

Thermal Module (2128 Series)

User's Manual



V2.0.0

Foreword

This manual introduces the interfaces and video configuration of the 2128 series module. Read carefully before using the device, and keep the manual safe for future reference.

Safety Instructions

The following categorized signal words with defined meaning might appear in the manual.

Signal Words	Description
 DANGER	Indicates a high potential hazard which, if not avoided, will result in death or serious injury.
 WARNING	Indicates a medium or low potential hazard which, if not avoided, could result in slight or moderate injury.
 CAUTION	Indicates a potential risk which, if not avoided, could result in property damage, data loss, lower performance, or unpredictable result.
 NOTE	Provides additional information as the emphasis and supplement to the text.

Revision History

Version	Revision Content	Release Time
V2.0.0	Add the contents such as supporting lenses, expansion boards, and video configurations.	2024.07
V1.0.0	First release.	2024.01

Important Safeguards and Warnings

This section introduces content covering the proper handling of the device, hazard prevention, and prevention of property damage. Read carefully before using the device, comply with the guidelines when using it, and keep the manual safe for future reference.

Transportation Requirements



- Do not place heavy stress on the device, allow it to fall, violently vibrate or immerse it in liquid during transportation. Handle the device with care to avoid damaging the internal precision parts.
- Pack the device with packaging provided by its manufacturer or packaging of the same quality before transporting it.
- Keep the original packing material well in case you need it to pack the Camera and send it back for repair when problems occur. we will assume no responsibility for any damage or problems caused during transportation due to the incomplete package being sent.

Storage Requirements



- Store the device under allowed humidity and temperature conditions.
- Do not place the device in a humid, dusty, extremely hot or cold site that has strong electromagnetic radiation
- Do not place heavy stress on the device, allow it to fall or collide with other objects, violently vibrate or immerse it in liquid during storage.
- Store the device in a well-ventilated place

Installation Requirements



- All installation and operations must conform to the local electrical safety code and standards.
- Strictly comply with the local electrical safety code and standards, and check whether the power supply is correct before operating the device.
 - ◇ When selecting the power adapter, the power supply requirements (such as rated voltage) are subject to the device label.
 - ◇ We recommend using the power adapter provided with the device.
 - ◇ The power supply must conform to the requirements of ES1 in IEC 62368-1 standard and be no higher than PS2. Please note that the power supply requirements are subject to the device label.
- Use the device within the allowed humidity (less than 95% RH) and altitude (less than 3000 m) conditions.
- Do not expose the device to heat sources such as a radiator, heater, stove or other types of heating equipment. This is to avoid the risk of fire.
- Make sure that the power is off when you connect the cables, install or disassemble the device.

- If the device produces smoke, an odd odor, noise, or behaves faulty, cut the power immediately, and contact the local dealer or service center at your earliest convenience. Do not disassemble the device. We assume no responsibility for issues caused by uninstructed maintenance.

 WARNING

- Do not install the device in an environment that has strong vibrations.
- Make sure the wire diameter of the cables meets the requirements of the corresponding distance to avoid equipment damage caused by undervoltage and overcurrent.
- Do not connect the device to two or more kinds of power supplies, to avoid safety risks and damage to the device.
- Do not place heavy stress on the device, allow it to collide with other objects, and do not violently vibrate or immerse it in liquid during installation.
- Do not expose the device to environments with strong magnetic fields to avoid damage to the device.



- Do not use a temperature measuring device to measure temperatures that extend beyond its measuring range.
- Do not place the device in a highly humid, extremely hot or cold site. Refer to the device specifications for the detailed requirements.
- Do not expose the device to corrosive environments such as coastal areas, sea areas with thick salt fog, environments with acid gas, chemical plants and the seaside.
- Do not place the device in environments with smoke, vapor, heavy dust, or that have high temperatures to avoid damage to the device.
- Do not block the ventilation opening near the device to avoid the device being damaged from heat accumulation.
- Do not aim the lens at intense radiation sources (such as the sun, lasers and molten steel) to avoid damage to the thermal detector and the visible lens.
- Protect the accessories that come with the device for future maintenance and debugging.



After unpacking, even if the packing bag is damaged or leaking air, the normal use of the device will not be affected.

