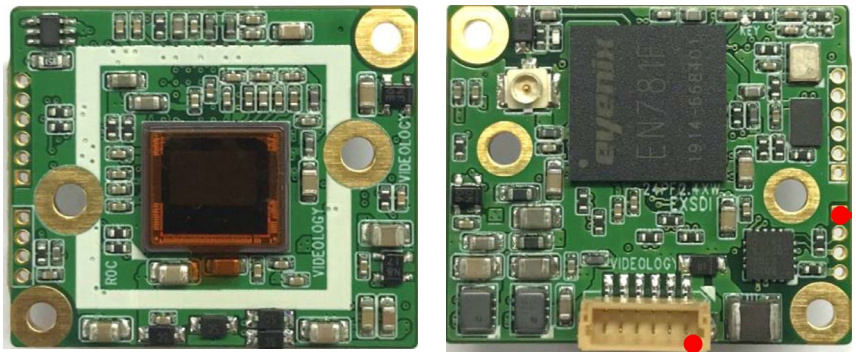
VIDEOLOGY®
IMAGING SOLUTIONS INC.
Original Equipment Manufacturer

Instruction manual
24PF2.4XW-I Series
Board Camera I²C version
Preliminary



24PF2.4XW shown

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Document History

Revision	Issue date	Reason	CN Issued
Rev A	11/02/2020	Initial release	20-0065
Rev B	02/02/2021	Added option to change I2C address	21-0010
Rev C	15/04/2021	New option: flex zoom & cursor commands	

1. Introduction

For this camera we have three different firmware variations. An instruction manual is available for each variant.

1.1 Firmware Versions

I²C version
If a PC or laptop is used an I²C controller must be connected to it. A separate instruction manual is available describing how to use this interface.

Visca version
In this mode a standard serial communication link is used. If A PC or laptop is used an USB to Serial converter must be used that is compatible to 3.3 V logic. Do not connect the camera directly to a RS-232 port!

Keyboard / Joystick version

If it is required to change some camera settings without connecting a PC using the on screen menu it is possible to connect a keyboard to the camera.

1.2 I²C version

This document describes the I²C firmware version.

2. Mechanical

2.1 Connectors

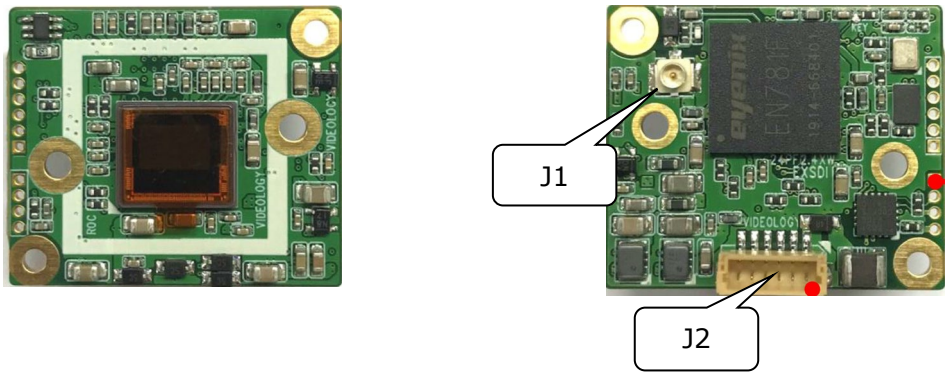


Figure 1. Camera board (Connectors)

Pin #	Pin name
1	SDI out
2	GND

Table 1. Connector J1 – HIROSE-U.FL-R-SMT-1(10)

Pin #	Function
1	5VDC
2	GND
3	CVBS
4	GND
5	Input for keyboard/joystick
6	Serial output port to PC

Table 2. Connector J2 - JST-BM06B-SRSS

3. I²C Communication Specification

The camera uses a 2 wire serial (I^2C) communication interface for control and configuration. This serial bus consists of a line for the clock signal (I2C-SCL), a line for the data signal (I2C-SDA), and a line for ground. The camera will act as a slave device on this bus. The protocol supports clock speeds from 1 kHz – 100 kHz.

The camera address is **0x70/0x71**.

