VIDEOLOGY®
IMAGING SOLUTIONS INC.
Original Equipment Manufacturer

Application Note

24C1.2XU3 MIPI 720P UVC camera

Preliminary

Information may change without notice.

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

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Table of Contents

1. Document History

Revision	Issue date	Reason	CN#
Rev 1.0	3-August-2018	Initial release	
Rev A	3-August-2018	Initial release USA	18-0047

2. Introduction

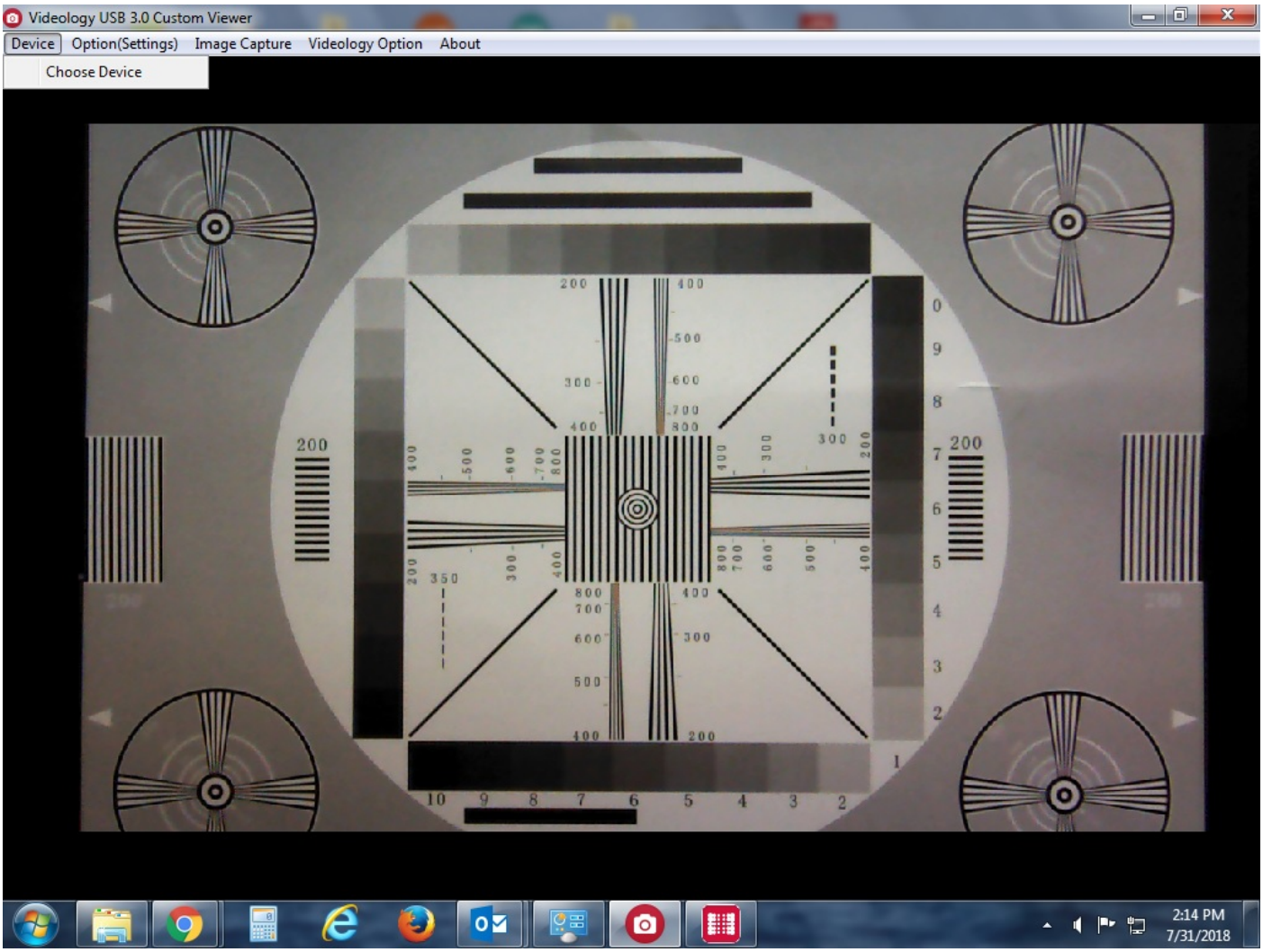
The 24C1.2XU3 is a UVC compliant 1.26 Mpixel Color USB3.0 camera designed around a 1/6" format CMOS sensor with a MIPI CSI-2 output and a Cypress CX3 MIPI input/ USB3 output bridge.

The camera will output 30 fps at the maximum resolution of 1.26MP (1296 x 976) (FUTURE). It is currently operating at 30fps in 720p resolution (1280 x 720) and at 55fps in VGA (640 x 480). Higher frame rates are available at lower resolutions (future).

The camera is available with an M12 lens mounts.

3. Basic Operation

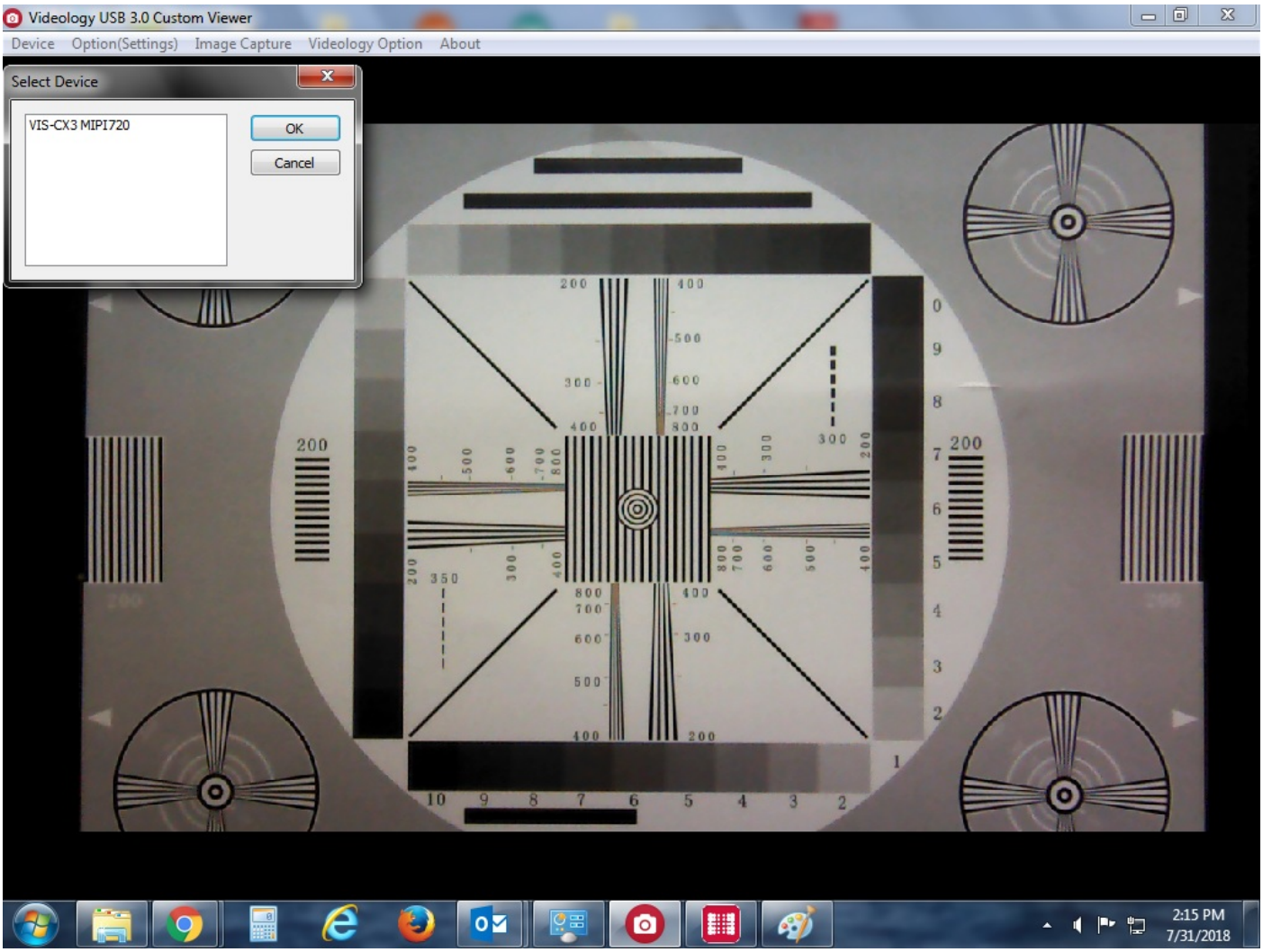
- Copy the provided viewer software to your hard drive. Alternately, this camera will work with a windows compatible UVC viewer such as AMCap.
- Plug the camera into a USB3.0 port.
- Launch the Videology UVC viewer (VideologyUSB3.0ViewerN.exe)



