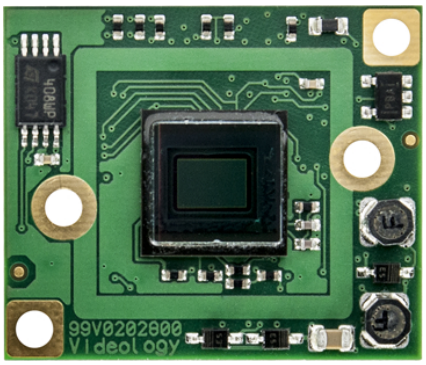
VIDEOLOGY

**IMAGING SOLUTIONS INC.**

*Original Equipment Manufacturer*

# Application Note
# 20B14X / 21B14X
# 20B14XDIG / 21B14XDIG

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***For technical assistance with this product, please contact the supplier from whom the product was purchased.***

**Videology® Imaging Solutions, Inc.**
37M Lark Industrial Parkway
Greenville, Rhode Island 02828 USA
Tel: (401) 949 – 5332 Fax: (401) 949 – 5276
North/South American Sales: sales@videologyinc.com
***www.videologyinc.com***

**Videology® Imaging Solutions, Europe B.V.**
Neutronenlaan 4
NL-5405NH Uden, The Netherlands
Tel: +31 (0) 413 256261 Fax: +31 (0) 413 251712
European Sales: info@videology.nl
***www.videology.nl***

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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 20/21B14xDIG is a CMOS based camera family with a digital (CCIR656 based) and analog output. It is mechanically comparable with Videology's 20/21K14X 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 21K14 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:

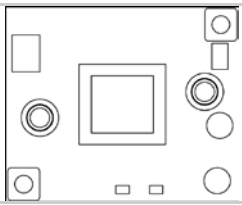
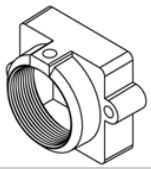
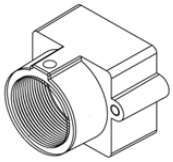
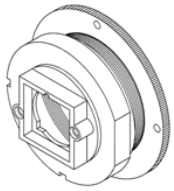
- USB 2.0 Board: Videology product that has same dimensions (22x26mm). When two boards are stacked together a complete USB 2.0 camera is available.
- Ethernet interface (not yet available)

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

## 3. Specification

| | 20B14X (NTSC)<br>20B14XDIG (NTSC) | 20B14X (PAL)<br>20B14XDIG (PAL) |
|---|---|---|
| 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,<br>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 | $I^2C$ control | |
| Power supply | 5VDC +/- 5% (not polarity protected) | |
| Power consumption | < 0.8W | |

**Lens options (X-value)**

| | | | |
|---|---|---|---|
|  |  |  |  |
| 20/21B14**7**<br>20/21B14**7**DIG<br>No lens mount | 20/21B14**2**<br>20/21B14**2**DIG<br>Pinhole lens mount | 20/21B14**5**<br>20/21B14**5**DIG<br>M-12 lens mount | 20/21B14**8**<br>20/21B14**8**DIG<br>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

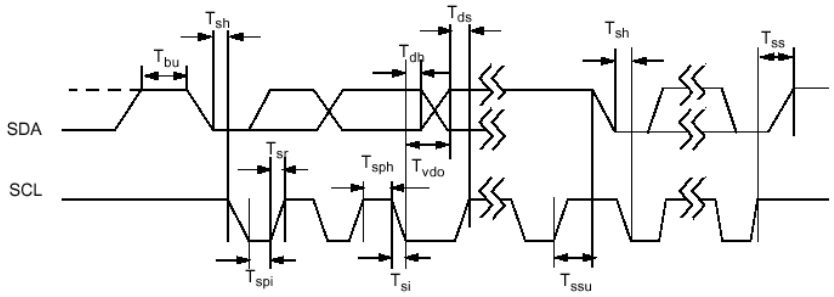
The camera has a serial control interface via three wires:

- Data wire
- Clock wire
- Ground wire

This interface operates similar as to the $I^2C$-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 is 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).




Communication Timing

| $I^2C$ 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 |

$I^2C$ 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 0ne 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 Videology. 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.

