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Operation Manual

CAMERA Link

IC-M29S-CL

High-Speed High-Resolution Camera Technology

Revision 1.2

Revision History

Revision	Date	Description
1.0	20.07.2015	Initial Release
1.1	05.08.2015	Power Connector Drawing Correction
1.2	08.09.2015	Drawings Update

1. Introduction

Thank you and congratulations for purchasing the ISVI IC-M29S-CL (hereafter referred to as “camera”). We have designed this camera to provide outstanding imaging performance and give you years of reliable service. As you become familiar with the camera, you will appreciate the high quality of its production and the excellence in its engineering design.

Please read and fully understand the entire manual before proceeding to operate your camera!

1.1. Statement of Intended Use and Liability

Intended Use Statement

This camera is a highly sophisticated electronic image capture device designed for use in industrial machine vision systems.

The intended use and safe operation of the camera shall not be interfered with, even by unforeseen external forces. Intended use and safe operation of the camera shall be carried out only by qualified technicians trained in the installation and operation of electronic image capturing devices, accident prevention and common safeguards for handling sensitive electronic devices. Operating the camera for any purpose other than the stated intended use or by unqualified personnel may result in personal injury or property damage for which the manufacturer assumes no liability.

Limitation of Liability and Indemnity Statement

This camera has been built to the high quality standards of ISVI Corp. and is delivered in full working order with factory default settings. Please read and understand this manual and follow all safeguards and cautions for your safety and to prevent damage to the camera. Please do not attempt to install this camera without adequate training and knowledge of this specific camera. Any use or operation, modification or repair in contravention of this document is at your own risk and will immediately void the user’s warranty. By acceptance of this camera you hereby assume all liability consequent to your use or misuse of this camera.
To the maximum extent permitted by applicable law, ISVI Corp. shall not be liable for any damages suffered as a result of using, modifying, contributing, copying, distributing, or downloading the materials, use of the camera operation manual or use of any ISVI product and/or software. In no event shall ISVI be liable for any indirect, extraordinary, exemplary, punitive, special, incidental, or consequential damages (including, without limitation, loss of data, revenue, profits, use or other economic advantage) however arising, whether for breach or in tort, even if ISVI has been previously advised of the possibility of such damage. You agree that you have sole responsibility for adequate protection and backup of data and/or equipment used in connection with the product and software and will not make a claim of any nature against ISVI for lost data, inaccurate output, work delays or lost profits resulting from the use of any and all ISVI products and materials . You agree to indemnify, hold harmless and defend ISVI, together with its affiliates, parent and subsidiary entities, successors, assigns, partners, managers, members, employees, officers, directors and shareholders, from and against any and all damages, liens, liabilities, losses, demands, actions, causes of action, claims, costs and expenses (including, without limitation, reasonable attorneys' fees, charges and disbursements, as well as the cost of in-house counsel and appeals) arising from or related to ISVI, the use of this Operation Manual or any ISVI product and/or software.

Camera specifications, documentation, software applications and options are subject to change at any time and at the sole discretion of ISVI Corporation without notice.

1.2. Precautions

The following precautions must be heeded to avoid personal injury and damage to the camera and/or supporting equipment.
Failure to comply with any of the following precautions will void the user's warranty.

DO NOT attempt to disassemble, modify or repair the camera. Please contact your local ISVI Global Sales Partner if you require repair or modification.

DO NOT short circuit any output or input signals.

DO NOT allow high-voltage or electrostatic discharge to come into contact with the camera. The camera should be unpacked and handled in a clean, ESD protected workspace.

DO NOT operate the camera with any other voltage than is specified in this operation manual.

DO NOT expose the camera to electromagnetic fields. Image quality will degrade and, if strong enough, damage to the camera may occur.

DO NOT allow direct laser beams, direct sunlight or other high-intensity light to project directly onto the imaging sensor.

DO NOT expose the camera to temperatures and humidity levels outside of those specified in this operations manual.

DO NOT install the camera in a tightly enclosed space without ensuring proper heat dissipation and adequate ventilation.

DO NOT allow condensation to form on or in the camera and DO NOT allow the camera to come into contact with any liquids, cleaning agents or solvents. Should the camera require cleaning, then only with a clean, lint-free cloth.

DO NOT expose the camera to shock and vibration levels outside of those specified in this operations manual.

DO NOT allow foreign objects or particles to enter the camera. Immediately install the camera lens mount cover when lens is not mounted. When installing lenses, ensure that they are clean and they are not cross-threaded, tilted or otherwise damaged. Contamination of the optical path/sensor may occur and/or removal of the lens may become impossible. Installation of a lens should take place in a clean environment to avoid airborne contamination of the optical path.

DO NOT attempt to clean the camera's optical path yourself. Any damage to the optical path occurring from the user's attempt at cleaning it will void the warranty. If the optical path becomes contaminated, then please contact your local ISVI Global Sales Partner for assistance.

DO NOT apply unnecessary pressure or stress on the camera's cable connectors or pull or damage the camera cables.

DO NOT use mounting screws longer or with different thread pitch than specified in the operation manual.

1.3. Standards Conformity

CE marking and certification

(as per EN 50022-Class A Device)
The CE mark is a declaration by a manufacturer that European Union directives and regulations controlling a specific product have been certifiably met.
This camera fulfills the requirements of current EU regulations relating to EN 50022. A corresponding declaration of conformity and documentation are available upon request.

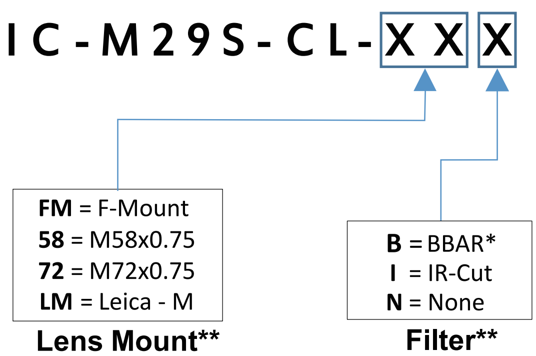
Federal Communications Commission (FCC / USA and Canada)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the Operation Manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. Camera complies with FCC Form 47 Rules.
Changes or modifications to this unit not expressly approved by the part responsible for FCC compliance could void the user's authority to operate the equipment.

Restriction of Hazardous Substances (RoHS).

The EU Directive 2002/95/EC Restriction of Hazardous Substances (RoHS) has been in effect since July 1, 2006 and has been revised in 2011. The changes to Directive 2011/65/EU, also known as "RoHS II" will slowly take effect over 6 years. This directive restricts the use of six hazardous materials in EEE products. This camera meets the current requirement for RoHS compliancy.

1.4. Ordering Information



* Monochrome standard with BBAR filter
** Custom OEM available

Contents

2. Overview

The ISVI IC-M29S-CL is a monochrome area scan camera utilizing the ON Semiconductor (previously Truesense Imaging) KAI-29050, a high-sensitivity, high-dynamic range 29-megapixel CCD sensor. The IC-M29S-CL has an 8/10/12-bit, 2-tap, base configuration Camera Link digital interface and a rugged, compact form factor. Its flexible acquisition modes include Free-Run, Trigger Master, Trigger Slave and Trigger Overlap. It also has a rich feature set making the camera adaptable to any application environment.

The IC-M29S-CL combines the best possible CCD image quality with a very high resolution and extremely simple connectivity to provide its user with the highest possible performance for the most demanding applications.
The IC-M29S-CL is suitable for a wide range of application areas including Factory Automation, Metrology, large-scale 3D imaging, AOI, Flat Panel Inspection, LED Inspection, Print Inspection, Intelligent Transportation Systems, Aerial Mapping, Aeronautics, Defense and more.

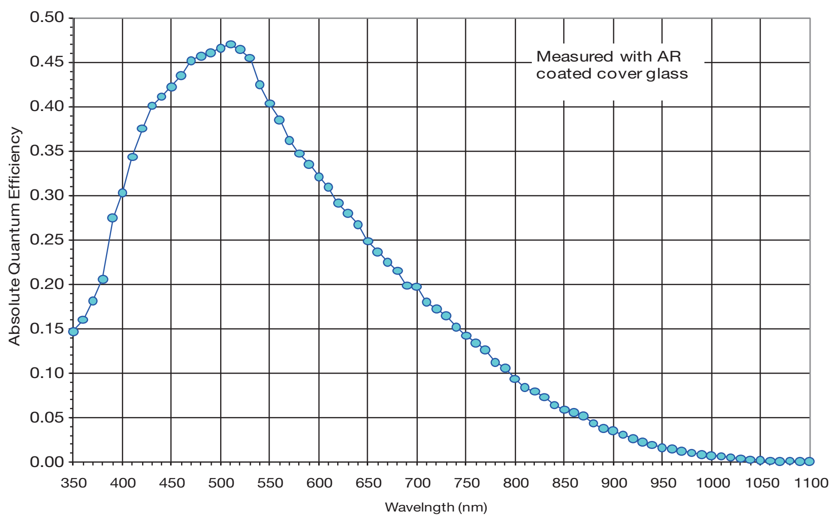
2.1. Main features

- ROI (Region Of Interest) - freely programmable
- FFC (Flat Field Correction)
- DPC (Defective Pixel Correction)
- 2x2 & 4x4 Binning
- Gain control - overall and individual taps
- Black clamp level control
- Gamma, programmable and download/upload LUT
- Acquisition modes: Freerun / Trigger Master / Trigger Slave
- Image data output & speed selectable
- Exposure time control
- Test pattern
- External trigger input / External strobe output
- Temperature monitoring
- User settings saving areas

2.2. Specification

Sensor	High-Sensitivity, Low-Noise CCD, Onsemi KAI-29050
Resolution	6576(H) x 4384(V) Active Pixels
Pixel Area Size	5.5µm(H) x 5.5µm(V)
Frame Rate	4.45Hz Full Frame (224.7 msec)
Active Area Size	Diameter : 43.7mm, 36.17mm(H) x 24.11mm(V), 35mm Optical Format
Output Format	8/10/12-bit Monochrome
CL Interface	2 Tap Base Configuration, Single Cable
Dynamic Range	64dB
Full Well Capacity	20000 e^-
SNR	> 55dB
Sensitivity	34 uV/e-
Acquisition Control	Free Run - Trigger Master - Trigger Slave - Overlap Mode
Exposure Control	Programmable from 100 µsec to 7 sec in 100 µsec steps
Analog Control	Gain & Black Offset Level 0 - 700, 0.035dB Steps
Digital Control	Gamma, Programmable and Download / Upload LUT
Image Control	Flat Field Correction, Defect Pixel Correction
Special Functions	User Flat Field Correction (FFC) calibration saving User Defect Pixel Correction (DPC) calibration saving User Programmable H&V Region of Interest (ROI) Binning 2x2 and 4x4
Lens Mounts	F-Mount, M72, M58, LM(Leica M), Custom OEM
Operating Temperature	0℃ to +40℃, ext. temp. possible with reduced performance
Storage Temperature	-10℃ to +70℃
Relative Humidity	20% - 90% non-condensing
Shock / Vibration	25G (Half sine 6-10ms XYZ) / 10G (5-150Hz, 1min, XYZ)
MTBF	> 78,500 h
Power Requirements	12VDC ± 10%, 14.4W, ≤ 50mV Ripple
Dimensions	75mm x 75mm x 43.4mm without lens mount and connectors
Weight	460g (without lens mount), 600g (included F-Mount)
Compliancy	Camera Link v2.0, RoHS, CE, FCC

