

## 24C24XW Series

# 1080p Mini CMOS Color Camera Series

with MIPI, BT.1120 and AHD/TVI output



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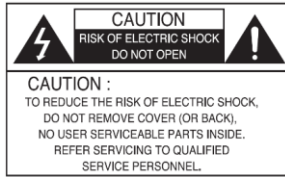
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## 2. Warning and Safeguards



- **Read instructions before operating camera.**
- Please read/follow all instructions and read all warnings before operating the camera.
- Installation and servicing should only be done by Qualified Service and Installation Personnel.
- Installation shall be done in accordance with all local and national electrical and mechanical codes.
- Avoid mounting in direct sunlight.
- To reduce the risk of fire or electric shock, do not expose this appliance to rain, water or wet locations.
- If the camera is to be mounted outdoors a secondary waterproof enclosure should be used.

### 2.1 Precautions

- Do not put objects inside the unit. Make sure that no metal objects or flammable substances get inside the camera. It could cause fire, short-circuits or damages.
- Be careful when handling the unit.
- To prevent damage, do not drop the camera or subject it to strong shock or vibration.
- Install away from electric or magnetic fields.
- Protect from humidity and dust.
- Protect from high temperature.
- Be careful when installing close to the ceiling, in a kitchen or boiler room, as the temperature may raise to high levels.
- Cleaning - Dirt can be removed from the cabinet only by wiping it with a soft cloth moistened with a soft detergent solution.
- Mounting Surface - The mounting surface material must be strong enough to secure the camera.
- Avoid viewing a very bright object (such as light fittings) during an extended period.

### 2.2 Care of the Unit

- Remove dust or dirt on the surface of the lens with a blower (commercially available).
- Avoid the use of volatile solvents such as thinners, alcohol, benzene and insecticides. They may damage the surface finish and/or impair the operation of the camera.
- Be careful not to spill water or other liquids on the unit.

### 2.3 Operating and Storage Location

- Extremely hot or cold places; operating temperature  $-10^{\circ}\text{C}$ - $50^{\circ}\text{C}$  ( $32^{\circ}\text{F}$  –  $122^{\circ}\text{F}$ ) however, we recommend that the unit be used within a temperature range of  $0^{\circ}\text{C}$  –  $45^{\circ}\text{C}$  ( $32^{\circ}\text{F}$  –  $113^{\circ}\text{F}$ )
- Damp or dust places
- Places exposed to rain
- Places subject to strong vibration
- Close to generators of powerful electromagnetic radiation such as radio or TV transmitters.



If the product is to be put out of operation definitively, take it to a local recycling plant for disposal which is not harmful to the environment.

## 3. Document History

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### Document History

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Revision	Issue Date	Reason
Rev A	02/29/2024	Initial Version

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## Table of Contents

<b>1.</b>	<b>Prior to Using</b> .....	<b>2</b>
1.1	License Agreement (Software):.....	2
1.2	Limited Warranty (Hardware and Software):.....	2
1.3	Limited Liability (Hardware and Software):.....	2
<b>2.</b>	<b>Warning and Safeguards</b> .....	<b>3</b>
2.1	Precautions .....	3
2.2	Care of the Unit.....	3
2.3	Operating and Storage Location .....	3
<b>3.</b>	<b>Document History</b> .....	<b>4</b>
<b>4.</b>	<b>Introduction</b> .....	<b>9</b>
<b>5.</b>	<b>Specification</b> .....	<b>10</b>
5.1	Opto-Electric.....	10
5.2	HD Transmission Distance.....	11
5.3	Electrical.....	11
5.4	Environmental.....	11
5.5	Mechanical.....	11
5.6	Connectors.....	12
5.7	Accessories .....	12
5.8	Lens Mount Options .....	12
<b>6.</b>	<b>Dimensions</b> .....	<b>13</b>
6.1	Dimensions .....	13
<b>7.</b>	<b>Connectors</b> .....	<b>14</b>
7.1	Connectors.....	14
<b>8.</b>	<b>I<sup>2</sup>C Camera Communications</b> .....	<b>16</b>
8.1	Communication interface specification.....	16
8.1.1	Camera I <sup>2</sup> C control .....	17
8.1.2	Bootloader I <sup>2</sup> C control .....	18
<b>9.</b>	<b>Detailed Register Information</b> .....	<b>20</b>
9.1	Standard Control.....	20
9.2	Gamma.....	20
9.3	Black Correction.....	21
9.4	Hue & Saturation .....	22
9.5	Automatic Exposure.....	22
9.5.1	Automatic Exposure .....	23
9.5.2	Full Manual Exposure .....	23
9.5.3	Manual Exposure.....	24
9.6	Backlight Compensation .....	25
9.7	Automatic White Balance.....	26
9.8	Manual White Balance .....	27
9.8.1	Manual White Balance Correction.....	27
9.8.2	Color Correction Matrix .....	27
9.9	Lens Shading Compensation.....	28
9.10	Edge Enhancement.....	29
9.11	Noise Reduction .....	30
9.11.1	Defect Pixel Correction Filter.....	30

9.11.2	Push to White gain settings (read only).....	30
9.11.3	Color Correction gain settings (read only).....	30
9.12	Analog Output Controls.....	31
9.12.1	Current Screen Resolution (read only).....	31
9.13	ISP Power Management (read only).....	31
9.14	GPIO.....	32
9.15	Camera status.....	32
9.16	Upgrade State.....	33
9.16.1	ISP Firmware Version.....	33
9.16.2	NVM User Space Version.....	33
9.16.3	NVM Factory Version.....	33
9.17	NVM Register Save/Restore and Restart Commands.....	34
9.17.1	Store Current Register Settings.....	34
9.17.2	Recover Factory Register Settings.....	34
9.17.3	Recover Factory Calibration Parameters.....	34
9.17.4	Reboot.....	34
9.17.5	Start Bootloader.....	34
9.18	Camera Type and Framerate.....	35
9.19	Camera Model.....	35
9.20	Configuration Register.....	35
9.21	I <sup>2</sup> C Control.....	36
9.21.1	I <sup>2</sup> C Status Byte.....	36
9.21.2	I <sup>2</sup> C ACK Polling.....	36
9.21.3	Enhanced I <sup>2</sup> C Clock Stretch.....	36
9.22	Bootloader.....	36
9.23	Firmware Status.....	37
9.24	Password Protection.....	37
9.25	Microcontroller Software Version.....	37
<b>10.</b>	<b>Updating the Firmware.....</b>	<b>38</b>
10.1	Non-volatile register and calibration parameters.....	38
10.1.1	NVM image format.....	39
10.1.2	NVM example.....	41
10.2	Updating Controller firmware.....	42
10.2.1	Bootloader commands.....	42
10.2.2	Update sequence for the controller firmware.....	43
10.2.3	Firmware image format.....	44
10.2.4	Firmware image example.....	45
10.3	Updating the ISP Firmware.....	46
<b>11.</b>	<b>Calibration and Default Settings.....</b>	<b>47</b>
11.1	Calibration Parameters.....	47
<b>12.</b>	<b>Register Summary.....</b>	<b>49</b>
12.1	List of the Control Registers.....	49
<b>13.</b>	<b>Communication.....</b>	<b>54</b>
<b>14.</b>	<b>Contact Information.....</b>	<b>55</b>

## List of Figures

---

FIGURE 1 INTRODUCTION.....	9
FIGURE 2 CAMERA DIMENSIONS .....	13
FIGURE 3 GAMMA TABLE 0 TO TABLE 1 .....	21
FIGURE 4 BLACK CORRECTION FOR GAMMA; LEFT GAMMA, RIGHT CORRECTED GAMMA CURVE.....	21
FIGURE 5 BLC WINDOWS.....	25
FIGURE 6 LENS SHADING COMPENSATION.....	29
FIGURE 7 COMMUNICATION KITS .....	54

## List of Tables

---

TABLE 1. GENERAL SPECIFICATIONS .....	10
TABLE 2. HD TRANSMISSION DISTANCE .....	11
TABLE 3. ELECTRICAL .....	11
TABLE 4. ENVIRONMENTAL .....	11
TABLE 5. MECHANICAL .....	11
TABLE 6. CONNECTORS.....	12
TABLE 7. ACCESSORIES .....	12
TABLE 8. LENS MOUNT OPTIONS .....	12
TABLE 9. MAIN CONNECTOR J100 .....	14
TABLE 10. OPTIONS CONNECTOR J102 .....	14
TABLE 11. BOARD TO BOARD CONNECTOR J101 .....	15
TABLE 12. I <sup>2</sup> C CONTROL.....	17
TABLE 13. I <sup>2</sup> C BOOTLOADER COMMAND INTERFACE.....	18
TABLE 14. STANDARD CONTROL .....	20
TABLE 15. GAMMA.....	20
TABLE 16. AUTOMATIC EXPOSURE.....	23
TABLE 17. FULL MANUAL EXPOSURE .....	23
TABLE 18. MANUAL EXPOSURE .....	24
TABLE 19. BACKLIGHT COMPENSATION .....	25
TABLE 20. AUTOMATIC WHITE BALANCE .....	26
TABLE 21. MANUAL WHITE BALANCE CORRECTION .....	27
TABLE 22. AUTO / MANUAL COLOR CORRECTION.....	28
TABLE 23. DEFAULT CCM MATRIX COEFFICIENTS.....	28
TABLE 24. LENS SHADING COMPENSATION .....	28
TABLE 25. EDGE ENHANCEMENT .....	29
TABLE 26. NOISE REDUCTION .....	30
TABLE 27. PUSH TO WHITE GAIN SETTINGS (READ ONLY) .....	30
TABLE 28. COLOR CORRECTION GAIN SETTINGS (READ ONLY) .....	30
TABLE 29. ANALOG OUTPUT CONTROLS.....	31
TABLE 30. CURRENT SCREEN RESOLUTION .....	31
TABLE 31. ISP POWER MANAGEMENT.....	31
TABLE 32. GPIO .....	32
TABLE 33. STATUS CONTROL .....	32
TABLE 34. UPGRADER (R/W) .....	33

TABLE 35. ISP FIRMWARE VERSION.....	33
TABLE 36. NVM USER SPACE VERSION.....	33
TABLE 37. NVM REGISTER SAVE/RESTORE AND RESTART COMMANDS.....	34
TABLE 38. CAMERA TYPE AND FRAMERATE.....	35
TABLE 39. CAMERA MODEL.....	35
TABLE 40. CONFIGURATION REGISTER.....	35
TABLE 41. I2C CONTROL.....	36
TABLE 42. BOOTLOADER.....	36
TABLE 43. FIRMWARE STATUS.....	37
TABLE 44. PASSWORD PROTECTION.....	37
TABLE 45. MICROCONTROLLER SOFTWARE VERSION.....	37
TABLE 46. COMPLETE LIST OF THE CONTROL REGIST.....	53

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## 4. Introduction

This document describes how to use the features of this wide dynamic range HD camera. The output signal is available in AHD or TVI and at the same time MIPI or BT.1120 format.

As the preferred alternative to the Videology 2xC21xW camera it uses the same small formfactor of 22 x 26 mm. The main connector and mounting holes are identical to the 2xC21xW. Due to its digital output connector it can support a USB Interface board (See 24C24xW-USB version).

