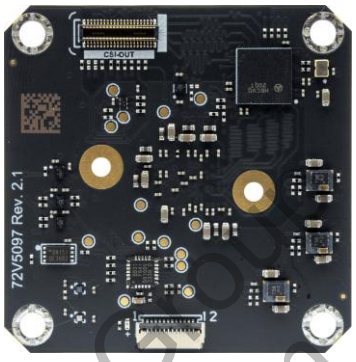
User Guide

Videology®
Industrial-Grade Cameras
an InTest Company

2.3 MP Global Shutter MIPI Camera



SCAILX-2GS234
Color and Monochrome version

Videology Industrial-Grade Cameras

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2. Warning and Safeguards

- Read instructions before operating the 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.

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 damage.
- 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 the camera from humidity, dust, and high temperatures.
- Be careful when installing the camera close to the ceiling, in a kitchen or boiler room, as the temperature may rise 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

- Consult the datasheet of the camera for temperature limits and guidance.
- Avoid damp or dust places.
- Avoid places exposed to rain.
- Avoid places subject to strong vibration
- Avoid 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

Document History

Revision	Issue Date	Reason
0.1		Initial Creation
0.2	22/08/2023	Change register addresses
0.3	17/10/2023	Change Set-state command
0.4	06/11/2023	
0.6	15/12/2023	Update I^2C commands
0.7		Add header4 for registers
0.8	15/01/2023	Add IO function descriptions
0.9	01/02/2024	Reformat, change font
0.10	15/02/2024	
0.11	01/03/2024	Update PWM period for Sync output
0.12	14/03/2024	Added AWB manual X/Y
0.13	17/04/2024	Update Camera Type register, update register ranges and step size. Add LED codes.
Rev. A	19/07/2024	Initial release
Rev. B	14/07/2025	Update board thickness to 1.6 mm

4. Table of Contents

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5. Description

This document describes the specification and the usage guide for the Global Shutter MIPI Camera.

5.1 Features

- Scaling (zoom) / Panning
- Camera Sync
- Flash
- Trigger
- Anti-Flicker
- Face detection
- Special Effects
- Test Pattern Generation

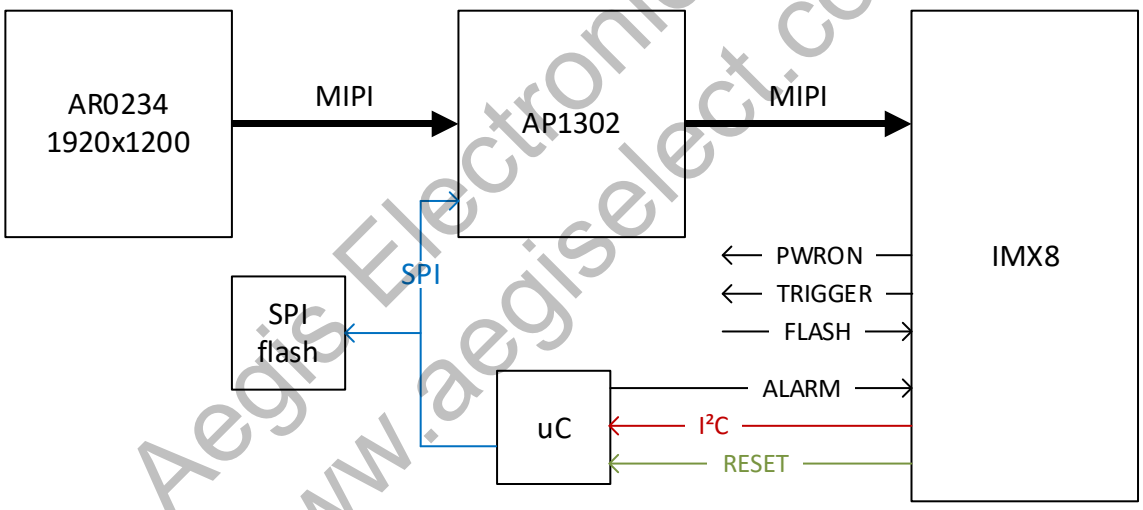


Figure 1. Block diagram

6. Specification

6.1 Opto-Electric

Specification Item	Specification		
Image sensor	OnSemi AR0234CS 2.3Mp Global Shutter		
Active pixels	1920x1200		
Pixel size	3.0 µm		
Image size	5.76 x 3.6 mm		
Sensor type	Color	Monochrome	
Optical size	1/2.6 inch (6.8 mm)		
Shutter type	Global Shutter		
Resolutions[1]	1920 x 1200 1600 x 1200 1200 x 1200 1920 x 1080 1440 x 1080 1080 x 1080 1366 x 1024	1280 x 1024 1024 x 1024 1280 x 960 1366 x 768 1024 x 768 1280 x 720 960 x 720	1024 x 576 768 x 576 960 x 540 720 x 540 854 x 480 640 x 480
Framerate	0 ~ 120 fps		
Pixel clock rate	90 MHz		
Sensitivity	< 0.1 lux	< 0.05 lux	
Signal to Noise Ratio (SNR)	38 dB		
Dynamic range	71.4 dB		

6.2 Interfaces

Specification Item	Specification
Control interface	I^2C
Video output	MIPI

6.3 Electrical

Specification Item	Specification
Supplied Voltage[2]	+5 V ± 10%
Current drawn @ 5 V	120 fps: 220 mA 60 fps: 140 mA 30 fps: 170 mA Standby: 17 mA
Power consumption Standby	0.7 ~ 1.1 W < 85 mW

[1] *The resolutions defined here are the fixed resolutions; this camera can support any resolution up to 1920x1200.*

[2] *Camera will operate from 3 V ~ 5.5 V (Do not exceed 5.5 V). Supply voltage below 3.5 V may result in reduced picture quality, depending on the stability of the supply voltage.*

6.4 Environmental

Specification Item	Specification
Operating temperature	-25 °C ~70 °C (-13 °F ~ 158 °F)
Operating humidity	< 90% (non-condensing)
Storage temperature	-40 °C ~ 85 °C (-40 °F ~ 185 °F)
Storage humidity	< 75%

6.5 Functional

Specification Item	Specification
Automatic Exposure control (AE)	Auto / Manual / ROI / Face
Brightness	0 ~ 255
Contrast	0 ~ 255
Gamma	0.4 ~ 1.0
Saturation	0 ~ 255
Sharpness/Blur control	Yes
Noise reduction	Yes
Automatic color adjustment	Auto / Manual / Push2White / Set
Manual color adjustment	Yes
BLC	Yes
HDR	No
Mirror/Flip	Yes
Panning	Yes (128 steps)
Digital zooming	Yes
Upgradable	Yes
Video format selection	Yes
Trigger	Yes
Flash	Yes
Sync	Yes
Lens shading correction	Yes
Face detection	Yes
Anti Flicker	Yes
JPEG quality control	Yes
Filter effects	Yes

7. Mechanical

The camera's dimensions are shown in Figure 2 and Figure 3.

