Meridian Innovation MI0801 Thermal Camera Module

Data sheet

Revision 1.0.5 – April 2022

Contents

1. OVERVIEW 3

2. KEY FEATURES 3

3. ORDER INFORMATION 4

4. PIN INFORMATION 4

5. RECOMMENDED SYSTEM SETUP 5

6. FUNCTIONAL DESCRIPTION 6

7. TECHNICAL SPECIFICATION 7

7.1. Thermal Imaging Sensor Characteristics 7
7.1.1. General 7
7.1.2. Accuracy 8

7.2. Electrical Characteristics 9
7.2.1. Absolute Maximum Rating 9
7.2.2. Nominal Operating DC Characteristics 10

7.3. Dynamic Timing Characteristics 11
7.3.1. System Clock 11
7.3.2. System Reset 11
7.3.3. Timing Characteristics 11

8. PACKAGE INFORMATION 12

9. REVISION HISTORY 13

10. LEGAL INFORMATION 13

11. CONTACTS INFORMATION 13

12. APPENDIX A – FPC CONNECTOR MAPPING 14

13. APPENDIX B – ARRAY ORIENTATION AND DETECTOR ENUMERATION 14

1. OVERVIEW

Meridian Innovation's MI0801 is a long-wave infrared (LWIR) thermal imaging camera module, powered by SenXor™ technology and featuring 4,960 pixels arranged in an 80 by 62 pixel focal point array (FPA).

SenXor™ technology is Meridian Innovation's patented CMOS-compatible thermal sensor array. Its hybrid architecture yields the synergy of microbolometer and thermopile pixel technology. The sensor array is wafer-level vacuum-packaged (WLVP). WLVP refers to a microchip that is made of two CMOS wafers bonded together with a vacuum cavity in between. The base wafer – referred to as the *active wafer* -- contains the thermal sensor array and the readout circuit. The top wafer – referred to as the *cap wafer* – transmits LWIR radiation while keeping the pixels of the array in vacuum for optimal operation.

The WLVP chip is attached and wire-bonded to a PCB substrate and its housing includes a lens assembly designed to transmit LWIR radiation and focus it on the thermal sensor array. The PCBA has an FPC-connector for interfacing to a thermal image processing system by means of a flat strip cable.

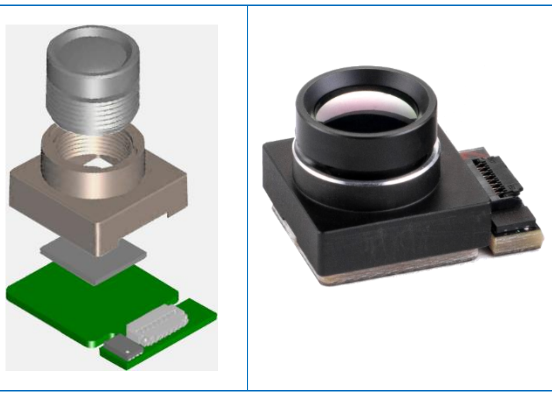

Fig. 1. Schematic diagram of the MI0801 camera module – showing the screw-mount lens, the sensor chip housing, the WLVP chip, and the PCB with an FPC connector and a memory chip holding the calibration data – and a picture of the actual module with a dual-element Ge lens MI0801M0G.

2. KEY FEATURES

- Nearly 5,000 pixels arranged in an 80 (H) by 62 (V) pixel array, rendering sufficient complexity in the thermal image to enable thermal data analytics and inference
- Radiometric output, i.e. per pixel temperature output
- Screw-type mount of the lens, enabling customisable FoV according to application
- Continuous operation and thermal video stream due to shutterless design
- Intrinsic sensor protection due to WLVP
- Factory calibration per pixel, resulting in high uniformity and accuracy of the temperature readout
- Cost effective

3. Order Information

The MI0801 ordering code includes a three-symbol encoding of the specific lens and packaging, as per the Table 1.

Table 1. Ordering Information

Product Code	Package	Resolution (H x V)	Lens	FoV (D/H/V), °	Minimum Quantity
MI0801M0G	PCBA	80 x 62	2-element, Ge	55/44/35	100
					
MI0801M1C	PCBA	80 x 62	1-element, Chalcogenide	143/90/66	100
					

4. Pin Information

The MI0801 interfaces to a host system via a 15-pin FPC-connector with 0.3 mm pitch. Current generation of the MI0801M0G features such connector from Hirose Electric Co., FH26W-15S-03SHW. The pin information is shown in Table 2.

