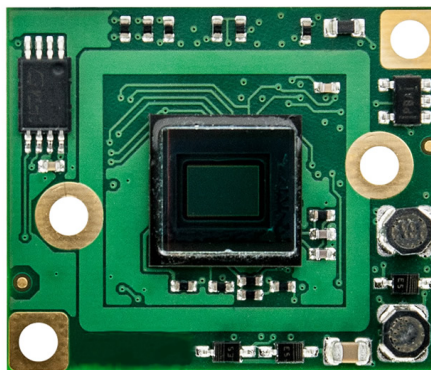


Application Note RHPC-2500/01



RHPC-2500



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Doc # RHPC-2500

Revision: B

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1. Document History

Revision	Issue Date	Reason	CN#
Rev A	07-09-12	Initial release	12-0135
Rev B	07-24-13	Technical specs, mechanical drawing, pin out update	13-0047

2. Introduction

The RHPC-2500 is a CMOS based camera family with a digital (CCIR656 based) and analog output. It is mechanically comparable with Videology's RHPC-2500 CCD camera family (identical dimensions -22x26mm- and mounting holes). However the sensor has no under plate, and is therefore mounted flat on the PCB. This will have effect on the depth of the camera. It is lower than with the RHP-2000 family.

The digital output is described fully in this document. The camera must be connected via the 30-pin board-to-board connector. This 30-pin board-to-board connector can be used to "piggy-back" an application PCB.

Examples of application PCB's are:

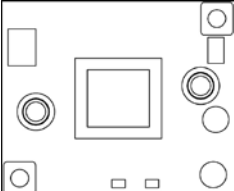
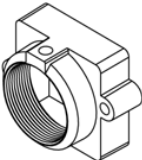
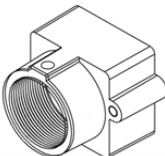
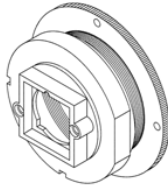
- USB 2.0 Board: RHP International product that has same dimensions (22x26mm). When two boards are stacked together a complete USB 2.0 camera is available.
- Ethernet interface (not yet available)

This document is written to give technical background on specific features of this camera module.

3. Specification

	RHPC-2500		RHPC-2501	
Image Sensor	1/4" CMOS			
Resolution (HxV)	640 x 480 max			
Frame Rate	30fps		25fps	
Sensitivity	< 0.05 lux, (50 IRE) F1.2, 3200 ⁰ K, lens transmission 80%, scene reflection 75%			
Signal to Noise Ratio	> 46 dB digital output			
Gamma	0.45 default			
Gain Control	Automatic 36 dB (AGC default) or Fixed options via software			
Scan Mode	Interlaced			
Mirror Mode	Selectable via software			
Synchronization	Internal			
Back Light Compensation	Default off (selectable via software)			
White Balance Mode	AWB (fixed modes selectable via software)			
Contour Enhancement	Default on			
Iris Control	Electronic Rolling Shutter			
Shutter Speed	Automatic from 1/60 to 1/100,000		Automatic from 1/50 to 1/100,000	
Video Outputs	8-bit digital YUV 4:2:2 @ CCIR656 and CVBS			
Control communication	I ² C control			
Power supply	5VDC +/- 5% (not polarity protected)			
Power consumption	< 0.8W			

Lens options (X-value)

			
RHPC-2500 No lens mount	RHPC-2500 Pinhole lens mount	RHPC-2500 M-12 lens mount	RHPC-2500 C/CS lens mount

4. Functional description

Camera has an automatic gain control in default mode. This function assures that the output signal remains constant at a certain level. This control circuit works with an integrator. The integrator generates from the video signal, which is a signal that corresponds with the average value of the video signal. This average is compared with an internal reference and depending on the outcome of the gain will increase or decrease.

However for some applications it is required that the AGC is overridden by a fixed gain level. This mode is called the manual gain control.