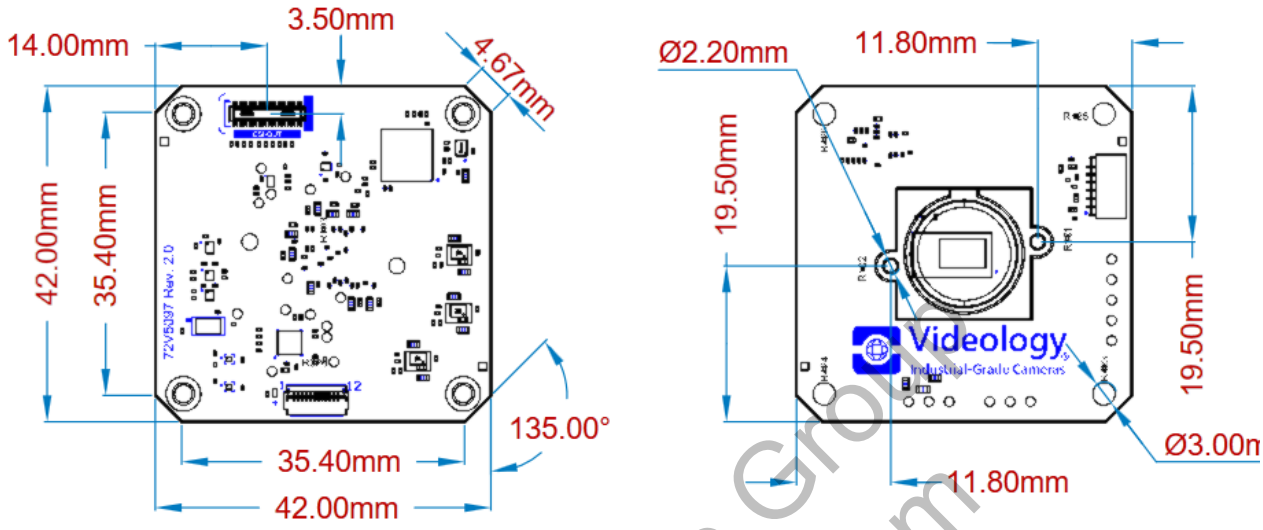


Figure 2. Camera Dimensions

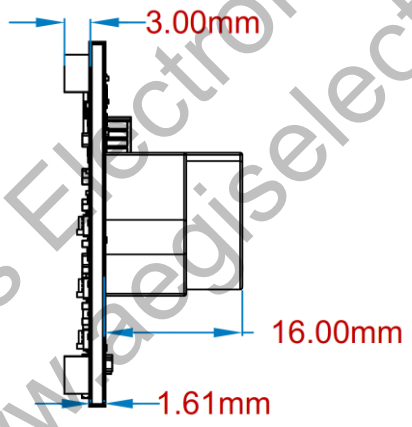


Figure 3. Camera height dimensions

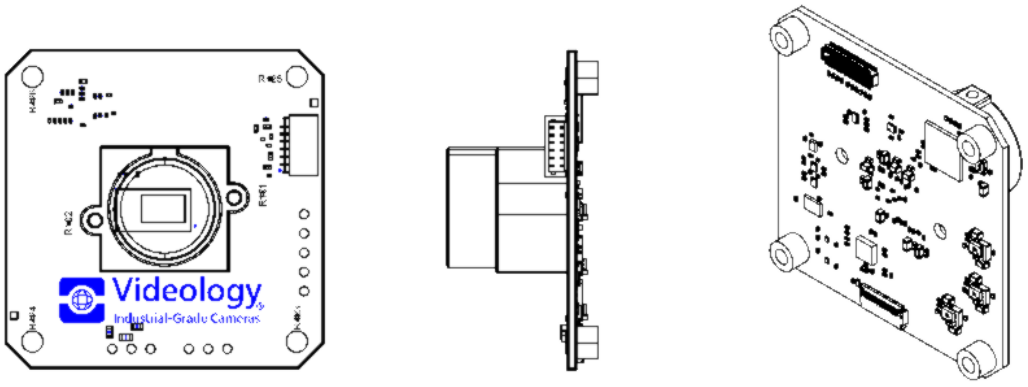


Figure 4. Camera orientations

7.1 Mechanical size

Specification Item	Specification
Dimensions WxHxD	42 x 42 x 7.15 mm 42 x 42 x 20 mm (/w lens mount M12)
Weight Lens / Weight Controller	Bare board 5.5 g Incl. M12 lens mount 15 g Incl. pinhole lens mount 10.5 g
Lens mount	M12, M12-Pinhole or CS

Table 1. Dimensions

7.2 Connectors

Connector Identifier	Connector Type	Description
J400	DF40C-40DP-0.4V(51)	MIPI / Power connector
P200	WR-WTB 1mm 6p	Trigger/ Sync & FLASH
J300	WR-FPC ZIF 0.5mm 12p	(Debug)

Table 2. Connectors

7.2.1 Connector P200

Trigger/ Sync & FLASH	
Pin #	**Function**
1	Sync Output (PWM) (3.3 V)
2	GND
3	FLASH (3.3 V)
4	GND
5	Sync Input (3.3 V)
6	+5 V

Table 3. Trigger / Sync connector

- Sync Output (PWM), Free running PWM signal.
- Flash: On during exposure.
- Sync Input: Exposure triggers when Sync Input.

7.2.2 Connector J400 Pinning

MIPI / Power connector			
Pin #	**Function**	**Pin #**	**Function**
1	MIPI-CLK-N	2	GND
3	MIPI-CLK-P	4	FLASH-OUT (3.3 V)
5	GND	6	TRIGGER-IN (3.3 V)
7	MIPI-D0-N	8	GND
9	MIPI-D0-P	10	RSTN
11	GND	12	ALARM (3.3 V)
13	MIPI-D1-N	14	GND
15	MIPI-D1-P	16	PWR-ON (On = 1 V ~ 5 V)

17	+5V	18	+5V
19	-	20	-
21	-	22	-
23	+5V	24	+5V
25	VIO (3.3 V output)	26	I^2C-SCL (3.3 V)
27	GND	28	I^2C-SDA (3.3 V)
29	MIPI-D2-N	30	GND
31	MIPI-D2-P	32	reserved
33	GND	34	reserved
35	MIPI-D3-N	36	GND
37	MIPI-D3-P	38	reserved
39	GND	40	reserved

Table 4. MIPI / Power connector

- FLASH-OUT: On during exposure.
- TRIGGER-IN: Can be used to trigger exposure (reserved).
- ALARM: High, On Error.
- PWR-ON: Pull High to power on camera.

7.3 Lens mount options

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

Model name: SCAILX-2GS234-xy		Description
x	X	No lens mount
	2	M12-pinhole lens mount
	5	M12 lens mount
	8	CS lens mount
y	C	Color
	IR	Color, without IR filter (IR pass-through)
	M	Monochrome

Table 5. Camera part number and lens mount options

8. Camera Communications

8.1 Communication interface specification

This camera uses I²C to control the camera's functions. The camera's I²C device address is programmable. The default camera I²C device (8-bit) address is: **0x70.**

Some aspects of the I²C 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 I²C status byte can be added to the result to reflect the I²C status (default disabled)

When clock stretch is disabled, the user must wait an undefined time before reading the data. I²C 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 I²C specification). When ACK polling is enabled, the camera will disable the I²C and re-enable I²C after the task is completed. The user can poll the I²C bus by writing to the I²C bus. (Do not read to check if the I²C bus is available!)

Check I²C bus ready command:

START | 0X70 | ACK/NACK | STOP

→ in case of NAK on I²C bus → retry

Or

START | 0X70 | 0X00 | ACK/NAK | STOP

→ in case of NAK on I²C bus → retry

I²C read example, status byte disabled:

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

I²C read example, status byte enabled:

START | 0X70 | 0X31 | REGISTER | START | 0X71 | I²C STATUS | REGISTER VALUE | STOP

8.1.1 Camera I²C 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	Yes/No[3]
0x31	8-bit Register Read	Yes/No [3]
0x32	16-bit Register Write	Yes/No [3]
0x33	16-bit Register Read	Yes/No [3]
0x34	32-bit Register Write	Yes/No [3]
0x35	32-bit Register Read	Yes/No [3]
0x39	Read face coordinates	No
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

Table 6. I²C camera command interface

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

Reading an 16bit register examples:

START | 0X70 | 0X33 | REGISTER ADDRESS | START | 0X71 | REGISTER VALUE [0:1] | STOP

Or

START | 0X70 | 0X33 | REGISTER ADDRESS | STOP | START | 0X71 | REGISTER VALUE [0:1] | STOP

Reading an 32bit register examples:

START | 0X70 | 0X35 | REGISTER ADDRESS | START | 0X71 | REGISTER VALUE [0:3] | STOP

Or

START | 0X70 | 0X35 | REGISTER ADDRESS | STOP | START | 0X71 | REGISTER VALUE [0:3] | STOP

[3] *Password protection depends on register function.*

Writing an 8bit register example:

START	0X70	0X30	REGISTER ADDRESS	REGISTER VALUE	STOP

Writing an 16bit register example:

START	0X70	0X32	REGISTER ADDRESS	REGISTER VALUE [0:1]	STOP

Writing an 32bit register example:

START	0X70	0X34	REGISTER ADDRESS	REGISTER VALUE [0:3]	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 10.1.2.

NVM Read Command:

START	0X70	0X51	PAGE	ADDRESS	SIZE	START	0X71	CHUNK OF BYTES	STOP

Or

START	0X70	0X51	PAGE ADDRESS	SIZE	STOP	START	0X71	CHUNK OF BYTES	STOP

NVM Write Command:

START	0X70	0X50	PAGE ADDRESS	CHUNK OF DATA BYTES	STOP

→ in case of NAK on I²C bus → retry

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

START	0X70	0X52	PAGE	STOP

8.1.2 Bootloader I²C 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 I²C command interface for the bootloader is different than the camera's I²C commands in paragraph 8.1.1. The Camera's bootloader I²C 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 I²C bus

Table 7. I²C Bootloader command interface

Updating the Firmware can be done in chunks of 8, 16, 32 or 64 bytes, default is chunks of 16 bytes (it is defined by the firmware image format). The camera will block the I²C bus when it is busy, any I²C command send when the camera is busy results in a NAK response on the I²C bus. This allows polling to check whether the camera's I²C is available. Always use a I²C write command to check. Use command 0x00 for checking the I²C bus.

8.2 Status and Error LED codes

Status / Error	LED Code	Description
Startup	OFF	Camera is starting
Init	ON	Camera is initializing
Format Change	ON	Host set camera to formats change mode, MIPI lanes are disabled.
Format Change Done	OFF	Host sets camera to format change Done, MIPI is enabled.
Normal operating	ON (250 ms) / OFF (1 s)	Normal operation mode
Upgrade	ON	Camera is in upgrade mode
Power Down / Standby	ON (100 ms) / OFF (3 s)	Camera is in power down mode
Error	ON (250 ms) / OFF (250 ms)	Camera is in error state.

