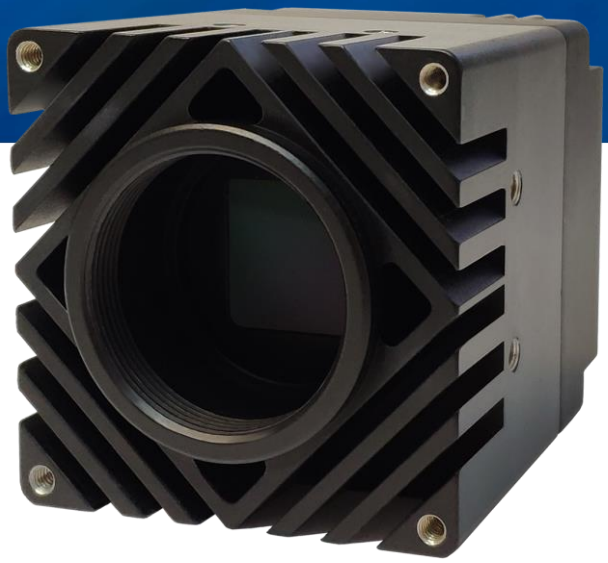
IRON

SDI

User Manual



February 2021 - Rev 1.3

KAYA INSTRUMENTS

www.kayainstruments.com

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

Table of Contents

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

1 Figures & Tables

1.1 List of Figures

1.2 List of Tables

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

2 Revision History

Ver	Date	Notes
1.0	12.01.2020	Initial release
1.1	20.05.2020	Added the Subsampling mode
1.2	31.12.2020	Added section no. 6: Quick Startup Guide Added section no. 7: Image Processing Flow. Added appendix no. 1 – firmware update. Section no. 8: updated new commands and re-ordered them.
1.3	28.02.2021	Section no. 8: added subsection 8.13 – “Genlock”

Table 1 - Revision History

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

3 Introduction

3.1 Safety Precautions

With your ***Iron*** camera in hand, please take the time to read through the precautions listed below in order to prevent preventable and unnecessary injuries and damage to you, other personnel or property. Read these safety instructions carefully prior to your first use of the product, as these precautions contain safety instructions that must be observed. After reading through this manual, be sure to follow it to prevent misuse of product.

⚠ Caution! Read Carefully and do not disregard these instructions.
In the event of a failure, disconnect the power supply Disconnect the power supply immediately and contact our sales personnel for repair. Continuing to use the product in this state may result in a fire or electric shock.
If an unpleasant smell or smoking occurs, disconnect the power supply. Disconnect the power supply immediately! Continuing to use the product in this state may result in a fire or electric shock. After verifying that no smoking is observed, contact our sales personnel for repair.
Do not disassemble, repair or modify the product. This may result in a fire or electric shock due to a circuit shortage or heat generation. Contact our sales personnel prior to inspection, modification or repair.
Do not place the product on unstable surfaces. Otherwise, it may drop or fall, resulting in injury to persons or the camera.
Do not use the product if dropped or damaged. Otherwise, a fire or electric shock may occur.
Do not touch the product with metallic objects. Otherwise, a fire or electric shock may occur.
Do not place the product in dusty or humid environments, nor where water may splash. Otherwise, a fire or electric shock may occur.
Do not wet the product or touch it with wet hands. Otherwise, the product may fail or it may cause a fire, smoking or electric shock.
Do not touch the gold-plated sections of the connectors on the product. Otherwise, the surface of the connector may be contaminated by sweat or skin-oil, resulting in contact failure of a connector, malfunction, fire or electric shock due to static electricity discharge.
Do not use or place the product in the following locations. ▪ Unventilated areas such as closets or bookshelves. ▪ Near oils, smoke or steam. ▪ Next to heat sources. ▪ A closed (and not running) car where the temperature becomes high. ▪ Static electricity replete locations ▪ Near water or chemicals. Otherwise, a fire, electric shock, accident or deformation may occur due to a short circuit or heat generation.
Do not place heavy objects on the product. Otherwise, the product may be damaged.
Be sure to discharge static electricity from body before touching any sensitive electronic components. The electronic circuits in your computer and the circuits on the ***Iron*** camera and the ***Predator II*** board are sensitive to static electricity and surges. Improper handling may seriously damage the circuits. In addition, do not let your clothing come in contact with the circuit boards or components. Otherwise, the product may be damaged.

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

3.2 Disclaimer

This product should only be used for image capturing and processing. KAYA Instruments will assume no responsibility for any damage that may ensue by the use of the camera for any purpose other than intended, as previously stated. Without detracting from what was previously written, please be advised that the company will take no responsibility for any damages caused by:

- Earthquake, thunder strike, natural disasters, fire caused by use beyond our control, wilful and/or accidental misuse and/or use under other abnormal and/or unreasonable conditions.
- Secondary damages caused by the use of this product or its unusable state (business interruption or others).
- Use of this product in any manner that contradicts this manual or malfunctions that may occur due to connection to other devices. Damage to this product that is out of our control or failure due to modification
- Accidents and/or third parties that may be involved.

Additionally, KAYA Instruments assumes no responsibility or liability for:

- Erasure or corruption of data caused by the use of this product.
- Any consequences or other abnormalities following the use of this product

Repairs to this product are carried out by replacing it on a chargeable basis and not by repairing the faulty device. Non-chargeable replacement is offered for initial failure, as long as it is reported no later than two weeks post-delivery of the product.

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

4 Overview

This user manual provides a detailed overview of KAYAS's IRON SDI cameras operation. All cameras are suited for a wide variety of applications such low light surveillance, special effects, sports broadcasting, etc.

With our customers' convenience in mind we had made sure that connecting and streaming can be easily achieved in few easy steps and require little configurations. Control of the camera as well as advanced configurations are made easy using the SDIControlPoint software and terminal, enabling enhanced streaming and image processing of the cameras' outputs. Hardware reference is covered in chapter 9, Hardware Reference.

It is important to note that some parameters might vary slightly compared to this document or may be absent entirely, subject to the active firmware capabilities: a firmware upgrade might be needed to support complete functionality set. Please feel free to contact our support team at support@kayainstruments.com with any questions that may arise.

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

5 Supported Formats

Iron SDI camera support multiple standard video formats including HD-SDI, 3G-SDI, 6G-SDI and 12G-SDI, depending on the camera's sensor resolution. Changing format can be done dynamically, using serial interface, or format configuration can be saved and loaded on startup.

Table no. 2 describes the supported formats:

Mode	IIRON SDI 205	IRON SDI 305	Video Standard	Resolutions supported	Frame rates supported (fps)
HD-SDI	V	V	ST 292 (ST 274)	1080i 10-bit 4:2:2	50, 59.94, 60
				1080p 10-bit 4:2:2/RAW	23.98, 24, 25, 29.97, 30
			ST 292 (ST 2048-2)	2K 10-bit 4:2:2	23.98, 24, 25, 29.97, 30
3G-SDI			ST 425-1 (ST 274)	1080p 10-bit 4:2:2/RAW	50, 59.94, 60
			ST 425-1 (ST 2048-2)	2K 10-bit 4:2:2	47.95, 48, 50, 59.94, 60
6G-SDI	X		ST 2081-10 M1, (ST 2036-1)	UHD 10-bit 4:2:2	23.98, 24, 25, 29.97, 30
			ST 2081-10 M1, (ST 2048-1)	4K 10-bit 4:2:2	23.98, 24, 25, 29.97, 30
12G-SDI			ST 2082-10 M1, ST 425-5 (ST 2036-1)	UHD 10-bit 4:2:2	50, 59.94, 60
			ST 2082-10 M1, ST 425-5 (ST 2048-1)	4K 10-bit 4:2:2	47.95, 48, 50, 59.94, 60

Table 2 – Supported SDI parameters

6 Quick Start Guide

6.1 Camera Connection

KAYA's Iron SDI cameras are easy to set up and operate. The camera needs to be connected to a power source, using the supplied cable, and to an SDI capture card or monitor. Under normal circumstances the camera will start streaming to an SDI input as soon as it is powered.

