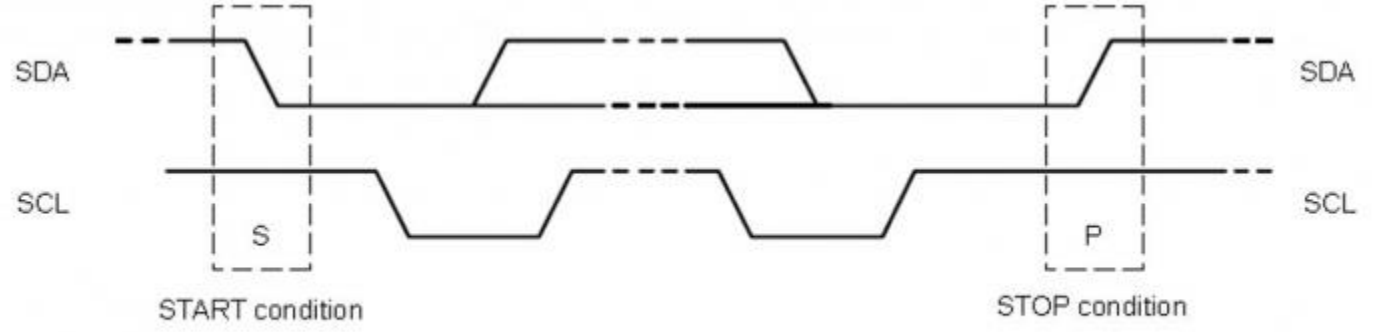
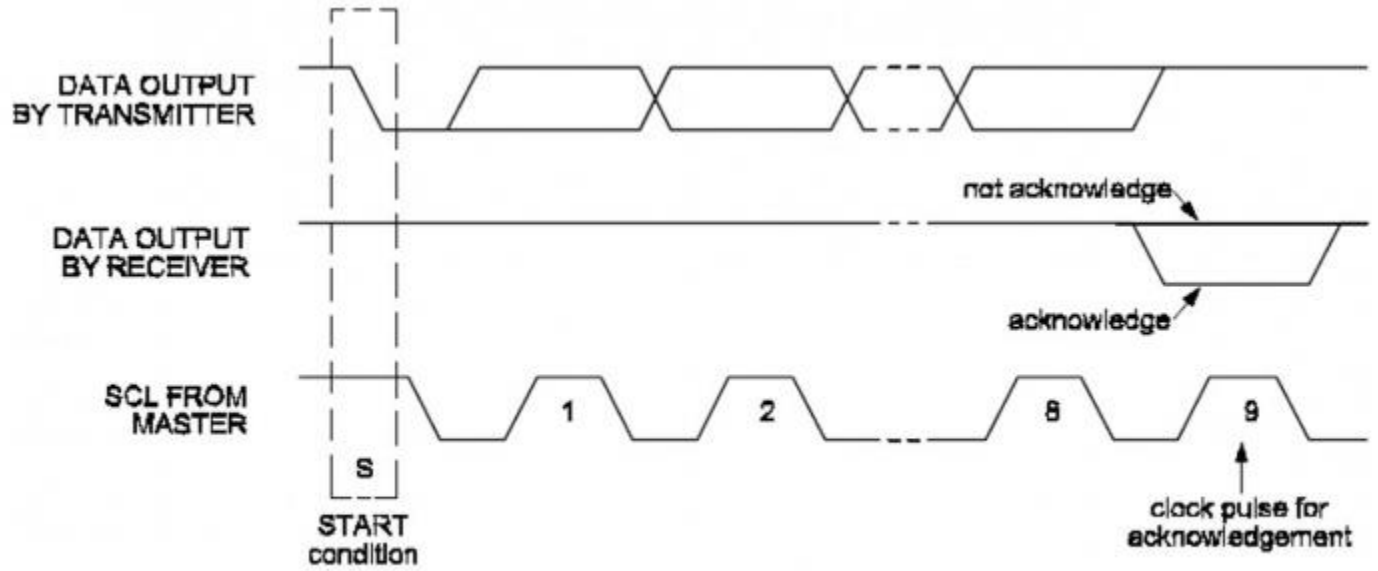
Communication protocol

The communication protocol of MLX90640-D55 Thermal Camera is I2C, which supports I2C high-speed mode (up to 1MHz), and can only be used as a slave device on the I2C bus. The SDA and SCL ports can withstand 5V voltage and can be directly connected to the 5V I2C bus , the device address of the module can be programmed, there can be up to 127 addresses, the factory default value is 0x33. Like the general I2C bus, there are three types of signals in the process of data transmission: start signal, end signal and response signal



起始和停止条件

Start signal: SCL is high level, SDA is converted from high level to low level.
End signal: SCL is high level, SDA is converted from low level to high level.
It can be seen that the start signal and the end signal are completed when the SCL bus is high.



I^2C 总线的响应

Response signal: During the 9th clock period after each byte transmission, the sending

data end device releases the SDA bus, and the receiving data end device pulls down the SDA bus to indicate the received byte (ACK), or the SDA bus is high Ping no acknowledgment (NoACK).