4. Menu operation

4.1 Device

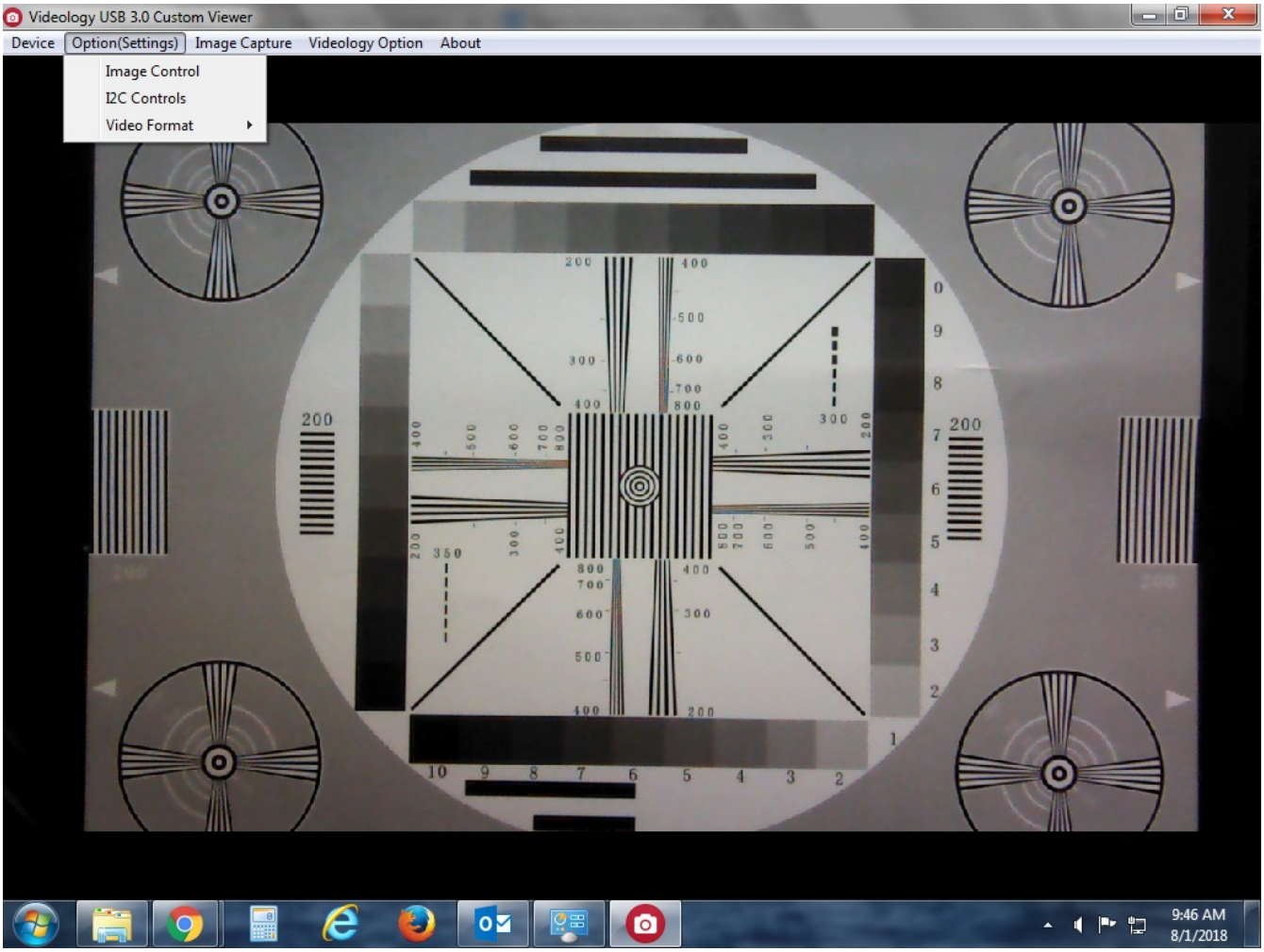
- Select Device if no image is present, please select “Device” and choose the Videology Camera. It will show up as seen below.



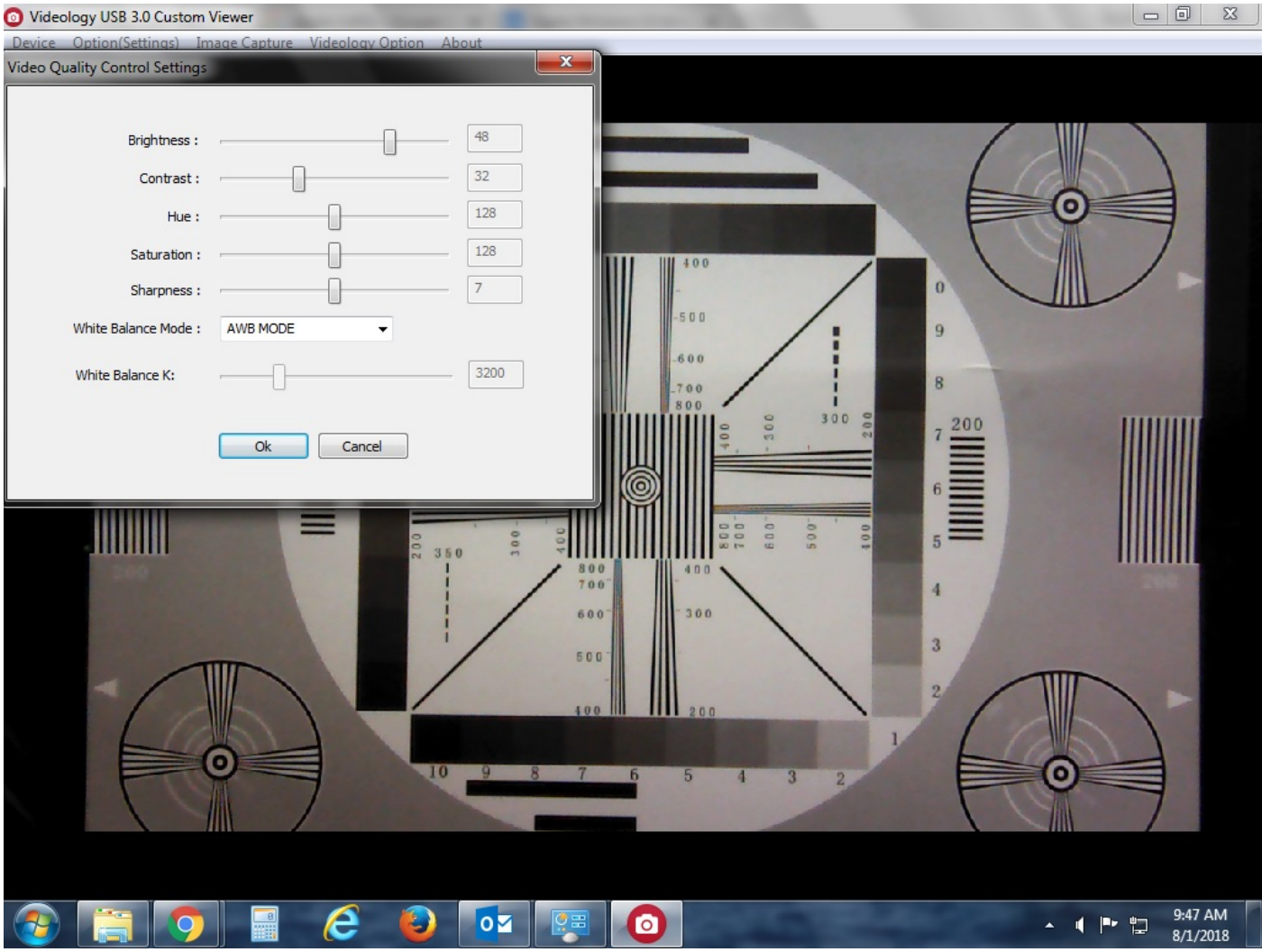
4.2 Option (Settings)

4.2.1 Options (Settings) -> Image Control

Select Options (Settings) -> Image Control to control the standard UVC functions that the camera supports.

