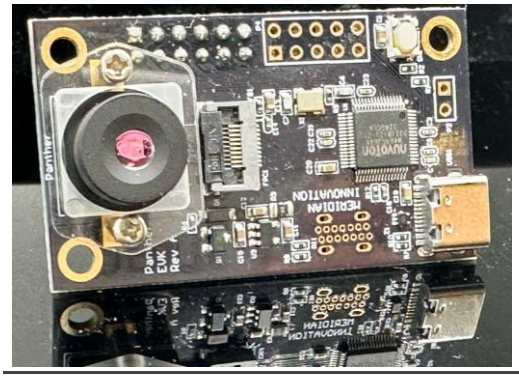



MI1602 Camera Module Evaluation Kit User Manual

Version:	0.2

Revision	*Date*	*Comment*
0.1	2 Apr 2025	Initial Release for Panther
0.2	3 Apr 2025	Fix merge view firmware version difference

Contents

1. Overview

This user manual is aimed to give users a fast introduction to the use of the MI1602 Camera Module Evaluation Kit (EVK) and its accompanying software.

1.1. MI1602 Camera Module Evaluation Kit (EVK)

The MI1602 Camera Module EVK contains

- MI1602 Camera Module
- MI48E4 Thermal Image Processor (TIP) Board
- Graphical User Interface (GUI) software

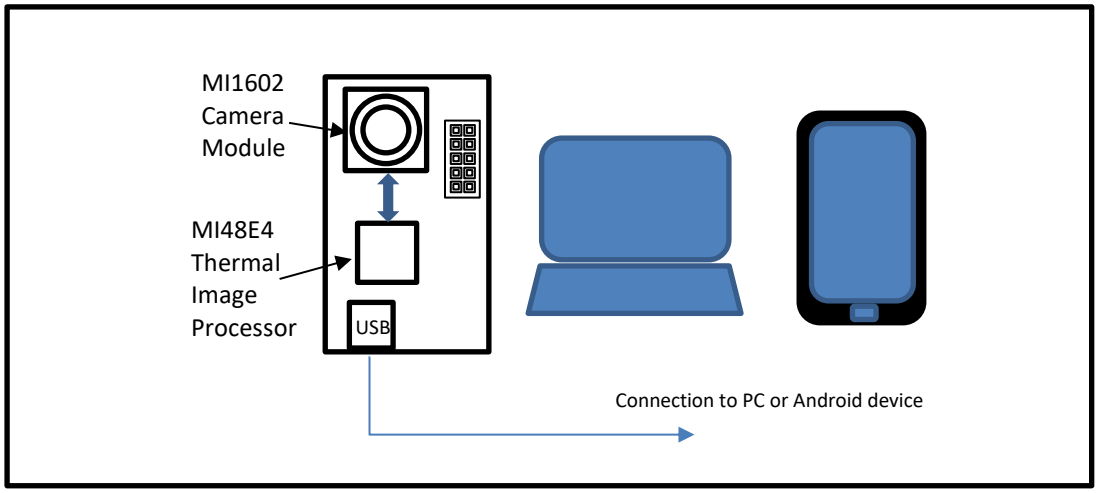
Together, these components combine to form a thermal camera system capable of capturing 160-by-120 thermal images. This kit is designed to be connected via USB to a host PC and controlled using the provided GUI software.

The MI48E4 Thermal Image Processor (TIP) Board support either USB interface, or SPI/I2C interface.

- USB Interface, supports direct connection to the host (PC or Android device)
- SPI/I2C Interface, requires External Interface Processor Board to convert the USB to SPI/I2C

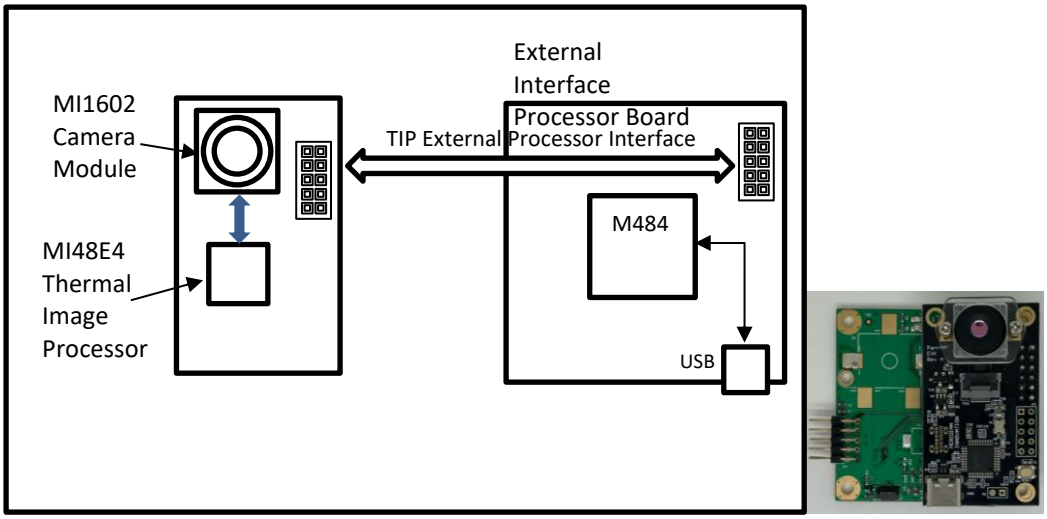
1.2. EVK Internal Connections (USB)

The following diagram provides a high-level view of the physical and electrical connections within components of the EVK.



