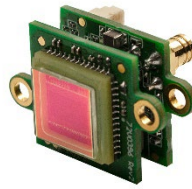




# 24C46XXX-2 Series

## User Guide

# PRELIMINARY



24C46XXX-2



24C462XXX-2



24C465XXX-2

Industrial-Grade Cameras

Aegis Electronic Group, Inc.  
[www.aegiselect.com](http://www.aegiselect.com)

# Warning and Safeguards



- **Read instructions before operating camera.**
- Please read/follow all instructions and heed 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.


## 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.

## 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.

## 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 place
- 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 a disposal which is not harmful to the environment.

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# Introduction & Document History

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## Introduction

This document describes the specification, functional operation and command interface to the 24C46 camera.

The 24C46 camera comes in various formats, interfaces and functions. The video output interface is coaxial or twisted pair, and the video type can either be AHD or TVI. The framerate can be 25 or 30 fps.

The output formats TVI, AHD and the framerates 25 or 30 fps are determined by a specific firmware version.

## Document History

Revision	Issue Date	Reason	CN#
0.2.4		Initial Creation	N/A
A	17-08-2020	First draft	N/A
A-final	21-01-2021	Second draft	N/A
A.1	20-06-2022	Update Electrical Specification/Add Twisted-pair output Update part numbering	N/A
A.2	27/06/2022	Add 3D images	N/A
A.3	15/07/2022	Reformatted to user guide design	N/A
A.4	29/07/2022	Update Table of contents, Add register 0x7A and 0x7B, add Twisted pair picture	N/A
A5	01/09/2022	Reformatted into new layout	N/A
B	10/25/2022	Initial Release	22-0036
C	19/12/2022	Update part number	22-0036

# Specifications

This chapter includes specifications for:

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Note: Design and specifications are subject to change without notice.

## Opto-electric

Image sensor	CMOS 1/3" 2.1MP
Recording Pixels	1920 x 1080
Pixel / image size	2.8µm x 2.8µm / 5.42mm x 3.068mm
Scanning system	Progressive
Shutter type	Rolling Shutter, automatic/fixe
Resolution / Framerates	2.1 MP (1920x1080) 30/25 fps
Pixel clock rate	74.25MHz
Sensitivity	< 0.5 Lux
	3.6 V/lux-sec
Signal to Noise ratio	42.0 dB
AGC	Automatic/manual
Synchronization	Internal
Mirror/flip	Horizontal & Vertical On/Off
Video output interfaces	Coaxial: TVI or AHD Twisted pair: TVI or AHD

## Electrical

Supplied Voltage	5V ±10% (4 – 5.5V)
Current drawn @5V	Typical: 180mA Max: 220mA
Power consumption	0.9W (max 1.1W)
Communication	I <sup>2</sup> C
Dynamic range	60.0 dB

## Transmission Distance

TVI / AHD Coaxial	>500m (1,600ft)
TVI / AHD Twisted pair	>300m (950ft)

## Environmental

Operating Temperature	-30°C ~ 60°C (-22°F ~ 140°F)
Operating Humidity	20% ~ 90% RH
Storage Temperature	-40°C ~ 105°C (-22°F ~ 221°F)
Storage Humidity	94% RH

## Mechanical

Dimensions WxHxD	17.2mm x 16.6mm x 27mm (0.67" x 0.65" x 1.06") no lens mount	
Weight	4 Grams (0.14 oz.)	
Connectors	Analogue TVI/AHD Coaxial	MMCX (coax 75Ω)
	Analogue TVI/AHD Twisted pair (100Ω impedance)	Würth WR-WTB 1.0mm (665 303 124 022)
	Power/GPIO 5-pin	Würth WR-WTB 1.0mm (665 305 124 022)

Part Number Options

24C46XXXX-2	Replace <b>ABCD</b> in type number: 24C46 <b>ABCD</b> -2
A 24C465	X = no lens mount, no housing 0 = no Lens mount, 1 spacer ring 1 = Pin Hole Lens mount, 1 spacer ring 2 = Pin Hole Lens mount, 2 spacer-rings + backplate 3 = M12 Lens Mount, 1 spacer ring 5 = M12 Lens Mount, 2 spacer-rings + backplate 6 = CS mount is also possible, 1 spacer ring 7 = CS mount is also possible, 2 spacer-rings + backplate
B 24C465T	T = TVI output A = AHD output
C 24C465TP	N = 30 fps P = 25 fps
D 24C465TPC	C = Coaxial D = Twisted Pair
-2 24C465TPC-2	Revision 2 Note: without the (-2) in the model number, the 1 <sup>st</sup> revision is assumed

AC Specification

I <sup>2</sup> C	5kHz – 100kHz (up to 400kHz may be possible)
ADH -3dB point	72MHz
TVI -3dB point	72MHz

Output Formats

The camera supports a range of standard formats as shown in Table 1

HD mode	Sub sampling Mode	Frame rate [Hz]	Resolution Horz x Vert	Line freq. [kHz]	Pixel clock [MHz]
1080p	N/A	30	1920x1080	33.75	74.25
1080p	N/A	25	1920x1080	28.125	

Table 1. Standard formats supported

# Connectors, Lens and Form Factor

This chapter includes:

Connectors.....	13
Lens Mount Options.....	13

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The camera is a double board design with overall dimensions as shown Below.

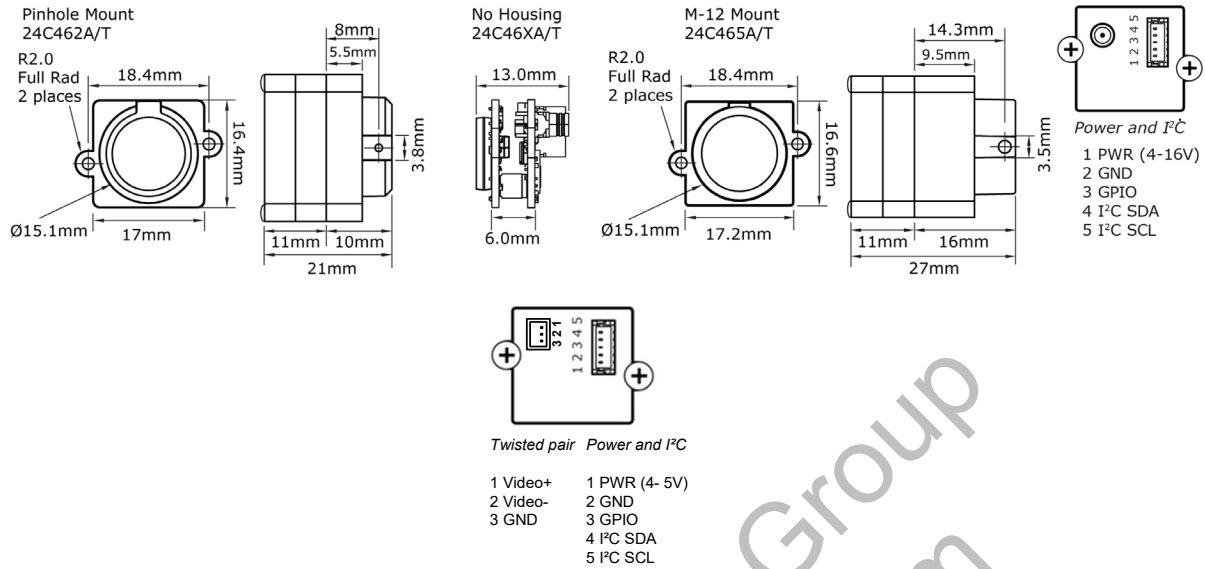


Figure 1 Camera Dimensions (no Lens)

## Connectors

Coaxial MMCX (coax 75Ω)	
Pin #	Function
1	TVI or AHD
2	Ground

Table 2. Coaxial MMCX connector

Twisted pair 1.0mm	
Pin #	Function
1	TVI or AHD (positive)
2	TVI or AHD (negative)
3	Ground

Table 3. Twisted pair connector

Power/Control/GPIO connector 1.0mm	
Pin #	Function
1	Power IN 5V
2	Ground
3	GPIO
4	I²C SDA
5	I²C SCL

Table 4. Power, Control and GPIO connector

## Lens Mount Options

The camera model is available with either an M12 Pinhole, M12 or CS lens mount.