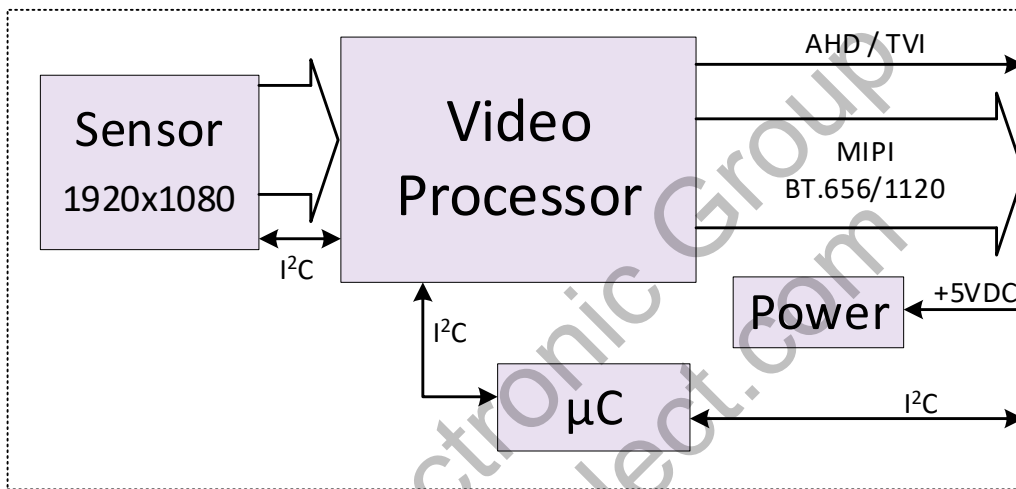


Figure 1 Introduction

Different versions of this camera are available including alternative digital output formats, and either 25 or 30 Hz.

It has many advanced features like Backlight Control, Lens Shading Correction, Dead Pixel Correction, 2D Noise Reduction, De-mosaic, Color / Gamma Correction, De-color, Edge Enhancement, Contrast & Brightness Control, Hue & Saturation Control and Automatic White Balance.

## 5. Specification

### 5.1 Opto-Electric

Description	
Image sensor	1/2.7"
Active Pixels	1960x1120
Pixel size	3.0x3.0 $\mu\text{m}$
Effective image size	5.880 mm x 3.360 mm (Diagonal :6.77mm)
Scanning system	progressive
Aspect ratio AHD / TVI	16:9
Aspect ratio digital	16:9 for 1920x1080 16:9 1280x720 <i>Other resolutions available upon request</i>
Shutter type	Rolling
Framerate	25/30fps
Analog Output mode	AHD/TVI 1920x1080p@30fps AHD/TVI 1920x1080p@25fps AHD 1280x720p@30fps AHD 1280x720p@25fps
Digital Output mode BT.1120	1920x1080p@30fps 1920x1080p@25fps 1280x720p@30fps 1280x720p@25fps Pixel clock rate: 74.25 MHz
Digital Output mode MIPI	1920x1080p@30fps 1920x1080p@25fps 1280x720p@30fps 1280x720p@25fps MIPI lane: 4 lanes MIPI lane clock: 148.5MHz, MIPI data rate: 1188Mbps
<i>Other video formats, 2-Lane MIPI or BT.656 outputs are available upon request. MOQ may apply. Please contact our sales department for further information.</i>	
Sensitivity	<0.5 Lux color
Dynamic Range	120 dB
Signal to Noise ratio	44.9dB
Video output interfaces	AHD / TVI / BT.1120 / MIPI
White balance range	2,000K ~ 11,000K

Table 1. General specifications

Note: Video formats and output configurations; BT.1120, MIPI and AHD or TVI modes are fixed. The user cannot change these, please consult the Product Data Sheet for ordering information.

Other video formats, 2-Lane MIPI or BT.656 outputs are available upon request. Please contact our sales department for further information.

## 5.2 HD Transmission Distance

Description	Value
TVI / AHD single ended 75Ω	Up to 500m (1,600ft) with high quality cable

Table 2. HD Transmission Distance

## 5.3 Electrical

Description	Value
Supply Voltage	5V ± 0.75V
Max Current drawn @5V	Typical 0.25 A
Power consumption 1080p	1.25W
Communication	I <sup>2</sup> C (400kHz)

Table 3. Electrical

## 5.4 Environmental

Description	Value
Operating Temperature	-40°C ~ 60°C
Operating Humidity	30% - 90%
Storage Temperature	40°C ~ 85°C
Storage Humidity	<85%RH

Table 4. Environmental

## 5.5 Mechanical

Description	Value
Dimensions	26mm x 22mm
Weight	3g or 13.5g including M12 lens mount

Table 5. Mechanical

## 5.6 Connectors

Description	Manufacturer	Mating connector
J100-8P Main connector	Wurth Elektronik PN# 665108131822	Housing: Wurth PN# 665008113322 Crimp contacts: Wurth PN# 66510113722
J101-30P Board to Board connector	Molex PN# 501920-3001	Connector: Molex PN# 52991-0308
J102-6P Options connector	JST PN# SM06B-SURS-TF	Housing: JST PN# SUHR-06V-S-(B) Crimp contacts: JST PN# SSUH-003T-P0.15

Table 6. Connectors

## 5.7 Accessories

Part Number	Description
60C1041	6.89in (175mm) 8-pin JST with flying leads

Table 7. Accessories

## 5.8 Lens Mount Options

The camera model is available with either an M12 Pinhole, M12 or CS lens mount. Table 8 gives the part number for each configuration.

Lens interface	Camera type number
M12 Pin Hole mount (w/o lens)	24C242
M12 mount (w/o lens)	24C245
No lens mount	24C247
CS-lens mount (w/o lens)	24C248

Table 8. Lens Mount Options

# 6. Dimensions

## 6.1 Dimensions

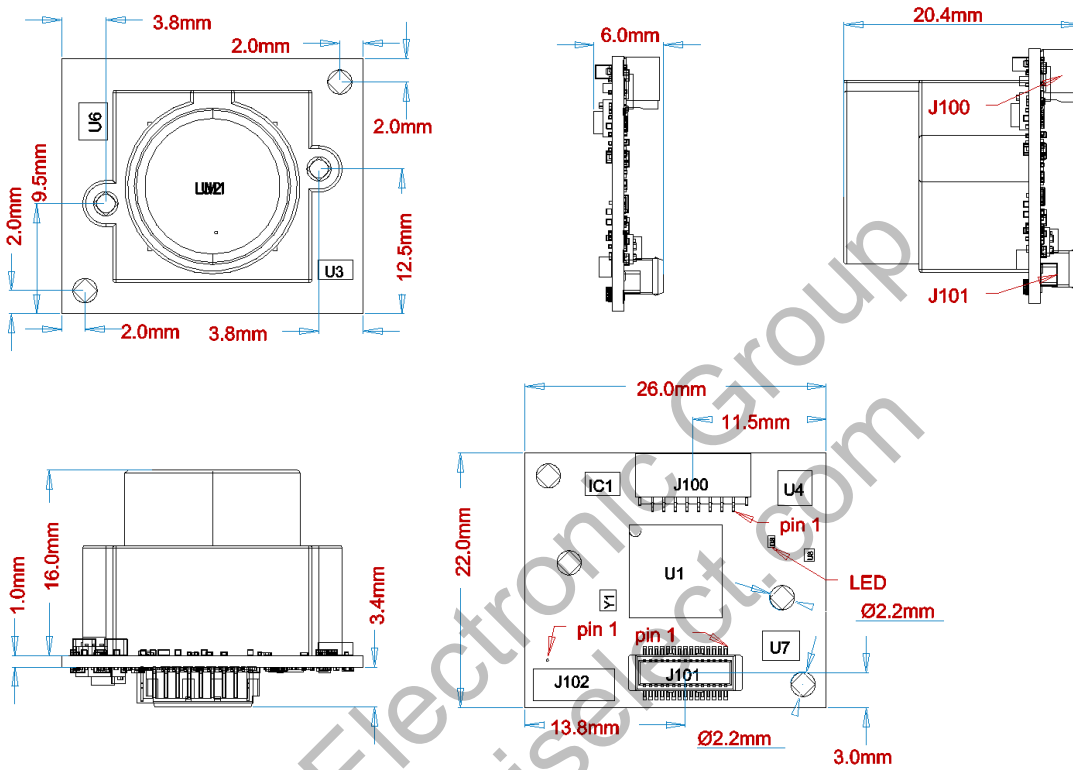


Figure 2 Camera Dimensions

# 7. Connectors

## 7.1 Connectors

Power/Control/Video	
Pin #	Function
1	Reserved
2	Ground
3	I <sup>2</sup> C SDA
4	I <sup>2</sup> C SCL
5	Video Ground
6	Video Out (TVI / AHD)
7	Ground
8	Power in 5V

Table 9. Main connector J100

Options	
Pin #	Function
1	ADC input (Reserved)
2	Reserved
3	Ground
4	Reserved
5	Reserved
6	Reserved

Table 10. Options connector J102

Board to board connector - MIPI		Board to board connector – BT.1120
Pin #	Function	Function
1	Ground	Ground
2	Ground	Ground
3	MIPI Clock P	DOUT 8
4	MIPI D3 P	DOUT 0
5	MIPI Clock N	DOUT 9
6	MIPI D3 N	DOUT 1
7	Unused	DOUT 10
8	MIPI D2 P	DOUT 2
9	Unused	DOUT 11
10	MIPI D2 N	DOUT 3
11	Unused	DOUT 12
12	MIPI D1 P	DOUT 4
13	Unused	DOUT 13
14	MIPI D1 N	DOUT 5
15	Unused	DOUT 14
16	MIPI D0 P	DOUT 6
17	Unused	DOUT 15
18	MIPI D0 N	DOUT 7
19	PCLK	PCLK
20	NC	NC
21	NC	NC
22	Ground	Ground
23	HSYNC	HSYNC
24	VSNC	VSNC
25	Reserved	Reserved
26	ADC input	ADC input
27	I <sup>2</sup> C SDA	I <sup>2</sup> C SDA
28	I <sup>2</sup> C SCL	I <sup>2</sup> C SCL
29	Video Out (TVI / AHD)	Video Out (TVI / AHD)
30	Power In 5V	Power In 5V

Table 11. Board to board connector J101

# 8. I<sup>2</sup>C Camera Communications

## 8.1 Communication interface specification

This camera uses I<sup>2</sup>C to control the camera's functions. The camera's I<sup>2</sup>C device address is programmable. The default camera I<sup>2</sup>C device (8-bit) address is: **0x70**.

Some aspects of the I<sup>2</sup>C protocol can be controlled by register settings:

- Clock stretch can be enabled or disabled (default enabled).
- Ack polling can be disabled or enabled (default enabled).
- A I<sup>2</sup>C status byte can be added to the result to reflect the I<sup>2</sup>C status (default disabled)

When clock stretch is disabled, the user must wait an undefined time before reading the data. I<sup>2</sup>C re-starts are not possible in this case.

Ack polling is used in case the Camera need to perform a task that takes longer than 25ms (conform I<sup>2</sup>C specification). When Ack polling is enabled, the camera will disable the I<sup>2</sup>C and re-enable I<sup>2</sup>C after the task is completed. The user can poll the I<sup>2</sup>C bus by writing to the I<sup>2</sup>C bus. (Do not read to check if the I<sup>2</sup>C bus is available!)

### Check I<sup>2</sup>C bus ready command:

START 0X70 ACK/NAK STOP  
 → in case of NAK on I<sup>2</sup>C bus → retry

Or  
 START 0X70 0X00 ACK/NAK STOP  
 → in case of NAK on I<sup>2</sup>C bus → retry

### I<sup>2</sup>C read example, status byte disabled:

START 0X70 0X31 REGISTER START 0X71 REGISTER VALUE STOP

### I<sup>2</sup>C read example, status byte enabled:

START 0X70 0X31 REGISTER START 0X71 I<sup>2</sup>C STATUS REGISTER VALUE STOP

### 8.1.1 Camera I<sup>2</sup>C control

Most registers are accessible without password protection, some are protected, updating the ISP Firmware or Factory settings requires a password.