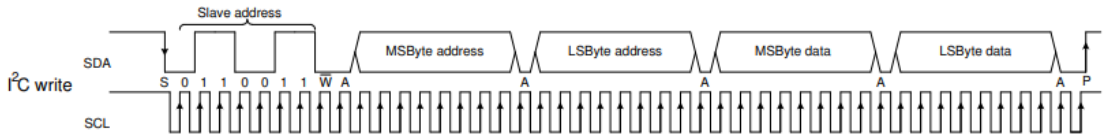


Figure 4 I²C write command format (default SA=0x33 is used)

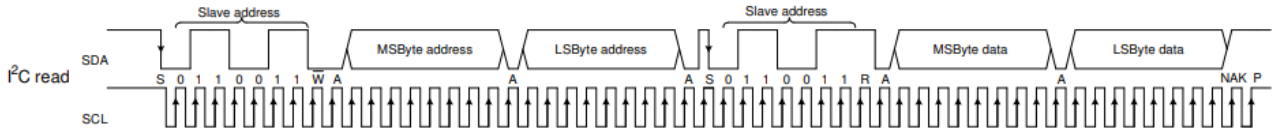
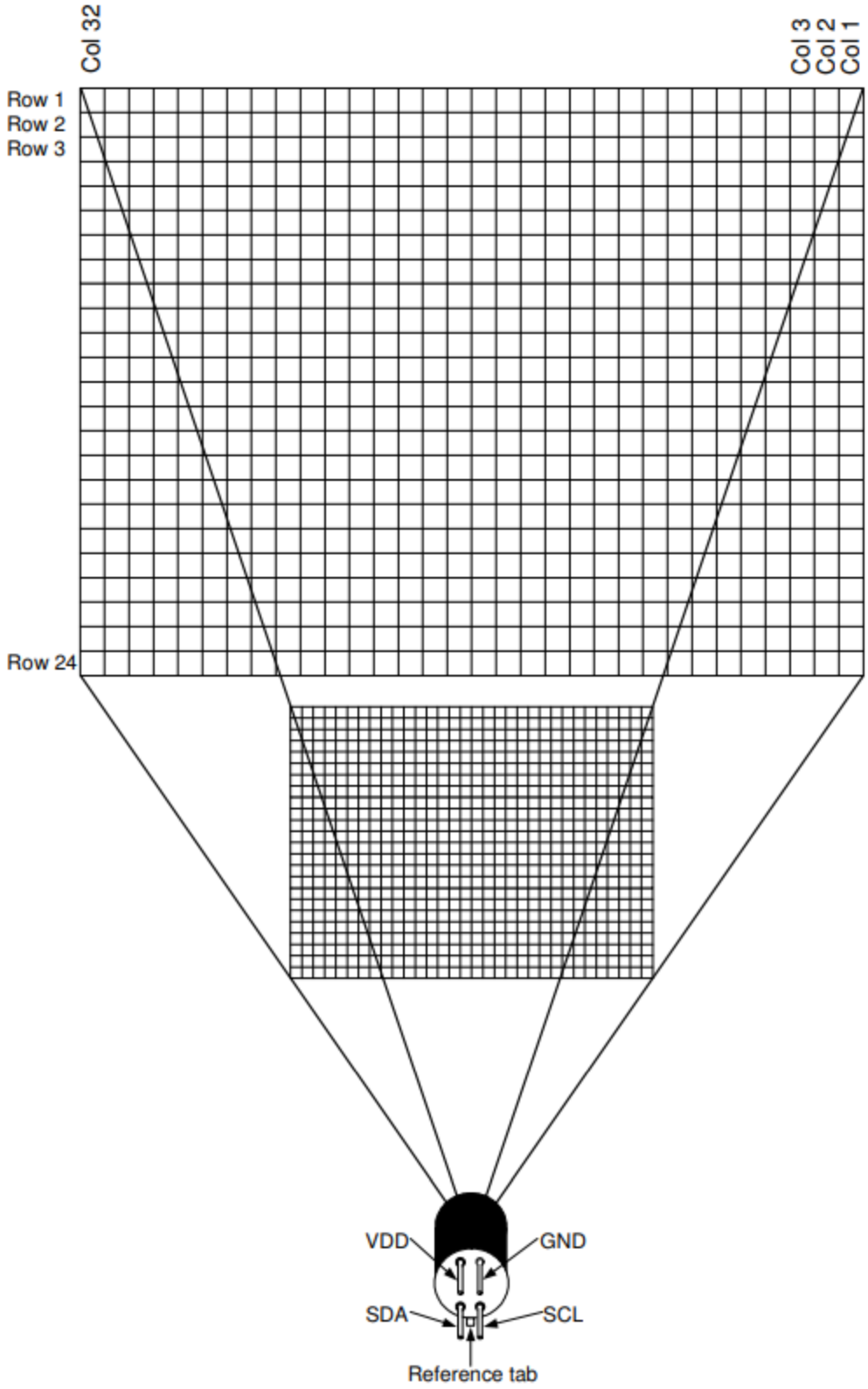


Figure 5 I²C read command format (default SA=0x33 is used)

Device Address: The master addresses the slave by sending a 7-bit slave address after a START condition. The first seven bits are dedicated to this address, and the 8th is the read/write (R/W) bit. This bit indicates the transfer direction, The high level means that the master will read data from the slave, and the low level means that the master will send data to the slave.



The MLX90640-D55 Thermal Camera consists of a total of 768 IR sensors (also called pixels). The row and column positions of each pixel are identified as Pixel(i, j), where i is its row number (from 1 to 24), and j is Its column number (from 1 to 32), the pixel specific to a certain plane can refer to the above figure

- It should be noted that the original sensor is allowed to have less than 4 dead points when the sensor leaves the factory,and each dead point is marked in the EEPROM table, so the module may have a certain probability of dead points, that is to say, this cannot be used as a return. According to the goods, the original recommendation for this is to use the average value of adjacent pixels instead.