Table 5 below gives the part number for each configuration.

Lens interface	Camera type number
M12 Pin Hole mount (w/o lens)	24C462
M12 mount (w/o lens)	24C465
No lens mount	24C46X
CS-lens mount (w/o lens)	24C468

Table 5. Lens Mount Options

The overall dimensions of camera with M12 lens mount are shown below.

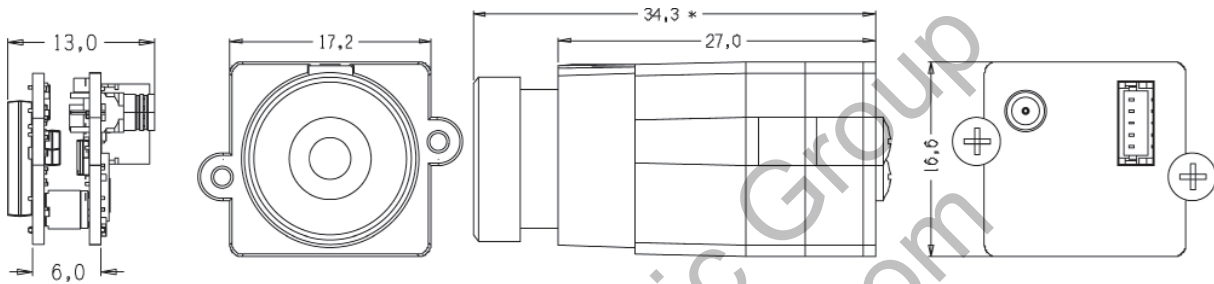


Figure 2 Cameras with M12 Lens Mount

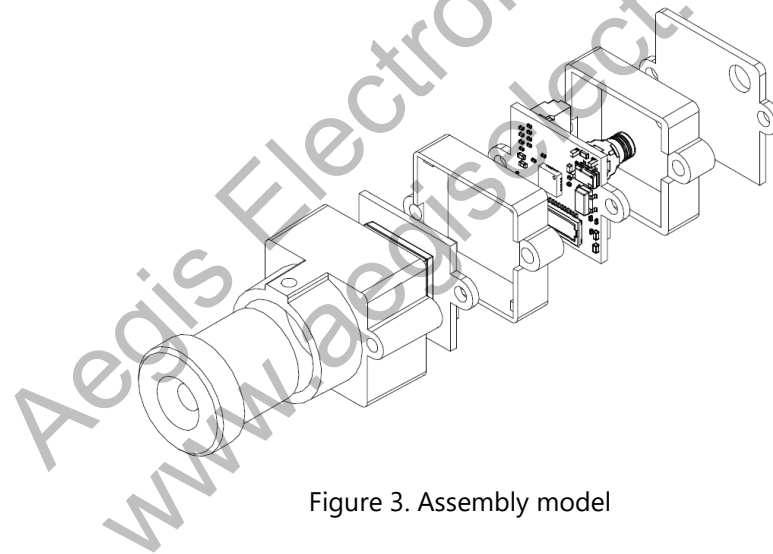
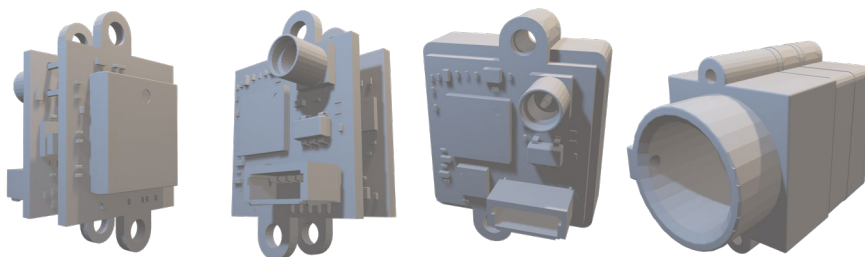


Figure 3. Assembly model



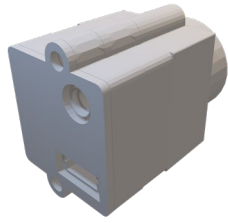


Figure 4. Coaxial 3D model

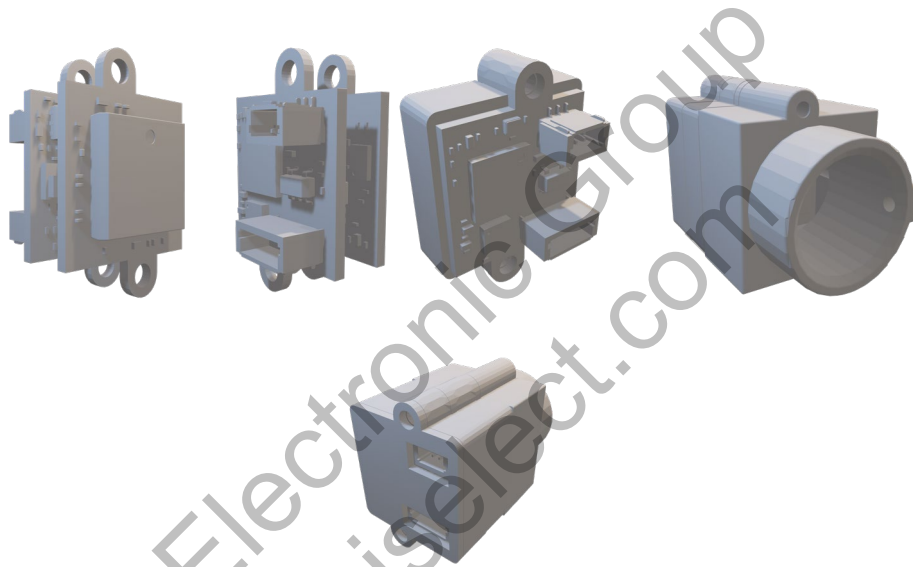


Figure 5. Twisted Pair 3D model

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

This chapter includes:

- I<sup>2</sup>C Addressing and Commands .....17
  - I<sup>2</sup>C Command bytes ..... 17
  - Registers ..... 17
  - EERPOM ..... 17
  - Serial Number ..... 18
  - Image Processor ..... 18
- Timing .....18

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The camera uses a two-wire serial (I<sup>2</sup>C) communication interface for control and configuration. This serial bus consists of a line for the clock signal (I<sup>2</sup>C-SCL), a line for the data signal (I<sup>2</sup>C-SDA), and a line for ground. The camera will act as a slave device. The protocol supports clock speeds from 5 kHz – 100 kHz. (Higher clock speeds up to 400 kHz may be possible, lower clock speeds down to 2 kHz may be possible)

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

Writing to the camera can be a single block of data containing device address, register address or command and data. Reading consists of a command and data block and complies with the standard I<sup>2</sup>C protocol.

### I<sup>2</sup>C Addressing and Commands

Below the I<sup>2</sup>C address and commands for the camera can be found.

Device Address	Command	Description
0x70/0x71	0x30/0x31	Camera Register Access
	0xA0/0xA1	EEPROM 1 <sup>st</sup> page
	0xA2/0xA3	EEPROM 2 <sup>nd</sup> page
	0xA4/0xA5	EEPROM 3 <sup>rd</sup> page (password protected)
	0xA6/0xA7	EEPROM 4 <sup>th</sup> page (password protected)
	0x25	Unique Serial Number
	0x28/0x29	ISP Register access (password protected)
	0x38 – 0x50	Bootloader command range

Table 6. Valid values for to command Byte

#### I<sup>2</sup>C Command bytes

The camera has several user accessible command registers (0x30/0x31) which can be used to configure and control the camera behavior. These registers can be used to control: exposure, gain, shutter, white-balance, backlight, contrast, brightness, saturation, hue, sharpness, noise filtering, etc.