Operation Requirements

 DANGER

- Prevent liquid from flowing into the device to avoid damage to its internal components.
- Do not insert foreign matter into the device to avoid the risk of short circuits, damaging the device and injuring people.

 WARNING

- Do not dismantle to device, it can only be repaired by qualified professionals. We assume no responsibility for issues caused by uninstructed maintenance.
- The operating temperature of the device must meet the requirements.



- Do not stain or damage optical components such as the lens and glass.
- Use a clean cloth or lens wipe to gently wipe off the dust on the visible window. Dried stains can be washed with clean water or ordinary diluted detergent. Do not use alkaline detergents to

clean the device, and do not vigorously wipe the device with a damp cloth to avoid permanently damaging the glass.

- Operating temperature: –40 °C to +70 °C (–40 °F to 158 °F).

Maintenance Requirements.



- Do not allow liquid to get into the device to avoid damage to the internal components. If any liquid flows into the device, immediately disconnect the power supply, unplug all the cables connected to the device, and contact after-sales service.
- Use the accessories suggested by the manufacturer. Installation and maintenance must be performed by qualified professionals.
- Use the accessories suggested by the manufacturer. Installation and maintenance must be performed by qualified professionals



Contact your local dealer or the service center nearest to you if the device fails to work normally. Do not dismantle or modify the device without a qualified professional present. We assume no responsibility for issues caused by uninstructed maintenance.



Clean the device body with a soft dry cloth. If there are any stubborn stains, clean them away with a soft cloth dipped in a neutral detergent, and then wipe the surface dry. Clean the device body with a soft dry cloth. If there are any stubborn stains, clean them away with a soft cloth dipped in a neutral detergent, and then wipe the surface dry.

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1 Performance Parameters

Thermal	CA160D 640 (Security)	CA161D 640 (Radiometry)	CA140D 384 (Security)	CA141D 384 (Radiometry)
Detector Type	Vanadium oxide uncooled focal plane detector			
Effective Pixels	640 (H) × 512 (V)		384 (H) × 288 (V)	
Pixel Pitch	12 μm			
Frame Rate (fps)	50	25	50	25
Spectral Range	8 μm–14 μm			
Physical Characteristics				
Focal Length (mm)	9/13/25/		9/13	
	F1.0		F1.0	
Field of view	51.4° × 41.1°/32.9° × 26.6°/ 17.7° × 14°		28.7° × 21.7°/20.1° × 15.1°	
Dimension	17.3 mm × 17.3 mm × 10.5 mm (1.02" × 1.02" × 2.97") (L × W × H) (lense excluded)			
Net Weight (lens excluded)	5 g (0.01 lb)			
Image				
Brightness, Contrast, Sharpness Adjustment	Yes			
Gain Control	Auto/Manual			
Noise Reduction	2D NR/3D NR			
Image Flip, Mirror	Yes			
Color Palettes	18 (white hot/black hot/fusion/rainbow/golden autumn/midday/iron red/amber/jade/sunset/icfire/painting/pomegranate/emerald/spring/summer/autumn/winter)			
Reticle	Display/Disappear/Hide			
Image Processing	UVC/Digital filtering noise reduction /Digital detail enhancement			
Temperature measurement (Only for devices with the temperature measurement function)				
Temperature Measurement Range	Low Temperature Mode: −20 °C to +150 °C (−4 °F to +302 °F) High Temperature Mode: 0°C to +550 °C (+212 °F to +1022 °F)			
Temperature Error Range	Max. (±2 °C, ±2%); Operating temperature: −20 °C to +50 °C (−4 °F to +122 °F)			
Interface				
Expansion Interfaces	USB (2.0)/CVBS/MIPI/BT.656			
Serial Communication	UART/USB serial interface			
Power				
Power Supply	3.8–5.5 VDC			
Typical Power Consumption@25°C	< 0.75 W		< 0.7 W	

Environment	
Operating Temperature	–40 °C to +70 °C (–40 °F to +158 °F)
Storage Temperature	–40 °C to +80 °C (–40 °F to +176 °F)
Operating Humidity	95% (no condensation)
Vibrate	6.06 g (0.01 lb), random vibration, all axial directions



CVBS output only supports 25 fps.