Table 2. FPC Connector Pin Description

Pin No	Pin Name	Type	Description
1	SYSCLK	I	System Clock
2	VSS	P	Ground
3	RST_N	I	System Reset (active low)
4	SSREGN	I	SPI Slave Select, Control Registers Space (active low)
5	SSDATAN	I	SPI Slave Select, ADC Data (active low)
6	MOSI	I	Master Output Slave Input of the SPI Bus
7	MISO	O	Master Input Slave Output of the SPI Bus
8	SCK	I	SPI Bus Clock
9	CAPTURE	I	Data Acquisition Trigger
10	SSFLASHN	I	SPI Slave Select, Flash Memory on the MI0801 PCB (active low)
11	DATA_AV	O	Data Available signal
12	VDD	P	3.3 V Power supply
13	VDD	P	3.3 V Power supply

14	VSS	P	Ground
15	VSS	P	Ground

The recommended connection to the integrating system is by means of a flat-strip FPC cable and a corresponding FPC connector. The mapping of the FPC-connector pads on the MI0801M0G to the PCB of the integrating system is shown in Appendix A.

5. Recommended System Setup

The recommended usage of MI0801 camera module is in combination with its companion integrated circuit MI48xx as seen in Fig. 2.

The MI48xx plays the role of a low-level thermal imaging processor, and handles the exact control signalling necessary to capture raw sensor data from the thermal imaging array of the MI0801. It also provides standard interfaces for communication with a host controller. In the case of the MI48Ax for example, these interfaces are the Inter-Integrated Circuit (I^2C) bus – for conveying commands and obtaining status, and the serial peripheral interface (SPI) – for the readout of thermal data obtained by the MI48Ax. In addition to the I^2C and SPI interfaces, the MI48Ax provides a digital signal to alert the host controller that new thermal image data is available, as shown in Fig. 2.

The MI48Ax also performs low-level processing of the data read out from the camera modules. Specifically, it handles the per-pixel calibration, performs bad pixel correction (BPC), and converts the raw camera data to temperature, and in this way greatly facilitates the development of applications embedding the MI0801 camera module.

To ensure the best accuracy and stability of the temperature readout, a dedicated voltage regulator for the camera module is also recommended.

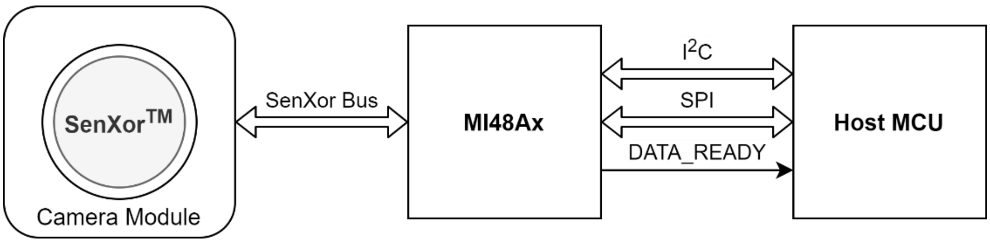

Fig. 2. Recommended system architecture embedding the camera module MI0801, the thermal imaging processor MI48Ax, and a host MCU.