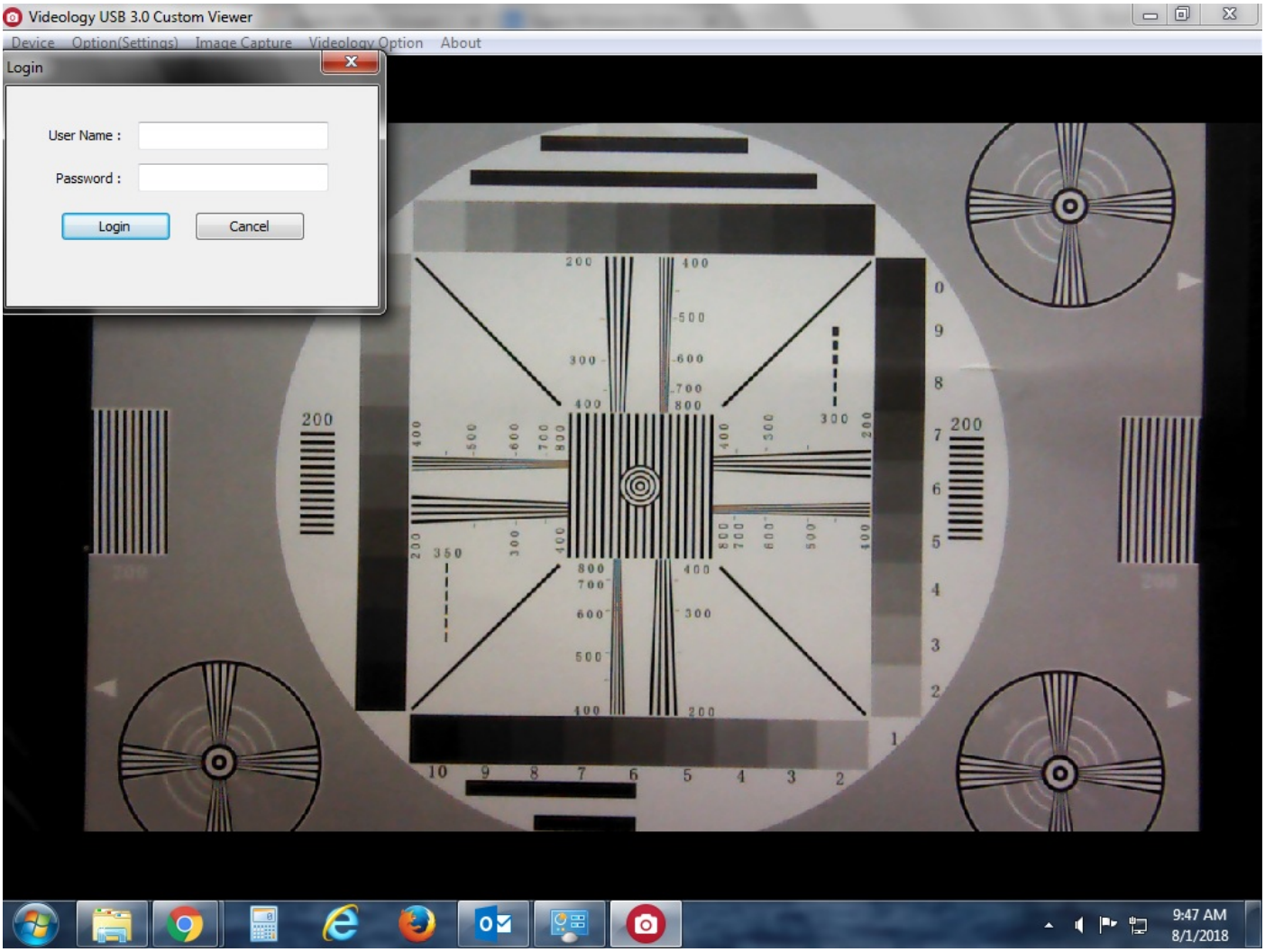


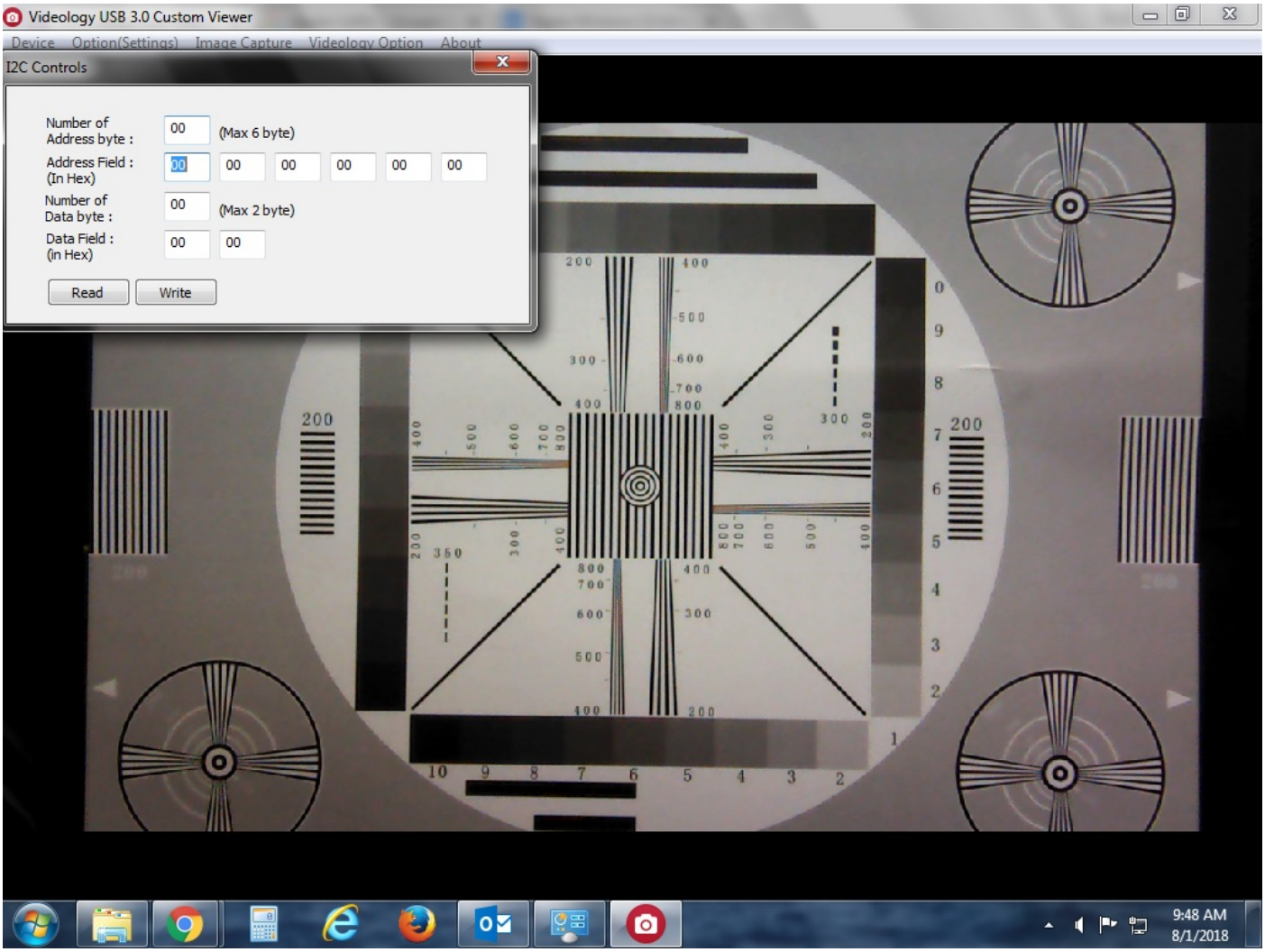
- From this menu you can control Brightness, Contrast, Hue, Color Saturation, Sharpness (Edge Enhancement), and White balance.



4.2.2 Options (Settings) -> I2C Controls

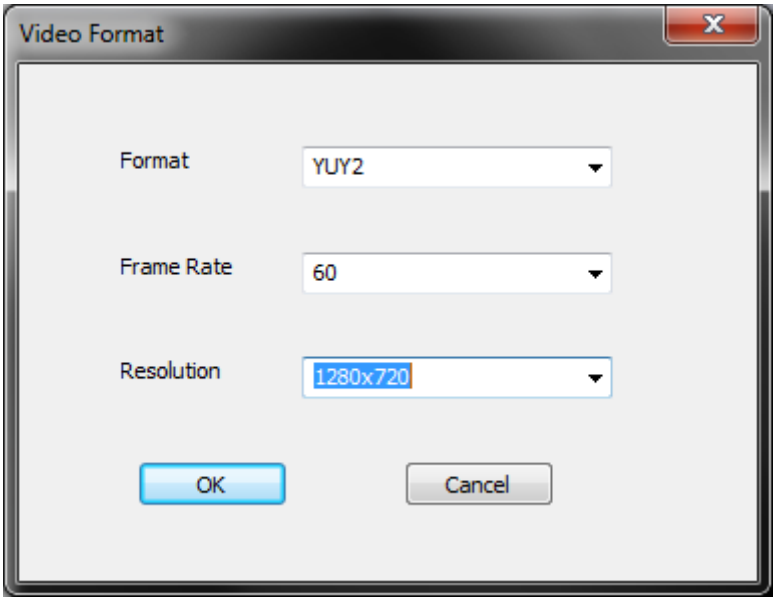
Select Options (Settings) -> I2C Controls to send commands directly to the various camera components. The Username is admin. The Password is admin. This is described in more detail in section 6.