5. Software Control

The camera has a serial control interface via three wires:

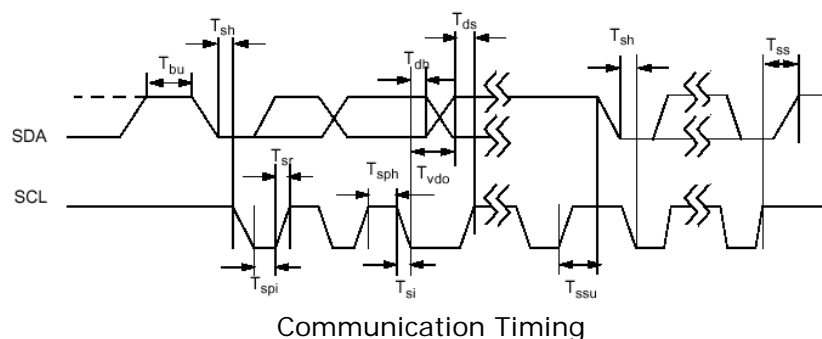
- Data wire
- Clock wire
- Ground wire

This interface operates similar as to the I²C-protocol.

Data, address and registers are all 8-bit words. The graphic interface is shown in figure 5. The maximum speed limitation is 100kHz. The minimum speed should be higher than 1KHz.

The write action to the EEPROM needs to be done with a delay time between the write actions of at least 10msec. This is due to fact the data needs to be stored after it has been received. This takes some time.

A wait time is further required between commands, so that the internal communication has the time to make the required internal communication. The delay time between the commands should be at least 12msec (since with most commands an EEPROM write action is involved).



I ² C timing basic freq=100KHz				
name		unit	min	max
T_{bu}	High stable period data	us	4	
T_{sh}	Start hold time	us	2.5	
T_{db}	Data hold time	us	1	
T_{ds}	Data stable time rising clock	us	1.5	
T_{ss}	Stop time	us	2.5	
T_{sr}	Rising time clock			0.5
T_{sph}	Clock high period	us	4.2	
T_{spi}	Clock low period		4.2	
T_{si}	Faling time clock			0.5
T_{ssu}				
F_{clk}	Clock frequency	KHz	1	110

I²C address camera: 0x70/71

The communication protocol exists out of two blocks. The first one is the command block and is **always** 4 bytes.

<START> < CamAddrW>ackn<mode>ackn <Addr1>ackn<Addr2>ackn <STOP>

The CamAddrW=0x70.

Mode can be:

- 0x00: write data to camera's EEPROM in data block One byte.
- 0x01: read data from camera's EEPROM in data block. One byte
- 0x02: write data to camera's Sensor in data block two bytes
- 0x03: read data from camera's Sensor in data block. two bytes
- 0x12: Prevent camera from starting from EEPROM settings (note no recovery possible!)
- 0x24 Eeprom dump action, write up to 16 bytes in to the EEPROM

The second part is the data block (can be write or read) and will be 2 or 3 bytes. The number of bytes is determined by the

<START> < CamAddrW/ CamAddrR >ackn<data1>ackn/Nack<STOP> (mode 0/1)

Or

<START> < CamAddrW/ CamAddrR >ackn<data1>ackn <data2> ackn/Nack<STOP> (mode 0/1)

Writing mode0:

Command block

start	0x70	ack	0x00	ack	EEpr address	ack	register	ack	stop
-------	------	-----	------	-----	--------------	-----	----------	-----	------

Data Block

Start	0x70	ack	data	ack	stop
-------	------	-----	------	-----	------

Writing mode2:

Command block

start	0x70	ack	0x02	ack	MSB reg addr	ack	LSB reg addr	ack	stop
-------	------	-----	------	-----	--------------	-----	--------------	-----	------

Data Block

Start	0x70	ack	Data MSB	ack	Data LSB	ack	stop
-------	------	-----	----------	-----	----------	-----	------

Reading mode1:

Command block

start	0x70	ack	0x01	ack	EEpr address	ack	register	ack	stop
-------	------	-----	------	-----	--------------	-----	----------	-----	------

Data Block

Start	0x71	ack	data	Nack	stop
-------	------	-----	------	------	------

Writing mode3:

Command block

start	0x70	ack	0x03	ack	MSB reg addr	ack	LSB reg addr	ack	stop
-------	------	-----	------	-----	--------------	-----	--------------	-----	------

Data Block

Start	0x71	ack	Data MSB	ack	Data LSB	Nack	stop
-------	------	-----	----------	-----	----------	------	------

EEPROM dump mode:

Command block

start	0x70	ack	0x12	ack	EEpr page address	ack	Start reg addr	ack	stop
-------	------	-----	------	-----	-------------------	-----	----------------	-----	------