2 Interfaces

This chapter introduces the interface definition and description of common interface of 2128 module without expansion board, including power interface of module component, LVDS interface, CVBS interface, USB interface, BT.656 standard interface, and UART communication interface.

Figure 2-1 2128-common interface connector pin

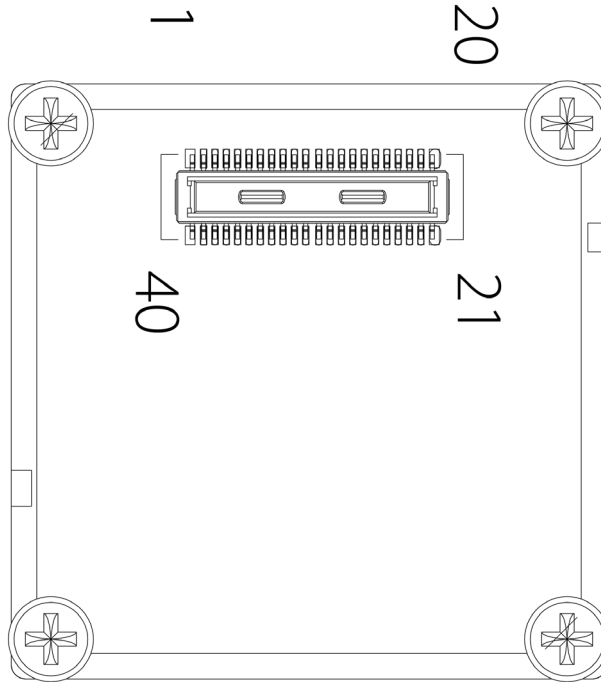


Table 2-1 Definition of DF40C-70DP-0.4V(51) connector interface

Pin	Definition	Type	Description	
1, 40	+5V	Power	Power input (5 VDC $\pm$ 10%)	
2, 38	+1.2V		Power output (1.2 V)	
39	+3.3V		Power output (3.3 V)	
3, 8, 13, 18, 21, 23, 26, 32, 37	GND		Grounded	
4	UART1_RXD_3V3	Input/Output	Serial communication interface (3.3 V)	
36	UART1_TXD_3V3	Input/Output	Debugging serial interface (3.3 V)	
7	DEBUG_UART0_TXD			
33	DEBUG_UART0_RXD	Input	Module program interface (3.3 V)	
5	SPI_CS _n			
6	SPI_MOSI			
35	SPI_MISO			
34	SPI_CLK	Output	BT656 video signal (3.3 V)	Data signal
9	BT656_D6_3V3			
10	BT656_D4_3V3			
11	BT656_D2_3V3			
12	BT656_D0_3V3			
27	BT656_D1_3V3			

Pin	Definition	Type	Description	
28	BT656_D3_3V3			
29	BT656_D5_3V3			
30	BT656_D7_3V3			
31	BT656_CLK_3V3			Clock signal
14	LVDS_CLK_P	Output	LVDS output (3.3 V)	Clock signal
15	LVDS_CLK_N			Data signal
16	LVDS_DATA0_P			
17	LVDS_DATA0_N			
24	LVDS_DATA1_N			
25	LVDS_DATA1_P			
22	CVBS_OUT	Output	CVBS output	Data signal
19	USB_D-	Output	USB output	Data signal
20	USB_D+			



Hirose 40-core DF40C-70DP-0.4V(51) connector.

3 Mainboard Interfaces

3.1 USB Type-C expansion board

The USB Type-C expansion board includes the USB Type-C interface. For the interface definition, see Table 3-1.