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

| Mirror mode: |
|---|
| 1) Read register 0x3254<br>2) Read register 0x301c (mirror status = bit[0] (0=normal, 1=mirror)<br>3) If mode needs to be changed<br>a) Set register 0x301c bit[0] accordingly. All other bits should NOT be changed.<br>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. |
| 1): 0x70,0x03,0x32,0x54- 0x71, datMSB, datLSB.<br>2): 0x70,0x03,0x30,0x1c- 0x71, datMSB, datLSB.<br>3) set bit[0] of reg 0x301c and send it→): 0x70,0x02,0x30,0x1c- 0x70, datMSB, datLSB.<br>set bit[0] of reg 0x3254 and send it→): 0x70,0x02,0x32,0x54- 0x70, datMSB, datLSB. |

| Flip mode: |
|---|
| 1) Read register 0x3254.<br>2) Read register 0x301c (flip status = bit[1] (0=normal, 1=flip)<br>3) If mode needs to be changed:<br>a) Set register 0x301c bit[1] accordingly. All other bits should not be changed.<br>b) Set register 0x3254. In case of flip b[1] = 1, in normal mode b[1] = 0; |
| 1): 0x70,0x03,0x32,0x54- 0x71, datMSB, datLSB.<br>2): 0x70,0x03,0x30,0x1c- 0x71, datMSB, datLSB.<br>3) set bit[1] of reg 0x301c and send it→): 0x70,0x02,0x30,0x1c- 0x70, datMSB, datLSB.<br>set bit[1] of reg 0x3254 and send it→): 0x70,0x02,0x32,0x54- 0x70, datMSB, datLSB. |

| Auto exposure saturation point |
|---|
| 1) Read register 0xa804 to check if the camera is in AEX mode. Value 0x000f is AEX mode, 0x0000 is manual exposure mode.<br>2) If mode is not correct load register 0xa804 with 0x000f.<br>3) Read current saturation point from register 0xa812<br>4) Load register 0xa812 with the new saturation level data |
| 1): 0x70,0x03,0xa8,0x04- 0x71, datMSB, datLSB.<br>2) datMSB =0x00, datLSB = 0x0f send it→): 0x70,0x02,0xa8,0x04- 0x70, 0x00, 0x0f.<br>3) 0x70,0x03,0xa8,0x12- 0x71, datMSB, datLSB.<br>4) 0x70,0x02,0xa8,0x12-0x71,sat lev MSB. Sat lev LSB. |

| Shutter speed |
|---|
| 1) Read register 0xa804 to check if the camera is in manual mode. Value 0x000f is AEX mode, 0x0000 is manual exposure mode.<br>2) If mode is not manual load register 0xa804 with 0x0000.<br>3) Read current shutter value from register 0x3012.<br>4) Load register 0x3012 with the new shutter value |
| 1) 0x70,0x03,0xa8,0x04- 0x71, datMSB, datLSB.<br>2) 0x70,0x02,0xa8,0x04- 0x70, 0x00, 0x00<br>3) 0x70,0x03,0x30,0x12- 0x71, shutMSB, shutLSB.<br>4) 0x70,0x02,0x30,0x12- 0x71, new shutMSB, new shutLSB. |

| Auto white balance mode |
|---|
| 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 atime)

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 Videology. Please contact Videology 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.

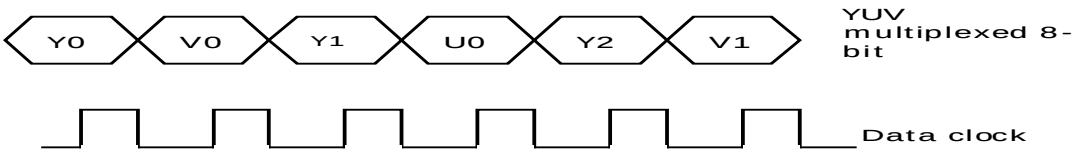
1) Read current status global overlay by reading register 0x4f02. If the MSbit (b[15] is set the global overlay is active. This does not mean that the overlays are visible. Also the individual overlay must be active to make the visible.
2) Enable the global overlay by loading register 0x4f02 with value 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:
    - 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:




CCIR656 format

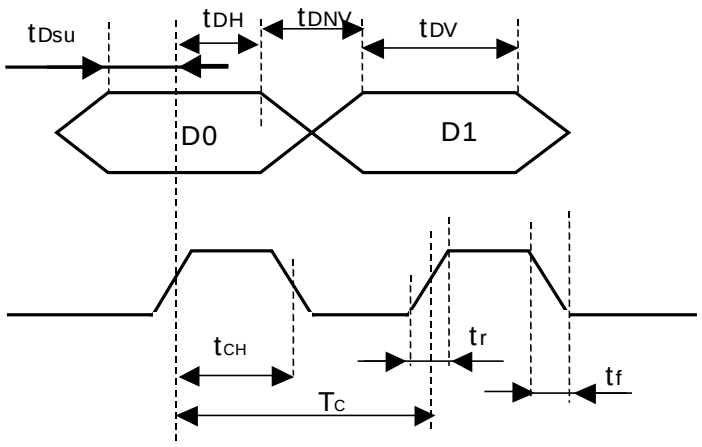
Note that the camera can offer two additional bits (lower). So the total data has is 10 bits wide. See also the connector pin out.

### 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:




*Pixel Timing*

| Item | description | 20/21B14XDIG | |
|---|---|---|---|
| | | 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.

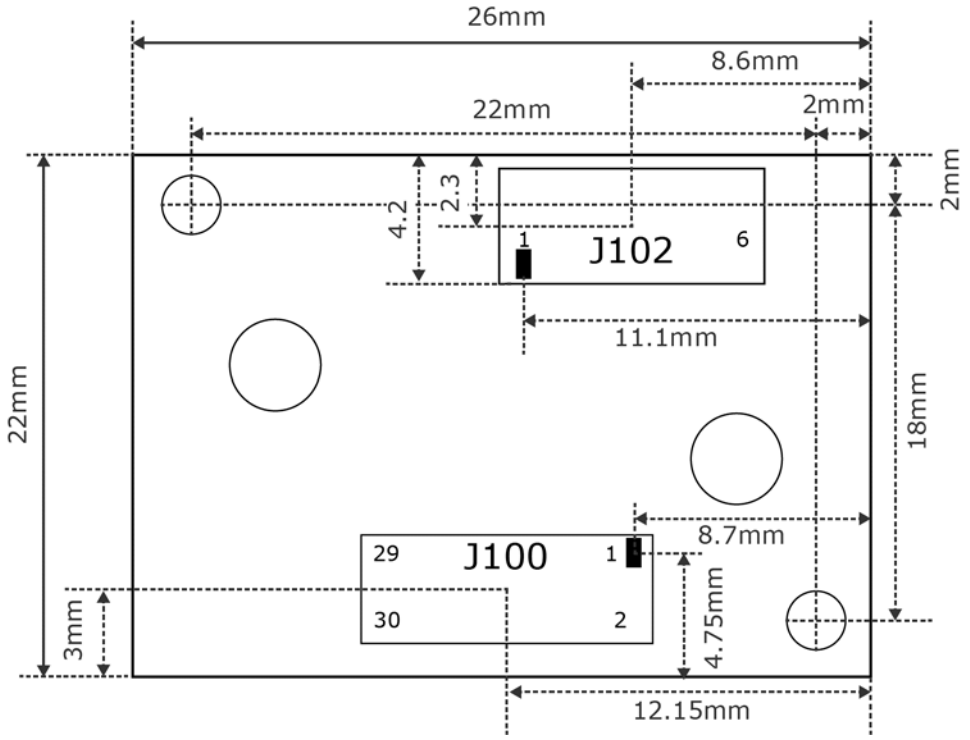
## 7.1. Board-to-board connector J100

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 | $I^2C$ data |
| 13 | YUV5 CCIR656 | 28 | $I^2C$ 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) |

## 8. Contact Information

**For technical assistance with this product, please contact the supplier from whom the product was purchased.**

For OEM inquiries, contact Videology® Imaging Solutions:

**Americas, Middle East, Far East & Australia:**
Videology® Imaging Solutions Inc.
37M Lark Industrial Parkway
Greenville, RI 02828
USA

Tel: (401) 949-5332
Fax: (401) 949-5276

**Europe & N. Eurasia:**
Videology® Imaging Solutions Europe B.V.
Neutronenlaan 4
5405 NH Uden
The Netherlands

Tel: +31 (0) 413-256261
Fax: +31 (0) 413-251712

Please visit our website: videologyinc.com

**VIDEOLOGY IMAGING SOLUTIONS** is an ISO 9001 registered video camera developer and manufacturer serving industrial, machine vision, biometric, security, and specialty OEM markets. Videology designs, develops, manufactures, and distributes video, image acquisition, and display technologies and products to OEMs worldwide.