2.3. Sensor spectral response (Quantum efficiency)



2.4. Mechanical dimension

- F Mount

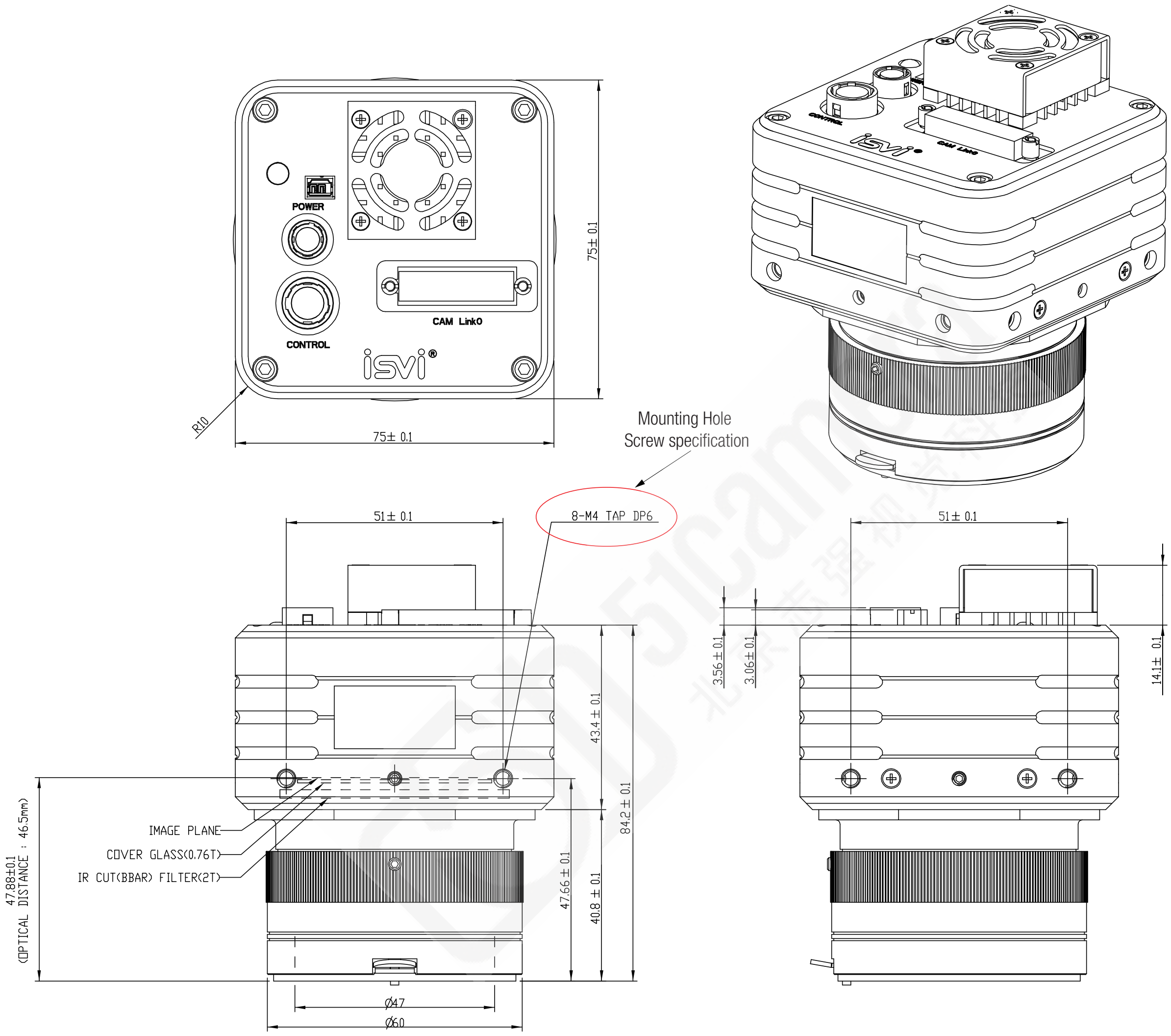


Figure 2.3 Outline drawings (F Mount)

- M58 Mount

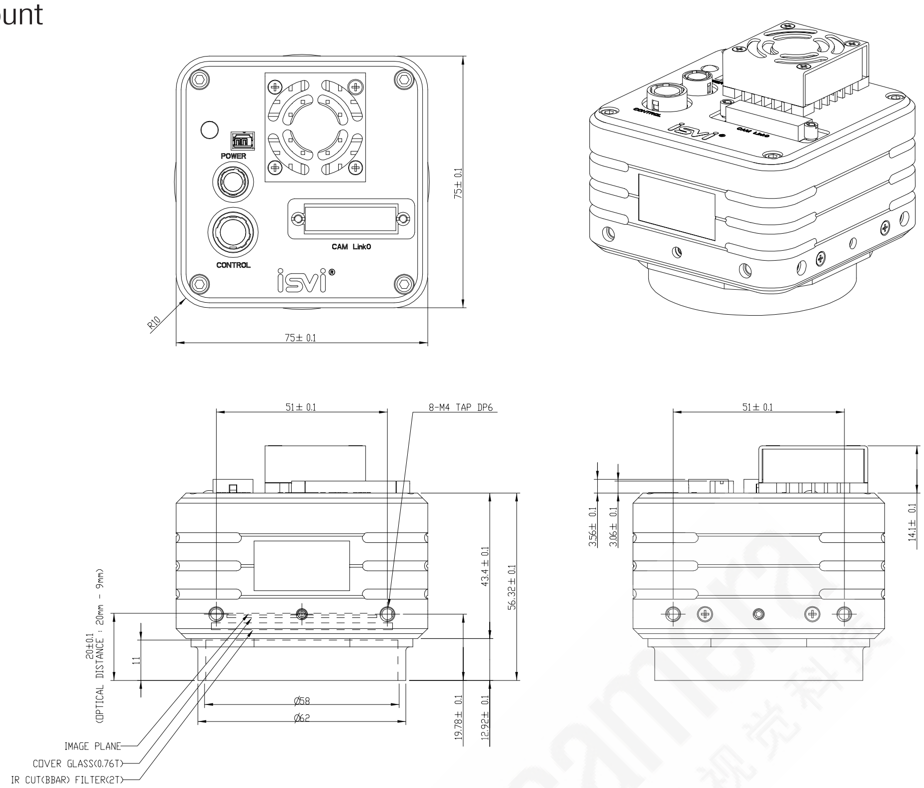


Figure 2.4 Outline drawings (M58 Mount)

- M72 Mount

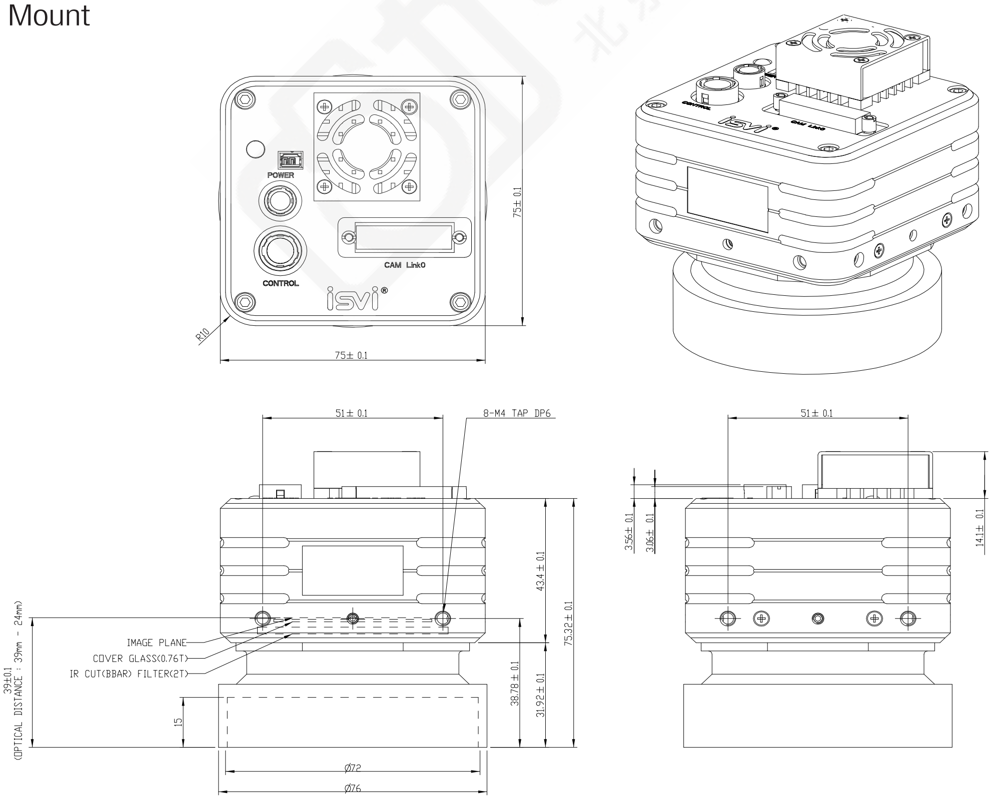


Figure 2.5 Outline drawings (M72 Mount)

• LM (Leica M) Mount

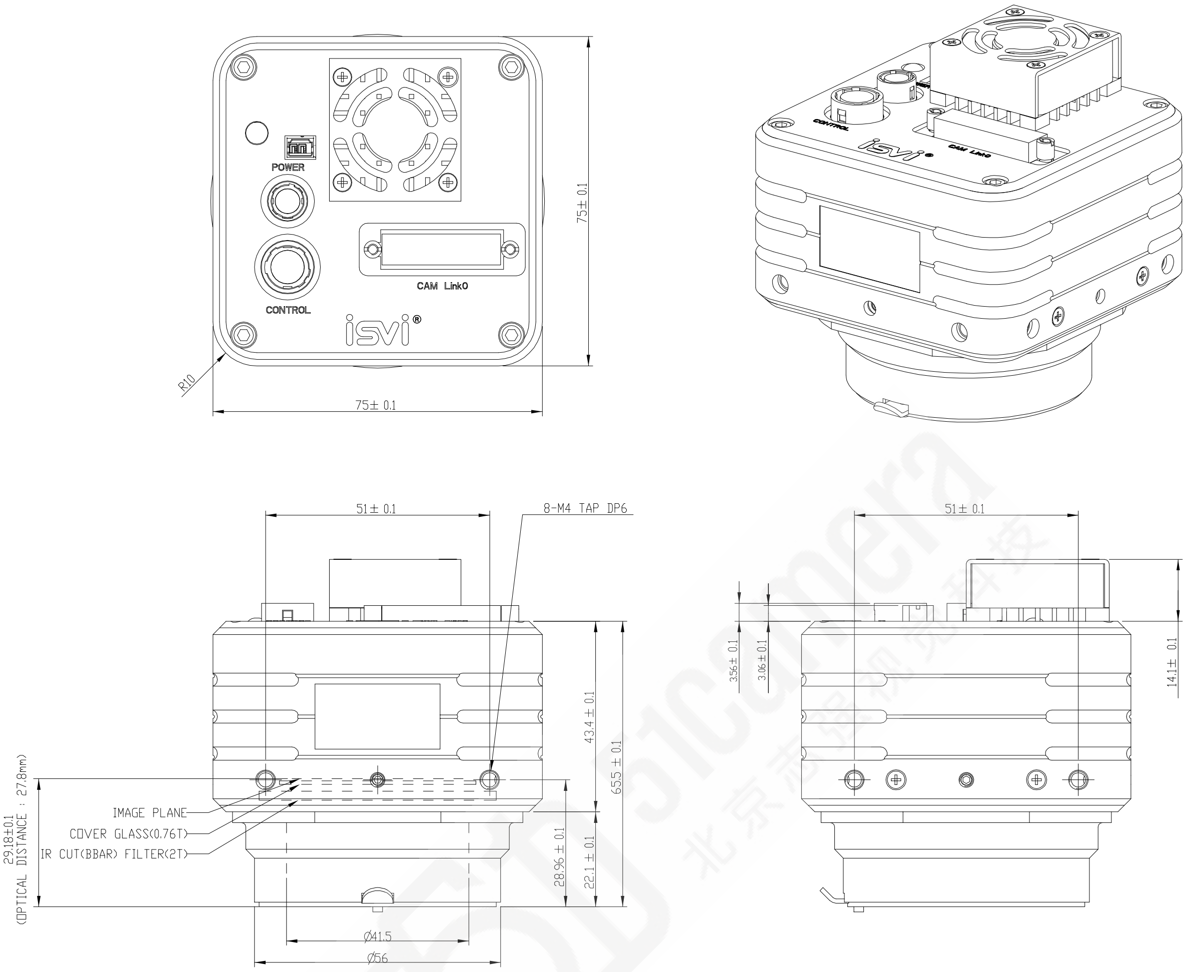


Figure 2.6 Outline drawings (LM Mount)

3. Installation

In this section you will find information on the proper means of mounting your camera in your system, connecting the camera to a frame grabber and power supply, as well as ensuring proper electrical connections to the camera's I/O signals.

3.1. Mounting the camera

The camera has 8 mounting holes, 2 each top, bottom and sides. See the highlighted mounting hole specification in Fig. 2.3 for their location and specifications.

Ensure that the maximum internal thread depth indicated in Fig 2.3 is not exceeded. The maximum torque which can be applied to the mounting screws is 1.7Nm.
Using screws which are too long or are over-tightened may damage the camera!

3.2. Thermal management

Mounting the camera properly and adequately is required to ensure proper thermal management, which ensures the best possible image quality. Thermal management means conducting heat away from the sensor in order to keep it as cool as possible. Heat is one of the primary causes of dark current noise on the sensor which increases photo response non-uniformity, dark signal non-uniformity, fixed-pattern noise and other image degrading effects.

The optimal conduction of heat from the sensor to the front and side surfaces is ensured by the design of this camera. In addition to its internal thermal management design, this camera comes with an active cooling fan to help maintain a constant operating temperature at any given ambient temperature. However, it is still necessary to transfer heat away from the camera surfaces by mounting the camera to a solid metal surface of adequate mass using the mounting holes found on the camera. The attachment of heat sinks to the camera sides can also aid in the transference of heat.

This camera is designed to operate at an ambient temperature between 0°C and +40°C. Operating the camera between 40°C and maximum 70°C will result in reduced image performance and camera lifetime. Do not operate the camera at temperatures above 70°C!

