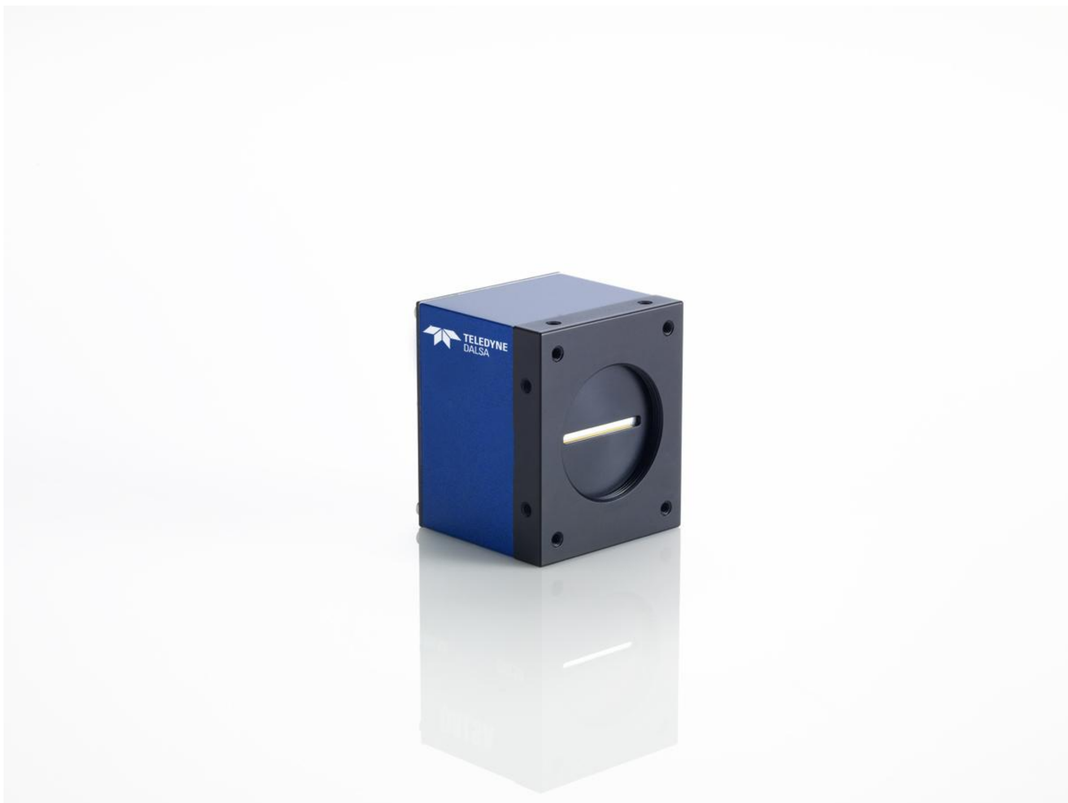
Spyder3 SG-14

Monochrom Camera User's Manual



31 May 2013
03-032-20123-01
www.teledynedalsa.com

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A Teledyne Technologies Company

About Teledyne Technologies and Teledyne DALSA, Inc.

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Teledyne DALSA, a Teledyne Technologies company, is an international leader in high performance digital imaging and semiconductors with approximately 1,000 employees worldwide, headquartered in Waterloo, Ontario, Canada. Established in 1980, the company designs, develops, manufactures and markets digital imaging products and solutions, in addition to providing MEMS products and services. For more information, visit Teledyne DALSA's website at www.teledynedalsa.com.

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Industry Standards

Spyder GEV cameras are 100% compliant with the GigE Vision 1.0 specification. This specification defines the communication interface protocol used by GigE Vision devices. For more information on these requirements refer to the following site:
http://www.machinevisiononline.org/public/articles/details.cfm?id=2761

Spyder GEV cameras implement a superset of the GenICam™ specification which defines device capabilities. This description takes the form of an XML device description file respecting the syntax defined by the GenApi module of the GenICam specification. For more information on these requirements refer to the following site: www.genicam.org.

Contents

The Spyder3 SG-14 Cameras

Camera Highlights

The Spyder3 SG-14 GigE Vision (GEV) are high sensitivity dual-line scan cameras. When operating in high sensitivity (dual line scan) mode the Spyder3 GEV camera has 3x the responsivity of Teledyne DALSA's Spyder2 line scan camera. Plus, the GigE Vision interface eliminates the need for a frame grabber, resulting in significant system cost savings.

The Spyder3 cameras are supported by Teledyne DALSA Sapera™ software libraries featuring CamExpert for simplified camera set-up and configuration.

Features

- Broadband responsivity up to 408 ±16 DN (nJ/ cm2) @10dB gain
- 1024, 2048, or 4096 x 2 pixels, 14 µm x 14 µm (1k and 2k) and 10 µm x 10 µm (4k) pixel pitch, 100 % fill factor
- High or low speed (40 or 80 MHz)
- Up to 68 KHz line rates
- Dynamic range up to 1400 : 1
- Data transmission up to 100 meters
- RoHS and CE compliant
- GenICam-compliant
- Programmable gain, offset, exposure time and line rate, trigger mode, test pattern output, and camera diagnostics
- Tall pixel, high sensitivity, or low sensitivity mode available
- Flat-field correction—minimizes lens vignetting, non-uniform lighting, and sensor FPN and PRNU

Applications

- FPD inspection
- Pick and place
- Container inspection
- Wood / tile / steel inspection
- 100 % print inspection (lottery tickets, stamps, bank notes, pay checks)
- Postal sorting
- Glass bottle inspection
- Industrial metrology
- Food inspection
- Web inspection

Models

The Spyder3 SG-14 camera is available in the following configurations:

Table 1: Camera Models Overview

Model Number	Description
SG-14-01K40-00-R	1k resolution, 1 sensor tap, 40 MHz data rate, 36 kHz line rate, RoHS compliant.
SG-14-01K80-00-R	1k resolution, 2 sensor taps, 80 MHz data rate, 68 kHz line rate, RoHS compliant.
SG-14-02K40-00-R	2k resolution, 1 sensor tap, 40 MHz data rate, 18.5 kHz line rate, RoHS compliant.
SG-14-02K80-00-R	2k resolution, 2 sensor taps, 80 MHz data rate, 36 kHz line rate, RoHS compliant.
SG-14-04k80-00-R	4k resolution, 2 sensor taps, 80 MHz data rate, 18.5 kHz line rate, RoHS compliant.

Table 2: Software

Software	Product Number / Version Number
Sapera LT, including CamExpert GUI application	Version 7.1 or later. Tested and recommended.
QuickCam	Version 2.0. Compliant.
Pleora Technologies Inc.'s Coyote	Compliant.
Third party software. E.g. CVB and NI.	Compatible. Drivers need to be provided by the third party.

Camera Performance Specifications

Table 3: Camera Performance Specifications

Feature / Specification	1k	2k	4k
Imager Format	dual line scan	dual line scan	dual line scan
Resolution	1024 x 2 pixels	2048 x 2 pixels	4096 x 2 pixels
Pixel Fill Factor	100 %	100 %	100 %
Pixel Size	14 µm x 14 µm	14 µm x 14 µm	10 µm x 10 µm
Output Format (# of taps)	1 or 2 depending on model	1 or 2 depending on model	2
Sensitivity Mode	High, low, or tall pixel	High, low, or tall pixel	High, low, or tall pixel
Antiblooming	100x	100x	100x
Gain Range	-10 dB to +10 dB	-10 dB to +10 dB	Not available. Calibrated at 0 dB.
Speed	**1k**	**2k**	**4k**
Minimum Internal Line Rate	300 Hz	300 Hz	300 Hz
Maximum Line Rate			
80 MHz model	68 kHz	36 kHz	18.5 kHz
40 MHz model	36 kHz	18.5 kHz	NA
Data Rate	40 or 80 MHz	40 or 80 MHz	80 MHZ
Optical Interface			
Back Focal Distance	6.56 ± 0.25 mm		
Lens Mounts	M42 x 1, C and F (1k and 2k) M58 x 0.75, F (4k)		

Feature / Specification	1k	2k	4k
Sensor Alignment			
x	±50 µm		
y	±50 µm		
z	±0.25 mm		
Θz	±0.2°		
Mechanical Interface	**1k and 2k**		**4k**
Camera Size	72 mm x 60 mm x 65 mm, all models		
Mass	< 300 g		
Connectors			
power connector	6 pin male Hirose		
GigE connector	RJ45		
GPI/ O connector	High density 15-pin dsub		
Electrical Interface			
Input Voltage	+12 V to +15 V		
Power Dissipation	< 9 W		< 9 W (4k)
Operating Temperature	0 °C to 65 °C		
Bit Width	8 or 12 bit, user selectable		
Output Data Configuration	GigE Vision		

Table 4: Camera Operating Specifications

Specifications	Unit		-10 dB			0 dB			+10 dB	
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
Broadband responsivity	DN/ (nJ/ cm²)									
1k and 2k Dual line			652.8			2064			6528	
1k and 2k Single line			326.4			1032			3264	
4k Dual line			431			1363				
4k Single line			216			682				
Random noise rms	DN									
1k and 2k			3	6.5		9.2	20.5		30	65
4k						10	24			
Dynamic range	DN:DN									
1k and 2k Dual line		500:1	1400:1		203:1	324:1		59:1	108:1	
1k and 2k Single line		500:1	1400:1		203:1	324:1		59:1	108:1	
4k Dual and Single			1225:1			387:1				
FPN global	DN p-p									
Uncorrected				52.8			169.6			536
Corrected				32			32			64
PRNU ECD										
Uncorrected local	%			8.5			8.5			11.5
Uncorrected global	%			10			10			10
Corrected local	DN p-p			80			80			95
Corrected global	DN p-p			80			80			95
4k Dual and Single										
Corrected local	DN p-p			32			32			
Corrected global	DN p-p			80			80			
Uncorrected local	%			9.5			9.5			

Uncorrected global	%			20			20			
PRNU ECE										
Uncorrected local	%			8.5			12			37
Uncorrected global	%			10			12			37
Corrected local	DN p-p			80			237			752
Corrected global	DN p-p			80			208			752
4k Dual and Single										
Corrected local	DN p-p			237			237			
Corrected global	DN p-p			237			237			
Uncorrected local	%			9.5			9.5			
Uncorrected global	%			20			20			
SEE (calculated)	nJ/ cm²									
1k and 2k Dual line			6.35			1.92			0.61	
1k and 2k Single line			12.2			4.0			1.2	
4k Dual line			9.2			2.9				
4k Single line			18.0			5.7				
NEE (calculated)	pJ/ cm²									
Dual line			4.6			4.5			4.6	
Single line			9.2			9.3			9.2	
4k Dual line			7.0			8.1				
4k Single line			14.0			16.1				
Saturation output amplitude	DN					3968±80				
DC offset	DN			96			160			336

Test conditions unless otherwise noted:

- 12-bit values, Flat Field Correction (FFC) enabled.
- CCD Pixel Rate: 40 MHz per sensor tap
- Line Rate: 5000 Hz
- Nominal Gain setting unless otherwise specified
- Light Source: Broadband Quartz Halogen, 3250k, with 750 nm high-pass filter installed
- Ambient test temperature 25 °C
- Unless specified, all values are referenced at 12 bit
- Exposure mode disabled.
- Unless specified, dual line mode.

Note: PRNU measured at 50% SAT.

Certifications

Table 5: EMC Compliance Standards

Compliance
The CE Mark, FCC Part 15, and Industry Canada ICES-003 Evaluation of the Teledyne DALSA Spyder GigE SG-14 cameras meet the following requirements:
EN 55022 Class A, and EN 61326 Emissions Requirements, EN 55024, and EN 61326 Immunity to Disturbances

Responsivity

Figure 1: Spyder3 GigE Vision 1k and 2k Responsivity

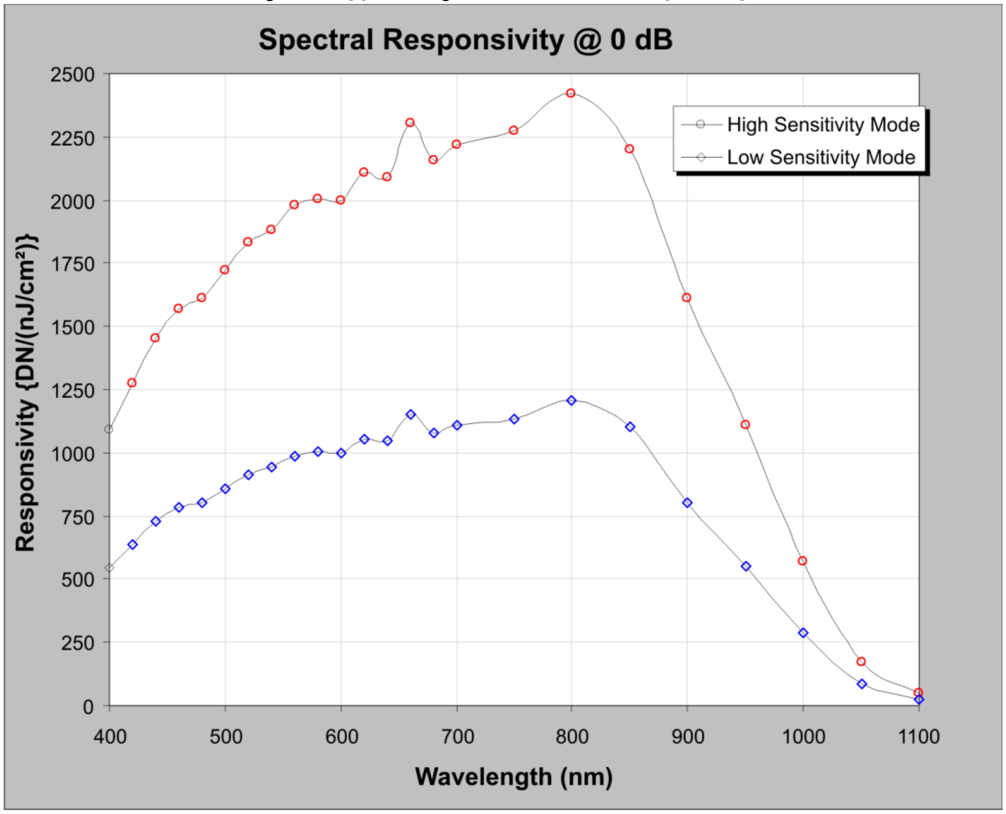
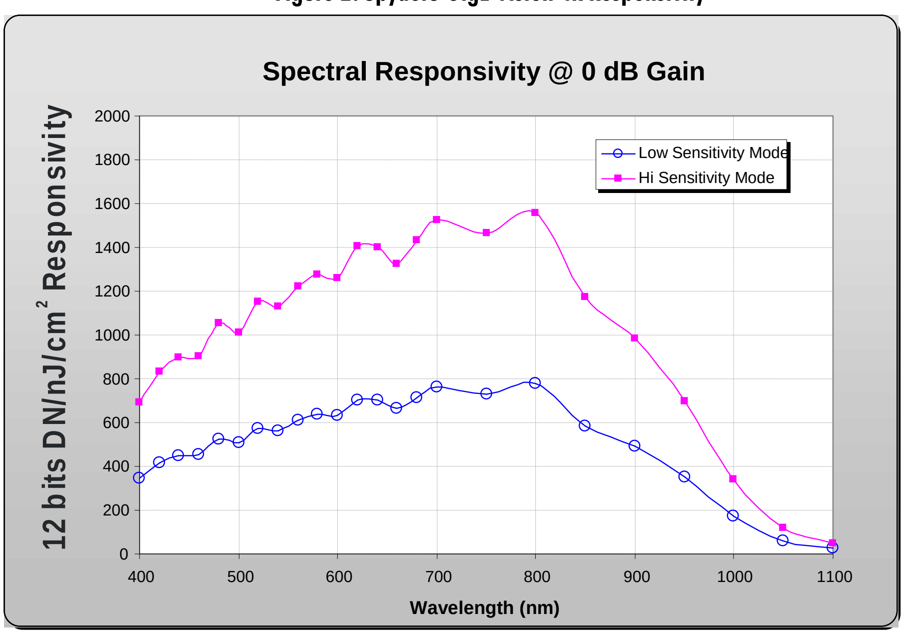


Figure 2: Spyder3 GigE Vision 4k Responsivity



Mechanicals

Figure 3: Spyder3 1k and 2k GigE Vision Mechanical

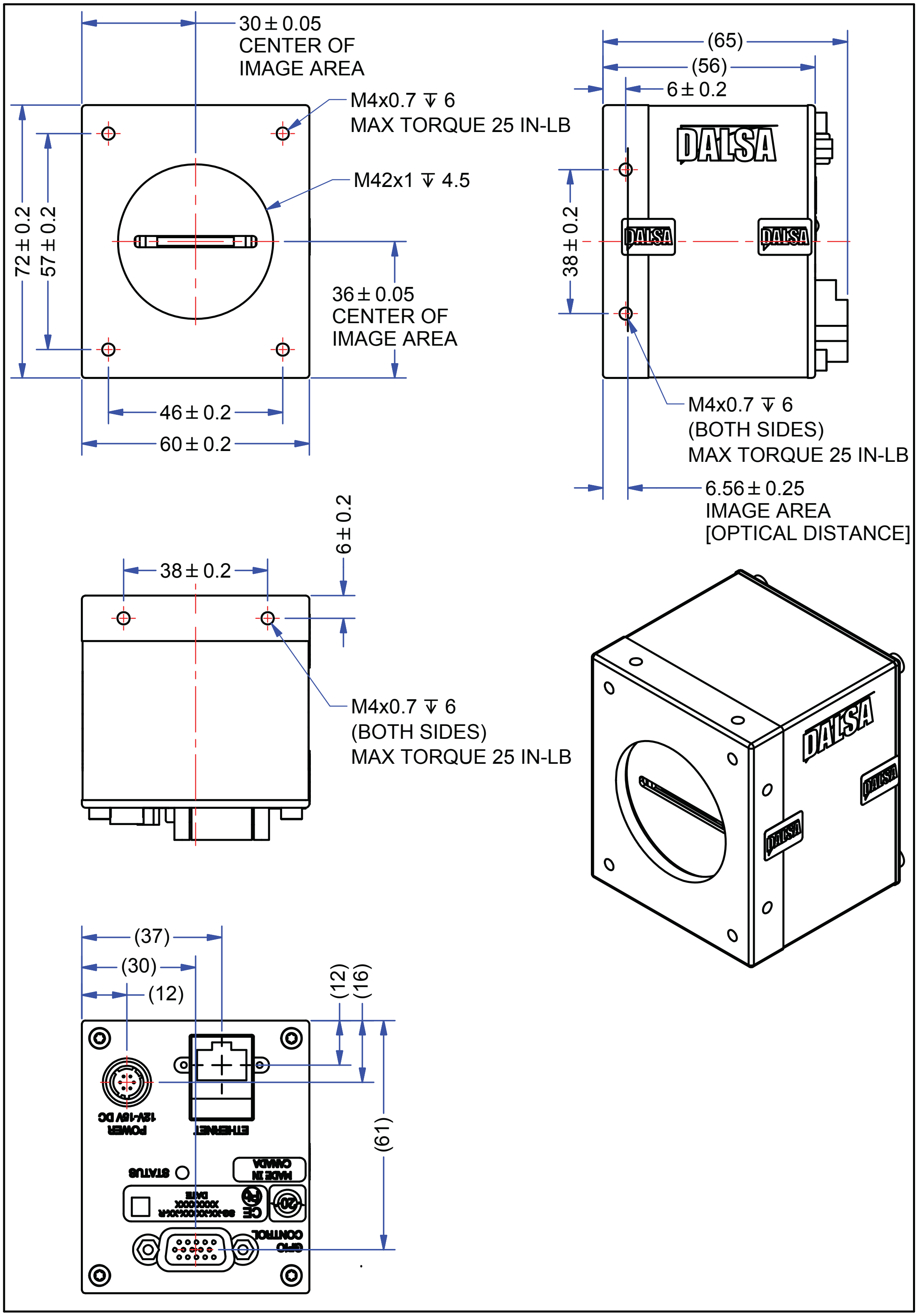
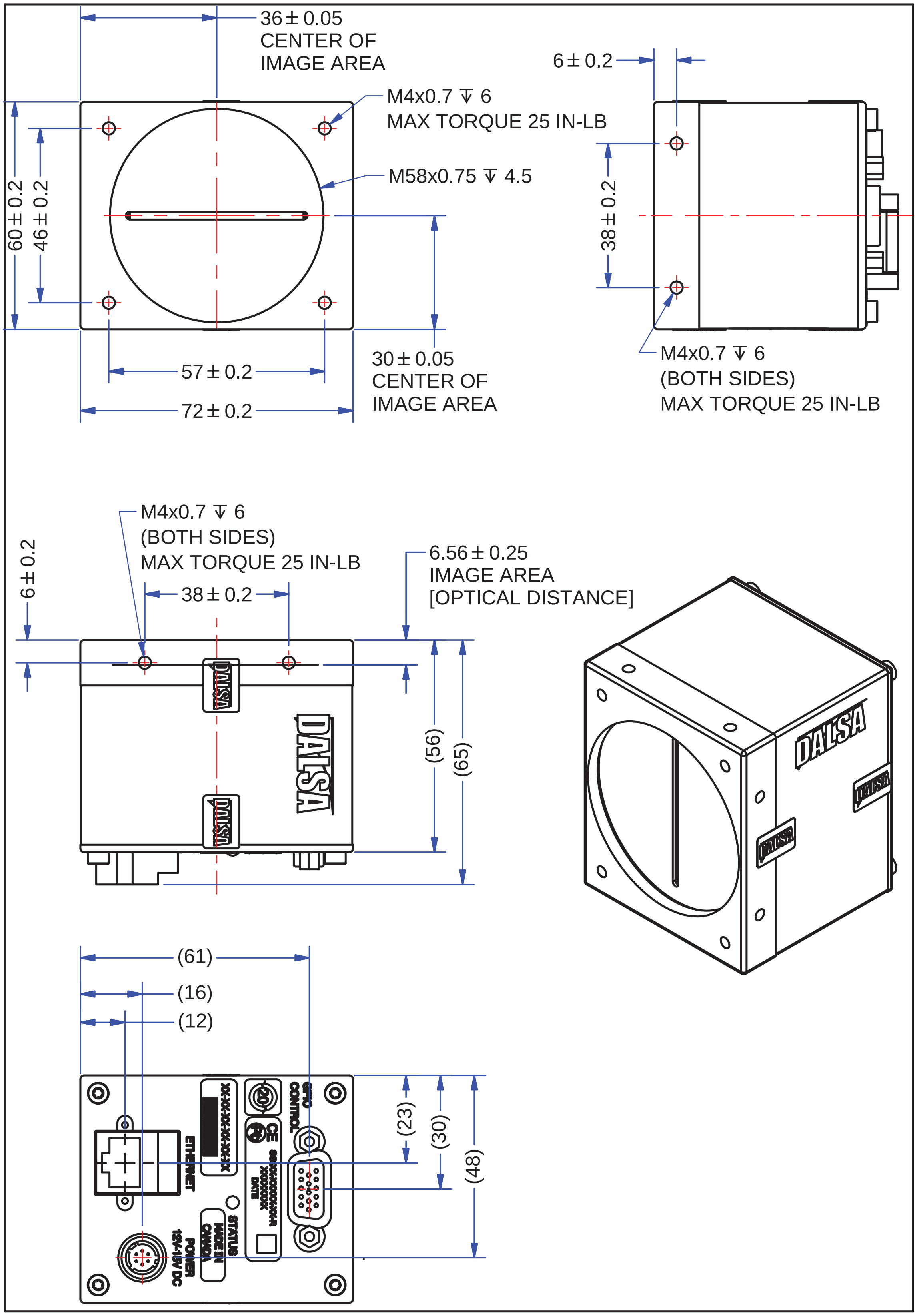


Figure 4: Spyder3 4k GigE Vision Mechanical



Mounting

Heat generated by the camera must be allowed to move away from the camera. Mount the camera on the frontplate (using the provided mounting holes) with maximum contact to the area for best heat dissipation.