The user can control the camera basic functions with the following settings. These settings are volatile until the registers are stored using the save command.

The command block is always 4 bytes long. It contains the camera address (write only = 0x70), a mode byte, device address and register address.

The Data block is either read or write, depending upon the camera address used. An address of 0x70 denotes a write command, an address of 0x71 denotes a read command. Similarly, the mode byte of the command block also indicates a read or write. This is indicated with the least significant bit: a 0 indicates a write action and a 1 a read action.

3.1 Timing

NOTE: THERE IS A MINIMUM DELAY TIME (DELAY1) REQUIRED BETWEEN THE COMMAND AND DATA BLOCK. THIS DELAY DEPENDS ON THE DIRECTION OF COMMUNICATION (WRITE OR READ).
ADDITIONALLY, THERE IS A MINIMUM DELAY TIME (DELAY2) BETWEEN A DATA BLOCK AND THE NEXT COMMAND BLOCK.

Command block	Delay1	Data block	Delay2	Command block	Delay1	Data block

Table 1 below gives the minimum values for delay1 and delay2 for the various read and write operations.

Type of communication	Minimum Delay (ms)	
	Delay 1	Delay 2
Read from command register followed by any read or write	5	1
Write to command register followed by any read or write	1	80
Read from NVM followed by any read or write	5	1
Write to NVM followed by any read or write	1	10

Table 1. Minimum value of delay1 between command and data bytes

3.2 The command block

Each command block consists of 4 bytes, as shown below:

Command block									
	Byte 1		Byte 2		Byte 3		Byte 4		
Start	Cam addr W	A	Mode byte r/w	A	Dev add	A	Reg addr	A	Stop

A= acknowledge

- The 1st byte is the camera address. The only valid value is the camera write address, default 0x70

- The 2nd byte is the mode byte. The mode byte tells the camera whether the host wants to read or write to the camera. If the host wants to read the LS-bit is 1; for a write the LS-bit is 0.
- The 3rd byte is the device address inside the camera.
- The 4TH byte is the register address. This byte can have any value between 0x00 and 0xff.

Valid values for the mode byte and device address can be found in table 2 below:

Mode value (2nd byte)	Device address	description
0x00/0x01	0x30	Command register access
	0xA0	NVM page

Table 2. Valid values for the mode byte and device address

3.3 **The Data block**

This block is generally 2 bytes. The difference here is that the camera can either send or receive data via this block.

The format for each type of operation is shown below.

Data block: data sent from Host to camera					
	Byte 1		Byte 2		
start	Cam addr W	A	data	A	stop

A= acknowledge

Data block: data sent from Camera to Host					
	Byte 1		Byte 2		
start	Cam addr R	A	data	NA	stop

NA= Not acknowledge

The first byte is either the camera write or read address. The default camera write address is 0x70, and the default read address is 0x71. The second byte is the data byte

4. Registers

Description of sequence for register access

Write:
<start> <0x70> <0x00> <0x30> <register address> <stop> <Start> <0x70> <value> <stop>
Read:
<start> <0x70> <0x01> <0x30> <register address> <stop> <Start> <0x71> <value> <stop>

4.1 Shutter speed

Shutter speed can be set to manual, auto, auto-deblur or flickerless. In Flickerless mode the shutter speed will be automatically fixed to 1/100s or 1/120s for 25 fps or 30 fps; for 50 fps or 60 fps the shutter speed will be automatically fixed to 1/200s or 1/240s.

Register 0x00

Shutter Speed (0x00)		
Manual		
0x00	1/25(30)	
0x01	1/50(60)	
0x02	1/100(120)	
0x03	1/200(240)	
0x04	1/400(500)	
0x05	1/800(1000)	
0x06	1/1600(2000)	
0x07	1/3200(4000)	
0x08	1/6400(8000)	
0x09	1/12800(15000)	
0x0A	1/25600(30000)	
Auto		
0x0F	AUTO-Normal	default
0x1F	AUTO-Deblur	
Flickerless		
0x10	Flickerless	

4.2 Sense-up mode

The sense-up mode is the extended integration time. For Auto exposure mode in a night situation when the exposure time and the gain are already at a maximum, the brightness still can be too low. With the Sens-up function, which integrates multiples frames, the scene gets brighter at the expense of slower scene updates.

