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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

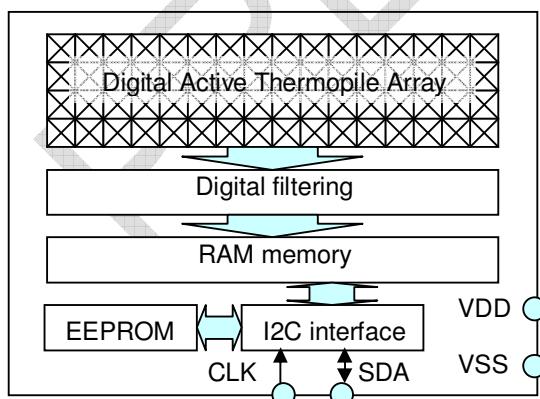
Ordering Information



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

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

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PRELIMINARY

2 Glossary of terms

POR	Power On Reset
PTAT	Proportional To Absolute Temperature sensor (package temperature)
IR	Infra Red
IR_data	Infrared data (raw data from ADC proportional to IR energy received by the sensor)
ADC	Analog To Digital Converter
Ta	Ambient Temperature measured from the chip – (the package temperature)
To	Object Temperature, 'seen' from IR sensor
TGC	Temperature Gradient Coefficient
FOV	Field Of View
ESD	Electro-Static Discharge
EMC	Electro-Magnetic Compatibility
I²C	Inter-Integrated Circuit communication protocol
SDA	Serial Data
SCL	Serial Clock
DSP	Digital Signal Processing
HFO	High Frequency Oscillator (RC type)
FpS	Frames per Second – data refresh rate
MD	Master Device
SD	Slave Device
TBD	To Be Defined
NA	Not Applicable

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

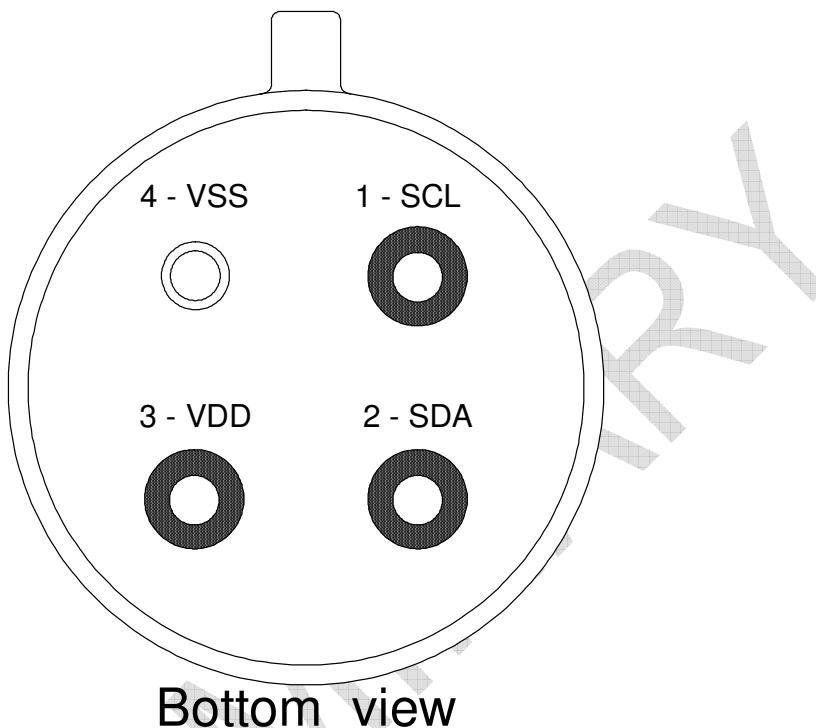


Figure 1 Pin description

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
I^2C compatible 2-wire interface Sensor chip						
Slave address	SA	Factory default		60		hex
Input high voltage	$V_{IH}(T_a, V)$	Over temperature and supply	0.7VDD			V
Input low voltage	$V_{IL}(T_a, V)$	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^2C 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	$T_{Thdac(MD)}$	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	$T_{Thdac(SD)}$	9-th SCL falling edge, Slave			0.45	μs
EEPROM						
Slave address	SA	Factory default		50		hex
I^2C 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 $V_{DD} = 2.6\ldots 3.3\text{V}$ but the best performance is at $V_{DD}=2.6\text{V}$