Advanced camera settings can be configured using the provided serial command line interface. The camera can also be controlled using KAYA's SDIControlPoint application. For more details, see section 8, Camera Operation.

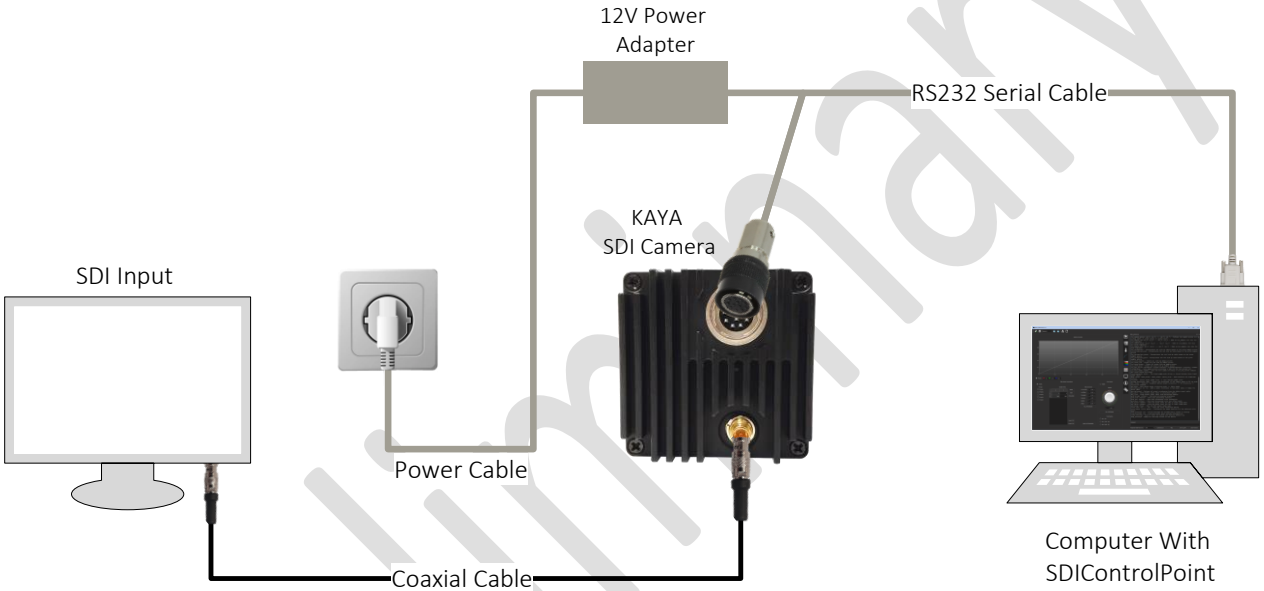


Figure 1 – Camera connections diagram

6.1.1 Power and Image Streaming

1. Connect the camera to an SDI Input using a coaxial cable
2. Connect the camera to a 7-18V power source.
3. Video should start streaming to the SDI capture card or monitor.

6.1.2 Advanced Control

1. Connect the camera's GPIO to a serial RS232 port (cable provided).
2. Connect to the camera's command user interface via a standard serial terminal (see section 8.2, Terminal Usage) or KAYA's SDIControlPoint application.
3. To chance the video mode use the video_mode command (see section 8.7.1, video_mode).
4. To save the current settings use the save_settings command (see section 8.4.1, save_settings).

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

6.2 Troubleshooting

1. Make sure that the camera is connected to a 7-18V power source.
2. Make sure that all components are properly connected (camera, cables and capture card). See Figure 1 and section 9.2 Micro BNC Connector.
3. Make sure that the coaxial cable supports the proper output stream bandwidth:

   - 3G SDI for 2k video streaming.
   - 12G SDI for 4k video streaming.

4. Check to see whether the LED on the back of the camera is blinking green. The issue may be resolved by power cycling the camera (turning power off and back on). More LED indicators are described in section no. 9.1 (Status LED).
5. Make sure the SDI input (SDI capture card or monitor) supports the output video format of the camera – contact the SDI input's manufacturer for support and additional information. To change the camera's output video mode, see section 8.7.1, video_mode <mode>.

7 Image Processing Flow

Figure 2 describes the image processing flow in KAYA's SDI cameras, from a raw image acquired by the sensor and to an SDI-standard compatible output. All commands implemented in the processing pipe are described in chapter no. 8, "Camera Operation".

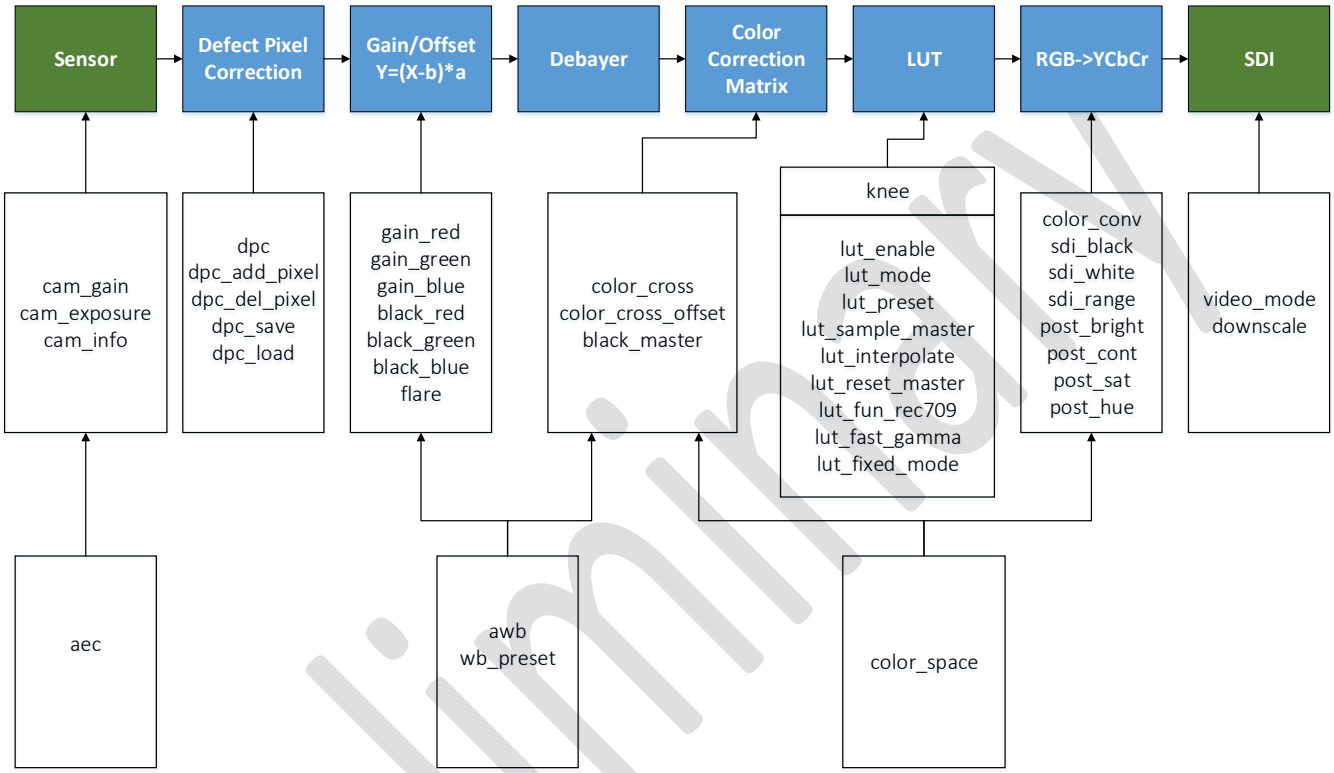


Figure 2 – Image Processing Flow

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

8 Camera Operation

8.1 SDIControlPoint

KAYA Instruments provides a free, open-source camera control software (named: SDIControlPoint). A downloadable file as well as the software's user manual (KAYA SDIControlPoint Manual.pdf) are available at the following address for your convenience: cloud.kayainstruments.com/s/SDI

8.2 Terminal Usage

8.2.1 Terminal

The Iron SDI can be controlled via a simple terminal connection. All commands consist of ASCI characters.