Data Block

start	0x70	ack	Dat0	ack	Dat1.....	ack	Dat _n (n is max 15)	ack	stop
-------	------	-----	------	-----	-----------	-----	--------------------------------	-----	------

5.1. Camera configuration:

The device addresses have two values, one for read, and one for a write action. The difference is that the last bit (LSB) is set to **1**. For communication, the following device addresses are available:

Device	Device write	Device read
EEPROM page 1	0xa0	0xa1
EEPROM page 2	0xa2	0xa3
EEPROM page 3	0xa4	0xa5
EEPROM page 4	0xa6	0xa7

Table 1. Device addresses

5.2. I²C Address

The camera has an extra I²C address, which can be programmed so that more than one camera can be connected to I²C bus. **The camera has address 0x70/0x71.**

However if register 0x50 of the last EEprom page (0xa6/0xa7) is loaded with a different value as 0xff (in case of 0xff the default I2C address is used) this value will be used as new I2C slave address.

Note in case the EEprom register is changed, this only will be effective after re-powering the camera.

Also note that the default address is no longer valid. In case you have lost the I²C-address you can use Videology's B14 controller software to find the new address and to change it.

5.3. EEprom map

The camera has an 8K EEprom. The 8K are spread over 4 pages of each 256 bytes (2Kbits). The first page is used to store customised setting, which will be used at start-up of the camera. The data is stored in such a way that inside the Eeprom's first page you see groups of 4 bytes: <MSB reg addr>, <LSB reg addr>, <MSB data>, <LSB data>.

Page 2,3 and 4

The camera has the capability to trim the picture position slightly. The required data for this function is stored in the pages 2,3 and 4 (till reg address 0x7f).

The last part of page 4 (0x80-0xef) can be used for some special customised sensor settings. They should be stored in the following format: <MSB reg addr>, <LSB reg addr>, <MSB data>, <LSB data>.

In case register 0x00 of the second eeprom page (0xa2/a3) is loaded with 0xff the trim function is NOT active.

Register 0x50 (page 4) is used to load a different I2C slave address. In case this is loaded with 0xff, the default I2C address (0x70) will be used.

5.4. Software control function

This is a description to set or change some of the settings inside the camera module.

The settings which can be changed are:

- Mirror, this is a horizontal flip of the image
- Flip, this is a vertical flip of the image
- Auto exposure saturation point
- Shutter speed
- AWB auto and freeze mode
- Enable/disable overlay
- Trim image

To set these functions and store them in the camera we strongly recommend to use the software tool "21B14 camera control". This is available via RHP International. The advantage is that settings can be stored easier inside the camera when you use this tool, without the risk of damaging the camera.

However in case you need to switch dynamically in your application certain modes, you have to address the camera via I²C.

The communication protocol has a device address, two register addresses and two data bytes. See figure 1.

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In the tables below you find per command the required actions to change the camera mode:

Mirror mode:
<ol style="list-style-type: none"> 1) Read register 0x3254 2) Read register 0x301c (mirror status = bit[0] (0=normal, 1=mirror) 3) If mode needs to be changed <ol style="list-style-type: none"> a) Set register 0x301c bit[0] accordingly. All other bits should NOT be changed. b) Set register 0x3254 bit[0]. In case of mirror b[0]=1, in normal mode b[0]=0. All other bits should NOT be changed.
<ol style="list-style-type: none"> 1): 0x70,0x03,0x32,0x54- 0x71, datMSB, datLSB. 2): 0x70,0x03,0x30,0x1c- 0x71, datMSB, datLSB. 3) set bit[0] of reg 0x301c and send it→): 0x70,0x02,0x30,0x1c- 0x70, datMSB, datLSB. set bit[0] of reg 0x3254 and send it→): 0x70,0x02,0x32,0x54- 0x70, datMSB, datLSB.

Flip mode:
<ol style="list-style-type: none"> 1) Read register 0x3254. 2) Read register 0x301c (flip status = bit[1] (0=normal, 1=flip) 3) If mode needs to be changed: <ol style="list-style-type: none"> a) Set register 0x301c bit[1] accordingly. All other bits should not be changed. b) Set register 0x3254. In case of flip b[1] = 1, in normal mode b[1] = 0;
<ol style="list-style-type: none"> 1): 0x70,0x03,0x32,0x54- 0x71, datMSB, datLSB. 2): 0x70,0x03,0x30,0x1c- 0x71, datMSB, datLSB. 3) set bit[1] of reg 0x301c and send it→): 0x70,0x02,0x30,0x1c- 0x70, datMSB, datLSB. set bit[1] of reg 0x3254 and send it→): 0x70,0x02,0x32,0x54- 0x70, datMSB, datLSB.