Memory and registers

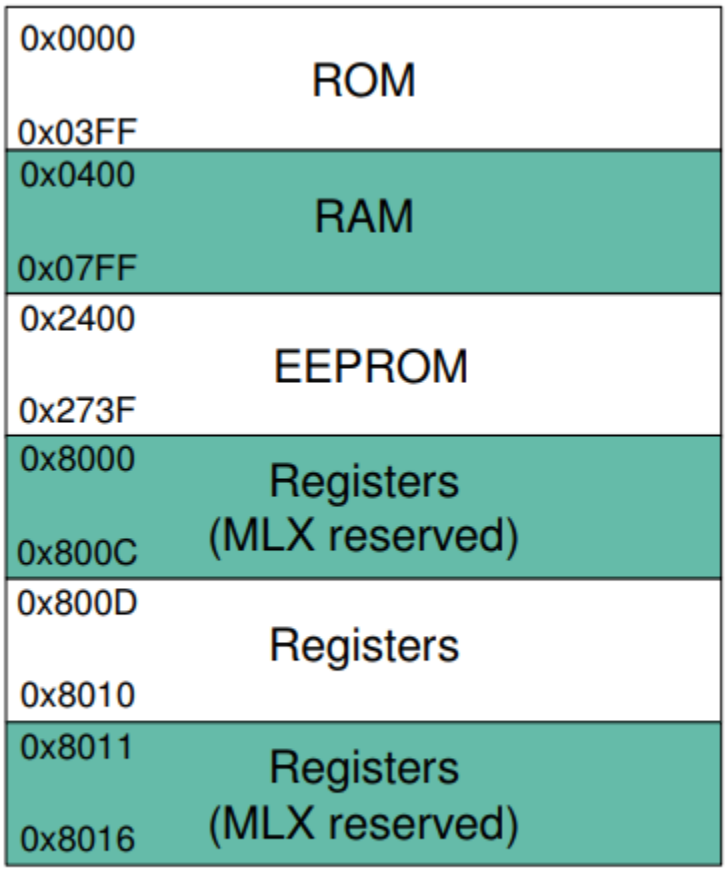


Figure 10 MXL90640 memory map

The above picture shows the distribution of RAM area and control registers of MLX90640, in which there are two data modes in RAM area, and EEPROM is used to store calibration constants and device configuration parameters, as shown in the following figure:

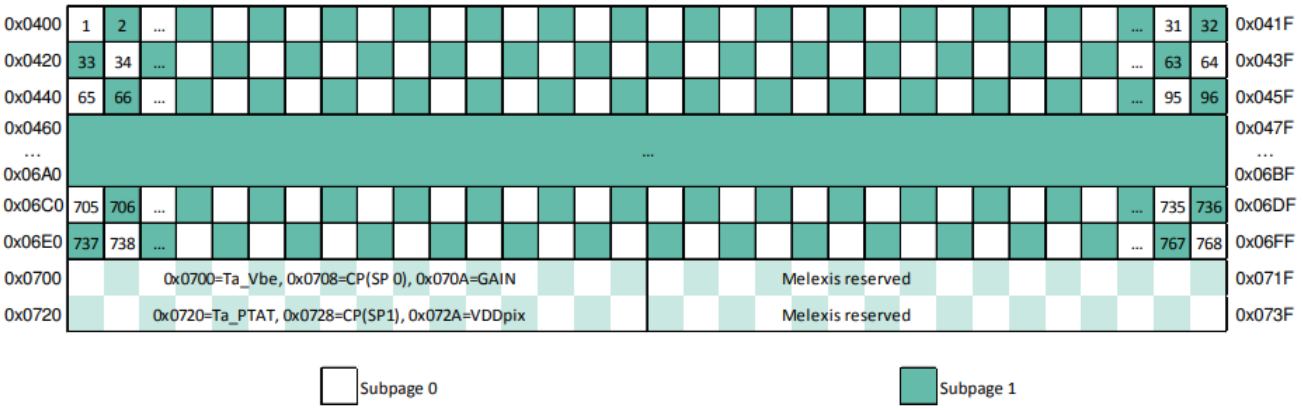


Figure 14 RAM memory map (Chess pattern mode) – factory default mode

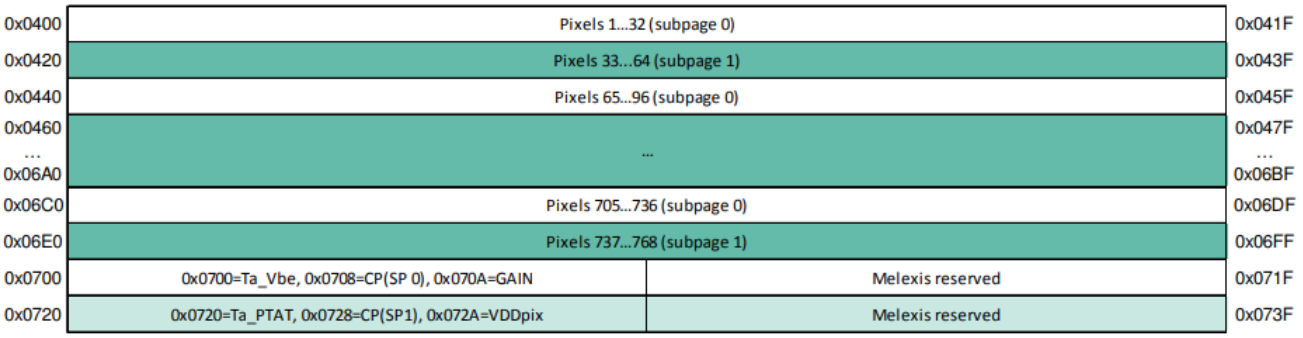


Figure 15 RAM memory map (Interleaved mode)

Refresh rate

This module support 8 kinds of refresh rate, up to 64Hz. The refresh rate is configured by registers 1-0x800D