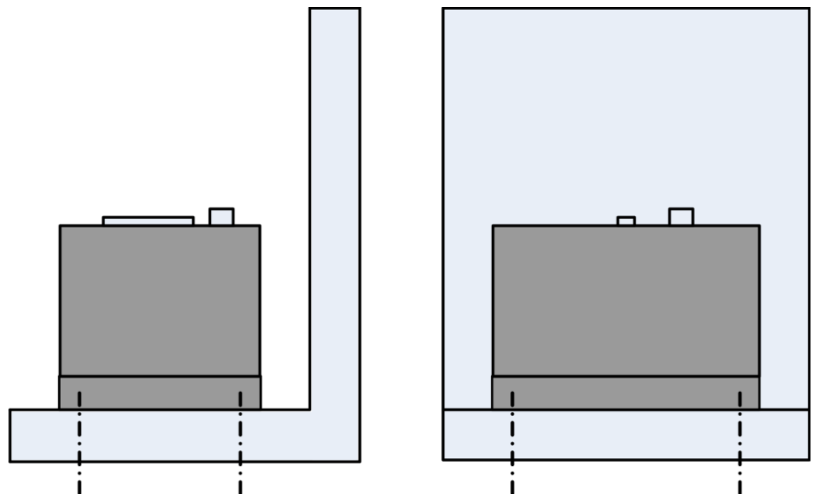


Figure 5: Spyder3 Mounting Example

Image Sensor

The camera uses Teledyne DALSA's dual line scan sensor. The camera can be configured to read out in either high or low sensitivity mode, tall pixel mode and forward or reverse shift direction.

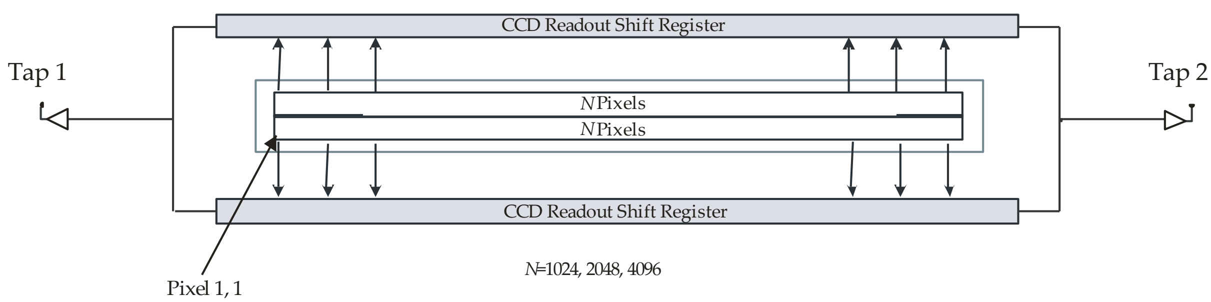


Figure 6: 2 Tap Sensor Block Diagram

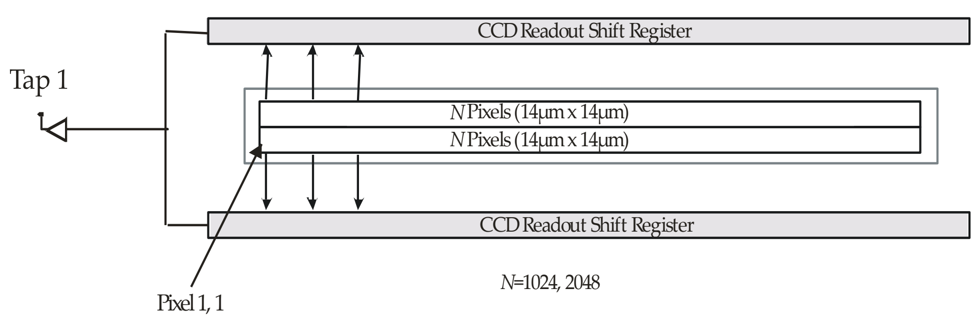


Figure 7: 1 Tap Sensor Block Diagram (1k and 2k only)

Software and Hardware Setup

Host System Requirements

To achieve best system performance, the following minimum requirements are recommended:

- Operating system: Windows XP Professional, Windows Vista, Windows 7 (either 32-bit or 64-bit for all) are supported.

Network Adapter Requirements

- GigE network adapter (either PCI card or LOM): For high performance you must use a Intel PRO/ 1000 MT adapter.

The Spyder3 GEV camera works only with network adapters based on the Intel 82546, 82541, and 82540 network chips. The driver will also function with adapters based on the Intel 82544 chip, but these are not recommended due to bugs in the chip that can cause control packets to be lost if sent while data is streaming.

Ethernet Switch Requirements

When you require more than one device on the same network or a camera-to-PC separation of more than 100 metres, you can use an Ethernet switch. Since the Spyder3 GEV camera complies with the Internet Protocol, the camera should work with all standard Ethernet switches. However, switches offer a range of functions and performance grades, so care must be taken to choose the right switch for a particular application.

Setup Steps: Overview

Take the following steps in order to setup and run your camera system. They are described briefly below and in more detail in the following sections.

1. Install and Configure Ethernet Network Card

If your host computer does not have a Gigabit network adapter or equivalent (PCI bus Gigabit NIC) already installed, then you need to install one.

For Gigabit performance we recommend the Intel PRO/ 1000 MT adapter, or equivalent. Follow the manufacturer's installation instructions.

A GigE Vision compliant XML device description file is embedded within the camera's firmware allowing GigE Vision compliant applications (e.g. Pleora`s Coyote, and SaperaLT) to recognize the camera's capabilities immediately after connection. The Spyder3 camera was tested with and supports SaperaLT which gives you access to the CamExpert GUI, a GigE Vision compliant application.

Software Installation

Install **Sapera LT with CamExpert** to control the Spyder3. You can access Sapera drivers, SDKs, and demos from the following link: http:/ / www.teledynedalsa.com/ mv/ support/ driverSDKlist.aspx

2. Connect Power, Ethernet and I/O Cables

- Connect a power cable from the camera to a +12 VDC to +15 VDC power supply.

- Connect the Ethernet cable from the camera to the computer Ethernet jack.
- If using the external signals connect the external control cable to the camera.

3. Establish communicating with the camera

Start the GUI and establish communication with the camera.

4. Check camera LED, settings and test pattern

Ensure that the camera is operating properly by checking the LED, the current settings, and by acquiring a test pattern.

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5. Operate the Camera

At this point you will be ready to operate the camera in order to acquire and retrieve images, set camera functions, and save settings.

Step 1. Ethernet Network Card: Install and Configure

Install Network Card

The following network card has been tested and is recommended for use with this camera: Intel Pro/ 1000 MT Desktop Adapter (33-MHz, 32-bit PCI). Order Code: PWLA8391GT (single packs). Follow the manufacturer's recommendations to install this card in the host PC.

Configure Network Card

The configuration shown here uses the Windows XP operating system as the host platform.

The camera communicates using the Ethernet connection and employs the static IP address: **192.168.5.100** (default). A static address ensures the fastest operation. Alternatively, you can use a dynamic IP address.

To configure the network card from the host PC:

1. In the Start menu under "Control Panel" select "Network Connections," and configure the network card as follows:
2. Select the installed network card and click on "Change settings of this connection."
3. Enable the "Internet Protocol (TCP/ IP)" option only.

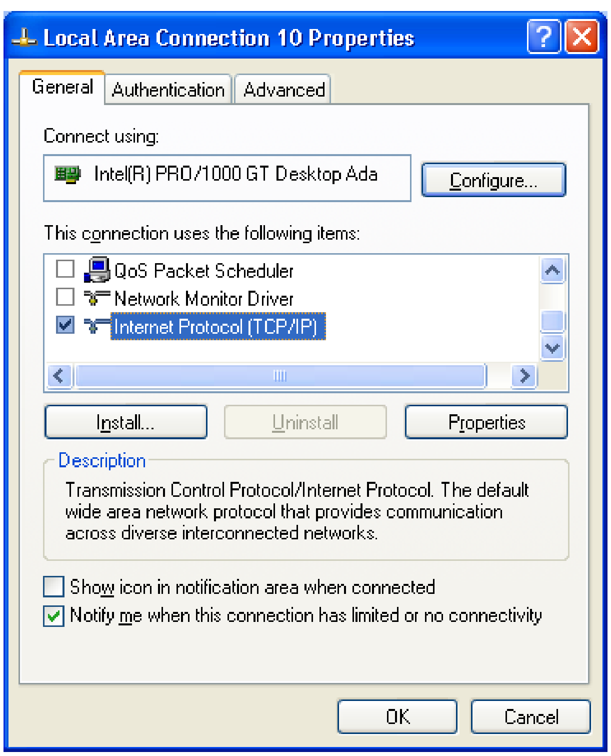


Figure 8. Internet Protocol

4. With "Internet Protocol (TCP/ IP)" selected, click on the "Properties" button.

5. Select "Use the following IP address" and set the IP address to any address in this subnet other than 192.168.5.100, which is used by the camera. In the example below, the address 192.168.5.50 is used. Alternatively, select "Obtain an IP address automatically" to use a dynamic address.
6. Set subnet to: 255.255.255.0 and click on "OK."

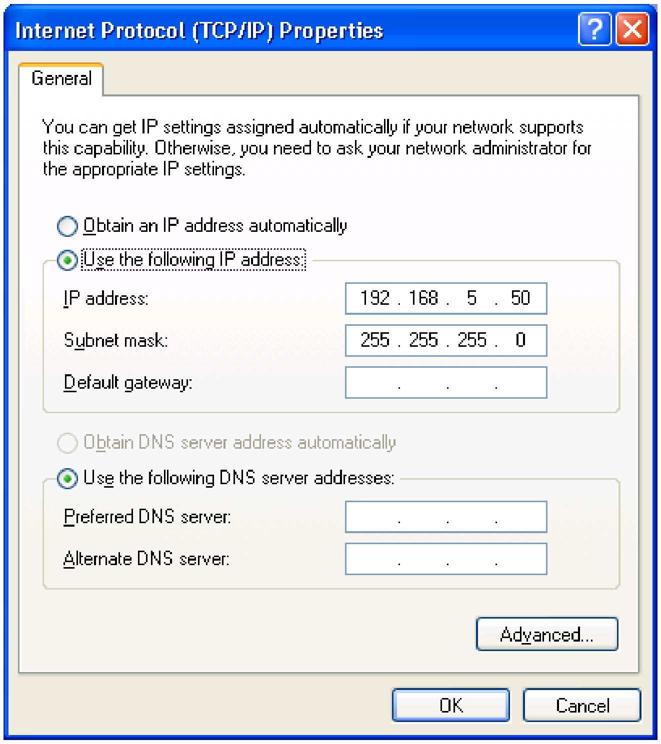


Figure 9. IP Address

7. Click "OK" to save settings
8. Click on "Configure" button and select "Advanced" tab
9. Enable "Jumbo Frames" to greater than 9000 bytes. If your NIC does not support jumbo packets the image transfer speed will be slower.

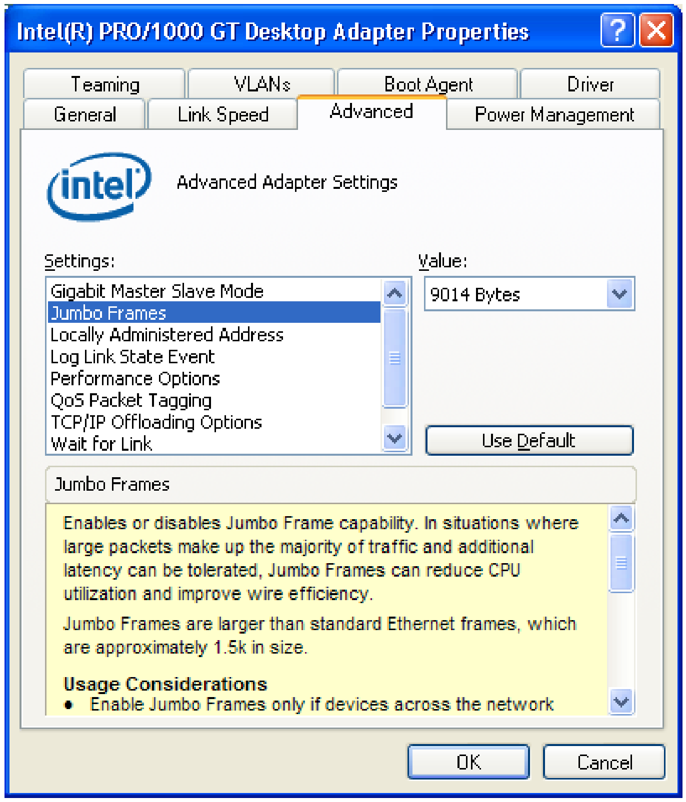


Figure 10. Jumbo Frames

10. Click "OK" to save settings

Step 2. Connect Power, Ethernet, and Trigger Cables

WARNING! Grounding Instructions
Static electricity can damage electronic components. Please discharge any static electrical charge by touching a grounded surface, such as the metal computer chassis, before performing any hardware installation.

The use of cable types and lengths other than those specified may result in increased emission or decreased immunity and performance of the camera.

All models

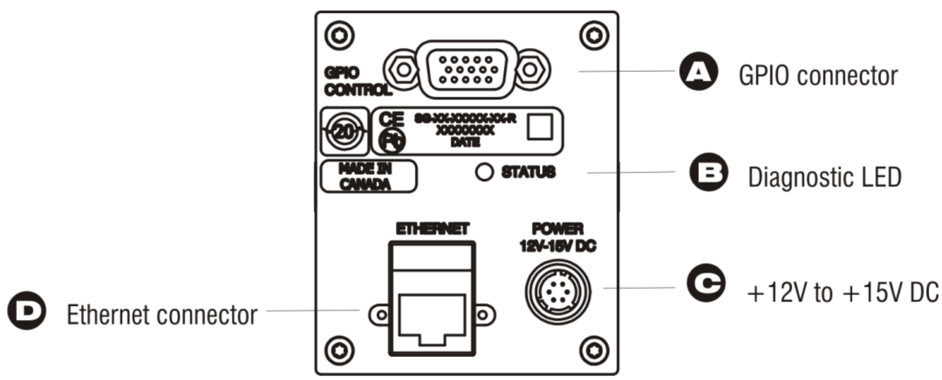


Figure 11: Input and Output, trigger, and Power Connectors

Power Connector

WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera. Input voltage requirement: +12 V to +15 V DC.

The camera requires a single 6-pin Hirose connector with a single voltage input +12 VDC to +15 VDC for power. The camera meets all performance specifications using standard switching power supplies, although well-regulated linear supplies provide optimum performance.

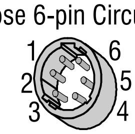
	Pin	Description
Hirose 6-pin Circular Male  Mating Part: HIROSE HR10A-7P-6S	1, 2, 3	Supply voltage—Min +12 VDC to Max +15 VDC
	4, 5, 6	Ground

Table 6. Hirose 6-Pin Power Pinout

WARNING: When setting up the camera's power supplies follow these guidelines:

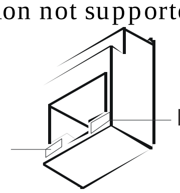
- Apply the appropriate voltages.
- Protect the camera with a 2 amp slow-blow fuse between the power supply and the camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible in order to reduce voltage drop.
- Use high-quality linear supplies in order to minimize noise.

Note: If your power supply does not meet these requirements, then the camera performance specifications are not guaranteed.

Ethernet Connector and Ethernet LED

The camera uses an RJ45 connector and a standard Cat 5 cable for Gigabit Ethernet signals and serial communications. The device supports 10/ 100/ 1000 Mbit/ s speeds.

Note: Router connection not supported. Connection to a network switch for a single camera is supported.



Ethernet Connection LED

Steady ON indicates that an Ethernet connection is successfully established at 1Gbps.

Data Transmission LED

Steady ON indicates that the camera is ready for data transmission. Flashing indicates that the camera is transmitting or receiving data.

EMC Compliance

In order to achieve EMC compliance, the Spyder3 camera requires the use of shielded CAT5e or CAT6 Ethernet cables.

Status LED

The camera is equipped with a red/ green LED used to display the status of the camera's operation. The table below summarizes the operating states of the camera and the corresponding LED states.
When more than one condition is active, the LED indicates the condition with the highest priority. Error and warning states are accompanied by corresponding messages that further describe the current camera status.

Priority	Color of Status LED	Meaning
1	Flashing Red	Fatal Error. For example, camera temperature is too high and camera thermal shutdown has occurred.
2	Flashing Green	Camera initialization or executing a long command.
3	Solid Green	Camera is operational and functioning correctly.

GPIO Connector: External Input

A single 15-pin general purpose input / output (GPIO) connector is used to receive or control external signals. For example, the GPIO connector can be used to receive EXSYNC, PRIN (pixel reset), and direction signals.

The GPIO connector is programmed through the GUI application. In CamExpert the relevant parameters are located in the category Inputs Group.

Figure 12: GPIO Connector and Pin Numbers

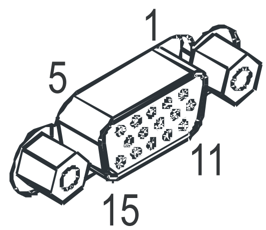


Table 7: GPIO Connector Pinout

Pin	Signal	Description	GenICam Default
1	INPUT_0+	LVDS/TTL format (positive)	EXSYNC +
2	INPUT_0-	LVDS (negative)	EXSYNC -
3	INPUT_1+	LVDS/TTL format (positive)	FrameTrig +
4	INPUT_1-	LVDS (negative)	FrameTrig -
5	GND		
6	INPUT_2+	LVDS/TTL format (positive)	Direction +
7	INPUT_2-	LVDS (negative)	Direction -
8	INPUT_3	TTL auxiliary input	
9	OUTPUT_3	TTL auxiliary output	
10	OUTPUT_2+	LVDS/TTL auxiliary output	
11	OUTPUT_0+	LVDS/TTL auxiliary output	
12	OUTPUT_0-	LVDS (negative)	
13	OUTPUT_1+	LVDS/TTL auxiliary output	
14	OUTPUT_1-	LVDS (negative)	
15	OUTPUT_2-	LVDS (negative)	

A schematic of the TTL input circuitry is shown in
Figure 13: TTL Input Schematic. The input signals are fed into the engine from external sources via the GPIO connector.

GPIO Isolation

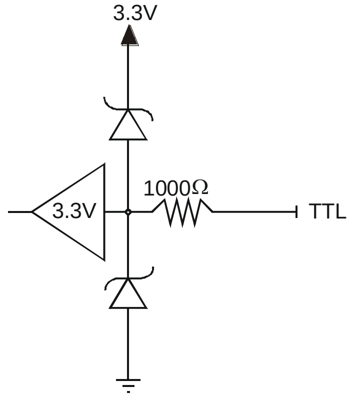
All of the GPIOs are isolated from the rest of the camera and the camera case. They are not isolated with respect to each other and share a common return (ground) through pin 5 of the GPIO connector.
Note: The shell connection of the GPIO connector is not isolated and it should not be used as a return (ground) for the GPIO signals. The shell connection is attached to the camera case.

GPIO Configuration

Refer to Appendix C: GPIO Control for a detailed description of the GPIO use-cases and configuration options.

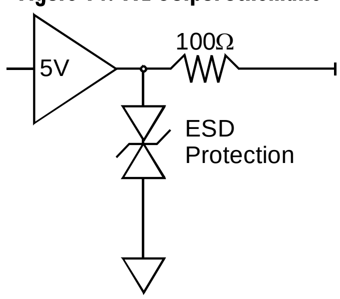
TTL Inputs and Outputs

Figure 13: TTL Input Schematic



- Termination: 1000 Ω series
- Input current: minimum 0 nA; maximum 2 mA
- Input voltage: maximum of low 0.66 V; minimum of high 2.6 V
- TTL inputs are maximum 5 V and 3.3 V logic tolerant

Figure 14: TTL Output Schematic



- Termination: 100 Ω series
- Output current: sink 50 mA; source 50 mA
- Output voltage: maximum of low 0.55 V @32mA; minimum of high 3.8 V @32mA.

LVDS Inputs and Outputs (LVDS compliant)

Figure 15: LVDS Input

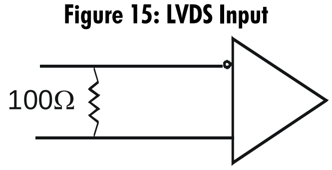
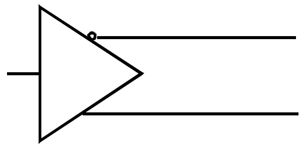


Figure 16Figure 17: LVDS Output



Step 3. Establish Communication with the Camera

Power on the camera

Turn on the camera's power supply. You may have to wait up to 60 seconds while the camera warms up and prepares itself for operation.

Connect to the camera

1. Start a new Sapera CamExpert application (or equivalent GigE Vision compliant interface) by double-clicking the desktop icon created during the software installation.
2. CamExpert will search for installed Sapera devices. In the Devices list area on the left side, the connected Spyder camera will be shown.
3. Select the Spyder camera device by clicking on the camera user-defined name. By default the camera is identified by its serial number.

Check LED Status

If the camera is operating correctly at this point, the diagnostic LED will flash for 10 seconds and then turn solid green.

Software Interface

All the camera features can be controlled through the CamExpert interface. For example, under the Sensor Control menu in the camera window you can control the frame rate and exposure times.

Using Sapera CamExpert with Spyder3 Cameras

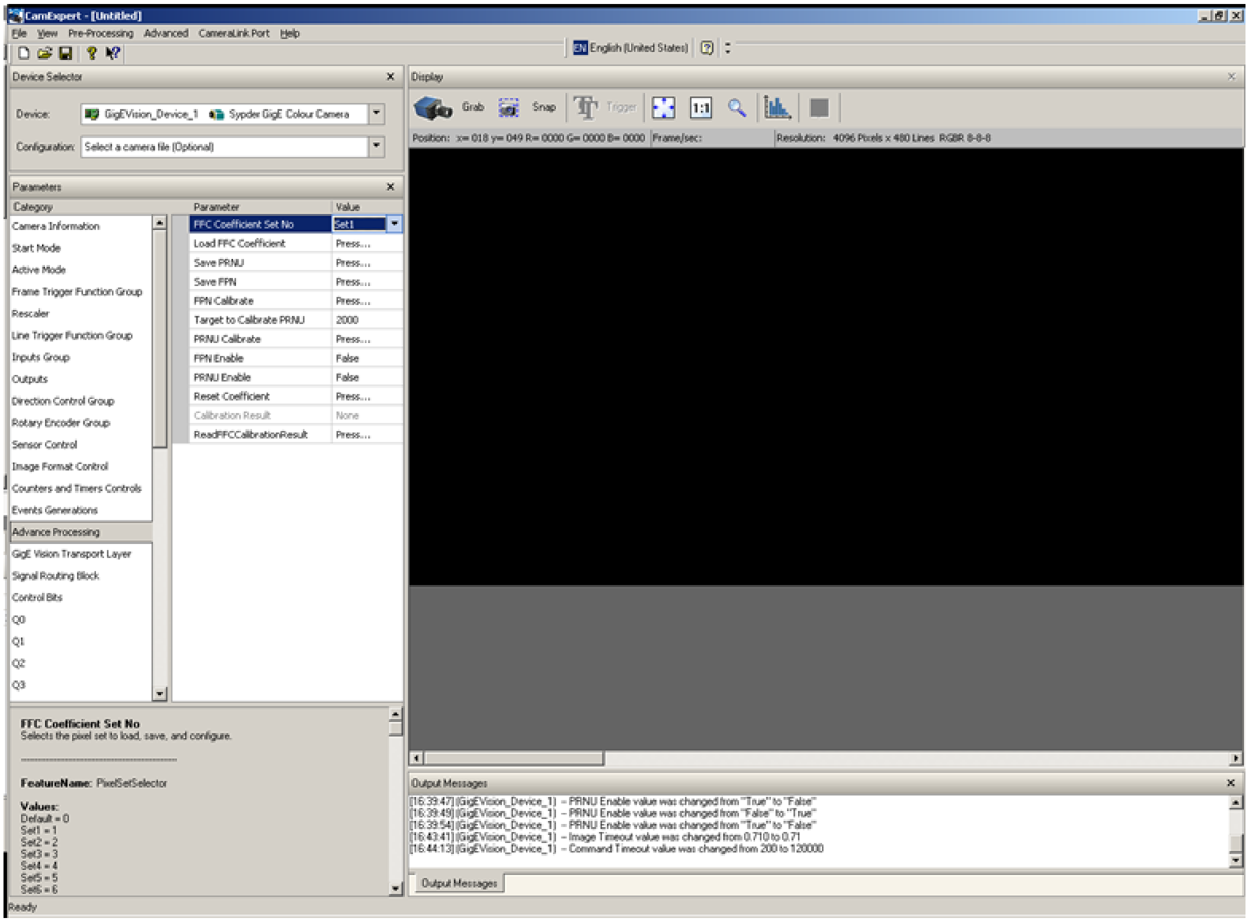
CamExpert is the camera interfacing tool supported by the Sapera library. When used with a Spyder3 camera, CamExpert allows a user to test all Spyder3 operating modes. Additionally CamExpert saves the Spyder3 user settings configuration to the camera or saves multiple configurations as individual camera parameter files on the host system (**.ccf*).