8.3 Register Overview

R = Readable, W = Writeable, P = Password protected, S = Can be Stored in NVM, T = command takes Time.

Register Address	Access	Width (bits)	Function
0x00	R/W/S	8	Dummy register
0x01	-	*8*	*Reserved (do not use)*
0x02	R/W/S	16	Brightness
0x04	R/W/S	16	Contrast
0x06	R/W/S	16	Saturation
0x08	-	*16*	*Reserved (do not use)*
0x0A	R/W/S	16	Sharpness
0x0C	R/W/S	16	Noise reduction
0x0E	R/W/S	16	Gamma

Register Address	Access	Width (bits)	Function
0x10	R/W/S/T	8	Format (SCAILX: R/W/T)
0x11	R/W/S/T	8	Format Type (SCAILX: R/W/T)
0x12	R/W/T	16	Format X (SCAILX: R/W/T)
0x14	R/W/T	16	Format Y (SCAILX: R/W/T)
0x16	R/W/S	8	Framerate (SCAILX: R/W)
0x18	R/W/S	16	Zoom
0x1A	R	16	Zoom Get
0x1C	R/W/S	8	Zoom Speed
0x1D	R/W/S	8	Pan Horizontal
0x1E	R/W/S	8	Pan Vertical
0x1F	R/W/S	8	Mirror / Flip
0x20	R/W/S	8	Automatic Exposure Mode
0x21	R/W/S	8	ROI Mode
0x22	R/W/S	8	AE Speed
0x24	R/W/S	32	Exposure Upper
0x28	R/W/S	32	Exposure Max
0x2C	R/W/S	16	Gain Upper
0x2E	R/W/S	16	Gain Max
0x30	R/W/S	16	Gain
0x30 ~ 0x33	-	*8*	*Reserved (do not use)*
0x34	R/W/S	32	Exposure
0x38	R/W/S	16	Brightness Value
0x3A	R/W/S	16	ISO
0x3C	R/W/S	16	AE Target
0x3E ~ 0x3F	-	*8*	*Reserved (do not use)*
0x40	R/W/S	8	BLC Mode
0x41	R/W/S	8	BLC Level
0x42	R/W/S	8	BLC Window X0
0x43	R/W/S	8	BLC Window Y0
0x44	R/W/S	8	BLC Window X1
0x45	R/W/S	8	BLC Window Y1
0x46	R/W/S	16	BLC Bound LO
0x48	R/W/S	16	BLC Bound HI
0x4A	R/W/S	8	BLC Ratio
0x4B	R/W/S	8	Face Level
0x4C	R/W/S	8	Face Weight
0x4D	R/W/S	8	Face Size Weight
0x4E	R/W/S	8	Face Selected Weight
0x4F	R/W/S	8	BLC ROI Level
0x50	R/W/S	8	AWB Mode
0x51	-	*8*	*Reserved (do not use)*
0x52	R/W/S	16	AWB Temperature
0x54	R/W/S	8	AWB Face
0x55	R/W/S	8	Face Detection
0x56	R/W/S	8	Anti Flicker Mode
0x57	R/W/S	8	Anti Flicker Frequency
0x58	R/W/S	16	Trigger Mode

Register Address	Access	Width (bits)	Function
0x5A	R/W/S	32	Trigger Offset
0x5E	R/W/S	16	Trigger Relative Offset
0x60	R/W/S	16	Sync PWM Duty Cycle
0x61 ~ 0x63	-	*8*	*Reserved (do not use)*
0x64	R/W/S	32	Sync PWM Period
0x68	R/W/S	8	Sync PWM
0x69	R/W/S	8	Flash
0x6A	R/W/S	8	Flash Delay
0x6B ~ 0x6F	-	*8*	*Reserved (do not use)*
0x70	R/W/S	16	Lens Shading Control
0x72	R/W/S	16	Lens Shading Falloff
0x74	R/W/S	8	Tone Map
0x75	R/W/S	8	JPEG Quality
0x76	R/W	8	Effects
0x77 ~ 0x7F	-	8	*Reserved (do not use)*
0x80	R/W/S	16	Face Detected
0x82	R/W/S	8	Face Detect On/Off
0x83	R/W/S	8	Face Detect Threshold
0x84	R/W/S	8	Face Detect Chroma Threshold
0x86	R/W/S	16	Face Minimum size
0x88	R/W/S	16	Face Maximum size
0x8A	R/W/S	16	AWB Manual X
0x8C	R/W/S	16	AWB Manual Y
0x8E ~ 0xDF			*Reserved (do not use)*
0xE0	R/W	8	Test pattern
0xE1 ~ 0E5	-	8	*Reserved (do not use)*
0xE6	R/W/S	8	ISP Boot
0xE7	R/W	8	Power
0xE8	W	8	Status Control
0xE9	R	8	Status Result
0xE8 ~ 0xEA		8	*Reserved (do not use)*
0xEB	R/W/P	8	Upgrader
0xEC	R	8	ISP Version Number (Minor)
0xED	R	8	ISP Version Number (Major)
0xEE	R	8	NVM Version Number (Minor)
0xEF	R	8	NVM Version Number (Major)
0xF0	R/W/(P)/T	8	Save / Restart
0xF1	R	8	Camera Type
0xF2	R	8	Framerate
0xF3	R	8	Camera Model
0xF4 ~ 0xF5	-	8	*Reserved (do not use)*
0xF6	R/W/S	8	I^2C Address
0xF7	R/W/P/S	8	I^2C Control
0xF8	W/P	8	Bootloader
0xF9	-	*8*	*Reserved (do not use)*
0xFA	R	8	Status
0xFB	R	8	Microcontroller Firmware Status

Register Address	Access	Width (bits)	Function
0xFC	W	8	Password LSB
0xFD	W	8	Password MSB
0xFE	R	8	Microcontroller Software Version (Minor)
0xFF	R	8	Microcontroller Software Version (Major)

Table 8. Register list

9. Detailed register usage information

9.1 Basic Controls

Dummy (R/W/S)

Register	Value	Default	Description
0x00	0x00 ~ 0xFF	0xFF	Dummy register

This is a dummy register that has no function.

Brightness (R/W/S)

Register	Value	Default	Description
0x02	16 bits	0x0000	0x0000 is the center. Format: s3.12[4]

The brightness value ranges from -32768 to 32767. The format is a two's complement value. Working values range from **-4096** to **4096**, best to use a step size[5] of **32**.

Contrast (R/W/S)

Register	Value	Default	Description
0x04	16 bits	0x0000	0x0000 is the center. Format: s3.12

The contrast value ranges from -32768 to 32767. The format is a two's complement value. Use a step size of **256**.

Saturation (R/W/S)

Register	Value	Default	Description
0x06	16 bits	0x1000	0x0000 = Monochrome 0x0800 = Neutral 0x1000 = Standard 0x2000 = Vivid Format: s3.12

Saturation ranges from 0x0000 to 0x2000, use a step size[5] of **32**.
e.g. the default 1.0 is 0x1000

Sharpness (R/W/S)

Register	Value	Default	Description
0x0A	16 bits	0x0000	0x0000 is the center. Format: s3.12

The sharpness value ranges from -32768 to 32767. The format is a two's complement value. Use a step size[5] of **256**.

[4] *Signed 16 bit value: 1-bit sign+3-bit integer+12-bit fraction*

[5] *The recommended step size will give 256 steps from minimum to maximum.*

Noise reduction (R/W)

Register	Value	Default	Description
0x0C	16 bits	0x0000	0x0000 is the center. Format: s3.12

The noise reduction value ranges from -32768 to 32767. The format is a two's complement value. Use a step size[5] of **256**.

Gamma (R/W)

Register	Value	Default	Description
0x0C	16 bits	0x0000	0x0000 is sRGB, sets the display gamma. Format: s3.12

The format is s3.12. Gamma is controllable from 0x600 to 0x8000. Gamma values lower than 0x600 result in the default **sRGB** gamma curve. To get the gamma multiply with 4096.

E.g: Gamma of **1.0** = 1.0 x 4096 = 0x1000 (4096)
Gamma of **2.5** = 2.5 x 4096 = 0x2800 (10240)

9.2 Video Format and framerate

In the SCAILX version of the firmware these registers will not be stored and/or recovered, because SCAILX will always set these registers when the video stream starts.

Format (R/W/S/T)

Register	Value	Default	Description
0x10	0x00 ~ 0xFF	0x03	0 = 1920 x 1200 (16:10) 1 = 1600 x 1200 (4:3) 2 = 1200 x 1200 (1:1 3 = 1920 x 1080 (16:9) 4 = 1440 x 1080 (4:3) 5 = 1080 x 1080 (1:1) 6 = 1366 x 1024 (4:3) 7 = 1280 x 1024 (5:4) 8 = 1024 x 1024 (1:1) 9 = 1280 x 960 (4:3) 10 = 1366 x 768 (16:9) 11 = 1024 x 768 (4:3) 12 = 1280 x 720 (16:9) 13 = 960 x 720 (4:3) 14 = 1024 x 576 (16:9) 15 = 768 x 576 (4:3) 16 = 960 x 540 (16:9) 17 = 720 x 540 (4:3) 18 = 854 x 480 (16:9) 19 = 640 x 480 (4:3)

The Formats register sets the output format (resolution). The maximum possible number of pixels of the sensor is always used. Setting the format takes time and can take up to 100 ms, the I²C will be blocked during this time.