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0	Control register 1 - 0x800D
Melexis reserved			Reading pattern	Resolution control		Refresh rate control			Select subpage			Enable subpages repeat	Enable data hold	Melexis reserved	Enable subpages mode	
															0	No subpages, only one page will be measured
															1	Subpade mode is activated (default)
														0		Keep this bit = "0" (default)
													0			Transfer the data into storage RAM at each measured frame (default)
													1			Transfer the data into storage RAM only if en_overwrite = 1 (check 0x8000)
												0				Toggles between subpage "0" and subpage "1" if Enable subpages mode = "1" (default)
												1				Select subpage determines which subpage to be measured if Enable subpages mode = "1"
									0	0	0					Subpage 0 is selected (default)
									0	0	1					Subpage 1 is selected
									0	1	0					Not Applicable
									0	1	1					Not Applicable
									1	0	0					Not Applicable
									1	0	1					Not Applicable
									1	1	0					Not Applicable
									1	1	1					Not Applicable
						0	0	0								IR refresh rate = 0.5Hz
						0	0	1								IR refresh rate = 1Hz
						0	1	0								IR refresh rate = 2Hz (default)
						0	1	1								IR refresh rate = 4Hz
						1	0	0								IR refresh rate = 8Hz
						1	0	1								IR refresh rate = 16Hz
						1	1	0								IR refresh rate = 32Hz
						1	1	1								IR refresh rate = 64Hz
				0	0											ADC set to 16 bit resolution
				0	1											ADC set to 17 bit resolution
				1	0											ADC set to 18 bit resolution (default)
				1	1											ADC set to 19 bit resolution
			0													Interleaved (TV) mode
			1													Chess pattern (default)
-	-	-	Melexis reserved													

The settings of the 8 refresh rates are determined by bit 7, bit 8, and bit 9 of the control register 1 (0x800D), among which there are chess mode (factory default setting), TV interleave mode, as shown below:

:

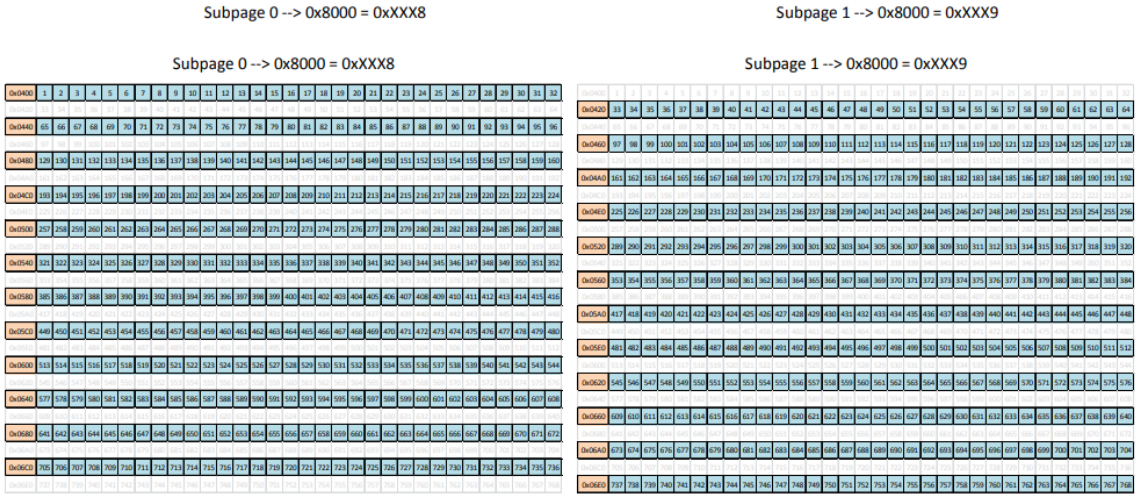


Figure 8 TV mode reading pattern (only highlighted cells are updated)

TV interleave mode

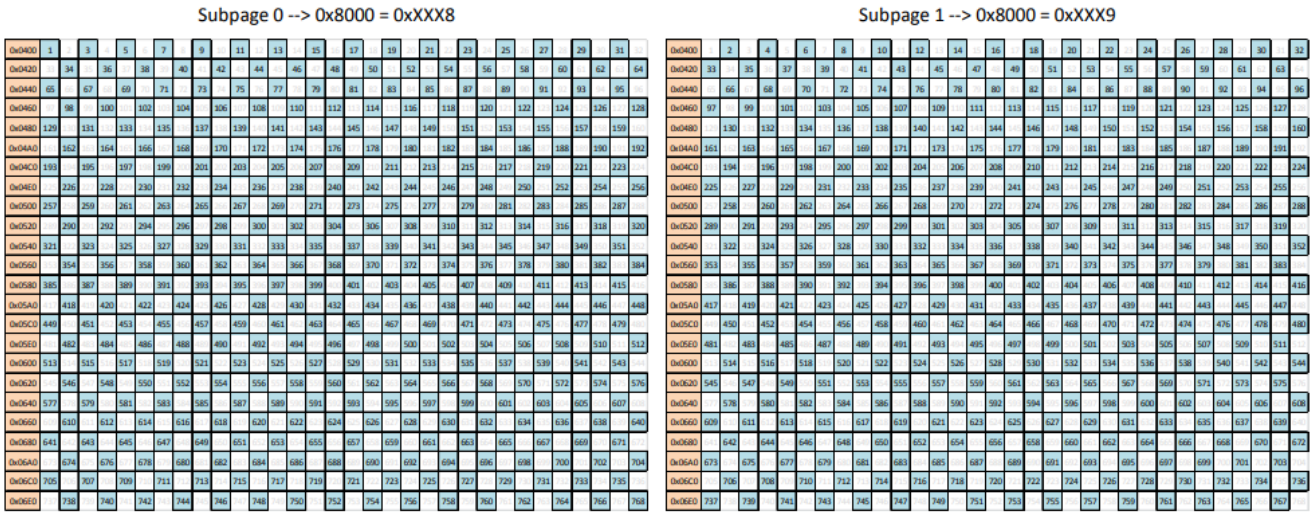


Figure 9 Chess reading pattern (only highlighted cells are updated)

The array frame is divided into two subpages and depending on bit 12 in “Control register 1” (0x800D). As a standard the MLX90640 is calibrated in Chess pattern mode, this results in better-fixed pattern noise behavior of the sensor when in chess pattern mode. For best results, we advise to use chess pattern mode.