Auto exposure saturation point
<ol style="list-style-type: none"> 1) Read register 0xa804 to check if the camera is in AEX mode. Value 0x000f is AEX mode, 0x0000 is manual exposure mode. 2) If mode is not correct load register 0xa804 with 0x000f. 3) Read current saturation point from register 0xa812 4) Load register 0xa812 with the new saturation level data
<ol style="list-style-type: none"> 1): 0x70,0x03,0xa8,0x04- 0x71, datMSB, datLSB. 2) datMSB =0x00, datLSB = 0x0f send it→): 0x70,0x02,0xa8,0x04- 0x70, 0x00, 0x0f. 3) 0x70,0x03,0xa8,0x12- 0x71, datMSB, datLSB. 4) 0x70,0x02,0xa8,0x12-0x71,sat lev MSB. Sat lev LSB.

Shutter speed
<ol style="list-style-type: none"> 1) Read register 0xa804 to check if the camera is in manual mode. Value 0x000f is AEX mode, 0x0000 is manual exposure mode. 2) If mode is not manual load register 0xa804 with 0x0000. 3) Read current shutter value from register 0x3012. 4) Load register 0x3012 with the new shutter value
<ol style="list-style-type: none"> 1) 0x70,0x03,0xa8,0x04- 0x71, datMSB, datLSB. 2) 0x70,0x02,0xa8,0x04- 0x70, 0x00, 0x00 3) 0x70,0x03,0x30,0x12- 0x71, shutMSB, shutLSB. 4) 0x70,0x02,0x30,0x12- 0x71, new shutMSB, new shutLSB.

Auto white balance mode
<ol style="list-style-type: none"> 1) Read the current white balance mode status from register 0xac04 (if value is 0x00ff than it is Auto white balance mode).

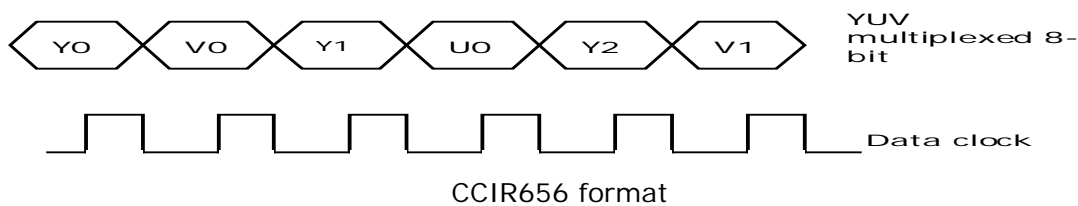
2) If mode is not correct load register 0xac04 with value 0x00ff.
1) 0x70,0x03,0xac,0x04- 0x71, wbmode MSB, wb modeLSB. 2) 0x70,0x02,0xac,0x04- 0x70, 0x00, 0xff.

Freeze mode:
To use this mode the camera must be first put in the freeze mode. The camera first needs to run in AWB mode. It will look for the most optimal white balance setting. When this is reached the AWB must be hold, and preferable the R/B gains must be stored and used when the camera is powered up again.
Put the camera in the freeze mode:
1) Make sure camera is in AWB mode by reading register 0xac04. Value 0x00ff means AWB mode. If the camera is not in the correct mode see table Auto White balance Mode. 2) If the AWB reached its most optimal position stop the AWB function by loading register 0xac04 with value 0x0000. 3) Wait 10 mSec. 4) Read the following registers: 0xac02, 0xac04, 0xac0a, 0xac0c, 0xac0e, 0xac10, 0xac12, 0xac14, 0xac16, 0xac18, 0xac10, 0xac1a, 0xac1c, 0xac1e, 0xac32, 0xac36, 0xac38, 0xac3a, 0xac3c, 0xac3e, 0xac40, 0xac42, 0xac44, 0xac46, 0xac48, 0xac4a, 0xac4c and 0xac4e. Wait 5 mS between each read command. 5) These values must be stored so that the can be loaded when the camera is powered up.
1) 0x70,0x03,0xac,0x04- 0x71, wbmode MSB, wb modeLSB.-->0x70,0x02,0xac,0x04- 0x70, 0x00, 0xff. 2) 0x70,0x02,0xac,0x04- 0x70, 0x00,0x00 3) Wait at least 10 mS 4) Read all register and wait 5 ms between each read action 5) Store all the value in the eeprom (store them in the eeprom (addr MSB, addr LSB, datMSB and datLSB). Wait 10mS between a write action. (use Eeprom dmp mode, to write 16 bytes at a time)