E.g. for the format 1280x720 the sensor uses 1920x1080 pixels and the output resolution is scaled to 1280x720. For the format 1280x960 the sensor will use 1600x1200 pixels and the output will be scaled down to 1280x960.

Format Type (R/W/S/T)

Register	Value	Default	Description
0x11	0x00 ~ 0xFF	0x00	0 = YUV422 (JFIF[6] color space) 1 = YUV420 (JFIF color space) 2 = YUV400 (JFIF color space) 3 = YUV422 (BT601 color space) 4 = YUV420 (BT601 color space) 5 = YUV400 (BT601 color space) 6 = RGB_888 7 = RGB_565 8 = RGB 555 9 = JPEG422 10 = JPEG420 11 = JPEG422 (EXIF) 12 = JPEG420 (EXIF) 13 = BAYER (16 bit) 14 = BAYER (12 bit) 15 = BAYER (10 bit) 16 = BAYER (8 bit)

The Format type register sets the YUV, RGB, JPEG or RAW(=Bayer) formats.
Setting the format type takes time and can take up to 100 ms, the I²C will be blocked during this time.

Format X (R/W/T)

Register	Value	Default	Description
0x12	16 bits	1920	Set horizontal resolution.[7]

Setting the format takes time and can take up to 100 ms, the I²C will be blocked during this time.

Format Y (R/W/T)

Register	Value	Default	Description
0x14	16 bits	1080	Set vertical resolution. [7]

Setting the format type takes time and can take up to 100 ms, the I²C will be blocked during this time.

Framerate (R/W/S)

Register	Value	Default	Description
0x16	16 bits	0x1E00 (100 fps)	Framerate in fps from 1 to 120 fps Sets the framerate and limits the AE to increase the framerate beyond this setting. This can be overruled by the Exposure Max register.

This register allows setting the framerate with an accuracy of 1/255th per second. For framerate of 10.5 fps the register value would be 0x0A80 (0x0A00 = 10 and 0x0080 = 0.5).
The framerate setting can be overruled by setting the exposure time beyond the framerate register time. Also, the AEX algorithm can overrule the framerate setting when the exposure is not limited. The exposure can be limited by the exposure upper and exposure max registers (see exposure s and gain in §9.5).

[6] *JFIF = JPEG File Interchange Format*
[7] *These registers are mutual exclusive with the Format register (0x10). These register do not get restored at power-on.*

9.3 Zoom & Pan

Zoom (R/W/S)

Register	Value	Default	Description
0x18	16 bit	0x0100	This register defines the target zoom factor.[8] Depending on the value, the ISP will gradually step from its current position towards target zoom factor. The default value is 1.0 and means that whole ROI will be mapped to output size as set in the current context (respecting the aspect ratio and output format). Higher values will gradually reduce the FOV, while maintaining the output size. The scaling factor will depend on the current FOV and output size and it can be either scaled up or scaled down. The FOV is independent of sensor mode. Alternatively, the user can control the desired scale factor. This can be achieved by using negative values. Value -1.0 means no scaling (if possible, at given sensor size and output size), values between 0.0 and -1.0 means scale down and values above mean scale up (e.g., -2.0 for 2x scaling). Since the scaling factor is in this case fixed, the FOV will depend on sensor readout mode. The "Zoom Get" register will be updated with the corresponding "positive" zoom value. Format: s7.8[11] (s7.8: 1-bit sign, 7-bit integer, 8-bit fraction)

Zoom Get (R)

Register	Value	Default	Description
0x1A	16 bits	RO	Get the actual zoom positive factor. Format: s7.8

Zoom Speed (R/W/S)

Register	Value	Default	Description
0x1C	0x00 ~ 0xFF	0x00	0x80 = Immediate 0x00 = stop 1(0x01) ~ 127(0x7F) = Linear (neg.)1(0xFF) ~ (neg.)127(0x81) = Fractional (Becomes slower when approaching zoom target)

This register sets zoom speed. There are two types of zoom movement: linear and fractional. In the Linear mode the zoom speed is constant and in the fractional mode the zoom-speed starts quick but slows down as the target zoom level approaches.

[8] *Setting the zoom factor too large may result in unpredictable behavior, try keeping the zoom factor under 32x.*

Pan Horizontal(R/W/S)

Register	Value	Default	Description
0x1D	0x00 ~ 0x80	0x40	0x00 ~ 0x40 = Pan Left 0x41 ~ 0x80 = Pan Right 0x40 = Center

Pan Vertical (R/W/S)

Register	Value	Default	Description
0x1E	0x00 ~ 0x80	0x40	0x00 ~ 0x40 = Pan Up 0x41 ~ 0x80 = Pan Down 0x40 = Center

9.4 Mirror & Flip

Mirror horizontal & Flip Vertical (R/W/S)

Register	Value	Default	Description
0x1F	0x00 ~ 0x03	0x00	0 = Normal 1 = Flip vertical 2 = Mirror horizontal 3 = Flip vertical flip and mirror horizontal

9.5 Exposure and Gain

Automatic Exposure Mode (R/W/S)

Register	Value	Default	Description
0x20	0x00 ~ 0x0C	0x0C	0x0 = Manual Exposure, manual Gain 0x1 = Manual BV[9], Manual Exposure, Auto Gain 0x2 = Manual BV, Manual Gain, Auto Exposure 0x3 = Manual BV, Manual ISO[10], Auto Exposure /Gain 0x4 = Manual BV, Auto Exposure /Gain 0x8 = Manual Exposure, Manual Gain, Tone map 0x9 = Auto BV, Manual Exposure, Auto Gain 0xA = Auto BV, Manual Gain, Auto Exposure 0xB = Auto BV, Manual ISO Auto, auto Exposure/Gain 0xC = Auto Brightness/Exposure/Gain

This register sets either different manual exposure modes or different automatic exposure modes. Writing 0x00 will set the camera to manual mode and writing 0x0C to this register will set the camera to operate fully in automatic mode.

1. Use manual exposure time and manual gain.
2. Use manual brightness Value and manual exposure time. The AEX algorithm calculates the gain accordingly.

[9] *BV = Brightness Value*
[10] *ISO = Sensitivity setting of the sensor*

3. Use manual brightness value and manual Gain. The AEX algorithm calculates the exposure time accordingly.
4. Use manual brightness value and manual ISO. The AEX algorithm calculates the exposure time and gain accordingly.
8. Use manual brightness value. The AEX algorithm calculates the exposure and gain accordingly.
9. Use manual exposure time and manual gain. Tone mapping may be used to achieve target image brightness.
10. Use target value and manual exposure time and the AEX algorithm calculates the gain accordingly.
11. Use target value and manual gain and the AEX algorithm calculates the exposure time accordingly.
12. Use target value and manual ISO and the AEX algorithm calculates the exposure time and gain accordingly.
13. Use target value and the AEX algorithm calculates the exposure time and gain accordingly. In this mode the camera operates fully in automatic mode.

ROI mode (Region Of Interest) (R/W/S)

Register	Value	Default	Description
0x21	0x00 ~ 0x07	0x04	Bit [0] = Bound enable/disable Bit [1] = Lock enable/disable Bit [2] = Face enable/disable

Bound: Set this bit to enable ROI based exposure.
Lock: Set this bit to lock the bound AE when the ROI is selected/found.
Face: Set this bit to enable face-based exposure.

The mixing ratio between ROI and FACE mode is specified in BLC RATIO register. The bounds are specified in BLC_LO and BLC_HI registers.

Note:
AE can use three different targets or combination thereof to set integration and gain:
- *Main AE target (full ROI)*
- *User ROI target (as set by ae_uroi_x0/y0/x1/y1)*
- *Face ROI target (using face information)*

Each of these have independent metrics and backlight compensation setting.

By default, the main AE target is used. Register BLC ratio controls how much of BLC ROI target gets combined into the main target. And face weight controls how much of face target gets combined into BLC ROI target.

In addition, the BLC hi/lo controls how far from the main target is the combined target allowed to deviate (in log2). For example:
- *When BLC ratio = 0.0, only main target will be used (no user or face ROI)*
- *When BLC ratio = 0.5, FACE weight = 0.0, BLC lo = -1.0 and BLC hi = 1.0, final target will be 50% of main target and 50% of user ROI, but not less than half or more than double of main target*
- *When BLC ratio = 1.0, FACE weight = 1.0, BLC lo = -2.0 and BLC hi = 2.0, final target will be based on face target, but not less than 1/4 or more than 4x of the main target*

AE Speed (R/W/S)

Register	Value	Default	Description

0x22	16 bit	0x0F00 (+15.0)	AE convergence speed per second sec. Format: s7.8

9.5.1 Exposure limits and gain limits

The exposure limits: “exposure upper” and “exposure max” are used by the AEX algorithm to limit the exposure time. Setting these limits beyond the framerate will lower the framerate to maintain the wanted brightness level.