Figure 3-1 2128-USB Type-C expansion board (mm [inch])

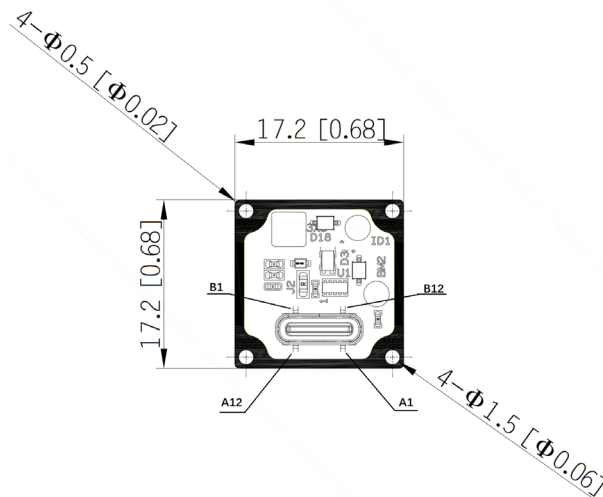


Table 3-1 Definition of WLUS-696A connector interface

Pin No.	Pin Name	Type	Description
A7, B7	USB_D-	Data negative signal	USB2.0
A6, B6	USB_D+	Data positive signal	
A1, A12, B1, B12	GND	Power	Grounded
A4, A9, B4, B9	+5 V	Power	Power input (5 VDC $\pm$ 10%)



J1 standard USB Type C connector

3.2 Expansion Board of USB White Plug

The expansion board of USB white plug includes the 4pin USB white plug interface. For the interface definition, see Table 3-2.

Figure 3-2 The expansion board of 2128-USB white plug (mm [inch])

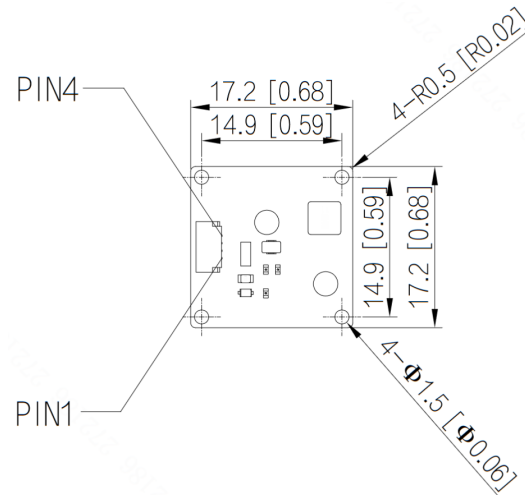


Table 3-2 Definition of 0.8T-WT-NP connector interface

Pin No.	Pin Name	Type	Description
1	GND	Power	Grounded
2	USB_DP	Data positive signal	USB2.0
3	USB_DM	Data negative signal	
4	+5 V	Power	Power input (5 VDC $\pm$ 10%)

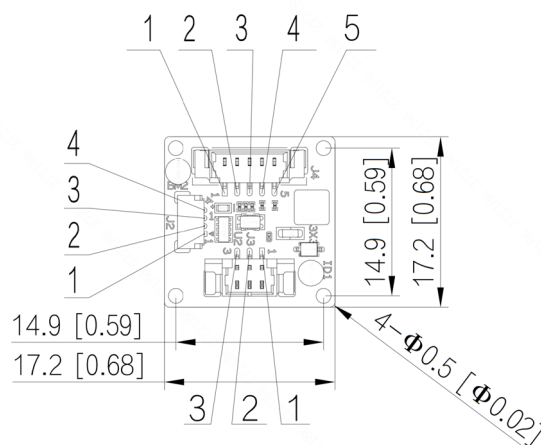


J2 white plug-1 row and 4 columns-0.8 mm-horizontal-beige-stick.

3.3 CVBS Expansion Board

The CVBS expansion board supports two CVBS interfaces, including module power interface and CVBS analog video interface.

Figure 3-3 2128-CVBS expansion board (mm [inch])



3.3.1 3-Pin CVBS interface

Table 3-3 Definition of J3 1.25T-7-LT-3A connector interface

Pin No.	Pin Name	Type	Description
1	+4.5–20 V	Power	Power input (4.5–20 VDC)
2	GND		Grounded
3	CVBS	Output	CVBS video signal



J3 white plug-1 row and 3 rows-1.25 mm-vertical-bilateral card hole-full package-pickup cap-stick.

3.3.2 5-Pin CVBS interface

Table 3-4 Definition of J4 1.25T-1-LT-5A connector interface

Pin No.	Pin Name	Type	Description
1	+4.5–20 V	Power	Power input (4.5–20 VDC)
2	GND		Grounded
3	CVBS	Output	CVBS video signal
4	UART1_TXD_3V3	Input/Output	Serial communication interface (3.3 V)
5	UART1_RXD_3V3		



J1 white plug-1 row and 5 rows-1.25 mm-vertical-bilateral card hole-full package-pickup cap-stick.