8.2.2 Terminal Settings

The terminal interface is RS232 TTL which is connected via the GPIO connector. The default interface settings are:

- 115200 baud
- 8 bit data
- no parity
- 1 stop bit
- no flow control

The camera accepts commands in text form and responds in text messages. Every command is confirmed by either an "OK" or a "FAIL" to indicate whether it had been successfully implemented or not, respectably; errors have to be handled by the user or a host software which is used to control the device. Depending on the **prompt** setting one may receive a "=>" prompt after start up. Commands can then be sent to control the device or receive information.

8.2.3 General Command Format

If the **prompt** command is enabled the firmware will send its prompt ("=> ") when awaiting commands. Every command line is accepted as a single text line, terminated by either CR or LF. The command consists of a command string, possibly followed by one or more parameters separated by a single space. Depending of the command the parameters can come in one of these formats:

- Signed decimal : -323, 422
- Hexadecimal: 0x35ff34aa
- String : any_string

The command will be executed and may produce some text output in a single line or more, followed by a single status line consisting of either "OK" or "FAIL". In case of failure an error code may be added in the same line, e.g. "FAIL 3".The lines sent by the firmware are terminated with both CR and LF. Most commands do have parameters. The parameters depend on the given command.

8.3 Commands

8.3.1 Help dialog

Typing **help** will give a full list of supported commands. It is possible to get a detailed help for each command by typing "help <cmd>".

Example:

help video_mode<Enter>
video_mode <video mode> - set video mode

8.3.2 Set Functions

Running a command with its required matching parameters will change the settings.

Example:

Command: **video_mode 5**
Response: **OK** (returned)

8.3.3 Get Functions

Any setting can be checked by running a function ***without parameters.*** The output of the **get** function represents a valid command followed by parameters. This string can be parsed by external applications to extract the current settings out of the system.

Example:

Command: **video_mode**
Response: **video_mode 5** (returned)
OK (returned)

8.3.4 List of Commands

#	Command	Parameters	Description
1	help		gives a full list of supported commands
2	save_settings		Saves the current settings into camera non-volatile memory
3	load_settings		load saved settings on demand
4	reset_settings		Resets the system into factory default run
5	dump_settings		dumps current settings configured on the device
6	prompt	<flag>	Set prompt mode of the command output
7	reboot		Preforms a system reboot
8	fw_update		Set the system into firmware update mode
9	version		Dumps a detailed version information about the system
10	name	<name string>	Sets the device name
11	flip	<mode>	Sets the image flip or rotation mode

12	temp	<sensor id>	Sets the image flip or rotation mode
13	cam_gain	<gain>	Set the analog gain for the sensor
14	cam_exposure	<time>	Sets the exposure time/shutter width
15	cam_info		Reports the min / max gain and exposure
16	video_mode	<mode>	Sets the output video mode
17	downscale	<channel=1> <downscale> <reserved=0>	The **downscale** command is used to output Full HD or 2K resolution from UHD or 4K downscaled source image
18	sdi_black	<offset>	Sets the black level for SDI in legal range mode
19	sdi_white	<offset>	Sets the white level for SDI in legal range mode
20	sdi_range	<flag>	Sets the SDI output range type
21	post_bright	<offset>	Sets post processing brightness
22	post_cont	<factor>	Sets post processing contrast
23	post_sat	<factor>	Sets post processing color saturation
24	post_hue	<offset>	Sets post processing color hue offset angle
25	wb		Triggers single shot white-balance
26	awb	<flag>	Enable continuous white balance adjustment.
27	wb_preset	<id>	Sets calibrated white balance presets
28	gain_red	<gain>	Sets gain factor for red component for selected output channel
29	gain_blue	<gain>	Sets gain factor for blue component for selected output channel
30	gain_green	<gain>	Sets gain factor for green component for selected output channel
31	black_master	<offset-red> <offset-green> <offset-blue>	Sets the black-level offset for red, green and blue-components for selected output channel.
32	black_red	<offset>	Sets offset for red component for selected output channel as black level setting
33	black_blue	<offset>	Sets offset for blue component for selected output channel as black level setting
34	black_green	<offset>	Sets offset for green component for selected output channel as black level setting
35	flare	<red level> <green level> <blue level>	Sets flare compensation level (= Defogging)
36	color_cross	<c0> .. <c8>	Sets the color cross talk matrix
37	color_cross_offset	<red_offset> <green_offset> <blue_offset>	Sets the color cross talk offset
38	color_conv	<c0> .. <c8>	Sets the color conversion matrix
39	color_space	<color space>	Change the color space matrix
40	dpc	<flag>	Enable deflect pixel correction
41	dpc_add_pixel	<x> <y>	Adds a pixel coordinate to defect pixel table or dumps the whole table
42	dpc_del_pixel		Deletes all pixel coordinates from the defect pixel table
43	dpc_save		Saves defect pixel table to persistent memory
44	dpc_load		Loads defect pixel table from persistent memory
45	knee	<flag> <knee_point> <knee_slope> <white_clip>	Knee function for highlight control
46	lut_enable	<reserved=0> <flag>	Enables the function for look up table
47	lut_mode	<mode>	Selects the LUT operational mode
48	lut_preset	<index>	Selects the preset storage for the current LUT interpolator
49	lut_sample_master	<xi_0><yi_0> ... <xi_7> <yi_7>	Defines the sample points in a lookup table for all colors
50	lut_sample_red	<xi_0><yi_0> ... <xi_7> <yi_7>	Same as lut_sample, but only for the red component

51	lut_sample_green	<xi_0><yi_0> ... <xi_7> <yi_7>	Same as lut_sample, but only for the green component
52	lut_sample_blue	<xi_0><yi_0> ... <xi_7> <yi_7>	Same as lut_sample, but only for the blue component
53	lut_interpolate		Interpolates all look up tables based on the given sample point
54	lut_interpolate_red		Interpolates the red look up table based on the given sample points
55	lut_interpolate_green		Interpolates the green look up table based on the given sample points
56	lut_interpolate_blue		Interpolates the blue look up table based on the given sample points
57	lut_reset_master		Clears all color channels look up sample points
58	lut_reset_red		Clears all red look up sample points
59	lut_reset_green		Clears all green look up sample points
60	lut_reset_blue		Clears all blue look up sample points
61	lut_fun_rec709	<threshold> <linear-contrast> <linear-brightness> <contrast> <gamma> <brightness>	Sets new LUT sample points according to REC.709 for selected LUT preset
62	lut_fast_gamma	<gamma>	The fast gamma function uses the same formula as the lut_fun_rec709 command, but the user only has to specify the desired gamma value.
63	lut_fixed_mode	<mode>	The fixed gamma mode contains three presets which are shown in the table below
68	stat_rgb		Dumps the average image value for each color channel (RGB)
69	aec	<enable> <setPoint> <speed>	Auto Exposure and Gain are used to control the picture brightness by adjusting Exposure and Gain values automatically in order to reach desired luminance level

Table 3 – List of commands

8.4 Settings Handling

8.4.1 save_settings

Saves the current settings into camera non-volatile memory. These parameters will be automatically applied upon camera startup.

8.4.2 load_settings

The **load_settings** command can be used to load saved settings on demand, which will overwrite the current camera settings.

8.4.3 reset_settings

Resets the system into factory default run.

8.4.4 dump_settings

The **dump_settings** command dumps current settings configured on the device.

Remarks:

1. Some commands have no settings that can be dumped and thus do not show up when **dump_settings** is used.

8.5 System Commands

8.5.1 prompt <flag>

Set prompt mode of the command output.