Register 0x01

Sense-up (0x01)			
0x00		OFF	default
0x01	2x	2 times	
0x02	4x	4 times	
0x03	8x	8 times	
0x04	16x	16 times	
0x05	32x	32 times	

4.3 **Color Gain**

Color gain (color saturation) refers to how pure or intense the color in an image is. When color is fully saturated (100%), the color is considered in purest (truest) version. An 0% saturation appears as gray. You can increase the saturation beyond the 100% in under-exposure situations. The color gain can be set in the range: 0(0%) to 20 (~200%); default = 10 (=100%)

Register 0x03

Color Gain (0x03)		
0 ~ 20	Color Gain	Default = 10

4.4 **Image Orientation**

The video output image can be horizontally reversed (mirror) and/or vertically reversed (=flip).

Register 0x05

Image Orientation (0x05)			
Bit 0 Bit 1	Mirror Flip	0 = OFF, 1 = ON	Default = 0x00

4.5 **Sharpness Level**

The camera is equipped with an edge enhancement feature which can be used to create sharper edges, giving the appearance of higher resolution.

Register 0x06

Sharpness Level (0x06)		
0 ~ 10	Sharpness Level	Default = 5

4.6 **Gamma correction**

The camera has a built in gamma correction. The gamma correction factor can be set in the range between 0.45 and 0.75 in steps of 0.05. The values refer to the gamma correction as implemented in the camera; this is the reciprocal value of that is applied in the monitor. Thus when the gamma correction register value is set to 0,45 it means that the monitor should matches a gamma correction value of 1/0,45 = 2,22.

Register 0x0C

Gamma (0x0C)		
5	0.45	default
6	0.50	
7	0.55	
8	0.60	
9	0.65	
10	0.70	
11	0.75	

4.7 **White Balance**

Several White Balance Modes are available:

1. ATW: Normal mode. The white balance is continuously working along with the color temperature changes in the range of 2,000K~8,500K.
2. ATWext: Auto Tracing White Balance Mode. The White balance is continuously working along with the color temperature changes in the range of 1,800K~11,000K.
3. MANUAL: White balance is fixed to the settings by Manual RED-gain and BLUE-GAIN. This mode can be used only when the color temperature does not vary.
4. ONE PUSH AWB trigger: Wait for the user to use the on screen menu to select this option.
5. ONE PUSH AWB mode: The actual white balance settings are applied in the current lighting condition. This is done immediately.

Register 0x08

White Balance (0x08)	
0	Auto
1	Auto Ext.
2	Manual
3	One Push Preset
4	One Push Command

4.7.1 **Manual Blue Gain**

Register 0x09

Blue Gain (0x09)		
0 ~ 20	Blue Gain	Default = 10

4.7.2 **Manual Red Gain**

Register 0x0A

Red Gain (0x0A)		
0 ~ 20	Red Gain	Default = 10

4.8 **AGC (gain control)**

Manual gain or Maximum gain for Auto mode. For Manual exposure mode, this command is used to force a manual gain value. For the Auto exposure mode it provides the maximum gain that will be applied.

Register 0x0B

AGC (0x0B)		
0 ~ 10	Gain	Default = 7

4.9 **Defog**

In abnormal climate conditions such as fog or rain the image has a low dynamic range and low contrast ratio compared to ordinary images. The defog feature enhances the image and effectively restores details for colors, contrast and sharpness to obtain accurate and natural video.

Register 0x0D

Defog (0x0D)		
0	OFF	Default
1	On-Auto	
2	On-Manual	

4.10 **Defog Level**

Register 0x0E

Defog Level (0x0E)		
0	Low	
1	Mid	Default
2	High	

4.11 **BLC,HLC & WDR Mode**

Register 0x10

BLC,HLC & WDR mode (0x10)		
0	OFF	Default
1	BLC	
2	HLC	
3	WDR	

4.11.1 **BLC Mode**

The BLC only functions for the Auto Exposure mode. Then the auto exposure control compares the measured image brightness with the target point and the exposure time and the gain are adjusted accordingly to meet the target requirement.

In the BLC mode the image brightness of the BLC window is assigned more priority compared with the area outside the window.