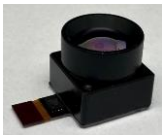
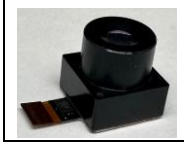
1.3. EVK Internal Connections (SPI/I2C)

The following diagram provides a high-level view of the physical and electrical connections within components of the EVK.



1.4. MI1602 Camera Module - Panther

The MI1602 Camera Module is a thermal imaging sensor, capable of capturing 160x120 (19,200)-pixel images of long wave infrared radiation (LWIR). It is factory calibrated and has a completely digital interface. No mechanical shutter is employed nor required. Its patented fabrication and wafer-level vacuum packaging ensures low cost of ownership, enabling many new applications to employ LWIR thermal imaging technology. At the time this document is prepared there are 2 types of Camera Modules available.

MI1602M5S 	FOV H:45, V:34, D:56
MI1602M6C 	FOV H:88, V:66, D:110

1.5. MI48E4 Thermal Image Processor (TIP)

The MI48E4 TIP is a Meridian Innovation product made specifically to interface with the MI1602 Camera Module as a companion chip. It is a 7mm x 7mm LQFP64 chip. This companion chip performs all the low-level computations and signal timing required to process the raw data from the MI1602 Camera Module, thus removing this burden from any external processors.

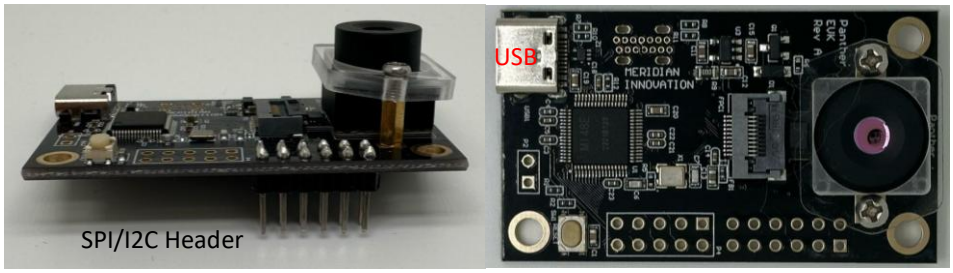
The MI48E4 TIP also provides the external interface which is made up of common electrical buses and interfaces.

- The Universal Serial Bus (USB) interface is provided to transfer thermal image data with the MI48E4 TIP and control MI1602 module parameters.
- The serial peripheral interface (SPI) bus is provided to transfer thermal image data with the MI48E4 TIP as a SPI slave device. The Inter-Integrated Circuit (I^2C) bus is provided to control MI1602 module parameters. The DATA_READY Interrupt is a digital signal output from the MI48E4 TIP to alert the external processor of available image data for reading.

1.6. MI48E4 Thermal Image Processor Board

The MI48E4 Thermal Image Processor Board demonstrates how the MI1602 Camera Module and MI48E4 TIP are connected.

It provides an USB Type C receptacle connector and a standard 2.54mm 12-pin header containing the SPI/I2C interface for easy integration into any external processor or system. If the MI48E4 Thermal Image Processor Board is connected to the External Interface Board the USB Type C port is automatically disabled.



1.7. Optional External Interface Processor Board (Order Separately)

The External Interface Processor Board is an example of an external system that interfaces with the MI48E4 TIP using the TIP SPI/I2C Interface.

There are 2 kinds of external interface board, one is SPI/I2C to USB and the other is SPI/I2C to Wifi.

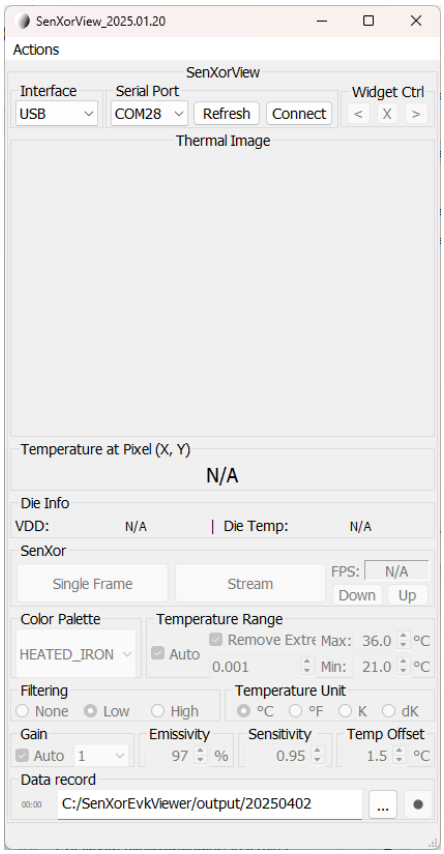
For the SPI/I2C to USB, the external processor is the Nuvoton M484SIDAE. This External Processor Board is shipped pre-loaded with Meridian Innovation's firmware to demonstrate the TIP External Interface communication protocol. This board is only required if you need to develop your system with SPI/I2C interface. The External Processor Board also features a USB Micro B connector plug, and should be connected to a host PC via a USB 2.0 High-speed (HS) port for power and communication.

