuring objects with low emissivity is a very sophisticated issue and infra-red measurements of such materials are a specialized field.

What can be done to solve that problem? Look at paintings – for example, oil paints are likely to have emissivity of 0.85...0.95 – but keep in mind that the stability of the paint emissivity has inevitable impact on measurements.

It is also a good point to keep in mind that not everything that looks black is “black” also for IR. For example, even heavily oxidized aluminum has still emissivity as low as 0.30.

How high is enough? Not an easy question – but, in all cases the closer you need to get to the real object temperature the higher the needed emissivity will be, of course.

With the real life emissivity values the environmental IR comes into play via the reflectivity of the object (the sum of Emissivity, Reflectivity and Absorptivity gives 1.00 for any material). The larger the difference between environmental and object temperature is at given reflectivity (*with an opaque for IR material reflectivity equals 1.00 minus emissivity*) the bigger errors it produces.

After I put the MLX90620 in the dashboard I start getting errors larger than specified in spite that the module was working properly before that. Why?

Any object present in the FOV of the module provides IR signal. It is actually possible to introduce error in the measurements if the module is attached to the dashboard with an opening that enters the FOV. In that case portion of the dashboard opening will introduce IR signal in conjunction with constraining the effective FOV and thus compromising specified accuracy. Relevant opening that takes in account the FOV is a must for accurate measurements. Note that the basic FOV specification takes 50% of IR signal as threshold (in order to define the area, where the measurements are relevant), while the entire FOV at lower level is capable of introducing lateral IR signal under many conditions.

When a hot (cold) air stream hits my MLX90620 some error adds to the measured temperature I read. What is it?

IR sensors are inherently sensitive to difference in temperatures between the sensitive element and everything incident to that element. As a matter of fact, this element is not the sensor package, but the sensor die inside. Therefore, a thermal gradient over the sensor package will inevitably result in additional IR flux

between the sensor package and the sensor die. This is real optical signal that can not be segregated from the target IR signal and will add errors to the measured temperature.

Thermal gradients with impact of that kind are likely to appear during transient conditions. The sensor used is developed with care about sensitivity to this kind of lateral phenomena, but their nature demands some care when choosing place to use the MLX90620 in order to make them negligible.

I measure human body temperature and I often get measurements that significantly differ from the +37°C I expect.

IR measurements are true surface temperature measurements. In many applications this means that the actual temperature measured by an IR thermometer will be temperature of the clothing and not the skin temperature. Emissivity (explained first in this section) is another issue with clothes that has to be considered. There is also the simple chance that the measured temperature is adequate – for example, in a cold winter human hand can appear at temperatures not too close to the well known +37°C.

I consider using MLX90620AAA to measure temperature within car compartment, but I am embarrassed about the Sun light that may hit the module. Is it a significant issue?

Special care is taken to cut off the visible light spectra as well as the NIR (near IR) before it reaches the sensitive sensor die. Even more, the glass (in most cases) is not transparent to the IR radiation used by the MLX90620. Glass has temperature and really high emissivity in most cases – it is “black” for IR of interest. Overall, Sun behind a window is most likely to introduce relatively small errors. Why it is not completely eliminated after all? Even visible light partially absorbed in the filter of the sensor has some heating potential and there is no way that the sensor die will be “blind” for that heating right in front of it.