BLC is used to improve the visibility for a dark object in front of a bright back light (for example a person standing in front of a brightly lit window).

4.11.2 **HLC Mode**

For High Light compensation the highlight areas that exceed a certain HLC level are cut out and replaced with colored masks. The color can be set with HLC color.
For compensation these cut-out areas are excluded from the brightness measurement.

4.11.3 **WDR mode**

The camera can be set in Normal mode or in WDR mode. In WDR (wide dynamic range) mode the visibility for both high bright areas and dark areas in the image are improved significantly by double captures of the image with long and short exposure times.

As a side issue the frame rate becomes only half due to the double captures.
The WDR level can be selected from LOW, MID and HIGH. Care should be taken to select WDR mode HIGH because video may lose its quality in some environments by the over-compensation.

4.12 **BLC-show**

Register 0x11

BLC-show (0x11)		
0	OFF	Default
1	ON	

4.13 **HLC Level**

Register 0x12

HLC level (0x12)		
0 ~ 20	HLC level	Default = 10

4.14 **BLC Position**

Register 0x13

BLC Position (0x13)			
Bits [3..0]	0 ~ 13	Horizontal position	Default = 8
Bits [7..4]	0 ~ 13	Vertical position	Default = 7

4.15 **BLC Size**

Register 0x14

BLC Size (0x13)			
Bits [3..0]	0 ~ 13	Horizontal size	Default = 3
Bits [7..4]	0 ~ 13	Vertical size	Default = 3

4.16 **WDR Level**

Register 0x15

WDR Level (0x15)		
0	Low	
1	Mid	Default
2	High	

4.17 **2D Noise Reduction Level**

2D noise reduction works on a single video frame and is more suitable for moving targets, when compared to the 3D mode.

Register 0x17

2DNR (0x17)		
0	OFF	Default
1	Low	
2	Mid	

3	High

4.18 **3D Noise Reduction Level**

3D Noise Reduction (3D-NR) is a very sophisticated and powerful time-based noise reduction technology. The noise is monitored for the several video frames and cancellation or reduction of the noise is performed by using multiple consecutive frames (over time).

Therefore it works mainly on static parts of the scene where the noise is also most visible. A higher setting reduces noise much more but results in losing the sharpness and adds a tail effect or motion blur for fast moving targets in the scene at low light.

Register 0x18

3DNR (0x18)		
0	OFF	Default
1	Low	
2	Mid	
3	High	

4.19 **Day-night Mode**

DAY & NIGHT is used to switch between color or black/white (B/W) depending on how bright the scene is. So in low light situations it switches to B/W; afterwards when the brightness of the scene increases it will switch back to color.

Register 0x20

Day/Night (0x20)		
0	B/W	
1	Color	Default
2	Auto	

4.19.1 **Day-night Delay**

The D/N-delay specifies the delay before the actual switch occurs after exceeding the DAY to NIGHT or NIGHT to DAY threshold levels.

Register 0x22

Day/Night Delay (0x22)		
0	Low	
1	Mid	Default
2	High	

4.19.2 **Day-night Threshold**

The Day/Night threshold sets the light level for switching from Day to Night and vice versa. A low threshold level causes the camera to enter NIGHT at a lower light level. A higher threshold level causes the camera to exit NIGHT at a higher light level.

Register 0x23

Day/Night threshold (0x23)

0 ~ 20	HLC level	Default = 13

4.20 **Brightness**

When the camera is set in the Auto exposure mode, the camera controls the shutter speed and gain automatically in such way that the (average) brightness of the image matches the auto exposure value.

Register 0x27

Brightness (0x27)		
0 ~ 20	HLC level	Default = 10

4.21 **Digital Zoom, Pan Tilt Control**

The camera support Digital Zoom. Pan and Tilt (horitontal and Vertical movement) can be controlled. Below the coördinates can be found for the PN/Tilt function.