Command	Command description	Password Protected
0x30	8-bit Register Write	
0x31	8-bit Register Read	
0x32	16-bit Register Write	
0x33	16-bit Register Read	
0x34	32-bit Register Write	
0x35	32-bit Register Read	
0x40	ISP SPI-Flash Write	Yes
0x41	ISP SPI-Flash Read	Yes
0x42	ISP SPI-Flash Erase	Yes
0x43	ISP SPI-Flash get ID	Yes
0x44	ISP SPI-Flash Block Erase	Yes
0x45	ISP SPI-Flash get Status	Yes
0x47	ISP SPI-Flash get CRC	Yes
0x50	NVM Write	User space: No Factory space: Yes
0x51	NVM Read	No
0x52	NVM Erase All	Yes
0x61	Read Serial number	No
0xA0	ISP direct register access	Yes

Table 12. I<sup>2</sup>C Control

#### Reading an 8bit register examples:

START 0X70 0X31 REGISTER ADDRESS START 0X71 REGISTER VALUE STOP  
 Or  
 START 0X70 0X31 REGISTER ADDRESS STOP START 0X71 REGISTER VALUE STOP

#### Writing an 8bit register example:

START 0X70 0X30 REGISTER ADDRESS REGISTER VALUE STOP

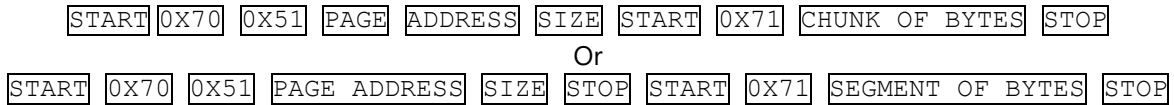
#### Read serial number:

START 0X70 0X61 START 0X71 READ 16 BYTES STOP  
 Or  
 START 0X70 0X61 STOP START 0X71 READ 16 BYTES STOP

The User NVM pages can be written to the cameras and both the User and Factory NVM pages can be read in chunks of 8, 16, 32 or 64 bytes (default is 16 bytes). Writing factory NVM page or erasing all NVM pages requires a password. There is no need to erase an NVM page before writing.

When Writing to NVM space make sure to write a full page of 256 bytes (in chunks). NVM pages are protected with a CRC. As defined in paragraph 0

**NVM Read Command:**



**NVM Write Command:**



**NVM Erase Command: (don't use, for testing/debugging only)**



**8.1.2 Bootloader I<sup>2</sup>C control**

Updating the Camera Firmware requires the Camera's bootloader. Once the bootloader is started the Camera's firmware can be updated. The Camera's firmware is protected with a CRC. If the CRC does not match, then the camera will always start the bootloader at power-on. A correct firmware image will have to be programmed to recover. To check if the camera started the bootloader the bootloader identifier can be read.

The I<sup>2</sup>C command interface for the bootloader is slightly different than the Camera's I<sup>2</sup>C commands. The Camera's bootloader I<sup>2</sup>C device address is always **0x70** and cannot be changed.

Command	Command description
0x38	Write Flash
0x39	Read Flash
0x41	Get Calculated CRC
0x44 0x01	Erase Flash
0x46 0x01	Reboot
0x47	Read Bootloader Identifier
0x00	Check I <sup>2</sup> C bus

Table 13. I<sup>2</sup>C Bootloader command interface

Updating the Firmware can be done in segments of 8, 16, 32 or 64 bytes, default is segments of 16 bytes (it is defined by the firmware image format). The camera will block the I<sup>2</sup>C bus when it is busy, any I<sup>2</sup>C command send when the camera is busy results in a NAK response on the I<sup>2</sup>C bus. This allows polling to check whether the camera's I<sup>2</sup>C is available. Always use a I<sup>2</sup>C write command to check. Use command 0x00 for checking the I<sup>2</sup>C bus.

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## 9. Detailed Register Information

### 9.1 Standard Control

Register	Default	Range	Description
0x01	0x80	0x00-0xFF	<b>Brightness</b>
0x57	0x80	0x00-0xFF	<b>Contrast</b>
0x55	0x00	0x00-0x03 Bit [1] Bit [0]	<b>Mirror</b> Horizontal mirror (flip) Vertical mirror
0x04	0x01	0x00-0xFF	<b>Gamma 0</b>
0x05	0x01	0x00-0xFF	<b>Gamma Black Correction 0</b> (0 – 10)
0x06	0x01	0x00-0xFF	<b>Gamma 1</b>
0x07	0x01	0x00-0xFF	<b>Gamma Black Correction 1</b> (0 – 10)
0x08	0x80	0x00-0xFF	<b>Hue</b> (degrees: -128° to +127°)
0x09	0x80	0x00-0xFF	<b>Saturation</b> 0x80 = 1x

Table 14. Standard Control

### 9.2 Gamma

Gamma can be set from 0.45 to 1.0 in steps of 0.05. (values: 0x0 to 0xB)

Register value	Gamma
0x00	0.45
0x01	0.50
0x02	0.55
0x03	0.60
0x04	0.65
0x05	0.70
0x06	0.75
0x07	0.80
0x08	0.85
0x09	0.90
0x0A	0.95
0x0B	1.00
0x0C-0x0F	-
0x10	Custom Gamma 0
0x11	Custom Gamma 1
0x13-0xFF	-

Table 15. Gamma

Two gamma tables and corresponding black correction can be selected. Gamma table 0 used in bright light conditions and table 1 is used in low light conditions, see Figure 3. To have a fixed gamma for all light conditions make table 0 and table 1 the same.

One User gamma curve is stored in user calibration NVM and can be selected by selecting a gamma of 0x10 or 0x11. These NVM tables are the same for normal and dark conditions.

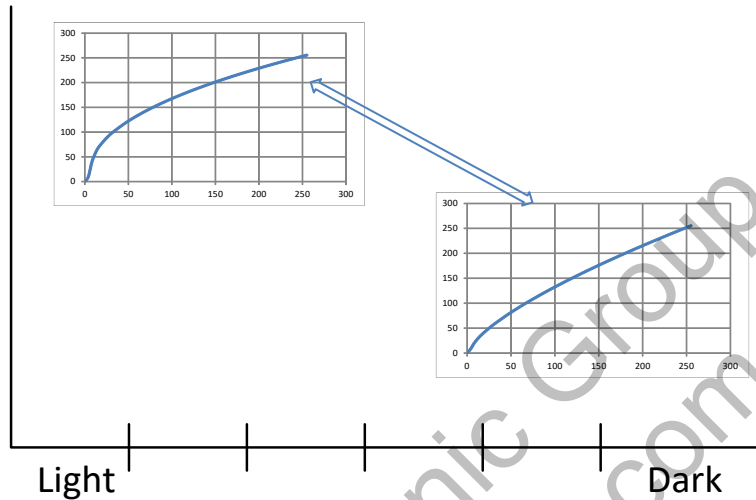


Figure 3 Gamma table 0 to table 1

The gamma will automatically change from bright light to low light conditions when both gamma tables are different. The ratios between table 0 and table 1 are stored in the Calibration parameters and are not directly accessible.

### 9.3 Black Correction

The gamma black correction can be set to adjust black in dark areas. Only the dark areas will be affected. The black level correction level can be set from 0 to 20. The higher the value the darker dark areas will become. *Figure 4* shows the black correction effect on a gamma curve of 0.45.

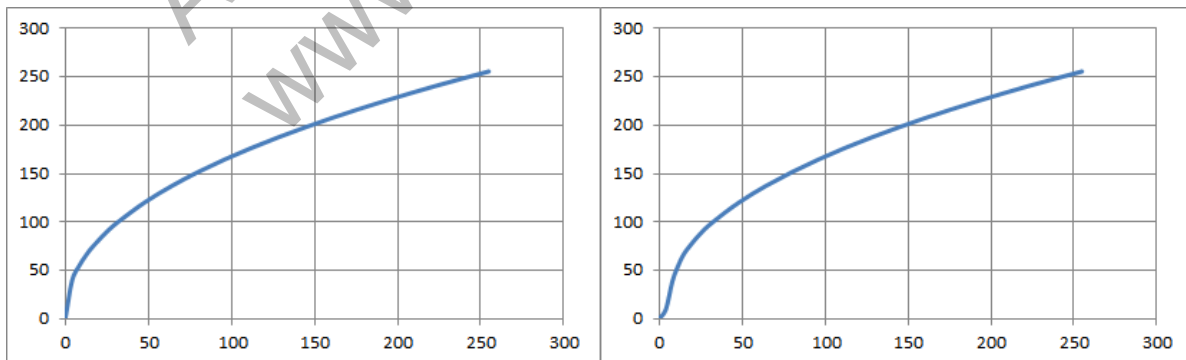


Figure 4 Black correction for gamma; left Gamma, right corrected Gamma curve

## 9.4 Hue & Saturation

Hue and saturation can be adjusted using register settings. It is possible to adjust hue and saturation for ambient light conditions using Cb/Cr matrixes. The coefficients of Cb/Cr matrixes for hue and saturation are stored in the NVM calibration parameters and are not directly accessible.

## 9.5 Automatic Exposure

Register	Default	Range	Description	
0x0A	0x03	0x00-0xFF	Automatic Exposure Up Speed	
0x0B	0x03	0x00-0xFF	Automatic Exposure Down Speed	
0x0C	0x0C	0x00-0xFF	Automatic Exposure Hysteresis	
0x0D	0x18	0x00-0xFF	<b>Automatic Exposure Digital Gain Limit</b> Default = 1.5x Bits[7:4] = 0-15x Bits[3:0] = fraction 1/16 <sup>th</sup>	
0x0E	0x40	0x01-0x7F	<b>AEX Analogue Gain Limit</b>	
0x0F	0x00	0x00-0x03 Bit[1:0]  Bit[7]	<b>Exposure Mode</b> 0 - Automatic 1 - Full Manual (Shutter/Analog Gain/ Digital Gain) 2 - Manual Exposure Fine = 0, Fixed = 1	
0x10	0x01	0x01-0xFF	<b>Manual exposure Analogue Gain</b>	
0x11	0x80	0x00-0xFF	<b>Manual Exposure Shutter</b> 0 = off 0xFF = max shutter	
0x12	0x0D 13 <sub>10</sub>	0x00-0x25	<b>Manual Exposure - Fixed Shutter time</b>	
			Register	Shutter (s)
			0	1/25
			1	1/30
			2	1/40
			3	1/45
			4	1/50
			5	1/60
			6	1/70
			7	1/75
			8	1/80
			9	1/90
			10	1/100
			11	1/120
			12	1/125
			13	1/150
			14	1/200
			15	1/250
			16	1/300
17	1/400			
18	1/500			

			19	1/600
			20	1/700
			21	1/750
			22	1/800
			23	1/900
			24	1/1000
			25	1/2000
			26	1/3000
			27	1/4000
			28	1/5000
			29	1/6000
			30	1/7000
			31	1/8000
			32	1/9000
			33	1/10000
			34	1/20000
0x13	0x80	0x02-0xFF	<b>Automatic Exposure Set Target Weight</b> AEX reference level	
0x14	0x00	0x00 – 0x06	<b>Anti Flicker</b>	

Table 16. Automatic Exposure

### 9.5.1 Automatic Exposure

A higher target reference level will result in brighter video. Regulation for exposure can be adjusted using the following parameters: Up Speed, Down Speed, Hysteresis, digital gain limit and analogue gain limit. Making the speed too fast or making the hysteresis too small will result in oscillations. To limit the noise the digital gain can be limited. For the least noise digital gain limit can be set to 1. To get the most sensitivity the gain limits can be set to maximum, but at low light this will result in a noisy picture.

### 9.5.2 Full Manual Exposure

In manual exposure mode the shutter time and gain can be set. The shutter can be controlled by either using fixed shutter times or a variable shutter time ranging from 0 to 255. A digital gain value below 0x10 will result in gains below 1x, this should be avoided in normal conditions.

Register	Default	Range	Description
0x1A	0x01	0x10-0xFF	<b>Manual Exposure Digital gain</b> 0x10 = 1x 0x20 = 2x

Table 17. Full Manual Exposure

### 9.5.3 Manual Exposure

Manual exposure mode will calculate the best shutter and gain according to a single exposure value.