A detailed description of each of the control registers is given in chapter 1

#### Registers

The camera is controlled via registers. Below the I<sup>2</sup>C command-protocol is shown:

Write:                           <0x70> <0x30> <register> <data>  
 Read:                            <0x70> <0x31> <register> <0x71> <data>  
 Read with status:           <0x70> <0x31> <register> <0x71> <status> <data>

#### EEPROM

The EEPROM can be access using the following commands:

Write:                           <0x70> <0xA0~0xA7> <addr> <data [0:15]>  
 Read:                            <0x70> <0xA0~0xA7> <addr> <0x71> <data [0:15]>  
 Read with status:           <0x70> <0xA0~0xA7> <addr> <0x71> <status> <data [0:15]>

To store the camera settings the user registers settings can be stored in EEPROM page 0. At power-up the camera will use the user register settings stored in EEPROM page 0. EEPROM addresses are shown in

Table 7. The EEPROM contains user stored register settings and Factory register settings. When restoring to factory settings the User register settings will be overwritten.

The user Calibration settings are stored in page 1; these can be modified by the user. The Factory Calibration parameters are also stored in EEPROM. When restoring to factory settings the User calibration parameters will be overwritten.

EEPROM Page	Command Addr. W/R	Contents
0	0xA0/0xA1	User Startup Camera Register Settings
1	0xA2/0xA3	User Startup Calibration Parameters
3	0xA4/0xA5	Factory default Camera Register Settings
4	0xA6/0xA7	Factory default Calibration Parameters

Table 7. EEPROM page addresses and contents

*Note: EEPROM page2 and Page3 contain factory settings; do not modify these!*

#### Serial Number

Each camera has a unique serial number that can be read using the following commands:

Read: `<0x70> <0x25> <0x71> <data [0:15]>`  
 Read with status: `<0x70> <0x25> <0x71> <status> <data [0:15]>`

#### Image Processor

The ISP registers can be accessed using the following commands. All ISP registers are password protected and should not be accessed.

Write `<0x70> <0x28> <base[0:1]> <address[0:1]> <data[0:3]>`  
 Read: `<0x70> <0x29> <base[0:1]> <address[0:1]> <0x71> <data>`  
 Read with status: `<0x70> <0x29> <base[0:1]> <address[0:1]> <0x71> <status> <data>`

#### Timing

The camera uses I<sup>2</sup>C Clock stretching; when the I<sup>2</sup>C master does not support clock stretching it may be necessary to reduce the I<sup>2</sup>C clock frequency and possibly delays may be required to prevent bus errors.

Different commands have different delays. An I<sup>2</sup>C write command does not need a delay between command and data, however the commands may take time to execute and therefore a delay between write commands may be required.

For read commands, the camera will use clock-stretching. Clock stretching is only performed on the SCL falling edge associated with the ACK or NACK bit. Additionally, enhanced-clock-stretching is default enabled to allow the full command to be finished before the SCL line goes high. The enhanced clock stretch can be disabled.

The camera also supports an I<sup>2</sup>C ACK-polling method, that can be enabled or disabled by a register setting (see chapter 0). In the ACK-polling mode the camera will disable the I<sup>2</sup>C bus after every command and only re-enable the I<sup>2</sup>C bus when the command is executed and finished. The I<sup>2</sup>C master can then poll

the I<sup>2</sup>C bus and check when the camera is responding to I<sup>2</sup>C commands and then send the next command. This eliminates the need for delays.

The Bootloader always operates in ACK polling mode.

After power on the I<sup>2</sup>C will not be available until the camera has fully booted, this will take about 3 to 4 seconds.

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# Detailed Register Information

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

- Standard Control .....22
  - Gamma .....22
  - Black Correction.....23
  - Hue and Saturation .....24
- Automatic Exposure .....24
  - Automatic Exposure .....26
  - Anti-Flicker.....26
  - Manual Exposure.....26
  - Backlight Compensation .....26
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## Standard Control

Register	Default	Range	Description
0x00	0x80	0x00-0xFF	<b>Brightness</b>
0x01	0x40	0x00-0xFF	<b>Contrast</b>
0x02	0x00	0x00-0x01 Bit [1] Bit [0]	<b>Mirror</b> Horizontal mirror Vertical mirror
0x03	0x00	0x00-0xFF	<b>Gamma 0</b>
0x04	0x00	0x00-0xFF	<b>Gamma Black Correction 0</b> (0 – 20)
0x05	0x00	0x00-0xFF	<b>Gamma 1</b>
0x06	0x00	0x00-0xFF	<b>Gamma Black Correction 1</b> (0 – 20)
0x07	0x80	0x00-0xFF	<b>Hue</b> (degrees: -128° to +127°)
0x08	0x2E	0x00-0xFF	<b>Saturation</b> 0x20 = 1x 0x2E = 1.44x

## Gamma

Two gamma tables and its corresponding black correction can be selected. Gamma table 0 is for bright light conditions and table 1 is for low light conditions, see Figure 6. To have a fixed gamma for all light conditions make table 0 and table 1 the same.

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 8. Gamma

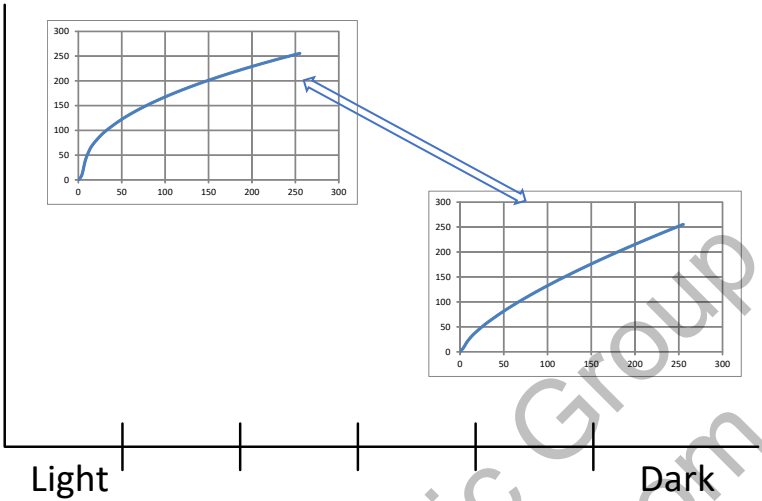


Figure 6. Gamma table 0 to table 1

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.

Two custom gamma tables can be selected when selecting a gamma value of 0x10 or 0x11. These Gamma curves are defined in the calibration parameters and are not directly accessible.

**Black Correction**

The gamma black correction can be set to adjust back in dark areas. Only dark areas are affected. The black level correction level can be set from 0 to 20. The higher the value the darker dark areas will become. Figure 7 show the black correction effect on a gamma curve of 0.45.

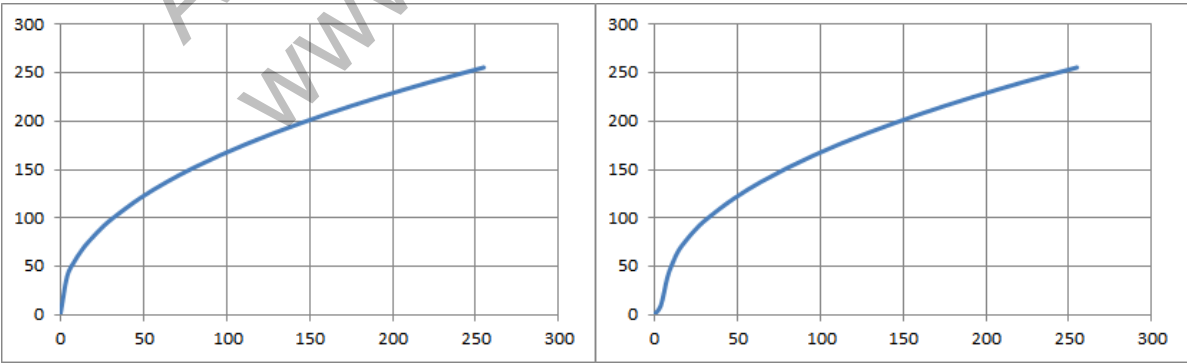


Figure 7. Black correction for gamma

## Hue and 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 EEPROM calibration parameters and are not directly accessible.