3.4 MIPI Expansion Board

The MIPI expansion board includes module power interface (5 VDC), MIPI interface, and UART communication interface.

Figure 3-4 2128-MIPI expansion board (mm [inch])

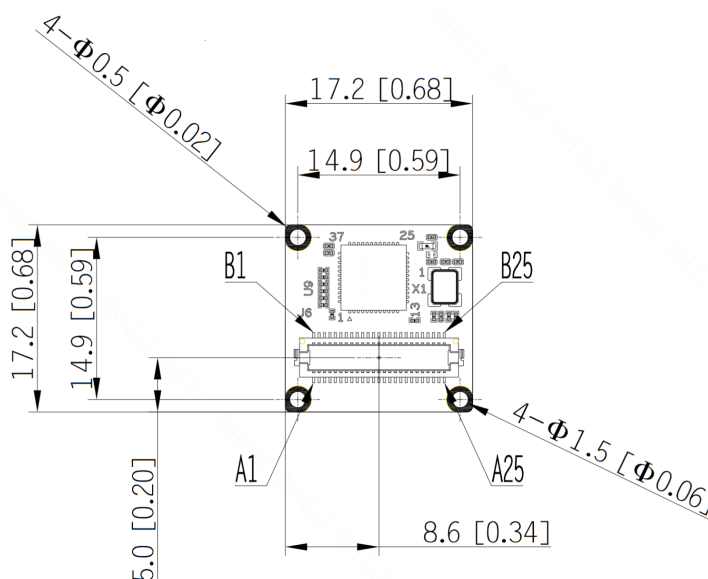


Table 3-5 Definition of DF12NB-50DS-0.5V(51) connector interface

Pin No.	Pin Name	Type	Description	
B1, B2	+5 V	Power	Power input (5 VDC ± 10%)	
B3	+3.3 V		Power output (+3.3 V)	
A1, A2, A3, A5, A7, A17, A23, B4, B7, B17, B23	GND		Grounded	
A6	BT656_CLK_3V3	Output	BT656 video signal (3.3 V)	Clock signal
A8	BT656_D1_3V3			Data signal
A9	BT656_D3_3V3			
A10	BT656_D5_3V3			
A11	BT656_D7_3V3			
B8	BT656_D0_3V3			
B9	BT656_D2_3V3			
B10	BT656_D4_3V3			
B11	BT656_D6_3V3			
B21	MIPI_O_CLK_N	Output	MIPI signal	Clock signal
A21	MIPI_O_CLK_P			Data signal
B18	MIPI_O_DATA1_N			
B19	MIPI_O_DATA0_N			
B20	MIPI_O_DATA2_N			
A18	MIPI_O_DATA1_P			
A19	MIPI_O_DATA0_P			
A20	MIPI_O_DATA2_P			
A22	SPI_MOSI	Input/Output	Reserved SPI (3.3 V)	
A12	SPI_CLK			
B22	SPI_MISO			
B12	SPI_CS _n			
B25	UART1_RXD_3V3	Input/Output	Serial communication interface (3.3 V)	
A25	UART1_TXD_3V3			



Board to board-2 row 25 columns-0.5 mm-vertical male connector-5.00 mm-stick.

4 Module Configuration

4.1 UVC Video Configuration

4.1.1 UVC Video Data Format

By default, the security module is 50 FPS single YUV output, 16 bit, and video conforms to YUV422 format (UYVY).

By default, the radiometry module is 25 FPS, RAW and YUV data splicing output, the first half of each line is RAW data, 14 bit. The second half of each line is YUV data image, 16 bit, and the video conforms to YUV422 format (UYVY).

See the following table for resolution configuration. The security module has 6 lines of redundancy, and the radiometry module has 8 lines of redundancy.