11	21	31	41	51	61	71	81	91	A1	B1	C1	D1	E1	F1	111	121	131
12	22																132
13			XY														
14																	
15																	
16																	
17																	
18																	
19																	
1A									AA								
1B																	
1C																	
1D																	
1E																	
1F																	
111																	
112																	
113	213																1313

4.21.1 **Digital Zoom**

Register 0x2A

Digital zoom (0x2A)			
10 ~ 250	1.0x ~ 25.0x	Zoom	Default = 10

4.21.2 **Digital Zoom-Pan Position**

Register 0x2B

Pan (0x2B)		
1 ~ 13	position	Default = 7

4.21.3 **Digital Zoom-Tilt Position**

Register 0x2C

Tilt (0x2C)		
1 ~ 13	position	Default = 7

4.22 **DWDR Mode**

Register 0x2E

DWDR (0x2E)		
0	OFF	Default
1	Low	
2	Mid	
3	High	

4.23 **Resolution mode**

The camera supports a number of different resolution and framerate modes. The 720P image is scaled down from 1080P and outputs 1280x720 video without loss of field view. The video output with the selected resolution is available on the serial digital output either as HD-SDI or EX-SDI.

Register 0x50

Resolution (0x50)		
0	1080p	25 fps
1	1080p	30 fps
2	1080p	50 fps
3	1080p	60 fps
4	1080p	50 fps
5	1080p	60 fps
6	720p	25 fps
7	720p	30 fps
8	720p	50 fps
9	720p	60 fps

4.24 **CVBS Format**

Select the CVBS output in 4:3 or 16:9 format.

Register 0x51

CVBS format (0x51)		
0	4:3	Default
1	16:9	

4.25 **SDI or EX-SDI output**

Select either HD-SDI or EX-SDI

Register 0x52

SDI or EX-SDI output (0x52)		
0	HD-SDI	Default
1	EX-SDI	

4.26 **OSD Key control**

The camera is provided with an OSD Menu. The Left, Right Up, Down, Enter & Exit keys to navigate through the menu can be controlled.

Register 0x40

OSD Control (0x40)	
1	Left
2	Right
3	Up
4	Down
5	Enter/Set
6	Exit

4.27 **On Screen Display**

The actual zoom ratio, camera ID and camera title (name) can be independently displayed on the screen.

- The camera ID is the camera address between 1 and 7 to identify the camera in a multiple camera configuration as used for VISCA communication (it is defined in the OSD menu in the category SYSTEM>COMM.SETUP>CAM ID)
- The camera title is a textual name, which can be set in the OSD menu in the category SPECIAL>TITLE SET.
- The zoom ratio appears on the bottom right corner. The format is DZx.x and x.x is the actual digital zoom ratio.

Register 0x53

On Screen Display (0x53)		
Bit 0	Zoom ratio	0 = OFF, 1 = ON
Bit 1	Camera ID	0 = OFF, 1 = ON
Bit 2	Camera Title	0 = OFF, 1 = ON

4.28 **Memory Save & Factory Defaults**

The actual camera settings as set by various commands can be saved in NVM so that these will be recovered automatically at the next power-up.

Register 0x60

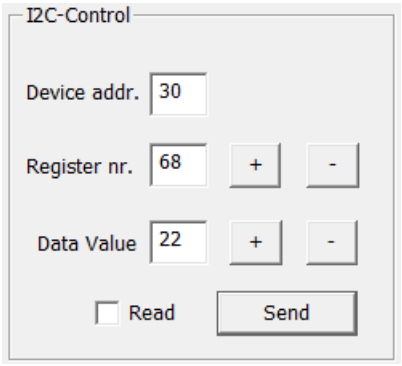
Store settings / Factory defaults (0x52)		
0	Store Register settings	Memory Save
1	Factory Reset	Factory defaults