An important component of CamExpert is its live acquisition display window which allows immediate verification of timing or control parameters without the need to run a separate acquisition program.

For context sensitive help, click on the button then click on a camera configuration parameter. A short description of the configuration parameter will be shown in a popup. Click on the button to open the help file for more descriptive information on CamExpert.

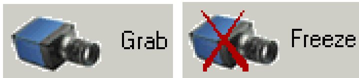
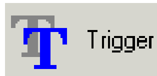
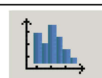
The central section of CamExpert provides access to the Spyder3 parameters. Note: The availability of the parameters is dependent on the CamExpert user setting.

CamExpert Panes



The CamExpert application uses 5 windows to simplify choosing and configuring camera files or acquisition parameters for the installed device.

- **Device Selector pane:** View and select from any installed Sapera acquisition device. Once a device is selected CamExpert will only present acquisition parameters applicable to that device. Optionally select a camera file included with the Sapera installation or saved by the user.
- **Parameters pane:** Allows viewing or changing all acquisition parameters supported by the acquisition device. CamExpert displays parameters only if those parameters are supported by the installed device. This avoids confusion by eliminating parameter choices when they do not apply to the hardware in use.
- **Display pane:** Provides a live or single frame acquisition display. Frame buffer parameters are shown in an information bar above the image window.
- **Control Buttons:** The Display pane includes CamExpert control buttons. These are:

	**Acquisition control button:** Click once to start live grab, click again to stop.
	**Single frame grab:** Click to acquire one frame from device.
	**Software trigger button:** With the I/O control parameters set to Trigger Enabled / Software Trigger type, click to send a single software trigger command.
	**CamExpert display controls:** (these do not modify the frame buffer data) Stretch image to fit, set image display to original size, or zoom the image to any size and ratio.
	**Histogram / Profile tool:** Select to view a histogram or line/column profile during live acquisition.

- **Output Message pane:** Displays messages from CamExpert or the device driver.

Step 4. Camera Settings and Test Patterns

Review a Test Pattern Image

The camera is now ready to retrieve a test pattern. The Spyder3 cameras include a built-in test pattern generator that can be used to confirm camera Ethernet connections without the need for a camera lens or proper lighting. The test patterns are useful for verifying camera timing and connections, and to aid in system trouble shooting.

Using CamExpert, select **Image Format Control > Test Image Selector** and choose one of the available test images. Select live grab to see the pattern output. The following test patterns are available:

Figure 18. Grey horizontal step

Figure 19. Grey horizontal ramp

At this point you are ready to start operating the camera in order to acquire images, set camera functions, and save settings.

Camera Operation

Factory Settings

The camera ships and powers up for the first time with the following factory settings:

- High sensitivity mode
- Forward CCD shift direction
- 8 bit, 2 tap
- No binning
- Exposure mode: internal sync & maximum exposure time
- 5, 000 Hz line rate
- Factory calibrated analog gain and offset
- Factory calibrated FPN and PRNU coefficients

Check Camera and Sensor Information

Camera and sensor information can be retrieved via a controlling application—in the examples shown here, CamExpert. Parameters such as camera model, firmware version, sensor characteristics, etc. are read to uniquely identify the connected device.

The camera information parameters are grouped together as members of the Camera Information set.

GigE Vision Input Controls

Camera Information	
Parameter	**Options**
Manufacturer Name	
Model Name	
Manufacturer Info	
Camera Version	**Read Only Parameters**
Firmware Version	
Camera serial ID number	
Camera Temperature	
Camera Voltage	
User ID	Define a camera name up to 64 characters
Read temperature	In general, the temperature read is 15 C greater than the temperature at the front plate. The temperature should not exceed 80 °C.
Read Camera input voltage	Click to read the voltage from the camera

Verify Temperature and Voltage

To determine the voltage and temperature at the camera, use the **Read Voltage and Temperature** feature found in the **Camera Information** set.

The temperature returned is the internal chip case temperature in degrees Celsius. For proper operation, this value should not exceed 80 °C. If the camera exceeds the designated temperature it will shut down and will not turn on until the camera's temperature is 73 ºC or less. Use the **reset camera** function.

The voltage displayed is the camera's input voltage. Note that the voltage measurement feature of the camera provides only approximate results (typically within 10%). The measurement should not be used to set the applied voltage to the camera, but only used as a test to isolate gross problems with the supply voltage.

Saving and Restoring Camera Settings

The parameters used to select, load and save user sets are grouped together under the Camera Information set of features.

GigE Vision Input Controls

Camera Information	
Parameter	**Description**
User Set Selector / Device Configuration Selector	Selects the camera configuration set to load feature settings from or save current feature settings to: factory (default) or user sets. The Factory / Default set contains default camera feature settings. User camera configuration sets contain feature settings previously saved by the user.
User Set Load / Load GigE Configuration	Load the set specified by User Set Selector to the camera and make it the active / current set.
User Set Save / Save Configuration	Save the current set as selected user set.

Description of the Camera Settings

The camera operates in one of three settings:

1. Current session
2. User setting
3. Factory setting (Default, read-only)

The current settings can be saved (thereby becoming the user setting) using the User Set Save parameter. A previously saved user setting (User Set 1) or the factory settings can be restored using the User Set Selector and User Set Load parameters.

The relationship between these three settings is illustrated here and described below:

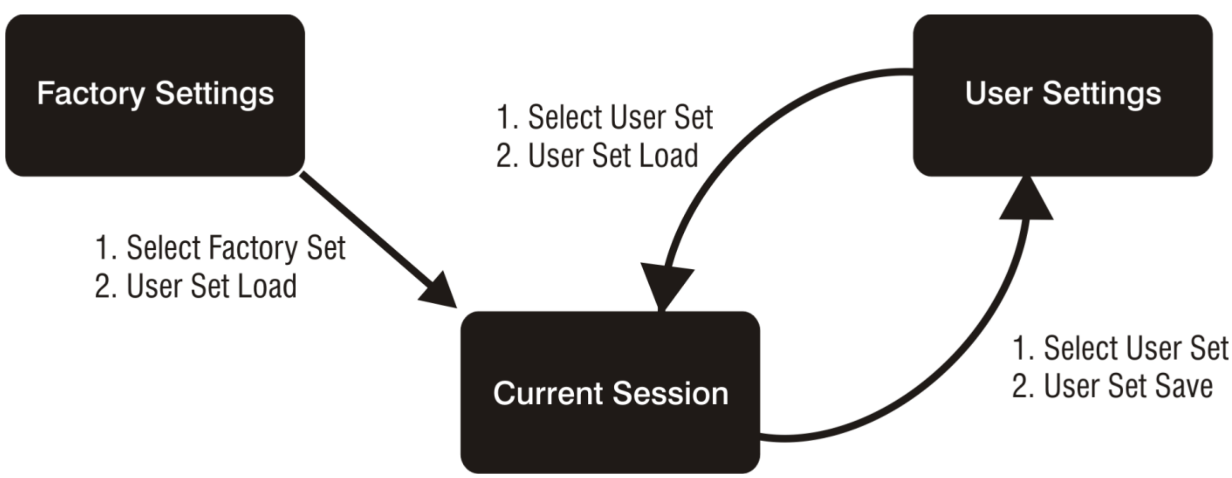


Figure 20. Relationship between the Camera Settings

Current Session Active Setting

The active setting for the current session is the set of configurations that are operating while the camera is currently running, including all unsaved changes you have made to the settings before saving them.

These active settings are stored in the camera's *volatile* memory and will be lost and cannot be restored if the camera resets or if the camera is powered down or loses power.

To save these settings for reuse the next time you power up or reset the camera, or to protect against losing them in the case of power loss, you must save the current settings using the **User Set Save** parameter. Once saved, the current settings become your **User Set 1**.

User Setting

The user setting is the saved set of camera configurations that you can customize, resave, and restore. By default the user settings are shipped with the same settings as the factory set.

The command **User Set Save** saves the current settings to non-volatile memory as a **User Set**. The camera automatically restores the last saved user settings when it resets and / or powers up.

To restore the last saved user settings, select the **User Set** parameter you want to restore and then select the **User Set Load** parameter.

Factory (Default) Settings

The default setting is the camera settings that were shipped with the camera and which loaded during the camera's first power-up. To load or restore the original factory settings, at any time, select the **Default / Factory Setting** parameter and then select the **User Set Load** parameter.

Note: By default, the user settings are set to the factory settings.

Please note: the following features are not restored during a factory setting load / restore:

- FFC Coefficients set number
- Analog Gain selector
- Blacklevel selector
- Digital Offset selector
- Background Subtract selector
- Line selector
- PRNU CalibrationTarget
- Gain Calibration Target
- Gain Calibration Selector

Timing: Exposure and Synchronization

Image exposures are initiated by an event. The trigger event is either the camera's programmable internal clock used in free running mode, an external input used for synchronizing exposures to external triggers, or a programmed function call message by the controlling computer.

Trigger commands are available as members of the Sensor Control set.

GigE Vision Input Controls

Line Trigger	
Trigger Mode	The state of the line trigger. If OFF, then the line trigger is internally generated. If ON, then triggered by an external signal.
Trigger Source	The external source that causes a line trigger. The line trigger is from the GPIO_PIN0. This feature is available only when Line Trigger Mode is set to ON.
Trigger Activation	Determines the type of signal (high or low) that will cause a line trigger. Line Trigger Mode must be ON.
External Line Trigger Frequency	Reads the external line trigger frequency. NOTE: The camera cannot detect frequency less than 5 Hz and will display 1 if it cannot detect a signal. This feature is available when the Line Trigger Mode is set o ON and Sensor Direction Control is set to External.

The three trigger modes are described here:

Free running (trigger disabled)

The camera free-running mode has a programmable internal timer for line rate and a programmable exposure period. Line rate is 0.1 fps to the maximum supported by the sensor. Exposures range from the sensor minimum to a maximum also dependent on the current line rate. This always uses Synchronous mode where exposure is aligned to the sensor horizontal line timing.

External trigger

Exposures are controlled by an external trigger signal. External signals are isolated by an opto-coupler input with a time programmable debounce circuit. The following section provides information on external trigger timing.

Software trigger

An exposure trigger is sent as a control command via the network connection. Software triggers can not be considered time accurate due to network latency and sequential command jitter. But a software trigger is more responsive than calling a single-line acquisition (Snap command) since the latter must validate the acquisition parameters and modify on-board buffer allocation if the buffer size has changed since the last acquisition.

Timing

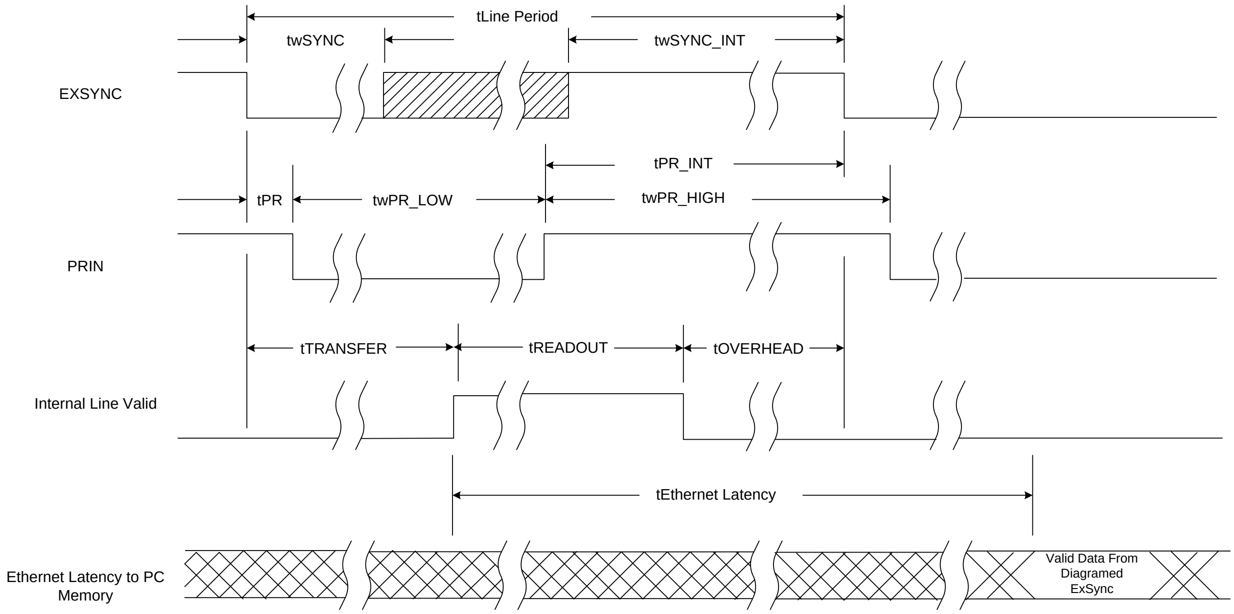


Table 8: Timing Parameter Table

	Units	Min.	Typ.	Max.	Notes
tLine_Period	µs	27.78		1000	1K 1 Tap
		14.71		1000	1K 2 Tap
		54.1		1000	2K 1 Tap
		27.78		1000	2K 2 Tap
		54.1		1000	4k 2 Tap
twSync	ns	100			
twSYNC_INT	ns	100 (3000*)			For exposure mode 4 this value needs to be >3000ns other wise >100ns
tPR	ns	0			
twPR_LOW	ns	3000			
twPR_HIGH	ns	3000			
tPR_INT	ns	3000			

Table 9: tReadout Values

tREADOUT		
Sensor Size	**# Taps**	**Readout Time**
1024	1	25600ns
1024	2	12800ns
2048	1	51200ns
2048	2	25600ns
4096	2	

Table 10: tOverhead Values

tOVERHEAD		
Sensor Size	# Taps	Readout Time
1024	1	725ns
1024	2	450ns
2048	1	1400ns
2048	2	725ns

Overhead Delay

Overhead_Delay can range from 5 to 6μs and depends on the internal operations of your computer.

Exposure Controls

The camera can grab images in one of seven ways. The camera's line rate (synchronization) can be generated internally through the **Acquisition Line Rate** feature (a member of the **Sensor Control** set of features) or set externally with an **EXSYNC** signal, depending on your mode of operation.

To select how you want the camera's line rate to be generated:

1.	First set the camera mode using **Exposure Mode** and **Line Trigger Mode** commands.
2.	Next, if using mode 2, 6, or 7 (see below) use the commands **Acquisition Line Rate Abs** and/ or **Exposure Time Abs** to set the line rate and exposure time.

GigE Vision Input Controls

Sensor Control	
Exposure Mode	This feature is used to set the operation mode of the Exposure (or shutter): Off, Timed, Trigger Width. If Off is selected then the camera uses the maximum time according to its line rate.
Line Trigger Group	
Line Trigger Mode	The state of the line trigger. If the trigger is off, then the line trigger is internally generated. Otherwise, the line trigger is caused by an external signal. Modes: Off or On.

Set the Exposure Mode

Sets the camera's exposure mode allowing you to control your sync, exposure time, and line rate generation.

Mode	LineTriggerMode	ExposureMode	Programmable Line Rate	Programmable Exposure Time	Description
A	Off (Internal)	Timed (Internal)	Yes	Yes	Internal line rate and exposure time. Exposure mode enabled.
B	On (External)	Off (Internal)	No	No	Maximum exposure time. Exposure mode disabled.
C	On (External)	TriggerWidth (Internal)	No	No	Smart EXSYNC. Exposure mode enabled.
D	On (External)	Timed (Internal)	No	Yes	Fixed integration time. Exposure mode enabled.
E	Off (Internal)	Off (Internal)	Yes	No	Internal line rate, maximum exposure time. Exposure mode disabled.

Note: When setting the camera to external signal modes **EXSYNC** must be supplied.

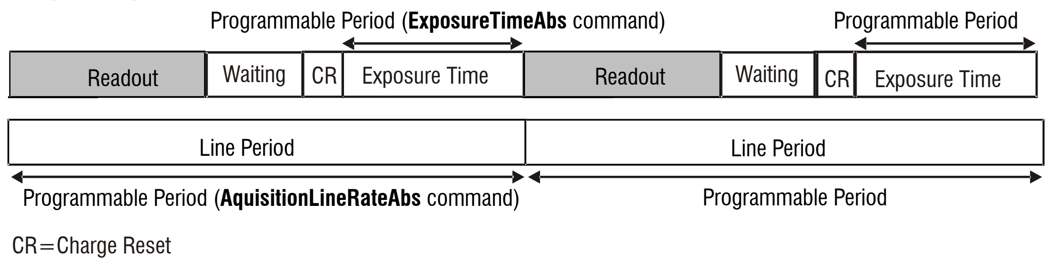
Exposure Modes in Detail

Mode A. Internally Programmable Line Rate and Exposure Time (Factory Setting): ExposureMode Timed and LineTriggerMode Off (Internal)

Operates at a maximum line rate and exposure time.

- When setting the line rate (using the **AcquisitionLineRateAbs** command), exposure time will be reduced, if necessary, to accommodate the new line rate. The exposure time will always be set to the maximum time (line period – line transfer time – pixel reset time) for that line rate when a new line rate requiring reduced exposure time is entered.
- When setting the exposure time (using the **ExposureTimeAbs** command), line time will be increased, if necessary, to accommodate the exposure time. Under this condition, the line time will equal the exposure time + line transfer time.

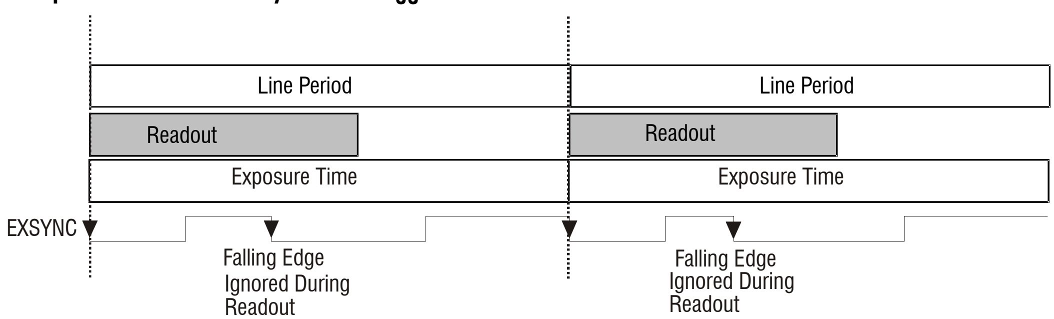
Example 1: Exposure Time less than Line Period



Mode B. External Trigger with Maximum Exposure: ExposureMode Off and LineTriggerMode On (External)

Line rate is set by the period of the external trigger pulses. The falling edge of the external trigger marks the beginning of the exposure.

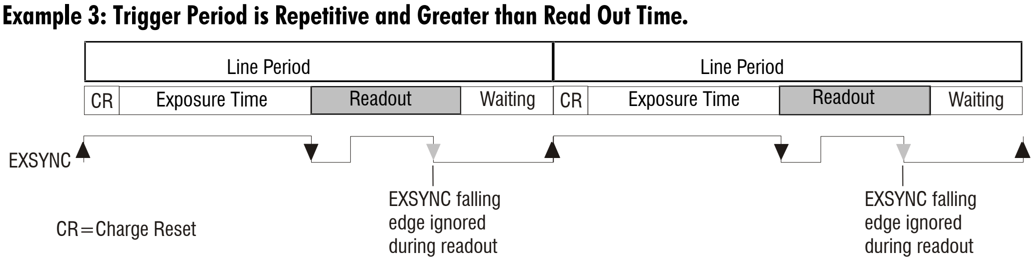
Example 2: Line Rate is set by External Trigger Pulses.



Mode C. Smart EXSYNC, External Line Rate and Exposure Time: ExposureMode TriggerWidth and LineTriggerMode On (External)

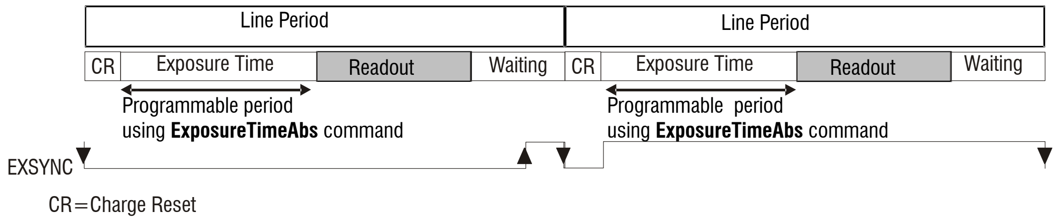
In this mode, EXSYNC sets both the line period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout.

Example 3: Trigger Period is Repetitive and Greater than Read Out Time.



Mode D. External Line Rate and Internally Programmable Exposure Time: ExposureMode Timed and LineTriggerMode On (External)

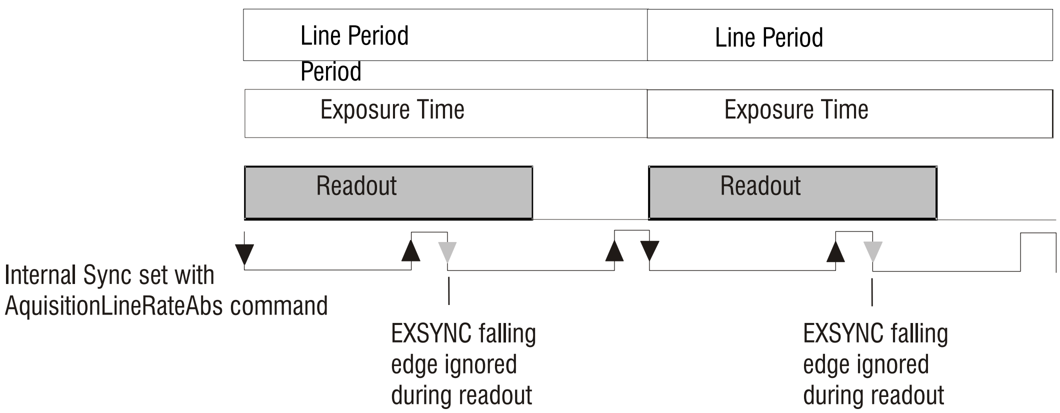
Figure 21: EXSYNC controls Line Period with Internally controlled Exposure Time



Mode E. Internally Programmable Line Rate, Maximum Exposure Time: ExposureMode Off and LineTriggerMode Off (Internal)

In this mode, the line rate is set internally with a maximum exposure time.