## Automatic Exposure

Register	Default	Range	Description																						
0x09	0x80	0x00-0xFF	Automatic Exposure Target Level																						
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 64 <sub>10</sub>	0x00-0x7F	<b>AEX Analogue Gain Limit</b> <table border="1"> <thead> <tr> <th>Register value</th> <th>Gain Limit</th> </tr> </thead> <tbody> <tr><td>2</td><td>16x</td></tr> <tr><td>4</td><td>32x</td></tr> <tr><td>8</td><td>48x</td></tr> <tr><td>16</td><td>64x</td></tr> <tr><td>32</td><td>80x</td></tr> <tr><td><b>64</b></td><td><b>96x</b></td></tr> <tr><td>80</td><td>102x</td></tr> <tr><td>96</td><td>106x</td></tr> <tr><td>112</td><td>109x</td></tr> <tr><td>127</td><td>127x</td></tr> </tbody> </table>	Register value	Gain Limit	2	16x	4	32x	8	48x	16	64x	32	80x	<b>64</b>	<b>96x</b>	80	102x	96	106x	112	109x	127	127x
Register value	Gain Limit																								
2	16x																								
4	32x																								
8	48x																								
16	64x																								
32	80x																								
<b>64</b>	<b>96x</b>																								
80	102x																								
96	106x																								
112	109x																								
127	127x																								
0x0F	0x00	0x00-0x03 Bit[0] Bit[1]	<b>Exposure Mode</b> Automatic = 0, Manual = 1 Fine = 0, Fixed = 1																						
0x10	0x10	0x00-0xFF	<b>Manual Exposure Gain</b> 0x10 = Digital and analogue gain = 1x 0x10-0x70 = analogue gain: 1x – 64x 0x70-0xFF = digital gain: 1x – 8.9375x																						
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</b> <table border="1"> <thead> <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> </tbody> </table>	Register	Shutter (s)	0	1/25	1	1/30	2	1/40	3	1/45	4	1/50										
Register	Shutter (s)																								
0	1/25																								
1	1/30																								
2	1/40																								
3	1/45																								
4	1/50																								

# Detailed Register Information

Register	Default	Range	Description																
			5 1/60																
			6 1/70																
			7 1/75																
			8 1/80																
			9 1/90																
			10 1/100																
			11 1/120																
			12 1/125																
			<b>13 1/150</b>																
			14 1/200																
			15 1/250																
			16 1/300																
			17 1/400																
			18 1/500																
			19 1/600																
			20 1/700																
			21 1/750																
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			29 1/6000																
			30 1/7000																
			31 1/8000																
			32 1/9000																
			33 1/10000																
			34 1/20000																
			35 1/30000																
			36 1/40000																
			37 1/50000																
0x13	0x00	0x00-0x06	<b>Automatic Exposure Anti Flicker</b>																
			<table border="1"> <thead> <tr> <th>Register</th> <th>Shutter Time</th> </tr> </thead> <tbody> <tr> <td><b>0</b></td> <td><b>OFF</b></td> </tr> <tr> <td>1</td> <td>1/120</td> </tr> <tr> <td>2</td> <td>1/60</td> </tr> <tr> <td>3</td> <td>1/30</td> </tr> <tr> <td>4</td> <td>1/100</td> </tr> <tr> <td>5</td> <td>1/50</td> </tr> <tr> <td>6</td> <td>AUTO</td> </tr> </tbody> </table>	Register	Shutter Time	<b>0</b>	<b>OFF</b>	1	1/120	2	1/60	3	1/30	4	1/100	5	1/50	6	AUTO
Register	Shutter Time																		
<b>0</b>	<b>OFF</b>																		
1	1/120																		
2	1/60																		
3	1/30																		
4	1/100																		
5	1/50																		
6	AUTO																		

## Automatic Exposure

Higher target level will result in brighter video. The regulation for exposure can be adjusted using the following parameters: Up Speed, Down Speed, Hysteresis, digital gain limit & 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 least noise digital gain limit can be set to 1. To get the best sensitivity the gain limits can be set to maximum, but at low light this will result in a noisy picture.

## Anti-Flicker

Anti-Flicker can be enabled. For 30Hz framerate the auto, 1/100 or 1/50 setting should be used. For 25Hz framerate the auto, 1/20, 1/60 or 1/30 settings can be used. In the Anti Flicker mode, the shutter will be fixed, the automatic exposure regulation will only adjust the gain.

## Manual Exposure

In manual exposure mode the gain and shutter 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 gain value below 0x10 will result in gains below 1x, these should be avoided. Gains between 0x10 and 0x70 will use analogue gain only, gain setting above 0x70 will use analogue gain of 64x and digital gain above 1x, each step above 0x70 add a factor of 1/16<sup>th</sup>. For example, 0x78 will result in a digital gain factor of 1.5x.

Register	Default	Range	Description
0x14	0x00	0x00-0x01 Bit[0]	<b>AEX BLC Windows Show</b> Backlight Compensation Window 1: Show BLC windows 0: Hide BLC windows
0x15	0x08	0x00-0x3F	Automatic Exposure BLC Window Weight
0x16	0x28	0x00-0x78	Automatic Exposure BLC Window X-Position
0x17	0x28	0x00-0x78	Automatic Exposure BLC Window Y-Position
0x18	0x50	0x00-0x78	Automatic Exposure BLC Window X-Size
0x19	0x50	0x00-0x78	Automatic Exposure BLC Window Y-Size

## Backlight Compensation

The BLC window can be made visible by setting the register value. The Weight factor determines whether the exposure is regulated inside or outside the BLC window. The position and size of the BLC window can be adjusted.

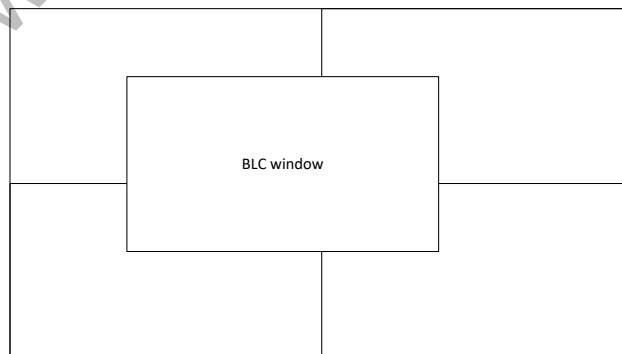


Figure 8. BLC window

## Automatic White Balance

Register	Default	Range	Description
0x1A	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 function finished
0x1B	0x00	0x00-0x01 Bit[0]	<b>White Balance Window Show</b> 1: Show AWB window, 0: Hide AWB window
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
0x27	0x00	0x00-0x01	White Balance Blue Gain High Byte

## Automatic White Balance

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

The 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 maximum 3 seconds, then lock it by setting the AWB to manual. When the Function completes the AWB will be in manual mode and the register read-back value is: 0x11

*Note: The automatic Push-to-White (0x10) function will block I<sup>2</sup>C for maximum 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.*

## Manual White Balance

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

## Manual White Balance Correction

Register	Default	Range	Description
0x28	0x00	0x00-0xFF Bit[0]	AWB Ratio Mode 0 = auto, 1 = manual

Register	Default	Range	Description
		Bit[4]	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

The AWB correction for ambient light can be set to automatic or manual. In automatic mode the AWB is automatically adjusted for bright and low light conditions using Red-to-Green and Blue-to-Green ratios. In manual mode, these ratios can be manual adjusted. This mode could be used for constant ambient light conditions. E.G.: An object under a constant artificial light source. The AWB correction for ambient light only is useful when AWB is in automatic mode. The AWB ratios for automatic mode are stored in the EEPROM calibration parameters and are not directly accessible.