6 Block diagram

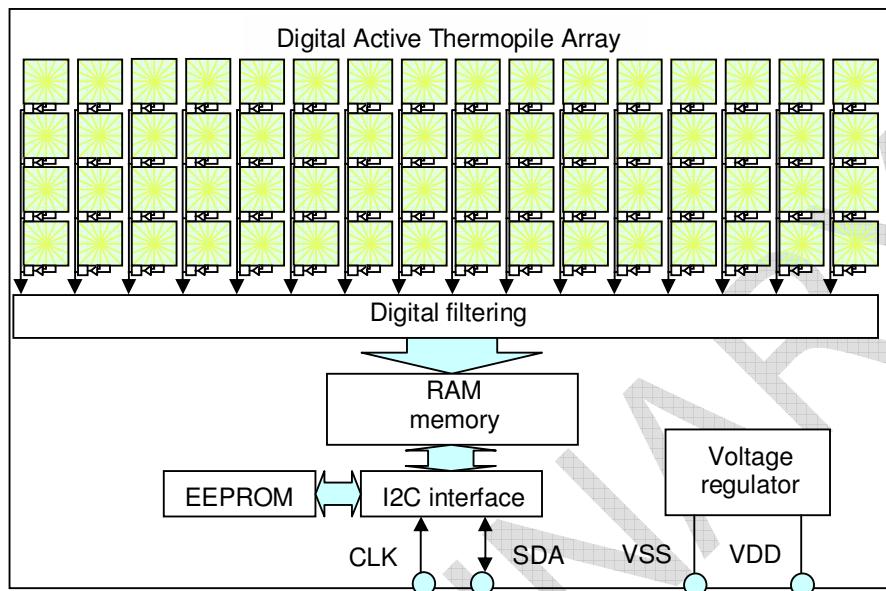


Figure 2 Block diagram

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

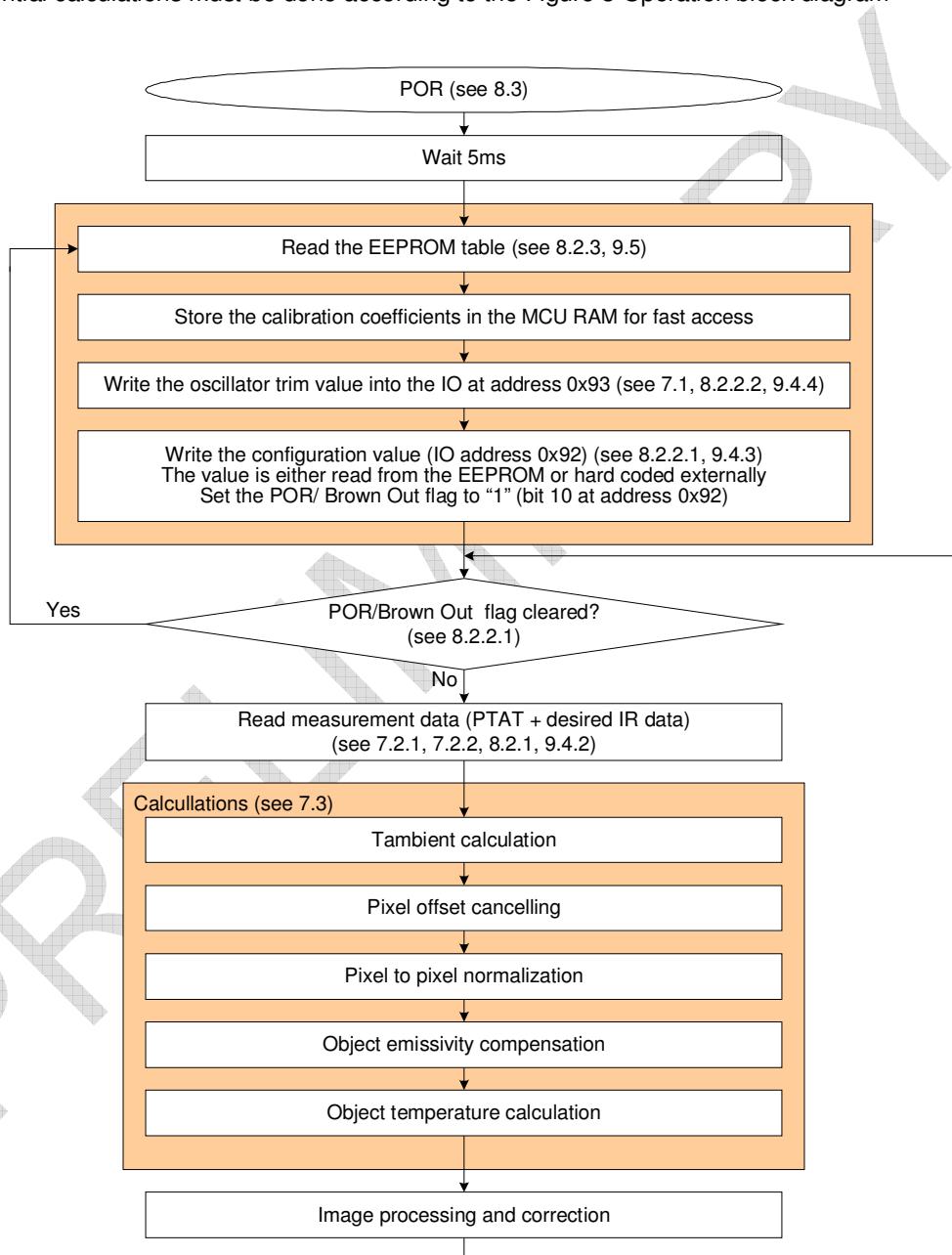


Figure 3 Operation block diagram

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.

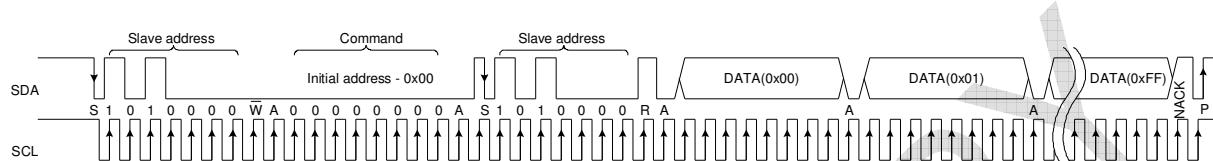


Figure 4 Whole EEPROM dump (SA = 0x50, command = 0x00)

- **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).

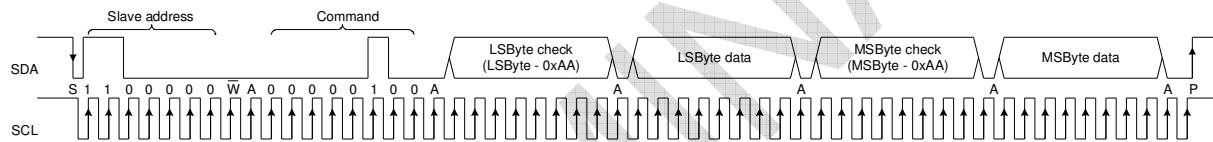


Figure 5 Write oscillator trimming (SA = 0x60, command = 0x04)

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. LSByte 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:

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

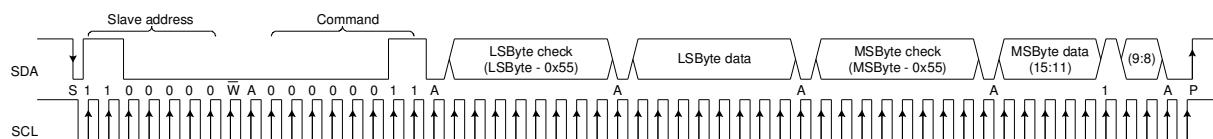


Figure 6 Write configuration register (SA = 0x60, command = 0x03)

NOTE: The user must ensure that the bit 10 (POR or Brown-out flag) in Configuration register is set to "1" by the MD. Further more this bit must be checked regularly and if it is cleared that would mean that the device has been reset and the initialisation procedure must be redone.

Example: If the value that has to be uploaded is 0x740E 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 = 0x03
4. LSByte check = LSByte – 0x55 = 0x0E – 0x55 = 0xB9
5. LSbyte = 0x0E
6. MSByte check = MSByte – 0x55 = 0x74 – 0x55 = 0x1F
7. MSbyte = 0x74
8. Stop condition (Rising edge of SDA while SCL is high)

The default configuration is:

- IR refresh rate = 1Hz;
- Ta refresh rate = 2Hz;
- Normal mode (no sleep);
- I²C FM+ mode enabled (maximum bit transfer up to 1000 Kbit/s);
- ADC low reference enabled;