Temperature measurement principle and measurement distance

Temperature measurement principle

What is infrared temperature measurement?(quoted from OPTRIS)

Next to time, temperature is the most frequently measured physical property. Infrared temperature measurement devices define the temperature according to the radiation law of Planck and Boltzmann through infrared radiation released by the measured object. But how does non-contact temperature measurement work?

Each body, with a temperature above the absolute zero of 0 K (-273.15°C) emits an electromagnetic radiation from its surface, which is proportional to its intrinsic temperature. A part of this radiation is infrared radiation which is used to measure temperature. The radiation of the body penetrates the atmosphere and can be focused on a detector element with the help of a lens. The detector element

generates an electrical signal proportional to the radiation. This signal is amplified and, using successive digital signal processing, is transformed into an output signal proportional to the object temperature. The measuring value can be shown on a display or released as a signal.

The emissivity ε (Epsilon) has a central importance, if the temperature is measured through radiation. The emissivity defines the relation of the radiation value in real and of the black body. This is maximal 1 for a black body. But only few bodies meet the ideal of the black body. For the calibration of sensors contact faces of radiators are generally used, which consists of the favoured wave length of 0.99.

Many bodies have a constant emissivity regarding the wave length, but do emit far less radiation than black bodies. They are called grey bodies. Bodies whos emissivity depends on the temperature and the wave length, such as metals, are called selective radiator. The missing radiation part is compensated in both cases through the definition of emissivity. When using a selective radiator, one needs to bear in mind the measured wave length (short-wave for metal).

The infrared sensor receives the emitted radiation from the object surface, but also reflected radiation form the surroundings and perhaps penetrated infrared radiation from the measuring object.

Measurement distance

The FOV of this module is determined by 50% radiation signal which is received by the thermopile, it is also influenced by the main axis of the sensor. The temperature measured is the weighted average of the detected object's temperature in FOV. To improve the accuracy, you should make sure that the detected object is in the FOV totally.

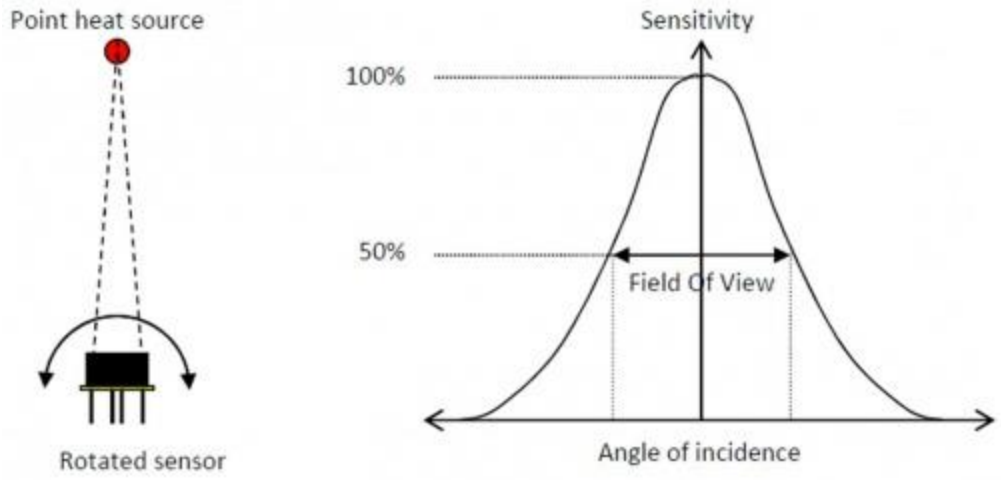
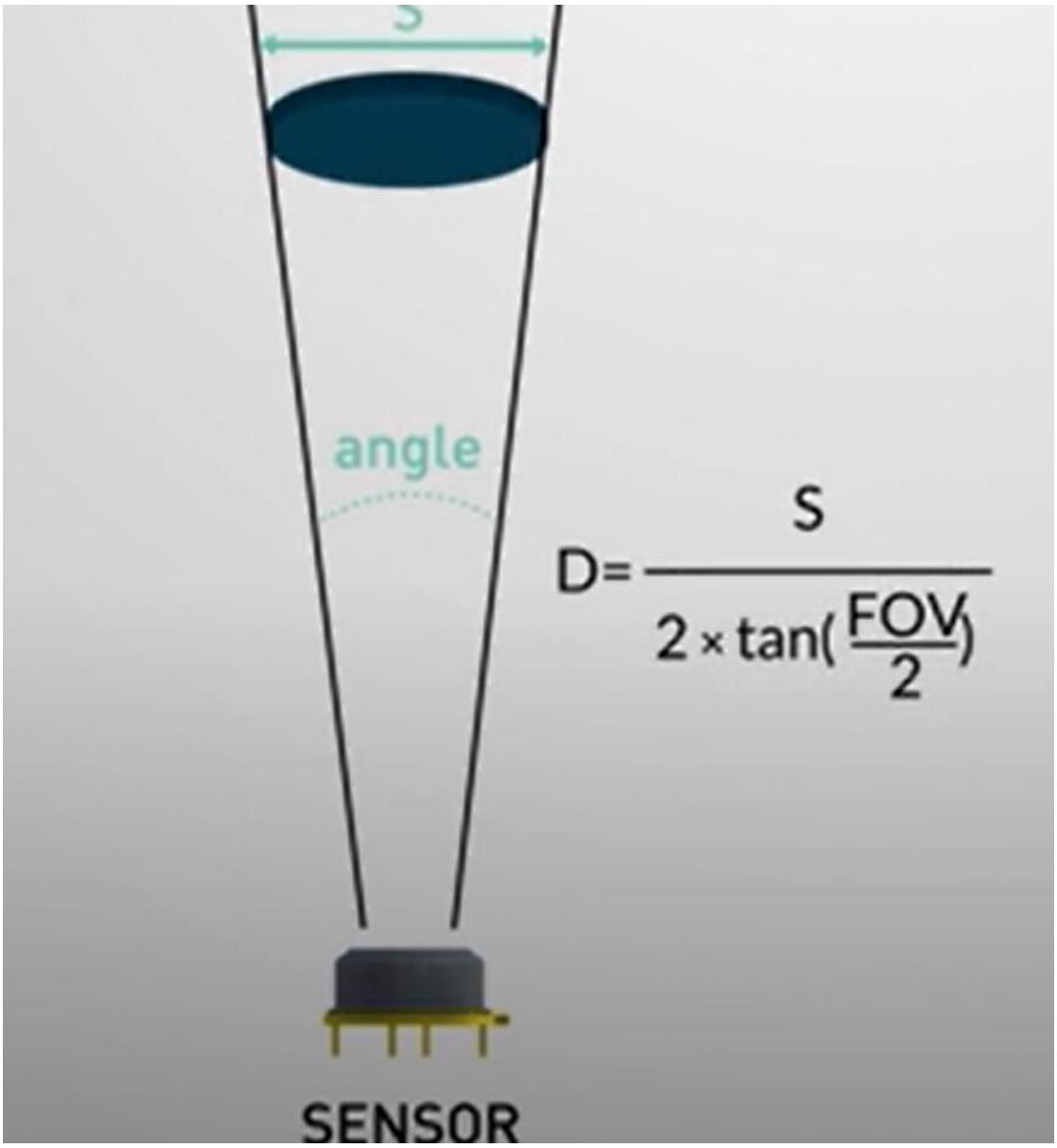