### Auto / Manual Color Correction

Color correction can be made using the CCR matrix.

Register	Default	Range	Description
0x2B	0x00	0x00-0xFF Bit[0] Bit[1] Bit[5:4]	White Balance CCR Mode WB Mode 0 = auto, 1 = manual WB toggle Table 0,1,2,3 = Manual, Low, mid, high
0x2C	0x27	0x00-0xFF	White Balance CCR M11
0x2D	0x83	0x00-0xFF	White Balance CCR M12
0x2E	0x84	0x00-0xFF	White Balance CCR M13
0x2F	0x90	0x00-0xFF	White Balance CCR M21
0x30	0x33	0x00-0xFF	White Balance CCR M22
0x31	0x83	0x00-0xFF	White Balance CCR M23
0x32	0x89	0x00-0xFF	White Balance CCR M31
0x33	0x96	0x00-0xFF	White Balance CCR M32
0x34	0x3F	0x00-0xFF	White Balance CCR M33

In automatic mode the matrixes in the calibration parameters are used and are automatically adjusted for ambient light. In Manual mode, the CCR coefficients can be set using the registers below. In manual mode, color is no longer automatically adjusted for ambient light conditions and the coefficients of the color matrix M11 to M33 are used. 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 9. Default CCR matrix coefficients

## Tuning and Testing CCR

When color correction is in automatic mode the toggling WB toggle bit[1] stores the current CCR coefficients to the registers M11 – M33 for readback when the bit[5:4] = 0.

In manual mode, the toggle bit[1] updates the M11-M33 registers to the manual setting when bit[5:4] = 0.

When bit[5:4] = 1, 2 or 3 then the M11-M33 registers are updated for the Low, Mid or High coefficients.

Writing to the M11-M33 register will update the table selected by bit[5:4].

0x00	Auto	bit[0]=0
0x01	Manual	bit[0]=1
0x02 / 0x00	Toggle bit[1] updates M11-M33 registers for readback current CCR coefficients for Auto mode	
0x10	Read/Write coefficients for Low temperature	bit[5:4]=01
0x20	Read/Write coefficients for Mid temperature	bit[5:4]=10
0x30	Read/Write coefficients for High temperature	bit[5:4]=11

Table 10. How to use the WB mode register 0x2B

## 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

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.

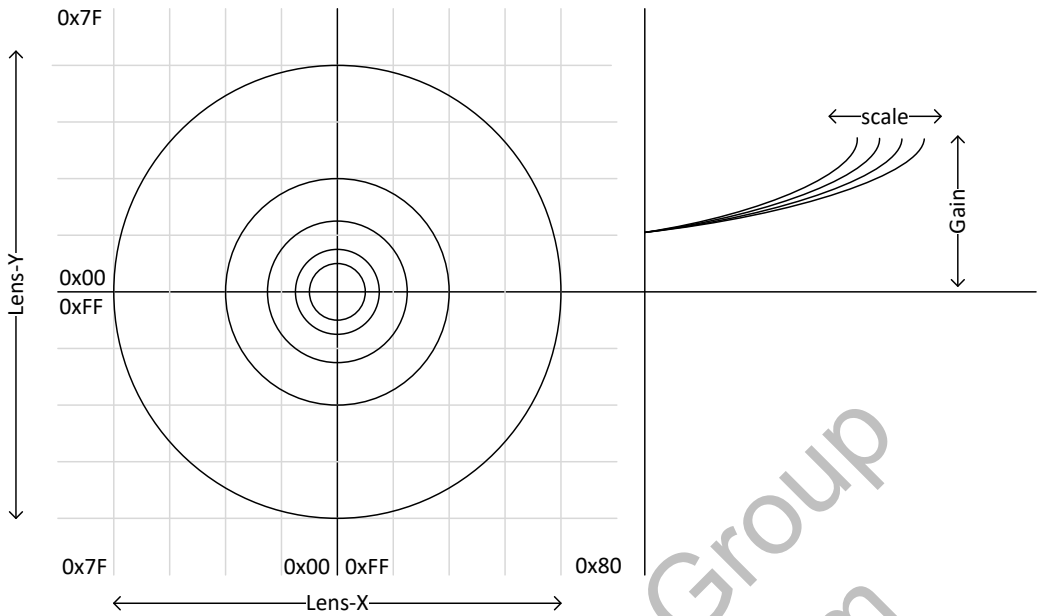


Figure 9. Lens shading compensation

Edge Enhancement

Register	Default	Range	Description
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

Sharpness can be adjusted using the edge enhancement registers.

## Noise Reduction

Register	Default	Range	Description
0x3F	0x01	0x00-0x01	Noise Reduction Enable
0x40	0x0C	0x00-0xFF	Noise Reduction Level
0x41	0x01	0x00-0x01	Noise Reduction Bilateral Filter Enable
0x42	0x00	0x00-0xFF	Noise Reduction Bilateral Filter Level
0x43	0x00	0x00-0xFF	Noise Reduction BLF High Frequency Level
0x44	0x20	0x00-0x3F	Noise Reduction DPC Level

The camera uses 3 types of noise reduction filters:

1. Noise reduction using Gaussian filter
2. Noise reduction using Bilateral filter
3. Noise reduction for Defect Pixel Correction

## Bilateral Filter

A bilateral filter is a non-linear, edge-preserving, and noise-reducing smoothing filter for images. When BLF is enabled then high frequency filter level can be set as well.

## 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. It is disabled when the register value is zero.

## Color Suppression

Color suppression can be enabled to reduce color in darker image areas.

Register	Default	Range	Description
0x45	0x00	0x00-0x01	Color suppression enable
0x46	0x00	0x00-0xFF	Color suppression level

The calibration parameters set a suppression level offset for ambient light conditions from bright to dark and are stored in the EEPROM and are not directly accessible.

## Test Patterns

Register	Default	Range	Description
0x47	0x00	0x00-0xFF	Test Pattern Selection
0x48	0x00	0x00-0xFF	Test Pattern Red R[9:2]
0x49	0x00	0x00-0xFF	Test Pattern Green 1 G1[9:2]
0x4A	0x00	0x00-0xFF	Test Pattern Green 2 G2[9:2]
0x4B	0x00	0x00-0xFF	Test Pattern Blue B[9:2]
0x4C	0x00	0x00-0xFF	Test Pattern R[1:0] G1[1:0] G2[1:0] B[1:0]

Test pattern can be enabled by writing a non-zero value to register 0x47. Various color adaptations to test patterns can be made using registers 0x48 to 0x4C.

## RGB Gain Read Back

Register	Default	Range	Description
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

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

## 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

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.

## 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

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

Write 0x00 = open-drain, low

Write 0x81 = push-pull, high

Write 0x80 = push-pull, low

Read returns mode and level.

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

## EEPROM Version

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

## EEPROM Register Save/Restore and Restart Commands

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

Register	Default	Value	Description
0xF0	WO	0x00-0xFF	<b>Save/Restore and Restart</b>
		0x00	Apply stored register settings, reset registers
		0x01	Store current register settings
		0x02	Recover factory register settings
		0x04	Recover factory Calibration parameters
		0x08	Recover all to factory defaults
		0x10	<reserved> (do not use)
		0x20	Restart using user stored register settings
		0x40	Restart using factory register settings
		0x80	Restart using factory settings
		0x99	Reboot
		0xA5	Reboot into bootloader

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

### Store Current Register Settings

This function stores the current register settings to EEPROM

### 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.

### 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.

### Recover All To Factory Defaults

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

### Restart Using User Stored Register Settings

Restart the camera using current register settings. This will reset the image processor, then apply the user calibration parameters and the user stored register settings.