7.1.1 Reading configuration

7.1.1.1 Reading configuration register

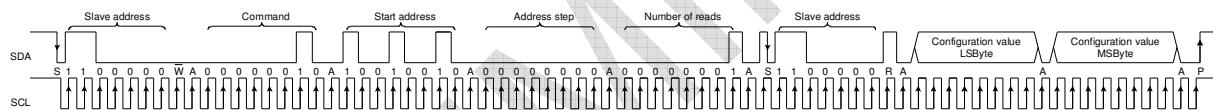


Figure 7 Reading configuration register (SA = 0x60, command = 0x02,
Start address = 0x92, Address step = 0x00, Number of reads = 0x01)

7.1.1.2 Reading oscillator trimming register

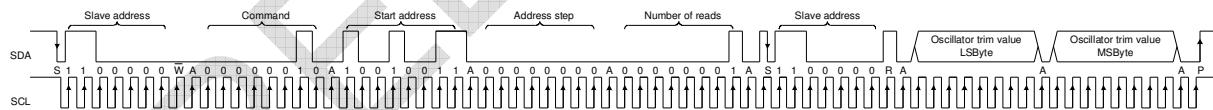


Figure 8 Reading configuration register (SA = 0x60, command = 0x02,
Start address = 0x93, Address step = 0x00, Number of reads = 0x01)

7.2 Read measurement data

7.2.1 PTAT data read

Absolute ambient temperature data of the device it self (package temperature) can be read by using following command:

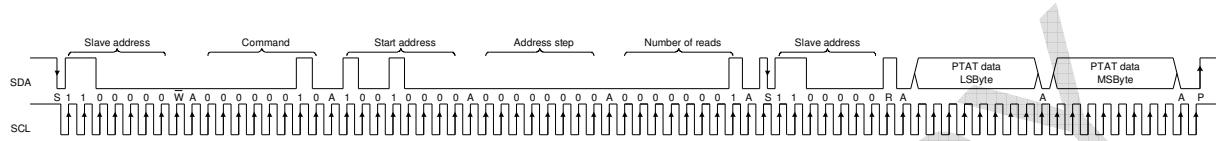


Figure 9 PTAT (SA = 0x60, command = 0x02, Start address = 0x90, Address step = 0x00, Number of reads = 0x01) measurement result read

$$PTAT_data = \{ PTAT_data_MSbyte : PTAT_data_LSbyte \}$$

7.2.2 IR data read

There are four options available for reading IR data: (See section 8.2.1 for an overview of the RAM addresses).

- **Whole frame read** (MELEXIS recommends the whole frame read for maximum refresh rate)

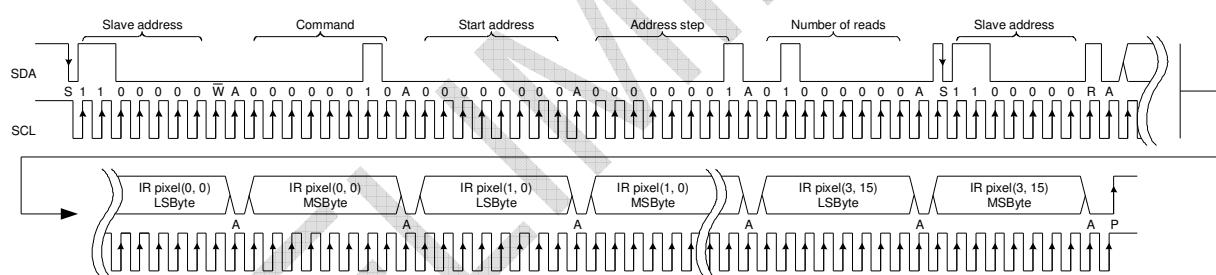


Figure 10 Whole frame (SA = 0x60, command = 0x02, Start address = 0x00, Address step = 0x01, Number of reads = 0x40) measurement result read