6. FUNCTIONAL DESCRIPTION

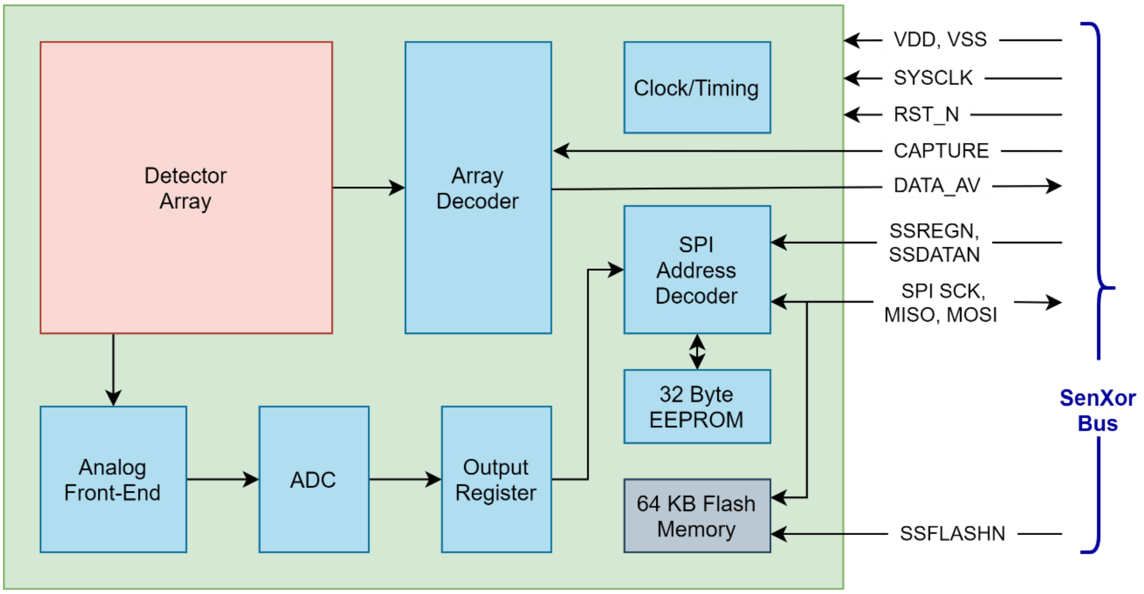

Fig. 3. Block diagram of the MI0801 camera module, showing major elements of the SenXor chip, the on-board flash memory and the SenXor Bus digital interface signals.

Table 3. FUNCTIONAL BLOCKS DESCRIPTION

Detector Array	An array of 80 x 62 LWIR detectors, each of which produces a voltage of magnitude that is dependent on the difference in temperature between the objects in the field of view and the die temperature.
Clocking Logic	System clock related circuitry, responsible for all timing and reset signalling supplied to the Array Decode Logic.
SPI Address Decoder	Address decoder for selecting the correct SPI slave device and registers of the MI0801 Camera Module. Three SPI select pins are supported. SSREGN enables access to the internal registers for control and status information. SSDATAN enables read access to the ADC data. SSFLASHN enables access to the onboard 64 KB flash memory.
Array Decode Logic	Row and column decode logic for the FPA, responsible for accessing each detector in sequence and routing its output via the Analogue Front End to the ADC.
Analogue Front End	Amplification and filtering the signals from the individual detectors so they are suitable for digitization by the ADC. This stage includes gain control for conditioning the analogue signal for digitization based on the scene temperature and frame rate.

ADC	Analogue to Digital Converter of the voltage signal from the Analogue Front End. Its output is buffered in the Output Register.
Output Register	The output register stores the converted digitized signal.
32 Byte EEPROM	Embedded EEPROM of factory programmed 32 bytes storing the unique device ID field.
64 KByte Flash	Factory programmed FLASH memory storing the per-pixel calibration look-up tables that are necessary for temperature conversion and radiometric output by the host system.

7. TECHNICAL SPECIFICATION

7.1. Thermal Imaging Sensor Characteristics

7.1.1. General

The thermal sensor array operates in the long-wave infrared range (LWIR) of the electromagnetic spectrum. Table 4 lists the essential characteristics of the sensor. Fig. 4 shows the estimated spectral response of an individual detector within the array, including the characteristics of the lens of the camera module.

Table 4. THERMAL IMAGING SENSOR CHARACTERISTICS

Parameter	Value	Unit
Wavelength detection range	8 – 14	µm
Focal point array shape	80 (H) x 62 (V)	Number of detectors
Total number of detectors	4960	Number of detectors
Non-functional detectors	< 0.5 %	
Detector pitch	45 (H) x 45 (V)	µm
Noise-equivalent temperature difference (NETD)	150 mK [1)]	mK
Scene temperature range:		
Factory calibrated	−20 to +400	°C
Operating temperature range	−20 to +85	°C
Frame rate (maximum)	25.5	Frames per second (FPS)

Notes:

1) Achievable with a combination of firmware and software filtering in the companion thermal imaging processor by Meridian Innovation, see MI48xx specification.