16 Mechanical specification

16.1 Package outline

The height of the can depends on the selected FOV of the array

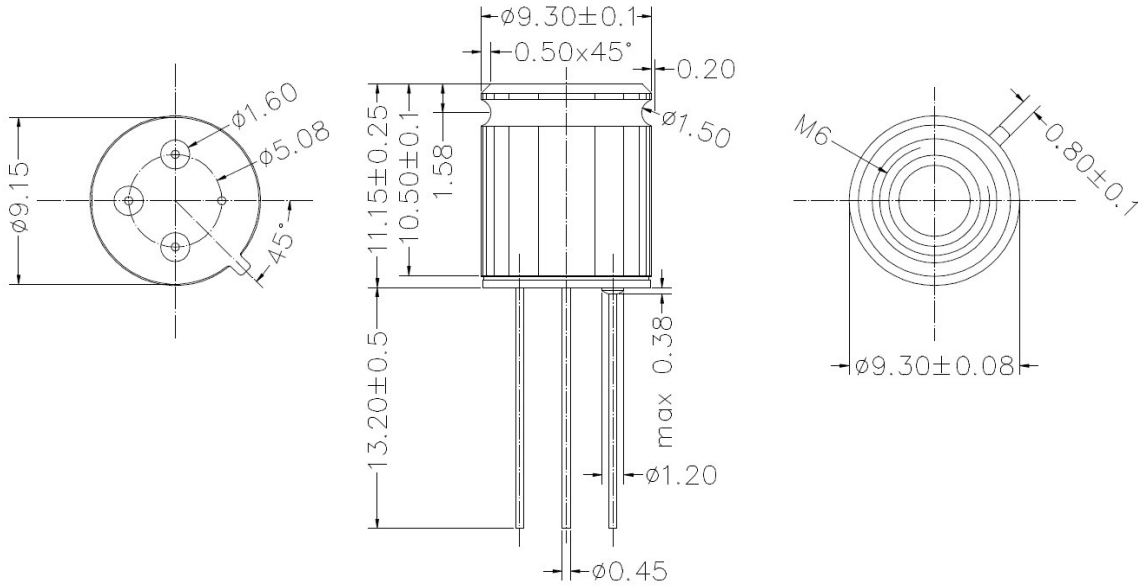


Figure 27 Mechanical drawing of Wide (60x15) FOV device (MLX90620BAB)

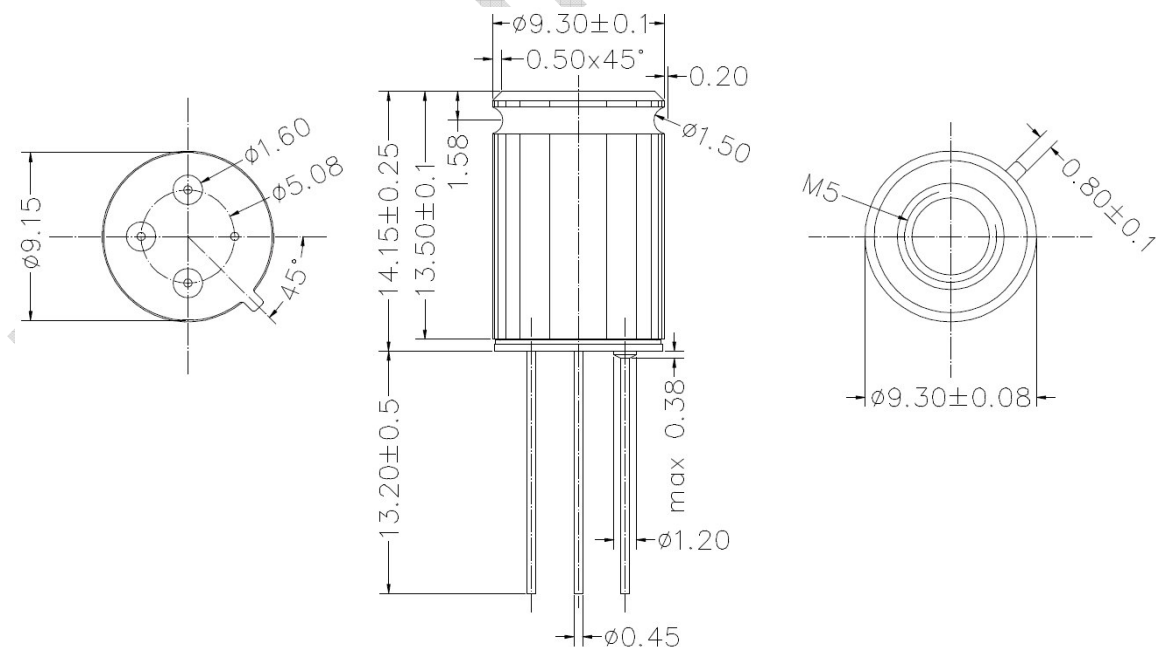


Figure 28 Mechanical drawing of Medium (40x10) FOV device (MLX90620BAD)

16.2 Part marking

TBD

17 References

[1] I²C-bus specification and user manual Rev. 03 — 19 June 2007

http://www.nxp.com/documents/user_manual/UM10204.pdf

18 Disclaimer

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