### Restart Using Factory Register Settings

Restart the camera using current register settings. This command will reset the image processor, then apply the user calibration parameters and apply the factory default register settings.

### Restart Using Factory Settings

Restart the camera using current register settings. This will reset the image processor, then apply the factory calibration parameters and the factory default register settings. The stored user settings will not be affected.

### Reboot

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

### Start 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 READ CHECKSUM function for this purpose).

## Camera Type and Framerate

Returns the camera framerate.

Register	Default	Range	Description
0xF4	RO	0x00-0x07 0x01 0x02 0x03 0x04	<b>Camera Type</b> TVI 30fps TVI 25fps AHD 30fps AHD 25fps
0xF5	RO	0x00-0xFF 30 <sub>10</sub> 25 <sub>10</sub>	<b>Framerate</b> 30fps 25fps

## Camera Model

Returns the camera model.

Register	Default	Range	Description
0xF6	RO	0x00-0xFF	Model

## 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] Bit[1] Bit[2]	0: Status Byte disabled 1: Status Byte enabled 0: ACK Polling enabled 1: ACK polling disabled 0: Enhanced clock stretch is enabled 1: Enhanced clock stretch is disabled

### 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.

### 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.

## 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.

## 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

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)

## 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.

## 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

## 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

# Serial Number

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## 16 byte Serial Number

A unique 16-byte serial number can be read using a special I<sup>2</sup>C command.

The Command Byte is 0x25

Read unique serial number:

<0x70> <0x25> <0x71> <data[0:15]>

# EEPROM

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## EEPROM Read And Write Functions

The EEPROM read and write functions allow transfer of up to 16Bytes per time. The EEPROM has four pages and page size of the EEPROM is 256 Bytes. Avoid crossing page boundaries when reading or writing.

E.g., do not write 16Bytes to address 0xFC, as this would cross the page boundary.

Write to EEPROM:

```
<0x70> <0xA0> <address> <0x71> <data[0:15]>  
<0x70> <0xA2> <address> <0x71> <data[0:15]>  
<0x70> <0xA4> <address> <0x71> <data[0:15]> *  
<0x70> <0xA6> <address> <0x71> <data[0:15]> *
```

Read from EEPROM:

```
<0x70> <0xA1> <address> <0x71> <data[0:15]>  
<0x70> <0xA3> <address> <0x71> <data[0:15]>  
<0x70> <0xA5> <address> <0x71> <data[0:15]>  
<0x70> <0xA7> <address> <0x71> <data[0:15]>
```

*\*note: These pages are password protected, because they contain factory defaults  
note: EEPROM read/write functions for the bootloader uses a different protocol.*

# Bootloader

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The camera has a bootloader that allows updating the firmware. The I<sup>2</sup>C commands for updating the firmware are slightly different from the normal operation of the camera. All I<sup>2</sup>C commands will result in the camera **temporary disabling the I<sup>2</sup>C interface**; the I<sup>2</sup>C interface will be re-enabled once the function has completed. This allows the I<sup>2</sup>C bus master to poll the I<sup>2</sup>C bus, since the camera will not respond until the camera has completed the command. This is also known as ACK-polling mode. While running the bootloader I<sup>2</sup>C restart commands are not allowed!

## Microcontroller Flash Programming

The functions for programming the firmware for the microcontroller can be found below. To program the firmware the flash needs to be erased. The firmware image can then be programmed. A CHECKSUM is used to verify whether the firmware image programmed into flash is correct. The CHECKSUM is defined as an addition of every byte in the firmware image. After programming the firmware image the CHECKSUM and the Size **MUST** be written. Writing CHECKSUM or the Size does not require erasing the flash. Reading the CHECKSUM will NOT return the programmed CHECKSUM; instead, the microcontroller will calculate the CHECKSUM of the current firmware image in flash and return the CHECKSUM; this can be used to check if writing the firmware image programmed was correct. CHECKSUM = addition of image bytes: CHECKSUM = byte[0] + byte[1] + byte[2] + . . . etc. CHECKSUM is 32 bit, Size is 16bit.

### Write data to Flash

<start> <0x70> <0x38> <address[0..1]> <data[0..15]> <stop>

Valid address range is 0x4000 ~ 0xF9E0

address: [1]=MSB, [0]=LSB

### Read data from Flash

<start> <0x70> <0x39> <address[0..1]> <stop> <start> <0x71> <data[0..15]> <stop>

### Write CHECKSUM to flash

<start> <0x70> <0x40> <CHECKSUM[0..3]> <stop>

CHECKSUM = addition of image bytes: CHECKSUM = byte[0] + byte[1] + byte[2] + . . . etc

### Read CHECKSUM

<start> <0x70> <0x41> <stop> <start> <0x71> <CheckSum[0..3]> <stop>

reads image stored in flash, calculates CheckSum then returns CheckSum

App size must be stored to flash for this function to work

### Write Size

<start> <0x70> <0x42> <size[0..1]> <stop>

Stores the image size to flash

## Read App Size

<start> <0x70> <0x43> <stop> <start> <0x71> <size[0..1]> <stop>

Reads size from flash

## Erase Flash

<start> <0x70> <0x44> <erase command> <stop>

(command=0x01 to erase the application)

## REBOOT

<start> <0x70> <0x46> < command> <stop>

(command=0x01 for reset, 0x02 for reboot, 0x04 to start application)

## Update Procedure:

1. Start Bootloader
2. Erase Flash
3. While ( I2C bus is not available) // poll i2c
4. While (not EOF) {
  - Read (max 16) bytes from image file
  - Calculate CHECKSUM of image // CHECKSUM = Byte[0] + Byte[1] + Byte[2] + etc. . .
  - While ( Write (max 16 bytes) data to Flash != I2C\_OK )
  - Size = Size + (max 16 bytes) // find image Size
5. While ( I2C bus is not available)
6. While (Write\_CHECKSUM != I2C\_OK) //write image CHECKSUM
7. While ( I2C bus is not available)
8. While ( Write\_Size != I2C\_OK) // write image size
9. While ( I2C bus is not available)
10. While (Read\_CHECKSUM != I2C\_OK) // check CHECKSUM of image in flash
11. While ( I2C bus is not available)
12. If Read\_CHECKSUM == Write\_CHECKSUM then reboot, camera will start normally
13. Else goto step 2 //(this should not happen)

*Note1: To check I<sup>2</sup>C is available (= Ack-polling) Do I<sup>2</sup>C write 1 byte: 0x70 0x00) or Read 1 dummy byte: 0x71 <1 dummy\_byte>*

*Note2: If the camera flash is not correctly programmed or the CHECKSUM does not match then the camera will start into bootloader. In bootloader all register read commands: (0x70 0x30 <register> 0x71 <data>) will result in: data = 0xFF. Also see chapter 0*

## Processor SPI Flash Programming

The firmware of the image processor can be updated using the functions below. The SPI flash needs to be erased before it can be written. After erasing the SPI flash can be programmed. After every erase or write

the SPI status needs to be checked until the write-in-progress bit becomes zero. The only way to verify the image is correctly written, is to read back the image and compare.

## Read data from SPI

```
<start> <0x70> <0x47> <address[0..2]> <stop> <start> <0x71> <data[0..15]> <stop>
```

Maximum 16 Bytes can be read in one command.

## Write data to SPI

```
<start> <0x70> <0x48> <address[0..2]> <data[0..15]> <stop>
```

The page size is 256 Bytes, within a single write the page boundary **should not be crossed**, because this would result in a page wrap-around and the data crossing the page boundary would be programmed at page start address.

Maximum of 16 bytes can be written in one command.