Flag	Function
0	No prompt
1 (reset)	'=>' prompt

8.5.2 reboot

Preforms a system reboot (warm start). A full reboot may take several seconds.

8.5.3 fw_update

Set the system into firmware update mode. The firmware update file should be uploaded using XMODEM protocol via standard serial port interface. Please see Appendix 1: Firmware Update for a detailed explanation.

Remarks:

1. Only official firmware update file, provided by KAYA Instruments should be used to update camera. Other binary files may, or may not harm the camera and make it un-usable.

8.5.4 version

Dumps a detailed version information about the system with system ID and firmware version.

Examples:

Command: **version**

Response: **platform: IronSDI**
device name: Empty
system-id: 003F001E-30324703-37313437-FFFFFFFF
hw revision: 00001602
system validity: LICENSED
feature mask HW: 0019A01C
feature mask SW: FFFFFFFF
resolution mask: 00000000-001FFFFF-000FFCFF
loader version: 0(2)
sw-release-id: V2.0
sw-release-date: 2020-10-01
sw-build-date: 2020-10-01
OK

8.5.5 name <name string>

The device name, which is shown in the output of the **version** command can be changed using **name** command. The chosen name must consist of maximum 32 characters with no spaces. The **save_settings** command must be used after a name change for it to take permanent effect.

Example:

name New_Device_Name_1

8.5.6 flip <mode>

Sets the image flip or rotation mode.

Mode	Function
0 (reset)	Normal (no flip)
1	Vertical flip
2	Horizontal flip
3	Rotated by 180°

8.5.7 temp <sensor id>

Dumps camera temperature values in degree centigrade. The output has the format **temp <id> <value> <name>**

Temperature Sensor ID	Function
0	Processor temperature (with 0.1°C accuracy)
1	Sensor temperature (with 0.1°C accuracy)

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

Example 1:

Command: **temp 0**
Response: **temp 0 43.3 Processor**
OK

Example 2:

Command: **temp 1**
Response: **temp 1 45.2 Sensor**
OK

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

8.6 Camera Commands

8.6.1 cam_gain <gain>

Set the analog gain for the sensor. Gain can be read at any time, including when the auto exposure control is enabled.

Value	Reset	Minimal	Maximal
gain	1000	1000 (1x 0dB)	252000 (252x 48dB)

Example:

Example to set gain of 3x
cam_gain 3000

8.6.2 cam_exposure <time>

Sets the exposure time/shutter width, in microseconds [µsec], in which sensor is exposed to light.

Remarks:
1. The exposure time might be adjusted, if video mode is changed using **video_mode** command and the value exceeds the maximum allowed value for the new video mode.
2. Exposure can be read at any time, also when the auto exposure control is enabled.

Example:

Example to set exposure of 10000usec
cam_exposure 10000

8.6.3 cam_info

Reports the min / max gain and exposure in the following order: minimum gain, maximum gain, minimum exposure, maximum exposure, natural multiplication factor (1x)

Example:

Command: **cam_info**
Response: **cam_info 1000 252000 75 33333 1000**
OK

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

8.7 Video Commands

8.7.1 video_mode <mode>

Sets the output video mode.

Mode ID	Resolution	Frame Rate
1	1920x1080p (FHD)	30
2	1920x1080p (FHD)	25
3	1920x1080p (FHD)	24
4	1920x1080p (FHD)	23.98
5	1920x1080p (FHD)	29.97
6	1920x1080p (FHD)	50
7	1920x1080p (FHD)	60
8	1920x1080i (FHD)	60
9	1920x1080i (FHD)	50
10	1920x1080i (FHD)	59.94
11	1920x1080p (FHD)	59.94
12	2048x1080p (2K)	30
13	2048x1080p (2K)	25
14	2048x1080p (2K)	24
15	2048x1080p (2K)	23.98
16	2048x1080p (2K)	29.97
17	2048x1080p (2K)	50
18	2048x1080p (2K)	60
19	2048x1080p (2K)	59.94
20	2048x1080p (2K)	48
21	2048x1080p (2K)	47.96
22	3840x2160p (UHD)	30
23	3840x2160p (UHD)	25
24	3840x2160p (UHD)	24
25	3840x2160p (UHD)	23.98
26	3840x2160p (UHD)	29.97
27	3840x2160p (UHD)	50
28	3840x2160p (UHD)	60
29	3840x2160p (UHD)	59.94
30	3840x2160p (UHD)	48
31	3840x2160p (UHD)	47.96
32	4096x2160p (4K)	30
33	4096x2160p (4K)	25
34	4096x2160p (4K)	24
35	4096x2160p (4K)	23.98
36	4096x2160p (4K)	29.97
37	4096x2160p (4K)	50
38	4096x2160p (4K)	60
39	4096x2160p (4K)	59.94
40	4096x2160p (4K)	48
41	4096x2160p (4K)	47.96

8.7.2 downscale <channel=1> <downscale> <reserved=0>

The **downscale** command is used to output Full HD or 2K resolution from UHD or 4K downscaled source image. The downscale is only applied if the current video mode allows it and the camera support 4K resolutions.

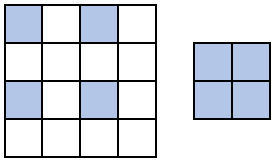


Figure 3 – Downscale example

The following table lists video modes which support the downscale.

Mode ID	Mode
1	1920x1080p 30
2	1920x1080p 25
3	1920x1080p 24
4	1920x1080p 23.98
5	1920x1080p 29.97
6	1920x1080p 50
7	1920x1080p 60
8	1920x1080i 60
9	1920x1080i 50
10	1920x1080i 59.94
11	1920x1080p 59.94
12	2048x1080p 30
13	2048x1080p 25
14	2048x1080p 24
15	2048x1080p 23.98
16	2048x1080p 29.97
17	2048x1080p 50
18	2048x1080p 60
19	2048x1080p 59.94
20	2048x1080p 48
21	2048x1080p 47.96

Remarks:

1. <channel> input parameter should always be 1
2. <reserved> input parameter should always be 0
3. The downscale is only applied if the current video mode allows it and the camera support 4K resolutions.

Example:

downscale 1 1 0

8.7.3 sdi_black <offset>

Sets the black level for SDI in legal range mode (see sdi_range).

An offset value of 0 will result in SDI black value of 64 (SMTP conform). When changing this value, the black level on the SDI interface can be set different than 64 (not SMTP conform). This value changes the SDI range limiter and will stretch output values to adapt to the new range.

Value	Reset	Minimal	Maximal
Offset	0	-60	+60

8.7.4 sdi_white <offset>

Sets the white level for SDI in legal range mode (see sdi_range). An offset value of 0 will result in an SDI white value of 940 (SMTP conform). When changing this value, the white level on the SDI interface can be set different than 40 (not SMTP conform). This value changes the SDI range limiter and will stretch output values to adapt to the new range.

Value	Reset	Minimal	Maximal
offset	0	-80	+79

8.7.5 sdi_range <flag>

Sets the SDI output range type.

Flag	Mode	Digital Code Range	Note
0	Legal	Y ranges from 64 + sdi_black offset Y ranges from 940 + sdi_white offset U/V range from 64 to 960	Used for broadcast and monitors with defined black and white levels.
1	Extended	Y/U/V range from 4 to 1019	Used for recoding with maximum dynamic.

Example:

// Enable the extended pixel range which depends on **sdi_black and sdi_white values.**
sdi_range 0

8.7.6 post_bright <offset>

Sets post processing brightness.

Y_out = Y + offset

Neutral value is 0.

Value	Reset	Minimal	Maximal
offset	0	-128	+127

8.7.7 post_cont <factor>

Sets post processing contrast.

Y_out = Y * factor / 128

Neutral value is 128.

Value	Reset	Minimal	Maximal
factor	128	0	255

Example:

```
// Set a contrast value of 1.23 => input value should be 157 = round (1.23 * 128.0)
post_cont 157
```

8.7.8 post_sat <factor>

Sets post processing color saturation.