Register	Default	Range	Description
0x47	0x10	0x00 – 0xFF	Manual Exposure Value
0x48	R	0x00 – 0xFF	Exposure Low Byte
0x49	R	0x00 – 0xFF	Exposure Mid Byte
0x4A	R	0x00 – 0xFF	Exposure High Byte
0x4B	R	0x00 – 0xFF	Exposure Top Byte

Table 18. Manual Exposure

The total exposure value is a 32bit number defined in Top, High, Mid and Low byte. This number is derived from the Exposure value in register 0x47 and the setting of the Analog Gain Limit and the Digital Gain Limit. When selecting Manual Exposure Mode, it is best to set the Analog Gain to zero and the digital gain limit to 0x10 (=1x) and adjust the exposure value. If the exposure is too low increase the Analog Gain Limit or the Digital Gain Limit and re-adjust the exposure value.

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### 9.6 Backlight Compensation

Register	Default	Range	Description
0x15	0x03	0x01 – 0xFF	AE window weight 0
0x16	0x02	0x01 – 0xFF	AE window weight 1
0x17	0x01	0x01 – 0xFF	AE window weight 2
0x18	0x01	0x01 – 0xFF	AE window weight 3
0x80	0xFF	0x00 – 0xFF	AE Window row 0
0x81	0xFF	0x00 – 0xFF	AE Window row 1
0x82	0xFF	0x00 – 0xFF	AE Window row 2
0x83	0xFF	0x00 – 0xFF	AE Window row 3
0x84	0xFF	0x00 – 0xFF	AE Window row 4
0x85	0xFF	0x00 – 0xFF	AE Window row 5
0x86	0xFF	0x00 – 0xFF	AE Window row 6
0x87	0xFF	0x00 – 0xFF	AE Window row 7

Table 19. Backlight Compensation

The backlight compensation window cannot be made visible on the screen. The Weight factor determines the weight of the region defined in the picture below.

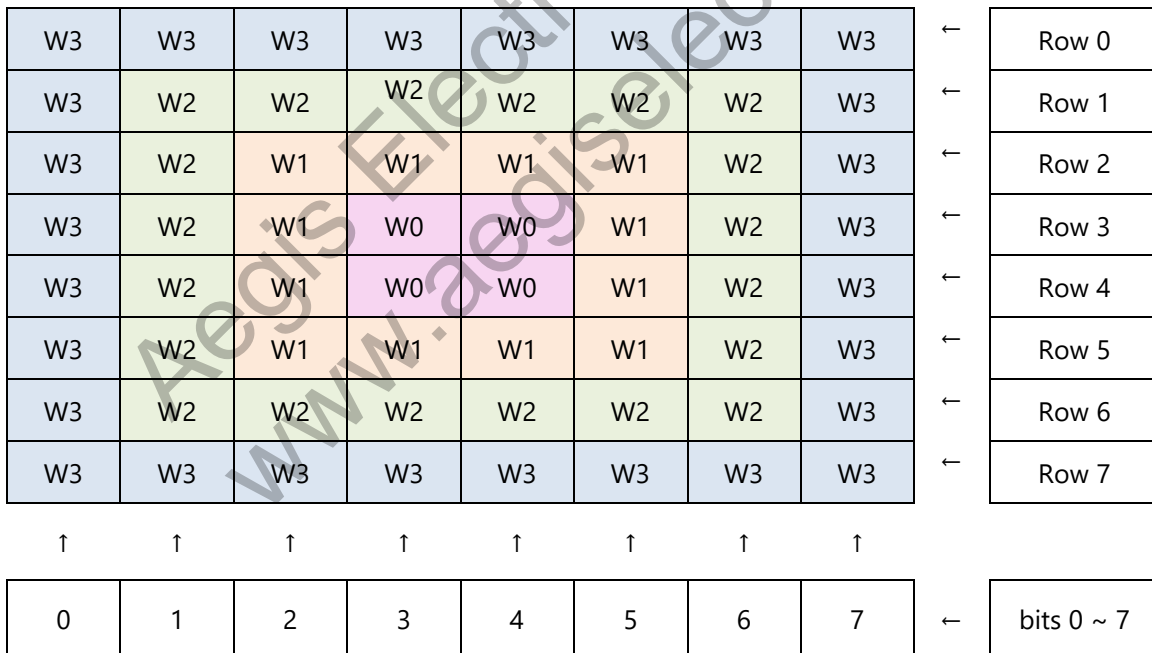


Figure 5 BLC windows

Each region in the 8 x 8 AE Window can be enabled or disabled using the AE Window row registers. Only enabled regions will be used to regulate the exposure.

### 9.7 Automatic White Balance

Register	Default	Range	Description
0x1B	0x00	0x00-0xFF W: 0x00 W: 0x01 W: 0x10 W: 0x90 R: 0x11	<b>White Balance Mode</b> Auto Manual Push-to-White (auto, 3 seconds) Push-to-White (manual) Push-to-White-set.
0x1C	0x00	0x00-0x78	White Balance Window X Start Position
0x1D	0x00	0x00-0x44	White Balance Window Y Start Position
0x1E	0x78	0x00-0x78	White Balance Window X Size
0x1F	0x78	0x00-0x44	White Balance Window Y Size
0x20	0x02	0x00-0xFF	White Balance Speed
0x21	0x06	0x00-0xFF	White Balance Hysteresis (Dead zone)
0x22	0x5D	0x00-0xFF	White Balance Red Gain Low byte
0x23	0x00	0x00-0x01	White Balance Red Gain High Byte
0x24	0x40	0x00-0xFF	White Balance Green Gain Low byte
0x25	0x00	0x00-0x01	White Balance Green Gain High Byte
0x26	0x5E	0x00-0xFF	White Balance Blue Gain Low byte
0x27	0x00	0x00-0x01	White Balance Blue Gain High Byte

Table 20. Automatic White Balance

The automatic white balance regulation window cannot be made visible on the screen. Position values that are out of range will result in max screen size. The size value is added to the position value but truncated to max screen size.

The automatic white balance regulation can be enabled and disabled. When enabled the AWB regulation uses the AWB window. The position and size of the AWB window can be adjusted. By default the AWB window is set to maximum.

AWB regulation can be adjusted using the speed and the Hysteresis setting. Setting the speed too fast or the hysteresis too small can result in oscillations. In automatic AWB mode, the Green gain is fixed and the Red and Blue gains are automatically adjusted.

The Push-To-White function will adjust the white balance automatically for a maximum of 3 seconds, or when the white point has been found. When the push-to-white function completes the AWB will be in manual mode and the mode register read-back value is: Push-to-White-set (0x11). The push-to-white-set value can be stored in NVM, so the camera always starts with this setting activated.

*Note: The automatic Push-to-White (0x10) function can take up to 3 seconds. The manual Push-to-White (0x90) requires the I<sup>2</sup>C bus master to set the AWB to auto (0x00) for at least 3 seconds, then give the manual Push-to-White (0x90) command. When the Function completes the AWB will be in manual mode and the register read-back value is: Push-to-White-set (0x11).*

## 9.8 Manual White Balance

When AWB is set to manual the Red, Green and Blue gain can be adjusted from 0 to 0x1FF.

### 9.8.1 Manual White Balance Correction

Register	Default	Range	Description
0x28	0x00	0x00-0xFF Bit[0]	AWB Ratio Mode 0 = auto, 1 =manual
0x29	0x80	0x00-0xFF	White Balance Red-to-Green Ratio
0x2A	0x80	0x00-0xFF	White Balance Blue Red-to-Green Ratio

Table 21. Manual White Balance Correction

The AWB ratios for automatic mode are stored in the NVM calibration parameters and are not directly accessible.

### 9.8.2 Color Correction Matrix

Color reproduction can be adjusted using the Color Correction Matrix.

In automatic mode the matrixes in the calibration parameters are used and are automatically adjusted for ambient light. In Manual mode, the CCM coefficients can be set using the registers below. In manual mode, color is no longer automatically adjusted and the coefficients of the color matrix M11 to M33 are used.

Register	Default	Range	Description
0x2B	0x00	0x00-0xFF Bit[0]	White Balance CCM Mode WB Mode 0 = auto, 1 =manual
		Bit[1]	Read CCM register values for selected color temperature and store the values in I2C software registers 0x2C .. 0x34
		Bit[2]	restore default calibration from NVM, this will update color tables inside the ISP using NVM
		Bit[3]	only valid if bit[0] set to manual when this bit is set the selected color table is used for initial values
		Bit[6:4]	These bits set the selected color table 0=currently active values M11..M33 Other values select the appropriate ISP registers 1=Low, 2=MidLow, 3=MidHigh, 4=High
0x2C	0x27	0x00-0xFF	WB Color Correction Table M11
0x2D	0x83	0x00-0xFF	WB Color Correction Table M12
0x2E	0x84	0x00-0xFF	WB Color Correction Table M13
0x2F	0x90	0x00-0xFF	WB Color Correction Table M21
0x30	0x33	0x00-0xFF	WB Color Correction Table M22

0x31	0x83	0x00-0xFF	WB Color Correction Table M23
0x32	0x89	0x00-0xFF	WB Color Correction Table M31
0x33	0x96	0x00-0xFF	WB Color Correction Table M32
0x34	0x3F	0x00-0xFF	WB Color Correction Table M33

Table 22. Auto / Manual Color Correction

The coefficients of color matrixes for automatic mode are stored in the EEPROM calibration parameters and are not directly accessible.

When register value < 0x80 then coefficient = value / 32

When register value ≥ 0x80 then coefficient = (128 – value) / 32

	R	G	B
R	M11 = 1.219	M12 = -0.094	M13 = -0.125
G	M21 = -0.500	M22 = 1.594	M23 = -0.094
B	M31 = -0.281	M32 = -0.688	M33 = 1.969

Table 23. Default CCM matrix coefficients

## 9.9 Lens Shading Compensation

Registers for controlling Lens shading compensation are shown below.

Register	Default	Range	Description
0x35	0x01	0x00-0x01	Lens shading compensation Enable
0x36	0x58	0x00-0xFF	Lens shading compensation RG Ratio
0x37	0x66	0x00-0xFF	Lens shading compensation GG1 Ratio
0x38	0x66	0x00-0xFF	Lens shading compensation GG2 Ratio
0x39	0x58	0x00-0xFF	Lens shading compensation BG Ratio
0x3A	0x0C	0x00-0xFF	Lens shading compensation Scale
0x3B	0xF4	0x00-0xFF	Lens shading compensation X-Position
0x3C	0x00	0x00-0xFF	Lens shading compensation Y-Position

Table 24. Lens Shading Compensation

Lens shading compensation can be enabled or disabled. All Bayer pixels can be adjusted: Red, Green1, Green2 and Blue. The R, G, B ratios behaves like extra gain or attenuation from the center towards the edges of the lens. The center position can be adjusted using the X and Y position registers. The scale adjusts the curvature of the adjustment.

To tune the lens shading correction, point the camera to a full grey (or white) image.

1. Set the scale register to maximum and set the R, G1, G2 & B ratio registers to the mid setting. You will see a dark spot in the image.
2. Use the position X and Y register to center the spot exactly in the middle of the image.
3. Change scale setting to a lower setting so that a small discoloration is visible on the outside or in the corners of the image. Adjust the R, G1, G2 & B ratio registers to correct the corners of the image

without discolorisation. This last step may take a few iterations.  
In the first iteration make sure R, G1, G2 and B ration are set at the same value.