– Single column read

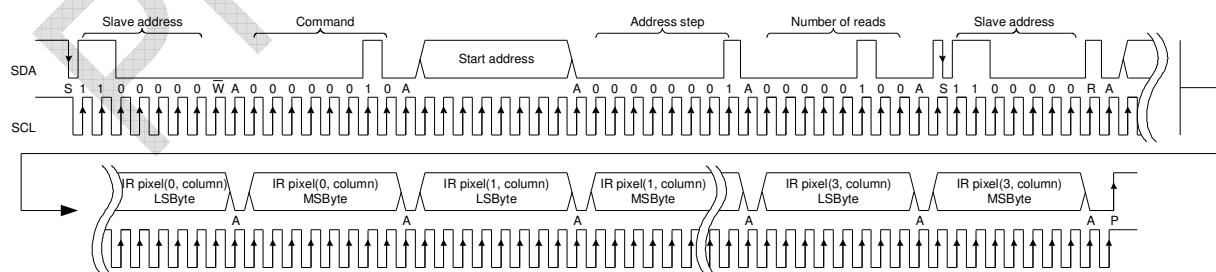


Figure 11 Single column (SA = 0x60, command = 0x02, Start address = 0x00...0x3C (step 0x04), Address step = 0x01, Number of reads = 0x04) measurement result read

- Single line read

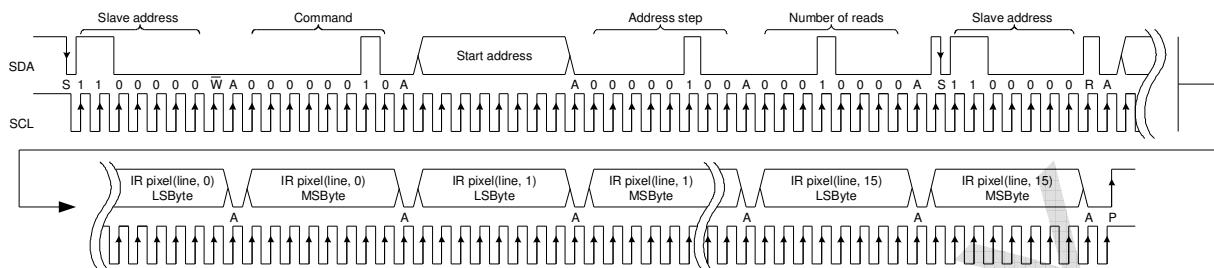


Figure 12 Single line (SA = 0x60, command = 0x02, Start address = 0x00...0x03 (step 0x01), Address step = 0x04, Number of reads = 0x10) measurement result read

- Single pixel read

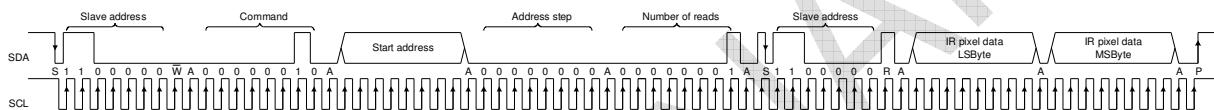


Figure 13 Single pixel (SA = 0x60, command = 0x02, Start address = 0x00...0x3F, Address step = 0x00, Number of reads = 0x01) measurement result read

- Compensation pixel read

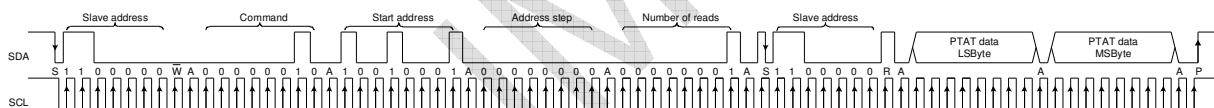


Figure 14 Compensation pixel (SA = 0x60, command = 0x02, Start address = 0x91, Address step = 0x00, Number of reads = 0x01) measurement result read

The 16bit data for each pixel is:

$$IR(i, j) \text{ _data} = \{IR(i, j) \text{ _data_MSbyte}: IR(i, j) \text{ _data_LSbyte}\}$$

7.3 Calculation

7.3.1 Calculation of absolute chip temperature Ta (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 Ta can be calculated using the formula:

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

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}		V_{TH0} of absolute temperature sensor
0xDB	V_{TH_H}		
0xDC	K_{T1_L}		K_{T1} of absolute temperature sensor
0xDD	K_{T1_H}		
0xDE	K_{T2_L}		K_{T2} of absolute temperature sensor
0xDF	K_{T2_H}		

Table 5 EEPROM parameters for Ta 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 Ta 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 Ta calibration values

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

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

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

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

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

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

Let's assume that the input data is:

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

Thus the ambient temperature is:

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

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

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

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

$$Ta \approx 28.16^\circ C$$

7.3.3 Calculation of T_o

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

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

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

$T_{a_0} = 25^{\circ}\text{C}$ 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 $\alpha_{(i,j)}$

$$\alpha_{(i,j)} = \frac{(256.\alpha_{0_H} + \alpha_{0_L})}{2^{\alpha_{0_SCALERE}}} + \frac{\Delta\alpha_{(i,j)}}{2^{\Delta\alpha_{SCALERE}}}$$