Figure 24: Field Of View measurement

For the relationship between the measurement distance and the field of view, please refer to the calculation formula shown in the

following figure mentioned by Melexis



Examples

Raspberry Pi

1. When using the sensor, please pay attention to avoid directly contact with the onboard IC devices by your hands, Pay attention to prevent static electricity and check the power supply to prevent reverse connection before powering on.

2. When the sensor is working, please avoid excessive vibration and do not plug or unplug cables. Since the core device MLX90640 has EEPROM, which will easily damaged by vibration and hot plug.

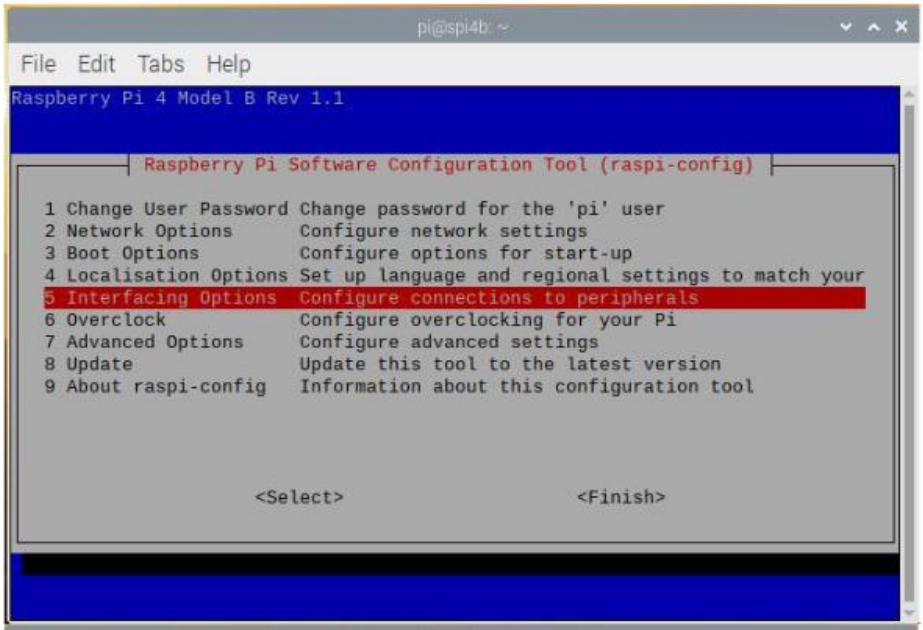
Hardware connection

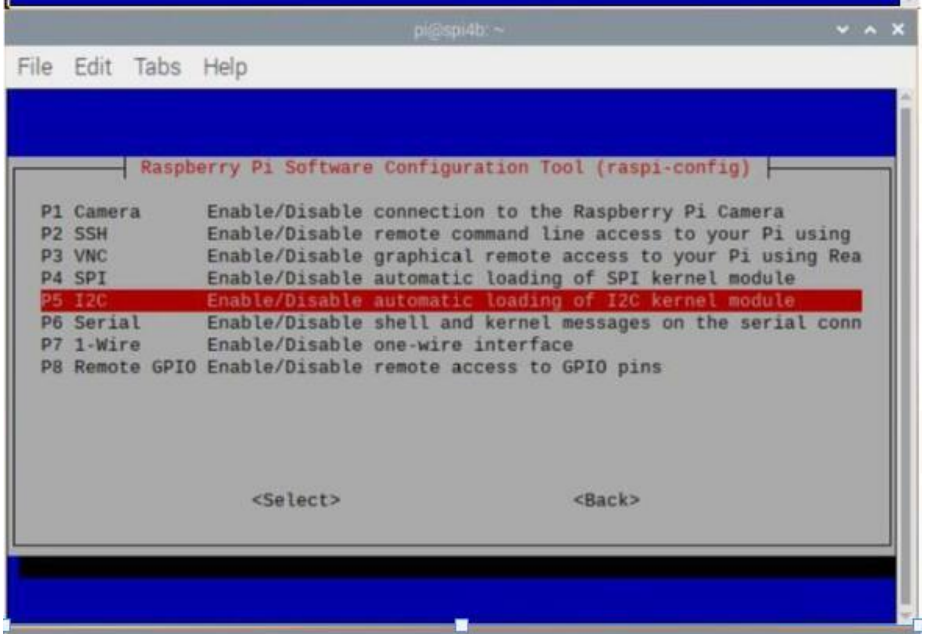
Raspberry Pi	MLX90640 Thermal Camera
5V	5V
GND	GND
SDA(BCM2)	SDA
SCL(BCM3)	SCL

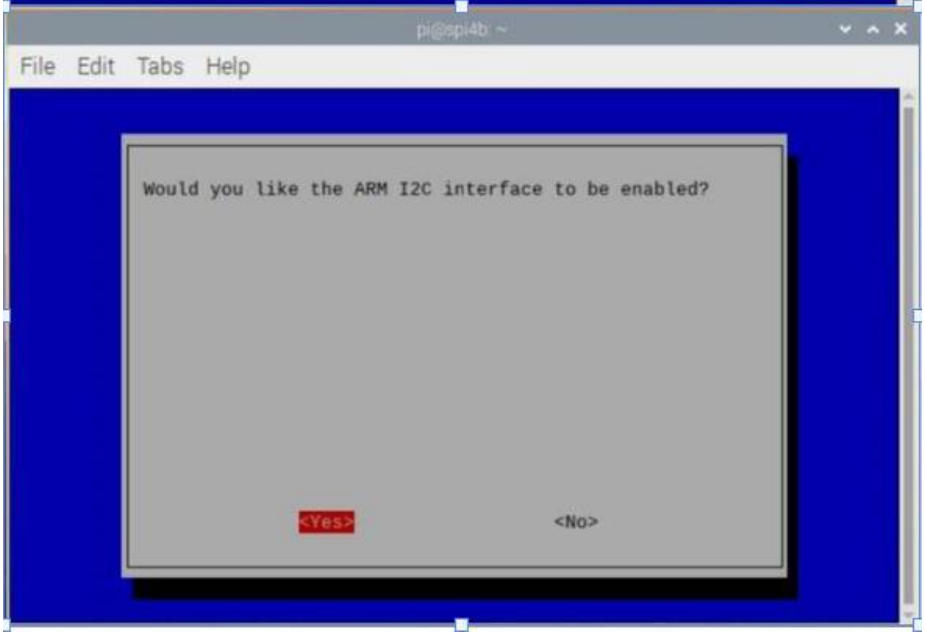
Use

Enter the following commands in the Raspberry Pi terminal. The first command enables hardware I2C. If it has been set, you can skip this command. The relevant settings are as follows:

```
sudo raspi-config

cd ~

wget https://www.waveshare.net/w/upload/c/c9/Mlx90640_thermal_camera.zip

unzip Mlx90640_thermal_camera.zip

cd mlx90640_thermal_camera/RaspberryPi/cpp/

chmod +x install.sh

sudo ./install.sh

make

sudo ./main
```


pi@spi4b: ~
File Edit Tabs Help
Raspberry Pi 4 Model B Rev 1.1