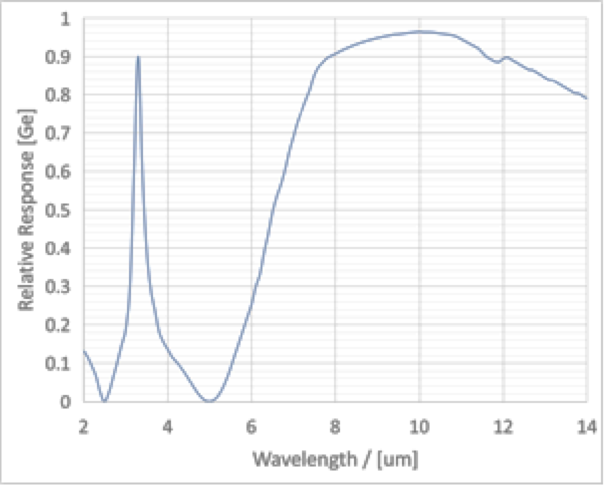

Fig. 4. Spectral response of MI0801M0G (Theoretical estimate).

7.1.2. Accuracy

Accuracy is defined for the MI0801M0G modules under isothermal conditions for both module and ambience, power supply voltage $V_{DD} = 3.3 \ \pm 0.01 \ V$, and the area of the target object exceeding the FOV of the module by 25 % or more, as shown in Fig. 5. Relative humidity should be below 95 % and there should be no condensing vapor or moisture on the lens.

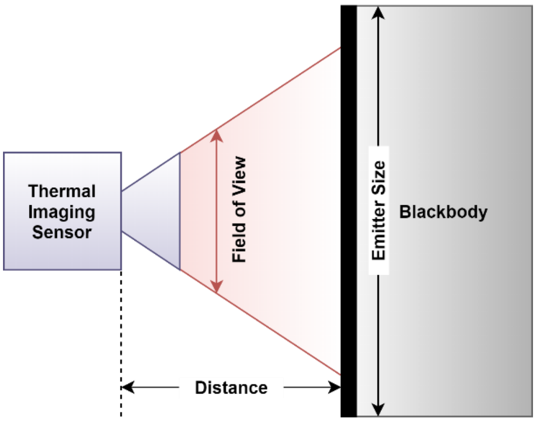

Fig. 5. Setup for module verification. The emitter size of the blackbody must nearly fill or exceed the field of view of the sensor.

Table 5. ACCURACY SPECIFICATION

	Operational chip temperature [1], ℃	Scene temperature, ℃	Maximum deviation[2], ℃
Frame Accuracy [3]	30.0	32.0 – 40.0	±0.8 (center 32x24) ±1.0 (entire FPA)
	30.0	10.0 – 32.0, 40.0 – 70.0	±1.5 (entire FPA)
	30.0	< 10.0, > 70.0	the bigger of ±2.0 (entire FPA) or 5%
Non-uniformity [4]	30.0	32.0 – 42.0	±0.5 (center 32x24) ±0.7 (entire FPA)
	30.0	10.0 – 32.0, 42.0 – 70.0	±1.0 (entire FPA)
	30.0	< 10.0, > 70.0	the bigger of ±2.5 (entire FPA) or 5%
Stability with respect to chip temperature	30.0	32.0 – 40.0	−0.21 ℃/℃
Stability with respect to V_{DD}	30.0	-	±1.0 ℃ / 100 mV

Noise [5]	1 FPS	9 FPS	25 FPS
RMSE (standard deviation)	±0.35	±0.9	±2.33

Notes:

1. SenXor chip temperature, as reported in frame header
2. Reported values are for MI0801M0G (dual element lens with 44° HFOV
3. Frame Accuracy is defined as the mean of all pixels in the array, i.e. the frame-average, for a frame that is obtained after averaging 1000 frames, i.e. not subject to random noise
4. Deviation of individual pixels from the frame-average
5. Intrinsic noise for the center (32x24) pixels of the array without software filtering.

7.2. Electrical Characteristics

7.2.1. Absolute Maximum Rating

Exceeding the values reported below at any time may lead to a performance deterioration, malfunction or destruction of the chip.