3.3. Mounting a Lens

This camera is equipped with a lens mount designed for use with high-precision industrial lenses. All lens mounts available for this camera are engineered with specific dimensions and very tight tolerances.
When mounting a lens to the camera, ensure that the lens is held parallel with the lens mount and never forcibly assert pressure to attach the lens. Ensure that the lens is not cross-threaded to the mount. Damage to the camera, lens mount and lens may occur!

When mounting an F-mount lens, ensure that the lens is inserted properly before turning counter-clockwise until the locking tab clicks into place.
When removing an F-mount lens, push the locking tab towards the camera body and turn the lens clockwise.

3.4. Camera connections

The camera connections are laid out on the back panel of the camera as follows:

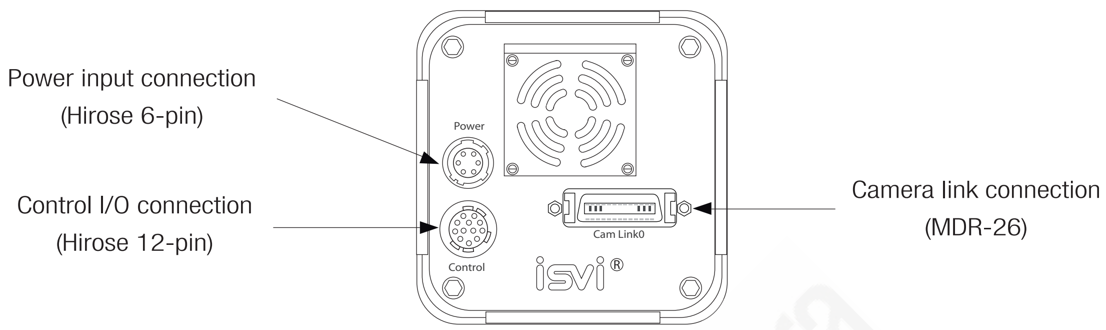
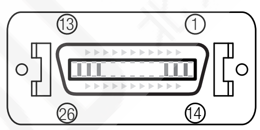


Figure 3.1 Camera connectors

3.4.1 Camera Link0 connection

The Camera Link0 connection adheres to the latest Camera Link Standard. It is used for data, communication and I/O signal transfer to/from a Base Configuration Camera Link frame grabber. It has a 2tap (8/10/12-bit) configuration.

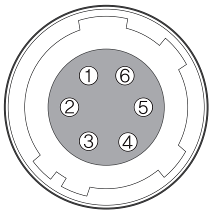


Pin No	I/O	Signal Name	Pin No	I/O	Signal Name
1	Ground	Inner shield	14	Ground	Inner shield
2	OUT	X0-	15	OUT	X0+
3	OUT	X1-	16	OUT	X1+
4	OUT	X2-	17	OUT	X2+
5	OUT	XCLKOUT-	18	OUT	XCLKOUT+
6	OUT	X3-	19	OUT	X3+
7	INPUT	RX+_SERTC+	20	INPUT	RX-_SERTC-
8	OUT	TX-_SERTFG-	21	OUT	TX+_SERTFG+
9	INPUT	CC1-(Trigger-)	22	INPUT	CC1+(Trigger+)
10	INPUT	CC2+	23	INPUT	CC2-
11	INPUT	CC3-	24	INPUT	CC3+
12	INPUT	CC4+	25	INPUT	CC4-
13	Ground	Inner shield	26	Ground	Inner shield

Figure 3.2 Camera Link0 Pin Assignments

3.4.2 Power input connection

The camera power input connector is a Hirose 6 pin connector (part # HR10A-7R-6P) and is used exclusively to power the camera. Pin layout and configuration are shown in Figure 3.3.



Power Connector

Pin Number	Signal
1, 2, 3	VCC, +12VDC
4, 5, 6	GND, Ground

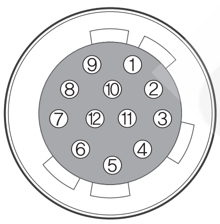
Mating connector: Hirose HR10(A)-7P-6S

Figure 3.3 Power input connector

It is recommended to use a direct current (DC) regulated power supply rated to at least 1.2 Amps current with output voltage of 12VDC ±10%. The camera employs a self-recovery fuse for protecting against reverse voltage and overvoltage. However, applying reverse voltage or overvoltage may damage the camera and void the warranty.

3.4.3 Control I/O connection

The Control I/O Connection is used for supplying the camera with an external TTL trigger input as an alternative to the CC1 Trigger Input on the Camera Link connection. It is also used for supplying an external strobe output trigger which is synchronized with the start of exposure.



Control Connector

Pin Number	Signal
1	+ Trigger Input
2	- Trigger Input
3	Strobe Output
5	GND, Ground
4, 6-12	Reserved - Do not connect

Mating connector: Hirose HR10(A)-10P-12P

Figure 3.4: Power input connector

The reserved pins are used by the ISVI Camera Firmware Upgrade Cable for field firmware upgrading. Do not connect these pins – damage to the camera may occur! See seperate manual provided for more detailed information about firmware upgrading.

Do not apply voltage to the Strobe Output or GND pins. Damage to the camera may occur!

3.5 Trigger input circuit

Figure 3.5 shows the trigger signal input circuit of the 12-pin Control I/O connection. The trigger signal entered is delivered to the internal circuit through a photo coupler.

Trigger pulse width must be a minimum of 100μsec. If the trigger pulse width supplied to the camera is less than 100us, trigger signal will be ignored by the camera and an image will not be taken.

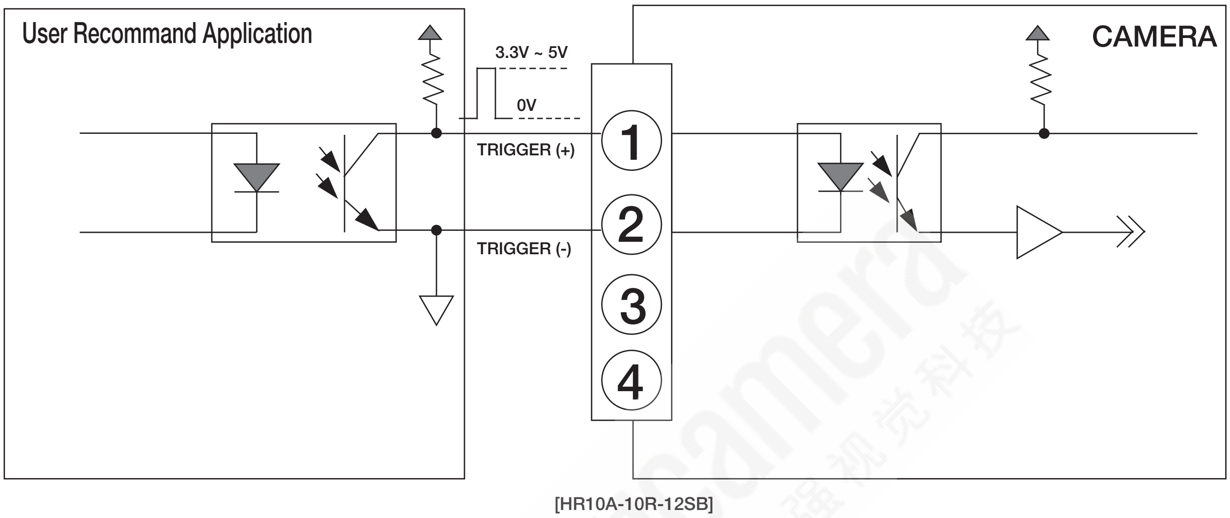


Figure 3.5: Trigger Input Circuit

3.6 Strobe output circuit

The strobe output signal is output through a TTL Driver IC with a 3.3 V output level. The start and the pulse width of the output signal is in synchronization with the exposure timing of the camera.

Do not apply any voltage to the Strobe Output pins – damage to the camera will occur and the warranty will be voided!

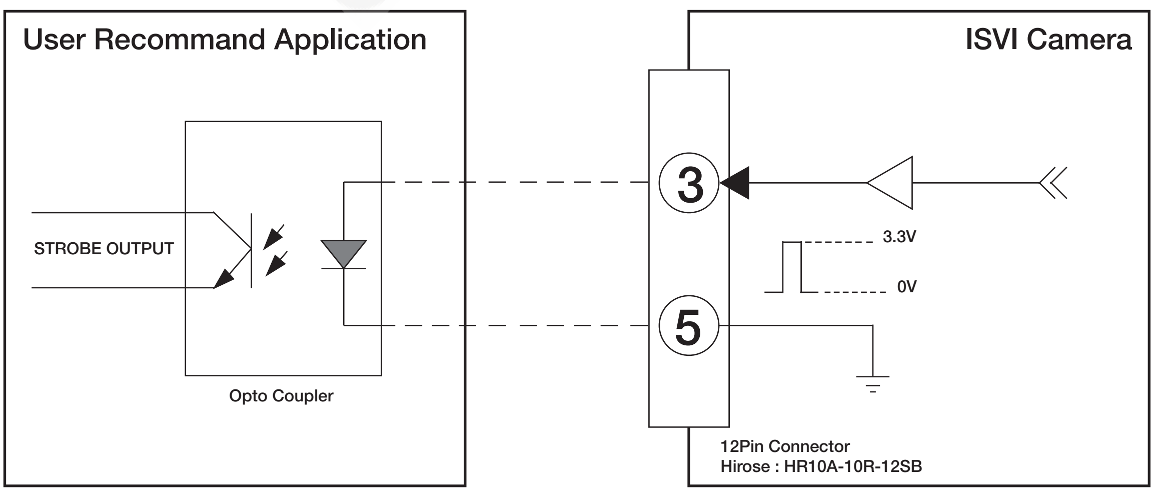


Figure 3.6: Trigger Output Schemetic

4. Image Acquisition

4.1. Overview

The camera has 5 acquisition modes which can be selected for a high degree of flexibility in any application environment.

- Free-Run
- Trigger Master
- Trigger Master Overlap
- Trigger Slave
- Trigger Slave Overlap

Each acquisition mode is selectable using the ISVI Camera Control Tool for this camera.

A red LED status light is on the back panel of the camera (see Figure 4.1) and indicates through its on/off timing which acquisition mode the camera is currently in.

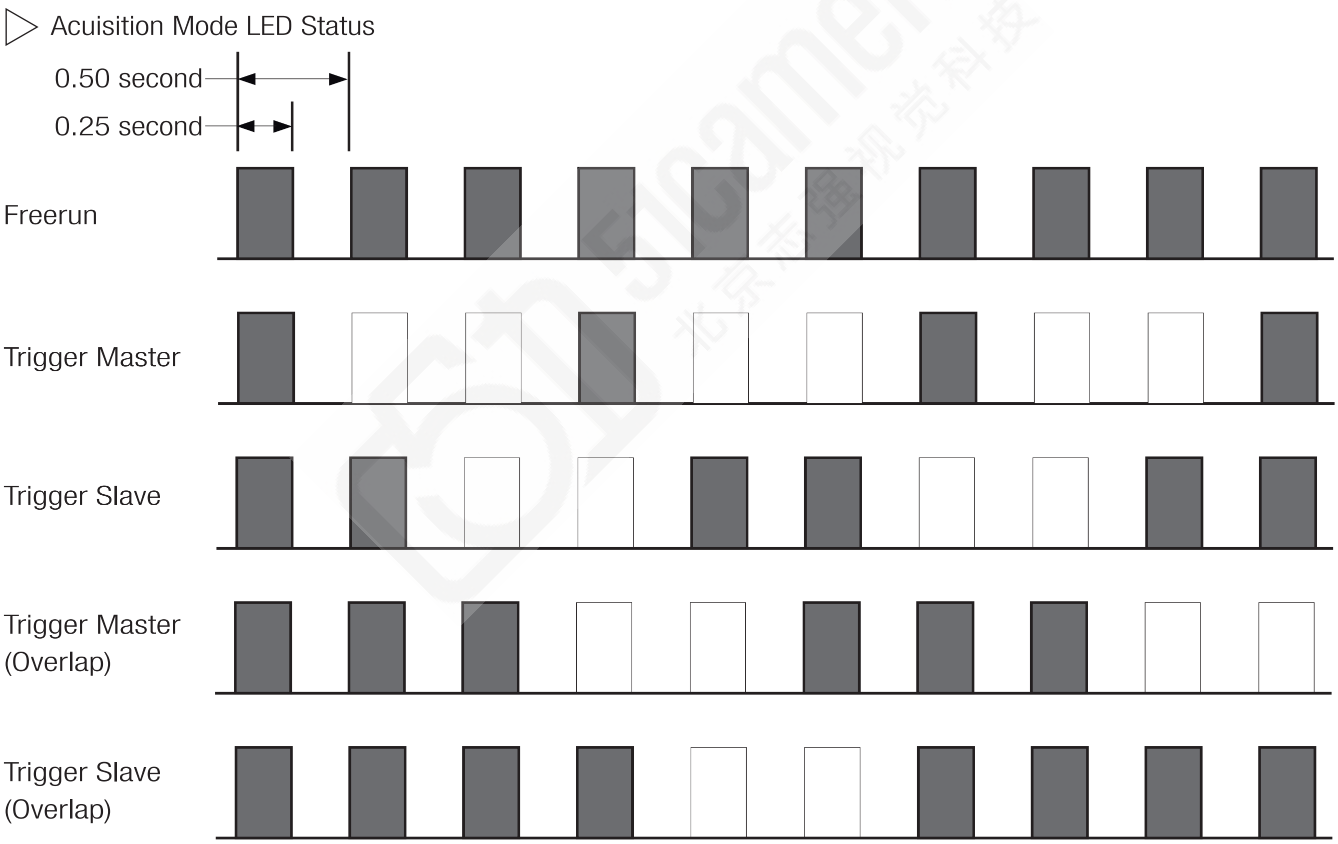


Figure 4.1: Acquisition Mode LED Status (Solid shaded areas indicate LED = ON)

The exact timing of Trigger Acquisition Modes is dependent on parameters both internal and external to the camera. Section 4 describes the dependencies of the internal parameters in relation to the external ones.