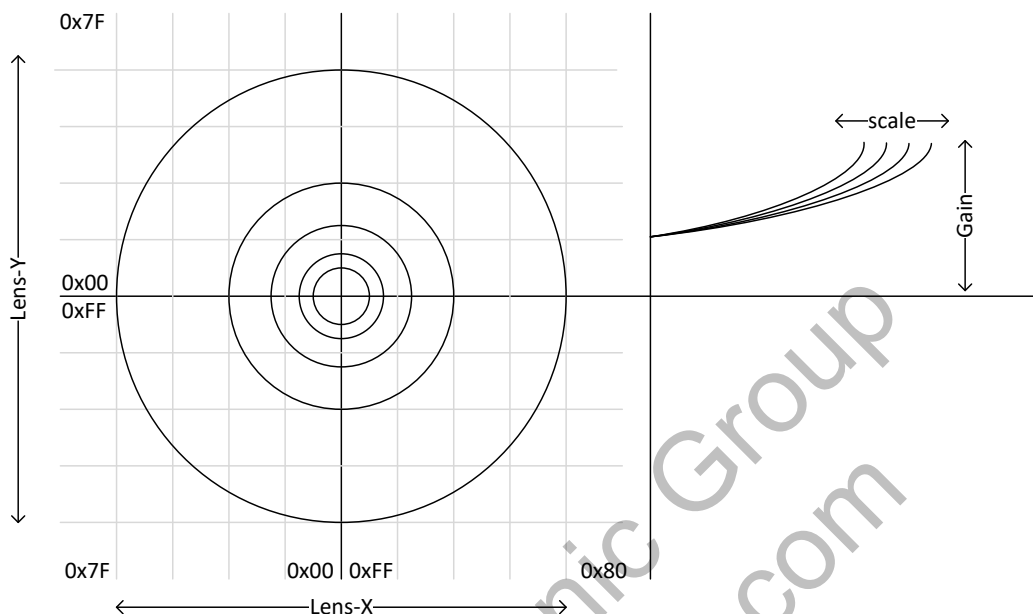


Figure 6 Lens shading compensation

### 9.10 Edge Enhancement

Register	Default	Range	Description
0x3D	0x07	0x00-0x07	<b>Edge Enhancement</b> Bit[0] Enable edge enhancement 0=off, 1=on Bit[2:1] reserved Bit[5:3] reserved Bit[7] Show edge
0x3E	0x20	0x00-0xFF	Edge Enhancement Level
0x41	0x08	0x00-0xFF	Edge Threshold

Table 25. Edge Enhancement

Sharpness can be adjusted using the edge enhancement registers. A higher level increases the sharpness. A threshold can be set to prevent increasing image noise, this however will also limit the amount of edge enhancement.

## 9.11 Noise Reduction

Register	Default	Range	Description
0x3F	0x01	0x00-0x01	Noise Reduction Enable 1 is on, 0 is off
0x40	0x0C	0x00-0xFF	Noise Reduction Level
0x44	0x20	0x00-0x3F	Noise Reduction DPC Level

Table 26. Noise Reduction

A higher value for noise reduction reduces the amount of noise. Keep in mind this will also lower the sharpness. There is always a tradeoff between noise reduction and edge enhancement or sharpness.

### 9.11.1 Defect Pixel Correction Filter

The defect pixel noise reduction filter can filter defect pixel noise and is enabled when the register value is greater than zero. The higher the DPC level the more blurred the picture will become. It is disabled when the register value is zero. Advice is to only use low levels of DPC.

### 9.11.2 Push to White gain settings (read only)

Register	Default	Range	Description
0x60	0x40	0x00-0xFF	Red gain low byte
0x61	0x00	0x00-0x20	Red gain High byte
0x62	0x40	0x00-0xFF	Green gain Low byte
0x63	0x00	0x00-0x20	Green gain high byte
0x64	0x40	0x00-0xFF	Blue gain Low byte
0x65	0x00	0x00-0x20	Blue gain high byte

Table 27. Push to White gain settings (read only)

These registers can be used to read back the RGB gain of the AWB system. This can be used to determine the RGB gains in current ambient lighting in order to set the RGB gains for manual mode. Write a dummy value to the register to update GAIN value, then read GAIN value.

### 9.11.3 Color Correction gain settings (read only)

Register	Default	Range	Description
0x66	0x40	0x00-0xFF	Red gain low byte
0x67	0x00	0x00-0x20	Red gain High byte
0x68	0x40	0x00-0xFF	Green gain Low byte
0x69	0x00	0x00-0x20	Green gain high byte
0x6A	0x40	0x00-0xFF	Blue gain Low byte
0x6B	0x00	0x00-0x20	Blue gain high byte

Table 28. Color Correction gain settings (read only)

These registers are read-only showing the actual settings.

## 9.12 Analog Output Controls

Register	Default	Range	Description
0x70	RW	0x00-0xFF Bit[0] Bit[1] Bit[2] Bit[3]	Control Hue enable Saturation enable Brightness enable Contrast enable
0x71	RW	0x00-0xFF	Contrast
0x72	RW	0x00-0xFF	Brightness
0x73	RW	0x00-0xFF	Saturation
0x74	RW	0x00-0xFF	Hue
0x75	RW	0x00-0xFF	Y-Gain
0x76	RW	0x00-0xFF	U-Gain
0x77	RW	0x00-0xFF	V-Gain
0x78	RW	0x00-0xFF	Cb-Offset
0x79	RW	0x00-0xFF	Cr-Offset

Table 29. Analog Output Controls

Analog output control registers allow control over the analog output signal (not to be confused with the digital imaging processing control registers 0x00-0x08). These registers should be used to adapt the analog signal to outside conditions like cable impedance mismatch or signal losses. These registers can also be used to adapt the video to the user's preference.

### 9.12.1 Current Screen Resolution (read only)

Register	Default	Range	Description
0xD0	RO	0x00-0xFF	Vertical resolution high byte
0xD1	RO	0x00-0x20	Vertical resolution low byte
0xD2	RO	0x00-0xFF	Horizontal resolution high byte
0xD3	RO	0x00-0x20	Horizontal resolution low byte

Table 30. Current Screen Resolution

These read only registers show the resolution of the output signal. To calculate the actual resolution, use this formula:  $Resolution = (high\ byte * 0x100) + Low\ byte$

## 9.13 ISP Power Management (read only)

Register	Default	Range	Description
0xDE	RW	0x00-0xFF	Reserved use

Table 31. ISP Power Management

*Do not use. This register allows some internal circuits of the ISP to be switched off and may damage the camera.*

### 9.14 GPIO

The GPIO can be controlled using register 0xE0.

Register	Default	Range	Description
0xE0	RW	0x00-0xFF Bit[0] Bit[7]	GPIO control GPIO level GPIO mode 0 = open-drain, 1 = push-pull

Table 32. GPIO

Write 0x01 = INPUT, open-drain, high, weak pull-up

Write 0x00 = OUTPUT, open-drain, low

Write 0x81 = OUTPUT, push-pull, high

Write 0x80 = OUTPUT, push-pull, low

*Note: Use only open-drain 0x01 mode for input function!*

### 9.15 Camera status

Register	Default	Range	Description
0xE8	WO	0x00-0xFF	0x01 - Camera state 0x02 - Is password set?
0xE9	RO	State values:  Password:	0 - STARTUP_STATE, 1 - INIT_STATE, 2 - NORMAL_OPERATING_STATE, 3 - UPGRADE_STATE 4 - CHECKING_STATE, 5 - ERROR_STATE, 6 - LOAD_DEFAULTS_STATE, 7 - DEBUG_STATE  0 - Password is not set 1 - Password is set

Table 33. Status Control

Status command is used to ask the camera for status on certain aspects of the camera. The result can be read in register 0xE9. The availability of the result may take a little time, up to 10ms can be expected before reading the result register succeeds.

## 9.16 Upgrade State

Register	Default	Range	Description
0xEB	R/W	0x00-0xFF	0x18 – Normal Operating 0x81 - Upgrade

Table 34. Upgrader (R/W)

This register allows changing the state the camera is operating in. The camera firmware is quite busy during normal operation. When changing the camera state to Upgrader state the camera will no longer make any changes to the video and control processing will be halted. I<sup>2</sup>C will be set to ACK Polling mode. Use this mode to Update the ISP firmware. To exit the upgrade mode without updating then return to the "Normal Operating" mode after updating the reboot command is or a power cycle is required.

### 9.16.1 ISP Firmware Version

Register	Default	Range	Description
0xEC	RO	0x00-0xFF	Minor number
0xED	RO	0x00-0xFF	major number

Table 35. ISP Firmware Version

### 9.16.2 NVM User Space Version

Register	Default	Range	Description
0xEE	RO	0x00-0xFF	NVM version Minor number
0xEF	RO	0x00-0xFF	NVM version Major number

Table 36. NVM User Space Version

### 9.16.3 NVM Factory Version

The NVM Version of the factory register configuration cannot be written or stored. When factory settings are restored to the User settings the version shown in the NVM User Version is the same as the Factory NVM version number. Factory Settings can be updated using the NVM write method, this however requires a password.

## 9.17 NVM Register Save/Restore and Restart Commands

This write-only register controls saving user settings, recovering to factory settings, restarting the camera and rebooting into bootloader for firmware update.

Register	Default	Password	Description
0xF0	WO	0x00-0xFF	<b>Save/Restore and Restart</b>
		No	0x01 - Save Register setting to User NVM space.
		-	0x02 - reserved.
		Yes	0x03 - Save Registers to Factory NVM space.
		-	0x04 - reserved.
		no	0x05 - Restore Registers from User NVM space.
		no	0x06 - Restore Registers from Factory NVM space.
		no	0x07 - Recover User NVM Register space from Factory space.
		no	0x08 - Recover User NVM Calibration space from Factory space.
		no	0x99 - Reboot.
		Yes	0xA5 - Reboot to bootloader.

Table 37. NVM Register Save/Restore and Restart Commands

Warning: Store & Recover functions take time, make sure to add enough delay after these commands have been issued!

### 9.17.1 Store Current Register Settings

This function stores the current register settings to NVRAM

### 9.17.2 Recover Factory Register Settings

This function restores the user stored register setting to its factory defaults. The camera needs to be restarted to use the factory default settings. This copies the factory register settings to the user register settings. User settings will be lost.

### 9.17.3 Recover Factory Calibration Parameters

This function restores the user Calibrations parameters to its factory defaults. The camera needs to be restarted to use the factory default settings. This copies the factory calibration parameters to the user calibration parameters settings. User settings will be lost.

### 9.17.4 Reboot

Reboot & restart the camera. Use this function after restoring to factory defaults.

### 9.17.5 Start Bootloader

If one needs to update camera firmware then the camera needs to be in Bootloader Mode. This function requires a password and does not recover by rebooting. After this function, the camera will always boot into bootloader, because the CHECKSUM stored in flash will be erased. Recovering can only be done by updating the firmware or by writing the original CHECKSUM back to flash. (use the READ CHECKSUM function for this purpose).

### 9.18 Camera Type and Framerate

Returns the camera framerate.

Register	Default	Range	Description
0xF1	R/W	0x00-0x07 0x01 0x02 0x03 0x04	<b>Camera Type</b> TVI 30fps TVI 25fps AHD 30fps AHD 25fps
0xF2	RO	0x00-0xFF 30 <sub>10</sub> 25 <sub>10</sub>	<b>Framerate</b> 30fps 25fps

Table 38. Camera Type and Framerate

Register 0xF1 must be manually adjusted to the proper value that matches the ISP binary file that is used.

### 9.19 Camera Model

Returns the camera model.

Register	Default	Range	Description
0xF3	RO	0x00-0xFF	Model

Table 39. Camera Model

### 9.20 Configuration Register

It is used to turn features on and off. The value can be stored permanently by writing it to NVM.

Register	Default	Range	Description
0xF4	0	0x00-0xFF Bit[0]	Must be set when USB board is connected

Table 40. Configuration Register

When set, the firmware reads the status of J101 pin 26. While this pin is *low* the ISP is held in reset mode, or it goes into reset mode. The software keeps monitoring this pin, when this input goes *high* the reset is released and the ISP will load its firmware and start producing output signals on the MIPI or BT.1120 bus lines. This allows a connected interface board, for instance USB or other, to start or stop the digital video stream coming out of the camera.