## Read SPI-ID

```
<start> <0x70> <0x49> <ID_code> <stop> <start> <0x71> <ID[0..1]> <stop>
```

ID\_code: JEDEC/REMS = 0x90 or RDID = 0x9F

Error when id[0..1] is 0x99nn

## SPI Erase

```
<start> <0x70> <0x4A> <erase command> <stop>
```

command=0x01 to erase app

Chip erase takes typically 15 seconds (max 30s)

## SPI Block (64kB) Erase

```
<start> <0x70> <0x4C> <address[0..2]> <stop>
```

BLOCK\_NUMBER range: 0 to 15

Address = BLOCK\_NUMBER x 64 x 1024

Block erase takes typically 0.8 seconds (max 3.5s)

## Read SPI Status

```
<start> <0x70> <0x4B> <stop> <start> <0x71> <status[0..1]> <stop>
```

status[1] → done/idle = 0x00

bit[1] = write-enable

bit[0] = write-in-progress

bit[7:2] = reserved

Status0[0] → non-zero is error, zero is OK

## EEPROM Programming

EEPROM can be read and written from the bootloader.

### Read data from EEPROM

<start> <0x70> <0x4D> <address[1..0]> <stop> <start> <0x71> <data[0..15]> <stop>

Maximum 16 Bytes can be read in one command. Address = 0xAn, 0xmm, where n = 0x0~0x7 and m = 0x00 ~ 0xFF

### Write data to SPI

<start> <0x70> <0x4E> <address[1..0]> <data[0..15]> <stop>

The page size is 256 Bytes, within a single write the page boundary **should not be crossed**. Address = 0xAn, 0xmm, where n = 0x0~0x7 and m = 0x00 ~ 0xFF

## Bootloader Check

The bootloader ID can be read to check if the bootloader is running

<start> <0x70> <0x50> <stop> <start> <0x71> <ID-check> <stop>

ID-Check byte is 0xA5;

# Calibration and Default Settings

This chapter includes:

Calibration Parameters.....45

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## 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 Contrast[6];
    uint8_t control_CustomGamma0[21]; // Custom gamma curve 0
    uint8_t control_CustomGamma1[21]; // Custom gamma curve 1
} 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 RGainMin; //
    uint8_t RGainMax; //
    uint8_t BGainMin; //
    uint8_t BGainMaxL; // BGainMax = BGainMaxH << 8 | BGainMaxL
    uint8_t BGainMaxH; //
    uint8_t AWBLowRatio; // x-axis for AWB
    uint8_t AWBMidRatio; // x-axis for AWB
    uint8_t AWBHighRatio; // x-axis for AWB
    uint8_t AWBLowRgBgRatio[2]; // Rg/Rb
    uint8_t AWBMidRgBgRatio[2]; // Rg/Rb
```

```

uint8_t AWBHighRgBgRatio[2]; //Rg/Rb
uint8_t CCRLowTemperature[9]; //
uint8_t CCRMidTemperature[9]; //
uint8_t CCRHighTemperature[9]; //
uint8_t SetCCHECKSUMSLowRatio; // x-axis for CCR&CS
uint8_t SetCCHECKSUMSMidRatio; // x-axis for CCR&CS
uint8_t SetCCHECKSUMSHighRatio; // x-axis for CCR&CS
uint8_t CSLowTemperature[2]; // Cbgain, Crgain
uint8_t CSMidTemperature[2]; // Cbgain, Crgain
uint8_t CSHighTemperature[2]; // Cbgain, Crgain
} cal_awb_t;

```