4.29 **FLEX commands**

Register 0x68 can be used to send zoom commands to the camera directly, and change the cursor position (pan/tilt). After sending any of these commands a second command is necessary to stop the action, so these commands are only suitable when an operator is in control of the camera. It is possible to have a zoom and cursor command running at the same time. It is also possible to change from zoom-in directly to zoon-out without stopping the zooming first. The same applies to the cursor command.
The speed of the operations can be adjusted.
The C-type enumeration shown below describes all possible command codes. Unrecognized codes are ignored. If the zoomfactor is changed this way it can also be stored in the camera.

```
typedef enum {
    FLEX_ZOOM_TELE       = 0x01,   // zoom in
    FLEX_ZOOM_WIDE       = 0x02,   // zoom out
    FLEX_ZOOM_STOP       = 0x03,   // stop the ongoing action
    FLEX_ZOOM_CLEAR      = 0x04,   // restore full screen mode without zoom
    FLEX_CURSOR_LU       = 0x05,   // move to upper left corner
    FLEX_CURSOR_LD       = 0x06,   // move to down left corner
    FLEX_CURSOR_RU       = 0x07,   // move to upper right corner
    FLEX_CURSOR_RD       = 0x08,   // move to down right corner
    FLEX_CURSOR_U        = 0x09,   // move up
    FLEX_CURSOR_D        = 0x0A,   // move down
    FLEX_CURSOR_L        = 0x0B,   // move left
    FLEX_CURSOR_R        = 0x0C,   // move right
    FLEX_CURSOR_END      = 0x0D,   // stop the ongoing action
    FLEX_CURSOR_CLEAR    = 0x0E,   // go to center without changing zoom factor
    FLEX_ZOOM_SPEED1     = 0x21,   // slowest
    FLEX_ZOOM_SPEED2     = 0x22,
    FLEX_ZOOM_SPEED3     = 0x23,
    FLEX_ZOOM_SPEED4     = 0x24,
    FLEX_ZOOM_SPEED5     = 0x25,
    FLEX_ZOOM_SPEED6     = 0x26,
    FLEX_ZOOM_SPEED7     = 0x27,   // fastest
    FLEX_CURSOR_SPEED1   = 0x31,   // slowest
    FLEX_CURSOR_SPEED2   = 0x32,
    FLEX_CURSOR_SPEED3   = 0x33,
    FLEX_CURSOR_SPEED4   = 0x34,
    FLEX_CURSOR_SPEED5   = 0x35,
    FLEX_CURSOR_SPEED6   = 0x36,
    FLEX_CURSOR_SPEED7   = 0x37    // fastest
} FLEX_CMD_T;
```

The GUI can be used to send the commands to the camera. The register is write only.



Register 0x68 (only available in firmware 1.7 and above)

Flex Command (write Only) (0x68)	
0x01 ~ 0x37	Command code

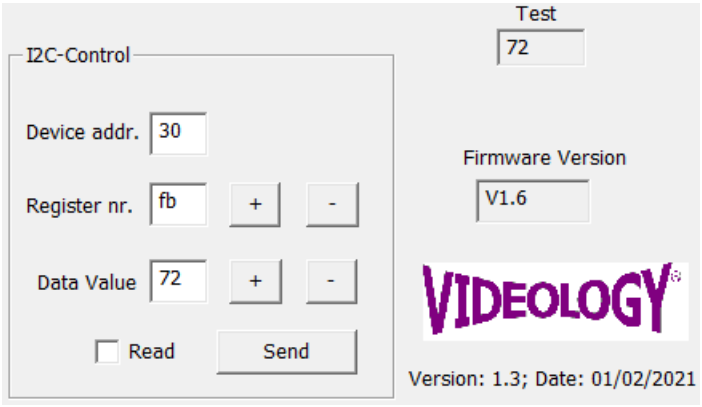
4.30 **I2C Base Address**

The default address is 0x70 / 0x71. By writing to this register this can be changed. This allows multiple camera's to be connected to the same I²C bus.
Valid numbers are in the range 0x02 … 0xFE. If an illegal value is used it will be replaced by the default value 0x70. Bit zero can be either 0 or 1, it is ignored by the firmware.

Register 0xFB (only available in firmware 1.6 and above)

I²C base Address (0xFB)		
0x02 ~ 0xFE	I2C slave address	Default = 0x70

In order to use this functionality the GUI tool must be updated to at least version 1.3
This version of the tool reads the base address to be used from a file called "settings.cfg"
The screen below shows how to change this register using this tool, in this example the address was changed to 0x72. After pressing the Send button it is important to also press the SAVE button to store the registers in non-volatile memory. When the camera is rebooted the new address will be used.