## 9.21 I<sup>2</sup>C Control

This register controls the I<sup>2</sup>C bus behavior.

Register	Default	Value	Description
0xF7	0x00	0x00-0x07	
		Bit[0]	0: Status Byte disabled 1: Status Byte enabled
		Bit[1]	0: ACK Polling enabled 1: ACK polling disabled
		Bit[2]	0: Enhanced clock stretch is enabled 1: Enhanced clock stretch is disabled

Table 41. I2C Control

### 9.21.1 I<sup>2</sup>C Status Byte

An extra status byte is transferred to the I<sup>2</sup>C bus master to indicate the data is valid when this mode is enabled. The I<sup>2</sup>C returns a zero byte before the data bytes when the data is valid. When the extra byte is non-zero then the data is not valid.

E.g., read from register 0x00: <0x70> <31> <0x00> <0x71> <status> <value>

When <status> is 0x00 then register <value> is valid.

### 9.21.2 I<sup>2</sup>C ACK Polling

In case the I<sup>2</sup>C master does not support clock stretch for I<sup>2</sup>C read commands using restart or clock stretch time exceeds 25ms or in case the I<sup>2</sup>C master has difficulty in meeting the specification ACK polling can be enabled. In this mode, the camera will disable the I<sup>2</sup>C interface after every command and only re-enable the I<sup>2</sup>C interface when the data is available. This allows the I<sup>2</sup>C master to poll the I<sup>2</sup>C bus; only when the I<sup>2</sup>C is re-enabled will the camera respond, thus eliminating the need for adding delays, because the I<sup>2</sup>C master can poll. Disabling ACK polling and disabling clock stretch will require delays between write and read commands.

### 9.21.3 Enhanced I<sup>2</sup>C Clock Stretch

Clock stretch is always enabled and can be enhanced for I<sup>2</sup>C reads using restart, by making bit[2] zero, this function will add extra clock stretch to give the camera time to prepare data to be read. When this bit is set to 1 the extra clock stretch is disabled and only stretch for I<sup>2</sup>C protocol handling is done. Disabling I<sup>2</sup>C stretch may require delays between writing command and reading the result. Max clock-stretch time is 25ms (according to the I<sup>2</sup>C specification). When the stretch time has exceeded 25ms, the camera will reset the I<sup>2</sup>C interface. The master will have re-send the command.

## 9.22 Bootloader

This write-only register controls a reboot or reboot into the boot loader.

Register	Default	Value	Description
0xF8	WO	0x01	Reboot
		0x02	Reboot into bootloader

Table 42. Bootloader

Reboot the camera into the bootloader. Use this to update the firmware. Firmware can only be updated from the bootloader. This function requires a password and does not recover by rebooting. After this function, the camera will always boot into bootloader, because the CHECKSUM stored in flash will be erased. Recovering can only be done by updating the firmware or by writing the original CHECKSUM back to flash. (use the bootloader's READ CHECKSUM function for this purpose)

### 9.23 Firmware Status

This register provides information about the firmware status.

Register	Default	Range	Description
0xFB	RO	0x00-0xFF	A non-zero value indicates preliminary, test or debug version. This register should read back zero for released firmware versions.

Table 43. Firmware Status

### 9.24 Password Protection

Writing to these write-only registers allows access to the password restricted functions.

Register	Default	Range	Description
0xFC	WO	0x00-0xFF	Password MSB
0xFD	WO	0x00-0xFF	Password LSB

Table 44. Password Protection

### 9.25 Microcontroller Software Version

The Software Version of the Microcontroller can be read via registers 0xFE-0xFF.

Register	Default	Range	Description
0xFE	RO	0x00-0xFF	Firmware version Minor number
0xFF	RO	0x00-0xFF	Firmware version Major number

Table 45. Microcontroller Software Version

## 10. Updating the Firmware

---

The camera's firmware can be updated. There are 3 parts that can be updated:

1. The Non-Volatile register and calibration-parameter spaces
2. The Microcontroller Firmware
3. The Image Processor (ISP) Firmware

The NVM and ISP Firmware can be updated while the camera is in normal operating mode, however the controller firmware can only be updated when the bootloader is started.

In normal operating mode the camera can be set to updating state by giving the upgrader command (write 0x81 to register 0xEB). Updating state is required for the ISP firmware update.

### 10.1 Non-volatile register and calibration parameters

The NVM space can be updated while the camera is operating normally. There are 4 NVM spaces (or pages) each containing 256 bytes.

1. User register settings
2. User calibration parameters
3. Factory register settings (requires a password for writing)
4. Factory calibration parameters. (Requires a password for writing)

When registers are stored using the register-store command the User register NVM space is used. The user register and user calibration space can be updated from an image file (\*.img).

The User NVM pages can be written to the cameras and both the User and Factory NVM pages can be read in segments of 8, 16, 32 or 64 bytes. Writing factory NVM page or erasing all NVM pages requires a password. There is no need to erase an NVM page before writing.

When Writing to NVM space make sure to write a full page of 256 bytes (in segments). NVM pages are protected with a CRC. If the CRC of User spaces does not match, then the camera will automatically copy the Factory settings to the User settings at power-on.

When the CRC of the Factory settings does not match, then the camera will boot but remain in update-mode until the Factory settings are programmed and the camera is re-started.

Only the NVM Read and Write command should be used, the Erase command is for testing/debugging purpose and erases all 4 NVM spaces (including the Factory settings)

**NVM Read Command:**

START	0X70	0X51	PAGE ADDRESS	SIZE	START	0X71	SEGMENT OF BYTES	STOP
-------	------	------	--------------	------	-------	------	------------------	------

Or

START	0X70	0X51	PAGE ADDRESS	SIZE	STOP	START	0X71	SEGMENT OF BYTES	STOP
-------	------	------	--------------	------	------	-------	------	------------------	------

**NVM Write Command:**

START	0X70	0X50	PAGE ADDRESS	CHUCK OF DATA BYTES	STOP
-------	------	------	--------------	---------------------	------

 → in case of NAK on I<sup>2</sup>C bus → retry

**NVM Erase Command:** *(don't use, for testing/debugging only)*

START	0X70	0X52	PAGE	STOP
-------	------	------	------	------

**10.1.1 NVM image format**
**NVM Memory Map**

0x0000 – 0x00FF = User register space  
 0x0100 – 0x01FF = User calibration space  
 0x0200 – 0x02FF = Factory register space  
 0x0300 – 0x03FF = Factory calibration space

**Special addresses**

0x0nEE 0x0nEF = version number for User or Factory space  
 0x0nFC 0x0nFD = NVM block identifier  
 0x0nFE 0x0nFF = CRC

**Version number**

0xnn 0xmm = version nn.mm

**Block Identifier**

0x01 0x00 = User Register space  
 0x02 0x00 = User calibration space  
 0x00 0x01 = Factory register space  
 0x00 0x02 = Factory calibration space

**CRC**

0xnn 0xmm = CRC = 0xmmnn

**16-bit CRC Algorithm**

The CRC is defined as CCITT-16 16-bit polynomial (0x1021), equivalent to the following algorithm:

1. XOR the input with the most-significant bits of the current CRC result. If this is the first iteration of the CRC unit, the current CRC.
2. result will be the set initial value (0xFFFF).
3. If the MSB of the CRC result is set, shift the CRC result and XOR the result with the polynomial.
4. If the MSB of the CRC result is not set, shift the CRC result.
5. Repeat steps 2 and 3 for all 8 bits.

The algorithm is described in the following example.

```
unsigned short UpdateCRC (unsigned short CRC_acc, unsigned char CRC_input)
{
    unsigned char i; // loop counter
    #define POLY 0x1021
    // Create the CRC "dividend" for polynomial arithmetic (binary arithmetic
    // with no carries)
    CRC_acc = CRC_acc ^ (CRC_input << 8);
    // "Divide" the poly into the dividend using CRC XOR subtraction
    // CRC_acc holds the "remainder" of each divide
    //
    // Only complete this division for 8 bits since input is 1 byte
    for (i = 0; i < 8; i++)
    {
        // Check if the MSB is set (if MSB is 1, then the POLY can "divide"
        // into the "dividend")
        if ((CRC_acc & 0x8000) == 0x8000)
        {
            // if so, shift the CRC value, and XOR "subtract" the poly
            CRC_acc = CRC_acc << 1;
            CRC_acc ^= POLY;
        }
        else
        {
            // if not, just shift the CRC value
            CRC_acc = CRC_acc << 1;
        }
    }
    // Return the final remainder (CRC value)
    return CRC_acc;
}
```

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### 10.1.2 NVM example

```
////////////////////////////////////  
// NVM contents  
// Date & Time: xx/xx/xxxx xx:xx:xx  
// Factory version: 0.0  
// User version: 0.0  
////////////////////////////////////  
// Start of page: 0 (User Registers)  
//// 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F  
0000 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0010 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0020 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0030 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0040 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0050 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0060 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0070 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0080 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0090 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
00A0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
00B0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
00C0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
00D0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
00E0 FF FF FF FF FF FF FF FF FF FF FF FF FF 00 00  
00F0 FF FF FF FF FF FF FF FF FF FF FF FF 01 00 36 46  
////////////////////////////////////  
// Start of page: 1 (User Calibration)  
//// 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F  
0100 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0110 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0120 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0130 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0140 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0150 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0160 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0170 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0180 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0190 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
01A0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
01B0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
01C0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
01D0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
01E0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
01F0 FF FF FF FF FF FF FF FF FF FF FF FF 02 00 6F 79  
////////////////////////////////////  
// Start of page: 2 (Factory Registers)  
//// 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F  
0200 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0210 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0220 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0230 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0240 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0250 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0260 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0270 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0280 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
0290 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
02A0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
02B0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
02C0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
02D0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  
02E0 FF FF FF FF FF FF FF FF FF FF FF FF 00 00
```



**Reboot Command:**

START 0X70 0X46 0X01 STOP

**Get Calculated CRC:**

START 0X70 0X41 STOP

Check I<sup>2</sup>C bus read until ACK

START 0X71 CRC LSB CRC MSB STOP

**Get Boot identifier:**

START 0X70 0X41 START 0X71 0XA5 0X5A STOP

Or

START 0X70 0X41 STOP START 0X71 0XA5 0X5A STOP

**10.2.2 Update sequence for the controller firmware**

Write the following commands to start the bootloader:

Write Password: write 0xnn to register 0xFC, write 0xmm to register 0xFD.<sup>1</sup>

Write 0xA5 to register 0xF0 to start the bootloader.

Wait 1 second for the bootloader to start.

Then erase the flash by writing command:

0X70 0X44 0X11

It takes some time to erase the flash. Use the check command to check when the I<sup>2</sup>C bus becomes available:

0X70 0X00

If NAK then check again until I<sup>2</sup>C gives an ACK

Write the firmware image in segments of 8, 16, 32 or 64 bytes.

(Check inside image file: *segmentsize = blocksize*)

Give the following command:

0X70 0X38 LSB ADDRESS MSB ADDRESS SEGMENT SIZE BYTE [0] . . . BYTE [SEGMENTSIZE]

*(In case the next segment write of data returns a NAK, then retry)*

In case the user wants to check the CRC, before the camera is rebooted to check whether the firmware update went correctly. The CRC can be read back from the camera, the camera will calculate the CRC of the image stored in flash and return the CRC value (this takes some time). Use the following command sequence:

0X70 0X41

Wait until I2C becomes available by sending the check command:

0X70 0X00

<sup>1</sup> The password is provided upon customer request only!!

If NAK then check again until I<sup>2</sup>C gives an ACK  
Now read the CRC by reading 2 bytes:

`0x70` `LSB OF CRC` `MSB OF CRC`

Compare the CRC with the following bytes located inside the firmware image, the Firmware image can be opened using a text editor.