```

typedef struct {
    uint8_t EdgeEnhancement_Pgain[6]; // bright region of edge boundary
    uint8_t EdgeEnhancement_Ngain[6]; // dark region of edge boundary
    uint8_t EdgePmax[3]; //
    uint8_t EdgeNmax[3]; //
    uint8_t EdgePThreshold[5]; //
    uint8_t EdgeNThreshold[5]; //
    uint8_t DefectPixelCorrection_Pgain[6]; // dpc p
    uint8_t DefectPixelCorrection_Ngain[6]; // dpc n
    uint8_t NoiseBLFOffset[6]; //
    uint8_t NoiseNFOffset[6]; //
    uint8_t NoiseReductionOffset[6]; // NoiseReductionOffset
    uint8_t ColorSuppressionOffset[6]; // ColorSuppressionOffset
    uint8_t ColorSuppressionY1[6]; //
    uint8_t ColorSuppressionY2[6]; //
} cal_optimize_t;

```

# Register Summary

This chapter includes:

Complete List of the Control Registers.....48

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## Complete List of the Control Registers

Register	Default	Range	Description																						
0x00	0x80	0x00-0xFF	<b>Brightness</b>																						
0x01	0x40	0x00-0xFF	<b>Contrast</b>																						
0x02	0x00	Bit [1] Bit [0]	<b>Mirror</b> Horizontal mirror Vertical mirror																						
0x03	0x00	0x00-0xFF	<b>Gamma 0</b>																						
0x04	0x00	0x00-0xFF	<b>Gamma Black Correction 0</b> (0 – 20)																						
0x05	0x00	0x00-0xFF	<b>Gamma 1</b>																						
0x06	0x00	0x00-0xFF	<b>Gamma Black Correction 1</b> (0 – 20)																						
0x07	0x80	0x00-0xFF	<b>Hue</b> (degrees: -128° to +127°)																						
0x08	0x2E	0x00-0xFF	<b>Saturation</b> 0x20 = 1x 0x2E = 1.44x																						
0x09	0x80	0x00-0xFF	Automatic Exposure Target Level																						
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	0x00-0x7F	<b>AEX Analogue Gain Limit</b> <table border="1" data-bbox="609 1150 1198 1543"> <thead> <tr> <th>Register value</th> <th>Gain Limit</th> </tr> </thead> <tbody> <tr><td>2</td><td>16x</td></tr> <tr><td>4</td><td>32x</td></tr> <tr><td>8</td><td>48x</td></tr> <tr><td>16</td><td>64x</td></tr> <tr><td><b>32</b></td><td><b>80x</b></td></tr> <tr><td>64</td><td>96x</td></tr> <tr><td>80</td><td>102x</td></tr> <tr><td>96</td><td>106x</td></tr> <tr><td>112</td><td>109x</td></tr> <tr><td>127</td><td>127x</td></tr> </tbody> </table>	Register value	Gain Limit	2	16x	4	32x	8	48x	16	64x	<b>32</b>	<b>80x</b>	64	96x	80	102x	96	106x	112	109x	127	127x
Register value	Gain Limit																								
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64	96x																								
80	102x																								
96	106x																								
112	109x																								
127	127x																								
0x0F	0x00	Bit[0]	<b>Exposure Mode</b> Automatic = 0 Manual = 1																						
0x10	0x10	0x00-0xFF	<b>Manual Exposure Gain</b> 0x10 = Digital and analogue gain = 1x 0x10-0x70 = analogue gain: 1x – 64x 0x70-0xFF = digital gain: 1x – 8.9375x																						
0x11	0x80	0x00-0xFF	<b>Manual Exposure Shutter</b> 0 = off																						

# Register Summary

Register	Default	Range	Description																																																																														
			0xFF = max shutter																																																																														
0x12	0x0D	0x00-0x25	<b>Manual Exposure Fixed Shutter</b> <table border="1"> <thead> <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><b>13</b></td><td><b>1/150</b></td></tr> <tr><td>14</td><td>1/200</td></tr> <tr><td>15</td><td>1/250</td></tr> <tr><td>16</td><td>1/300</td></tr> <tr><td>17</td><td>1/400</td></tr> <tr><td>18</td><td>1/500</td></tr> <tr><td>19</td><td>1/600</td></tr> <tr><td>20</td><td>1/700</td></tr> <tr><td>21</td><td>1/750</td></tr> <tr><td>22</td><td>1/800</td></tr> <tr><td>23</td><td>1/900</td></tr> <tr><td>24</td><td>1/1000</td></tr> <tr><td>25</td><td>1/2000</td></tr> <tr><td>26</td><td>1/3000</td></tr> <tr><td>27</td><td>1/4000</td></tr> <tr><td>28</td><td>1/5000</td></tr> <tr><td>29</td><td>1/6000</td></tr> <tr><td>30</td><td>1/7000</td></tr> <tr><td>31</td><td>1/8000</td></tr> <tr><td>32</td><td>1/9000</td></tr> <tr><td>33</td><td>1/10000</td></tr> <tr><td>34</td><td>1/20000</td></tr> <tr><td>35</td><td>1/30000</td></tr> <tr><td>36</td><td>1/40000</td></tr> <tr><td>37 (0x25)</td><td>1/50000</td></tr> </tbody> </table>	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	<b>13</b>	<b>1/150</b>	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	35	1/30000	36	1/40000	37 (0x25)	1/50000
Register	Shutter (s)																																																																																
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37 (0x25)	1/50000																																																																																
0x13	0x00	0x00-0x06	<b>Automatic Exposure Anti Flicker</b> <table border="1"> <thead> <tr> <th>Register</th> <th>Shutter Time</th> </tr> </thead> <tbody> <tr><td>0</td><td>OFF</td></tr> <tr><td>1</td><td>1/120</td></tr> <tr><td>2</td><td>1/60</td></tr> <tr><td>3</td><td>1/30</td></tr> </tbody> </table>	Register	Shutter Time	0	OFF	1	1/120	2	1/60	3	1/30																																																																				
Register	Shutter Time																																																																																
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## Register Summary

Register	Default	Range	Description						
			<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">4</td> <td style="text-align: center;">1/100</td> </tr> <tr> <td style="text-align: center;">5</td> <td style="text-align: center;">1/50</td> </tr> <tr> <td style="text-align: center;">6</td> <td style="text-align: center;">AUTO</td> </tr> </table>	4	1/100	5	1/50	6	AUTO
4	1/100								
5	1/50								
6	AUTO								
0x14	0x00	Bit[0]	<b>AEX BLC Windows Show</b> Backlight Compensation Window 1: Show BLC windows 0: Hide BLC windows						
0x15	0x08	0x00-0x3F	Automatic Exposure BLC Window Weight						
0x16	0x28	0x00-0x78	Automatic Exposure BLC Window X-Position						
0x17	0x28	0x00-0x78	Automatic Exposure BLC Window Y-Position						
0x18	0x50	0x00-0x78	Automatic Exposure BLC Window X-Size						
0x19	0x50	0x00-0x78	Automatic Exposure BLC Window Y-Size						
0x1A	0x00	0x00-0xFF W: 0x00 W: 0x01 W: 0x10 R: 0x11	<b>White Balance Mode</b> Auto Manual Push-to-White Push-to-White function finished						
0x1B	0x00	Bit[0]	<b>White Balance Window Show</b> 1: Show AWB window 0: Hide AWB window						
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						
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 CCR 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 CCR M11						
0x2D	0x83	0x00-0xFF	White Balance CCR M12						
0x2E	0x84	0x00-0xFF	White Balance CCR M13						
0x2F	0x90	0x00-0xFF	White Balance CCR M21						
0x30	0x33	0x00-0xFF	White Balance CCR M22						

## Register Summary

Register	Default	Range	Description
0x31	0x83	0x00-0xFF	White Balance CCR M23
0x32	0x89	0x00-0xFF	White Balance CCR M31
0x33	0x96	0x00-0xFF	White Balance CCR M32
0x34	0x3F	0x00-0xFF	White Balance CCR 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	<b>Edge Enhancement</b> Bit[0] Enable edge enhancement Bit[1] Edge RGB gamma enable Bit[2] Post edge enhancement enable Bit[7] Show edge
0x3E	0x20	0x00-0xFF	Edge Enhancement Level
0x3F	0x01	0x00-0x01	Noise Reduction Enable
0x40	0x0C	0x00-0xFF	Noise Reduction Level
0x41	0x01	0x00-0x01	Noise Reduction Bilateral Filter Enable
0x42	0x00	0x00-0xFF	Noise Reduction Bilateral Filter Level
0x43	0x00	0x00-0xFF	Noise Reduction BLF High Frequency Level
0x44	0x20	0x00-0x3F	Noise Reduction DPC Level
0x45	0x00	0x00-0x01	Color suppression enable
0x46	0x00	0x00-0xFF	Color suppression level
0x47	0x00	0x00-0xFF	Test Pattern Selection
0x48	0x00	0x00-0xFF	Test Pattern Red [9:2]
0x49	0x00	0x00-0xFF	Test Pattern Green 1 [9:2]
0x4A	0x00	0x00-0xFF	Test Pattern Green 2 [9:2]
0x4B	0x00	0x00-0xFF	Test Pattern Blue [9:2]
0x4C	0x00	0x00-0xFF	Test Pattern R[1:0] G1[1:0] G2[1:0] B[1:0]
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
0x70	RW	0x00-0xFF	Control Bit[0] Hue enable Bit[1] Saturation enable Bit[2] Brightness enable Bit[3] Contrast enable
0x71	RW	0x00-0xFF	Contrast

## Register Summary

Register	Default	Range	Description
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
0x7A	RW	0x00-0xFF	Burst Amplitude
0x7B	RW	0x00-0xFF	Sync Amplitude
0xE0	RW	0x00-0xFF Bit[0] Bit[7]	GPIO control GPIO level GPIO mode 0 = open-drain, 1 = push-pull
0xEE	R/W	0x00-0xFF	EEPROM version Minor number
0xEF	R/W	0x00-0xFF	EEPROM 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
0xF4	RO	0x01 0x02 0x03 0x04	<b>Camera Type</b> TVI 30fps TVI 25fps AHD 30fps AHD 25fps
0xF5	RO	0x00-0xFF 30 <sub>10</sub> 25 <sub>10</sub>	<b>Framerate</b> 30fps 25fps
0xF6	RO	0x00-0xFF	Model
0xF7	0x00	Bit[0] Bit[1] Bit[2]	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	Reboot

## Register Summary

Register	Default	Range	Description
		0x02	Reboot into bootloader
0xFA	RO		<reserved>
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

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# Communication

To communicate with the camera we offer a communication kit, wire leads and control software (24C46 camera control) and updater tool.

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

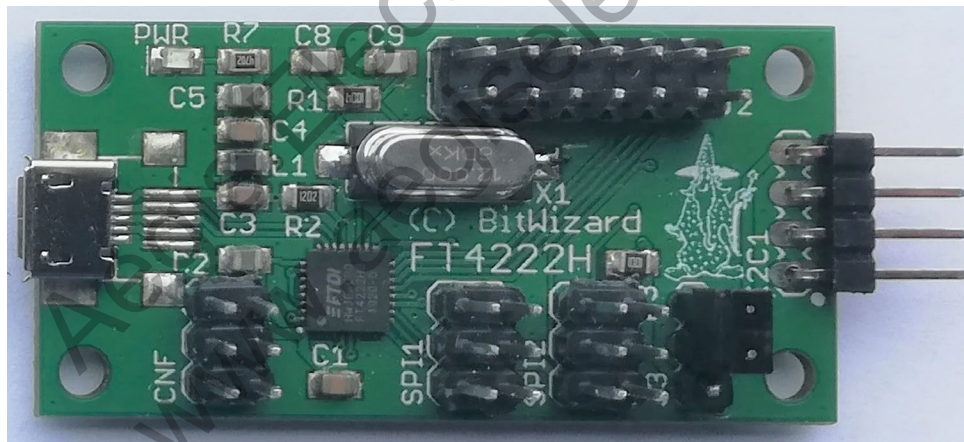


Figure 10. Communication kits

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