Frame Read Out period = 224.7msec

4.2. Free-run Mode

In Free-Run mode the camera creates its own internal trigger and continuously acquires images without the need for any external triggers. The exposure time is selectable by the user and it determines the cycle time of the internally generated trigger. The Free-Run mode is always running in Overlap mode (exposure during previous frame readout). Therefore, the maximum frame rate for a given exposure time can be achieved in this mode.

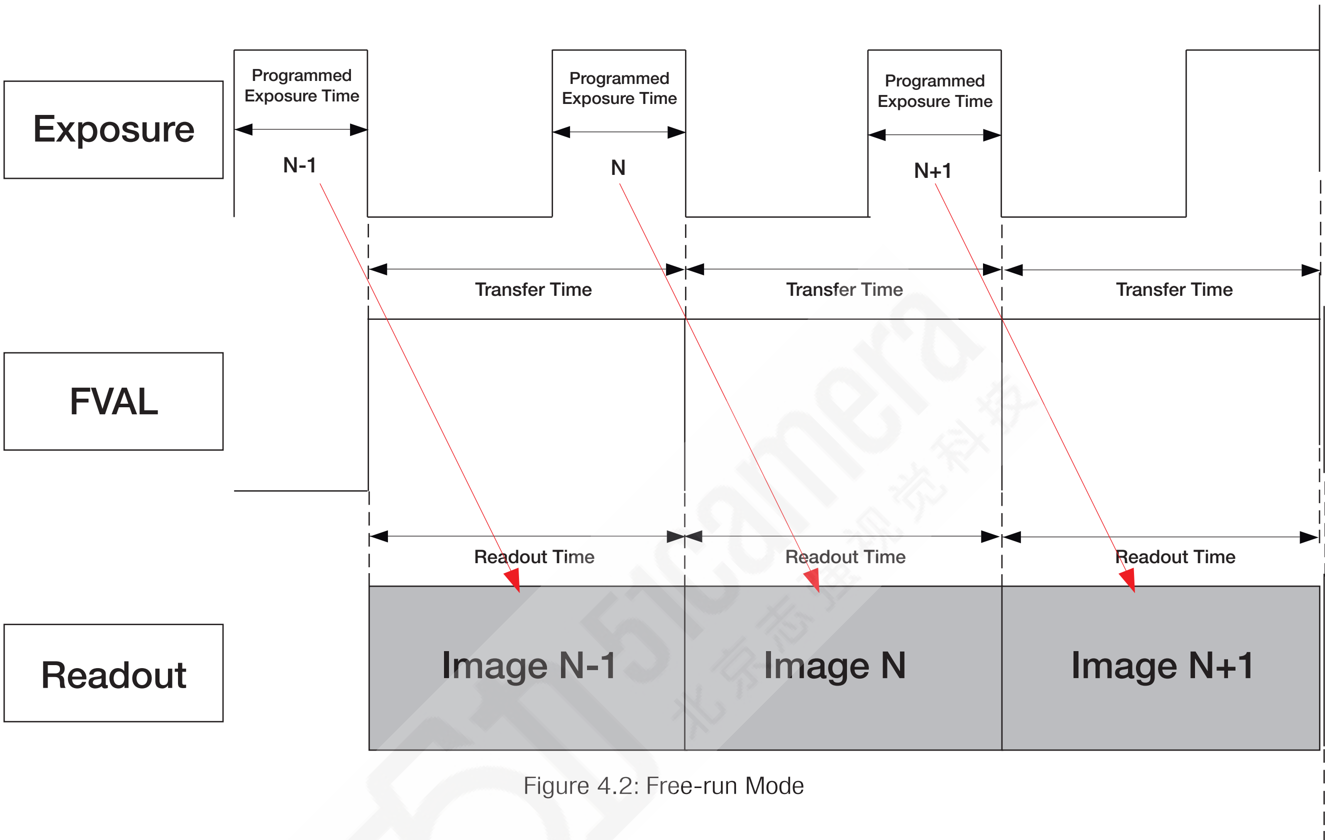


Figure 4.2: Free-run Mode

4.3. Trigger Master Mode

In Trigger Master mode the camera controls the Exposure period (Master condition) which is programmed in the camera by the user. The camera then waits for an external trigger to be applied to CC1 of the Camera Link connection or to the External Trigger pin of the I/O connection. Once a trigger is detected by the camera, then the programmed Exposure begins.

Readout of the image occurs after the end of the Exposure period.

If a new trigger is sent to the camera during the previous readout period, then it will be ignored. If a new trigger is sent to the camera during the previous exposure period, then the timing will be reset and the previous image will not be readout. Once programmed exposure and readout are completed the camera waits for the next valid trigger.

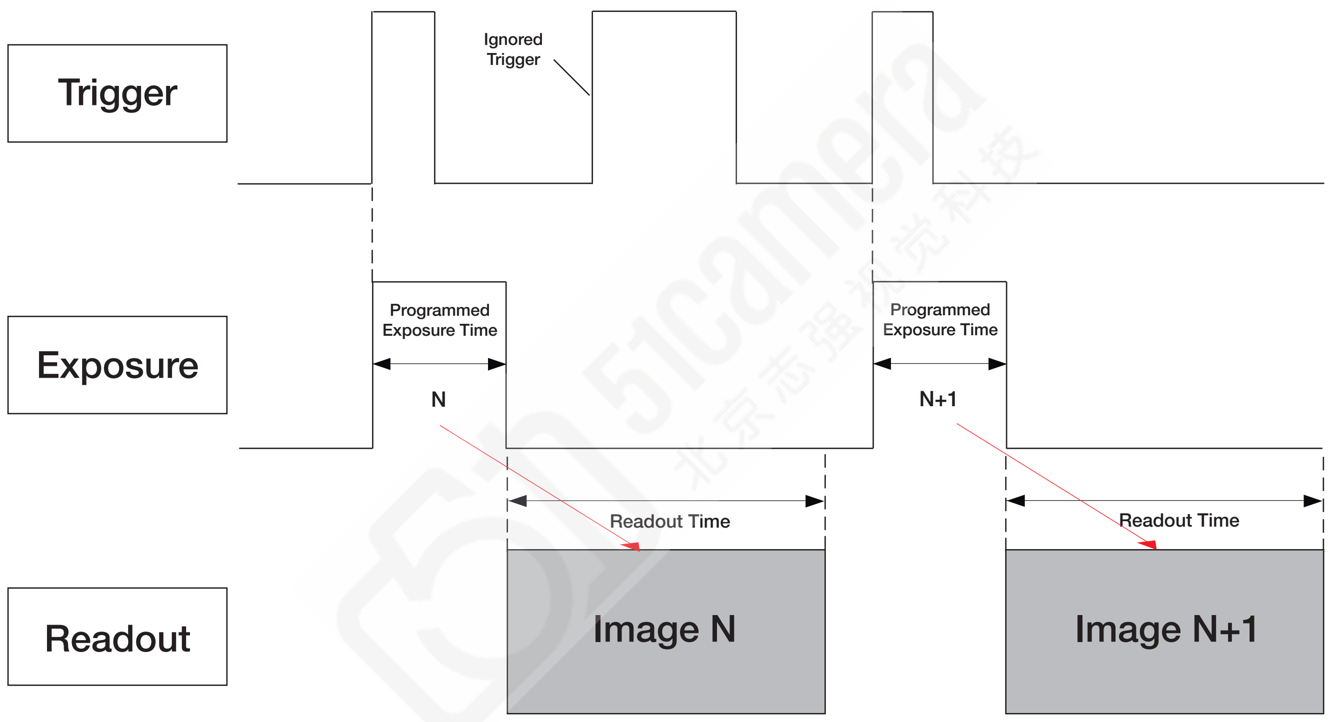


Figure 4.3: Trigger Master Mode

4.4. Trigger Master Overlap Mode

In Trigger Master Overlap mode the camera controls the Exposure period (Master condition) which is programmed in the camera by the user. The camera then waits for an external trigger to be applied to CC1 of the Camera Link connection or to the External Trigger pin of the I/O connection. Once a trigger is detected by the camera, then the programmed Exposure begins.

Readout of the image occurs at the end of the programmed Exposure period. The difference to standard Trigger Master mode is that a trigger can be applied and a new programmed Exposure period started for the next frame during the readout of the current frame. Fig. 4.4 shows the overlapping relationship of Trigger, Exposure and Read-out.

Applying a trigger during the previous frame's exposure period or at an interval shorter than the total readout period of 224.7msec will result in the trigger being ignored.

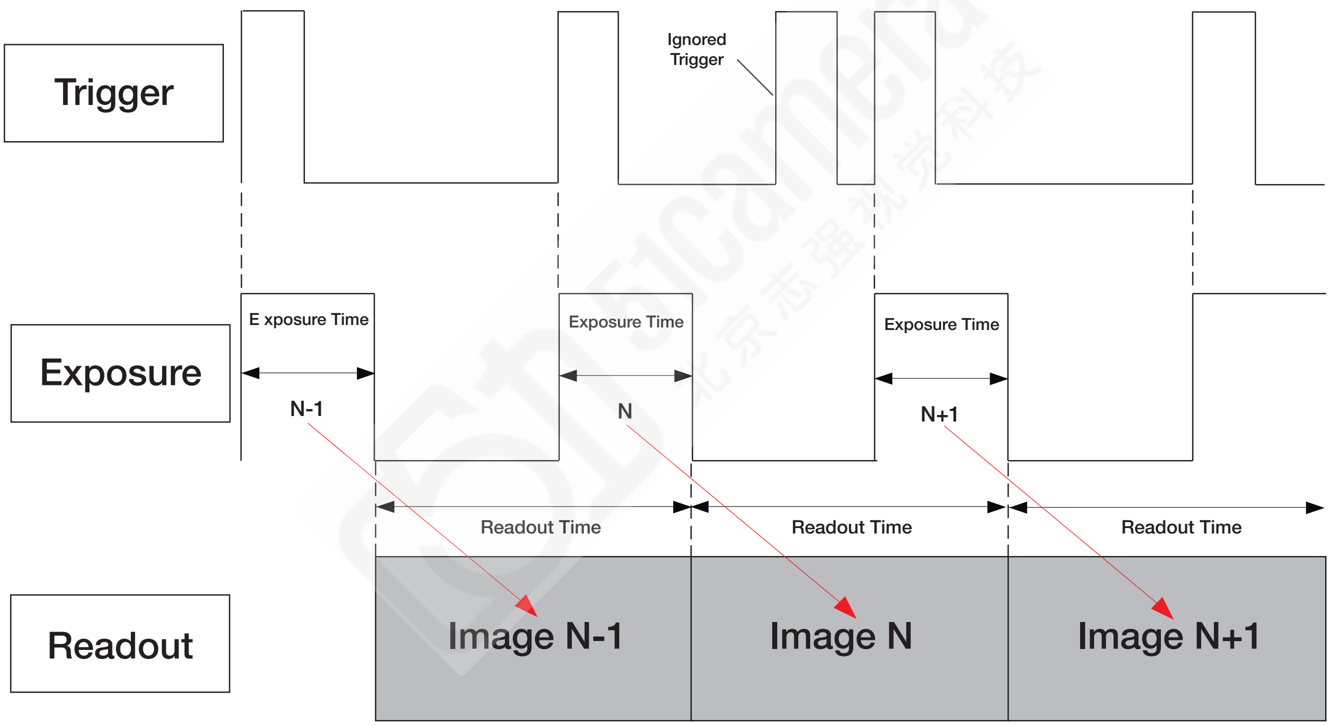


Figure 4.4: Trigger Master Overlap Mode (Transfer Time > Exposure time)

4.5. Trigger Slave Mode

In Trigger Slave Mode the Exposure period is controlled by the pulse width of the applied trigger signal (Slave condition). The camera waits for an external trigger to be applied to CC1 of the Camera Link connection or to the External Trigger pin of the I/O connection. Once a trigger is detected by the camera, the Exposure begins and ends when the state of the trigger changes (high to low or low to high).