Table 4-1 Resolution configuration

Resolution	Video frame rate	Configuration resolution (redundant lines are included)
640 (H) × 512 (V)	50	640 (H) × 518 (V)
	25	1280 (H) × 520 (V)
384 (H) × 288 (V)	50	400 (H) × 306 (V)
	25	800 (H) × 308 (V)

Figure 4-1 UVC output frame format (radiometry module)

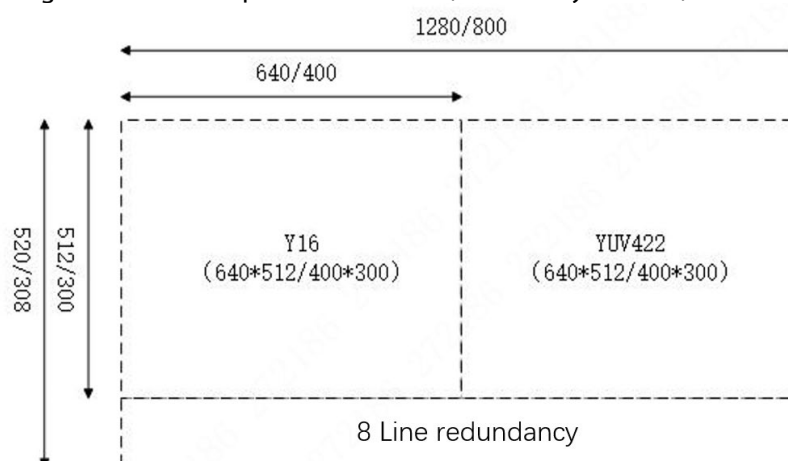
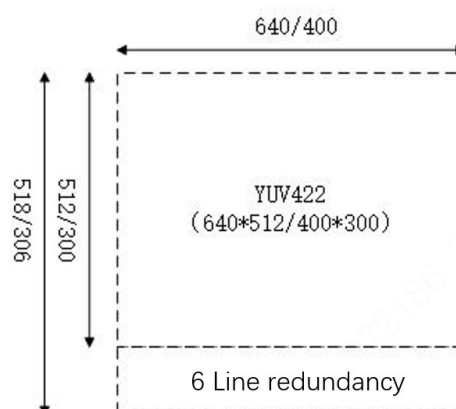


Figure 4-2 UVC output frame format (security module)



4.1.2 UVC Redundant Line Data

The 8 lines redundant data of the radiometry module is shown as following:

Heat map matrix (1368byte)								
cold/hot spot coordinate (16byte)	0xfe	hot.y[7:0]	0xfe	hot.y[15:8]	0xfe	hot.x[7:0]	0xfe	hot.x[15:8]
	0xfe	cold.y[7:0]	0xfe	cold.y[15:8]	0xfe	cold.x[7:0]	0xfe	cold.x[15:8]
cold/hot spot temperature (24byte)	0xfe	hotTemp * 200[7:0]	0xfe	hotTemp * 200[15:8]	0xfe	hotTemp * 200[23:16]	0xfe	hotTemp * 200[31:24]
	0xfe	coldTemp * 200[7:0]	0xfe	coldTemp * 200[15:8]	0xfe	coldTemp * 200[23:16]	0xfe	coldTemp * 200[31:24]
	0xfe	avgTemp * 200[7:0]	0xfe	avgTemp * 200[15:8]	0xfe	avgTemp * 200[23:16]	0xfe	avgTemp * 200[31:24]
0~11 temperature rules (312byte)	0xfe	ruleId[7:0]						
	0xfe	maxTemp*200[7:0]	0xfe	maxTemp*200[15:8]	0xfe	maxTemp*200[23:16]	0xfe	maxTemp*200[31:24]
	0xfe	minTemp*200[7:0]	0xfe	minTemp*200[15:8]	0xfe	minTemp*200[23:16]	0xfe	minTemp*200[31:24]
	0xfe	avgTemp*200[7:0]	0xfe	avgTemp*200[15:8]	0xfe	avgTemp*200[23:16]	0xfe	avgTemp*200[31:24]

The 6 lines redundant data of the security module only includes cold/hot spot coordinate



- The cold/hot spot is the coldest/hottest spot of the global image, the coordinate system is 8192, and the coordinate starts from the upper left corner of the image.
- The temperature rule information includes the rule ID, minimum temperature, maximum temperature, and average temperature. At most 12 rules can be set.
- The value of cold/hot spot and temperature measurement rules are multiplied by 200 during transmission. The data is transmitted in little-endian mode, and 0 xfe is inserted in the low bit of every 8 bits of data to avoid the synchronization code.