The values reported below are guaranteed by characterization results, not tested in production.

All interface-related pins are referred to as I/O.

Table 6. ABSOLUTE VOLTAGE RATINGS

Symbol	Parameter	Min	Max	Unit
V_{DD}-V_{SS}	DC Power Supply	−0.3	3.6	V
V_{IN}	I/O voltage	−0.3	3.6	V
ESD(HBM)	ESD(HBM)		2	kV
ESD(CDM)	ESD(CDM)		0.5	kV

Table 7. ABSOLUTE CURRENT RATINGS

Symbol	Parameter	Min	Max	Unit
I_{DD}	Maximum Current into V_{DD}		200	mA
I_{SS}	Maximum Current out of V_{SS}		100	
I_{IO}	Maximum Current Sunk by a I/O pin		20	
	Maximum Current Sourced by a I/O pin		20	
	Maximum Current Sunk by total I/O pins		100	
	Maximum Current Sourced by total I/O pins		100	
LU	Static latch-up class (at T_A = 25°C)		200	

Table 8. ABSOLUTE ENVIRONMENTAL RATINGS

Symbol	Parameter	Min	Max	Unit
T_A	Ambient (Operating) Temperature	−40	85	°C
T_{ST}	Storage Temperature	−40	85	°C
P_A	Ambient Pressure		110	kPa
R_H	Relative Humidity		95	%
G_{SH}	Mechanical Shock		1	G

7.2.2. Nominal Operating DC Characteristics

Table 9. VOLTAGE CHARACTERISTICS

Symbol	Parameter	Min	Typical	Max	Unit
V_{DD}	Power Supply	3.2	3.3	3.4	V
V_{IO}	IO logic levels	3.0	3.3	3.6	V

Table 10. CURRENT CONSUMPTION [1)]

Symbol	Parameter	Min	Typical	Max	Unit
I_{DD_A}	Active (thermal image acquisition)	10.0	11.7	14.0	mA
I_{DD_S}	Stand-by		0.6		mA

[1)] Measured at V_{DD} = 3.3 V and T_A = 25 °C.

7.3. Dynamic Timing Characteristics

7.3.1. System Clock

The MI0801 timing is driven by an external oscillator of 3 MHz, with a tolerance not exceeding 30 ppm. Internally, it generates all necessary timing for its operation and interfaces. Typically, SYSCLK will be generated by the companion chip MI48XX, which interfaces directly to the MI0801 via the SenXor bus.

7.3.2. System Reset

The MI0801 is reset by asserting 0 to the RST_N – pin 3 of the FPC connector on the PCBA package. The RST_N pin must be held low (below 0.2 V_{DD}) for at least 32 µs in order to take effect. Similarly, RST_N is considered released after the pin is held high (above 0.7 V_{DD}) for at least 32 µs.

The time between de-asserting the RST_N pin and attempting to acquire the first image from the connected camera module is 6 milliseconds, as shown in Fig. 6.

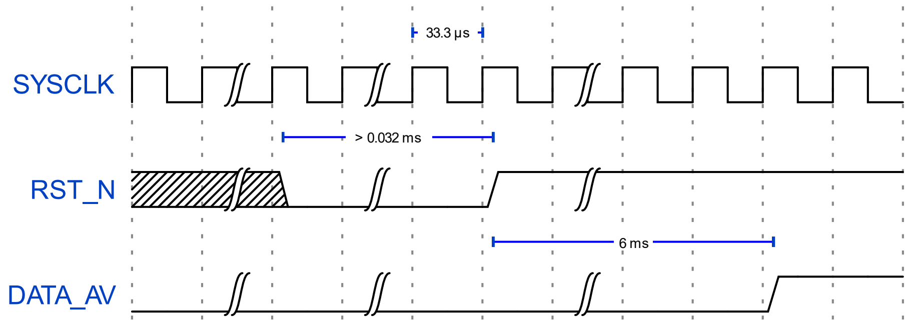

Fig. 6. Timing diagram indicating the minimum duration of a valid reset assertion, and the minimum time before a frame can become available for readout.