Readout of the image occurs after the end of the exposure period.

If a new trigger is sent to the camera during the previous readout period, then it will be ignored. Once exposure and readout are completed the camera waits for the next valid trigger.

Minimum pulse width is 100μsec.

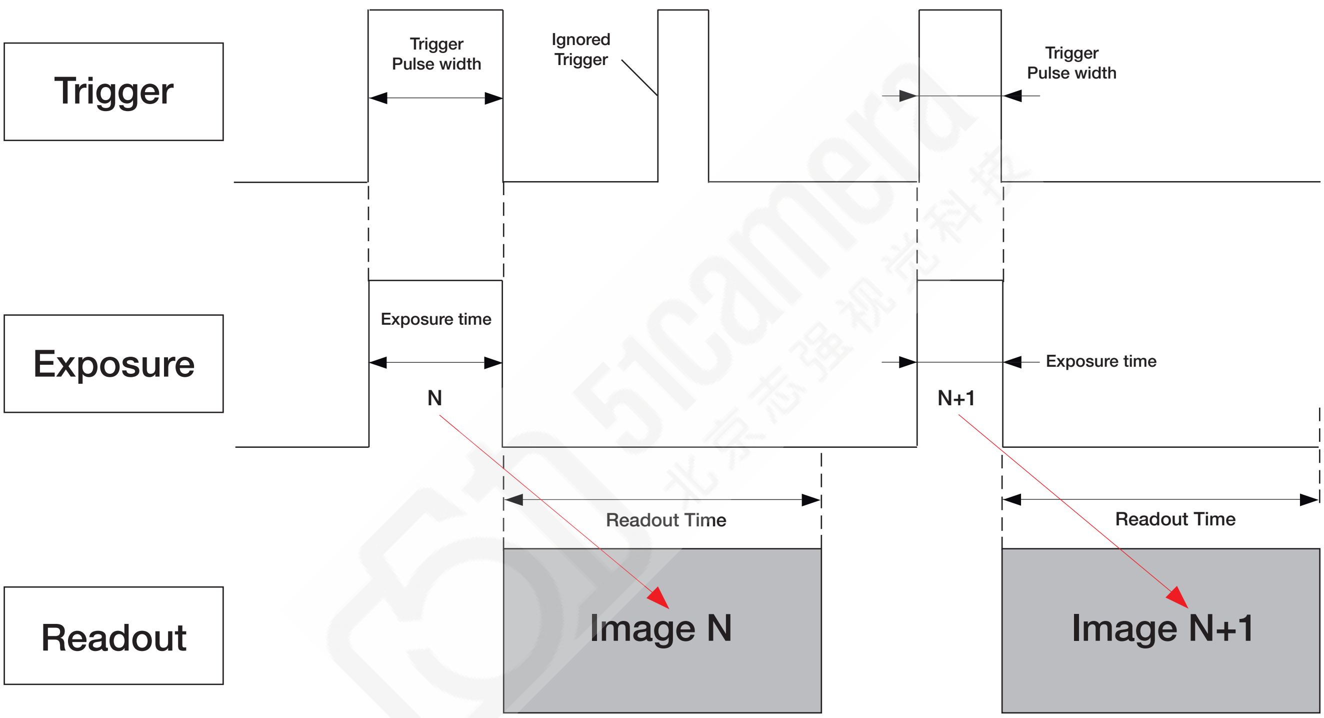


Figure 4.5: Trigger Slave Mode

4.6. Trigger Slave Overlap Mode

In Trigger Slave Overlap Mode the Exposure period is controlled by the pulse width of the applied trigger signal (Slave condition). The camera waits for an external trigger to be applied to CC1 of the Camera Link connection or to the External Trigger pin of the I/O connection. Once a trigger is detected by the camera, then the Exposure begins and ends when the state of the trigger changes (high to low or low to high).

Readout of the image occurs at the end of the programmed Exposure period. The difference to standard Trigger Slave mode is that a trigger can be applied and a new Exposure period started for the next frame during the read-out of the current frame. Fig. 4.6 shows the overlapping relationship of Trigger, Exposure and Readout.

Applying a trigger during the previous frame's exposure period or at an interval shorter than the total readout period of 224.7msec will result in the trigger being ignored.

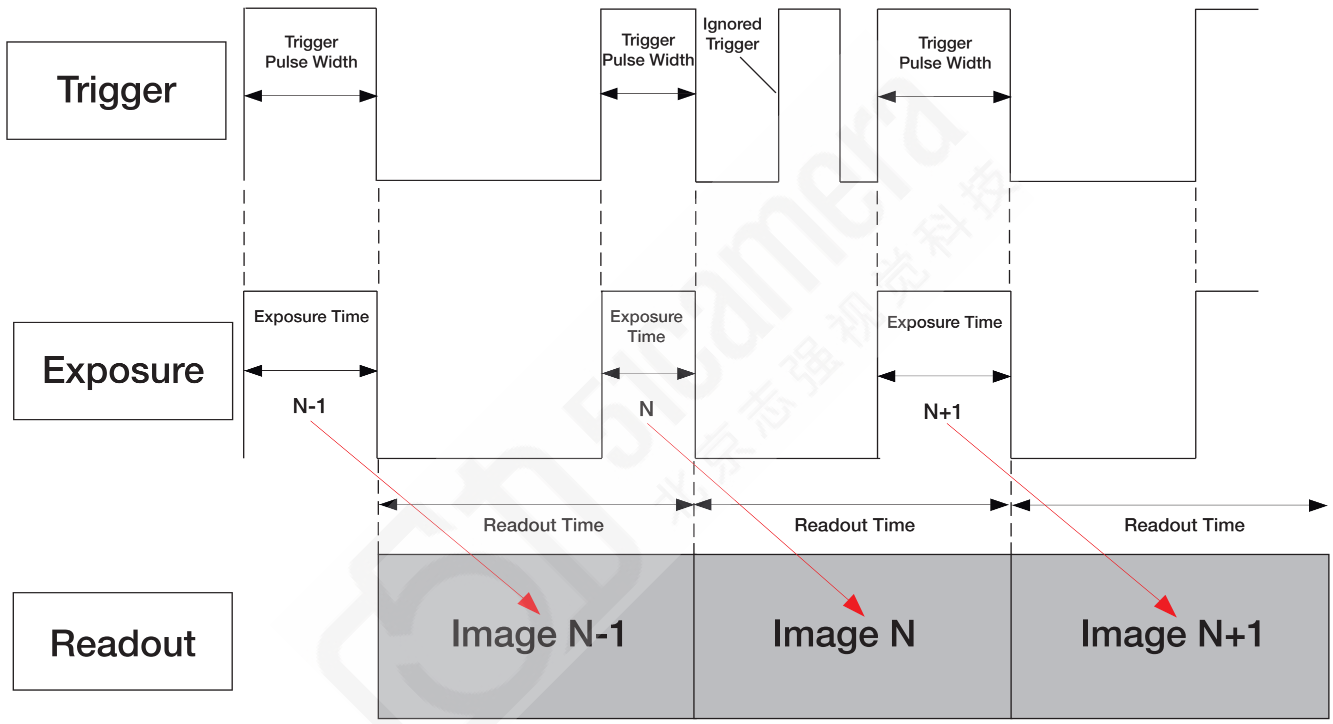


Figure 4.6: Trigger Slave Overlap Mode

5. Camera Control and Features Description

This camera has very flexible special features which help the user to achieve a high level of image quality and allow the camera to be adapted to a wide variety of application environments.

The features of this camera are controlled using the ISVI Camera Control Tool designed for this camera model. The use of the Camera Control Tool is described in this section.

Alternatively, the user can control the camera by direct command communication with a PC-based terminal emulator. The command structure for this is listed in the next section – Command Structure.

5.1. Camera Control Tool Installation

The Camera Control Tool is a program provided to users to control all parameters of the camera and to save the desired settings to user pages for later recall.

Always use the latest version of the Camera Control Tool for your camera. You can download the latest version from www.isvi-corp.com or contact your local ISVI agent.

Save the Control Tool file to the PC which will be used to control the camera over the Camera Link frame grabber. It is a single executable file. The frame grabber should already be installed with required drivers and supporting software installed. The camera should be connected to the frame grabber and power applied to the camera.

Start the program by double clicking on the executable file. The program will automatically start a search for the proper CLSER.DLL and COM port to make the connection to the camera through the frame grabber. See Fig. 5.1.

Once detected,

- it will automatically connect to the camera,
- show which port it has connected to,
- load the current settings of the camera into the GUI,
- and show the "Done" message.

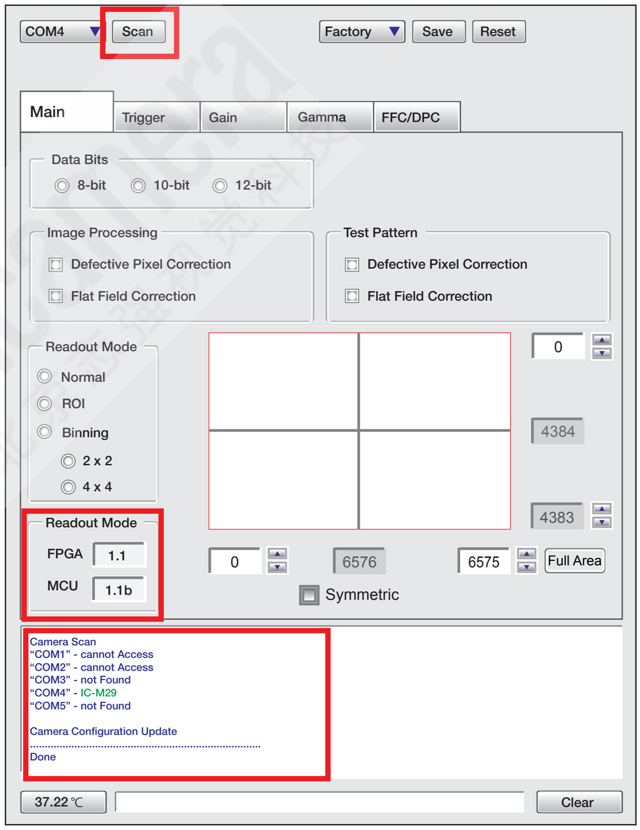


Figure 5.1: Camera Control Tool - connecting to the camera

If the program does not detect the camera, ensure that the CLSER.DLL provided by the frame grabber manufacturer has been properly installed, the camera has power and is connected to the frame grabber with a working Camera Link cable. Press the "Scan" button. If the problem persists, please call your local ISVI agent for assistance.

5.2. User Workspace

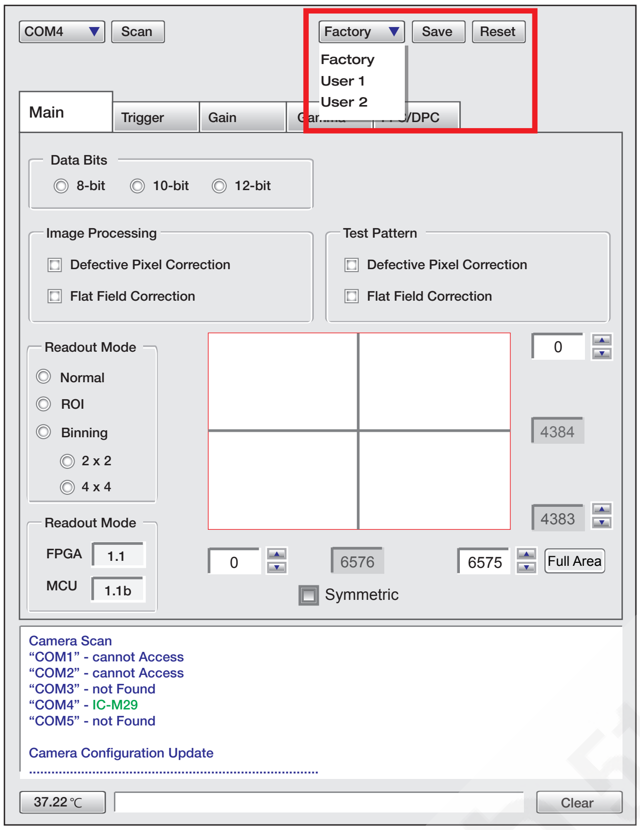


Figure 5.2 User workspace

The User Workspace shown Figure 5.2 provides the user with a Factory Default area and 2 areas to which settings can be saved.
The settings for each area is stored in the camera's non-volatile memory. To save settings to a user area select User1 or User2, make the changes to any settings and then press the save button. Selecting the user area will load the saved settings into the GUI from the camera.

If changes have been made to settings but not saved and you want to go back to previously saved settings press the Reset button. To load the factory settings, select Factory. Switching from one User Area to another will not save the current settings to the current User Area – the user must press the Save button to save the settings before switching to a new user area.