4.31 **Password**

Register 0xFC / 0xFD

16bit Password (0xFC/0xFD)		
[15..8]	MSB password	0xFC
[7..0]	LSB password	0xFD

4.32 **NVM Magic Number**

Magic number is required to write NVM registor storage directly, to indicat NVM storage has valid register settings.

Register 0xFE

Magic (read Only) (0xFE)		
0x5A	Magic Number	Default = 0x5A

4.33 **Version**

Register 0xFF

Version(read only) (0xFF)	
Bits [7..4]	Major 0 ~ 9
Bits [3..0]	Minor 0 ~ 9

4.34 **Error status Registers**

Registers 0x80 ~ 0x84

register	module	error description
0x80	main	0x00 = MAIN_NO_ERROR 0x01 = APPLY_SETTINGS_FAILED
0x81	camreg	0x00 = CAMREG_NO_ERROR 0x01 = INVALID_USER_AREA_ADDRESS 0x02 = READ_ACCESS_DENIED 0x03 = INVALID_REGISTER 0x04 = ERROR_REG_HAS_NO_NVM_STORAGE 0x05 = ERROR_NVM_PASSWORD_PROTECTED 0x06 = ERROR_VALUE_INVALID 0x07 = WRITE_ACCESS_DENIED 0x08 = REGISTER_PASSWORD_PROTECTED 0x09 = NVR_READ_DURING_INITIALISATION 0x0A = WRITE_DURING_INITIALISATION 0x0B = INVALID_VALUE 0x0C = NVR_MAGIC_FAILED 0x0D = NVR_SW_VERSION_FAILED

0x82	flash	0x00 = FLASH_NO_ERROR
		0x01 = INVALID_FLASHPAGE // invalid pages addressed
		0x02 = OUTSIDE_BLOCK_SIZE // start address outside block size
		0x03 = BLOCK_BOUNDARY_CROSS // some bytes cross the block boundary
		0x04 = NO_XRAM_SIZE_SPACE // no room for temporary xdata space

0x83	user_cmd	0x00 = VISCA_NO_ERROR 0x01 = TX_PACKET_SEND_TIMEOUT 0x02 = TX_WRITE_FAILED 0x03 = RX_HEADER_ERROR 0x04 = RECEIVE_TIMEOUT 0x05 = RX_1ST_REPLY_ERROR 0x06 = RX_TERMINATOR_ERROR 0x07 = RX_FINAL_TERMINATOR_ERROR 0x08 = ERRMSG_MESSAGE_LENGTH_ERROR 0x09 = ERRMSG_SYNTAX_ERROR 0x0A = ERRMSG_COMMAND_BUFFER_FULL 0x0B = ERRMSG_COMMAND_CANCELLED 0x0C = ERRMSG_NO_SOCKET 0x0D = ERRMSG_COMMAND_NOT_EXECUTABLE 0x0E = ERRMSG_UNDEFINED_ERROR 0x0F = INVALID_REGISTER_VALUE

0x84	camif	0x00 = CAMIF_NO_ERROR
		0x01 = SMB_ERROR_ARBLOST // I2C Lost arbitration
		0x02 = SMB_ERROR_ILLSTOP // I2C Slave Transmitter:
		illegal Stop or bus error detected
		0x03 = SMB_ERROR_UNDEF // I2C all other undefined interrupt cases
		0x04 = I2C_ILL_BLOCKSIZE // I2C command or data block size
		combination with R/W unknown
		0x05 = ERROR_COMMAND_BLOCK_EXPECTED
		0x06 = ERROR_DATA_BLOCK_WRITE_EXPECTED
		0x07 = ERROR_DATA_BLOCK_READ_EXPECTED

5. User registers & NVM

Description of sequence for register access

Write:
<start> <0x70> <0x00> <0xA0> <register address> <stop> <Start> <0x70> <value> <stop>

Read:
<start> <0x70> <0x01> <0xA0> <register address> <stop> <Start> <0x71> <value> <stop>

5.1 NVM register storage

Registers 0x00 ~ 0x7F

Direct access to the NVM register storage is password protected!

5.2 User Registers

Registers 0x80 ~ 0x9F

The camera has 32 bytes of free user register/memory storage available.

6. Contact

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

For OEM inquiries, contact Videology® Imaging Solutions:

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Please visit our website: videologyinc.com

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