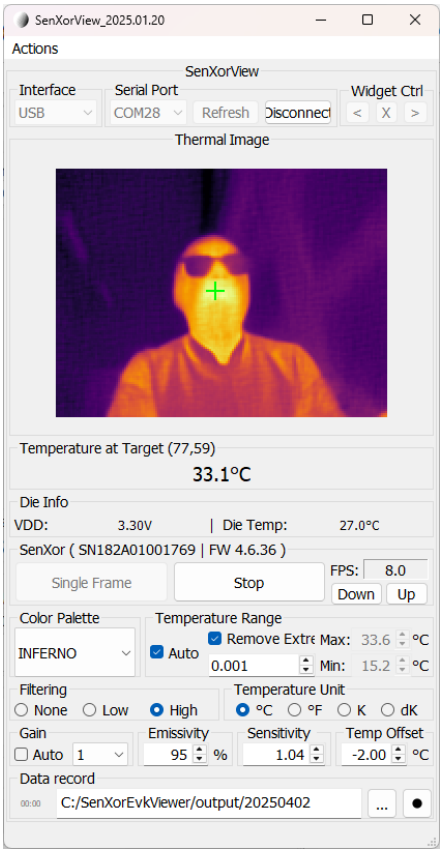
For the SPI/I2C to Wifi, the external processor is the ESP32S3. This External Processor Board is shipped pre-loaded with Meridian Innovation's firmware to demonstrate the TIP External Interface communication protocol. This board is only required if you need to develop your system with SPI/I2C interface with Wifi.

1.8. EVK Graphical User Interface (GUI) Software

The EVK GUI software is a computer program that allows a computer user to control the External Interface Processor board, view the thermal images captured, and more. The GUI currently only supports computers with Windows-based operating systems.

The screen shots below show example images from the GUI. In the descriptions that follow items shown in "*quotes and italics*" refer to the corresponding elements of the GUI.





2. GUI Software

The following sections describe how to obtain, run and operate the GUI on a Windows-based computer with a USB 2.0 High-Speed connector socket or TCP/IP.

2.1. Minimum System Requirements

The GUI currently only supports computers running Windows 10/11. It also requires at least one USB 2.0 port supporting USB.

2.2. Obtaining and Launching GUI

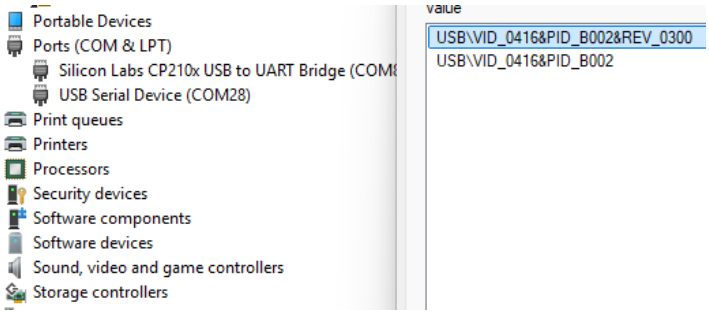
Please contact us to obtain the latest GUI software in .exe format for Window .

Note that most GUI controls are disabled upon launch.

2.3. Connection

Connect the EVK to a computer using a USB 2.0 A-Male to Type-C (if you using USB direct connection) or Micro B cable (if you are using External Interface Processor Board) or TCP/IP Protocol.

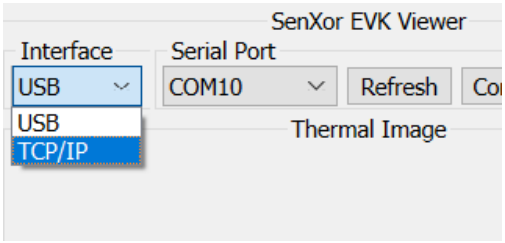
USB



The EVK should enumerate as a "*USB Serial Device (COMx)*" in Windows' "*Device Manager*" window, where x is an integer. The EVK is a USB Communications Device Class (CDC) device and has a USB Vendor ID of 0416 (hex) and a USB Product ID of B002 (hex).

TCP/IP Protocol

If there is any EVK running with TCP/IP server, the GUI can also get the raw data through TCP/IP Protocol. Please make sure the client device is able to connect to server under the same local network.