Figure 22: Mode 7 Camera Timing



Line Rate

To set the camera's line rate, use the **Line Rate** feature found in the **Sensor Control set**. This feature is only available while the camera is operating in **Internal Imaging Mode** (Trigger Mode off).

GigE Vision Input Controls

Sensor Control	
Parameter	**Description**
Line Rate (Hz)	Camera line rate, in Hz. 300 Hz min., 68000 Hz max. Only available when the camera is in Internal Mode—trigger is disabled (Trigger Mode off). Line rates are in the following configurations: 1k 1 tap: **300-36000** Hz 1k 2 tap: **300-68000** Hz 2k 1 tap: **300-18500** Hz 2k 2 tap: **300-36000** Hz 4k 2 tap: **300-18500** Hz

Exposure Time

To set the camera's exposure time, use the **Exposure Time** feature found in the **Sensor Control** set. This feature is used to set the exposure time in µs. This feature is only available when the Exposure Mode is set to Timed. The allowable range is from 3 µs to 3300 µs.

GigE Vision Input Controls

Sensor Control	
Parameter	**Description**
Exposure Mode	This feature is used to set the operation mode of the Exposure (or shutter): Timed, Trigger Width, Off (maximum, according to line rate).
Exposure Time	This feature is used to set the Exposure time (in microseconds) when Exposure Mode is set to Timed. min 3, max 3300 us.

Triggers

GigE Vision Input Controls

Frame Trigger Function Group	
The Frame Trigger Control section describes all features related to frame acquisition using trigger(s). One or many Trigger(s) can be used to control the start of an Acquisition, of a Frame. It can also be used to control the exposure duration at the beginning of a frame.	
Parameter	**Description**
Trigger Overlap	Specify the type of trigger overlap permitted with the previous frame. This defines when a valid trigger will be accepted (or latched) for a new frame
Trigger Delay Raw	Specifies the delay in microseconds (µs) to apply after the trigger reception before activating it The delay of the selected trigger in 1 µs increments.
Frame Trigger Source	The line that triggers a frame trigger when Frame Start Trigger Mode is On.
Frame Trigger Software Toggle	Trigger Software is a command that can be used by an application to generate an internal trigger when Trigger Source is set to Software. To generate a trigger, choose false first then choose true.
Active Mode	
Frame Active Trigger Activation	Specifies what type of signal (i.e. high, or low) causes a variable length frame trigger.
Frame Active Trigger Mode	Specifies whether the external variable length frame trigger is on or off. This trigger takes precedence over the FrameStartTrigger.
Frame Active Delay	Enable the delayer.

Start Mode	
Frame Start Trigger Mode	Specifies whether the external fixed length frame trigger is on or off. If the FrameTriggerActiveMode is on then it takes precedence.To turn On, please DeviceScanType to Linescan (Start Mode).
Frame Start Trigger Activation	Specifies what type of signal(i.e. high, or low) causes a fixed length frame trigger when Frame Start Trigger Mode is On.
Frame Start Delay	Enable the delayer.

GigE Vision Input Controls

Line Trigger Function Group	
The Line Trigger Control section describes all features related to line acquisition using trigger(s). One or many Trigger(s) can be used to control the start of an Acquisition, of a Line. It can also be used to control the exposure duration at the beginning of a line.	
Parameter	**Description**
Line Trigger Mode	The state of the line trigger. If the trigger is off, then the line trigger is internally generated otherwise it is caused by an external signal
Line Trigger Source	The external line that causes a line trigger.The line trigger is from GPIO_PIN0. This feature is available only when Line Trigger Mode in set to On.
Line Trigger Activation	Specifies what type of signal(i.e. high, or low) causes a line trigger if Line Trigger Mode is On.
External Line Trigger Frequency	Reads the external line trigger frequency. NOTE: The camera cannot detect frequency less than 5 Hz and will display 1 if it cannot detect a signal. This featuer is available when the Line Trigger Mode is se to ON and Sensor Direction Control is set to External
Read External Line Frequency	Read the external line trigger frequency and updates the ExternalLineTriggerFrequency register. This feature is available when the Line Trigger Mode is set to On.

Input / Output Control

CamExpert groups the camera I / O Controls Parameters in either the Inputs group or the Outputs. These parameters allow configuring the Spyder3 inputs and outputs for type of signal and signal polarity.

GigE Vision Input Controls

Inputs Group	
This group contains the features that allow the configuration of the camera physical input lines (pins)	
Parameter	**Description**
Line Selector	This feature selects which physical line (or pin) of the external device connector to configure. When a Line is selected, all the other Line features will be applied to its associated I/O control block and will condition the resulting input or output signal. Line0-- Line Trigger, Line1-- Frame Trigger, Line2 -- Direction.

	If rotary encoder is used, Line0 -- Phase A , Line2 -- Phase B
Line Format	This feature returns or sets (if possible) the current electrical format of the selected physical input Line: No connect, TTL, LVDS
Line Connector Pin	Enumeration of the physical line (or pin) on the device connector. This feature is not available when Line Format is set to Not Connected and when Line Selector is set to a line smaller than Line2
Line Function	Displays the line function
Line Debounce Factor	This feature control the minimum period of a input line transition before detecting a signal transition.

Outputs Group	
Parameter	**Description**
Output Selector	This feature selects which physical line (or pin) of the external device connector to configure. When a Line is selected, all the other Line features will be applied to its associated I / O control block and will condition the resulting input or output signal. Line0 outputs signals at PLC_Q0; Line1 outputs signals at PLC_Q1; Line2 outputs signals at PLC_Q2; Line3 outputs signals at PLC_Q3.
Output Format	This feature returns or sets (if possible) the current electrical format of the selected physical output Line: No Connect, TTL, or LVDS

Gain, Black Level, and Background

The cameras provide gain and black level adjustments in the digital domain for the sensor. The gain and black level controls can make small compensations to the acquisition in situations where lighting varies and the lens iris cannot be easily adjusted. The user can evaluate gain and black level using CamExpert.

The parameters that control gain, black level, and background are grouped together in the Analog Controls set.

Note that calibrating the gain can take up to 10 seconds. Adjust the GUI's timeout values (in the Advanced Processing set) accordingly.

A section describing camera calibration in detail is available later in this manual.

GigE Vision Input Controls

Analog Controls	
Parameter	**Description**
Gain Selector	Select the channel to control the gain for All digital channels of taps
Analog Gain (dB)	Set the gain as an amplification factor applied to the video signal -10 dB to +10 dB
Black Level Selector	Select which black level is controlled by the black level parameters.

Black Level	Control the analog black level offset as an absolute physical value.
Digital Gain (DN)	Sets the digital system gain control.
Digital Gain (dB)	Digital gain amplification in dB for a specified tap.
Digital Offset Selector	Tap selector. Select the tap to apply the digital offset.
Digital Offset (DN)	The digital offset enables the subtraction of the artificial A/ D offset (the analog offset) so that application of the PRNU coefficient does not result in artifacts at low light levels due to the offset value.
Background Subtract Selector	Tap selector. Select which tap to apply the background subtract.
Background Subtract (DN)	Used to increase image contrast after FPN and PRNU calibration. Subtract a background value from the digitized image data (in DN).

Table 11: Gain Range by Camera Model

	1K /2K Cameras	4K Cameras
Analog Gain	-10 dB to +10 dB Calibrated 0 dB (default)	Not available in GigE Calibrated -10 dB (default)
Digital Gain	4096 (0 dB)(default) to 65535 (> 20 dB)	4096 (0 dB) - 12953 (+10 dB) (default)

Image Size

To set the height of the image, and therefore the number of lines to scan and transmit, use the parameters grouped under the Image Format Control set.

GigE Vision Input Controls

Image Format Control	
Parameter	**Description**
Maximum Image Width	This feature represents the maximum width (in pixels) of the image after horizontal binning, decimation or any other function changing the horizontal dimensions of the image. Default width: size of the sensor.
Image Width	Current width of the image / area of interest (in pixels). This value is dependent on the horizontal binning and maximum width values. Default size width: size of the sensor.
Image Height	Actual image height in active image pixels. Default height: 480 pixels. Maximum height: 16, 383 pixels.
Image Offset	Image start position (in pixels). The horizontal offset from the origin to the AOI (in pixels). Default offset: 0.

Image Flip Horizontal	This feature is used to flip horizontally the image sent by the device. Default value: not flipped.

Pixel Format

Use the Pixel Format feature found in the **Image Format Control** set to select the format of the pixel to use during image acquisition as either Mono 8 or Mono 12 bit depth.

GigE Vision Input Controls

Image Format Control	
Parameter	**Description**
Pixel Format	Mono 8 Mono 12

Sensitivity Mode

To set the sensitivity mode use the **Sensitivity Mode** feature found as part of the **Image Format Control** set. When using high sensitivity mode, the cameras responsivity increases. High sensitivity mode permits much greater scanning speeds in low light. It can also allow for reduced lighting levels. The available modes are: Low, High, and Tall.

More description and examples of the sensititivy mode can be found in the Appendix.

GigE Vision Input Controls

Image Format Control	
Parameter	**Description**
Sensitivity Mode	High Low Tall

Sensor Direction Control

Found in the **I / O Control** > **Direction Control** set of features. Note: This feature is available when in high sensitivity mode only.

Note: the **Sensor Shift** features are not available when the camera is in low or tall pixel sensitivity modes.

GigE Vision Input Controls

Direction Control	
Parameter	**Description**
Sensor Scan Direction	When in high sensitivity mode, selects the forward or reverse CCD shift direction or external direction control. This accommodates object direction change on a web and allows you to mount the camera "upside down"
Sensor Shift External Direction	The current sensor shift direction when the direction is

	externally controlled. This feature is only available wne sensorScanDirection is set to External.
Read Sensor Shift Direction	Read current direction of the external signal that controls the sensor shift direction. This feature is available only when sensorScanDirection is set to External.

Sensor Shift Direction

When in high sensitivity mode, you can select either forward or reverse CCD shift direction. Selectable direction accommodates object direction change on a web and allows you to mount the camera "upside down".

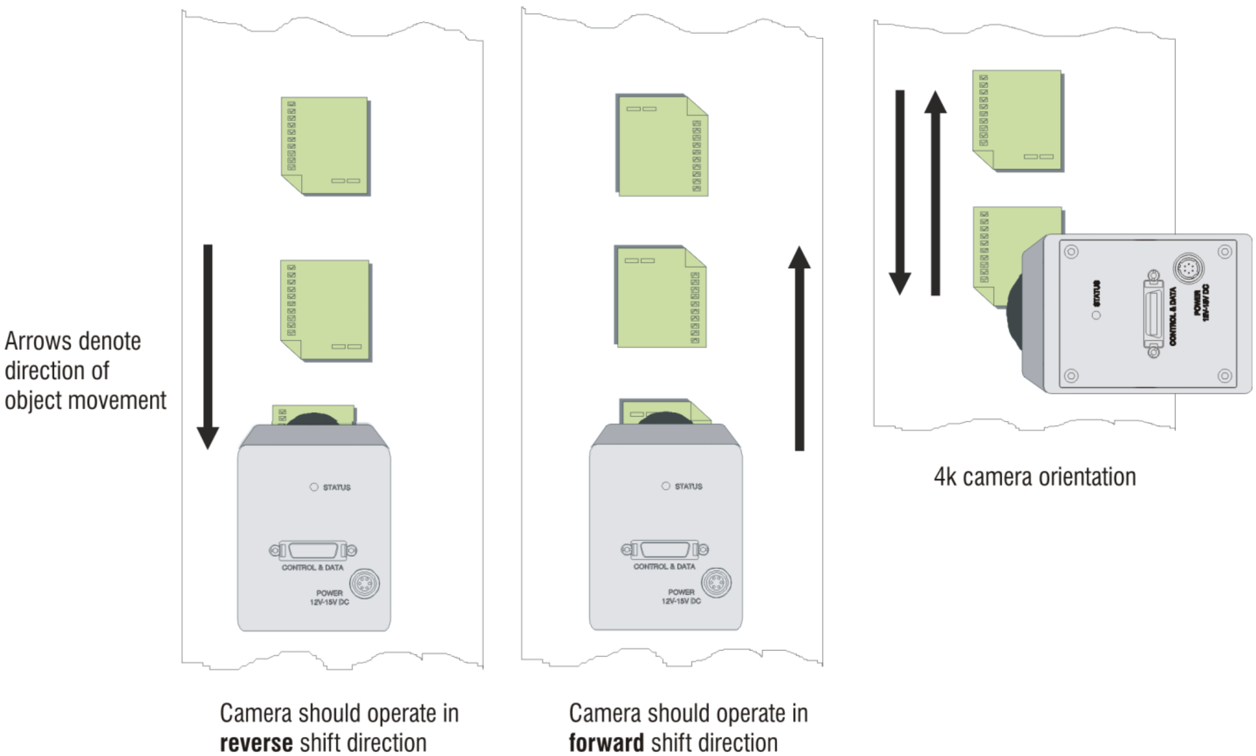


Figure 23: Object Movement and Camera Direction Example using an Inverting Lens

Binning

Binning is the combining of two or more image sensor pixels to form a new combined pixel prior to readout or digitizing. A binned image using the same exposure settings as a non-binned image will show an improved signal-to-noise ratio, reduced scanning times (due to lower spatial resolution) and save as a smaller image file size compared with a non-binned image, at the expense of lower image resolution.

For this camera, the default binning value is 2 x 2, 4 physical pixels on the sensor are combined into one image pixel. This operating mode is ideal for applications that require faster acquisition and processing times and require greater signal collection.

The **Binning Horizontal** feature in the **Image Format Control** set represents the number of horizontal pixels that will be combined (added) together.

GigE Vision Input Controls

Image Format Control	
Parameter	**Description**
Binning Horizontal	This feature represents the number of horizontal photo-sensitive cells that must be combined (added) together. Update the SensorWidth, Width and OffsetX registers when changing this value.

Resetting the Camera

The feature **Camera Reset**, part of the **Camera Information** set, resets the camera.

The camera resets with the last saved settings and the baud rate used before the reset. Previously saved pixel coefficients are also restored.

GigE Vision Input Controls

Camera Information	
Parameter	**Description**
Camera Reset	Reset the camera and put it in its power-up state (either with the default factory settings or with saved user settings).

Camera Calibration

Processing Chain Overview and Description

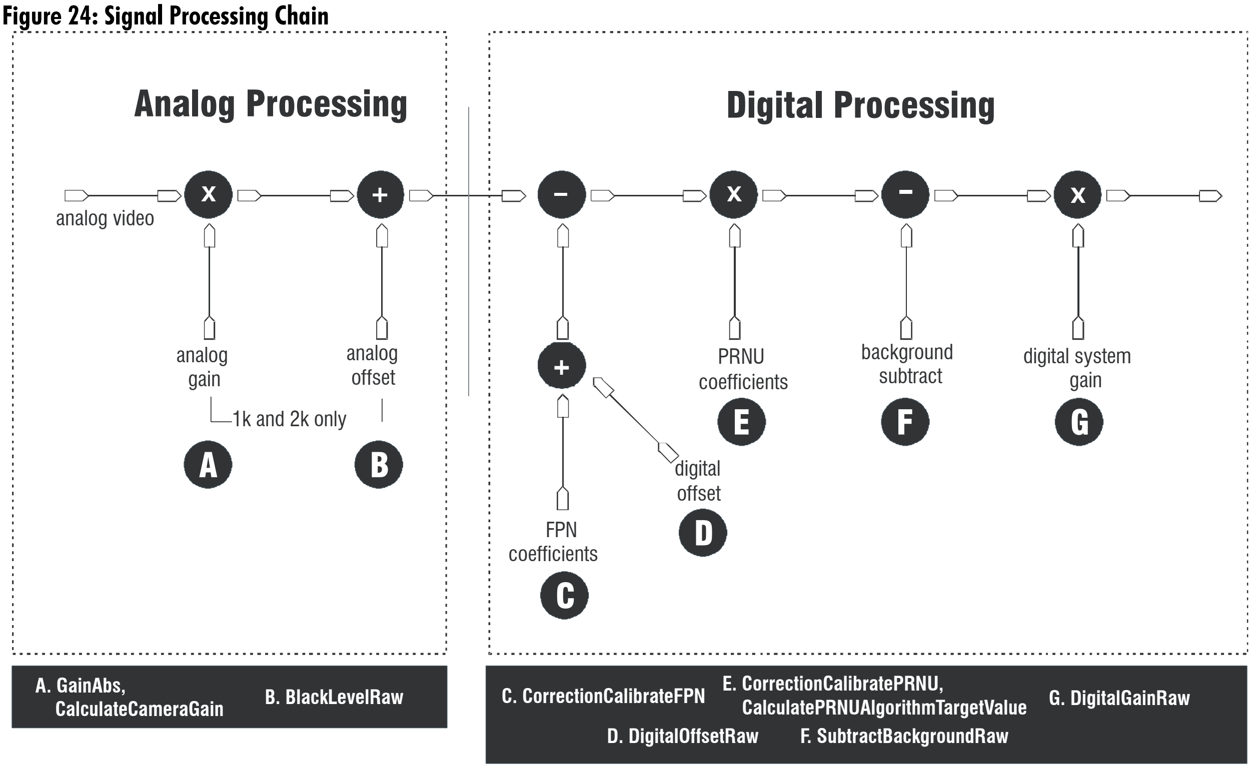
The following diagram shows a simplified block diagram of the camera's analog and digital processing chain.

The analog processing chain begins with an analog gain adjustment, followed by an analog offset adjustment. These adjustments are applied to the video analog signal prior to its digitization by an A/D converter.

The digital processing chain contains the FPN correction, the PRNU correction, the background subtract, and the digital gain and offset.

All of these elements are user programmable and most are members of the **Analog Controls** and **Data Processing** sets.

Figure 24: Signal Processing Chain



Analog Processing

Optimizing offset performance and gain in the analog domain lets you achieve a better signal-to-noise ratio and dynamic range than you would achieve by trying to optimize the offset in the digital domain only. Therefore, you should perform all analog adjustments prior to any digital adjustments.

1. Analog gain (the **Gain (dB)** or **Calibrate Gain Target** parameters in the **Analog Controls** set) is multiplied by the analog signal to increase the signal strength before the A/D conversion. It is used to take advantage of the full dynamic range of the A/D converter. For example, in a low light situation the brightest part of the image may be consistently coming in at only 50% of the DN. An analog gain of 6 dB (2x) will ensure full use of the dynamic range of the A/D converter. Of course the noise is also increased.
2. The analog offset or black level (**Black Level (DN)** command) is an "artificial" offset introduced into the video path to ensure that the A/D is functioning properly. The analog offset should be set so that it is at least 3 times the rms noise value at the current gain.

Digital Processing

To optimize camera performance, digital signal processing should be completed after any analog adjustments.

1. Fixed pattern noise (FPN) calibration (calculated using the **Calibrate FPN** parameter) is used to subtract away individual pixel dark current.
2. The digital offset (**Digital Offset (DN)** parameter) enables the subtraction of the "artificial" A/D offset (the analog offset) so that application of the PRNU coefficient does not result in artifacts at low light levels due to the offset value. You may want to set the **Digital Offset (DN)** value if you are not using FPN correction but want to perform PRNU correction.
3. Photo-Response Non-Uniformity (PRNU) coefficients (calculated using the **PRNU Target** and **Calibrate PRNU,** or **PRNU Calibration Algorithm Selector** parameters in the **Data Processing** family) are used to correct the difference in responsivity of individual pixels (i.e. given the same amount of light different pixels will charge up at different rates) and the change in light intensity across the image either because of the light source or due to optical aberrations (e.g. there may be more light in the center of the image). PRNU coefficients are multipliers and are defined to be of a value greater than or equal to 1. This ensures that all pixels will saturate together.
4. Background subtract (**Background Subtract (DN)** parameter) and system (digital) gain (**Digital Gain (DN)** parameter) are used to increase image contrast after FPN and PRNU calibration. It is useful for systems that process 8-bit data but want to take advantage of the camera's 12 bit digital processing chain. For example, if you find that your image is consistently between 128 and 255DN (8 bit), you can subtract off 128 (**Background Subtract (DN) 2048**) and then multiply by 2 (**Digital Gain (DN) 8192**) to get an output range from 0 to 255.

Analog Gain and Offset Adjustment

Optimizing offset performance and gain in the analog domain allows you to achieve a better signal-to-noise ratio (dynamic range). All analog signal processing chain commands should be performed prior to FPN and PRNU calibration and prior to digital signal processing commands.

Set Analog Gain

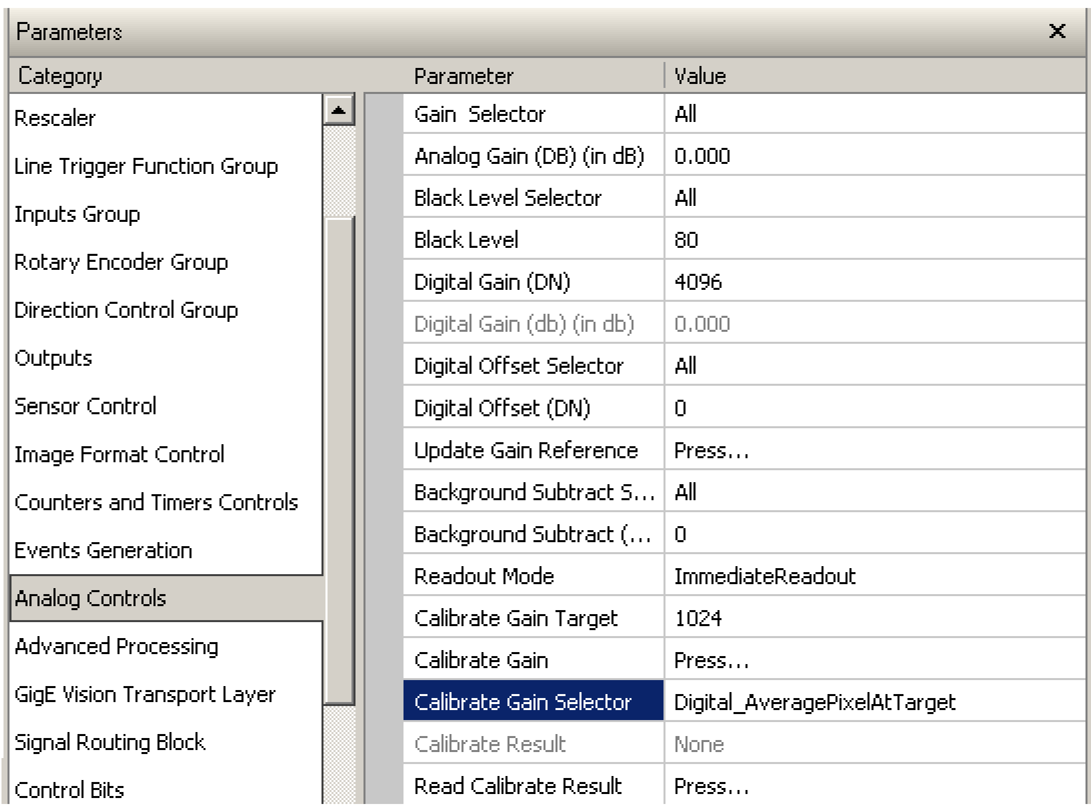
Analog gain is multiplied by the analog signal to increase the signal strength before the A/ D conversion. It is used to take advantage of the full dynamic range of the A/ D converter.