7.3.3. Timing Characteristics

Table 11. TIMING PARAMETERS

Symbol	Parameter	Min	Typical	Max	Unit
F_{SYSCLK}	System clock frequency		3		MHz
F_{SCK}	SPI clock frequency	10	14	20	MHz
$Duty_{SCK}$	SPI clock duty cycle		50		%
T_{DS}	SPI data setup time	2			ns
T_{DH}	SPI data hold time	5			ns

8. Package Information

Fig. 7. Shows the dimension details of the PCBA package of the MI0801 camera module. The weight of the entire assembly is less than 3 g.

The FPC connector has a pitch of 0.3 mm and a height of 1 mm. A typical connector part number is FH26W-51S-0.3SHW from Hirose Electric. The footprint of the connector on the module and on the corresponding host system PCB is shown in Fig. 9 of Appendix A.

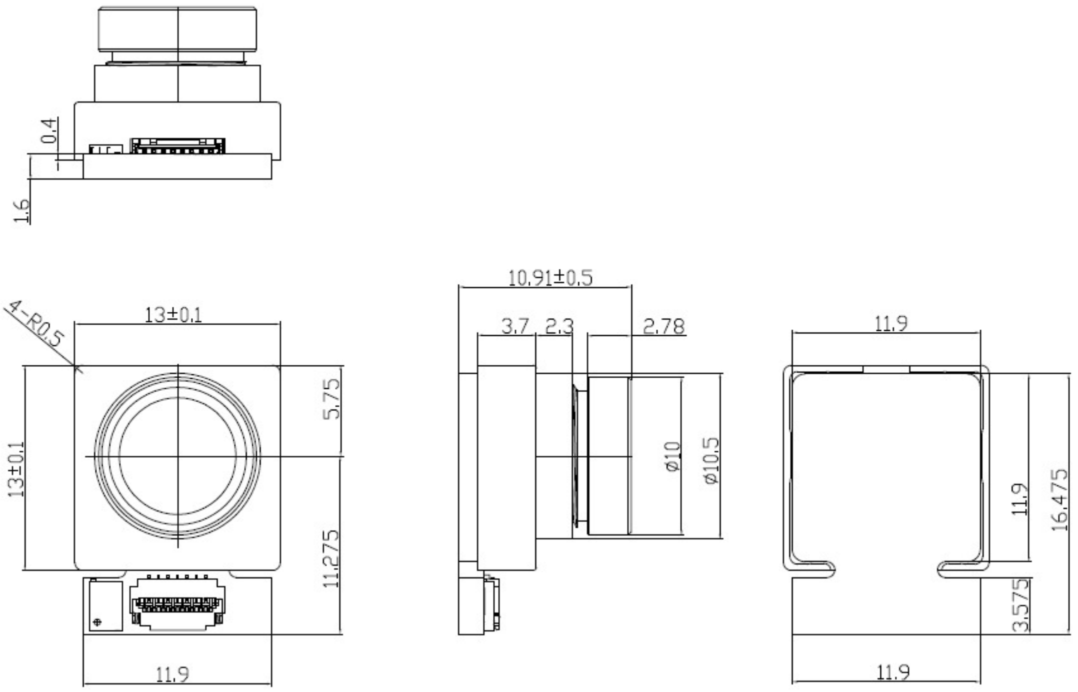

Fig. 7. Dimension of PCBA, including the lens. All dimensions are in mm, unless specified otherwise.

9. Revision History

Revision	*Date*	*Comment*
1.0.1	13 Nov 2019	Transfer from Product Brief to new template, Update according to Bobcat MP Specification V1.0. Remove unnecessary details on interface and internal operation.
1.0.2	09 Dec 2019	Updated SYSCLK info.
1.0.3	08 Dec 2020	Added Appendix A with mapping of FPC Connector pad layouts
1.0.4	28 May 2021	Updated Accuracy Specification, Thermal Characteristics Specification and Current Consumption
1.0.5	30 Apr 2022	Updated Certain TBD figures and accuracy related values. Added figures for Reset timing and for accuracy verification setup.

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11. Contacts Information

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12. APPENDIX A – FPC CONNECTOR MAPPING

Figure 8 shows the connection of the MI0801 camera module to an integrating system by means of an FPC flat strip cable and connector. Note that in this scenario, the FPC connector on the integrating PCB has reversed order of the pads, as displayed in Fig. 9.