Enable or disable overlay
In the camera 4 overlay images can be stored. Depending on the situation overlay's can be enabled or disabled. Note that these overlay images must be loaded by RHP International. Please contact RHP International for more information.
Global enabling of the overlay's: The camera can have up to 4 images loaded. By disabling the global overlay functions all active overlays will be stopped in one command. 1) Read current status global overlay by reading register 0x4f02. If the MSbit (b[15] is set the global overlay is active. This does not mean that the overlays are visible. Also the individual overlay must be active to make the visible. 2) Enable the global overlay by loading register 0x4f02 with value 0x8000, or disable global overlay by loading register 0x4f02 with 0x0000.
Enabling individual overlays: As mentioned above the camera can be loaded with maximum 4 overlay images. The can all be enabled or disabled individual. 1. Each overlay has its own overlay enable address. Overlay1 = 0x4f08, overlay2 = 0x4f0a, overlay3 = 0x4f0c and overlay4 = 0x4f0e. To read the status per overlay read the corresponding address. The MSbit (b[15]) indicates the status. 1 overlay is enabled, 0 overlay is disabled. 2. Set each overlay as required by setting in each register b[15] to the desired enable or disable mode. 3. The lowest two bits indicates which overlay should be loaded. We advise to use the following values for the lowest two bits per register: <ul style="list-style-type: none"> in reg 0x4f08→b[1,0] = 00 in reg 0x4f0a→b[1,0] = 01 in reg 0x4f0c→b[1,0] = 10 in reg 0x4f0e→b[1,0] = 3

6. The Digital Output Format

The 8-bit data format is shown in the figure below:



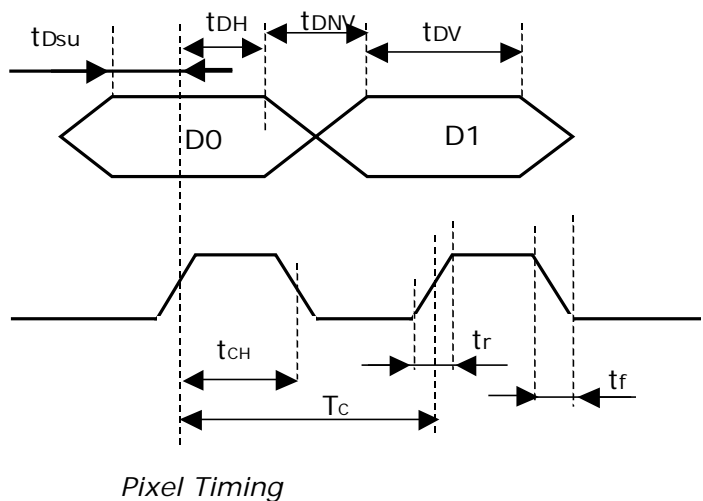
Note that the camera can offer two additional bits (lower). So the total data has is 10 bits wide. See also the connector pin out.

6.1. Timing

The camera data clock tolerance is 10ppm. A crystal with the same tolerance is used to generate the camera timing. The data clock frequency is:

TV-standard	Nominal frequency	Tolerance +/-
na	27000000 Hz	270 Hz

The timing is shown in figure below:



Item	description	RHPC-2500	
		min(ns)	max(ns)
T_c	Clock period	37.036	37,037
t_{CH}	Clock high time	10	19
t_r	Rise time		3
t_f	Fall time		3
t_{DSu}	Data setup	9	
t_{DH}	Data Hold	10	
t_{DNV}	Data not valid		6
t_{DV}	Data valid	8	

Pixel sequence during the horizontal blanking (8-bit format)

The synchronization code is a combination of 4 bytes. The first three bytes are always the same. The sequence is [0xFF], [0x00] and [0x00]. The values 0xFF and 0x00 will not occur in the normal video. The fourth byte gives the synchronization position. It makes use of 3 different signals: FIELD, VD and HD. The last 4 bits contain a protection code to check if an error occurred during the transfer of this position code's byte.