4.2 BT.656 Video Configuration

4.2.1 BT.656 Video Data Format

BT.656 (ITU-R) standard interface includes 1 clock signal and 8 data signals.

RAW and YUV data are progressive, the first half of each line is RAW data, 14 bit. The second half of each line is YUV data image, 8 bit, and the video conforms to YUV422 format (UYVY).

See the following table for module clock frequency and resolution configuration:

Table 4-2 Clock frequency and resolution configuration (BT.656)

Module model	Resolution	Video frame rate	Clock frequency	Configuration resolution (redundant lines are included)
Mino17	640 (H) × 512 (V)	50	88	1280 (H) × 520 (V)
		25	44	

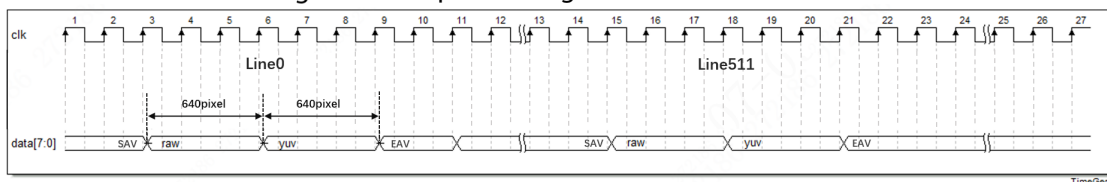


See the description of UVC redundant line data for the contents of the redundant line, and BT.656 does not contain heat map matrix.

4.2.2 BT.656 Digital Video Timing

Use the module (640 × 512) as an example

Figure 4-3 Sequence Diagram of BT.656



BT.656 Synchronization Code

Active line header SAV = 0xFF 0x00 0x00 0x80

Active line tail EAV = 0xFF 0x00 0x00 0x9D
Blank line header SAV = 0xFF 0x00 0x00 0xAB
Blank line tail EAV = 0xFF 0x00 0x00 0xB6

4.3 MIPI Video Configuration

4.3.1 Introduction of MIPI Tx

Camera Serial Interface 2 (CSI-2) is another high-speed interface defined by the MIPI Alliance, which is mainly used for connecting image acquisition modules and processors.

The MIPI interface of the module complies with the standard of MIPI-CSI-2 Protocol, includes 1 clock lane and 4 data lanes (actually 2 data lanes are used). RAW and YUV data are splicing output, the first half of each line is RAW data, 14 bit. The second half of each line is YUV data image, 8 bit, and the conforms to YUV422 format (YUYV).

See the following table for module clock frequency and resolution configuration:

Table 4-3 Clock frequency and resolution configuration (MIPI Tx)

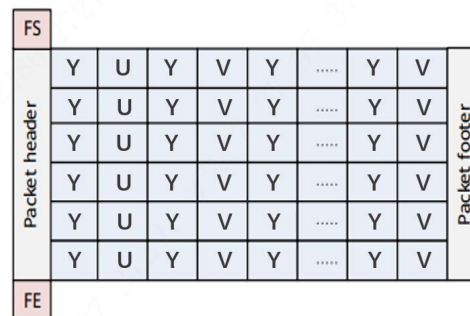
Module model	Resolution	Video frame rate	Clock frequency	Configuration resolution (redundant lines are included)
Mino17	640 (H) × 512 (V)	50	176	1280 (H) × 520 (V)
		25	88	

4.3.2 Data Format of MIPI Tx

When transferring multiple data packets, the controller will automatically switch between HS and LP modes according to the interval time.

Data transmission format: CSI-2 YUV422 8-bit, with alternating transmission of U and V components each line. The number of pixels in each packet is a multiple of 2.