Videology USB 3.0 Custom Viewer
Device
Option(Settings)
Image Capture
Videology Option
About
I2C Controls
Number of Address byte :
00
(Max 6 byte)
Address Field : (In Hex)
00
00
00
00
00
00
Number of Data byte :
00
(Max 2 byte)
Data Field : (in Hex)
00
00
Read
Write
9:48 AM
8/1/2018

4.2.3 Options (Settings) ->Video Format.

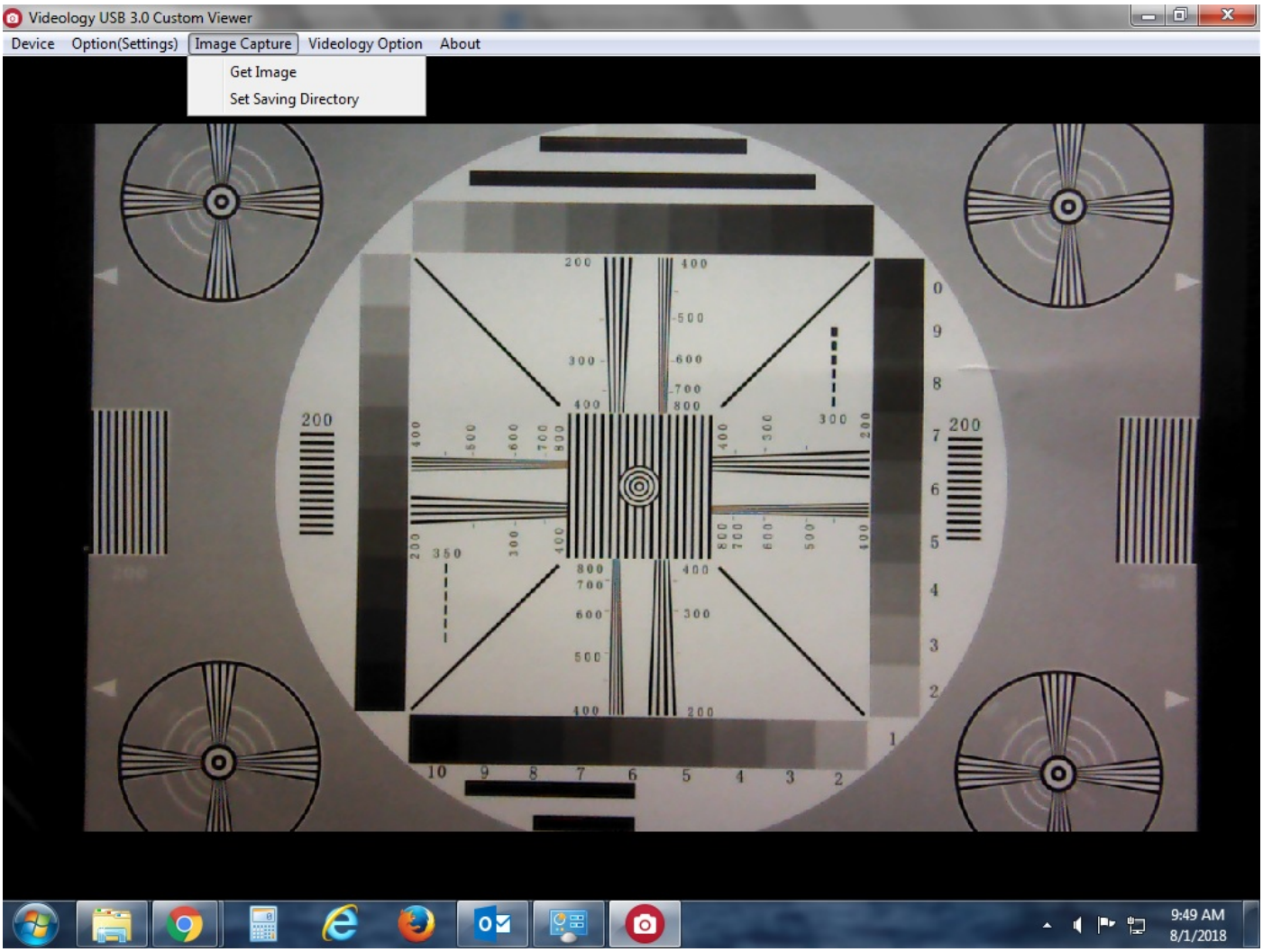
Select Options (Settings) ->Video Format 1280 x 720 @ 30fps or 640 x 480 @ 55fps.

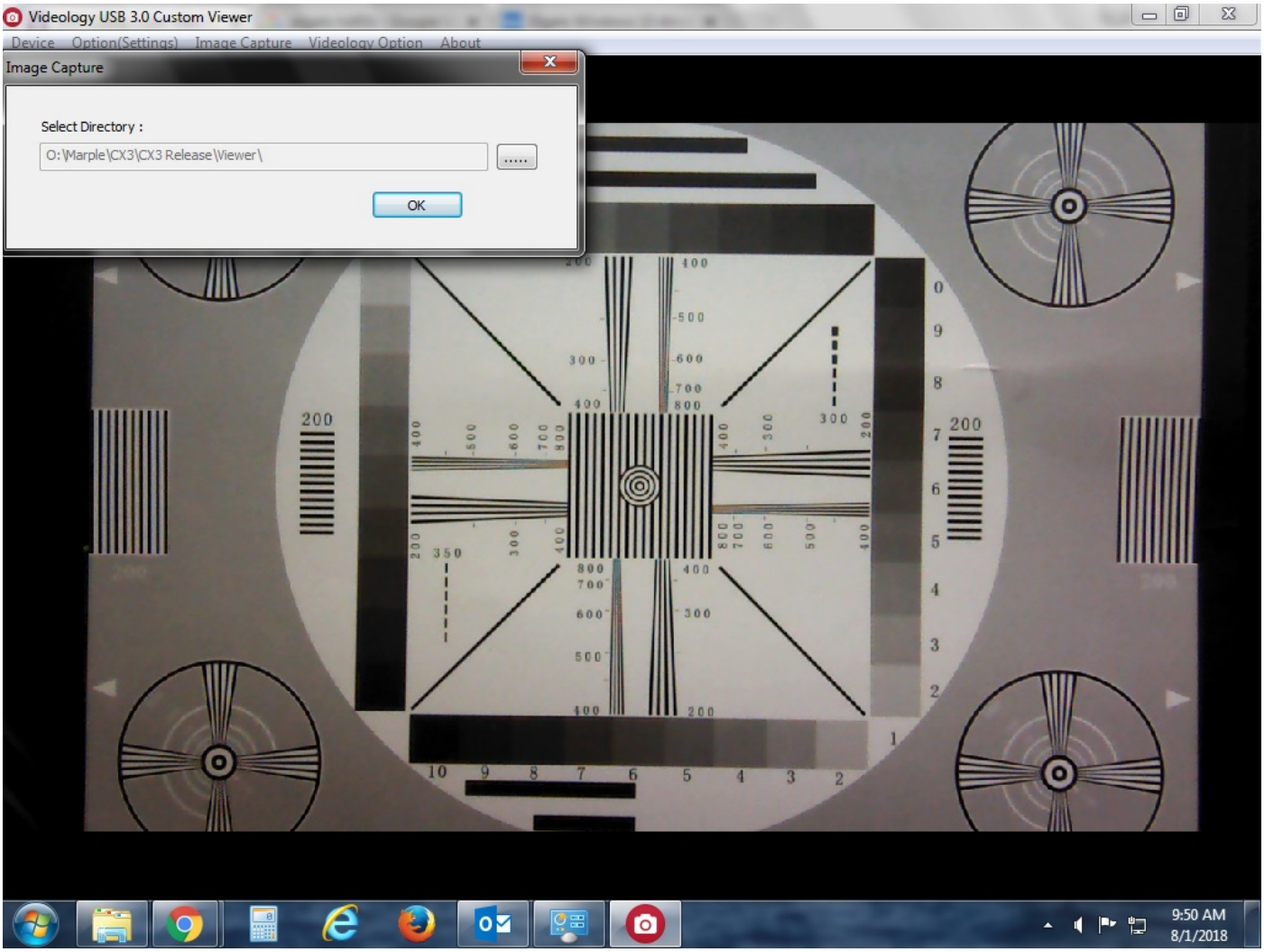


4.3 Image Capture

4.3.1 Image Capture ->Set Saving Directory

Select Image Capture ->Set Saving Directory to choose the directory where still capture images will be saved.