Function	Bit 7:	Bit 6: FIELD	Bit 5: VD	Bit 4: HD	Bit 3: P3	Bit 2: P2	Bit 1: P1	Bit 0: P0
0	1	0	0	0	0	0	0	0
1	1	0	0	1	1	1	0	1
2	1	0	1	0	1	0	1	1
3	1	0	1	1	0	1	1	0
4	1	1	0	0	0	1	1	1
5	1	1	0	1	1	0	1	0
6	1	1	1	0	1	1	0	0
7	1	1	1	1	0	0	0	1

7. Connectors

The camera has a board to board connector (J100) to make interconnections as easy as possible to the digital bus and an analog output connector J102.

7.1. Board-to-board connector J100

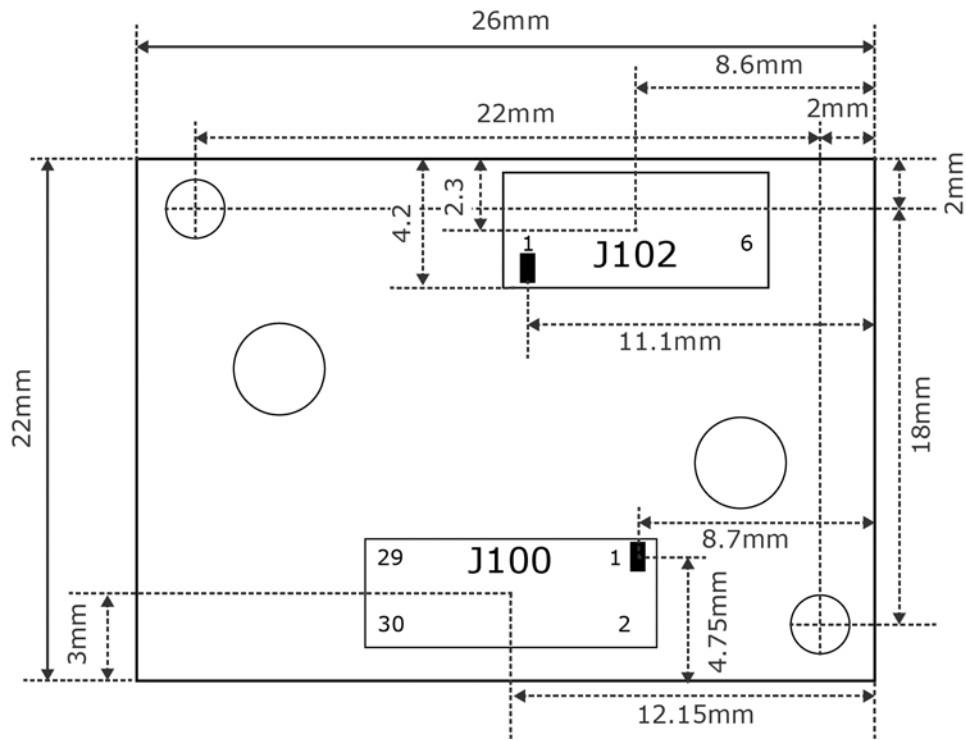
This connector is by Molex with type number: MOLEX-501920-3001.

The mating part is MOLEX-52991-0308, and must be used on the application side.

The connector is 30-pole and the pin out can be found in the table below:

Pin #	Function	Pin #	Function
1	GROUND	16	Not Connected
2	GROUND	17	YUV7 CCIR656
3	YUV0 CCIR656	18	Not Connected
4	Not Connected	19	Data Clock
5	YUV1 CCIR656	20	Not Connected
6	Not Connected	21	Not Connected
7	YUV2 CCIR656	22	GROUND
8	Not Connected	23	Test signal do not use
9	YUV3 CCIR656	24	Test signal do not use
10	Not Connected	25	Not Connected
11	YUV4 CCIR656	26	Not Connected
12	Not Connected	27	I ² C data
13	YUV5 CCIR656	28	I ² C clock
14	Not Connected	29	Not Connected
15	YUV6 CCIR656	30	+5V power supply in

**note these pins can move to different position in later redesigns!*



Camera Backside

7.2. Analog output connector J102

The connector type is a 6pin vertical JST: BM06B-SRSS

Pin number	Function
6	I2C data
5	I2C clock
4	Ground
3	CVBS Out
2	Ground
1	Power in (5V)



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