Cb,r_out = Cb,r * factor / 128

Neutral value is 128.

Value	Reset	Minimal	Maximal
factor	128	0	255

Example:

```
// Set a saturation value of 1.23 => input value should be 157 = round (1.23 * 128.0)
post_sat 157
```

8.7.9 post_hue <offset>

Sets post processing color hue offset angle.

Cb' = Cb * cos (offset * 90 / 128) + Cr * sin (offset * 90 / 128)
Cr' = -Cb * sin (offset * 90 / 128) + Cr * cos (offset * 90 / 128)

Neutral value is 0.

Value	Reset	Minimal	Maximal
value	0	-128 (-90 degree)	127 (+89 degree)

Example:

```
// Set a hue value of 12.3 => input value should be 17 = round (12.3 * 128.0 / 90.0)
post_hue 17
```

8.7.10 wb

Triggers single shot white-balance.

Example:

```
wb
```

8.7.11 awb <flag>

Enable continuous white balance adjustment. Compensate sensor output colors to true colors. The algorithm works on the assumption that average color of image in selected ROI is gray.

Enable	Function
0	disable
1	enable

8.7.12 wb_preset <id>

Sets calibrated white balance presets (gains and color-cross matrices). List of calibrated presets are described in the following table:

ID	Illumination	Color temperature
0	horizon	2200K
1	candle light (A)	2700K
2	fluorescent (TL84)	3700K
3	fluorescent (CWF)	4000K
4	daylight sunny (D50)	5000K
5	daylight (D65)	6500K
6	daylight cloudy (D75)	7500K
7	disable preset	

8.7.13 gain_red <gain>

Sets gain factor for red component for selected output channel. This function is for basic color correction or white balance.

red_out = red * gain / 256

Value	Reset	Minimal	Maximal
gain	256	0	2047

Example:

```
// Set a red gain value of 1.23 => input value should be 315 = round (1.23 * 256.0)
gain_red 315
```

8.7.14 gain_blue <gain>

Same as gain_red but for blue color channel.

8.7.15 gain_green <gain>

Same as gain_red but for green color channel.

8.7.16 black_master <offset-red> <offset-green> <offset-blue>

Sets the black-level offset for red, green and blue-components for selected output channel. The processing is done in linear RGB domain (pre gamma).

red_out = (red_in – offset-red) *4095 / (4095 – offset-red)

Value	Reset	Minimal	Maximal
offset	0	-2047	2048

Example 1:

```
// Set black-level for all components to 100
black_master 100
```

Example 2:

```
// Set black-level for red to 10, for green to 20 and blue to 30
black_master 10 20 30
```

8.7.17 black_red <offset>

Sets offset for red component for selected output channel as black level setting. The processing is done in the linear BAYER domain (pre de-bayering). The offset is defined as singed value. A value of zero is treated as neutral.

red_out = red + offset

Value	Reset	Minimal	Maximal
offset	0	-4096	4095

8.7.18 black_blue <offset>

Same as black_red but for blue color channel.

8.7.19 black_green <offset>

Same as black_red but for green color channel.

8.7.20 flare <red level> <green level> <blue level>

Sets flare compensation level (= Defogging). The processing is done in the linear BAYER domain (pre de-bayering). The level is defined as unsigned value. A value of zero is treated as neutral (disable flare).

$$\mathrm{red}_{\mathrm{out}} = \frac{4095 * (\mathrm{red}_{\mathrm{in}} - \mathrm{level} * -\mathrm{red})}{4095 - \mathrm{level} * -\mathrm{red}}$$

Value	Reset	Minimal	Maximal
offset	0	0	65535

Example 1:

// Set flare value of 0.1 (10%) => input value should be 6554 = round (0.1 * 65536.0)
flare 6554 6554 6554

Example 2:

Set same flare level for all components:
flare 6554

8.7.21 color_cross <c0> .. <c8>

Sets the color cross talk matrix, which can be used for correction of cross talk effects and color space shifts. The cross talk compensation unit performs a regular RGB to R'G'B' color space conversion, to compensate the cross talk between color components of the image. The matrix coefficients provide the ability to correct each pixel value with the following matrix operation:

R' = (R*c0 + G*c1 + B*c2) / 4096
G' = (R*c3 + G*c4 + B*c5) / 4096
B' = (R*c6 + G*c7 + B*c8) / 4096

Value	Reset	Minimal	Maximal
color_cross_c0	4096	-32768	32767
color_cross_c1	0	-32768	32767
color_cross_c2	0	-32768	32767
color_cross_c3	0	-32768	32767
color_cross_c4	4096	-32768	32767
color_cross_c5	0	-32768	32767
color_cross_c6	0	-32768	32767
color_cross_c7	0	-32768	32767
color_cross_c8	4096	-32768	32767

Example:

// Set a color_cross_c2 value of 1.23 => input value should be 5038 = round (1.23 * 4096)
color_cross 4096 0 5038 0 4096 0 0 0 4096

8.7.22 color_cross_offset <red_offset> <green_offset> <blue_offset>

Sets the color cross talk offset. In addition to the matrix multiplication (see **color_cross**) an offset can be added to the pixel values for R, G and B separately. This offset is applied after the matrix multiplication. A value of zero is treated as no offset.

Value	Reset	Minimal	Maximal
red_offset	0	-2048	2047
green_offset	0	-2048	2047
blue_offset	0	-2048	2047

8.7.23 color_conv <c0> .. <c8>

Sets the color conversion matrix. The following formula is used for the conversion:

Y = (c0*R + c1*G + c2*B) / 4096 + 64
Cb = (c3*R + c4*G + c5*B) / 4096 + 512
Cr = (c6*R + c7*G + c8*B) / 4096 + 512

Value	Reset	Minimal	Maximal
color_conv_c0	871	-8192	8191
color_conv_c1	2929	-8192	8191
color_conv_c2	296	-8192	8191
color_conv_c3	-469	-8192	8191
color_conv_c4	-1579	-8192	8191
color_conv_c5	2048	-8192	8191
color_conv_c6	2048	-8192	8191
color_conv_c7	-1860	-8192	8191
color_conv_c8	-188	-8192	8191

Example:

```
// Set a color_cross_c2 value of 1.23 => input value should be 5038 = round (1.23 * 4096)
color_conv 871 2929 5038 -469 -1579 2048 2048 -1860 -188
```

8.7.24 color_space <color space>

Change the color space matrix by updating the **color_conv** matrix coefficients according to standard RGB to YCbCr conversion method.

Value	Color Space	Usually used for
0 (reset)	Rec.709	HD / SDR
1	Rec.2020	UHD / HDR

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

8.8 Defect Pixel Correction

The defected pixel correction will correct up to 32 pixels in the sensor and up to 2 adjacent pixels in a row. The pixel correction coordinates represent pixels of sensor's visible ROI, therefore identifying the correct X and Y coordinate should be done using default, full resolution image.
The algorithm will correct the defect pixel based on the value of existing adjacent pixels. The correction for Mono and Color sensor is slightly different and described as follows:

The defect pixel $P(x, y)$ value will be the average value of two pixels from both sides of pixel $P(x, y)$ in the same row, corresponding to the same Bayer color element.

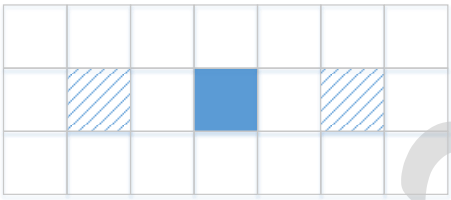


Figure 4 – Defect pixel correction position

8.8.1 dpc <flag>

Enable deflect pixel correction.

Flag	Function
0	No correction
1 (reset)	Correction enabled

8.8.2 dpc_add_pixel <x> <y>

Adds a pixel coordinate to defect pixel table or dumps the whole table. Valid values for the x and y coordinates.