The camera will remember the settings area (Factory, User1 or User2) last used before power-down and will power-up in the same settings area as power-up default.

Factory Default settings cannot be changed. They are listed in Figure 5.3.

Default (Factory) Settings	
Trigger Mode	Freerun
Output Pixel Format	12 bit
Sensor Ouput Channel	Quad Output
Camera Link Output Channel	2 TAB
External Trigger Source	Camera Link CC1
Trigger Source Polarity	Active High
Strobe Output Polarity	Active High
Exposure Time	10 ms
VGA Gain / Black Clamp level	0 / 0
DPC / FFC	On / Off

Figure 5.3 Factory Default Settings

5.3. Data Bits

The Data Bit Resolution feature provides the user with the choice of 8-bit, 10-bit or 12-bit digital resolution for the image data output. The user must ensure that the proper frame grabber camera file is used to capture the selected bit resolution. Please consult your frame grabber manual for more information.

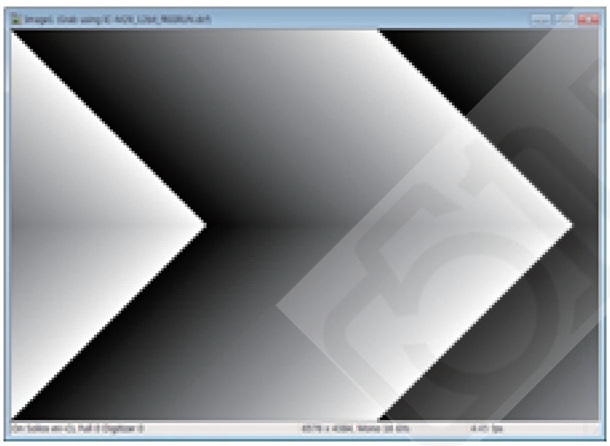
5.4. Image Processing

The Image Processing feature applies image correction algorithms in real time to every image. The check boxes provided on the Main tab allow the user to quickly turn the individual image processing features on/off. Check to turn on, uncheck to turn off Defect Pixel Correction and Flat Field Correction.

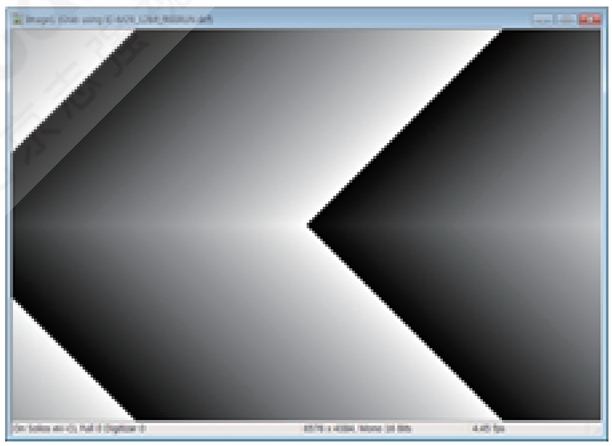
5.5. Test Pattern

In the Test Pattern section one of two test patterns can be chosen to be output from the camera. The test patterns are available in 8-bit, 10-bit and 12-bit Free-Run and Triggered Normal readout modes. Test patterns are a good way to check for proper connectivity and for verifying complete setup. The camera will output the selected test pattern until it is unselected.

Test Pattern #1 is a static grey-scale wedge pattern.
Test Pattern #2 is a grey-scale wedge pattern moving from right to left



Test Pattern #1 - fixed



Test Pattern #2 - moving

5.6. Readout Mode

The Readout Mode section provides selection of three readout modes:

Normal mode – Full Frame Readout

ROI mode – Region of Interest Readout

The ROI mode allows the user to reduce the area of the sensor which will be read out. Reducing the ROI will increase frame rate and reduce the amount of data transmitted to the frame grabber. Although the user can reduce both the horizontal (X) and vertical (Y) ROI, only the vertical reduction will result in an increased frame rate. Reduc-

ing either the X- or the Y-ROI or both will result in a reduction in the amount of data transmitted to the frame grabber.
The user can choose to set the desired ROI by adjusting the pixel offset in the X-direction and the line offset in the Y-direction. Additionally, the symmetry of the ROI can be automatically set or manually defined by the user. This allows for precise placement of the ROI anywhere within the full frame.

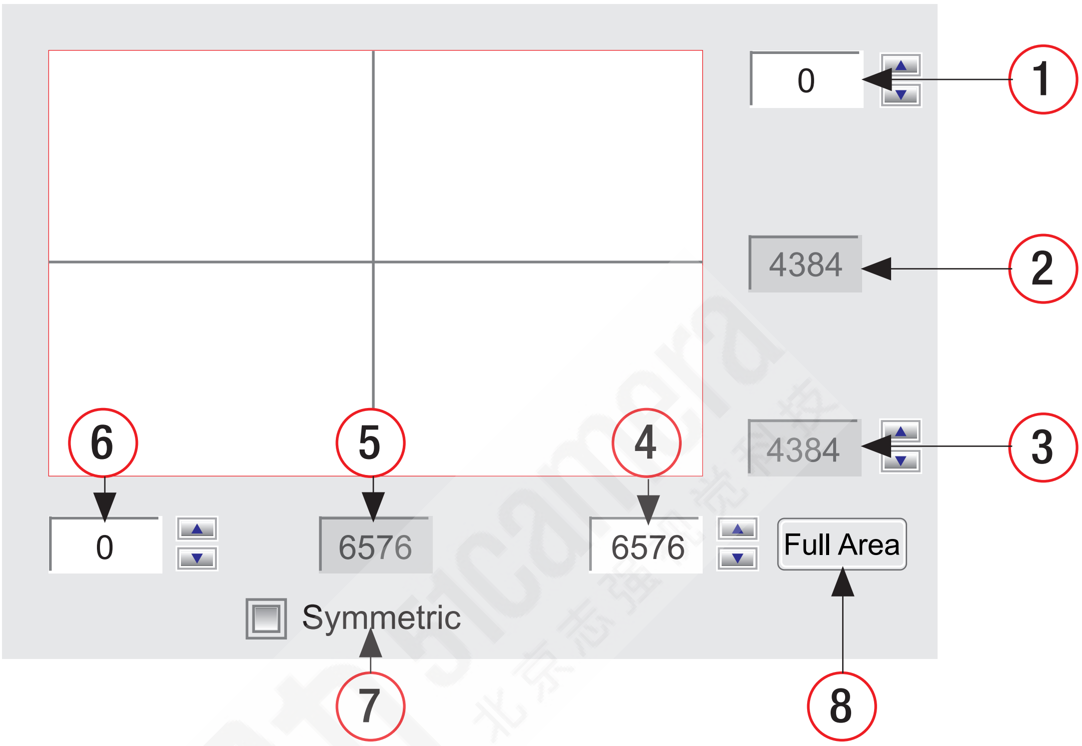


Figure 5.4: ROI Configuration Window

Fig. 5.4 shows the ROI Configuration window used to set the size and placement of ROI. Selecting ROI in the Readout Mode area will activate this window. Checking the Symmetric box will keep the ROI centered in both the X and Y directions.

1. Y-Offset Top — When 'Symmetry' is selected, this shows the automatic offset from the top of the full frame edge. When 'Symmetry' is not selected, the user can enter a value to offset the ROI from the top edge of the full frame. Adjusting the Y-Offset Top value automatically changes the ROI Y-Height.
2. Y-Height — Current ROI Height - Read only.
3. Y-Offset Bottom — When 'Symmetry' is selected, this shows the automatic offset from the top of the full frame edge - Read only.
4. X-Offset Right — When 'Symmetry' is selected, this shows the automatic offset from the right of the full frame edge. When 'Symmetry' is not selected, the user can enter a value to offset the ROI from the right of the full frame edge.
5. X-Width — Current ROI Width - Read only.
6. X-Offset Left — When 'Symmetry' is selected, this shows the automatic offset from the left of the full frame edge. When 'Symmetry' is not selected, the user can enter a value to

		offset the ROI from the left edge of the full frame. Adjusting the X-Offset Left value automatically changes the ROI X-Width.
7	Symmetric	Enables/disables Auto-Symmetry. When enabled, the user enters only the X-Offset Left and Y-Offset Top values and the ROI will automatically be changed and centered within the full frame and the calculated offsets displayed.
8	Reset	Reset the ROI to Full Frame size.

Binning Mode - 2x2 and 4x4 Pixel Binning Readout

The Binning mode adds the charges of neighboring pixels and outputs the added charge as a single pixel. By selecting 2x2 Binning the charges of 4 adjacent pixels are added together to form the signal of a single pixel. By selecting 4x4 Binning the charge of 16 adjacent pixels are added together. Fig. 5.5 shows the principle concept of the 2x2 and 4x4 binning modes. Binning allows the user to image in low-light environments, like florescence microscopy or surveillance applications.

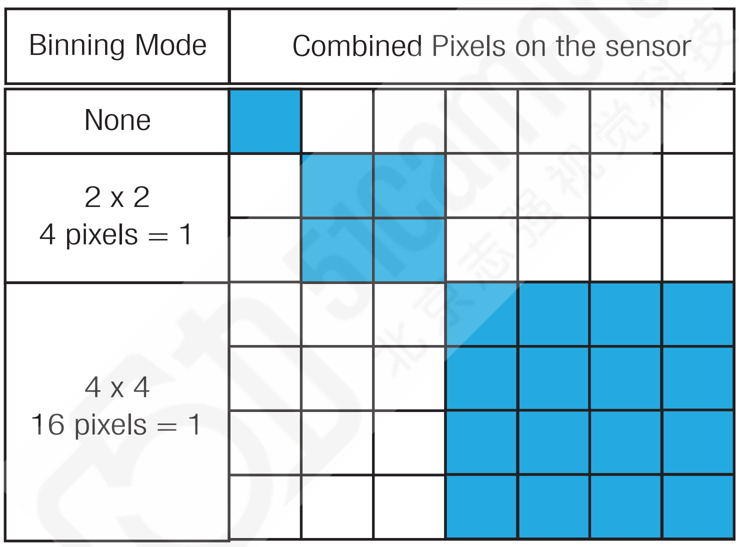


Figure 5.5: Binning Mode

Binning provides several beneficial results:

- An increase in signal equal to the number of pixels binned – 4-times and 16-times the sensitivity. This allows the camera to detect fainter light sources and reduce exposure time.
- An increase in frame rate due to the reduction in exposure time and a reduction in the number of pixels to be measured.

  Binning frame rates:
  - Normal mode: 4.45 Hz (for comparison)
  - 2x2 = 7.8 Hz
  - 4x4 = 12.3 Hz
- An increase in the signal to noise ratio resulting from a single read error being applied to the charge of the binned pixels rather than the addition of multiple read errors if the pixels were read individually.

- An increase in the dynamic range of the sensor resulting from the larger charge capacity of the summing node (typically 1.65-2 times increase in well depth).

The tradeoff for the gains due to binning are:

- A loss of image resolution equal to the binning level.
  - 2x2 Binning resolution is: 3288 x 2192 pixels
  - 4x4 Binning resolution is: 1644 x 1096 pixels
- An increase in dark current proportional to the number of pixels binned.

5.7. Version Information

The camera sends information about its hardware and firmware versions to the Camera Control Tool. These fields are read only. This information is useful to see which hardware/firmware version is installed in a particular camera for maintenance or technical support.

5.8. Communication Window

The Communication Window in the Camera Control Tool shows the communication between the program and camera whenever commands and responses are sent/received after changing a setting in any of the parameter fields. At the bottom of the Communication Window is an entry field which acts as a HyperTerminal and can be used to send commands direct to the camera according to the Command Code Structure listed in Section 6. Pressing Clear will clear the communication log display.

5.9. Temperature Sensor

The camera employs a temperature sensor at the imaging sensor and the current value can be accessed by pressing the temperature button in the lower left of the Main tab. The imaging sensor's temperature can be retrieved on demand to provide current temperature feedback to the user's imaging system.

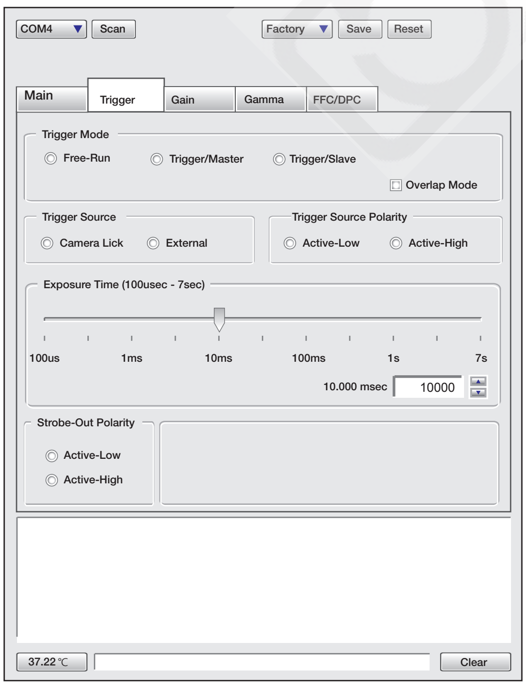


Figure 5.6 Trigger Mode

5.10. Trigger Mode

In the Trigger Mode section of the Camera Control Tool, Figure 5.6. the user can select the mode of image acquisition. For a detailed explanation of each mode please refer to Section 4.