1. Minimum gain is used from start and AE is increasing exposure time up to "upper exposure".
2. Once "upper exposure" is exhausted AE starts increasing gain up to "upper gain". Best performing gain is always used first, so analog gain will typically be used up before digital gain.
3. Once "upper gain" is exhausted AE again starts increasing exposure time up to "max exposure".
4. After that gain is increased up to max gain.
   (this value is logarithmic, e.g., gain max = 3.0 means 8x gain).

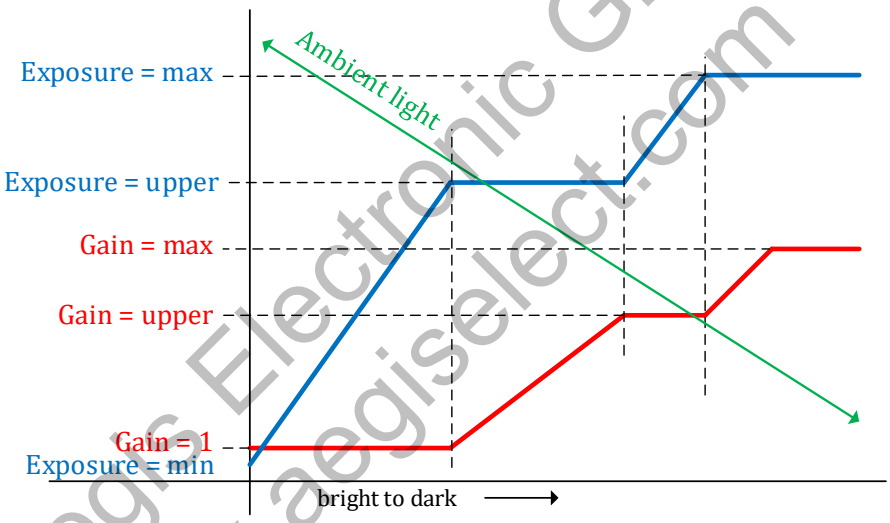


Figure 5 Exposure and Gain

Exposure Upper (R/W/S)

Register	Value	Default	Description
0x24	32 bits	33333	Exposure upper in microseconds (default 33.333 ms). Upper Exposure Time in microseconds. As the scene brightness reduces, Auto Exposure algorithm first increases exposure time to maintain the image brightness. Once exposure upper threshold is reached, AE algorithm starts increasing the gain instead, up to gain upper. A value of zero will set the maximum allowed exposure time to maintain the current framerate.

Exposure Max (R/W/S)

Register	Value	Default	Description
0x28	32 bits	33333	Maximum Exposure Time in microseconds. Absolute maximum exposure time that Auto Exposure algorithm will use. Once this threshold is reached, the AE algorithm will continue to use gain up to Gain Limit. A value of zero will set the maximum allowed exposure time to maintain the current framerate.

Gain Upper (R/W/S)

Register	Value	Default	Description
0x2C	16 bits	0x0800 (8.0x)	Sets the gain upper. (format = '255'.'255', so a gain of 1.5x = '1'.'128' = 0x0180) Upper Gain. Once gain upper is reached, Auto Exposure algorithm starts increasing exposure time beyond exposure upper up to exposure max. Format: u8.8

Gain Max (R/W/S)

Register	Value	Default	Description
0x2E	16 bits	0x0580 (+5.5x)	Sets the gain max. (format = '255'.'255', so a gain of 1.5x = '1'.'128' = 0x0180) Absolute maximum gain to be used by Auto Exposure algorithm in log2 format (gain = 2^gain_max). Format: s7.8

Gain (R/W/S)

Register	Value	Default	Description
0x30	16 bits	0x0100 (1.0x)	Sets the manual gain value. (format = '255'.'255', so a gain of 1.5x = '1'.'128' = 0x0180)

In the manual modes the gain can be set.

Exposure (R/W/S)

Register	Value	Default	Description
0x34	32 bits	33333	Sets the manual exposure value in microseconds.

In the manual modes the exposure can be set.

Brightness Value (R/W/S)

Register	Value	Default	Description
0x38	16 bits	0x0800	Sets the manual brightness value. Brightness Value is used in manual exposure modes. Format: s7.8 / 255.255, so a BV of 8.0 = 0x08.0x00 = 0x0800)

In the manual modes or semi-automatic modes, the Brightness Value can be set.

ISO (R/W/S)

Register	Value	Default	Description
0x3A	16 bits	0x0064	Sets the ISO speed used in manual exposure modes.

In the manual modes or semi-automatic modes, In the manual modes the ISO can be set.

AE Target (R/W/S)

Register	Value	Default	Description
0x3C	16 bits	0xFDCD (-2.2)	Sets the target reference level for the Automatic Exposure algorithm. (This is a logarithmic scale.) Format: s7.8

The Automatic Exposure target can be set by the AE target register. AE pixel value target (before gamma) in logarithm. Pixel value target is 2^ae_pv_target. E.g. -2.4 means 2^-2.2 = ~22% of signal range.
e.g: -2.2 → -3 + 0.8 → -3 = 0xFD, 0.8 = 0xCD

9.5.2 Backlight compensation for ROI.

BLC Mode (R/W/S)

Register	Value	Default	Description
0x40	0x00 ~ 0x03	0x00	0x0 = auto average 0x1 = auto wide center 0x2 = auto narrow center 0x3 = auto spot other = pointer to 8 weight table

BLC Level (R/W/S)

Register	Value	Default	Description
0x41	0x00 ~ 0x80	0x00	Sets the amount of backlight compensation.

BLC Window Position (R/W/S)

Register	Value	Default	Description
0x42	0x00 ~ 0x80	0x00	X0 – horizontal start position
0x43	0x00 ~ 0x80	0x00	Y0 – vertical start position
0x44	0x00 ~ 0x80	0x80	X1 – horizontal end position
0x45	0x00 ~ 0x80	0x80	Y1 – vertical end position

BLC Bound Hi / Lo (R/W/S)

Register	Value	Default	Description
0x46	16 bits	0xFD00 (-3.0)	BLC bound LO, format is s7.8, decrease to allow more face underexposure.[11]

[11] *Format s7.8 means Two's complements, 1 sign bit, 7 bits whole numbers, 8 bits faction.*

0x48	16 bits	0x0300 (3.0)	BLC bound HI, format is s7.8, increase to allow more face overexposure.

AE pixel value low bound in log, based on BLC window detection.

These parameters allow user to control FPS under different light conditions. This is how exposure and gain are used as light
conditions go from bright to dark:

1. Minimum gain is used from start and AE is increasing exposure time up to "upper exposure".
2. Once "upper exposure" is exhausted AE starts increasing gain up to "upper gain". Best performing gain is always used first, so analog gain will typically be used up before digital gain.
3. Once "upper gain" is exhausted AE again starts increasing exposure time up to "max exposure".
4. After that gain is increased up to (this value is logarithmic, e.g. reg(0x46) = 3.0 means 8x gain).

Note that there is also Brightness Values Max which can affect the above behavior and limit gain & exposure.

BLC Ratio (R/W/S)

Register	Value	Default	Description
0x4A	0x00 ~ 0x80	0x80	Sets the ratio between ROI and normal image exposure.

9.5.3 Backlight compensation for faces.

Face Level (R/W/S)

Register	Value	Default	Description
0x4B	0x00 ~ 0x80	0x80	Sets the amount of backlight compensation.

Face Weight (R/W/S)

Register	Value	Default	Description
0x4C	0x00 ~ 0x80	0x80	0x00 - use only ROI based AE target. 0x40 - between ROI and face-based target. 0x80 - only use face-based target. If only ROI Bound is enabled or if no faces are found, then only ROI based target is used.

Face Size Weight (R/W/S)

Register	Value		Default	Description
0x4D	0x00 ~ 0x80		0x80	0x00 - plain average of all faces. 0x40 – half plain average and half size weighted 0x80 - size weighted average.

Face Selected Weight (R/W/S)

Register	Value	Default	Description
0x4E	0x00 ~ 0x80	0x80	0x00 - do not prioritize selected face. 0x40 - between selected face and AE target

			0x80 - derived from all faces combined. Only use selected face.

BLC ROI Level (R/W/S)

Register	Value	Default	Description
0x4F	0x00 ~ 0x80	0x00	Sets the amount of backlight compensation for Region of Interest.