The **Analog Controls** > **Gain Selector** feature selects the tap to apply the gain value to. The **Gain (dB)** feature is then used to apply a gain value in a range from -10 dB to +10 dB.

Note: This feature is not available on the 4k camera model.

Calibrate Camera Gain

Instead of manually setting the analog gain to a specific value, the camera can determine appropriate gain values. This command calculates and sets the analog gain according to the algorithm determined by the first parameter using the **Calibrate Gain Selector** feature. This feature is not available for the SG-14-04K80 cameras.



Calibration algorithm to use:

Analog 8 to 13 Percent Above Target = This algorithm adjusts analog gain so that 8% to 13% of tap region of interest (ROI) pixels are above the specified target value (i.e. **Calibrate Gain Target Value**).

Analog Average Pixel at Target = This algorithm adjusts analog gain so that the average pixel value in tap's ROI is equal to the specified target value (i.e. **Calibrate Gain Target Value**).

Digital Average Pixel at Target = This algorithm adjusts digital gain so that the average pixel value in tap's ROI is equal to the specified target (i.e. **Calibrate Gain Target Value**).

Analog Peak Pixel a Target = This algorithm adjusts the analog gain so that the peak tap ROI pixels are adjusted to the specified target (i.e. **Calibrate Gain Target**).

Calibrate Gain Target. Calculation target in a range from 25% to 99% of raw DN (1024 to 4055 DN), 12 bit LSB.

Calibration Returns:

1. Success
2. Outside of specification > Analog gain set outside ±10 dB
3. Clipped to min > Analog gain set 0, (which may be below -10 dB) or System gain set to 0.
4. Clipped to max > Analog gain set to 1023, (which may be above +10 dB) or System gain set to 65,535 (16x).
5. Timeout > FPGA did not return new end of line statistics

Notes:

- This function requires constant light input while executing.
- If very few tap pixels are within the ROI, gain calculation may not be optimal.
- When all taps are selected, taps outside of the ROI are set to the average gain of the taps that are within the ROI.
- Perform analog gain algorithms before performing FPN and PRNU calibration.
- All digital settings affect the analog gain calibration. If you do not want the digital processing to have any effect on the camera gain calibration, then turn off all digital settings by sending the commands: DigitalOffsetRaw 0, EnablePixelCoefficients 0, SubtractBackgroundRaw 0, and DigitalGainRaw 4096

Please note: only the "Digital Average Pixel at Target" algorithm is available on 4k models.

Also note: the Calibrate Gain Selector command can take up to 10 seconds. Please adjust the GUI's timeout values (in the Advanced Processing set) accordingly.

Set Analog Offset (Black Level)

Sets the analog offset. The analog offset should be set so that it is at least 3 times the rms noise value at the current gain. The analog offset is configured for the noise at the maximum specified gain and as a result you should not need to adjust the analog offset.

The Black Level Selector parameter selects which tap is selected: All, Tap1, or Tap2. Followed by using the **Black Level (DN)** feature to select an offset value in a range from `0` to `255` DN (12 bit LSB).

Update Analog Gain Reference

The **Update Gain Reference** feature sets the current analog gain setting to be the 0 dB point. This is useful after tap gain matching allowing you to change the gain on all taps by the same amount.

Calibrate the Camera to Remove Non-Uniformity (Flat Field Correction)

Calibration Overview

When a camera images a uniformly lit field, ideally, all of the pixels will have the same gray value. However, in practice, this is rarely the case (see example below) as a number of factors can contribute to gray scale non-uniformity in an image: Lighting non-uniformities and lens distortion, PRNU (pixel response non-uniformity) in the imager, FPN (fixed pattern noise) in the imager, etc.

Figure 25. Image with non-uniformities

By calibrating the camera you can eliminate the small gain difference between pixels and compensate for light distortion. This calibration employs a two-point correction that is applied to the raw value of each pixel so that non-uniformities are flattened out. The response of each pixel will appear to be virtually identical to that of all the other pixels of the sensor for an equal amount of exposure.

Correction Overview

This camera has the ability to calculate correction coefficients in order to remove non-uniformity in the image. This video correction operates on a pixel-by-pixel basis and implements a two point correction for each pixel. This correction can reduce or eliminate image distortion caused by the following factors:

- Fixed Pattern Noise (FPN)
- Photo Response Non Uniformity (PRNU)
- Lens and light source non-uniformity

Correction is implemented such that for each pixel:

$$V_{output} = [(V_{input} - \text{FPN (pixel)} - \text{digital offset}) * \text{PRNU (pixel)} - \text{Background Subtract}] \times \text{System Gain}$$

where	V_{output}	=	digital output pixel value
	V_{input}	=	digital input pixel value from the CCD
	PRNU (pixel)	=	PRNU correction coefficient for this pixel
	FPN (pixel)	=	FPN correction coefficient for this pixel
	Background Subtract	=	background subtract value
	System Gain	=	digital gain value

The algorithm is performed in two steps. The fixed offset (FPN) is determined first by performing a calibration without any light. This calibration determines exactly how much offset to subtract per pixel in order to obtain flat output when the CCD is not exposed.

The white light calibration is performed next to determine the multiplication factors required to bring each pixel to the required value (target) for flat, white output. Video output is set slightly above the brightest pixel (depending on offset subtracted).

Flat Field Correction Restrictions

It is important to do the FPN correction first. Results of the FPN correction are used in the PRNU procedure. We recommend that you repeat the correction when a temperature change greater than 10°C occurs or if you change the analog gain, integration time, or line rate.

PRNU correction requires a clean, white reference. The quality of this reference is important for proper calibration. White paper is often not sufficient because the grain in the white paper will distort the correction. White plastic or white ceramic will lead to better balancing.

Note: If your illumination or white reference does not extend the full field of view of the camera, the camera will send a warning.

For best results, ensure that:

- 50 or 60 Hz ambient light flicker is sufficiently low not to affect camera performance and calibration results.
- For best results, the analog gain should be adjusted for the expected operating conditions and the ratio of the brightest to darkest pixel in a tap should be less than 3 to 1 where:

$$3 > \frac{\text{Brightest Pixel (per tap)}}{\text{Darkest Pixel (per tap)}}$$

- The camera is capable of operating under a range of 8 to 1, but will clip values larger than this ratio.

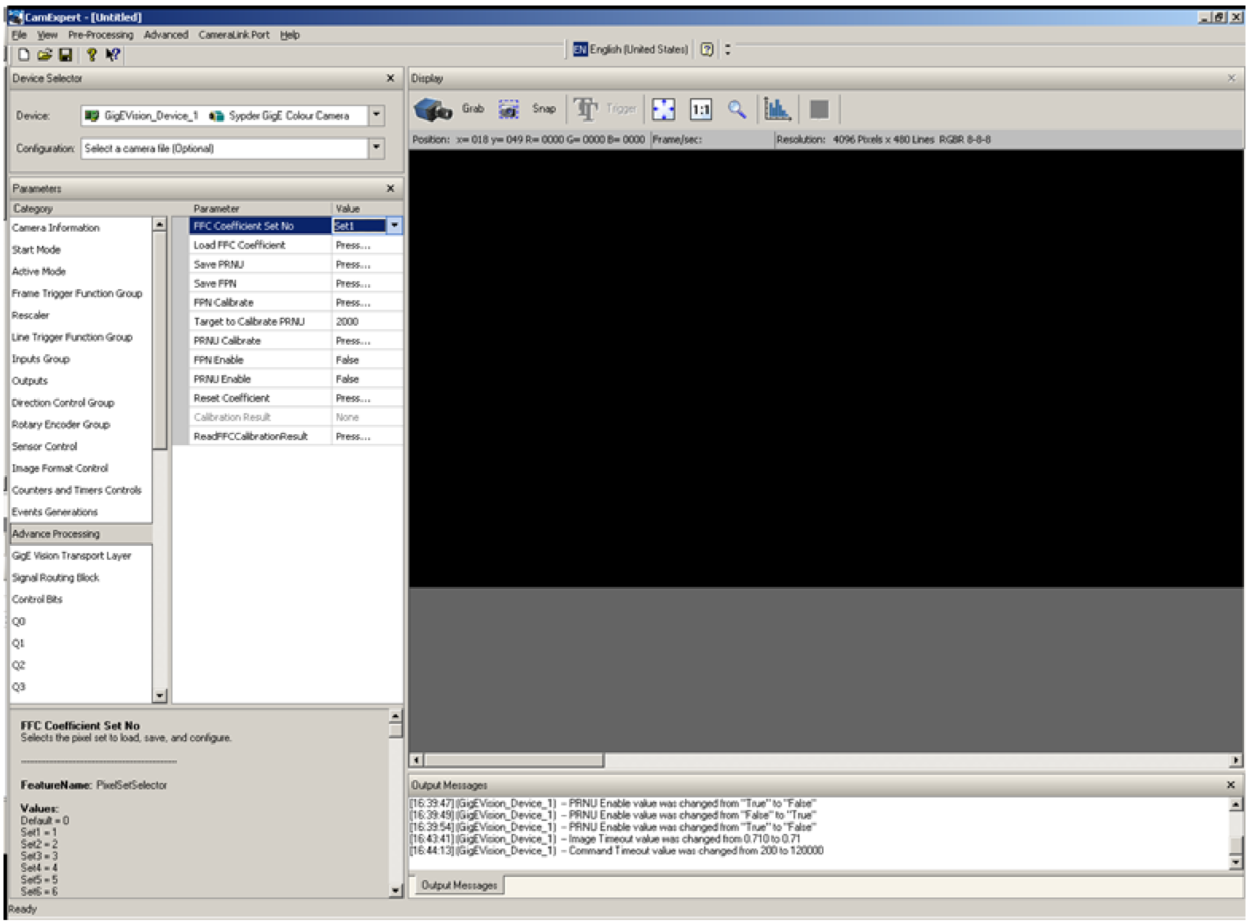
- The brightest pixel should be slightly below the target output.
- When 6.25% of pixels from a single row within the region of interest are clipped, flat field correction results may be inaccurate.
- Correction results are valid only for the current analog gain and offset values. If you change these values, it is recommended that you recalculate your coefficients.

Digital Signal Processing

To optimize camera performance, digital signal processing should be completed after any analog adjustments.

The FPN and PRNU calibration parameters are available as members of the Advanced Processing set and are only available to Guru users.

Figure 26. Advanced Processing / Calibration Parameters



GigE Vision Input Controls

Advanced Processing	
Parameter	**Description**
FFC Coefficient Set No.	Selects the pixel set to load, or save. There are 4 user sets available.
Load FFC Coefficient	Loads the Flat Field Correction Coefficients (specified by the Pixel Set Selector) from the cameras non-volatile memory.
Reset FFC Coefficients	Restores the cameras pixel coefficients to 0 for FPN and a PRNU factor of 1. This command does not reset saved coefficients.
Save PRNU	Write all current PRNU coefficients to non-volatile memory when Pixel Set Selector is not Default
Save FPN	Write all current FPN coefficients to non-volatile memory when Pixel Set Selector is not Default
FPN Calibrate	Perform a Fixed Pattern Noise calibration. Please block all light from entering the camera(i.e. cover the lens). *** WARNING: This command can take up to 3 seconds. Please adjust the GUI's timeout values
Target to Calibrate PRNU	The target value for the PRNU calibration algorithm
PRNU Calibrate	Calibrate PRNU coefficients. Ideally FPN calibration should be done before the PRNU calibration. To calibration PRNU, the direction must not be External. Always set proper target before click this button. *** WARNING: This command can take up to 15 seconds.
FPN Enable	Enables and disables the fixed pattern noise correction
PRNU Enable	Enables and disables the photo response non-uniformity correction
Calibration Result	Displays the result from the flat field calibration.
Read FFC Calibration Result	Read FFC Calibrate Result
Region of Interest X	The horizontal start of the region of interest. The region of interest is used specify which part of the sensor to calibrate.
Region of Interest Width	The width of the region of interest. The region of interest is used specify which part of the sensor to calibrate

Step 1: Prepare for Calibration

For best results, the camera should be setup for calibration with similar conditions as to those in which it will be used. For example, data mode, exposure times and line rates, scan direction, etc.

Step 2: FPN Calibration

Note that you do not need to turn off the FPN and PRNU coefficients before calibrating, the camera will do this automatically.

1. Stop all light from entering the camera. The best way to do this is to put on lens cap.
2. Calibrate FPN using the **FPN Calibrate** command.
3. Use the **Read FFC Calibration Result** parameter to determine if your calibration was a success or not.
4. To save the calibrated FPN coefficients to the FFC coefficient set shown, use the **Set FPN Save** parameter.

Step 3: PRNU Calibration: White Calibration

Performs PRNU calibration to user entered value and eliminates the difference in responsivity between the most and least sensitive pixel creating a uniform response to light. Using this command, you must provide a calibration target.

Executing these algorithms causes the **Background Subtract Raw** value to be set to 0 (no background subtraction) and the **Digital Gain Raw** value to 4096 (unity digital gain). The pixel coefficients are disabled (**Pixel Set Load 0**) during the algorithm execution but returned to the state they were prior to command execution.

1. Remove the lens cap and prepare a white, uniform target.
2. Adjust the line rate so that the average output is about 80% of the full output by: adjusting the lighting, if you are using an internal exposure mode. Or, adjust the line rate, if you are using the Smart Exsync mode.
3. Set the PRNU target value using the **Target to Calibrate PRNU** command. The target value (always counted as 12-bit) and is 1024 to 4055 DN. For example, if you want to set the target to 255 x 80% = 204 DN in 8-bit mode, then the target value is (204/ 255) x 4096 = 3277 DN in 8-bit mode. Therefore, you can set the target to 3300 DN: Target to Calibrate PRNU is 3300.
4. Calibrate the PRNU using the **PRNU Calibrate** command**.**
5. Use the **Read FFC Calibration Result** parameter to determine if your calibration was a success or not—see the belowfor the possible results.
6. To save the calibrated PRNU coefficients to the FCC coefficient set shown, use the **Set PRNU Save** parameter.
7. After the above command is completed, both the FPN and PRNU coefficients are automatically turned on.

PRNU Calibration Results

Success

PRNU calibration was successful.

Greater_than_1_percent_clipped

Greater than 1 % of PRNU coefficients have been calculated to be greater than the maximum allowable 8 or less than 1 (which will happen if the target is less than the maximum pixel output).

Timeout

FPGA did not return end-of-line statistics or video line.

Setting Digital Offset

The digital offset is set to zero when you perform FPN correction (**Enable FPN** feature). If you are unable to perform FPN correction, you can partially remove FPN by adjusting the digital offset.

Use the **Digital Offset Selector** to select the taps, and the **Digital Offset (DN)** parameter to choose the subtracted offset value in a range from 0 to 2048.

Subtracting Background

Use the **Background Subtract** features after performing flat field correction if you want to improve your image in a low contrast scene. It is useful for systems that process 8 bit data but want to take advantage of the camera's 12 bit digital processing chain. You should try to make your darkest pixel in the scene equal to zero.

Background Subtract Selector to select taps and Background Subtract (DN) to subtract a value in a range from **0** to **4095 DN.**

Setting Digital System Gain

Improve the signal output swing after a background subtract. When subtracting a digital value from the digital video signal, using the `Background Subtract DN` feature, the output can no longer reach its maximum.

Use this command to correct for this where:

$$\text{Digital Gain (DN)} = \frac{\text{max output value}}{\text{max output value - Background Subtract value}}$$

Gain Selector: Tap selection. Digital Gain Raw: Gain setting. The gain ranges are **0** to **65535**. The digital video values are multiplied by this value where:

$$\text{Digital Gain (DN)} = \frac{i}{4096}$$

Use this command in conjunction with the **Background Subtract Raw** command.

4k model limited to 12953 (0 dB effective at factory set analog gain of -10 dB).

Appendix A: Clear Dark Current

Gate Dark Current Clear

Image sensors accumulate dark current while they wait for a trigger signal. If the readout is not triggered in a reasonable amount of time, then this dark current accumulation may increase to an excessive amount. The result of this happening will be that the first row, and possibly additional rows (frames), of the image will be corrupt.

The sensor used in this camera contains two sources of dark current that will accumulate with time: 1) in the photo sensitive area, and 2) in the gates used to clock-out the charge.

The gate dark current can account for approximately 20% of the total dark current present. While the exposure control has direct control over the amount of dark current in the photo sensitive area, it has no control over the charge accumulated in the gates. Even with exposure control on, at low line rates, this gate charge can cause the camera to saturate.

Using the `Set Readout Mode (srm)` command, the camera user can control the camera's behavior in order to minimize the dark current artifact.

The modes of operation selected by the `srm` command are: Auto, On, or Off.

Note: When auto clear is ON in the HS, dual line mode, the leading TDI stage is transferred separately and stored in the camera memory. TDI summing is recreated by adding stored data to the trailing TDI stage in the camera processing chain. Due to digital summing, dark noise will increase by √2. A digital add will not increase dominant shot noise.

Auto Mode (srm 0)

Note: Teledyne DALSA recommends Auto mode for most users. In this mode the camera will automatically start and stop dark current clear, depending on line rate.

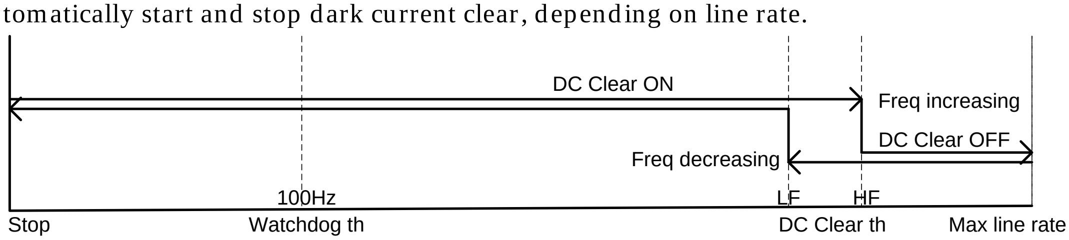


Figure 27: Gate Dark Current Clear in the Auto Mode.

To avoid corrupted lines due to jitter in External Trigger, the dark current clear switchover is controlled by hysteresis thresholds. Thresholds (LF and HF) are set to higher frequencies, 30-45% of the maximum line rate, so switchover will be transparent in an image.

However, if the external trigger frequency jumps back and forth over both thresholds in three consecutive lines, then a corrupted line will occur.

Threshold frequencies for each model are outlined in the tables below.

Table 12. Auto readout mode thresholds

HS Mode	Transition Frequencies (Hz)		
Model	**LF**	**HF**	Maximum Line Rate
SG-14-01K40-00-R	9818	11230	36000
SG-14-01K80-00-R	18149	20747	68000

SG-14-02K40-00-R	5113	5850	18500
SG-14-02K80-00-R	9821	11233	36000
SG-14-04K80-00-R	5113	5850	18500

LS and TP Mode	Transition Frequencies (kHz)		
Model	LF	HF	Maximum Line Rate
SG-14-01K40-00-R	13559	16407	36000
SG-14-01K80-00-R	25126	30395	68000
SG-14-02K40-00-R	7048	8529	18500
SG-14-02K80-00-R	13559	16407	36000
SG-14-04K80-00-R	7048	8529	18500

Immediate read out mode (default, srm 2)

In this mode the image is read out, including accumulated dark current, immediately following the trigger or the EXSYNC falling edge.
There are no line rate limitations other than the amount of gate dark current that can be tolerated at low line rates.
For information on artifacts that may be experienced while using this mode, see the Artifacts section below.
There are no timing or exposure anomalies other than situations where EXSYNC is removed from camera. In this case, the camera can be set to operate in a "watchdog" state.

The watchdog will start DC clear at frequencies = or < 10 Hz, where dark current is significant.
A small DN step will be visible in the image where the watchdog turns on and off.
The watchdog operates on the single threshold. If sync frequency is not in the sharp transition watchdog may cause corrupted lines crossing the threshold.

Gate dark current clear mode (always on, srm 1)

In this mode the gate dark current will be cleared continuously.
After the trigger (EXSYNC) is received, the dark current is cleared from the image sensor before the image is acquired. The line rate is limited to ½ the maximum line rate available for that model of camera.
For information on artifacts that may be experienced while using this mode, see the Artifacts section below.

Table 13.

	Max. Line Rate	
Model	Immediate Readout Mode	Dark Current Clear Mode
SG-14-01K40-00-R	36 KHz	18KHz
SG-14-01K80-00-R	68 KHz	34 KHz
SG-14-02K40-00-R	18.5KHz	9.25KHz
SG-14-02K80-00-R	36 KHz	18 KHz
SG-14-04K80-00-R	18.5KHz	9.25KHz

When operating in the dark current clear mode, there will be a slight delay, equivalent to one readout time, before the actual exposure is implemented. The actual exposure time will not be altered.

Table 14.

Model	Exposure Delay and Max Exposure Time in Auto Mode
SG-14-01K40-00-R	27.5 µs
SG-14-01K80-00-R	14.75 µs

SG-14-02K40-00-R	53.1µs
SG-14-02K80-00-R	27.5 µs
SG-14-04K80-00-R	53.1µs

Setting the Readout Mode

Use this command to control dark current in the vertical transfer gates.

Camera Link Command

Parameter	Description	Notes
srm	**0**: Auto. Clears dark current below ~ 30-45% of the maximum line rate **1**: Dark current clear. Always clears dark. Reduces the maximum line rate. **2**: Immediate readout. Does not clear dark current. (Default mode)	• The vertical transfer gates collect dark current during the line period. This collected current is added to the pixel charge. • If the user is in **sem 2** or **7** and **srm 2**, with **ssf** at 45% of the maximum (~ 30% in HS mode), and then srm 1 is selected, the following warning will be displayed, but the ssf value will not be changed: Warning 09: Internal line rate inconsistent with readout time> The effect in both internal and external line rate modes is that an EXSYNC is skipped and, therefore, the output will be at least twice as bright. • This value is saved with the camera settings. This value may be viewed using either the **gcp** command or the get **srm** command.
Example		
srm 0		

Appendix B: Sensitivity Mode

Sensitivity Mode and Pixel Readout

The camera has the option to operate in either high sensitivity or low sensitivity mode or in tall pixel mode.

When in high sensitivity mode, the camera uses both line scan sensors and its responsivity increases accordingly. When in low sensitivity mode, the camera uses the bottom sensor. When operating in tall pixel mode, the camera operates using both sensors, creating a 28µm x 14µm pixel.

High sensitivity mode permits much greater scanning speeds in low light. It can also allow for reduced lighting levels.

The sensitivity mode is software controlled through GigE-compliant interface using the **Sensitivity Mode** feature, part of the **Image Format Controls** set.

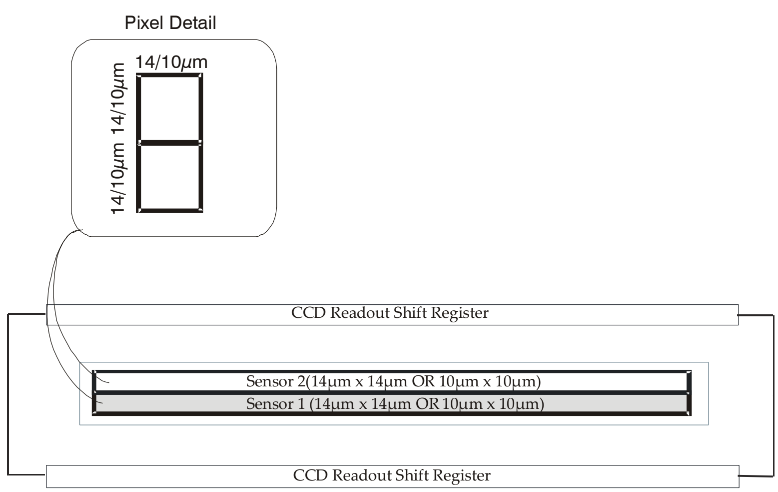


Figure 28: High Sensitivity Mode

In high sensitivity mode, the camera uses either a 14µm x 14µm pixel (1k and 2k models) or a 10µm x 10µm pixel (4k model) and captures the same image twice, resulting in a brighter image.