Free-Run is automatically in Overlap Mode when chosen. Trigger Master and Slave modes are non-Overlap modes until the Overlap Mode box is checked.

5.11. Trigger Source and Polarity

The trigger input source can be selected between Camera Link and External. The user should select the correct input dependent upon the imaging systems requirements.

- Camera Link: The camera expects the trigger to arrive over the Camera Link interface from the frame grabber on the camera control pin CC1.
- External: The camera expects a direct input trigger to arrive over pins 1&2 of the 12-pin Hirose I/O Control Connector on the back panel.

Please refer to Section 3 for a detailed explanation of the connector and proper electrical connections for the Trigger Input Circuit.

The trigger polarity can be selected between Active-Low and Active-High. Fig. 5.7 shows the association between polarity and trigger mode.

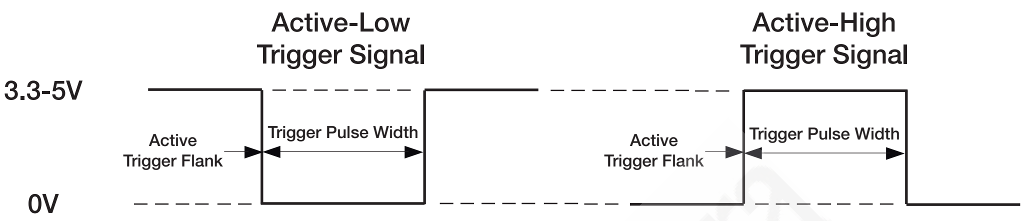


Figure 5.7. Trigger Polarity

5.12. Exposure Time

The Exposure Time is the period during which each pixel integrates photonic charge and converts it to an electrical charge prior to being read out of the imaging sensor. With the Camera Control Tool the user can program the exposure time as needed following these criteria:

- The range of exposure is from min. 100μsec – max. 7sec. in 100μsec increments.
- The exposure can be programmed only in Free-Run, Trigger Master and Trigger Master Overlap modes.
- The user can use either the slider or the direct entry cell to program the exposure.
- The direct entry cell shows the exposure time in μsec.
- After entering the exposure time, validate it by pressing the enter key.

5.13. Strobe-Out Polarity

The Strobe Output is used to trigger external devices such as lighting or shutter controllers. The polarity of the output can be selected as either Active-Low or Active-High depending on system requirements. Fig. 5.8 shows the association between Strobe-Out Polarity and Exposure.

Please refer to Section 3 for a detailed explanation of the connector and proper electrical connections for the Strobe Output Circuit.

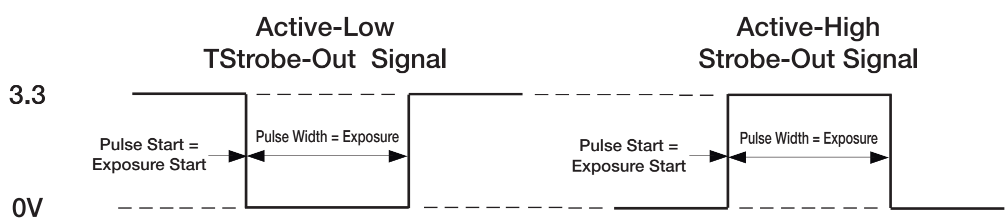


Figure 5.8. Stobe-Out Polarity

5.14. Gain

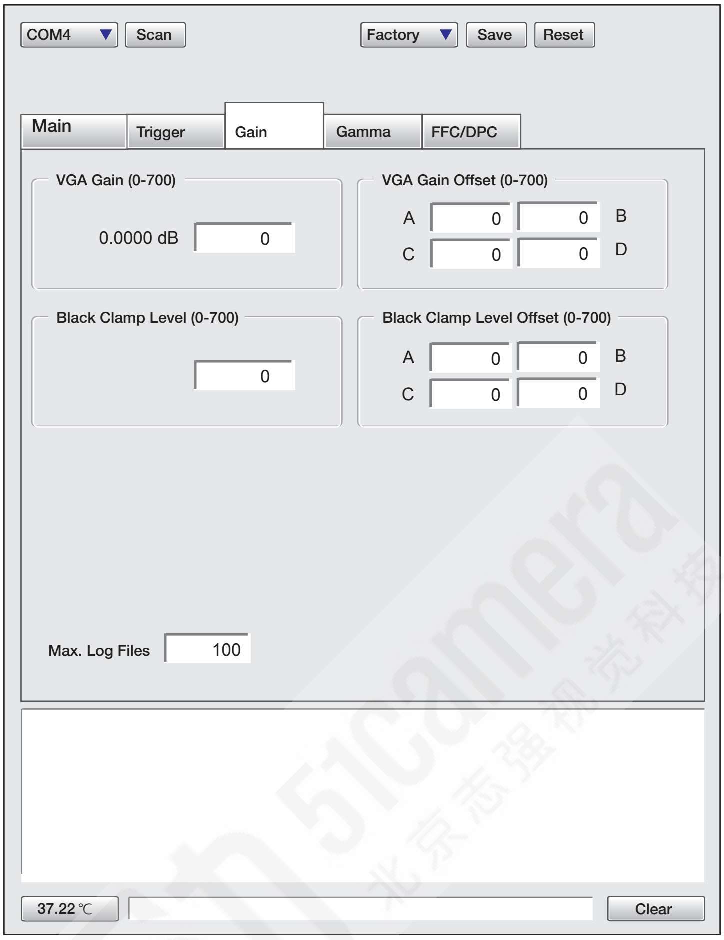


Figure 5.9. Gain Tap Window

The sensor in this camera is a 4-Tap design meaning that 4 quadrants of the sensor are read out simultaneously. Due to small level differences in the signals coming from each tap, the camera must have the taps balanced to create a uniform and seamless transition from one tap to the next. The camera is factory calibrated for balanced taps using a specific set of parameters. However, the user has the ability to control the Gain parameters manually in order to adapt the tap balancing to the application environment.

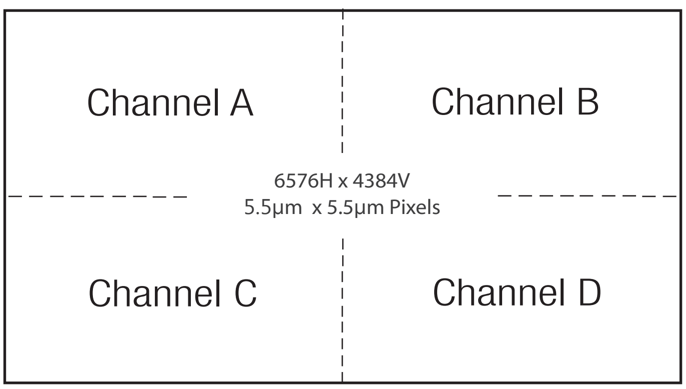


Figure 5.10. Sensor Tap Configuration

- VGA Gain (Variable Gain Amplifier)
  - o Sets the overall Gain factor globally to all sensor taps.
  - o The Gain range is from 0-700 units or 0-24.5dB, 1 unit = 0.035dB.
  - o Press Enter to confirm entry.
- VGA Gain Offset
  - o Sets the Gain factor for each sensor tap individually.
  - o The Gain range is from 0-700 units or 0-24.5dB, 1 unit = 0.035dB.
  - o Press Enter after each entry to confirm.
- Black Clamp Level
  - o The black clamp level is used to remove residual offsets in the signal chain and to track low frequency variations in the black level of the CCD.
  - o Sets the Black Clamp Level globally to all sensor taps.
  - o The adjustment range is from 0-700 units.
  - o Press Enter after each entry to confirm.
- Black Clamp Level Offset
  - o Sets the Black Clamp Level Offset for each sensor tap individually.
  - o The adjustment range is from 0-700 units.
  - o Press Enter after each entry to confirm.

5.15. Log Files

During the closing process of the Camera Control Tool it automatically creates a log file, recording all changes made to settings using the tool during that session.
In the Max. Log Files window the user can enter the number of log files which will be saved. The maximum value is 500. Example: If 100 is entered, the LAST 100 log files will be saved - overwriting the oldest log files once the 101st log file is created. The log files are saved to the Log folder located in the same path as the software program. The log files can be viewed with any text editor.

5.16. Gamma LUT

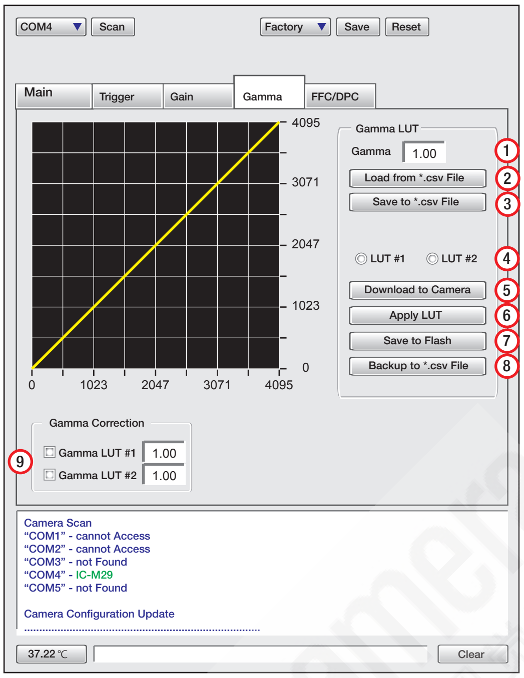


Figure 5.10. Gamma LUT Overview

The Gamma LUT provides the user with a high degree of flexibility to apply non-linear Gamma correction curve to the streaming images in real time, save the curve to camera memory, save the curve to host PC and recall saved curves. Fig 5.10 shows an overview of the Gamma LUT parameters.

(1)	Gamma	Enter gamma value, Gamma range: 0.01 – 85.00, press enter to validate. The graphical representation will change after validation of the entered value.
(2)	Load from *.csv File	loads .csv (comma separated value) LUT file from host PC to Camera Control Tool only. It does not load it to the camera.
(3)	Save to *.csv File	Gamma LUT seen in control tool is saved to .csv LUT file to host PC. It does not save the LUT saved in the camera to the host PC.
(4)	LUT #1, LUT #2	Select from 2 non-volatile user saving areas for LUT storage, LUT#1 and LUT#2.
(5)	Download to Camera	Send Gamma LUT to the camera.
(6)	Apply LUT	Activate Gamma LUT in user area and apply to images from the camera.
(7)	Save to Flash	Gamma LUT is saved in the camera.
(8)	Backup to *.csv File	Gamma LUT which is saved in the camera is saved to the host PC as .csv LUT file.
(9)	Gamma Correction	Switch on/off LUT#1 and LUT#2.

Example to create User LUT in user area LUT#1 and save to the camera:

1. Set Gamma value and press enter to validate (1)
2. Select user area LUT #1 (4)
3. Download new LUT to camera (5)
4. Apply new LUT to camera (6)
5. Save new LUT to camera flash (7)

5.17. FFC / DPC

Flat Field Correction (FFC) is a calibration procedure used to correct for pixel-to-pixel sensitivity differences on the imaging sensor and aberrations caused by the optical path. The camera is FFC calibrated by comparing and averaging several images in both dark and bright frame and applying gain offsets to each pixel to create a uniform output (flat-field).

Every large array imaging sensor has pixel defects which cannot be avoided during sensor production. Defect Pixel Correction (DPC) is a calibration procedure to correct for non- or under-responsive pixels, which can appear as white or dark pixels in the array. A next neighbor averaging is used to assign a value to the defective pixel.

This camera is delivered with factory calibrated FFC and DPC. These calibrations are done using nominal values to calculate the averages and offsets required and will work for most users. However, changing parameters such as using high gain, long or very short exposure times, high-temperature operation, etc., may require the user to recalibrate these corrections using the actual imaging environment and settings in order to achieve satisfactory results.