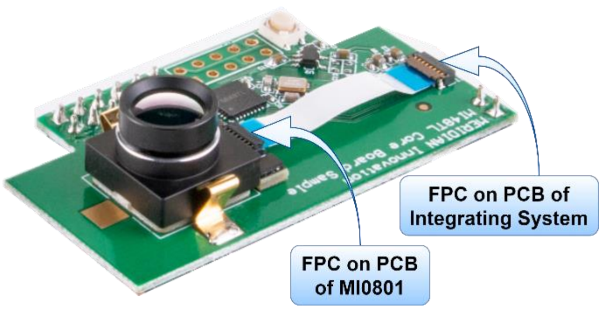
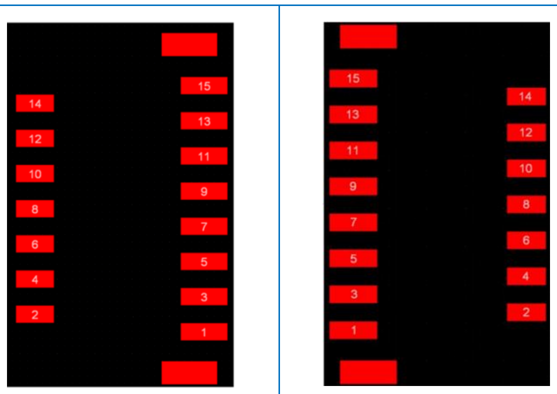


Fig. 8. An example of connecting the MI0801M0G to the PCB of the integrating system by an FPC flat strip cable and an FPC connector mount on the system PCB.



a) b)

Fig. 9. Pad layout of the FPC connector on the MI0801M0G PCB – a), and on the integrating system PCB – b). Note that the order is reversed when a flat-strip FPC cable is used.

13. APPENDIX B – ARRAY ORIENTATION AND DETECTOR ENUMERATION

The MI0801 module outputs the data of each detector of the focal point array in a serial fashion. It is important to note the correct enumeration of the detectors, when constructing a two-dimensional image from the serial stream of data.

The MI0801 contains 4960 detectors or pixels, arranged in 62 rows and 80 columns as shown in Fig. 10, assuming that you are facing the lens of the module. The value of pixel 1 is output first, and the value of pixel 4960 is output last, in a row-by-row fashion.

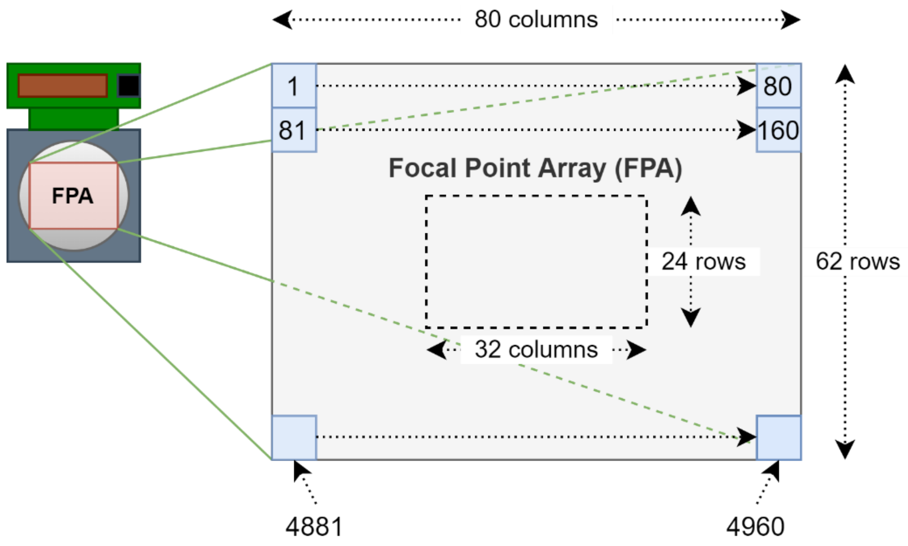


Fig. 10. When facing the lens of the MI0801 module, the individual detectors of the focal point array are enumerated as shown in the rectangular frame, from 1 to 4960. The temperature values are output serially, starting from that of detector 1, ending with that of detector 4960.