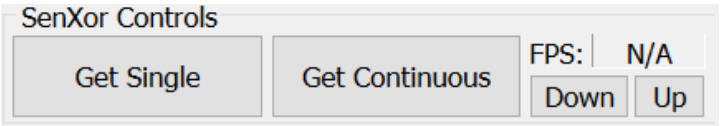


After launching the GUI software and physically connecting the USB cable, press "*Refresh*" on the GUI under the "*Serial Port*" section. The "*Serial Port*" selection drop-down should change from "*No suitable port found!*" to "*COMx*" if the EVK is detected properly. At the same time, the GUI will run TCP server once the connection is success with its valid IPv4Address and default port 3333.

Press "*Connect*" to establish a connection between the GUI and the EVK.

Note that most GUI controls are now enabled and start continuous capturing by default.

2.4. Capturing Image



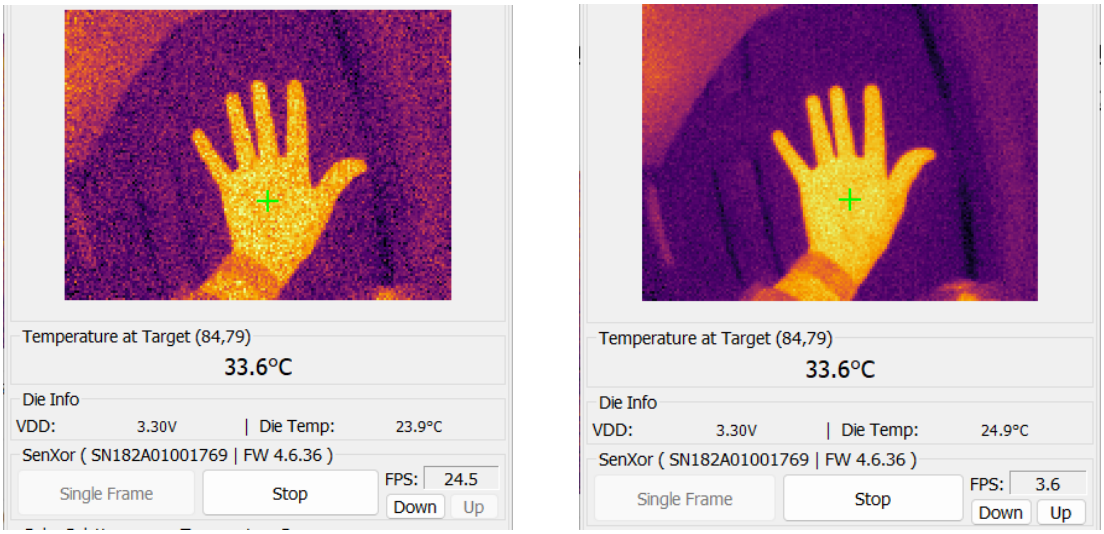
Press the "*Get Single*" button under "*SenXor Controls*". The EVK will capture a thermal image, which will be transmitted to and displayed on the GUI.

Press the "*Get Continuous*" button under "*SenXor Controls*". The EVK will begin to continuously capture thermal images, and the GUI display will be continuous updated. The "*FPS*" counter under "*SenXor Controls*" on the GUI will also continuously update to report the framerate of the EVK. "*FPS*" here stands for Frames Per Second. The FPS is mainly affecting the internal frame averaging.

The EVK always captures raw sensor data at 30 frames per second (FPS), which is then processed by the TIP companion chip into images of dense temperature data and TIP can stream out at maximum rate of 25 FPS. The TIP also features various post-processing functions.

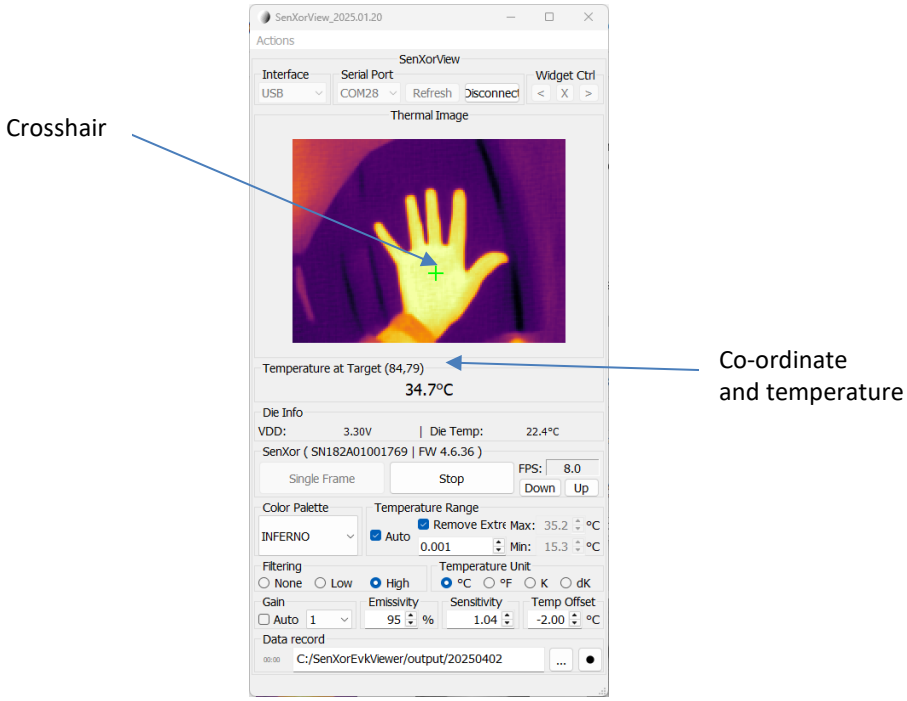
One such function is internal frame averaging. Depending on the application, it may be desirable to sacrifice framerate for higher accuracy and lower image noise. Internal frame averaging controls the number of frames (N) captured and averaged before output from the TIP. The resulting framerate is 30/N frames per second. Lower FPS means more frames are taking for internal averaging. By default, the range of FPS is set between 1 to 15.