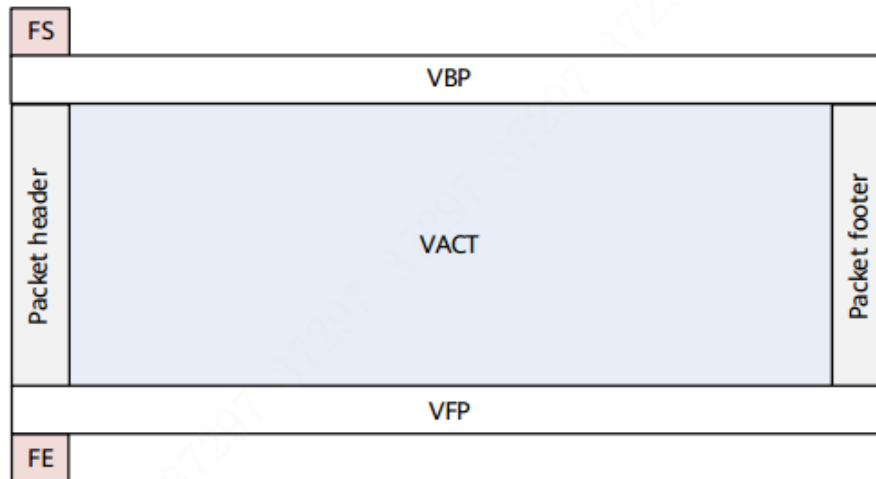
Figure 4-4 YUV422 8-bit format



4.3.3 Interface Timing of MIPI Tx

The Burst Mode timing of Video mode is shown in Figure 4-5. A frame of image contains four parts: VSA (vertical sync active), VBP (vertical back porch), VACT (vertical active lines), and VFP (vertical front porch). The vertical active lines include five parts: line sync start, blanking area back line, horizontal valid area, BLLP (Blanking or Low Power Interval), and blanking area front line. The invalid data line only includes line sync start and BLLP. Transmitting data through Burst Mode can fully utilize bandwidth, allowing effective data lines to enter the BLLP area. At this time, PHY is in LP mode, reducing power consumption.

Figure 4-5 Burst mode Timing



4.3.4 MIPI Collection Configuration Example

The following is an example code for the back end collection interface. Platforms of different chips might be different, and it is for reference only.

Attribute Configuration-MIPI

```
static combo_dev_attr_t MIPI_4lane_SENSOR_ATTR =
{
    .devno          = 0,
    .input_mode     = INPUT_MODE_MIPI,      /* input mode */
    .data_rate      = MIPI_DATA_RATE_X1,
    .img_rect       = {0, 0, 640, 512},
    {
        .mipi_attr =
        {
            DATA_TYPE_YUV422_8BIT: Fault recovery
            HI_MIPI_WDR_MODE_NONE,
            {0,1,2,3,-1,-1,-1,-1}
        }
    }
};
```

Attribute Configuration-Device

```
static hi_vi_dev_attr DEV_ATTR_BASE =
{
    OT_VI_INTF_MODE_MIPI_YUV422: Fault recovery
    HI_VI_WORK_MODE_MULTIPLEX_1: Fault recovery
    {0xFF000000,0xFF0000},
    HI_VI_SCAN_PROGRESSIVE,
    {-1, -1, -1, -1},
    OT_VI_DATA_SEQ_UVUV,

    {
        HI_VI_VSYNC_PULSE, HI_VI_VSYNC_NEG_LOW, HI_VI_HSYNC_VALID_SIG,
        HI_VI_HSYNC_NEG_HIGH, HI_VI_VSYNC_VALID_SIG, HI_VI_VSYNC_VALID_NEG_HIGH,

        {0,          VSF_HSYNC_ACT,          0,
          0,          VSF_VSYNC_VACT,        0,
          0, 0, 0}
    },
};
```

```
OT_VI_DATA_TYPE_YUV,  
HI_FALSE,  
{640,512,  
HI_DATA_RATE_X1  
};
```

Attribute Configuration-PIPE

```
static hi_vi_pipe_attr PIPE_ATTR_640X512 =  
{  
    HI_VI_PIPE_BYPASS_NONE,  
    HI_FALSE,  
    {640,512,  
    OT_PIXEL_FORMAT_YVU_SEMIPLANAR_422: Fault recovery  
    HI_COMPRESS_MODE_NONE,  
    HI_DATA_BIT_WIDTH_8: Fault recovery  
    HI_VI_BIT_ALIGN_MODE_HIGH,  
    {50,50,  
};
```