Raspberry Pi Software Configuration Tool (raspi-config)
1 Change User Password Change password for the 'pi' user
2 Network Options Configure network settings
3 Boot Options Configure options for start-up
4 Localisation Options Set up language and regional settings to match your
5 Interfacing Options Configure connections to peripherals
6 Overclock Configure overclocking for your Pi
7 Advanced Options Configure advanced settings
8 Update Update this tool to the latest version
9 About raspi-config Information about this configuration tool
<Select>
<Finish>


pi@spi4b: ~
File Edit Tabs Help
Raspberry Pi Software Configuration Tool (raspi-config)
P1 Camera Enable/Disable connection to the Raspberry Pi Camera
P2 SSH Enable/Disable remote command line access to your Pi using
P3 VNC Enable/Disable graphical remote access to your Pi using Rea
P4 SPI Enable/Disable automatic loading of SPI kernel module
P5 I2C Enable/Disable automatic loading of I2C kernel module
P6 Serial Enable/Disable shell and kernel messages on the serial conn
P7 1-Wire Enable/Disable one-wire interface
P8 Remote GPIO Enable/Disable remote access to GPIO pins
<Select>
<Back>


pi@spi4b: ~
File Edit Tabs Help
Would you like the ARM I2C interface to be enabled?
<Yes>
<No>

If the detecting has delay, you can try to modify the i2c speed in config.txt file

```
sudo nano /boot/config.txt
```