Human hand under different internal frame averaging. Lower FPS offers lower noise due to the averaging effect.



2.5. Display & Cursor Interactions

While there is an image displayed on the "*Thermal Image*" display area, it accepts cursor clicks on the displayed image to place a "*crosshair*" on a pixel. The array coordinates and temperature reading for that pixel is shown in the "*Image Info at Target*" area.

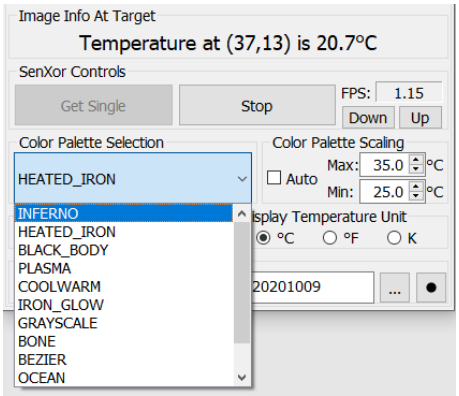


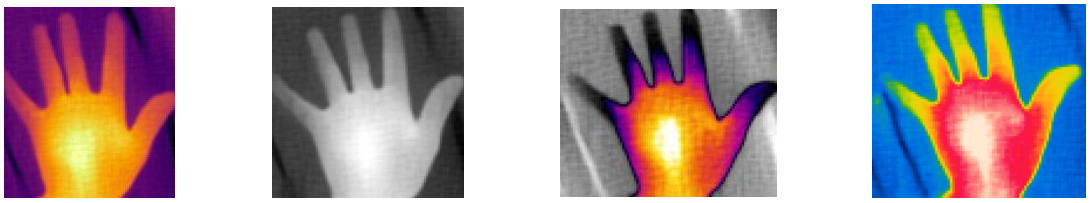
Note that the crosshair persists with new frames from "*Get Single*" or "*Get Continuous*" and the information for the target pixel will update correspondingly.

2.6. Color Palette and Scaling

The GUI performs its own post-processing functions (i.e. processing down on the host PC) before displaying the thermal data received over USB. One such function is to apply color to pixel values so that temperature differences are more visually significant.

Under "*Color Palette and Scaling*", there are a drop-down control to select different pre-set color palette mapping to the temperature value.