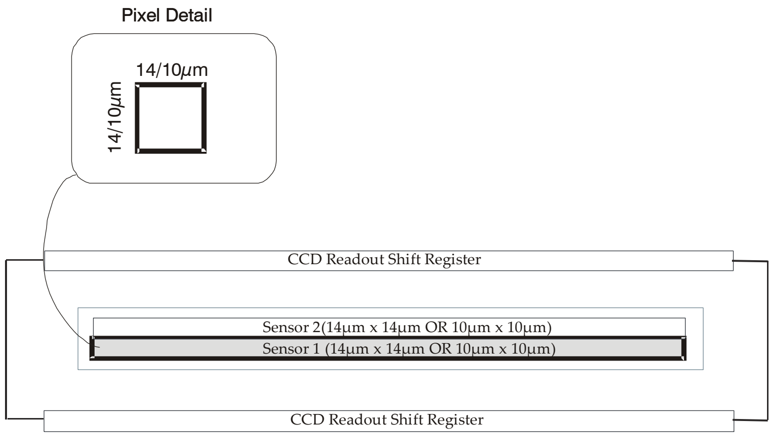


Figure 29: Low Sensitivity Mode

In low sensitivity mode, the camera uses either a 14 µm x 14 µm pixel (1k and 2k models) or a 10 µm x 10 µm pixel (4k model) and captures the image using one sensor (Sensor 1).

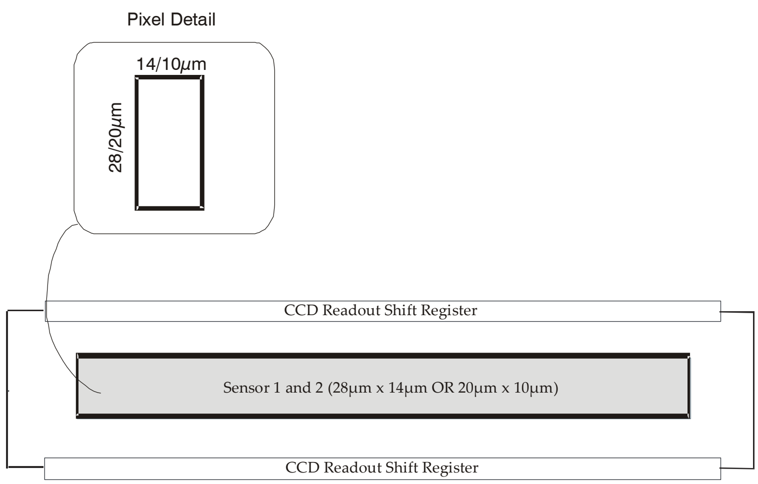


Figure 30: Tall Pixel Mode

In tall pixel mode, the camera uses a 28 µm x 14 µm pixel (1k and 2k) or a 20 µm x 10 µm pixel (4k model) and captures an image two times taller than in high or low sensitivity modes, resulting in a taller image.

Appendix C: GPIO Control

The camera's General Purpose Input / Output (GPIO) connector allows the camera to receive (and in some cases output) direct, real-time control signals that are independent from the Ethernet communications. For example, the GPIO connector can be used to control EXSYNC, PRIN (pixel reset), and direction signals.

You may want to use non-Ethernet control signals because Ethernet network protocols introduce a small but measurable and unpredictable lag that may not allow for extremely precise and reliable control of camera behavior, such as line rate, integration time, and readout direction.

In general, to configure the GPIO you need to accomplish three main tasks:

1. Assign a physical camera pin and signal to a GPIO Input number.
2. Map the GPIO Input or Output using the parameter commands located in the Line Trigger Function, Inputs, Outputs, Direction Control, and Sensor Control groups in the GUI. (Please note that this step has already been performed for the Beginner level scenarios described below.)
3. If you want to use applications other than those provided in the Beginner level examples, you can use the LUT programming language to map the GPIO Input Configuration to the GPIO Output Configuration in the Guru level.

Note: the screenshots presented in this section are from the CamExpert GUI. If you are using a different GUI the arrangement of the commands and parameters may be different.

GPIO Getting Started: Beginner Mode

NOTE: The following instructions are based on the default settings of the camera. Cameras are shipped from the factory in a default setting. Default settings are restored by loading the factory default (see Trigger Settings (GURU) for details).

The GPIO Connector

The GPIO connector is used to interface external signals in and out of the camera. The connector contains 15 pins that can configure 4 inputs and 4 outputs (See Figure 1 and Table 1). Three of the four inputs/ outputs (i.e. 0 to 2) can be configured as Off, LVDS (Low Voltage Differential Signal), or TTL (Transistor/ Transistor Logic). The remaining input and output (i.e. 3), can be configured as either Off or TTL.

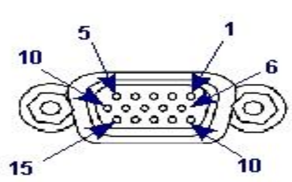


Figure 31: GPIO Pinout

Pin	Signal	Description
1	INPUT_ 0+	LVDS/ TTL format (positive)

Pin	Signal	Description
2	INPUT_0-	LVDS (negative)
3	INPUT_1+	LVDS/ TTL format (positive)
4	INPUT_1-	LVDS (negative)
5	GND	
6	INPUT_2+	LVDS/ TTL format (positive)
7	INPUT_2-	LVDS (negative)
8	INPUT_3	TTL auxiliary input
9	OUTPUT_3	TTL auxiliary output
10	OUTPUT_2+	LVDS/ TTL auxiliary output
11	OUTPUT_0+	LVDS/ TTL auxiliary output
12	OUTPUT_0-	LVDS (negative)
13	OUTPUT_1+	LVDS/ TTL auxiliary output
14	OUTPUT_1-	LVDS (negative)
15	OUTPUT_2-	LVDS (negative)

Table 15: GPIO Signals

Configure GPIO Signal Levels

Before using any external triggers, the input lines must be set to a proper signal level: either TTL (transistor-transistor logic) or LVDS (low-voltage differential signaling). The Spyder 3 GigE cameras hardwire 3 input lines that require signal level selection:

Line0 – line trigger or rotary encoder phase A input
Line1 - Frame trigger
Line2 – Direction control or rotary encoder phase B input

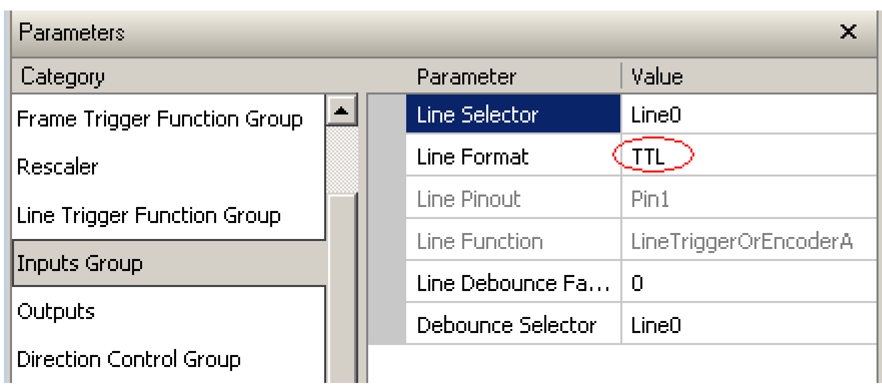


Figure 32: Inputs

Steps 1

Select the line: 0, 1, 2.

Steps 2

Select the corresponding signal format: TTL or LVDS.

This following section describes the steps required to run the camera in the available trigger modes. We start with free running mode.

Examples: Setting the Camera Modes

Free Run Mode: Internal Line Trigger, Internal Direction Control, Internal frame trigger

In the Line Trigger Function Group > set the parameter Line Trigger Mode value to Off,

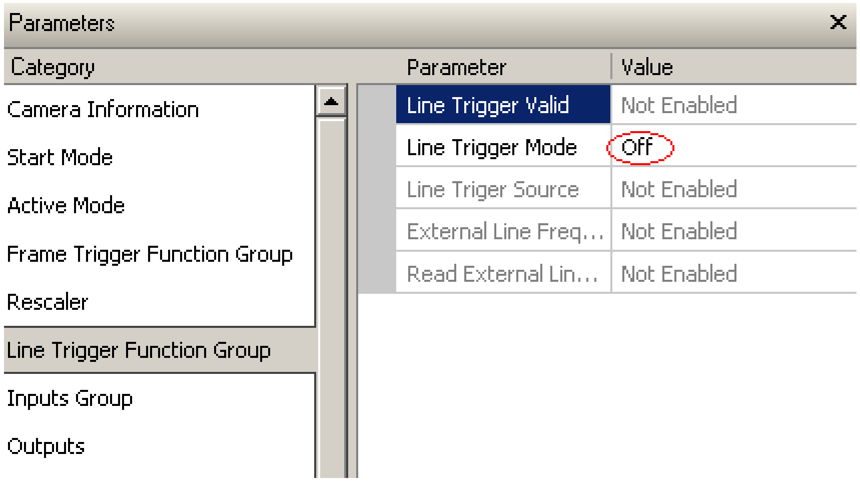


Figure 33: Line Trigger

In the Direction Control Group > set the parameter Sensor Scan Direction > to Forward or Reverse, depending on your application.

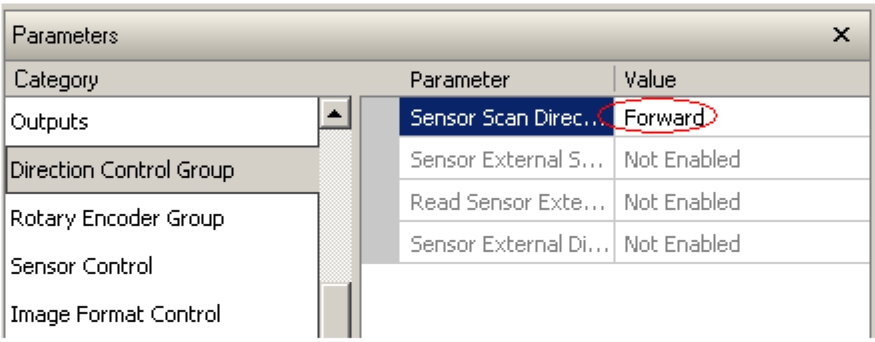


Figure 34: Scan Direction

In the Rotary Encoder Group > set the value to False.

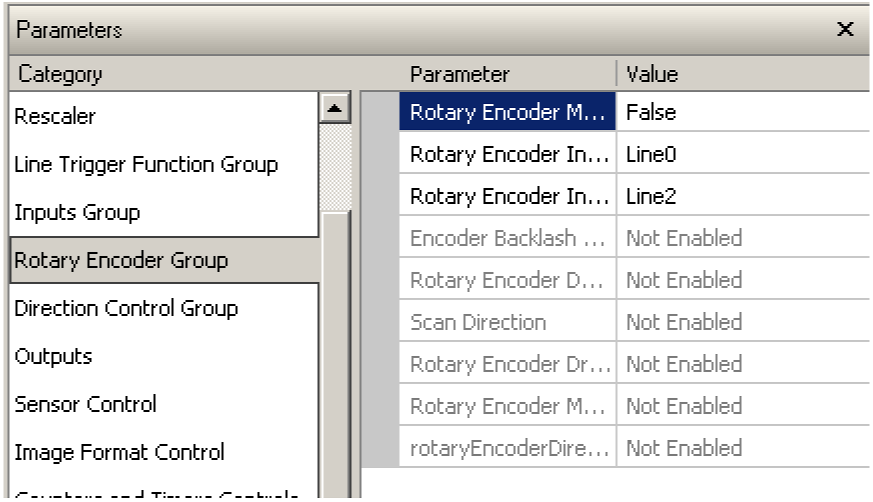


Figure 35: Rotary Encoder Group

In the Start Mode > set the Frame Start Trigger value Off.

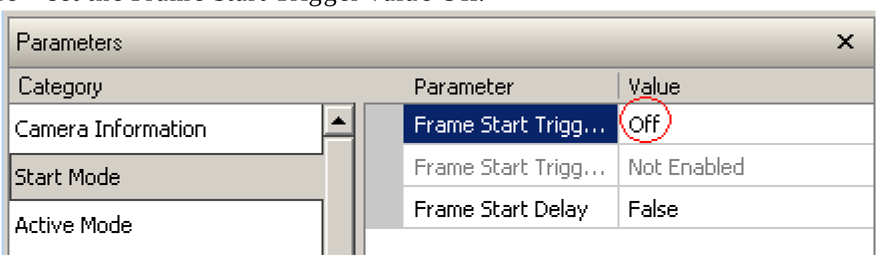


Figure 36: Start Mode

In the Active Mode > set the Frame Active Trigger value Off.

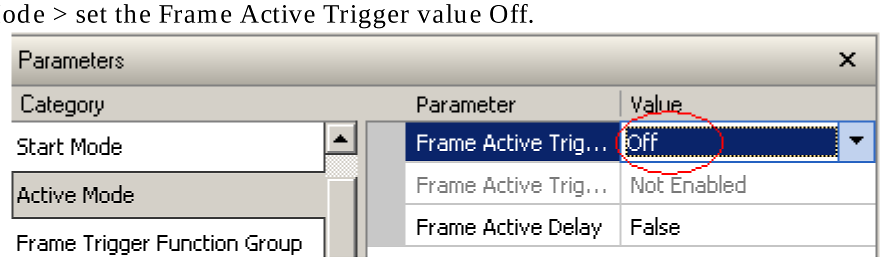


Figure 37: Active Mode

In the Sensor Control Group > set the desired exposure mode, exposure time and line rate.

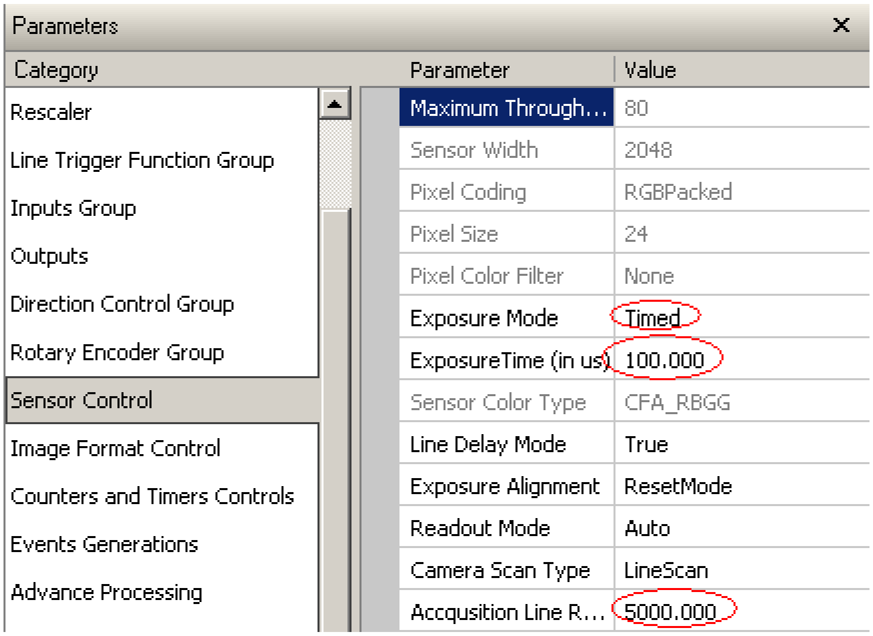


Figure 38: Exposure Mode, Time, and Line Rate Settings

Internal Line Trigger, External Direction Control, Internal frame trigger

Set the Frame Start Trigger and Frame Active Trigger values to off, as described above. Set the Line Trigger Mode value to Off and the Exposure Mode, Exposure Time and Line Rate as above.

In the Direction Control Group > set the Sensor Scan Direction to External.

Set the Input Direction Signal to Line 2 (as described at the start to this section).

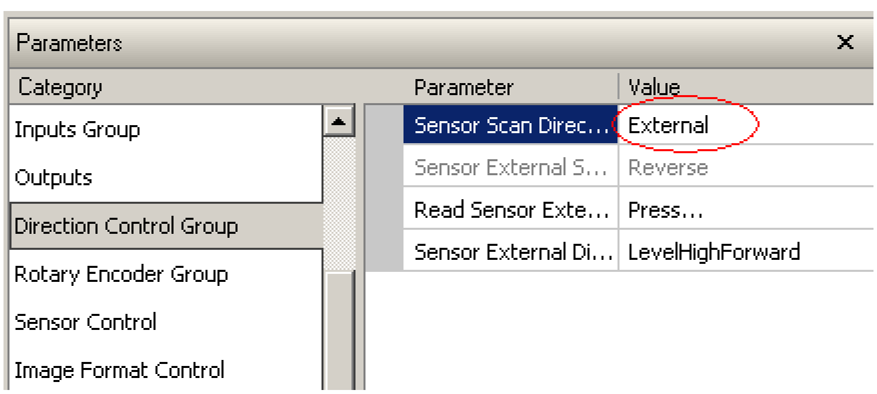


Figure 39: Scan Direction

External Line Trigger, Internal Direction Control, Internal frame trigger

In the Direction Control Group > set the parameter Sensor Scan Direction > to Forward or Reverse, depending on your application.
Set the Frame Start Trigger and Frame Active Trigger values to off, as described above.
In the Line Trigger Function Group > Set the Line Trigger Mode value to On.

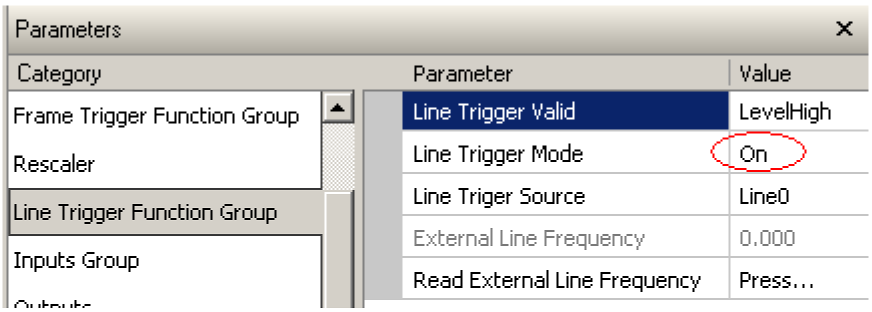


Figure 40: Line Trigger Mode

Set the Input Direction Signal to Line 0 (as described at the start to this section).

Verify the line frequency value by clicking the Read External Line Frequency parameter in the Line Trigger Function Group, as shown in the figure above.

If the rescaler is needed, set the rescaler as shown in the following figure:

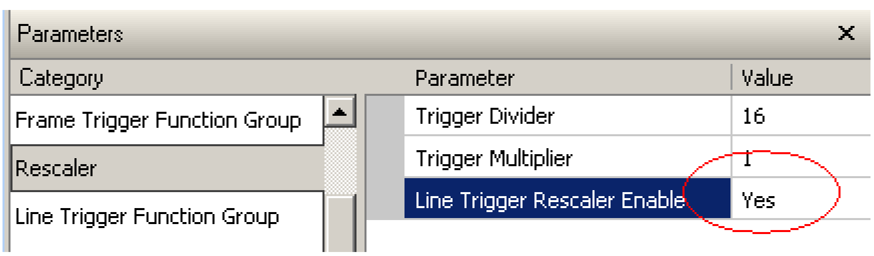


Figure 41: Rescaler

If the rescaler is enabled, the external line frequency will be modified using the Trigger Multiplier and Trigger Divider commands, as shown above. For details, please refer to the Rescaler section in the GURU section.

Note: the Trigger Multiplier takes the following three values only:
0 = frequency x 256
1 = frequency x 16
2 = frequency x 4096
For more information about the Rescaler, please refer to Rescaler in the GURU section.

External Line Trigger, External Direction Control from Rotary Encoder

Physically connect rotary Encoder phase A to pin1-5 if using TTL, or pin 1-2 if using LVDS, and phase B to pin 6-5 if using TTL, or pin6-7 if using LVDS.
In the Line Trigger Function Group > Set the Line Trigger Mode value to On.

Set Rotary Encoder Module to True.

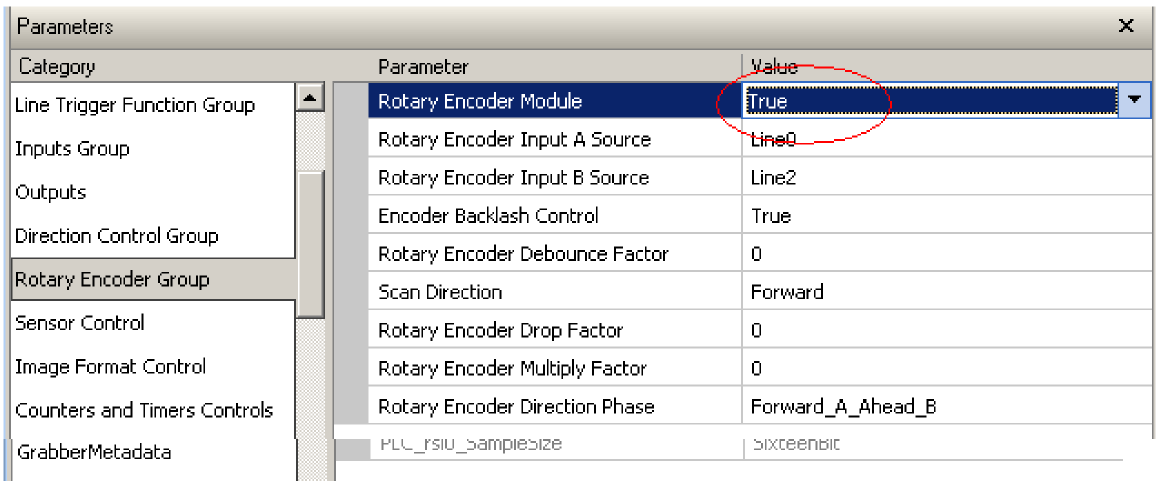


Figure 42: Rotary Encoder Module

Rescale the line trigger signal

The rotary encoder has its own built-in rescaler. Setting Rotary Encoder Multiply Factor to 0 produces an output frequency that is 4 times the rotary encoder output. To set the output to be the same as rotary encoder output, set the Rotary Encoder Multiply Factor to 1 and Rotary Encoder Drop Factor to 4.

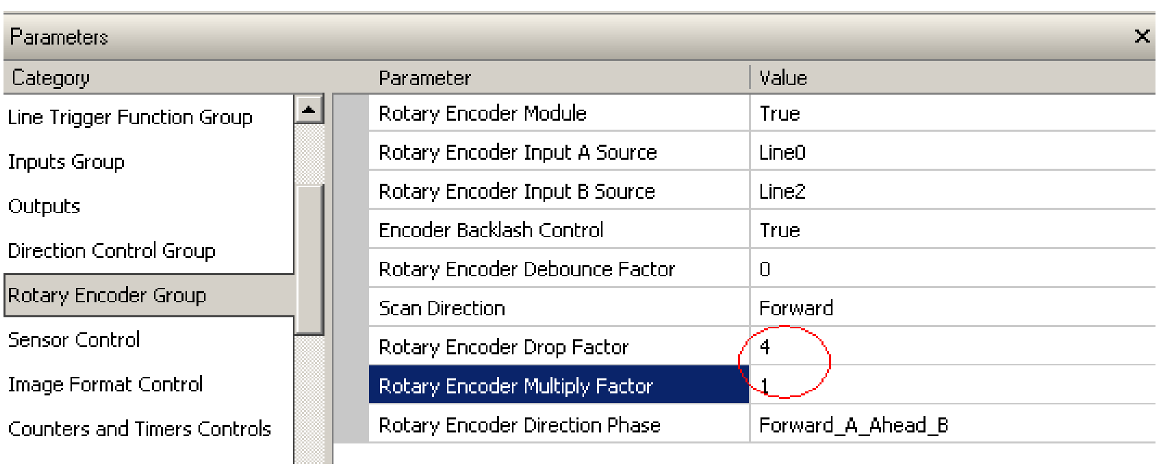


Figure 43: Rotary Encoder Multiply Factor

The forward and reverse direction is set by changing "Rotary Encoder Direction Phase".