9.6 Automatic White Balance

AWB Mode (R/W/S)

Register	Value	Default	Description
0x50	0x00 ~ 0x0F	0x0F	0x0 = AWB off 0x1 = Horizon illumination selected 0x2 = A illumination selected 0x3 = CWF illumination selected 0x4 = D50 illumination selected 0x5 = D65 illumination selected 0x6 = D75 illumination selected 0x7 = White point is defined by AWB Temperature 0x8 = Push to White[12] 0xF = auto

AWB Temperature (R/W/S)

Register	Value	Default	Description
0x52	16 bits	5000	Set temperature in Kelvin

AWB Face (R/W/S)

Register	Value	Default	Description
0x54	0x00 ~ 0xFF	0x00	0x00: faces not used. Other: faces used

9.7 Face detection & rectangles

Face Detection (R/W/S)

Register	Value	Default	Description
0x55	0x00 ~ 0xFF	0x00	Bit [0]: Face detection enabled /disabled. Bit [4]: Show rectangles around faces. Bit [5]: Show over-saturated regions. Note: writing to this field may cause format update.

[12] *Measure the white point, Illumination is automatically selected, white point is updated and AWB mode is automatically set to 0x0 after measure.*

9.8 Anti Flicker

Anti Flicker Mode (R/W/S)

Register	Value	Default	Description
0x56	0x00 ~ 0xFF	0x00	Bits [1..0]: Flicker mode 0x0 = Disabled, 0x1 = Force correction specified in frequency register 0x2 = Auto detect flicker.
			Bit [2]: FRC enable. If this bit is set, then the Flicker algorithm can reduce the framerate to mitigate flicker.
			Bit 3: FRC override upper. If this bit is set, then the anti-flicker algorithm can set the frame time longer than exposure limit time and thus reduce the framerate.
			Bit 4: FRC override max. If this bit is set, then the anti-flicker algorithm can set frame time longer than max exposure time and thus reduce the framerate.
			Bit 5: If this bit is set, then the anti-flicker algorithm will not change exposure time and will attempt to adjust frame time instead.
			Bit 6: ~~If this bit is set in iHDR mode and short exposure time is below flicker period then flicker on short exposure will be corrected on short by increasing it (at the cost of dynamic range).~~

Note: Under bright conditions the Anti Flicker algorithm cannot change the exposure time to mitigate flicker.

Anti Flicker Frequency (R/W/S)

Register	Value	Default	Description
0x57	0x00 ~ 0xFF	0x00	Set line frequency in Hz.

9.9 Input Trigger

Trigger mode (R/W/S)

Register	Value	Default	Description
0x58	16 bits	0x0308 0x0	bit 0-1: mode. Select how should ISP reacts on external frame trigger: 0x0 = Disabled / Ignore 0x1 = Sync to trigger only when trigger is detected, else run freely 0x2 = Only output frames when trigger is detected 0x3 = Output frame for every trigger and continue outputting while active.

Register	Value	Default	Description
			This mode is meant to be used when the trigger signal is sporadic (not periodic). On trigger positive edge (or negative if Edge Selection = 1) the image processor will initiate frame sequence ASAP. Frame output will start after overhead + integration time. The amount of overhead depends on the sensor used. Synchronization configuration options do not apply to this mode.
		0x2	bit 2-3: Sync mode. Select to which state of readout to sync: 0x0 = Sync to start of frame 0x1 = Sync to start of exposure 0x2 = Sync to center of exposure (center between start of exposure of first pixel and readout of the last pixel)
		-	bit 4-7: Read-only, write =don't care. Read will return GPIO pin used for Trigger function.
		1	bit 8: Reset Uptime. Reset uptime clock on next trigger edge. Timestamp can be embedded into the image. This bit can be used to synchronize timestamps across multiple cameras. This bit is cleared by firmware.
		1	bit 9: Reset frame counter. Reset frame counter on next trigger edge. This bit can be used to synchronize frame counters across multiple cameras. This bit is cleared by firmware.
		0	bit 10: Edge Selection 0 - trigger on positive edge, active time is high 1 - trigger on negative edge, active time is low
		0	bit 11: Predict Change. If this bit is set, any change in trigger period detected in recently seen periods will be applied to estimate next trigger.
		0x0	bit 12-14: Filter. This register sets how many recent triggers to use for calculating trigger period: 0x0 - use only 2 most recent edges 0x1 - use the last 3 edges 0x2 - use the last 4 edges etc. This can be used when there is significant jitter on the trigger signal. Filtering will slow down response time when trigger period is deliberately changed.
		0	bit 15: Hold-off_best, If this bit is set and holdoff is != 0, then any additional edges within holdoff time will be considered as candidates for the actual edge. If new edge (within holdoff time) is closer to expected period then new edge will be used.

Trigger Offset (R/W/S)

Register	Value	Default	Description

0x5A	32 bits	0xFFFFE700 (-25 us)	Offset to the trigger signal in microseconds. Format: s23.8

Trigger Offset Relative Period (R/W/S)

Register	Value	Default	Description
0x5E	16 bits	0x0000	Format: s3.12

9.10 Output Sync

Sync PWM Duty Cycle(R/W/S)

Register	Value	Default	Description
0x60	16 bits	0x0CCC 0.04999	Duty cycle (fraction of period when signal is high). Format: u0.16

Sync PWM Period (R/W/S)

Register	Value	Default	Description
0x64	32 bits	0x0186A000 100000.000	Period in microseconds. Format: u24.8 Period = 256 * 1000000 / Framerate The fraction bits(7..0) are ignored.

Sync PWM (R/W/S)

Register	Value	Default	Description
0x68	0x00 ~ 0xFF	0x06	0: enable 1: Refresh, set this bit to trigger refresh of PWM configuration. 2: Soft Refresh, set this bit to refresh PWM configuration on every start of frame.

9.11 Flash

Flash (R/W/S)

Register	Value	Default	Description
0x69	0x00 ~ 0xFF	0x00	0 = disable, other is enable

Flash Delay (R/W/S)

Register	Value	Default	Description
0x6A	0x00 ~ 0xFF	0x00	

9.12 Lens shading.

Lens Shading control (R/W/S)

Register	Value	Default	Description
0x70	16 bits	0xFEAE	Lens Shading control

Register	Value	Default	Description
		2	0-1: rb_mode
		3	2-3: rb_auto
		2	4-5: g1g2_mode
		2	6-7: g1g2_auto
		2	8-9: luma_mode
		1	10: cls_alg
		1	11: cls_median
		1	12: cls_unlock
		1	13: cls_bound
		1	14: manual_temp
		1	15: cls_agress_radius_bound

0-1: rb_mode, Global R, B correction mode:
- 0x0 = global R, B correction is disabled
- 0x1 = global R, B correction is locked (keep current value)
- 0x2 = global R, B is applied using LSC_TABLE_RB_ADR; converge immediately
- 0x3 = global R, B is applied using LSC_TABLE_RB_ADR

2-3: rb_auto: (3)
- 0x0 = global R, B auto correction is disabled
- 0x1 = global R, B auto correction is locked (keep current value)
- 0x2 = global R, B auto correction is enabled using comparison algorithm (LSC_CTRL[CLS] must be set).
- 0x3 = global R, B auto correction is enabled using paths algorithm (LSC_CTRL[CLS] must be set).

4-5: g1g2_mode, Global G1-G2 correction mode:
- 0x0 = global G1G2 correction is disabled
- 0x1 = global G1G2 correction is locked (keep current value)
- 0x2 = global G1G2 is applied using LSC_TABLE_G_ADR; converge immediately
- 0x3 = global G1G2 is applied using LSC_TABLE_G_ADR

6-7: g1g2_auto: (2)
- 0x0 = global G1G2 auto correction is disabled
- 0x1 = global G1G2 auto correction is locked (keep current value)
- 0x2 = global G1G2 auto correction is enabled (LSC_CTRL[CLS] must be set).

8-9: luma_mode, Global Luma correction mode:
- 0x0 = global luma correction is disabled
- 0x1 = global luma correction is locked (keep current value; only applicable when used with rb_mode and g1g2_mode locked)
- 0x2 = global luma is corrected using table in LSC_TABLE_Y_ADR
- 0x3 = global luma is corrected using LSC_CALIB_LUMA_FALLOFF

10: cls_alg (1)

11: cls_median (1)

12: cls_unlock, When set the color lens shading will be automatically applied after LSC table.
- 0x0 = Auto-CLS lens shading is locked
- 0x1 = Auto-CLS lens shading (post-process) is enabled

13: cls_bound, When set, the auto color lens shading will be bounded based on cls_g_delta, cls_r_min, cls_r_max, cls_b_min and cls_b_max registers.

14: manual_temp, When set the lens shading tables will use the LSC_MANUAL_TEMP register.

15: cls_agress_radius_bound, When set, the auto color lens shading will be sanity-check bounded based on cls_agress register based or radius.

Lens Shading Falloff (R/W/S)

Register	Value	Default	Description
0x72	16 bits	0x0D99 (0.849)	Format s3.12

9.13 Tone Map

Tone Map Control (R/W/S)

Register	Value	Default	Description
0x74	0x00 ~ 0xFF	0x0F	bit 0: TONEMAP On/Off bit 1: ATM On/Off bit 2: LTM On/Off bit 3: LTM contrast On/Off bit 4: Face Sat On/Off bit 5: Luminance Lens Shading via LTM On/Off

- ATM, Adaptive Tone Map
- LTM, Local Tone Map
- LTM Contrast
  If this bit is set FW will reduce local tone mapping strength when user increases contrast to improve perceived contrast.
- Face Sat
  If set, bit enables additional weighting of saturated pixels on the selected face.
- Luminance Lens Shading:
  This bit enables luminance lens shading compensation as part of local tone mapping instead of using LSC engine.