See comments at start of firmware image (see paragraph 10.2.3 for the image format)

The camera can then be rebooted using the newly programmed firmware, using the following command:

`0x70` `0x46` `0x01`

### 10.2.3 Firmware image format

0x1A00 = start of Firmware

0xF3F0 = LSB of CRC

0xF3F1 = MSB of CRC

0xF3F4 = LSB of firmware size

0xF3F5 = MSB of firmware size

0xF400 = User registers settings

0xF500 = User calibration parameters

0xF600 = Factory registers settings

0xF700 = Factory calibration parameters

0xF7FF = Last byte of image

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## 10.2.4 Firmware image example

```
// Intel-Hex File  origin.hex
// Date & Time: xx-xx-xxxx xx:xx:xx
// CRC  = 0x0000XXXX
// Size = 0xXXXX
[TOTALSIZE = nnnnn]
[BLOCKSIZE = 16]
////////////////////////////////////
// 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
1A00 02 A4 DC 78 0E EB F2 08 EA F2 08 E9 F2 08 ED F2
1A10 08 E2 F9 08 E2 FA 08 E2 78 1D C9 F2 08 EA F2 08
1A20 E9 F2 C2 01 7F B2 12 D4 E1 EF 30 E0 2B 78 12 E2
1A30 FB 08 E2 FA 08 E2 24 01 F9 E4 3A FA 78 1A EB F2
...
F3D0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
F3E0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
F3F0 E4 E4 FF FF F0 D9 FF FF FF FF FF FF FF FF FF
F400 00 01 02 03 04 06 08 0C 10 18 20 28 30 40 50 60
F410 80 A0 C0 E0 FF 00 01 02 03 04 06 08 0C 10 18 20
F420 28 30 40 50 60 80 A0 C0 E0 FF 00 01 02 03 04 06
...
F4F0 FF FF FF FF FF FF FF FF FF FF FF FF 00 02 A6 EB
F500 FF 00 80 80 80 80 01 00 00 A0 20 50 01 C0 10 40
F510 40 10 40 40 06 80 0A FF 00 00 FF FF FF FF FF FF
...
F5F0 FF FF FF FF FF FF 70 02 FF FF FF FF 00 01 A7 54
F600 00 01 02 03 04 06 08 0C 10 18 20 28 30 40 50 60
F610 80 A0 C0 E0 FF 00 01 02 03 04 06 08 0C 10 18 20
...
F6F0 FF FF FF FF FF FF FF FF FF FF FF FF 02 00 86 AD
F700 FF 00 80 80 80 80 01 00 00 A0 20 50 01 C0 10 40
F710 40 10 40 40 06 80 0A FF 00 00 FF FF FF FF FF FF
...
F7F0 FF FF FF FF FF FF 70 02 FF FF FF FF 01 00 B7 77
```

### In case of 32-byte segment size

```
// Intel-Hex File  origin.hex
// Date & Time: xx-xx-xxxx xx:xx:xx
// CRC  = 0x0000XXXX
// Size = 0xXXXX
[TOTALSIZE = nnnnn]
[BLOCKSIZE = 32]
////////////////////////////////////
// 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
1A00 02 A4 DC 78 0E EB F2 08 EA F2 08 E9 F2 08 ED F2 08 E2 F9 08 E2 FA 08 E2 78 1D C9 F2 08 EA F2 08
1A20 E9 F2 C2 01 7F B2 12 D4 E1 EF 30 E0 2B 78 12 E2 FB 08 E2 FA 08 E2 24 01 F9 E4 3A FA 78 1A EB F2
1A40 08 EA F2 08 E9 F2 D2 01 08 E2 FB 08 E2 FA 08 E2 F9 74 FF 12 31 52 80 13 78 12 E2 F9 08 E2 FA 08
1A60 E2 78 1A C9 F2 08 EA F2 08 E9 F2 78 0E E2 FB 08 E2 FA 08 E2 F9 12 30 EA 12 34 91 1B 8B 30 1A CA
...

```

## 10.3 Updating the ISP Firmware

List of commands:

### Get Flash Id

Command = 0x90 or 0x9F

START 0X70 0X43 COMMAND START 0X71 DATA[1:0] STOP

### Get Flash Status

START 0X70 0X45 START 0X71 DATA[1:0] STOP

### Write flash command:

START 0X70 0X40 ADDRESS[7:0] ADDRESS[15:8] ADDRESS[23:16] SEGMENT OF DATABYTES

STOP

→ in case of NAK on I<sup>2</sup>C bus → retry until ACK

### Read Flash command:

START 0X70 0X41 ADDRESS[7:0] ADDRESS[15:8] ADDRESS[23:16] SEGMENT SIZE STOP

START 0X71 SEGMENT OF DATA BYTES STOP

→ in case of NAK on I<sup>2</sup>C bus → retry read from 0x71 until ACK

### Erase All command:

START 0X70 0X42 0X01 STOP

Check flash status until status is: 0X00 0X00

### Calculate Flash CRC

CRC calculation requires a starting address1 and ending address2. The Controller will calculate the CRC of the Flash range and return the CRC.

START 0X70 0X47 ADDRESS1[7:0] ADDRESS1[15:8] ADDRESS1[23:16] ADDRESS2[7:0]

ADDRESS2[15:8] ADDRESS2[23:16] STOP

Check I<sup>2</sup>C bus ready until ACK can take up to 50ms.

START 0X70 DATA[1:0] STOP

$$\text{CRC}[15:0] = (\text{Data}[1] \ll 8) + \text{Data}[0]$$

Procedure:

Read ID, read Status (0x0000 is OK else FAIL)

Erase Flash command, read status (0x0000 is OK else FAIL)

Write flash segments of data, Read Status (0x0000 is OK else FAIL)

CRC command to verify, if the CRC is not correct, then retry the procedure.

*Note: We recommend using the GUI tool or the python scripts that are available upon request.*

# 11. Calibration and Default Settings

## 11.1 Calibration Parameters

Calibration parameters are stored in EEPROM page 1 & page 3. The parameters in Page 1 are the modifiable user parameters and are set at camera start-up.

Page 3 contains the non-modifiable factory calibration parameters; these parameters are used to restore the camera to factory default.

Below shows the full parameter structure stored in page 1 and in page 3 of the EEPROM:

```
typedef struct {
    cal_control_t control;
    cal_ae_t ae;
    cal_awb_t awb;
    cal_optimize_t optimize;
    uint8_t dummy[10];
} ppcalibrate_t;
```

```
typedef struct {
    uint8_t control_Contrast[6];
    uint8_t control_CustomGamma0[65]; // Custom gamma curve 0
} cal_control_t;
```

```
typedef struct {
    uint8_t Ref[3][2]; // (Ymax, Ymin)
    uint8_t SatTh[2]; // RGBSat, YSat
    uint8_t SatRatio[4]; // SetSaturationRatios
    uint8_t SatWeight; // SetSaturationWeight
} cal_ae_t;
```

```
typedef struct {
    uint8_t awb_RGainMin;
    uint8_t awb_RGainMax;
    uint8_t awb_BGainMin;
    uint8_t awb_BGainMaxL;
    uint8_t awb_BGainMaxH;

    uint8_t awb_AWBLowRatio; // x-axis for AWB
    uint8_t awb_AWBMidLowRatio; // x-axis for AWB
    uint8_t awb_AWBMidHighRatio; // x-axis for AWB
    uint8_t awb_AWBHighRatio; // x-axis for AWB
    uint8_t awb_AWBLowRgBgRatio[2]; // Rg/Rb
    uint8_t awb_AWBMidLowRgBgRatio[2]; // Rg/Rb
```

```
uint8_t awb_AWBMidHighRgBgRatio[2]; //Rg/Rb
uint8_t awb_AWBHighRgBgRatio[2]; //Rg/Rb
uint8_t awb_CCMLowTemperature[9];
uint8_t awb_CCMMidLowTemperature[9];
uint8_t awb_CCMMidHighTemperature[9];
uint8_t awb_CCMHighTemperature[9];
uint8_t awb_SetCCMCSLowRatio;
uint8_t awb_SetCCMCSMidLowRatio;
uint8_t awb_SetCCMCSMidHighRatio;
uint8_t awb_SetCCMCSHighRatio;

uint8_t awb_CSLowTemperature[2]; // Cbgain, Crgain
uint8_t awb_CSMidLowTemperature[2]; // Cbgain, Crgain
uint8_t awb_CSMidHighTemperature[2]; // Cbgain, Crgain
uint8_t awb_CSHighTemperature[2]; // Cbgain, Crgain
} cal_awb_t;

typedef struct {
    uint8_t optimize_EdgeEnhancement_Pgain[6]; // bright region of edge boundary
    uint8_t optimize_EdgeEnhancement_Ngain[6]; // dark region of edge boundary
    uint8_t optimize_EdgePmax[6];
    uint8_t optimize_EdgeMmax[6];
    uint8_t optimize_DefectPixelCorrection_Pgain[6]; // dpc p
    uint8_t optimize_DefectPixelCorrection_Ngain[6]; // dpc n
} cal_optimize_t;
```

# 12. Register Summary

## 12.1 List of the Control Registers

Register	Default	Range	Description																																
0x01	0x80	0x00-0xFF	<b>Brightness</b>																																
0x04	0x00	0x00-0xFF	<b>Gamma 0</b>																																
0x05	0x00	0x00-0xFF	<b>Gamma Black Correction 0</b> (0 – 20)																																
0x06	0x00	0x00-0xFF	<b>Gamma 1</b>																																
0x07	0x00	0x00-0xFF	<b>Gamma Black Correction 1</b> (0 – 20)																																
0x08	0x80	0x00-0xFF	<b>Hue</b> (degrees: -128 to +127)																																
0x09	0x2E	0x00-0xFF	<b>Saturation</b> 0x20 = 1x 0x2E = 1.44x																																
0x0A	0x03	0x00-0xFF	Automatic Exposure Up Speed																																
0x0B	0x03	0x00-0xFF	Automatic Exposure Down Speed																																
0x0C	0x0C	0x00-0xFF	Automatic Exposure Hysteresis																																
0x0D	0x18	0x00-0xFF	<b>Automatic Exposure Digital Gain Limit</b> Default = 1.5x Bits[7:4] = 0-15x Bits[3:0] = fraction 1/16 <sup>th</sup>																																
0x0E	0x20	0x01-0x7F	<b>AEX Analogue Gain Limit</b>																																
0x0F	0x00	Bit[0]	<b>Exposure Mode</b> Automatic = 0x00 Manual = 0x01																																
0x10	0x10	0x10-0xFF	<b>Manual Exposure Gain</b>																																
0x11	0x80	0x00-0xFF	<b>Manual Exposure Shutter</b> 0x00 = off 0xFF = max shutter																																
0x12	0x0D	0x00-0x25	<table border="1"> <thead> <tr> <th colspan="2"><b>Manual Exposure - Fixed Shutter time</b></th> </tr> <tr> <th>Register</th> <th>Shutter (s)</th> </tr> </thead> <tbody> <tr><td>0</td><td>1/25</td></tr> <tr><td>1</td><td>1/30</td></tr> <tr><td>2</td><td>1/40</td></tr> <tr><td>3</td><td>1/45</td></tr> <tr><td>4</td><td>1/50</td></tr> <tr><td>5</td><td>1/60</td></tr> <tr><td>6</td><td>1/70</td></tr> <tr><td>7</td><td>1/75</td></tr> <tr><td>8</td><td>1/80</td></tr> <tr><td>9</td><td>1/90</td></tr> <tr><td>10</td><td>1/100</td></tr> <tr><td>11</td><td>1/120</td></tr> <tr><td>12</td><td>1/125</td></tr> <tr><td>13</td><td>1/150</td></tr> </tbody> </table>	<b>Manual Exposure - Fixed Shutter time</b>		Register	Shutter (s)	0	1/25	1	1/30	2	1/40	3	1/45	4	1/50	5	1/60	6	1/70	7	1/75	8	1/80	9	1/90	10	1/100	11	1/120	12	1/125	13	1/150
<b>Manual Exposure - Fixed Shutter time</b>																																			
Register	Shutter (s)																																		
0	1/25																																		
1	1/30																																		
2	1/40																																		
3	1/45																																		
4	1/50																																		
5	1/60																																		
6	1/70																																		
7	1/75																																		
8	1/80																																		
9	1/90																																		
10	1/100																																		
11	1/120																																		
12	1/125																																		
13	1/150																																		