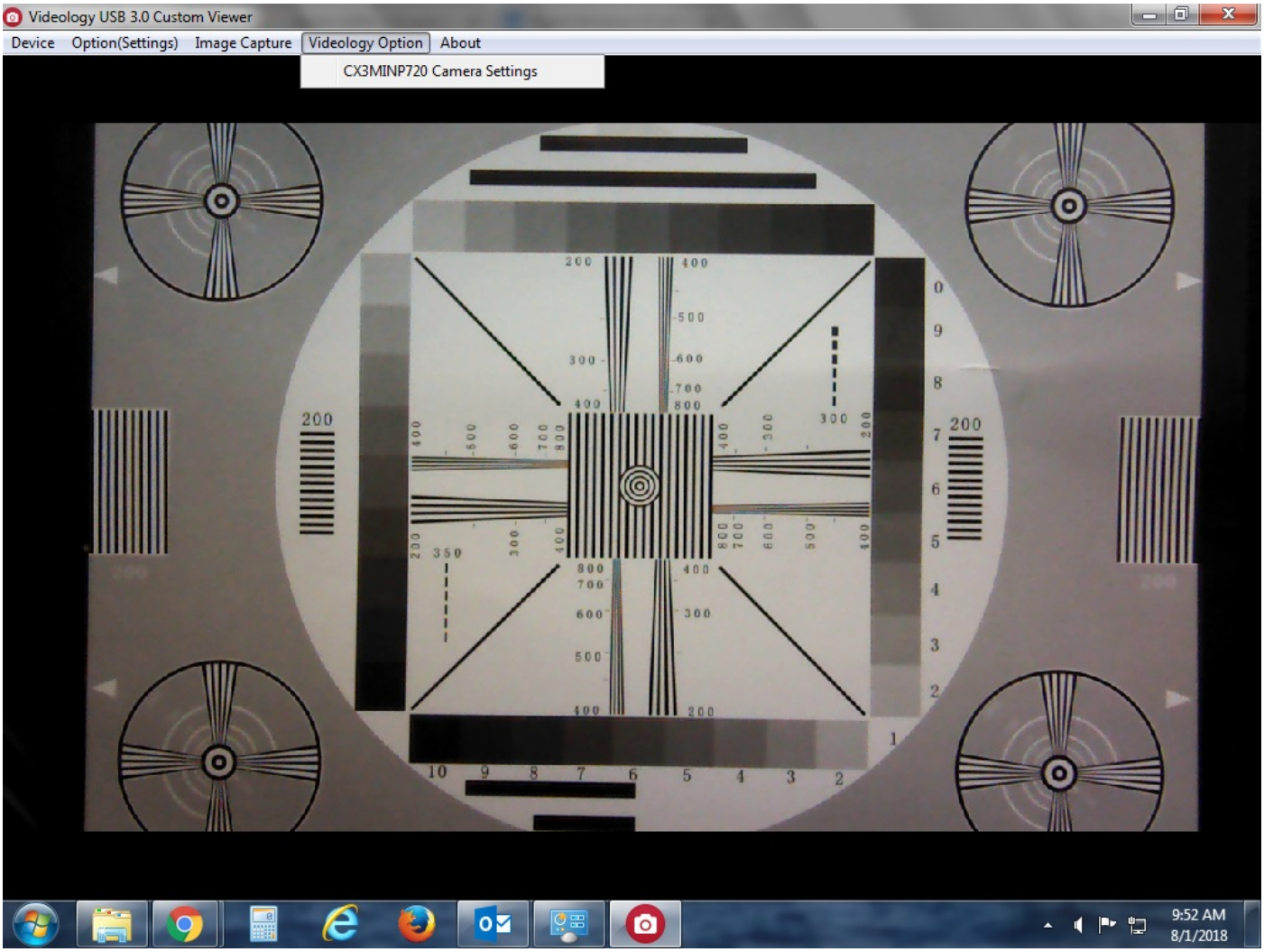




4.3.2 Image Capture ->Get Image

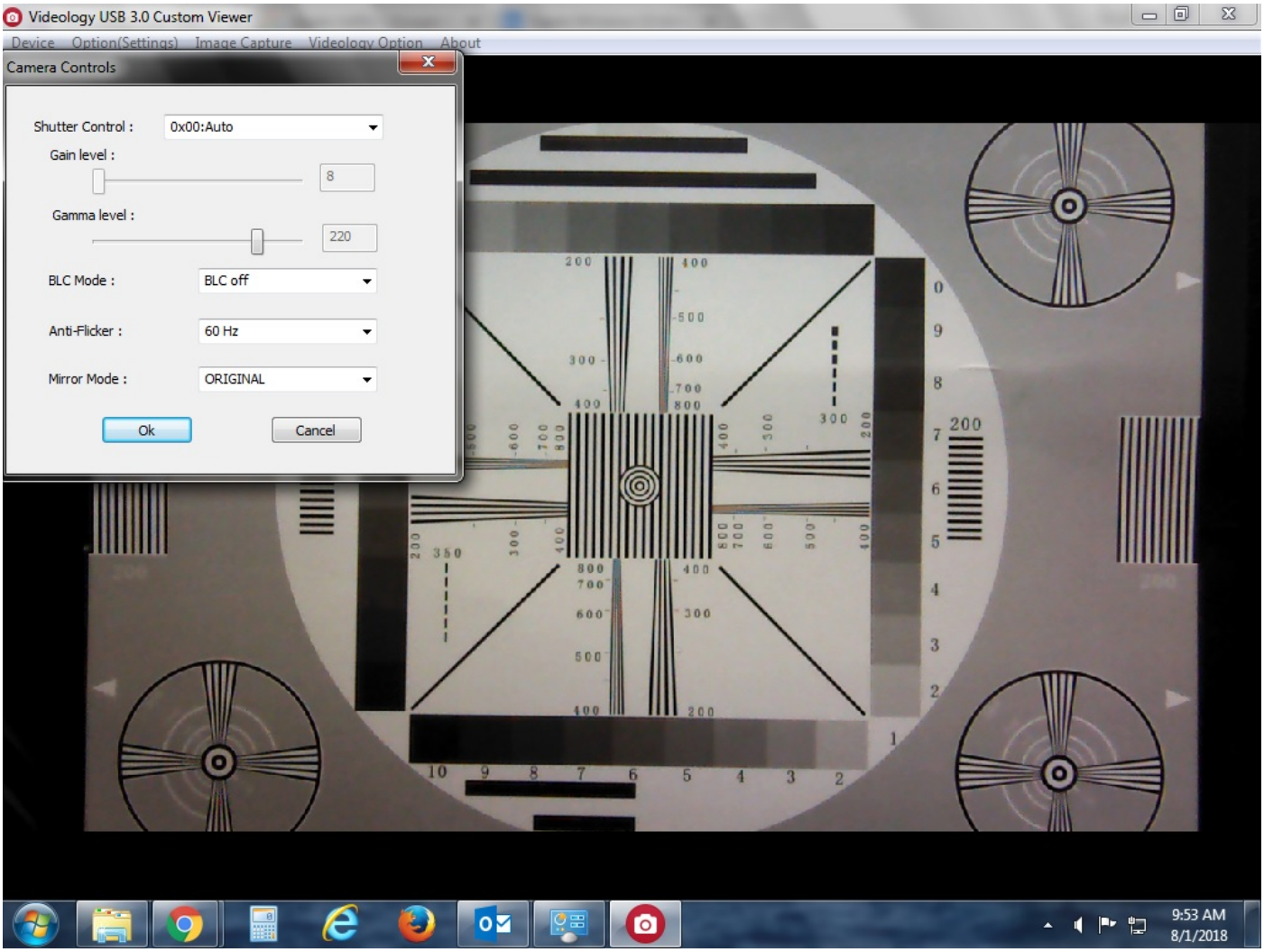
Select Image Capture ->Get Image to take a still image of 1280 x 720 resolution or 640 x 480 depending on the video format setting.

4.4 Videology Options



4.4.1 Videology Options -> CX3MIPI720p Camera Settings

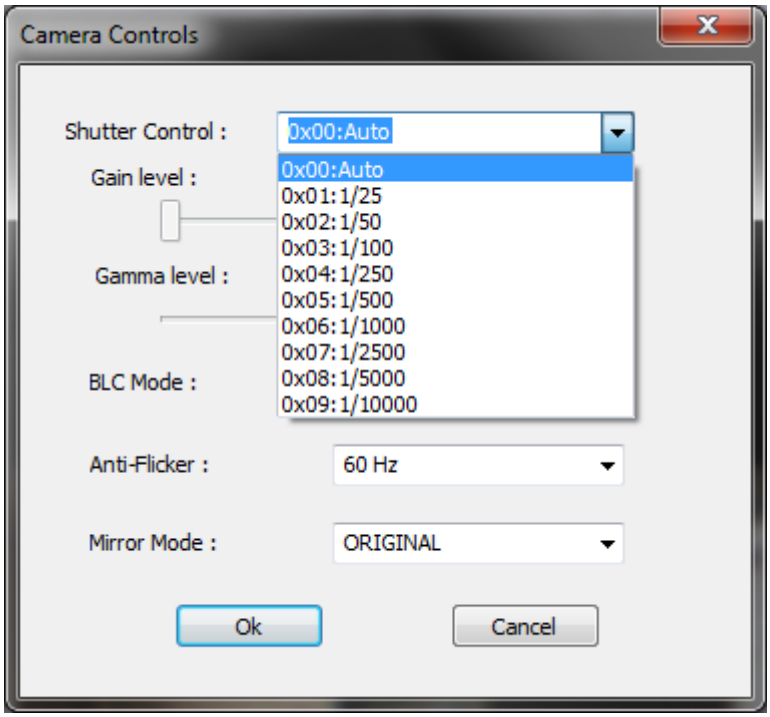
Select Videology Options -> CX3MIPI720p Camera Settings to control non-UVC Videology Specific functions