Value	Minimal	Maximal
X coordinate	0	<max_width> - 1
Y coordinate	0	<max_height> - 1

Example 1:

```
// Add pixel coordinate (123, 456) into defect pixel table
dpc_add_pixel 123 456
```

Example 2:

```
// Dump dead pixel table
Command: dpc_add_pixel
Response:  dpc_add_pixel 100 100
           dpc_add_pixel 200 200
           OK
```

8.8.3 dpc_del_pixel

Deletes all pixel coordinates from the defect pixel table.

8.8.4 dpc_save

Saves defect pixel table to persistent memory.

8.8.5 dpc_load

Loads defect pixel table from persistent memory.

8.9 Knee Function

8.9.1 knee <flag> <knee_point> <knee_slope> <white_clip>

Knee function for highlight control. 3 parameters can be set for the knee function:

Value	Reset	Minimal	Maximal
flag (enable)	0 (off)	0	1
knee_point [%]	85	50	100
knee_slope	140	100	200
white_clip [%]	109	100	109

Example:

```
// Enable knee at 85% with a slope of 1.4 and white clip at 109%
knee 1 85 140 109
```

8.10 Loop-up Table Management

The LUT Control can be used to re-map the image linear output in different manner. Mostly to compensate for the non-linear scene emission. Each index at the LUT corresponds to the original pixel value, and the LUT value at this index corresponds to the new value that the pixels should be replaced with.

Pixel value is replaced according to the following equation:

$$\overline{P_{red}(x,y)} = LUT_{red}[P_{red}(x,y)]$$
$$\overline{P_{green}(x,y)} = LUT_{green}[P_{green}(x,y)]$$
$$\overline{P_{blue}(x,y)} = LUT_{blue}[P_{blue}(x,y)]$$

Where P(x,y) is the pixel at offset X in horizontal and Y in vertical, of specific color.

Lookup table can be set in one of the following methods:

1. LUTs can be programmed using up to 24 sample points. All intermediate values are calculated with a spline interpolator (see **lut_sample_<channel>** commands).

2. LUTs can be programmed by specifying a set of parameters which will be used to calculate and apply a gamma curve according to REC.709 standard (see **lut_fun_rec709** command).
3. LUTs can be fast configured by specifying only the desired gamma value of the REC.709 gamma function (see **lut_fast_gamma** command).
4. LUTs can be configured with a fixed configuration of three presets which include the default REC.709 gamma curve and two HDR gamma curves: PQ and HLG (see **lut_fixed_mode** command).

8.10.1 lut_enable <reserved=0> <flag>

Enables the function for look up table.

Flag	Function
0	Disable (linear)
1 (reset)	Enable

Remarks:

1. <reserved> input parameter should always be 0

Example:

```
// Apply LUT table configuration.
lut_enable 0 1
```

8.10.2 lut_mode <mode>

Selects the LUT operational mode which are described in the following table:

Mode	Description
0	Table based using interpolation. The user has to specify a table with a maximum of 24 values. Intended for offline calibration.
1	Fast gamma mode where the user only specifies the desired gamma value. Can be used for gamma changes during runtime.
2	Fixed gamma mode where the user selects one of three fixed gamma tables.

8.10.3 lut_preset <index>

Selects the preset storage for the current LUT interpolator. There are up to 5 presets which can be modified.

Index	Factory preset
0	REC709
1	Linear
2	Linear
3	Linear
4	Linear

Example:

```
// Select lut preset 1
lut_preset 1
```

8.10.4 lut_sample_master <xi_0> <yi_0> ... <xi_7> <yi_7>

Defines the sample points in a lookup table for all colors. The x-value is the input value, the y-value is output.

Value	Minimal	Maximal
xi_n	0	1023
Yi_n	0	1023

Sets the up to 8 sample points of 24 for the look up definition for all colors. For setting more than 8 points, the function can be called multiple times. In case a x-position is set twice, the previous value is overwritten.

Remarks:

1. When more than 24 points are defined, an error message is dumped.
2. lut_sample_<color> command should be used to read back the current sample point. lut_sample_master will not return sample data.

Example:

```
// Add LUT sample points to preset 1 and start curve interpolation.
// Set following points: (0, 200), (1023, 800), (300, 500), (700, 600). This will result in new image range
// from 200 (index 0 and up) to 800 (index 1023 and down)

lut_enable 0 0                      // disable lut
lut_mode 0                          // select lut mode 0 (Table based using interpolation)
lut_preset 1                        // select preset 1 to modify
lut_reset                           // reset preset 0
lut_sample_master 0  200 1023 800   // up to 8 pairs of point
lut_sample_master 300 500 700 600   // up to 8 pairs of point
lut_interpolate                     // interpolate lut table, fill in values between the specified samples
lut_enable 0 1                      // enable lut
```

8.10.5 lut_sample_red <xi_0> <yi_0> ... <xi_7> <yi_7>

Same as lut_sample, but only for red component.

8.10.6 lut_sample_green <xi_0> <yi_0> ... <xi_7> <yi_7>

Same as lut_sample, but only for green component.

8.10.7 lut_sample_blue <xi_0> <yi_0> ... <xi_7> <yi_7>

Same as lut_sample, but only for red component.

8.10.8 lut_interpolate

Interpolates all look up tables based on the given sample points - fill in lut values in between the specified samples according to a spline interpolator.

8.10.9 lut_interpolate_red

Interpolates the red look up table based on the given sample points.

8.10.10 lut_interpolate_green

Interpolates the red look up table based on the given sample points.

8.10.11 lut_interpolate_blue

Interpolates the red look up table based on the given sample points.

8.10.12 lut_reset_master

Clears all color channels look up sample points.

8.10.13 lut_reset_red

Clears all red look up sample points.

8.10.14 lut_reset_green

Clears all green look up sample points.

8.10.15 lut_reset_blue

Clears all blue look up sample points.

8.10.16 lut_fun_rec709 <threshold> <linear-contrast> <linear-brightness> <contrast> <gamma> <brightness>

Sets new LUT sample points according to REC.709 for selected LUT preset. Sets the gamma curve for all color channels.

Value	Minimal	Maximal	REC.709
Threshold	0	1000	18
Contrast (linear)	0	10000	4500
Brightness (linear)	-1000	1000	0
Contrast (non-linear)	0	10000	1099
Gamma (non-linear)	0	1000	450
Brightness (nonlinear)	-1000	1000	-99

The following image shows the normalized REC.709 gamma curve and it's transition from linear to non-linear (power function) part. The linear part ranges from 0 to <0.018 and is computed by the following formula:

$$V_{out} = 4.5 * V_{in}$$

The maximum value in this range is:

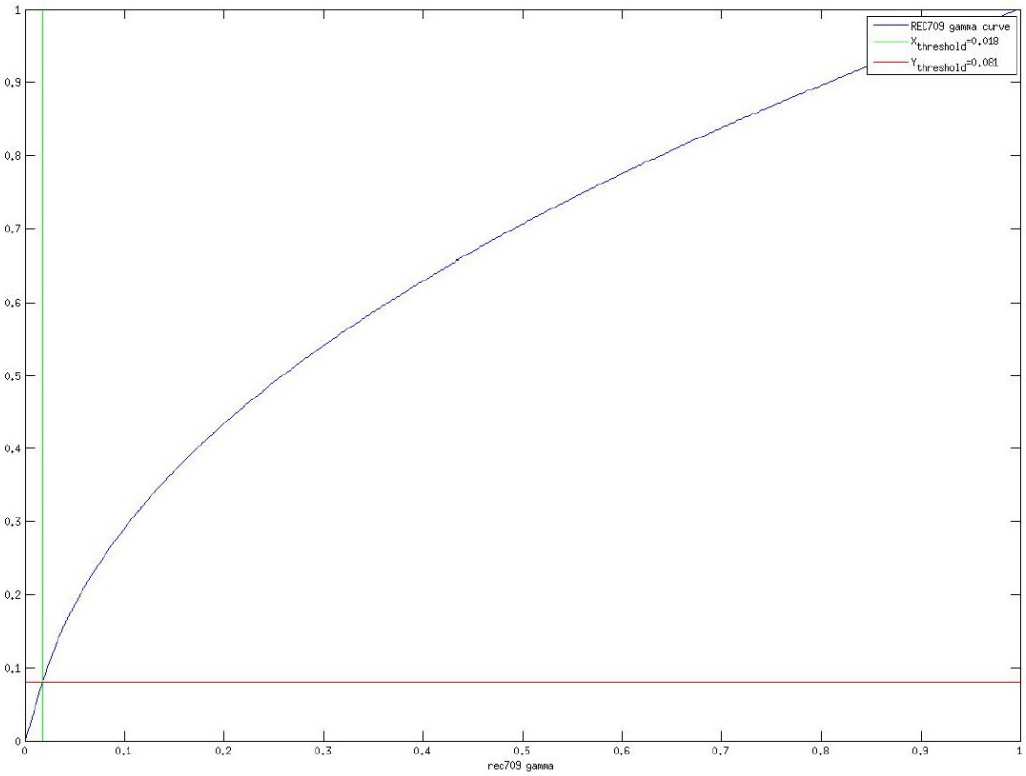
$$V_{out,min} = \lim_{V_{in} \to 0.018} (4.5 * V_{in}) = 4.5 * 0.018 = 0.081$$