Check the direction shown in the Direction Control Group to confirm the direction;

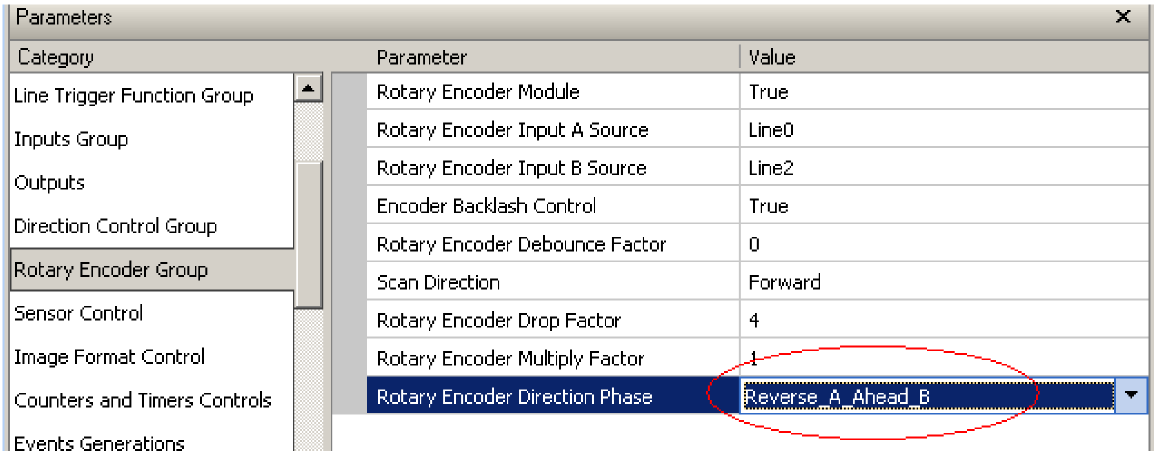


Figure 44: Rotary Encoder Direction Phase

In some situations, it is desirable to only respond to one direction, either forward or reverse, yEnable the Encoder Backlash Control function and the Scan Direction to desired direction.

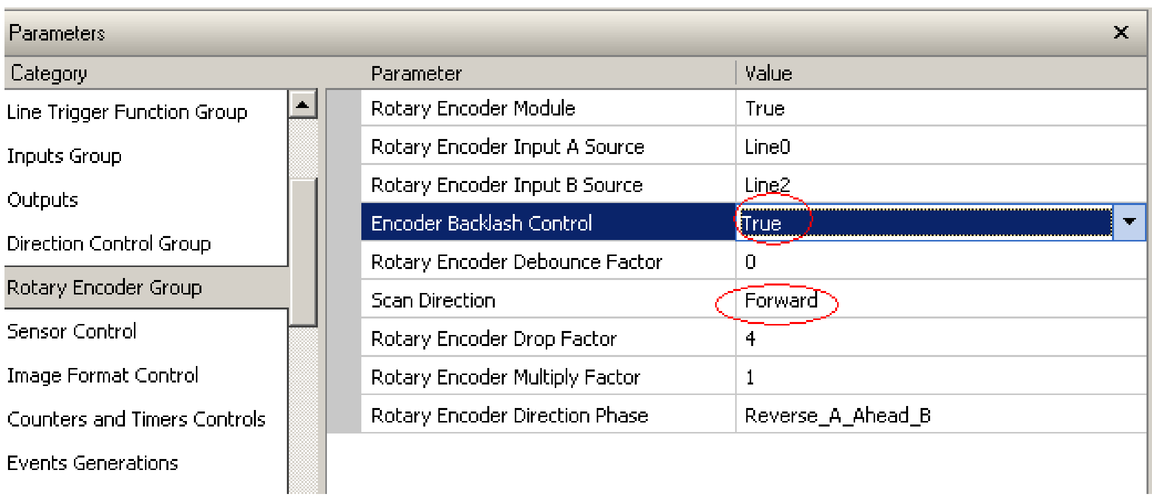


Figure 45: Encoder Backash Control

If the Backlash Control is disabled, the camera will respond to both directions. This may cause image artefacts when the direction changes. To avoid this, increase the Rotary Encoder Debounce Factor, as shown in the following figure.

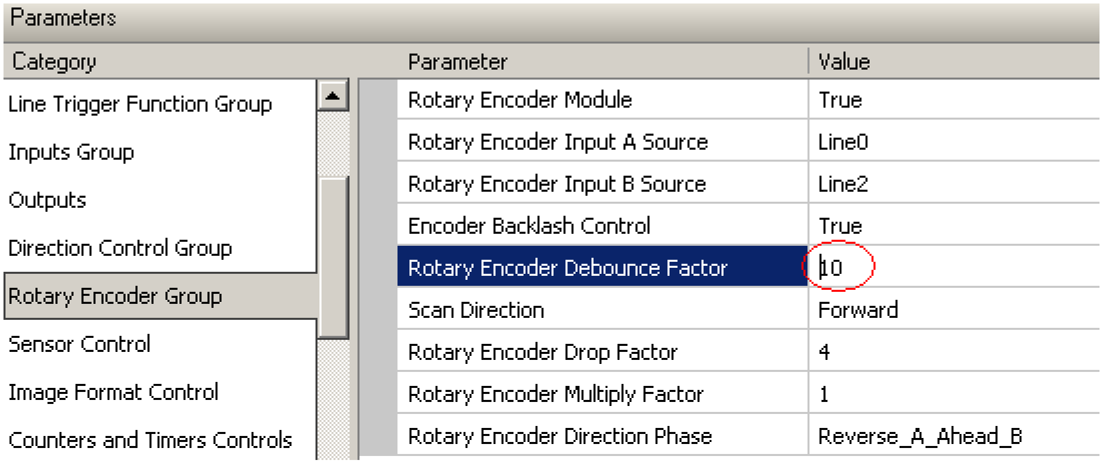


Figure 46: Rotary Encoder Debounce Factor

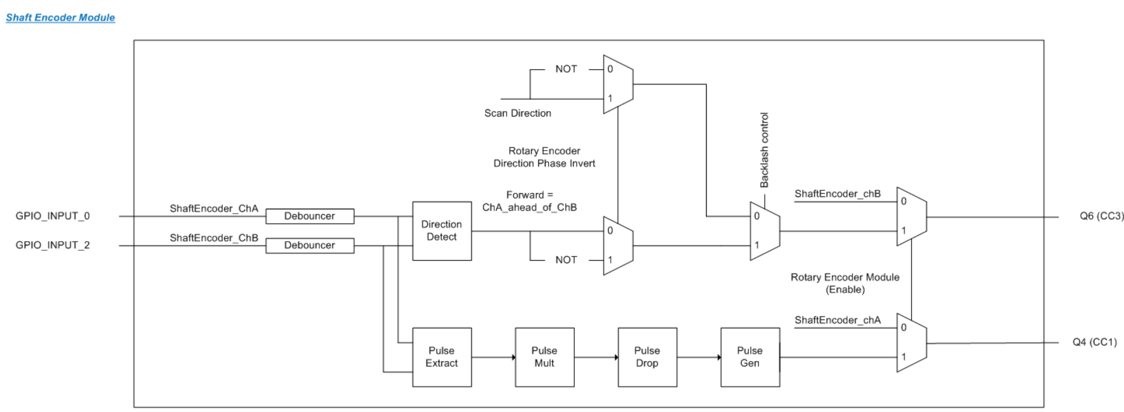


Figure 47: Shaft Encoder Module

External Frame Trigger: Frame Start Trigger mode

In the Frame Trigger Function Group > set the Device Scan Type to Linescan.

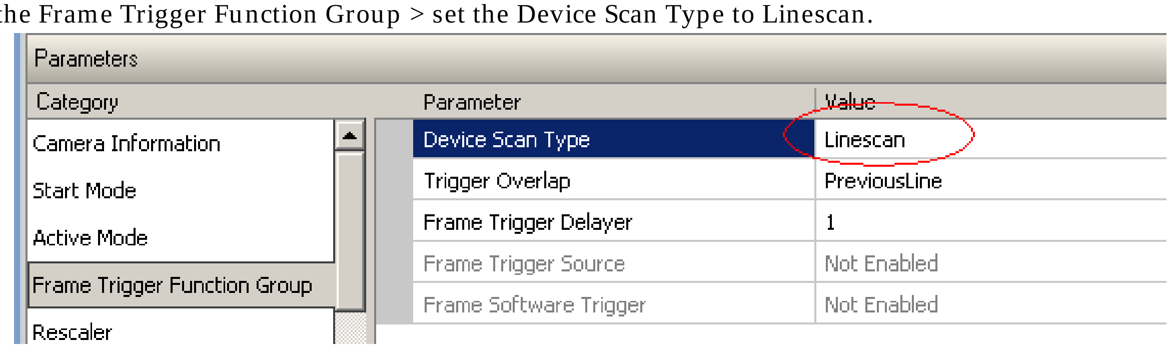


Figure 48: Device Scan Type

In the Active Mode group > ensure that the Frame Active Trigger Mode value is Off.

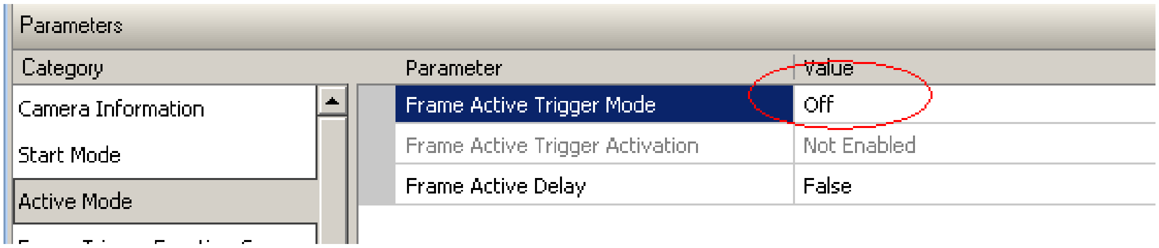


Figure 49: Frame Trigger Mode

In the Start Mode group > set the Frame Start Trigger Mode value to ON.

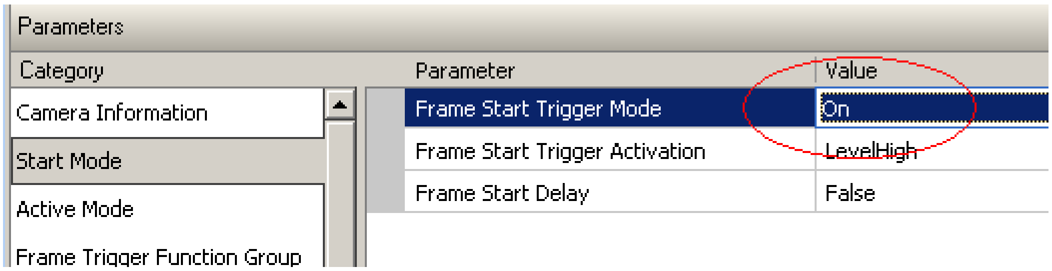


Figure 50: Frame Start Trigger Mode

Note on the Frame Start Trigger

When the frame trigger goes high the software grabs a predefined number of lines, as defined in width and height in Image Format Control.

For a software trigger toggle Frame software trigger from a False value to a True value, or from True to False depending on the Frame Active Trigger Mode.

Enable the delayer in the Start Mode group > set the Frame Start Delay value to True.

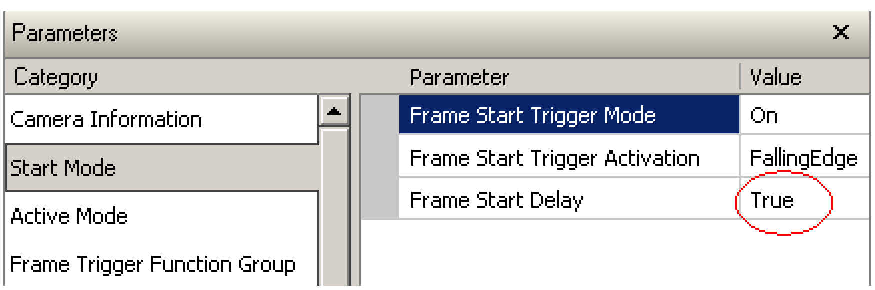


Figure 51: Frame Start Delay

In the Frame Trigger Function Group > set the Frame Trigger Delayer value.

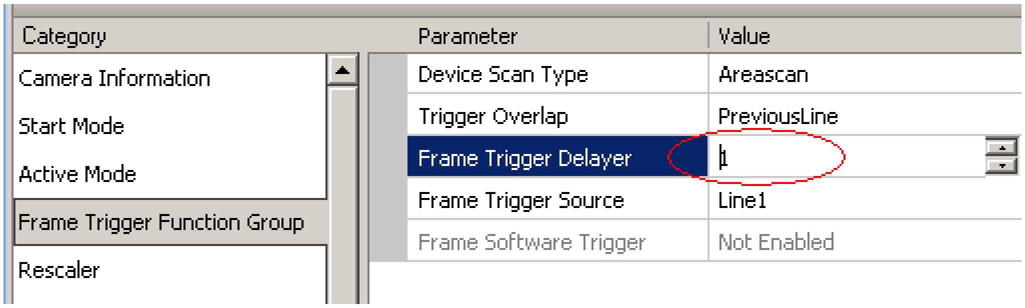


Figure 52: Frame Trigger Delayer

External Frame Trigger – Frame Active Trigger mode.

In the Start Mode group > Make sure Frame Start Trigger Mode is Off.

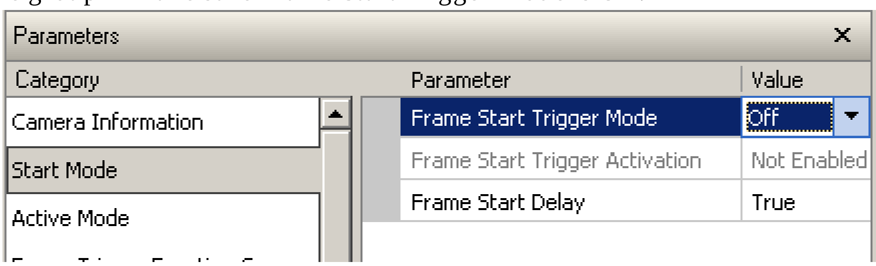


Figure 53: Frame Start Trigger Mode: Off

In the Frame Trigger Function Group > Set the Device Scan type to Areascan.

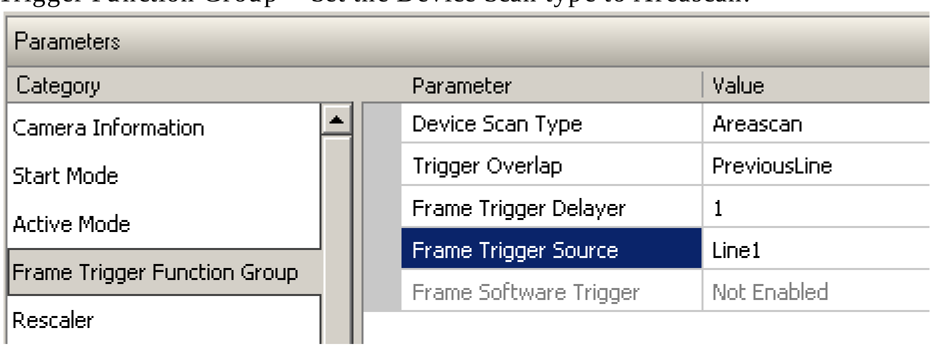


Figure 54: Frame Trigger Source

In the Active Mode group > set the Frame Active Trigger Mode value to ON.

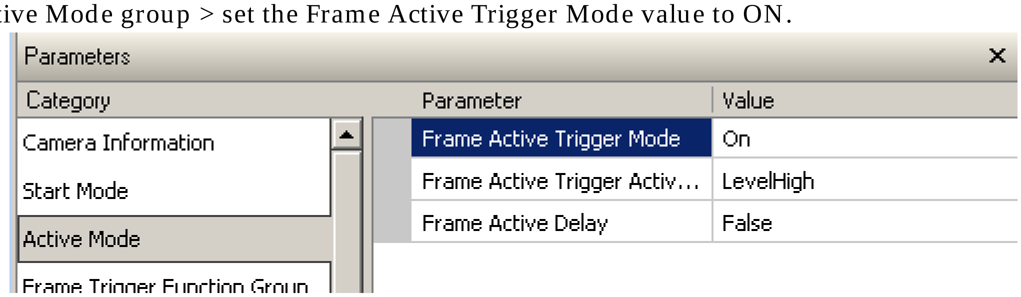


Figure 55: Frame Trigger Mode: On

Note on the Frame Active Trigger

When the frame trigger goes high, the PC will collect data until either, the signal goes low, or the frame buffer is filled. The frame height length will be determined by the length of the frame trigger.

At this point you can enable frame delayer as well.

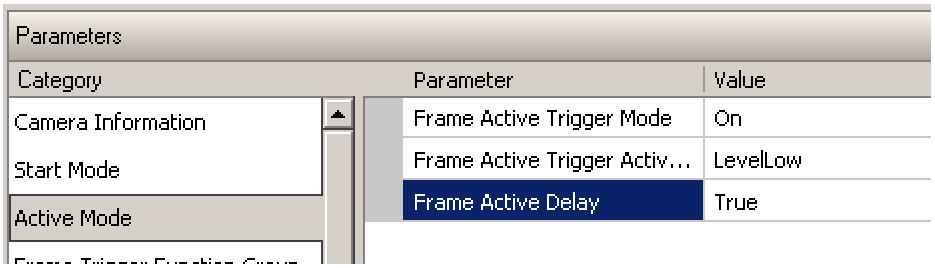


Figure 56: Frame Active Delay

Outputs

Outputs are used to control external devices and monitor internal signals.

Step 1

Select the output line.

Step 2

Set the Signal Routing Block parameter. Refer to section "PLC Input Signal Routing Block" for more detail about PLC settings.

Important Note: Signals PLC_10 to PLC_15 should not be changed unless you are **very** experienced with triggers and PLC settings.

Step 3

Set the signal output: Q0 to Q3.

Use the lookup table to output signals to one of 4 GPIO outputs.

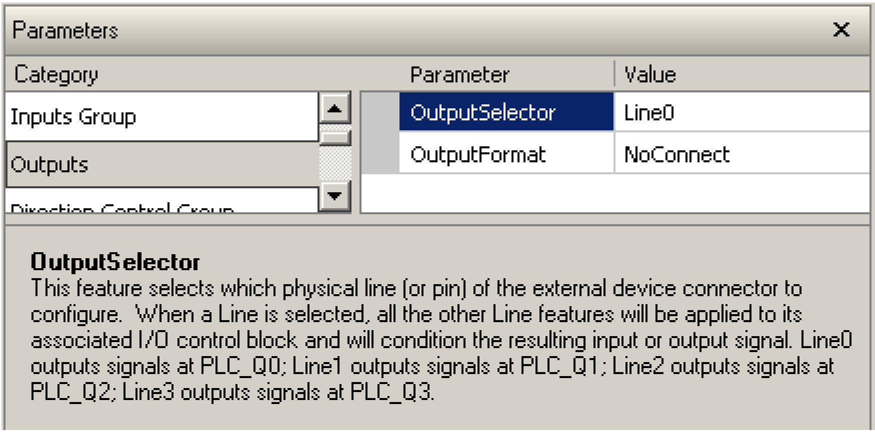


Figure 57: Output Selector

The signal to output can be selected from the Signal Routing Block parameters. For example, the following figures will output line 0. Please note that the frame valid (PLC_A4) is always high since Spyder3 is a line scan camera.

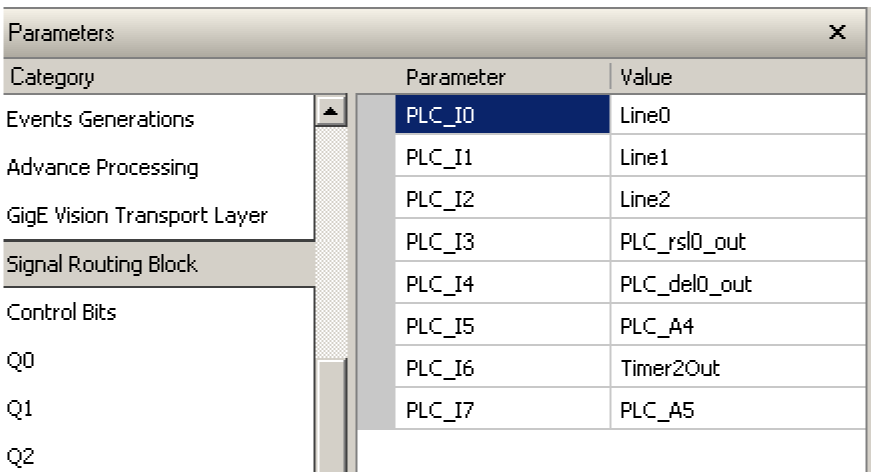


Figure 58: Signal Routing Block

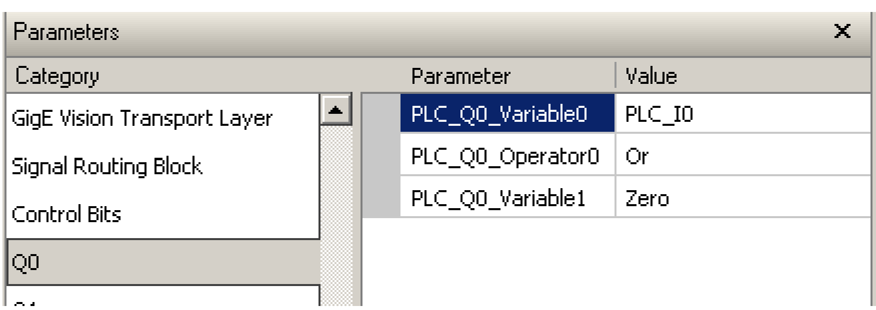


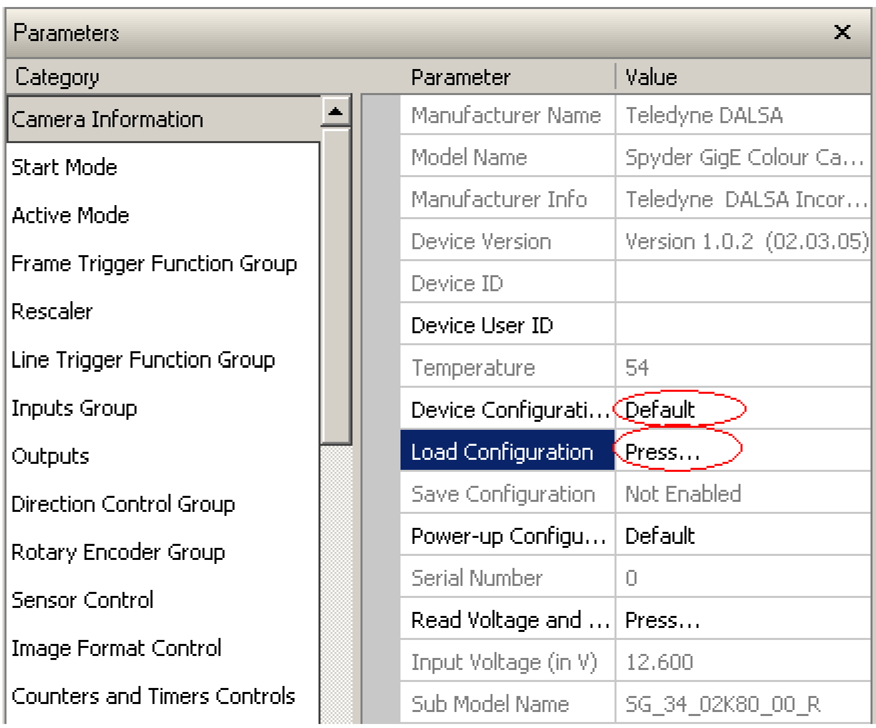
Figure 59: Signal Q0 linked to the value of parameter PLC_I0

Trigger Settings: GURU Mode

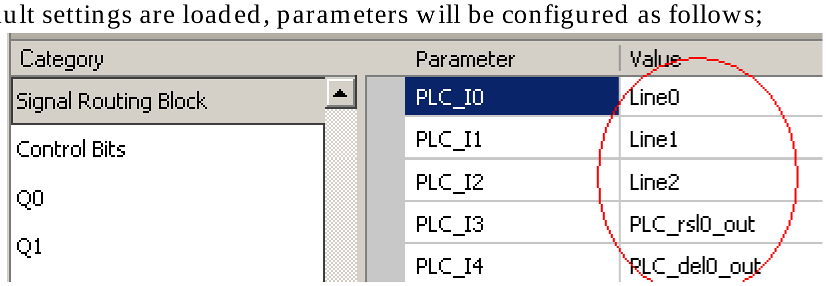
In most use-cases the camera mode settings described in the Beginner section will suffice. Using the commands and parameters available in the Guru level allow you to perform finer adjustments to the triggers or create different use-cases from the ones predefined in the Beginner level.