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 To 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 Ta 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 Ta 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 To calculations

7.3.4 Example for To 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:

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

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

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

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

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

Reference routine for To computation:

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

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

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

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

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

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

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

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

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

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

$TGC = 0x23 = 35$, decimal value

Sign check $35 < 127 \rightarrow TGC = 35$

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

$$\varepsilon = \frac{256 \cdot \varepsilon_H + \varepsilon_L}{32768} = \frac{256.121 + 153}{32768} = \frac{31129}{32768} \approx 0.949981$$

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

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

$$\alpha_{(2,8)} = \frac{\left(256.213 + 228 - \frac{35}{32} (256 \times 0 + 0) \right)}{2^{42}} + \frac{143}{2^{33}} \approx 2.9097 \cdot 10^{-8}$$

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

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

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 $\text{Pix}(i,j)$ where i is its row number (from 0 to 3) and j is its column number (from 0 to 15)

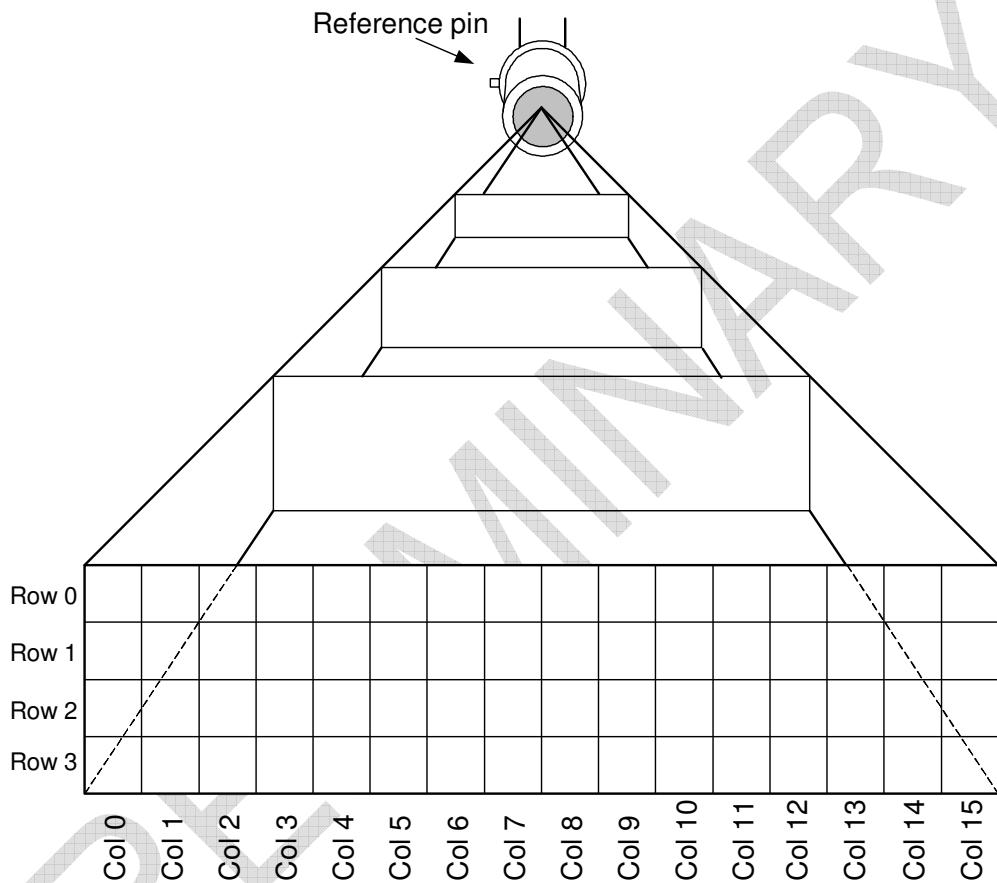


Figure 15 Pixel position in the whole FOV

8.2 MLX90620 address map

The MLX90620 address map is shown below:

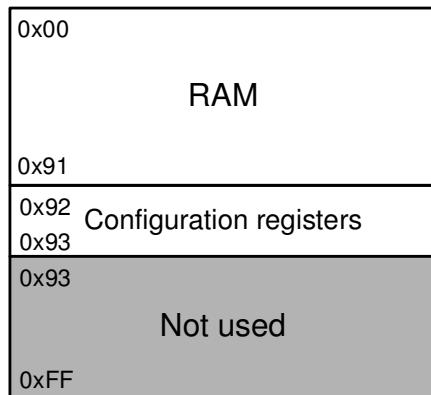


Figure 16 Address map

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)
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	NA	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	x	x	x	x	x	x	x	x	x	x	x	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																0 - ADC high reference enabled
0																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)
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	NA	7 bit value - Oscillator trim value
x	x	x	x	x	x	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 I_C 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								
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								
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								
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								
C8								
D0								
D8	TGC	Scale offset						
E0								
E8								
F0								
F8								

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 Gradien Coefficient
								B_{scale} - Scaling coefficient of slope of IR pixels offset
								V_{th_H} V_{th_L} - V_{th0} of absolute temperatire sensor
								K_{T1_H} K_{T1_L} - K_{T1} of absolute temperatire sensor
								K_{T2_H} K_{T2_L} - K_{T2} of absolute temperatire sensor

Table 14: DF...D8 EEPROM cell meaning

E7	E6	E5	E4	E3	E2	E1	E0	EEPROM cell meaning
						$\alpha_0\text{H}$	$\alpha_0\text{L}$	- Common sensitivity coefficient
					$\Delta\alpha_{\text{scale}}$			- Common sensitivity scaling coefficient
		ϵH	ϵL		$\Delta\alpha_{\text{scale}}$			- Individual sensitivity scaling coefficient
						ϵH	ϵL	- 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

PRELIMN

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.

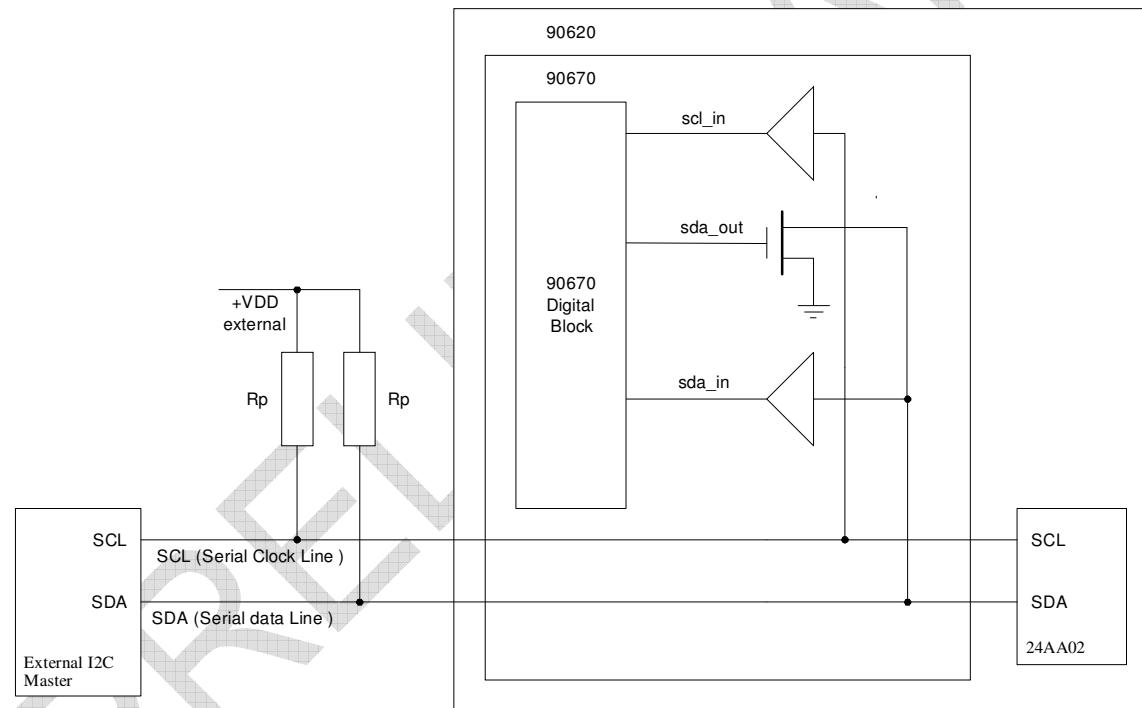


Figure 17 Communication pin diagram