9.14 JPEG

JPEG Quality (R/W/S)

Register	Value	Default	Description
0x75	0x00 ~ 0xFF	0xE9	JPEG Quality This value changes the JPEG compression and will affect the bitrate. Lower Quality means more compression which results in lower bitrate.

9.15 Effects

Effects (R/W)

Register	Value	Default	Description
0x76	0x00 ~ 0xFF	0x00	This field selects the special effect applied to the video 0x00 = No special effect (Normal) 0x01 = Alien 0x02 = Antique 0x03 = Black and White 0x04 = Emboss

			0x05 = Emboss Colored 0x06 = Greyscale 0x07 = Negative 0x08 = Bluish 0x09 = Greenish 0x0A = Reddish 0x0B = Posterize 1 0x0C = Posterize 2 0x0D = Sepia 1 0x0E = Sepia 2 0x0F = Sketch 0x10 = Solarize 0x11 = Foggy

9.16 Face detection

Detected Faces (R)

Register	Value	Default	Description
0x80	16 bits	RO	Detected faces: each bit indicates a face detected. 0x0001 -> face number 0 is detected. 0x0080 -> face number 7 is detected 0x1248 -> face numbers 3,6,9 and 12 are detected.

This register can be polled to check for detected faces.

Faces detection speed (R/W)

Register	Value	Default	Description
0x82	0x00 ~0xFF	0	0 – Face detection is disabled. 1 – Face detection every 0.1 seconds 10 – Face detection every 1 seconds 20 – 2 seconds Etc.

Faces detection speed (R/W)

Reading face coordinates requires a special I²C command.

START	0X70	0X39	ADDRESS	SIZE	0X71	DATA[63~0]	STOP

Size = number of bytes to read (max 64 bytes in one I²C transfer)
Address = location within the coordinates struct (see below). E.g. Address of 0x20 points to the x0[0] coordinate. Address of 0x40 points to the y0[0] coordinate.

```
struct {
    struct {
        uint8_t age; // age in frames
        uint8_t id;  // face id number
    }face_id[16];
    uint16_t x0[16];
    uint16_t y0[16];
```

```
        uint16_t x1[16];
        uint16_t y1[16];
    }face_t;
```

Faces detection threshold (R/W)

Register	Value	Default	Description
0x83	0x00 ~ 0xFF	0x80	Face detect threshold

Faces detection chroma threshold (R/W)

Register	Value	Default	Description
0x84	0x00 ~ 0x1F	0x0C	Face detect chroma threshold

Faces min/max size (R/W)

Register	Value	Default	Description
0x86	16 bits	0x0400	Minimum detectable face size in % Format s1.14 0x0400 = 0.0625
0x88	16 bits	0x4000	Maximum detectable face size in % Format s1.14 0x4000 = 1.0000

AWB manual X & Y (R/W)

Register	Value	Default	Description
0x8A	16 bits	0x0000	AWB manual X, format s16 negative = blue, positive = red
0x8C	16 bits	0x0000	AWB manual X, format s16 negative = green, positive = violet

AWM mode must be set to 0x0 in order to control X & Y gains

9.17 Test pattern

Test pattern(R/W)

Register	Value	Default	Description
0xE0	0x00 ~ 0xFF	0x00	0 = OFF, 1 = ON

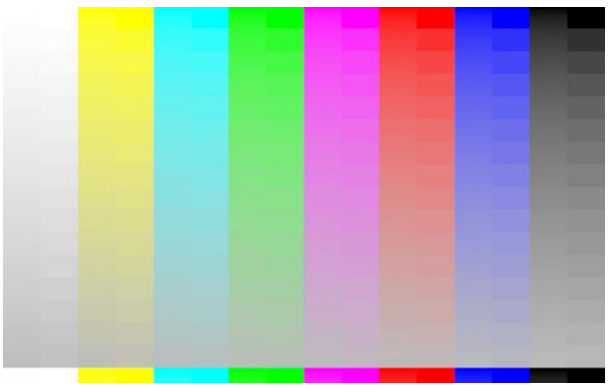


Figure 6 Test pattern

9.18 Misc controls

Set state *(W)*

Register	Value	Default	Description
0xE1	0x00 ~ 0x05	WO	Set Operating State 2 - Format change 3 - Format done 4 - Power Down 5 - Startup

Normally the user does not need to change the Operating state of the camera, however there may be situations where this may be required. E.G., when the host needs a special sequence of event to happen to capture MIPI correctly.
Some hosts require the MIPI bus to be silent before initializing the MIPI receiver or when changing formats. In this case the host can sequence the behavior of the camera.

Format change example:

1. Set state to format change: MIPI is disabled.
2. Re-configure the Host MIPI receiver.
3. Change the camera Format.
4. Set state to Format done: MIPI is enabled.
5. state will be in Normal operating when completed.

ISP Boot (R/W/S)

Register	Value	Default	Description
0xE6	0x00 ~ 0xFF	0x00	Boot number for ISP

This register allows selecting the ISP's boot code at startup. After setting this register it needs to be stored into NVM after changing to be effective at the next boot.

Power (R/W)

Register	Value	Default	Description
0xE7	0x00 ~ 0xFF	0x00	Write 0 for power up or other for power down

The camera can be powered down (is same as standby) and powered up while maintain I^2C access to the camera, this is a semi-standby mode. This function is similar to the "Set State" function, with the difference that this register can be read to get the power state, while the "Set State" Register is write only.

Status Control (W)

Register	Value	Default	Description
0xE8	0x00 ~ 0xFF	WO	0x01 - Camera state 0x02 - Is password set? 0x03 - Microcontroller temperature in °C. 0x04 - Sensor temperature Enable. (No Status Result) 0x05 - Get Sensor temperature in °C.

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.

Status Result (R)

Register	Value	Default	Description
0xE9	RO	State	0 - STARTUP_STATE 1 - INIT_STATE 2 - FORMAT_DONE_STATE 3 - FORMAT_CHANGE_STATE 4 - NORMAL_OPERATING_STATE 5 - UPGRADE_STATE 6 - CHECKING_STATE 7 - POWER_DOWN_STATE 8 - ERROR_STATE 9 - DEBUG_STATE
		Password	0 - Password is not set 1 - Password is set
		Temperature	Temperature ±6 °C (two's complement)

After giving the status command in register 0xE8, the status result register will give the resulting value.

Upgrader (R/W)

Register	Value	Default	Description
0xEB	0x00 ~ 0xFF	0x00	0x18 – Normal Operating 0x81 - Upgrade

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^2C 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.

ISP version (R)

Register	Value	Default	Description
0xEC	0x00 ~ 0xFF	RO	ISP version Minor
0xED	0x00 ~ 0xFF	RO	ISP version Minor

NVM user space version (R)

Register	Value	Default	Description
0xEE	0x00 ~ 0xFF	RO	NVM version Minor
0xEF	0x00 ~ 0xFF	RO	NVM version Minor

NVM factory space 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 number 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.

Save Restart (W/(P))

Register	Password	Description
0xF0	No	0x01 - Store Register setting to User NVM space.
	-	*0x02 - Reserved (do not use)*
	Yes	0x03 - Store Registers to Factory NVM space.
	-	*0x04 - Reserved (do not use)*
	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.

Camera Type (R)

Register	Value	Default	Description
0xF1	0x00 ~ 0xFF	RO	Camera Type 0x01 - Color 0x02 - Monochrome
0xF2	0x00 ~ 0xFF	RO	Frame Rate
0xF3	0x00 ~ 0xFF	RO	Camera model

I²C address (R/W/S)

Register	Value	Default	Description
0xF6	0x00 ~ 0xFF	0x70	

The I²C device address can be changed. After writing to this register the I²C address changes immediately. To store the registers (including the new I²C device address) the new I²C device address needs to be used for the store command.

I²C Control (R/W)

Register	Value	Default	Description
0xF7	0x00 ~ 0xFF	0x00	Bit [0] - Include status byte in reads. (1 to enable) Bit [1] - ACK polling disable. (1 to disable) Bit [2] - I²C clock stretch disable. (1 to disable)

I²C behavior can be changed from the default, but it is not recommended.

Every read can include a status byte indicating whether the result is valid. (See the I²C-status table below)

ACK polling can be enabled or disabled. ACK polling allows the I²C-master to check whether the camera has completed the function for which a command was given. This avoids waiting for an undefined time, as re-tries can be done until the command is completed and an ACK is returned.

I²C -Clock stretching can be disabled for I²C-masters that do not support this. When clock stretching is disabled the I²C-restart command should not be used, in this case use separate I²C-write and I²C-read commands.