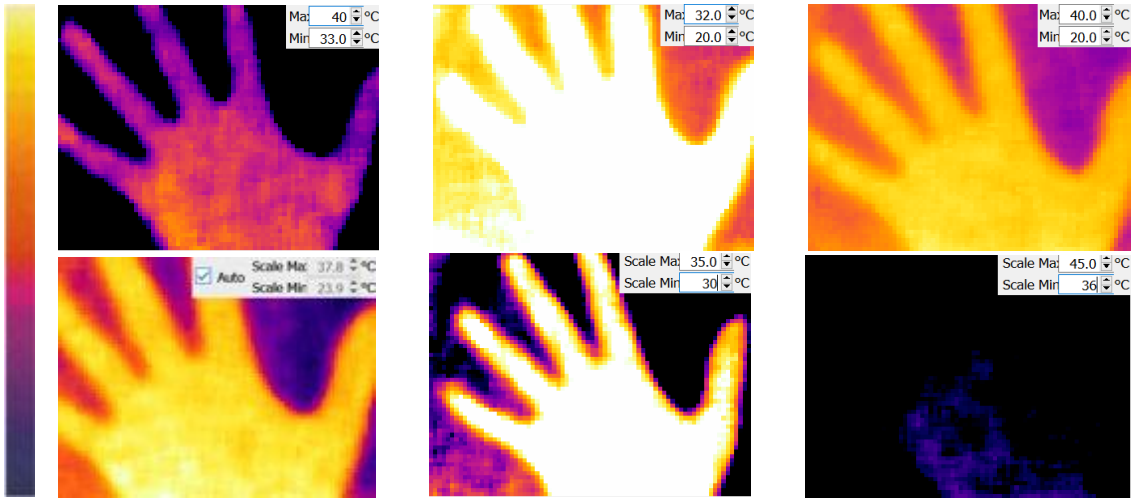




The "*Auto*" checkbox selects whether the color palette is scaled automatically to cover the minimum and maximum temperatures of the currently displayed image. While this is checked, "*Scale Min*" and "*Scale Max*" controls display the minimum and maximum temperature values. While this is unchecked, the "*Scale Min*" and "*Scale Max*" controls allow the user to manually adjust the minimum and maximum temperatures of the color scale.

Note that if a pixel on the image exceed the maximum temperature of the color palette scale, that pixel will be applied the color corresponding to the maximum value on the color palette scale, similar to a pixel below minimum temperature. On the other words, the scaling affects how the color palette spreading in between minimum and maximum temperature boundary. Please adjust the scaling range according to the target object and environment temperature to optimize visualization.

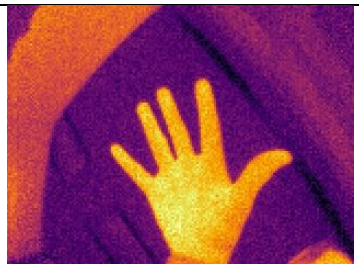
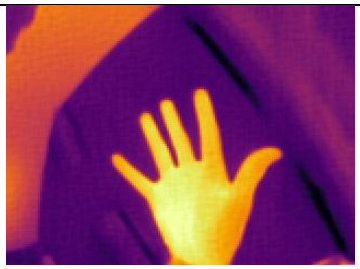
Take a human hand as example, under HEATED_IRON color palette:



2.7. Filtering and Temperature Unit

Another GUI post-processing function is the pixel filter. Currently there are three available modes, they are "*None*", "*Low*" and "*High*".

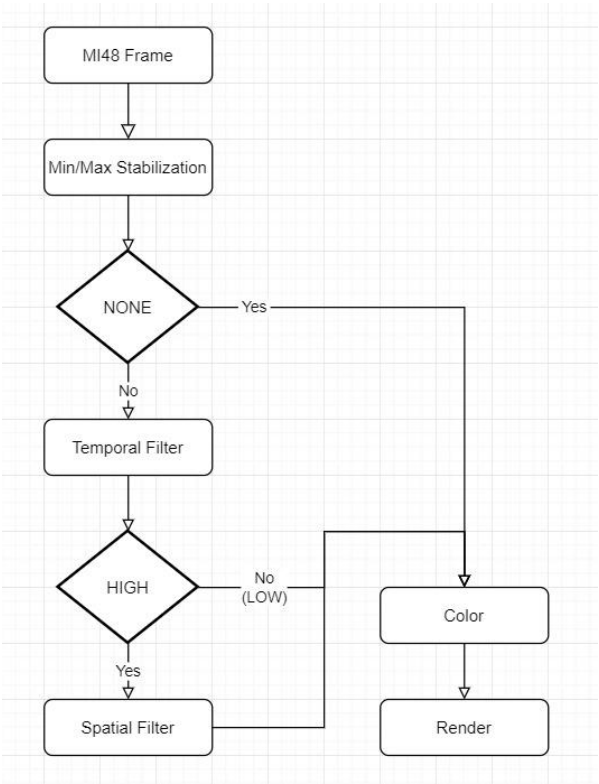
- With "*Low*" enabling a built in pipeline for noise reduction on rolling average running on the host PC.
- With "*High*", the noise reduction is processed by an AI pre-trained noise filter running on the host PC.
- With "*None*", the output data will simply steam through the GUI without any post-processing.

		
None	Low	High

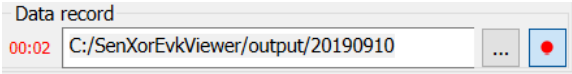
By simply observing the three images above, one can notice the effect of the pipeline. A visual difference can be seen between the "*None*" and "*High*" mode, with "High" having a much lower noise level as the number of saturated pixels have been reduced.

The right is the processing flow when the frame is received on the GUI. The GUI perform min/max stabilization which are used for the ColorMapping/Rendering. If None filter is used no further processing on the temperature data. If Low filter is selected a temporal filter (a rolling average filter) is performed. If high filter is selected the temporal filtered frame is passed to the Spatial Filter (CNN based) before pass to the ColorMapping and Rendering.

By default, all temperatures values displayed on the GUI is in degrees Celsius. This can be modified to degree Fahrenheit or Kelvin.