Register	Default	Range	Description
			14 1/200
			15 1/250
			16 1/300
			17 1/400
			18 1/500
			19 1/600
			20 1/700
			21 1/750
			22 1/800
			23 1/900
			24 1/1000
			25 1/2000
			26 1/3000
			27 1/4000
			28 1/5000
			29 1/6000
			30 1/7000
			31 1/8000
			32 1/9000
			33 1/10000
			34 1/20000
0x13	0x00	0x00-0x06	Automatic Exposure target
0x14	0x00	0x00-0x06	Anti Flicker
0x15	0x08	0x01-0xFF	Automatic Exposure BLC Window Weight 0
0x16	0x08	0x01-0xFF	Automatic Exposure BLC Window Weight 1
0x17	0x08	0x01-0xFF	Automatic Exposure BLC Window Weight 2
0x18	0x08	0x01-0xFF	Automatic Exposure BLC Window Weight 3
0x1A	0x00	0x00-0xFF	Digital Gain
0x1B	0x00	W: 0x00 W: 0x01 W: 0x10 R: 0x11	<b>White Balance Mode</b> Auto Manual Push-to-White Push-to-White function finished
0x1C	0x00	0x00-0x78	White Balance Window X-Position
0x1D	0x00	0x00-0x78	White Balance Window Y-Position
0x1E	0x78	0x00-0x78	White Balance Window X-Size
0x1F	0x78	0x00-0x78	White Balance Window Y-Size
0x20	0x03	0x00-0xFF	White Balance Speed
0x21	0x04	0x00-0xFF	White Balance Hysteresis
0x22	0x5D	0x00-0xFF	White Balance Red Gain Low byte
0x23	0x00	0x00-0x01	White Balance Red Gain High Byte
0x24	0x40	0x00-0xFF	White Balance Green Gain Low byte
0x25	0x00	0x00-0x01	White Balance Green Gain High Byte
0x26	0x5E	0x00-0xFF	White Balance Blue Gain Low byte

Register	Default	Range	Description
0x27	0x00	0x00-0x01	White Balance Blue Gain High Byte
0x28	0x00	0x00-0xFF Bit[0] Bit[4]	AWB Ratio Mode 0 = auto, 1 = manual AWB Normalization 0 = auto, 1 = manual
0x29	0x80	0x00-0xFF	White Balance Red-to-Green Ratio
0x2A	0x80	0x00-0xFF	White Balance Blue Red-to-Green Ratio
0x2B	0x00	0x00-0xFF Bit[0] Bit[1] Bit[5:4]	<b>White Balance CCM Mode</b> WB Mode 0 = auto, 1 = manual WB toggle Table 0,1,2,3 = Manual, Low, Mid, High
0x2C	0x27	0x00-0xFF	White Balance CCM M11
0x2D	0x83	0x00-0xFF	White Balance CCM M12
0x2E	0x84	0x00-0xFF	White Balance CCM M13
0x2F	0x90	0x00-0xFF	White Balance CCM M21
0x30	0x33	0x00-0xFF	White Balance CCM M22
0x31	0x83	0x00-0xFF	White Balance CCM M23
0x32	0x89	0x00-0xFF	White Balance CCM M31
0x33	0x96	0x00-0xFF	White Balance CCM M32
0x34	0x3F	0x00-0xFF	White Balance CCM M33
0x35	0x01	0x00-0x01	Lens shading compensation Enable
0x36	0x58	0x00-0xFF	Lens shading compensation RG Ratio
0x37	0x66	0x00-0xFF	Lens shading compensation GG1 Ratio
0x38	0x66	0x00-0xFF	Lens shading compensation GG2 Ratio
0x39	0x58	0x00-0xFF	Lens shading compensation BG Ratio
0x3A	0x0C	0x00-0xFF	Lens shading compensation Scale
0x3B	0xF4	0x00-0xFF	Lens shading compensation X-Position
0x3C	0x00	0x00-0xFF	Lens shading compensation Y-Position
0x3D	0x07	0x00-0x07 Bit[0] Bit[1] Bit[2] Bit[7]	<b>Edge Enhancement</b> Enable edge enhancement Edge RGB gamma enable Post edge enhancement enable Show edge
0x3E	0x20	0x00-0xFF	Edge Enhancement Level
0x3F	0x01	0x00-0x01	Noise Reduction Enable
0x40	0x0C	0x00-0xFF	Noise Reduction Level
0x41	0x08	0x00-0xFF	Edge Threshold
0x44	0x20	0x00-0x3F	Set dead pixel correction
0x47	0x10	0x00-0xFF	Manual Exposure Value
0x48	R	0x00-0xFF	Exposure Low byte
0x49	R	0x00-0xFF	Exposure Mid byte
0x4A	R	0x00-0xFF	Exposure High byte

0x4B	R	0x00-0xFF	Exposure Top byte
0x55	0x00	Bit [1] Bit [0]	<b>Mirror</b> Horizontal mirror Vertical mirror
0x57	0x40	0x00-0xFF	Contrast
0x60	RW	0x00-0xFF	RL Write to enable Read
0x61	RW	0x00-0xFF	RH Write to enable Read
0x62	RW	0x00-0xFF	GL Write to enable Read
0x63	RW	0x00-0xFF	GH Write to enable Read
0x64	RW	0x00-0xFF	BL Write to enable Read
0x65	RW	0x00-0xFF	BH Write to enable Read
0x66	RW	0x00-0xFF	Color Correction gain Read Gain low byte
0x67	RW	0x00-0xFF	Color Correction gain Read Gain high byte
0x68	RW	0x00-0xFF	Color Correction gain Green Gain low byte
0x69	RW	0x00-0xFF	Color Correction gain Green Gain high byte
0x6A	RW	0x00-0xFF	Color Correction gain Blue Gain low byte
0x6B	RW	0x00-0xFF	Color Correction gain Blue Gain high byte
0x70	RW	0x00-0xFF Bit[0] Bit[1] Bit[2] Bit[3]	Image Control Hue enable Saturation enable Brightness enable Contrast enable
0x71	RW	0x00-0xFF	Contrast
0x72	RW	0x00-0xFF	Brightness
0x73	RW	0x00-0xFF	Saturation
0x74	RW	0x00-0xFF	Hue
0x75	RW	0x00-0xFF	Y-Gain
0x76	RW	0x00-0xFF	U-Gain
0x77	RW	0x00-0xFF	V-Gain
0x78	RW	0x00-0xFF	Cb-Offset
0x79	RW	0x00-0xFF	Cr-Offset
0x80	0xFF	0x00-0xFF	AE Window row 0
0x81	0xFF	0x00-0xFF	AE Window row 1
0x82	0xFF	0x00-0xFF	AE Window row 2
0x83	0xFF	0x00-0xFF	AE Window row 3
0x84	0xFF	0x00-0xFF	AE Window row 4
0x85	0xFF	0x00-0xFF	AE Window row 5
0x86	0xFF	0x00-0xFF	AE Window row 6
0x87	0xFF	0x00-0xFF	AE Window row 7
0xD0	RO	0x01-0x04	Vertical resolution high byte
0xD1	RO	0x00-0xFF	Vertical resolution low byte
0xD2	RO	0x02-0x07	Horizontal resolution high byte
0xD3	RO	0x00-0xFF	Horizontal resolution low byte
0xDE	RW	0x00-0xFF	Reserved
0xE0	RW	0x00-0xFF Bit[0] Bit[7]	GPIO control GPIO level GPIO mode 0 = open-drain, 1 = push-pull

0xE8	W	0x00-0xFF	Status Control
0xE9	R		Status result
0xEB	R/W/P	0x00-0xFF	Upgrader
0xEF	R/W	0x00-0xFF	NVM version Major number
0xF0	WO	0x01 0x02 0x04 0x08 0x10 0x20 0x40 0x80 0x99 0xA5	<b>Save/Restore and Restart</b> Store current register settings Recover factory register settings Recover factory Calibration parameters Recover all to factory defaults <reserved> (do not use) Restart using user stored register settings Restart using factory register settings Restart using factory settings Reboot Reboot into bootloader
0xF1	RO	0x01 0x02 0x03 0x04	<b>Camera Type</b> TVI 30fps TVI 25fps AHD 30fps AHD 25fps
0xF2	R/W	0x00-0xFF 30 <sub>10</sub> 25 <sub>10</sub>	<b>Framerate</b> 30fps 25fps
0xF3	RO	0x00-0xFF	Model
0xF4	R/W	0x00-0xFF	Configuration bits
0xF6	R/W	0x7F	I <sup>2</sup> C Address
0xF7	R/W/P	Bit[0] Bit[1] Bit[2]	<b>I<sup>2</sup>C Control</b> 0: Status Byte disabled 1: Status Byte enabled 0: ACK Polling disabled 1: ACK polling enabled 0: Clock stretch is enabled 1: Clock stretch is disabled
0xF8	WO	0x01 0x02	Reboot Reboot into bootloader
0xFB	RO	0x00-0xFF	A non-zero value indicates preliminary, test or debug version. This register should read back zero for released firmware versions.
0xFC	WO	0x00-0xFF	Password MSB
0xFD	WO	0x00-0xFF	Password LSB
0xFE	RO	0x00-0xFF	Firmware Minor number
0xFF	RO	0x00-0xFF	Firmware Major number

Table 46. Complete List of the Control Register

## 13. Communication

To communicate with the camera Videology offers a communication kit, wire leads and control software for the 24C24xW camera.

A possible communication kit is the USB2.0 communication board to I<sup>2</sup>C as shown below.

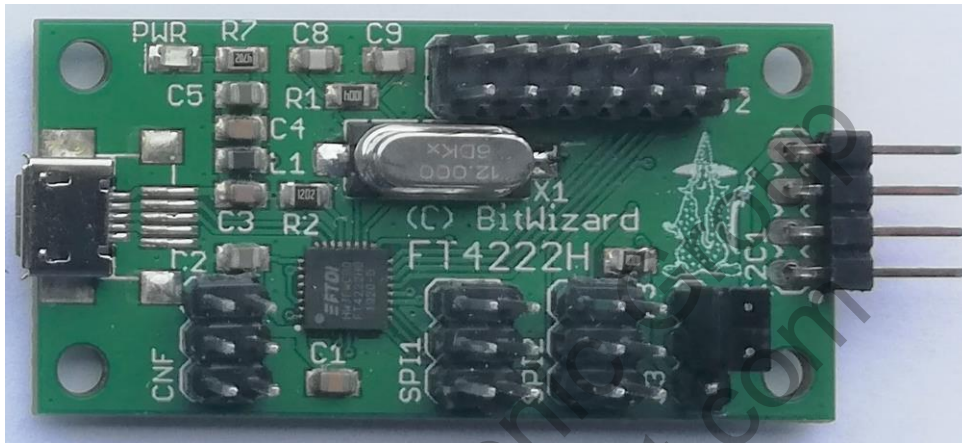


Figure 7 Communication kits

Please consult our website or contact Videology sales on the available I<sup>2</sup>C kits.



## 14. Contact Information

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### Excellence for More Than 25 Years

Founded in 1995, Videology is a global leader in the design, engineering and manufacturing of industrial-grade embedded video cameras, related systems, software and solutions. For more than 25 years we have been providing performance excellence in a broad spectrum of applications including biomedical devices, life sciences, banking, aerospace, traffic management, pipe inspection, and more. In October 2021, Videology was acquired by inTEST Corporation and currently is a part of the Process Technologies Division.



**Videology**<sup>®</sup>

Industrial-Grade Cameras

an inTEST Company

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