4.4.1.1 Videology Options -> CX3MIPI720p Camera Settings -> Shutter Control

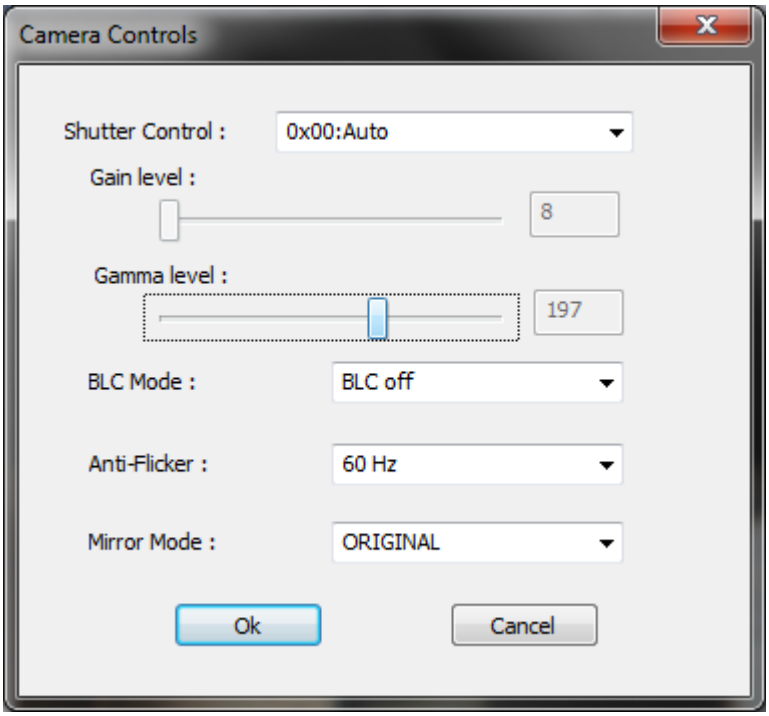
Select Videology Options -> CX3MIPI720p Camera Settings -> Shutter Control to control the cameras shutter.

Note that Gain is not available in Auto.



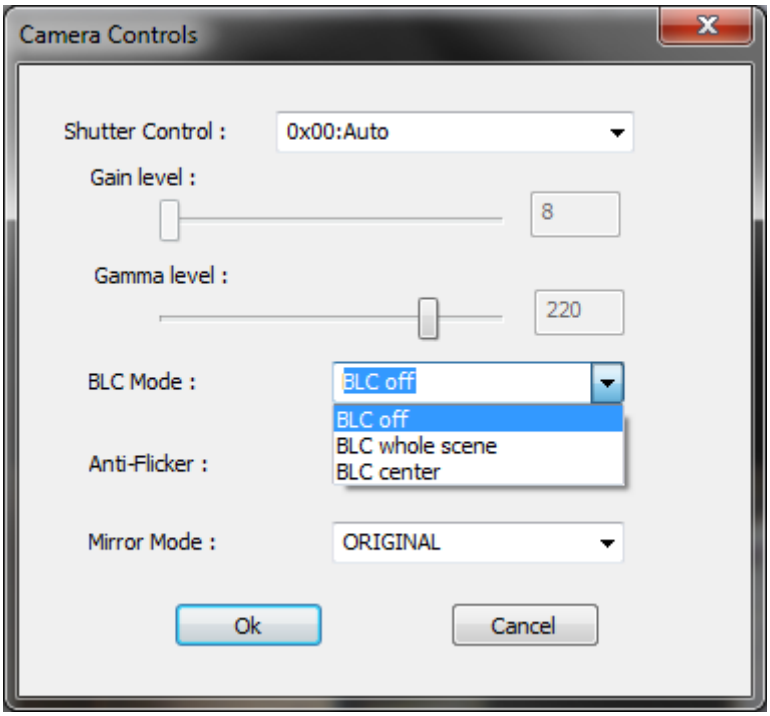
4.4.1.2 Videology Options -> CX3MIPI720p Camera Settings -> Gamma

Select Videology Options -> CX3MIPI720p Camera Settings -> Shutter Control to control the cameras Gamma compensation setting.



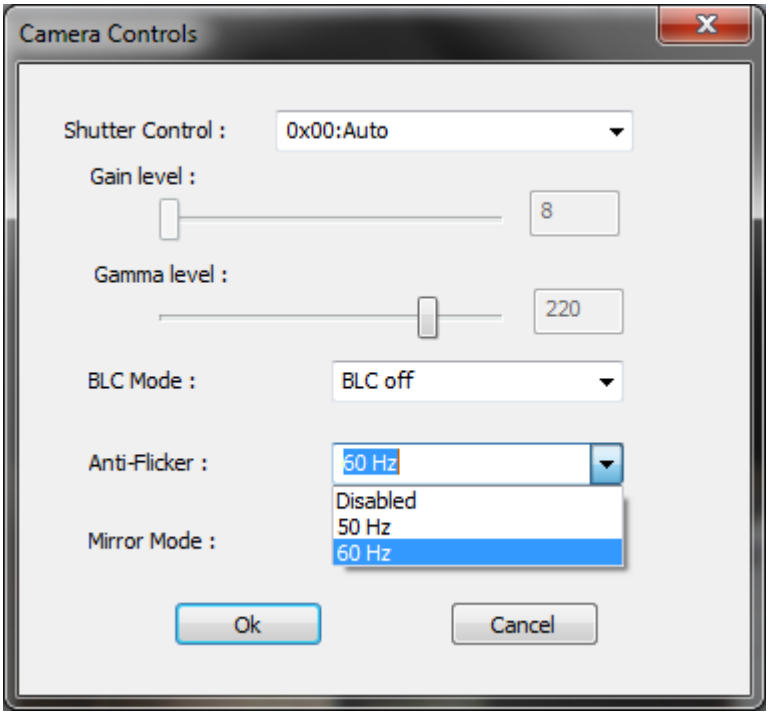
4.4.1.3 Videology Options -> CX3MIPI720p Camera Settings -> BLC Mode

Select Videology Options -> CX3MIPI720p Camera Settings -> BLC Mode to control the cameras BackLight Compensation setting.



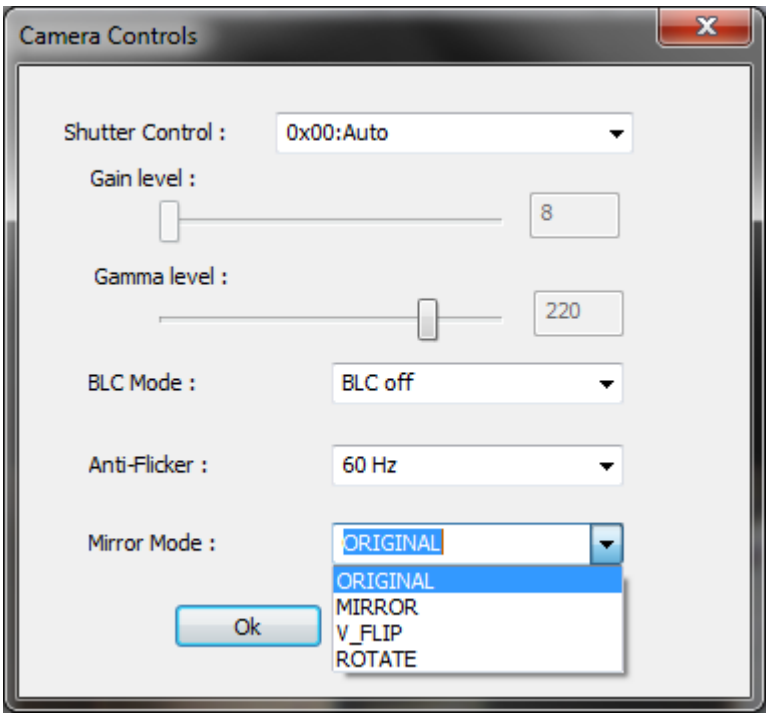
4.4.1.4 Videology Options -> CX3MIPI720p Camera Settings -> Anti-Flicker

Select Videology Options -> CX3MIPI720p Camera Settings -> Anti-Flicker to control the cameras anti-flicker frequency compensation.



4.4.1.5 Videology Options -> CX3MIPI720p Camera Settings -> Mirror Mode

Select Videology Options -> CX3MIPI720p Camera Settings -> Mirror-Mode to control the orientation of the cameras image.



5. I²C Camera Communications

The camera uses a 2 wire serial (I2C) 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.