2.8. Data Recording



The thermal data will be dumped when recording is activated to specific folder. The output format per frame is as following:

[PC Time from UTC], [frame number], [Senxor VDD], [Senxor Die Temperature],[Timestamp], [Cursor X], [Cursor Y], [Temperature at Cursor],[Frame Header][row*column thermal data]\n

```
2025-04-02T11:25:32.113+08:00,7249,3.3173,30.02,894427,0,0,19.3,7249,33173,30317,42,19.3674,19.4197,19.
2025-04-02T11:25:32.156+08:00,7250,3.3173,30.02,894538,0,0,19.4,7250,33173,30317,42,19.488,19.4156,19.7
2025-04-02T11:25:32.284+08:00,7251,3.3175,30.02,894648,0,0,19.5,7251,33175,30317,42,18.8361,19.1679,19.
2025-04-02T11:25:32.397+08:00,7252,3.3175,30.01,894758,0,0,19,7,52,33175,30316,4280,25.7179,25.6153,25.
2025-04-02T11:25:32.508+08:00,7253,3.3173,30.01,894868,0,0,19.5,7253,33173,30316,42,26.0345,25.7044,25.
2025-04-02T11:25:32.597+08:00,7254,3.3171,30.01,894978,0,0,19.6,7254,33171,30316,43,20.1199,19.9577,19.
2025-04-02T11:25:32.719+08:00,7255,3.3175,30.02,895089,0,0,19.7,7255,33175,30317,43,25.8285,25.7813,25.
2025-04-02T11:25:32.830+08:00,7256,3.3173,30.02,895199,0,0,19.8,7256,33173,30317,43,19.8763,19.9525,19.
2025-04-02T11:25:32.950+08:00,7257,3.3175,30.02,895309,0,0,19.9,7257,33175,30317,43,25.8706,25.8442,25.
2025-04-02T11:25:33.067+08:00,7258,3.3173,30.02,895419,0,0,19.7,7258,33173,30317,43,19.7183,19.4607,19.
2025-04-02T11:25:33.162+08:00,7259,3.3177,30.02,895529,0,0,19.2,7259,33177,30317,43,26.0345,25.7044,25.
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2025-04-02T11:25:33.392+08:00,7261,3.3175,30.02,895750,0,0,18.8,7261,33175,30317,43,25.8285,25.7813,25.
2025-04-02T11:25:33.495+08:00,7262,3.3175,30.02,895860,0,0,19.5,7262,33175,30317,43,19.8763,19.9525,19.
2025-04-02T11:25:33.604+08:00,7263,3.3177,30.01,895970,0,0,19.3,7263,33177,30316,44,25.8706,25.8442,25.
2025-04-02T11:25:33.725+08:00,7264,3.3175,30.01,896080,0,0,19.7,7264,33175,30316,44,19.7183,19.4607,19.
```

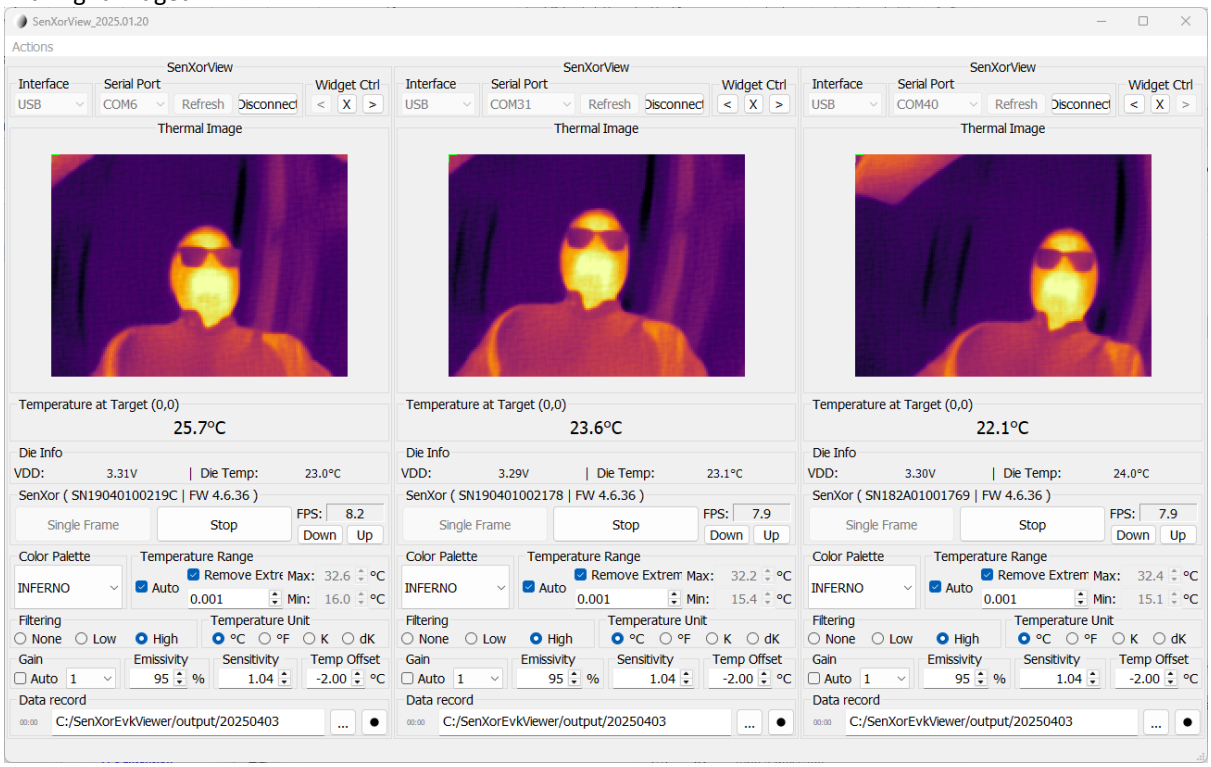
PC Time from UTC: The current time from UTC.