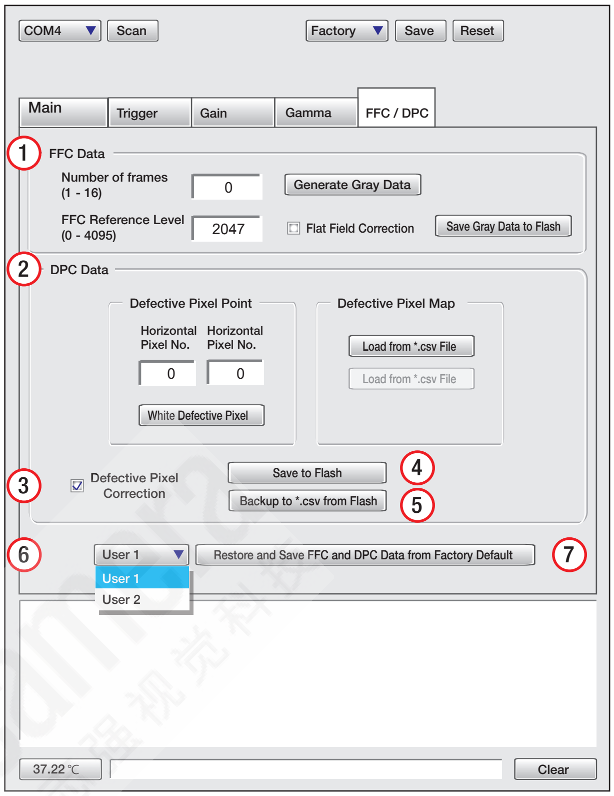


Figure 5.11. FFC/DPC Calibration Overview

The FFC and DPC correction features allow the user to create calibration data specific to the given environment. Fig. 5.11 shows the FFC/DPC tab overview in the Camera Control Tool.

1. FFC
   - o General setup
     - i. Aim the camera at a uniform white or grey card with a matt surface.
     - ii. Use the illumination at the intensity you plan on using in the actual application environment and the intensity required for the application. You can use either constant lighting or strobe lighting.

       If using strobe lighting, then ensure that the system will trigger the camera and strobe so they are synchronized and sends triggers to the camera during the calibration process.
     - iii. Select the Gain setting you will use in the actual application environment keeping in mind that increasing Gain will also increase noise in the image. Zero Gain is optimum.
     - iv. Select an exposure period which will allow you to achieve the average luminance level you expect to achieve in the actual application without reaching saturation in any part of the image. A middle grey value is optimum.
     - v. It is not required to capture a new dark field image as this was done at the factory and the offset data is saved in the camera.
     - vi. Choose User1 or User2 (6) saving area.

- Number of frames
    i. Enter the number of frames to capture for the grey field image averaging. Press enter to validate.
    ii. The more images captured the more accurate the offsets will be. No more than 16 are needed.
- Press 'Generate Grey Data' to capture the reference images. This may take some time as the camera MCU calculates the calibration data.
- FFC-Reference Level – Offset level set after Grey Data generation.
    i. Enter a value from 0-4095, 2047 is default.
    ii. Press enter to validate.
- Check 'Flat Field Correction' box to apply calibration and offset.
- Press 'Save Grey Data to Flash' to save calibration and offset to the camera.

2. DPC Data
    - General Setup
        i. The camera has been DPC calibrated at the factory for the known pixel defects at the time of production. New defect pixels may appear over time or during high-temperature operation.
        ii. If new defect pixels appear they can be added to the calibration individually or a new Defective Pixel Map can be generated using imaging processing software to detect and localize each defective pixel and to create a .csv coordinates file.
        iii. Choose User1 or User2 (6) saving area.
    - Defective Pixel Point
        i. Allows the manual entry of individual defective pixels.
        ii. Enter the X and Y pixel location of the defective pixel.
        iii. Press 'Write Defective Pixel'. This will store the data, but not save it to the camera.
        iv. Repeat ii and iii for each defective pixel.
        v. Press 'Save to Flash' (4) to save new DPC data to the camera.
        vi. Check 'Defective Pixel Correction' (3) to apply saved DPC data to streaming images.
    - Defective Pixel Map
        i. Use this function if you have used image processing software to create a DPC map in .csv format with the coordinates of all pixels you want corrected.
        ii. Press 'Backup to *.csv from Flash' (5) to see the header format required. The number at the end of the first line indicates the number of pixel defect coordinates in the table.
        iii. Press 'Load from *.csv File' to select the DPC map file.
        iv. Press 'Download to Camera' to send the data to the camera.
        v. Press 'Save to Flash' (4) to save the new DPC map data in the camera.
    - Backup to *.csv from Flash (5)
        i. Press this button to download a saved DPC map in *.csv format to the host PC.

3. Press 'Restore and Save FFC and DPC Data from Factory Default' (7) to erase current user-saved calibration data and restore Factory Default data to the camera. This is useful if attempts at user calibration are unsuccessful.

If you are having problems calibrating the camera, please contact your ISVI agent.

6. Communication / Command Code

This section provides information on communicating with the camera via Camera Link and a terminal emulator, as well as the command code structure and command code list.

6.1. Communication Specification

All communication with and configuration of the camera is done via Camera Link.

All camera setting commands requiring data transmission are delivered in Hexadecimal format. The camera can be set up from a PC running a terminal emulator software, user applications with emulation function or using the ISVI Camera Control Tool as described in Section 5.

6.2. Communication Settings

- Baud Rate : 19,200 bps
- Data Bit : 8 bit
- Parity : None
- Stop Bit : 1 bit
- Flow Control : None

6.3. Command Code Structure

< command > < parameter1 > < parameter2 > < \ r >

(0-2 Parameters follow the command)

- Example :
  - Set Exposure Time to 10 msec

Command	“set 10000<\r>”
	73 65 74 20 31 30 30 30 30 0D
Response	“OK<\r><\n>””
	4F 4B 0D 0A

6.4. Command Code List

Readout Mode

Type	Command	Response	Description
Get	“grm<\r>”	“<0I1I2><\r><\n>”	0 = Normal Mode 1 = ROI Mode 2 = Binning (2or4) Mode
Set	“srm <0I1I2><\r>”	“OK<\r><\n>”	

ROI Horizontal Area

Type	Command	Response	Description
Get	“gha<\r>”	“<0-6574> <1-6575> <\r><\n>”	<0-6574> starting point
Set	“Sha <0-6574> <1~6575> <\r>”	“OK<\r><\n>”	<1-6575> Endpoint

ROI Vertical Area

Type	Command	Response	Description
Get	“gva<\r>”	“<0-2190><\r><\n>”	<0-2190> starting point
Set	“sva <0-2190><\r>”	“OK<\r><\n>”	

Binning Mode

Type	Command	Response	Description
Get	“gbf<\r>”	“<0|1><\r><\n>”	0 = 2 by 2 binning 1 = 4 by 4 binning
Set	“sbf <0|1><\r>”	“OK<\r><\n>”	

Data Bits

Type	Command	Response	Description
Get	“gdb<\r>”	“<0|1|2><\r><\n>”	0 = 8-bit 1 = 10-bit 2 = 12-bit
Set	“sdb <0|1|2><\r>”	“OK<\r><\n>”	

Test Pattern Enable

Type	Command	Response	Description
Get	“gte<\r>”	“<0|1|2><\r><\n>”	0 = 8-bit 1 = 10-bit 2 = 12-bit
Set	“ste <0|1|2><0-255><\r>”	“OK<\r><\n>”	<0-255> speed of moving test image

LUT Mode

Type	Command	Response	Description
Get	“gls<\r>”	“<0|1|2><\r><\n>”	0 = Off 1 = LUT1 2 = LUT2
Set	“sls <0|1|2><\r>”	“OK<\r><\n>”	

Reset

Type	Command	Response	Description
Set	“rst <0|1><\r>”	“OK<\r><\n>”	0 = EPCS 1 = SDR

Defective Pixel Correction

Type	Command	Response	Description
Get	“gdc<\r>”	“<0|1><\r><\n>”	0 = Disable 1 = Enable
Set	“sdc <0|><\r>”	“OK<\r><\n>”	

Flat Field Correction

Type	Command	Response	Description
Get	“gfc<\r>”	“<0|1><\r><\n>”	0 = Disable 1 = Enable
Set	“sfc <0|1><\r>”	“OK<\r><\n>”	

Flat Field Offset

Type	Command	Response	Description
Get	“gfo<\r>”	“<0-4095><\r><\n>”	<0-4095> Flat Field Target Level
Set	“sfo <0-4095><\r>”	“OK<\r><\n>”	

Generate Flat Field Data

Type	Command	Response	Description
Set	“ggd <1-16><\r>”	“OK<\r><\n>”	<1-16> Number of frames

Save Flat Field Data

Type	Command	Response	Description
Set	“sgf <1-16><\r>”	“OK<\r><\n>”	Save Flat Field Data to nonvolatile memory

Trigger Mode

Type	Command	Response	Description
Get	“gtm<\r>”	“<0|1|2><\r><\n>”	0 = Free-Run Mode 1 = Trigger-Master Mode 2 = Trigger-Slave Mode
Set	“stm <0|1|2><\r>”	“OK<\r><\n>”	

Overlap Enable

Type	Command	Response	Description
Get	“goe<\r>”	“<0|1><\r><\n>”	0 = Disable 1 = Enable
Set	“soe <0|1><\r>”	“OK<\r><\n>”	

Trigger Source

Type	Command	Response	Description
Get	“gts<\r>”	“<0|1><\r><\n>”	0 = Camera Link CC1 1 = External Trigger Input
Set	“sts <0|1><\r>”	“OK<\r><\n>”	

Trigger Polarity

Type	Command	Response	Description
Get	“gtp<\r>”	“<0l1><\r><\n>”	0 = Active-Low 1 = Active-High
Set	“stp <0l1><\r>”	“OK<\r><\n>”	

Exposure Time

Type	Command	Response	Description
Get	“get<\r>”	“<100-7000000><\r><\n>”	Min. Exposure Time 100 = 100 usec Max. Exposure Time 7000000 = 7 sec
Set	“set <0l1><\r>”	“OK<\r><\n>”	

Strobe Out Offset

Type	Command	Response	Description
Get	“gso<\r>”	“<0-10000><\r><\n>”	Min. 0 = 0 usec Max. 10000 = 10,000 usec
Set	“sso <0-10000><\r>”	“OK<\r><\n>”	

Strobe Out Polarity

Type	Command	Response	Description
Get	“gsp<\r>”	“<0l1><\r><\n>”	0 = Active-Low 1 = Active-High
Set	“ssp <0-10000><\r>”	“OK<\r><\n>”	

VGA Gain

Type	Command	Response	Description
Get	“gvg<\r>”	“<0-7000><\r><\n>”	Min. VGA Gain 0 = 0 dB Max. VGA Gain 700 = 25.06 dB
Set	“svg <0-10000><\r>”	“OK<\r><\n>”	

VGA Gain Offset

<table>
<tr><th>Type</th><th>Command</th><th>Response</th><th>Description</th></tr>
<tr><td>Set</td><td>“sgo <0|1|2|3> <0-700><\r>”</td><td>“OK<\r><\n>”</td><td><0|1|2|3>
0 = Channel A
1 = Channer B
2 = Channel C
3 = Channel D
<0-700>
0 = 0 dB (Min.)
700 = 25.06 (Max.)</td></tr>
</table>

Optical Black Clamp Level

<table>
<tr><th>Type</th><th>Command</th><th>Response</th><th>Description</th></tr>
<tr><td>Get</td><td>“gcl<\r>”</td><td>“<0-700><\r><\n>”</td><td rowspan="2">0 = Min.Black Clamp Level
700 = Max. Black Clamp Level</td></tr>
<tr><td>Set</td><td>“scl <0-10000><\r>”</td><td>“OK<\r><\n>”</td></tr>
</table>

Optical Black Clamp Level Offset

<table>
<tr><th>Type</th><th>Command</th><th>Response</th><th>Description</th></tr>
<tr><td>Set</td><td>“sco <0|1|2|3> <0-700><\r>”</td><td>“OK<\r><\n>”</td><td><0|1|2|3>
0 = Channel A
1 = Channer B
2 = Channel C
3 = Channel D
<0-700>
0 = Min.
700 = Max.</td></tr>
</table>

Config Initialization

<table>
<tr><th>Type</th><th>Command</th><th>Response</th><th>Description</th></tr>
<tr><td>Get</td><td>“gci<\r>”</td><td>“<0|1|2><\r><\n>”</td><td rowspan="2">0 = Factory Default
1 = User 1
2 = User 2</td></tr>
<tr><td>Set</td><td>“sci <0-10000><\r>”</td><td>“OK<\r><\n>”</td></tr>
</table>

Load & Save Config

Type	Command	Response	Description
Load	“1cf <0|1|2><\r>”	“<0|1|2><\r><\n>”	0 = Factory Default 1 = User 1 2 = User 2
Save	“sct <1|2><\r>”	“OK<\r><\n>”	0 = User 1 1 = User 2

Current Temperature

Type	Command	Response	Description
Get	“gct<\r>”	“<s1> <s2><\r><\n>”	s1 = Fahrenheit’s temperature scale s2 = Celsius temperature scale

MCU Version

Type	Command	Response	Description
Get	“gmv<\r>”	“<s><\r><\n>”	Display MCU Version

Model Number

Type	Command	Response	Description
Get	“gmn<\r>”	“<s><\r><\n>”	Display Model Number

FPGA Version

Type	Command	Response	Description
Get	“gfv<\r>”	“<s><\r><\n>”	Display FPGA Version

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