The non-linear part ranges from 0.018 to 1 and is computed by the following formula:

$$V_{out} = 1.099 * V_{in}^{0.45} - 0.099$$

The minimum value in this range is:

$$V_{out,min} = 1.099 * 0.018^{0.45} - 0.099 = 0.081$$



To avoid a discontinuity in the gamma-function select the brightness (offset) for the non-linear part by the following formula:

$$V_{out,linear\ max} \approx V_{out,linear\ min}$$
$$brightness_{non-linear} \approx (Contrast_{linear} * threshold + Brightness_{linear}) - Contrast_{non-linear} * threshold^{Gamma}$$

Remarks:

1. The values are normalized to a range from 0.0 to 1.0 and multiplied by a scaling coefficient of 1000.

Example:

```
// Compute LUT sample points according to REC.709 and store in preset 1, then start curve interpolation

// <threshold>          18 => 0.018 * 1000
// <linear-contrast>    4500 => 4.5 * 1000
// <linear-brightness>  0 => 0 * 1000
// <contrast>           1099 => 1.099 * 1000
// <gamma>              450 => 0.45 * 1000
// <brightness>         -99 => -0.099 * 1000

lut_enable 0 0                  // disable lut
lut_mode 0                      // select lut mode 0 (Table based using interpolation)
lut_preset 1                    // select preset 1 to modify
lut_fun_rec709 18 4500 0 1099 450 -99
lut_interpolate                 // interpolate lut table – fill in values between specified samples
lut_enable 0 1                  // enable lut
```

8.10.17 lut_fast_gamma <gamma>

The fast gamma function uses the same formula as the lut_fun_rec709 command, but the user only has to specify the desired gamma value. All other values are fixed or computed as needed.

Value	Minimal	Maximal	REC.709
Gamma	1100	3000	2222

Remarks:

1. The value is normalized to a range from 0.0 to 1.0 and multiplied by a scaling coefficient of 1000.
2. Setting a value of 2222 will result in the default REC.709 gamma curve.

Example:

```
lut_mode 1          // select lut mode 1 (Fast gamma mode)
lut_enable 0 1      // make sure lut is enabled
lut_fast_gamma 2222
```

8.10.18 lut_fixed_mode <mode>

The fixed gamma mode contains three presets which are shown in the table below:

Mode	Description
0 (default)	REC.709 gamma curve
1	PQ gamma curve specified in ITU-R BT.2100 which can be used for HDR content
2	HLG gamma curve specified in ITU-R BT.2100 which can be used for HDR content

Examples:

```
lut_mode 2          // select lut mode 2 (Fixed gamma mode)
lut_enable 0 1      // make sure lut is enabled
lut_fixed_mode 0    // select fixed lut mode 0 (REC.709 gamma curve)
```

8.11 Image statistic commands

8.11.1 stat_rgb

Dumps the average image value for each color channel (RGB).

Examples:

Command: **stat_rgb**
Response: **stat_rgb 1040 896 1200**

8.12 Auto Exposure

8.12.1 aec <enable> <setPoint> <speed>

Auto Exposure and Gain are used to control the picture brightness by adjusting Exposure and Gain values automatically in order to reach desired luminance level. The algorithm calculates the average picture intensiveness inside the defined ROI and tries to adjust it to desired luminance level, by changing the exposure time and/or analog gain level.

The target luminance is set by the setPoint, this will determine how bright the image looks. A higher setPoint results in a brighter exposed image.

The speed determines how fast the exposure control reacts to luminescence changes. A higher value means a fast reaction to changes.

Parameter	Description	Minimal	Maximal	Default	Remarks
enable	Auto brightness compensation	0	1	0	0: Disable 1: Enable
setPoint	Target luminance	0	4095	1023	
speed	Control speed	3	30	8	

Example 1:

```
// Disable aec completely
aec 0
```

Example 2:

```
// Enable aec with luminance 1234. Remain other parameters with same value
aec 1 1234
```

Example 3:

// Enable aec with luminance 1234. Set speed at 25% => input value should be 8 = round (30 * 0.25). Remain other parameters with same value

aec 1 1234 8

8.13 Genlock

8.13.1 genlock <mode>

The genlock mechanism is used to synchronize multiple cameras video signals.

Mode	Description
0 (default)	Disabled – the genlock is off and the camera will work in free-run mode
1	Input Slave Auto – automatic genlock signal synchronization. When the genlock input cable is connected the camera, it will try to lock on the external tri-level sync signal, otherwise the camera will run in free-run mode. On lol (loss-of-lock) event the camera will return to free-run mode after specified timeout (see genlock_lol_filter command). Image may flicker or even disappear while camera tries to lock on external tri-level sync signal. The configured video mode (see video_mode command) must match the input sync signal for successful genlock operation.
2	Input Slave Force – genlock is always active and try to sync on external tri-level sync signal. Camera will not output any image unless genlock is synchronized. The configured video mode (see video_mode command) must match the input sync signal for successful genlock operation.

8.13.2 genlock_status

This command is used to check the current genlock status.

Status	Description
0	Genlock is disable or genlock is eanabled and successfully synchronized on external tri-level sync signal.
1	Genlock is enabled and failed to synchronize on external tri-level sync signal. This status indicates that either there is no input signal, the reference input signal doesn't match the configured video mode or the signal is unstable.

Example:

Command: **genlock_status**
Response: **genlock_status 0**

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

8.13.3 genlock_lol_filter <time_ms>

The loss-of-link (lol) timeout can be configured to prevent glitches in the unstable genlock signal. A loss-of-link is only registered when an unstable link is detected for more than a specified lol timeout, in which case the connection will be reset and an attempt will be made to synchronize the signal again. If a camera re-synchronizes often, it is advised to increase the lol timeout.

Value	Reset	Minimal	Maximal
time_ms	1000	0	10000

20 HaMesila St., Nesher 3688520, Israel
POB 25004, Haifa 3125001, Israel
Tel:(+972)-72-2723500 Fax:(+972)-72-2723511

9 Hardware Reference

9.1 Status LED

All SDI camera are equipped with a bi-color LED. Color coded indications are shown in the following table:

	LED state	Indication
	Fast flash green	Camera is connected, data is being transferred
	Solid green	Camera is connected, no data being transferred or settings are being updated
	Solid red	Internal error occurred / BIT failed

Table 4 – Connector indicator lamp states

9.2 Micro BNC Connector

To connect the Micro-BNC cable, first need to align the pin on the male end with the "L" shaped track on the female-connector of the Coaxial cable. Once aligned, the connector should be pushed in place (see figure no. 1). Only mild pressure should be applied to achieve this operation, otherwise it may cause unnecessary damage to the cable or the card.