Add the line below to the config.txt file, reboot and check it again

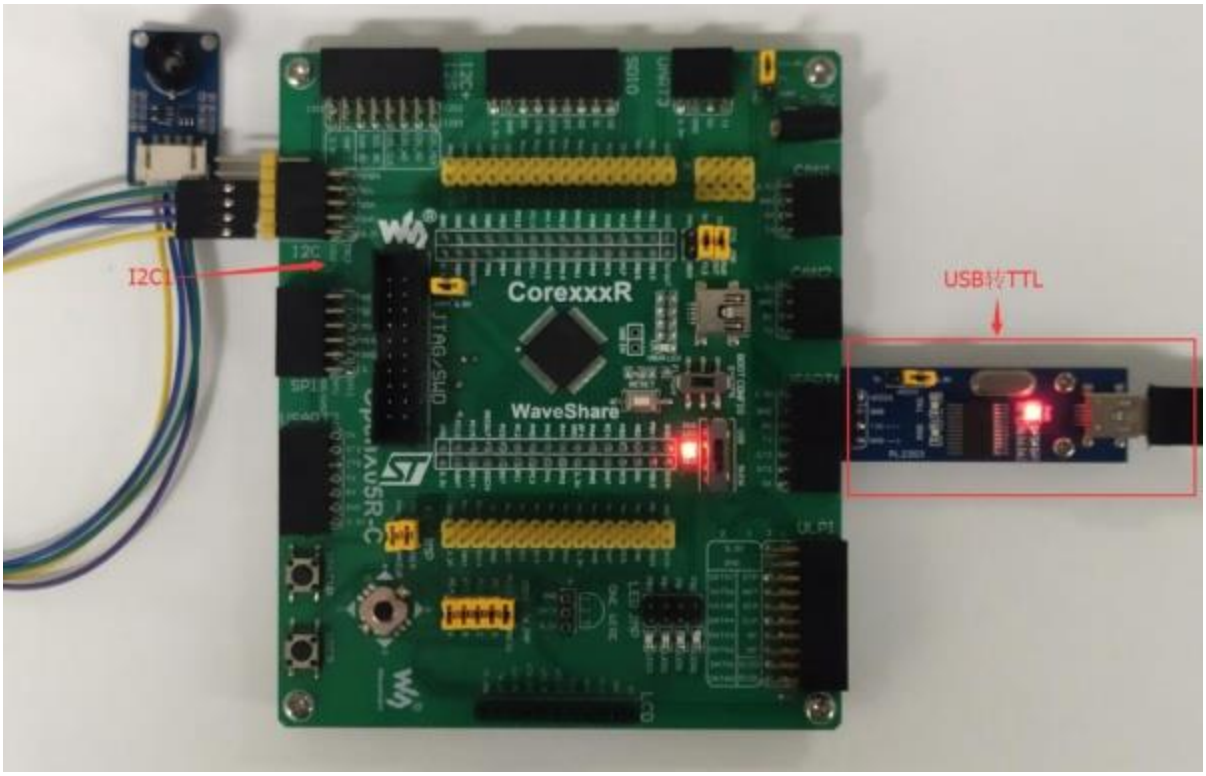
```
dtparam=i2c1_baudrate=1000000
```

STM32

1. When using the sensor, please pay attention to avoid directly contact with the onboard IC devices by your hands, Pay attention to prevent static electricity and check the power supply to prevent reverse connection before powering on.

2. When the sensor is working, please avoid excessive vibration and do not plug or unplug cables. Since the core device MLX90640 has EEPROM, which will easily damaged by vibration and hot plug.

Hardware connection



STM32	MLX90640 Thermal Camera
5V	5V
GND	GND
SDA(PB11)	SDA
SCL(PB10)	SCL

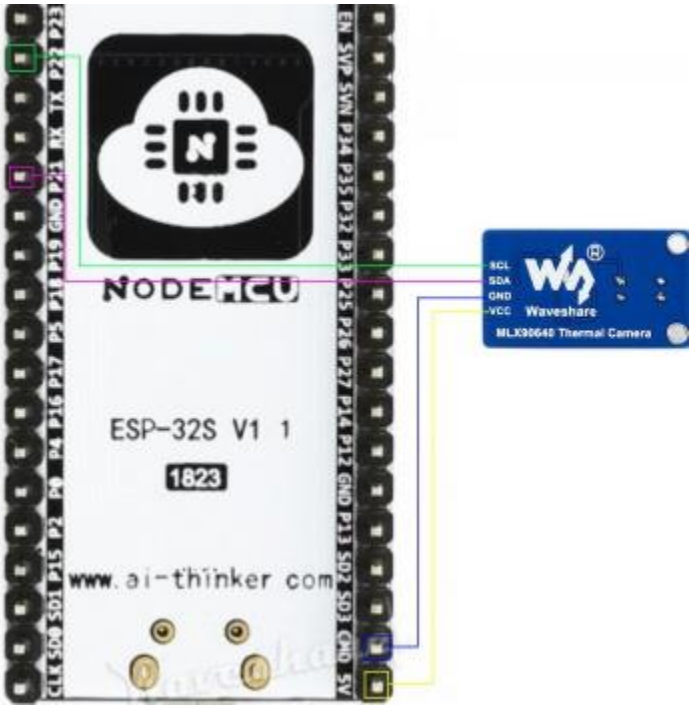
ESP32

1. When using the sensor, please pay attention to avoid directly contact with the onboard IC devices by your hands, Pay attention to prevent static electricity

and check the power supply to prevent reverse connection before powering on.

2. When the sensor is working, please avoid excessive vibration and do not plug or unplug cables. Since the core device MLX90640 has EEPROM, which will easily damaged by vibration and hot plug.

Hardware connection



ESP32	MLX90640 Thermal Camera
5V	5V
GND	GND
SDA(P21)	SDA
SCL(P22)	SCL

Test result