Frame number: It is counted by sensor firmware, read from SPI header.

Senxor VDD: The VDD value read from the senxor device.
Senxor Die Temperature: The die temperature read from the senxor device.
Timestamp: The time is counted according to system clock, in [hhmmss] format.
Cursor X: Current cursor X coordinate.
Cursor Y: Current cursor Y coordinate.
Temperature at Cursor: Current temperature at cursor.
Frame Header: 160 entries of the frame header
Thermal data: The temperature data of the pixels showing on thermogram, the format is depending on the GUI settings include filtering and unit.

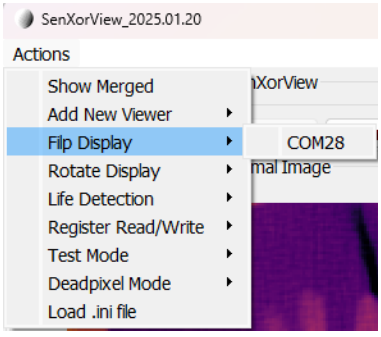
2.9. Multiple EVK connection

If there are more than one EVK connecting to the device, the GUI can expand to multiple widgets for different EVK. Under “Action” -> ”Add New Viewer” tag and new widget can be added on the left or right to the main window. Widget Ctrl controls the corresponding widget swap with left, close or swap with right widget.

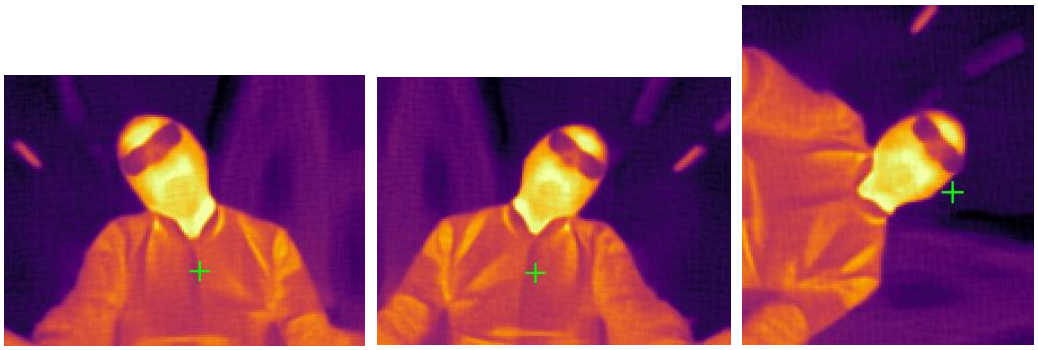


2.10. Flip & Rotation

In Actions menu, user can horizontally flip or rotate clockwise the thermogram. The selector is based on the connected EVK.

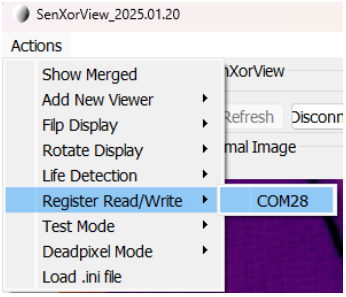


Default orientation, horizontal flip and rotation example



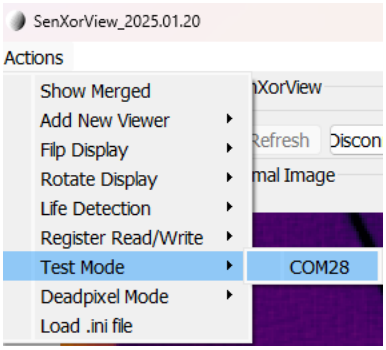
2.11. Register Read/Write

In the register menu, user can read or write to the MI48E4 TIP registers to get the status of the thermal sensor and the TIP, and change the settings of the thermal sensor and the TIP.



2.12. Test Mode

User can enable Test Mode feature Test Mode menu.



With the Test Mode enabled, the contour of the hot object on the scene is highlighted and the cursor point is determined by the centroid point of the hot object. This feature is designed for testing the thermal sensor on the hot object (such as a thermal black body) and the temperature of the cursor point can be output in the log file as shown in section 2.8 Data Recording.