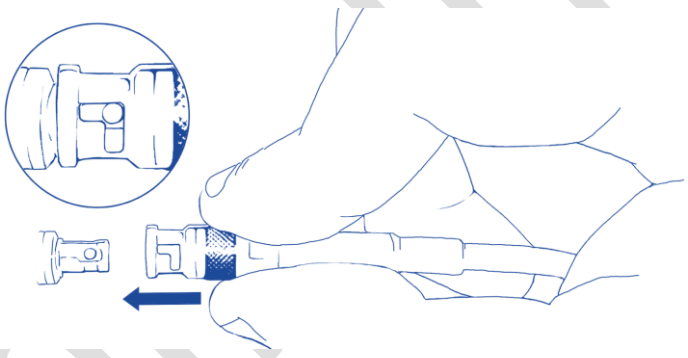


Figure 5 – Pushing the Micro-BNC connector into place

Once pushed all the way through, twist the connector clock-wise. The pin will move in the track locking the connector in position:

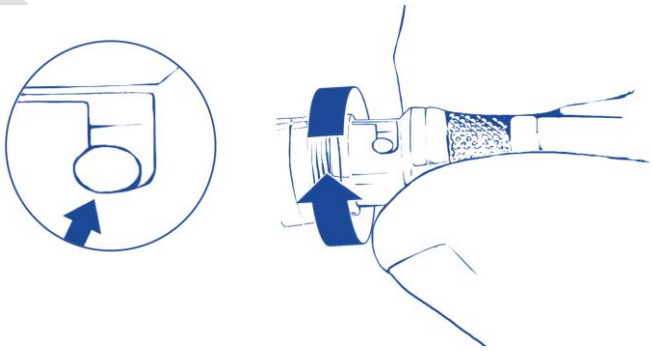


Figure 6 – Twisting the connector and securing it in position

The cable can be removed by reversing the steps: twisting the connector counter-clock-wise and pulling it out. Do not force the cable out! In case of resistance check for the pin location in relation to the track. Adjust as needed and only then pull the cable out.

10 Appendix 1: Firmware Update

Please note that the firmware can also be updated via the SDIControlPoint software that offers a user friendly GUI. For more information please refer to section 7.1 SDIControlPoint.

The Iron SDI Camera supports firmware update via serial terminal over RS232 protocol. To initiate a firmware update, follow the next steps:

5. Download the latest firmware from KAYA's website.
6. Please make sure to download the correct FW for the camera that you have, as installing an incorrect FW may cause the camera to malfunction.
7. Open serial emulated terminal (usage of Tera Term terminal is recommended) and set serial communication protocol to baud rate 115200, 8bit data, 1bit start, 1bit stop and no flow control.For example, in the Tera Term terminal, this should look as following (the port number might be different):

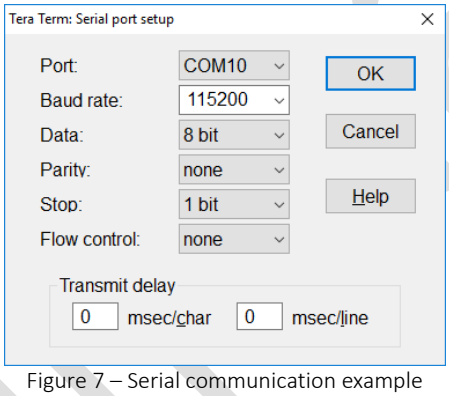


Figure 7 – Serial communication example

8. Choose the firmware update option by entering “fw_update”.
9. Under the “File” tab use the terminal “transfer” capability using the XMODEM protocol to initiate the firmware update. Choose “Send” and the firmware update file.

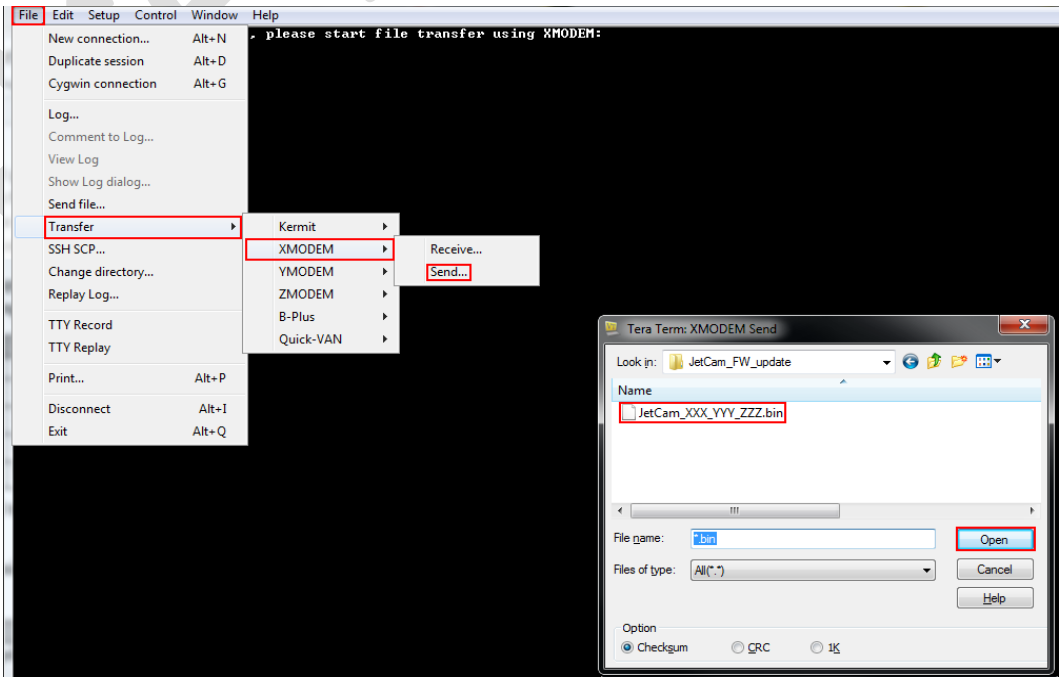


Figure 8 – Firmware terminal initiation

10. If no firmware will be sent during 1 minute, or in case of an error, the firmware update will fail and return to the previous operation mode.

```
IRON:> firmware
Now starting firmware update, please start file transfer using XMODEM:
The Firmware Update was UNSUCCESSFUL. Error: -1
IRON:>
```

Figure 9 – Firmware update fail

11. The firmware update process will take about 10 minutes.

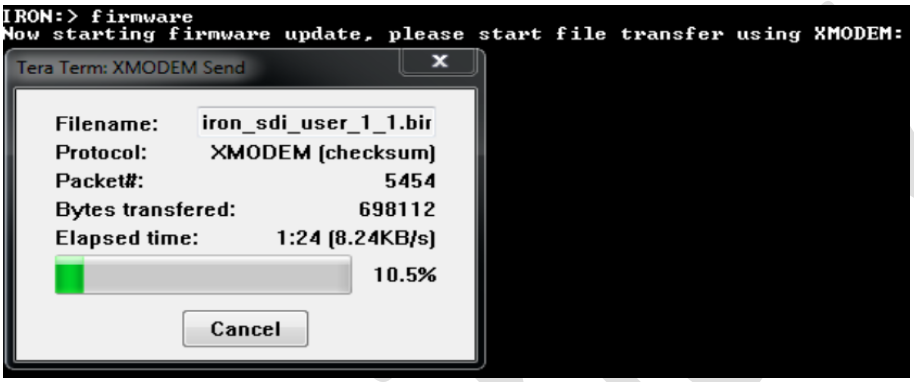


Figure 10 – Firmware update process

12. A successful update will result in an appropriate message

```
IRON:> firmware
Now starting firmware update, please start file transfer using XMODEM:
The Firmware Update was SUCCESSFUL file size: 6653440
IRON:>
```

Figure 11 – Firmware update succession

To apply the new firmware, the camera should be power cycled by disconnecting the power supply from the camera and connecting it back after a few seconds. After camera has been powered, it should be kept at least ~30 seconds with power before new firmware will be applied.