Status byte	Description	
0xFE	I2C_ERROR	A I²C error occurred, the result is not valid.
0xEF	I2C_BAD_COMMAND	An incorrect I²C command was given, the result is not valid
0xF5	I2C_COMMAND_FAIL	The I²C command failed, the result is not valid.
0x00	I2C_VALID	The I²C result is valid.
0xFF	I2C_NOTVALID	The I²C result is not valid.
0xF0	I2C_PASSWORD	A password was needed, the result is not valid.

Table 9. I²C status

Bootloader (W/P)

Register	Value	Default	Description
0xF8	0x00 ~ 0xFF	0x00	0x1 - Reboot 0x2 - Start Bootloader

Status (R)

Register	Value	Default	Description
0xFA	0x00 ~ 0xFF	RO	Reserved for internal use

MCU firmware Status (R)

Register	Value	Default	Description
0xFB	0x00 ~ 0xFF	RO	Reserved for internal use

Password (W)

Register	Value	Default	Description
0xFC	0x00 ~ 0xFF	WO	Password LSB
0xFD	0x00 ~ 0xFF	WO	Password MSB

Version (R)

Register	Value	Default	Description
0xFE	0x00 ~ 0xFF	RO	Firmware Version Minor
0xFF	0x00 ~ 0xFF	RO	Firmware Version Major

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 controller 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 chunks 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 chunks). 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 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	CHUNK OF BYTES	STOP

Or

START	0X70	0X51	PAGE ADDRESS	SIZE	STOP	START	0X71	CHUNK OF BYTES	STOP

NVM Write Command:

START	0X70	0X50	PAGE ADDRESS	CHUNK OF DATA BYTES	STOP

→ in case of NAK on I²C 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
where n = 0, 1 for User space or n = 2, 3 for Factory space.

Version number
0xpp 0xqq = version pp.qq eg. 1.20

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

10.1.2 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 also 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;
}
```

10.1.3 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 FF
0010 FF 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 FF
0030 FF 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 FF
0050 FF 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 FF
0070 FF 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 FF
0090 FF 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 FF
00B0 FF 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 FF
00D0 FF 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 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 FF
0110 FF 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 FF
0130 FF 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 FF
0150 FF 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 FF
0170 FF 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 FF
0190 FF 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 FF
01B0 FF 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 FF
01D0 FF 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 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 FF
0210 FF 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 FF
0230 FF 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 FF
0250 FF 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 FF
0270 FF 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 FF
0290 FF 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 FF
02B0 FF 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 FF
02D0 FF 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 FF FF 00 00
02F0 FF FF FF FF FF FF FF FF FF FF FF FF 00 01 26 65
////////////////////////////////////////////////////
// Start of page: 3 (Factory Calibration)
//// 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
0300 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0310 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0320 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0330 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0340 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0350 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0360 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0370 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0380 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0390 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
03A0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
03B0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
03C0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
03D0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
03E0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
03F0 FF FF FF FF FF FF FF FF FF FF FF FF 00 02 4F 3F
```


Note: Python scripts are available for generating the NVM image with the correct CRC.

10.2 Updating Controller firmware

To update the controller firmware the camera needs to be executing the bootloader.

10.2.1 Bootloader commands

Write flash command:

START | 0X70 | 0X38 | ADDRESS LSB | ADDRESS MSB | CHUNK OF DATABYTES | STOP

→ in case of NAK on I²C bus → retry

Read Flash command:

START | 0X70 | 0X39 | ADDRESS LSB | ADDRESS MSB | CHUNK SIZE | STOP

START | 0X71 | CHUNK OF DATA BYTES | STOP

→ in case of NAK on I²C bus → retry read from 0x71

Check I²C bus ready command:

START | 0X70 | ACK/NAK | STOP

→ in case of NAK on I²C bus → retry

Or

START | 0X70 | ACK/NAK | 0X00 | ACK/NAK | STOP

→ in case of NAK on I²C bus → retry

Erase Flash command:

START | 0X70 | 0X44 | 0X01 | STOP

Check I²C bus read until <ACK>

Reboot Command:

START | 0X70 | 0X46 | 0X01 | STOP

Get Calculated CRC:

START | 0X70 | 0X41 | STOP

Check I²C 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.[13]
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 I²C bus becomes available:

`0X70` `0X00`
If `NAK` then check again until I²C gives an `ACK`

Write the firmware image in chunks of 8, 16, 32 or 64 bytes.
(Check inside image file: chunksize = blocksize)
Give the following command:

`0X70` `0X38` `LSB ADDRESS` `MSB ADDRESS` `CHUNK SIZE` `BYTE[0]..BYTE[CHUNKSIZE]`
(In case the next chunk 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`
If `NAK` then check again until I²C 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`

[13] *The password is provided upon customer request only!!*

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

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 FF
F3E0 FF 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 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 chunk 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] | CHUNK OF DATABYTES | STOP

→ in case of NAK on I²C bus → retry until ACK

Read Flash command:

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

START | 0X71 | CHUNK OF DATA BYTES | STOP

→ in case of NAK on I²C bus → retry read from 0x71 until ACK

~~**Erase Flash page command:**~~

~~START | 0X70 | 0X44 | ADDRESS[7:0] | ADDRESS[15:8] | ADDRESS[23:16] | STOP~~

~~Check flash status until status is: 0X00 | 0X00~~

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 I²C bus ready until ACK can take up to 50ms.

START	0X70	DATA[1:0]	STOP

CRC[15:0] = (Data[1] << 8) + Data[0]

Procedure:

- Read ID, read Status (0x0000 is OK else FAIL)
- Erase Flash command, read status (0x0000 is OK else FAIL)
- Write flash chunks of data, Read Status (0x0000 is OK else FAIL)
- CRC command to verify, if CRC is not correct, then retry the procedure.

Use the GUI tool or python scripts (available upon request)!

11. Miscellaneous

11.1 Recommended lenses

For lenses recommended lenses, see www.videologyinc.com.

11.2 Abbreviations

Abbreviation	Full form	Description
MIPI	Mobile Industry Processor Interface	
IR	Infra-Red	
SPI	Serial Peripheral Interface	
I^2C	Inter Integrated Circuit	
µC	Microcontroller	
MCU	Micro Controller Unit	
EXIF	Exchangeable Image File	Metadata parameters
CRC	Cyclic Redundancy Check	
GUI	Graphical User Interface	
LSB	Least significant Bit	
MSB	Most Significant Bit	
BLC	Back Light Compensation	
HDR	High Dynamic Range	
ROI	Region Of Interest	
USB	Universal Serial Bus	
NVM	Non-Volatile Memory	
ISP	Image Signal Processor	
BV	Brightness Value	
ISO	International Organization for Standardization	Sensitivity setting of the sensor.
FOV	Field of View	
JFIF	JPEG File Interchange Format	JFIF uses all 256 levels of the 8-bit representation, so that Y=0 for black and Y=255 for peak white
SCAILX	Videology Embedded AI platform based on NXP IMX8M Plus SoM	
SoM	System-on-Module	
ACK	Acknowledge in I^2C communication	

12. Support

12.1 Videology Help Center

This is your go-to resource for all Videology product support questions. The answer to your question may be at your fingertips. Please see the Videology Help Center for valuable information and resources.

12.2 Contact Videology Support

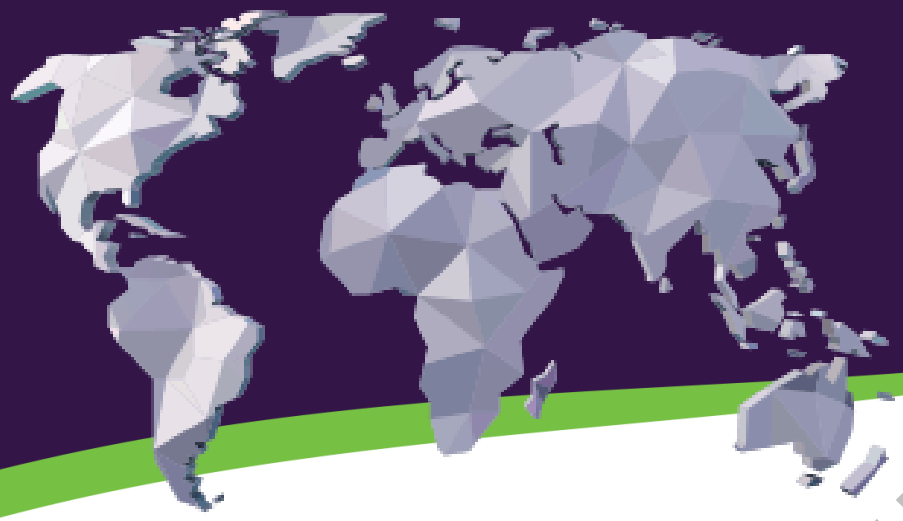
If you need any support on any Videology product, please fill out the form here to contact our support department: https://www.videologyinc.com/contact-videology-service

12.3 Videology RMA Policy

To learn more about our Return Material Authorization (RMA) policy, please visit the RMA Policy page on our website: https://www.videologyinc.com/return-authorization

12.4 Videology Terms and Conditions of Sale

Our global sales terms and conditions can be found on this link.



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