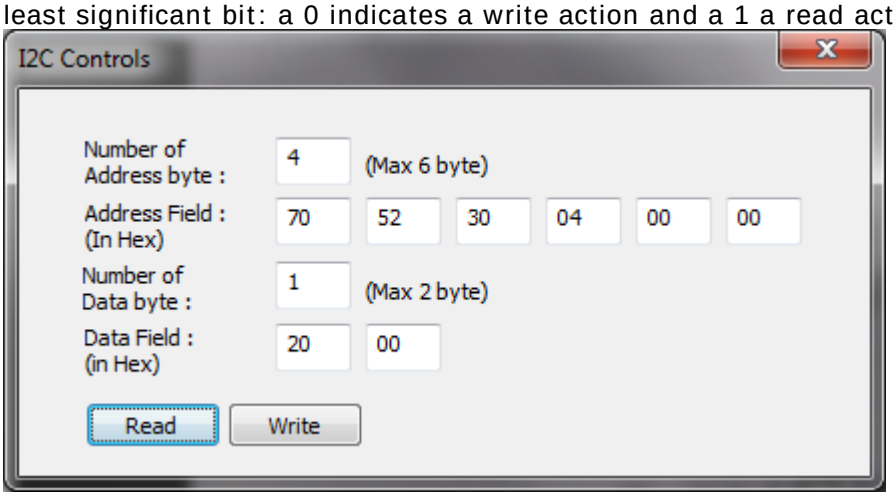
The protocol supports clock speeds from 1 kHz – 100 kHz. The interface for this bus is available via the usb3.0 connector/ CX3 interface via the Videology Viewer Software.

The camera address is 0x70/0x71.

The communication protocol consists of two blocks. The first block is a command block, followed by the data block.

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.



5.1 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**

Error! Reference source not found. below gives the minimum values for delay1 and delay2 for the various read and write operations.

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

Type of communication	**Minimum Delay (ms)**	
	Delay1	Delay2
Read from command register followed by another read	5	1
Write to command register followed by another write	1	80
Read from command register followed by a write to the EEPROM	5	1
Read from EEPROM followed by write to EEPROM	80	5
Write to DSP followed by a write to another device	1	80

5.2 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 the host wants to read or write to the camera. If the host wants to read the LS-bit is 1.
- The 3rd byte is the device address inside the camera.

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

Mode value (2nd byte)	Device address	description
0x52/0x53	0x30/0x31	Command access
	0xa0/0xa1	EEPROM 1st page
	0xa2/0xa3	EEPROM 2nd page
	0xa4/0xa5	EEPROM 3rd page
	0xa6/0xa7	EEPROM 4th page
	0x90/0x91	Device address 0x90/91 is the Sensor. In this case the data consist of bytes either for read or write.

- 4TH byte is the register address. This byte can have any value between 0x00 and 0xff.

5.3 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.

In order to send or receive two data bytes to the sensor, the device address 0x90 or 0x91 is used.

In this case the structure of the command block will be as shown below:

Data block: data from host to camera							
	Byte 1		Byte 2		Byte 3		
start	Cam addr W	A	Data byte MSB	A	Data byte LSB	A	stop

A= acknowledge

Data block: data from Camera to host							
	Byte 1		Byte 2		Byte 3		
start	Cam addr R	A	Data byte MSB	A	Data byte LSB	NA	stop

A= acknowledge, 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.

6. I²C Command registers

The camera has several user accessible command registers (mode byte is 0x52/0x53 and device address 0x30/0x31) which can be used to configure and control the camera behavior. These registers can be used to control exposure and gain control modes, image display settings, backlight and auto focus parameters etc.

A detailed description of each of the control registers is given in section 8.

In order to maintain the camera settings and configuration upon power cycling, the register settings are stored in an EEPROM. The EEPROM contents and addresses are given in **Error! Reference source not found.**

Table 2. EEPROM page addresses and contents

EEPROM Page	Device Addr. W/R	Contents
0	0xa0/0xa1	Startup command register settings
1	0xa2/0xa3	FPGA /Video processing default settings
3	0xa4/0xa5	Factory default command register settings.
4	0xa6/0xa7	Default sensor Register settings

It is not recommended for the user to change the registers in page 1, 2 or 3 of the EEPROM.. Therefore these registers are write protected.
This document only describes the command registers and EEPROM mapping.

6.1 Register Overview

Device Address(w/r)	Register Address	Limits	Function
			Camera
0x30/0x31	0x00	0 = auto 1 = 1/25 2 = 1/50 3 = 1/100 4 = 1/250 5 = 1/500 6 = 1/1000 7 = 1/2500 8 = 1/5000 9 = 1/10000	Shutter Speed
0x30/0x31	0x03	0x08 to 0x42	Gain Controls (Manual Shutter)
0x30/0x31	0x04	0x01 to 0x3F	Brightness (Exp. Reference)
0x30/0x31	0x05	00= None 01= Mirror 02=flip 03=both	Image orientation (mirror / flip)
0x30/0x31	0x06	0x00 to 0x0E	Sharpness
0x30/0x31	0x07	0x10 to 0x40	Contrast
0x30/0x31	0x08	0 – auto; 1 – manual	White Balance Mode
0x30/0x31	0x09	0x07 to 0x1B	White Balance Color Temperature MSB
0x30/0x31	0x0A	0x00 to 0xFF	White Balance Color Temperature LSB
0x30/0x31	0x0B	0= 960P 1= 720P 2 = 640 x 480	Resolution
0x30/0x31	0x0C	0x00 to 0xFF	Saturation
0x30/0x31	0x0D	0xEA to 0x16	Hue
0x30/0x31	0x0E	0x64 to 0xFA	Gamma
0x30/0x31	0x0F	0=OFF; 1=Full ROI; 2=Center ROI	BLC mode
0x30/0x31	0x10	0=DISABLED; 1=50Hz; 2=60Hz	Anti-Flicker
0x30 write only	0x50	Data = don't care	Restore Factory Settings
0x30 write only	0x51		Save Settings

7. Detailed register information

The following chapters describe each function and associated register(s) in more detail.

7.1 Shutter Speed control mode

The camera supports two basic exposure control modes which can be selected via register 0x00.

7.1.1 Full auto mode

0 = Full Auto

In full auto mode the camera will automatically adjust the shutter speed (integration time) and gain value to maintain a constant output level.

In this mode, register 0x04 serves as a reference level. The output level of the camera can be increased or decreased by raising or lowering the reference level.
When the scene illumination level is high, the output level is controlled predominantly by the shutter speed. When the scene illumination is low, the gain control is used predominantly to maintain the output level.

The operation in illustrated in figure 1 below.

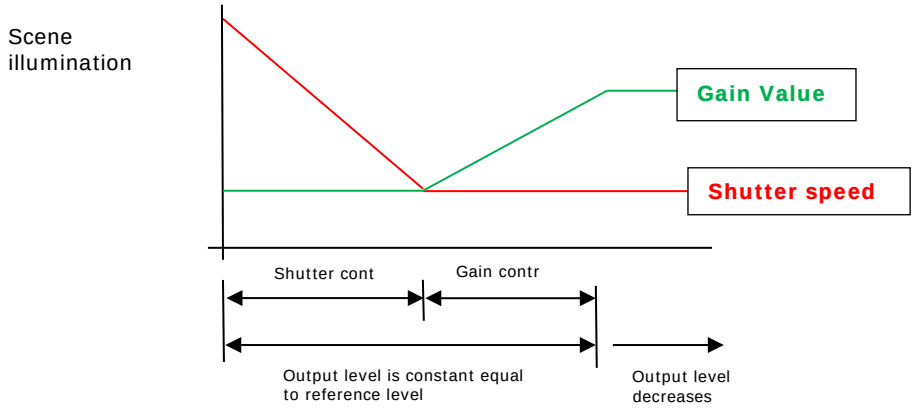


Figure 1. Auto Exposure mode

7.1.2 Fixed shutter Mode

There are 9 predefined shutter speeds selectable via register 0x00.
In this mode, the camera shutter speed can be set to one of 9 predefined values.

1 = 1/25
2 = 1/50
3 = 1/100
4 = 1/250
5 = 1/500
6 = 1/1000
7 = 1/2500
8 = 1/5000
9 = 1/10000

7.2 Manual (fixed) gain control

The gain can be set to a fixed value via register 0x03. The gain value is then set via register 0x03. Camera must be in manual shutter speed for this to take effect.

The range is from 0x08 (low) to 0x42(high).

7.3 Brightness Control

Register 0x4 controls the overall brightness (Y-offset) of the image.
The range is from 0x00 (low) to 0xFF(high).
Value 0x80 is the middle (default) value.

7.4 Image Orientation

Horizontal and vertical mirror images can be selected via bits[1:0] of register 0x05 as shown in the table below.

Reg 0x05 bits[1:0]	Image Orinetation
00	Normal
01	Horizontal Mirror
10	Vertical Mirror (FLIP)
11	Vertical & Horizontal Mirror

7.5 Edge Enhancement

The camera is also equipped with an edge enhancement feature which can be used to create sharper edges, giving the appearance of higher resolution. See Figure 2 below.

Register 0x06 sets the gain of the sharpness ranging from 0(=off) to 0x14(=maximum).
Note that in addition to providing a sharper looking image, the edge enhancement feature will also accentuate the noise.

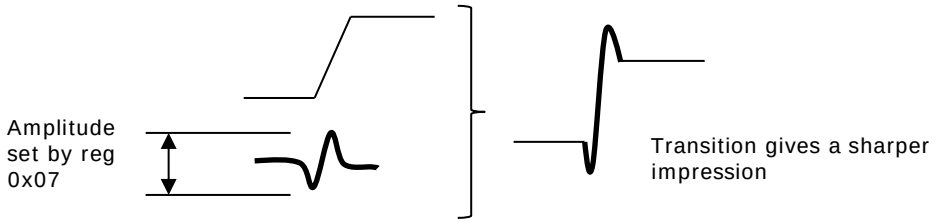


Figure 2. Edge enhancement

7.6 Contrast control

Register 0x07 controls the overall contrast (Y-gain) of the image.
The range is from 0x10 (low) for a contrast of 0.5 to 0x40(high) for a contrast of 2.0. A value of 0x20 is a contrast level of 1.0

7.7 White Balance control

The white balance feature enables you to adjust the tone according to the color temperature of the light source illuminating the subject. It allows the operator to see objects as they appear during daylight. The camera's white balance can be adjusted manually or performed automatically.

Manual adjustment includes setting the correct balance by both adjusting the red and blue gain values. This is accomplished by setting the slider to the correct color temperature.

Register 0x09 is the MBB. It can range from 0x07 to 0x1B
Register 0x0A is the LSB. It can range from 0x00 to 0xFF

For example:

A value in 0x09 of 07 combined with a value in 0x0A of 0x00 will give a color temperature of 0x07D0 = 2000 degrees. A value of 0x1B58 = 7000 degrees. These are the practical limits that can be adjusted for.

7.8 Resolution mode

At present, the camera supports two HD resolution display modes and one standard definition display mode.

The resolution is set via bits[5:4] of command register 0x0B as shown below.

Reg 0x0B B[5:4]	Resolution (pixel count)
02	VGA (640 x 480)
01	720P (1280 x 720)
00	960P (1280 x 960)

7.9 Saturation

Color saturation is controlled via register 0x0C

Saturation is the purity or vividness of a color, expressed as the absence of white. A color with 100% saturation contains no white. A color with 0% saturation corresponds to a shade of gray. Increasing the saturation can give the image brilliant color and "punch," but too much saturation distorts colors and causes problems such as unnatural-looking skin tones.

A value of 0x00 is NO COLOR; a value 0f 0x7F is unity; values from 0x80 to 0xFF result in boosted color saturation.

7.10 Hue

Hue control sets the amount of hue adjustment (rotation) applied to each pixel. Minus settings increases redness, while the plus settings increases yellowness

A value of 0x00 is no rotation.

Register 0x0D can be set ranging from 0xEA to 0x16.

7.11 Gamma correction

The camera has a built in gamma correction. The gamma correction factor can be set between 0.45 and 1.

The values are expressed as units multiplied by 100. This gamma value is the inverse of the final display gamma.

Register 0x0E can be set ranging from 0x64 (gamma = 1.0) to 0xFA (gamma = 0.4).

7.12 Back Light Compensation (BLC) mode

Back Light Compensation is used to improve the image quality when the subject is illuminated from behind such as when standing in front of a brightly lit window.
Normally the auto-exposure control would reduce the gain to keep all parts of the image within the desired range; this would result in the subject becoming a silhouette as shown in Figure 3.

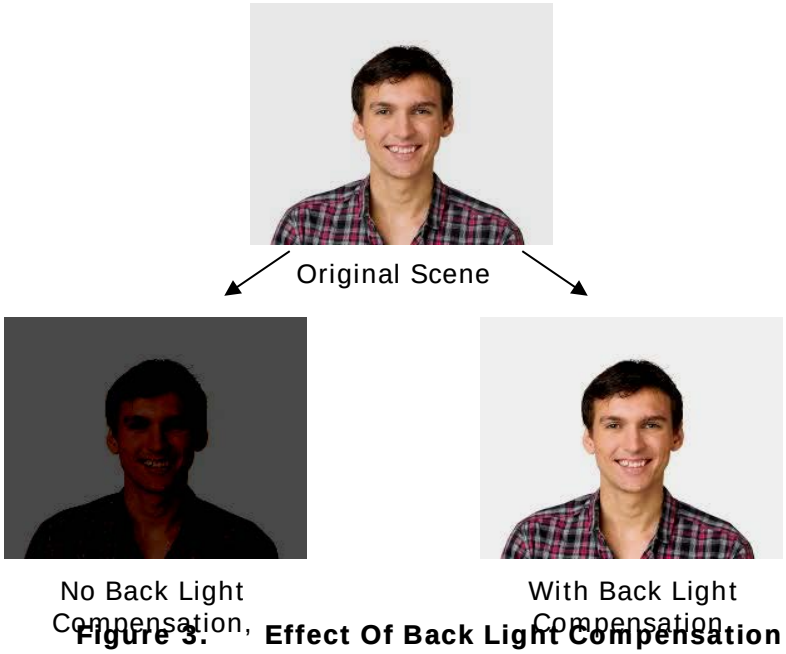


Figure 3. Effect Of Back Light Compensation

The BLC works by assigning more priority to a certain part of the image - the BLC Window.
The part of the image within this window is then given an extra weighting compared with remaining window when determining the exposure and gain values.

The BLC feature is activated by setting register 0x0F as follows:
0=OFF
1=Full scene: the entire field of view is used to calculate the BLC correction.
2=Center of the scene: only the center of the scene is used to calculate the BLC correction.

7.13 Flickerless Operation

The camera can be put in a 50Hz or 60Hz mode. This is to reduce the flicker that can result when using the camera under artificial lighting that is operating on either a 50HZ or 60Hz frequency.
The frequency settings is controlled via register 0x10 and results in slightly different frame rates for the 50 and 60 Hz options as shown below.

Reg 0x01 bit[7]	Frequency	Frame rates (Resolution)
2	60 Hz	720P: 30 fps
1	50 Hz	720P: 25 fps
0	None	off

7.14 EEPROM Register Save

The user registers can be saved in EEPROM so that that the customer's adjusted settings are loaded upon power-up.

This is a write only command to Address 0x51. The value in the data field is a don't care

7.15 EEPROM Restore Factory Default command

The user registers can be reset to the original factory settings.

This is a write only command to Address 0x50. The value in the data field is a don't care

8. Specifications

8.1 Opto-Electric

Electrical	24C1.2XU3
Optical Format	1/6” CMOS ON Semiconductor MT9M114
Aspect Ratio	4:3
Active Pixels	1296 x 976
Resolution	1280 x 720, 640 x 480
Pixel Size	1.9µm x 1.9µm
Color Filter Array	RGB Bayer
Frame rate	30 fps @ 720p 55 fps @ 640 x 480
Scan Mode	Progressive
Responsivity	2.25 V/lux-sec
SNR Max	36.8 dB
Dynamic Range	70.8 dB
Gain	Automatic / Manual
Shutter Type	Electronic Rolling Shutter
Shutter Speed	Auto exposure
	9 fixed speeds (1/25 sec. - 1/10,000 sec.)
Supply Voltage	USB3 / 5V
Power Consumption	<1W
Camera Controls	
via Videology viewer	Brightness, Contrast, Hue, Saturation, Sharpness, AWB, Manual WB, Auto Exposure, Gamma, BLC, Flicker Avoidance, Flip/Mirror
Environmental	
Operating Temperature	-30°C ~ 70°C (-22°F ~ 158°F)
Mechanical	
Dimensions W x H x D	Sensor 7.5mm x 7.5mm USB3 board 22mm x 26mm
Weight	TBD
Lens	M-12 board mount (32M04330F-14M)
	Alternate lens mount potential for M-5 in future
Connectors	USB 3.0 type micro B

9. Mechanical

The camera is a double board design with overall dimensions as shown in Figure 3.

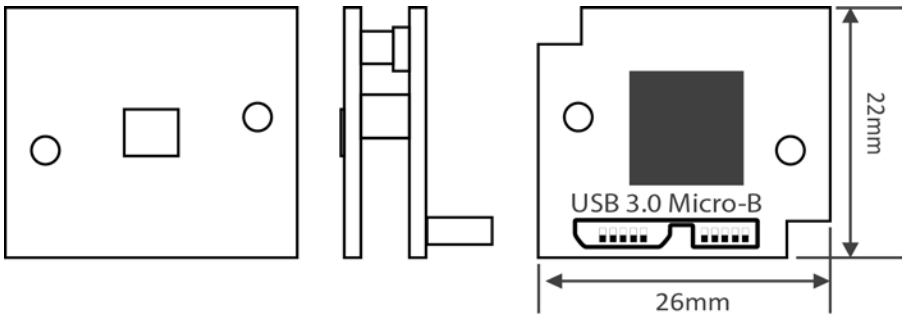


Figure 4. Camera Dimensions (no Lens Mount)

9.1 Connector

A single USB3.0 Micro-B with standard pinout

9.2 Lens options

M-12 board mount (32M04330F-14M)
Alternate lens mount potential for M-5 in future

10.Digital output

The camera has an 8 bit MIPI CSI2 output transported via USB3.0

10.1 Output formats

The output data is YUV422

11. Communication

In case of the USB3 version of the camera, communication is possible via the Videology USB 3 viewer.

12. Contact Information

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

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