The following instructions are based on the default settings of the camera. Cameras are shipped from the factory in a default setting. Default settings are restored by loading the factory default (see the figure below).

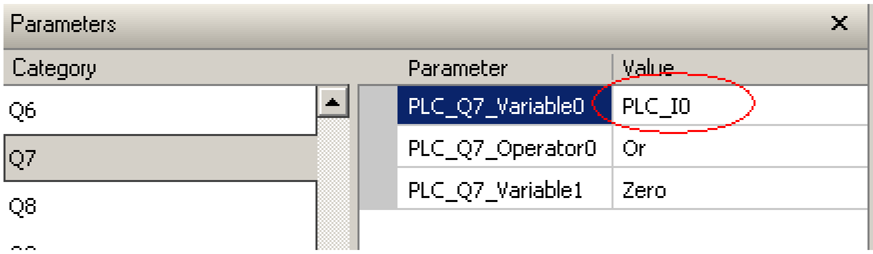
NOTE: loading the factory default will take 10 seconds or more to complete. If you are not using CamExpert, it is recommended that you set your GUI timeout values to maximum setting. If you do not adjust the GUI timeout, your GUI will disconnect during factory load.



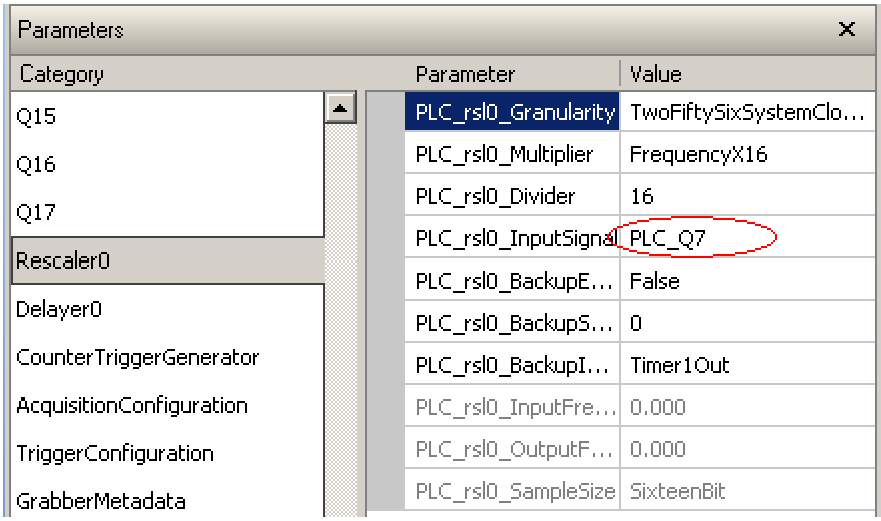
After Factory default settings are loaded, parameters will be configured as follows;



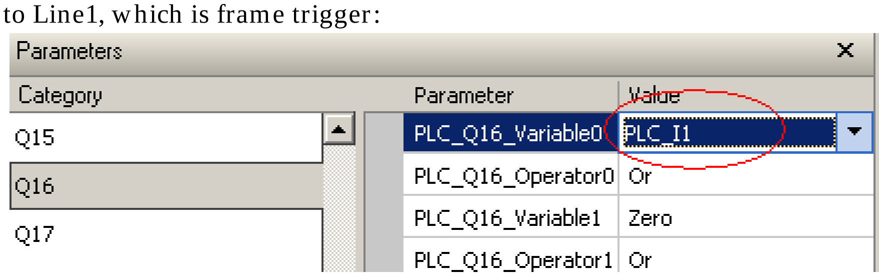
PLC_Q7_Variable0 is set to line0, which is line trigger input:



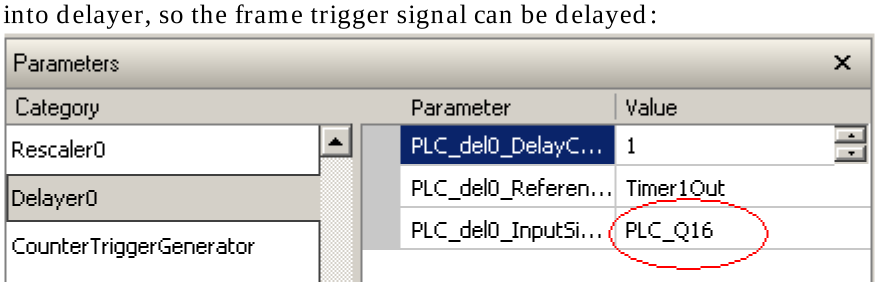
PLC_Q7 is fed to a rescaler input. So the rescaler will rescale line trigger signals:



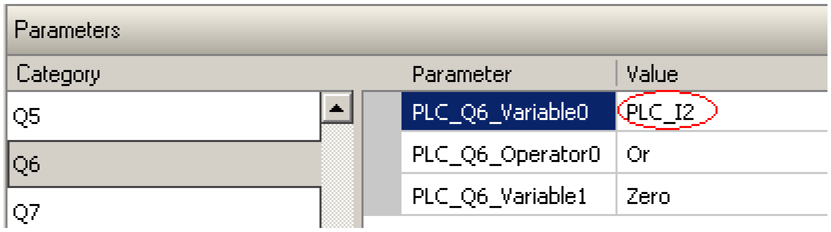
PLC_Q16 is set to Line1, which is frame trigger:



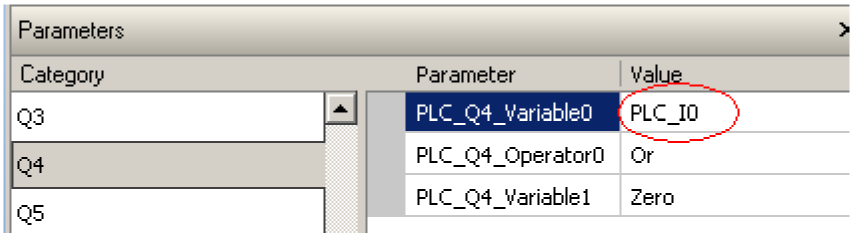
PLC_Q16 is fed into delayer, so the frame trigger signal can be delayed:



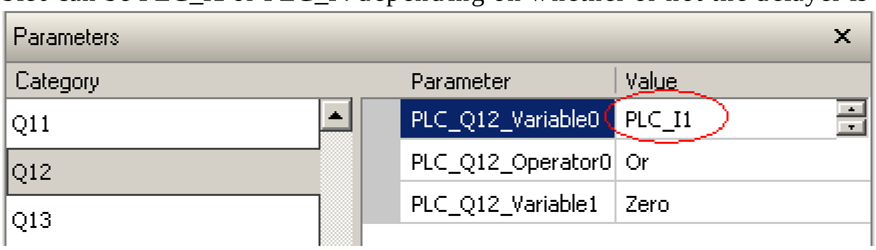
PLC_Q6 is direction and is fed by line2:



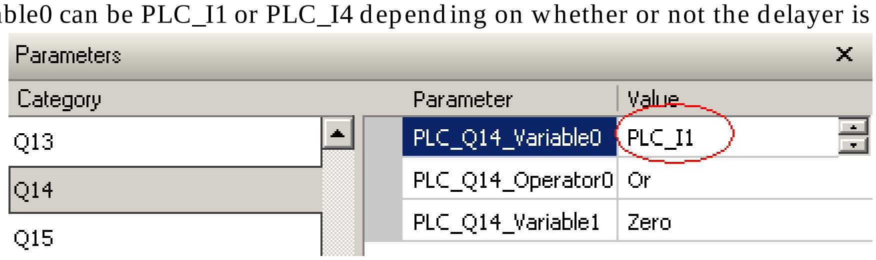
PLC_Q4_Variable0 can be PLC_I0 or PLC_I3, depending on whether or not the rescaler is enabled:



PLC_Q12_Variable0 can be PLC_I1 or PLC_I4 depending on whether or not the delayer is enabled:



PLC_Q14_Variable0 can be PLC_I1 or PLC_I4 depending on whether or not the delayer is enabled:



Pulse Generator

The behavior of the Pulse Generator is defined by their delay and width. The delay is the amount of time the pulse is inactive prior to the pulse, and the width is the amount of time the pulse is active.

The Pulse Generator signals can be set in either triggered or periodic mode. In triggered mode, the pulse generator is triggered by either the rising edge or high level of the input signal. When triggered, the pulse generator is inactive for the duration of the delay, then active for the duration of the width. After that, it will become inactive until the next trigger occurs. If a trigger occurs while pulse generator is already handling a previous trigger, the new trigger is ignored.

In periodic mode, the trigger continuously generates a signal that is based on the configured delay and width. The period of the pulse is therefore the delay time plus the width time.

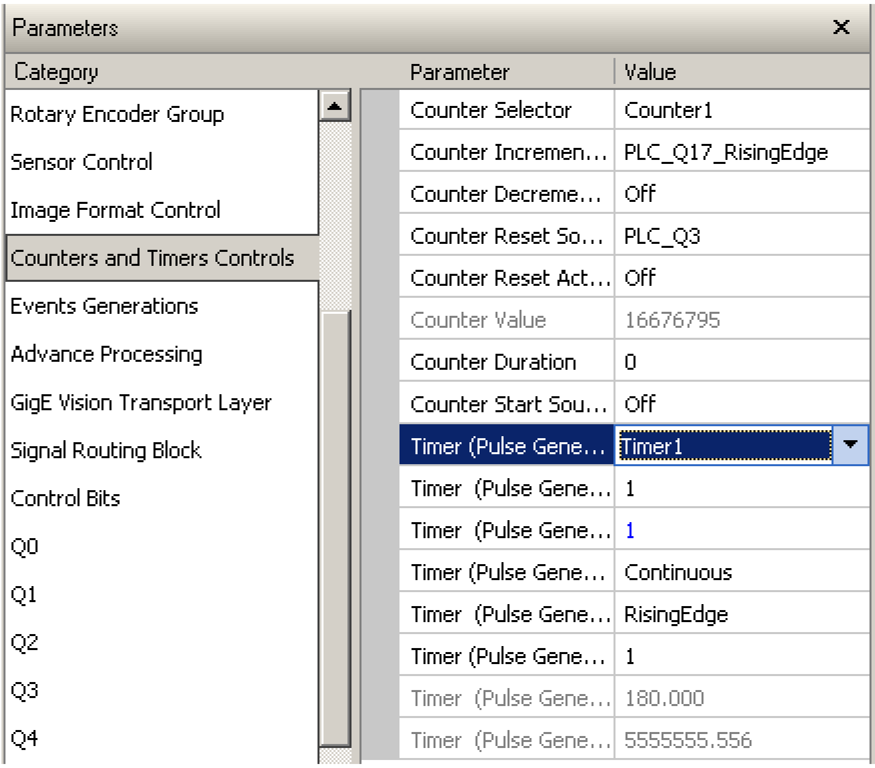


Figure 60: Pulse Generator

Pulse Generator 0 to 3

Selects which pulse generator to configure. To view the pulse generator properties, open the directory.

Width

Indicates the number of cycles (also determined by the granularity) that the pulse remains at a high level before falling to a low level.

Delay

Indicates the number of cycles (also determined by the granularity) that the pulse remains at a low level before rising to a high level.

Trigger Mode

Indicates how a triggered pulse generator will handle its triggers. The possible settings are:

- **Triggered on rising edge**: Indicates if a triggered pulse generator is triggered on the rising edge of an input
- **Triggered on high level**: Indicates is a triggered pulse generator is triggered on the high level of an input
- **Triggered on falling edge**: Indicates if a triggered pulse generator is triggered on the falling edge of an input
- **Triggered on rising AND falling edges**: Indicates if a triggered pulse generator is triggered on the rising edge of an input and on the falling edge of an input
- **Triggered on low level**: Indicates if a triggered pulse generator is triggered on the low level of an input

Pulse Period (ns)

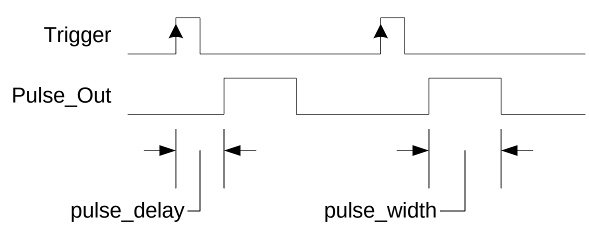
Displays the value of the parameter, in nanoseconds, of a complete delay-width cycle of the pulse generator. This value is computed every time the delay, width or granularity is modified and is available regardless of the periodic mode.

Pulse Frequency (Hz)

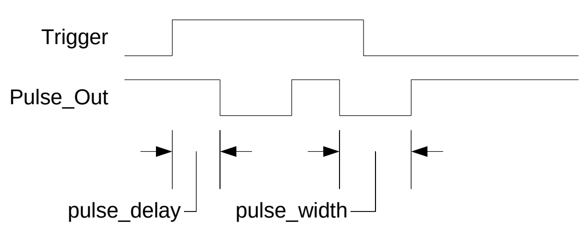
Displays the frequency of the pulse generator. This value is computed every time the delay, width or granularity is modified and is available regardless of the periodic mode.

Pulse Generator Timing

Positive Pulse Generated from a Rising Edge Trigger



Negative Pulse Generated from a Level High Trigger



The software can generate two internal signals using the internal pulse generators. The behavior of each of these two pulse generators is defined by a delay and a width. As shown in the accompanying diagrams, the delay is the time between the trigger and the pulse transitions. The width is the time the pulse stays at the active level before transitioning. The periodic mode, the delay determines the low time of the pulse. Each pulse generator generates a signal that can be used as an input to the GPIO Control Block. A triggered pulse generator needs an input signal that comes from an output of the GPIO Control Block.

Note: There is one clock cycle between the output signal of a pulse generator and the outputs of the GPIO Control Block.

The labels for the inputs from the pulse generators in the GPIO Control Block programming languages are:

- I7, for pulse generator 0

- I6, for pulse generator 1

Rescaler

The Rescaler lets you change the frequency of a periodic input signal. You can use the Rescaler to multiply the period by up to 4096 or divide it by up to 4095.

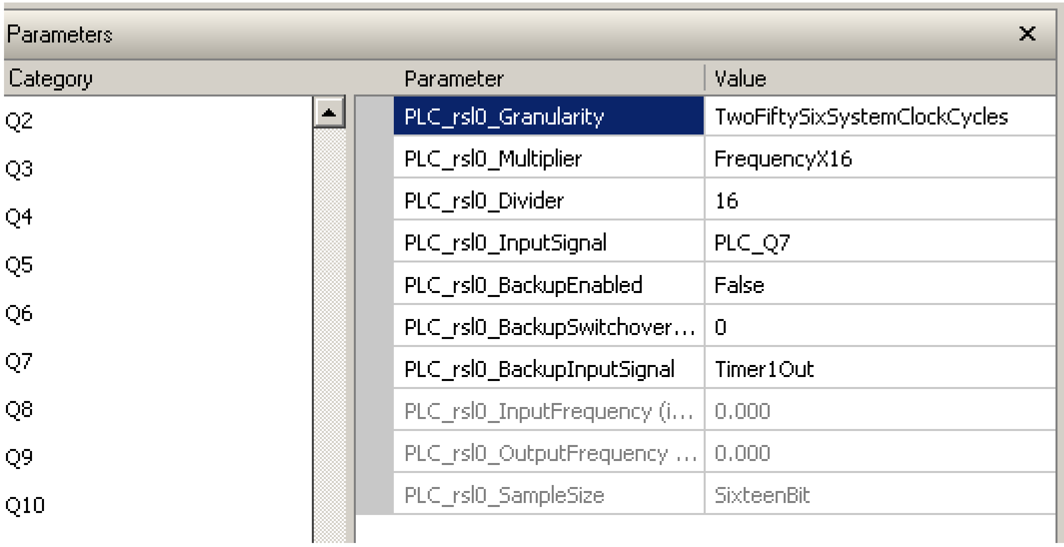


Figure 61: Granularity

The Rescaler is defined by the following settings:

Granularity

The granularity is the number of clock cycles during which the rescaler checks for activity on its input. The value to use depends on the period/ frequency of the input signal. If a frequency lies between two different granularity settings, the lowest setting will yield a better precision. The possible values are:

Acceptable Line rate relative to Granularity

Gran	Precision	Minimum Period	Maximum Period	Min. Frequency	Max. Freq. (ER<1%)
	(30 ns)	(s)	(s)	(Hz)	(Hz)
0	1	0.00000006	0.00197	509	333,333
1	4	0.00000024	0.00786	127	83,333
2	16	0.00000096	0.03146	32	20,833
3	256	0.00001536	0.50332	2.0	1,302

- The "Min. Frequency" is a fixed minimum, otherwise the incoming signal period counter gets saturated (reach the maximum count).
- The "Max. Freq." is a recommended maximum to get Error less than 1%.

Multiplicator

The multiplier applied to the input frequency. The possible values are:

- Frequency is multiplied by 256 (PLC_rsI0_Multiplier = FrequencyX256)
- Frequency is multiplied by 16 (PLC_rsI0_Multiplier = FrequencyX16)
- Frequency is multiplied by 4096 (PLC_rsI0_Multiplier = FrequencyX4096)

Divider

The divider applied to the input frequency. The resulting frequency is computed as follows:

$$output\_frequency = \frac{input\_frequency x multiplicator}{divider}$$

Input Selection

Indicates which label in the GPIO LUT will be associated with the rescaler. Make sure you select an input label that is not being used for its default behavior. For example, Q9 is used to send a trigger to pulse generator 0. If pulse generator 0 is used in triggered mode, then it will be triggered by Q9 and cannot be used as the input for the rescaler. The possible values are: Q3, Q7, Q8. Q9, Q10, Q11, Q16, and Q17.

Backup Enabled

Indicates if the rescaler will use a back-up input source if its main source stops its activity.

Backup Window

Specifies the window of time during which there can be no activity from the main input source before the rescaler switches to the back-up source. As soon as activity is detected, the rescaler returns to its main input source.

Backup Input

Same as the main input source

Granularity

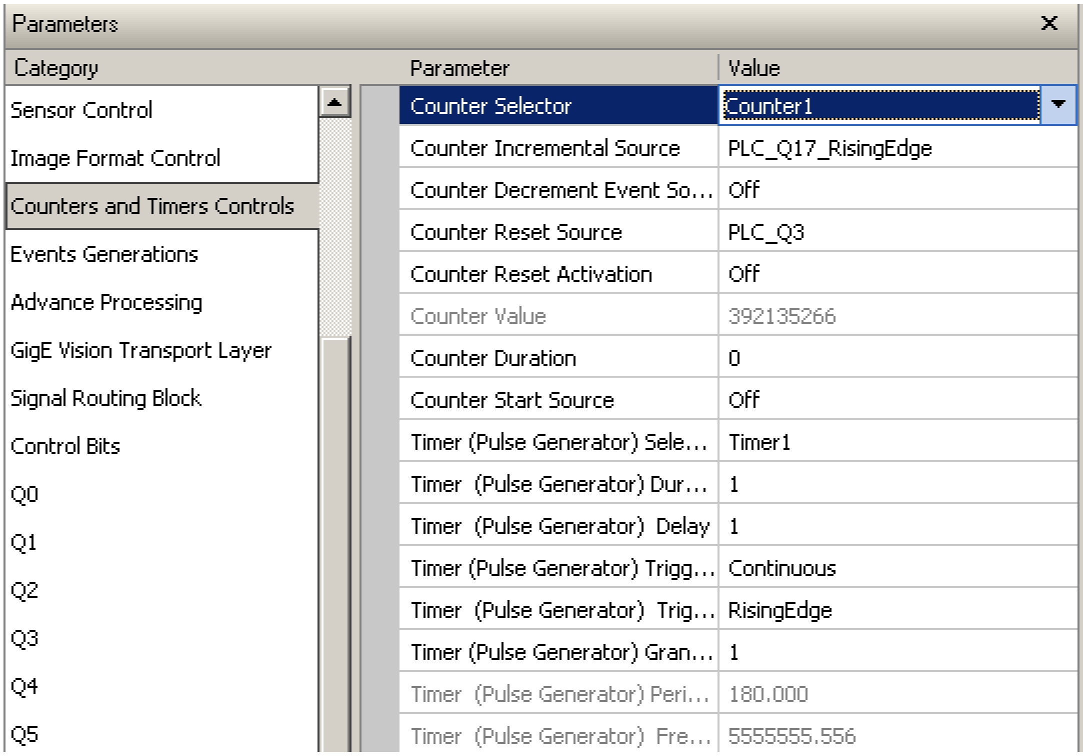
Indicates the number of PCI clock cycles that are used for each increment of the delay and width. The amount specified in the granularity is multiplied by 30 nanoseconds.

Other Rescaler equations are:

- Granularity_setting = [1, 4, 16, 256]
- Multiplier_setting = [16, 256, 4096]
- Divider_setting [15:0] = [0..65535]
- Granularity = 30ns x Granularity_setting
- sig_in_period_counter [15:0] = MIN(INT(Signal_In_Period / Granularity), 65535)
- multiplier_out [31:0] = sig_in_period_counter[15:0] x Multiplier_setting[15:0]
- divider_ou t[27:0] = INT (multiplier_out[31:0] / Divider_setting)
- Signal_Out_Period = MAX(divider_out[27:0], 2) x Granularity

Counter

The counter maintains a count value that can be increased, decreased, or cleared based on input signals. The counter outputs two signals (which are inputs to the GPIO LUT).



Counter Incremental Source

Specifies how the input for incrementing the count is handled. The counter's up event uses the Q17 label in the LUT. It can be one of the following settings:

- Disabled
- On the rising edge
- On the falling edge
- On both edges
- On the high level
- On the low level

Counter Decrement Event Source

Same as above but for the down event, but uses the Q16 label in the GPIO LUT.

Counter Reset Activation

Same as above but for the clear event. The clear event input of the counter does not have a predefined label on the GPIO LUT.

Counter Reset Source

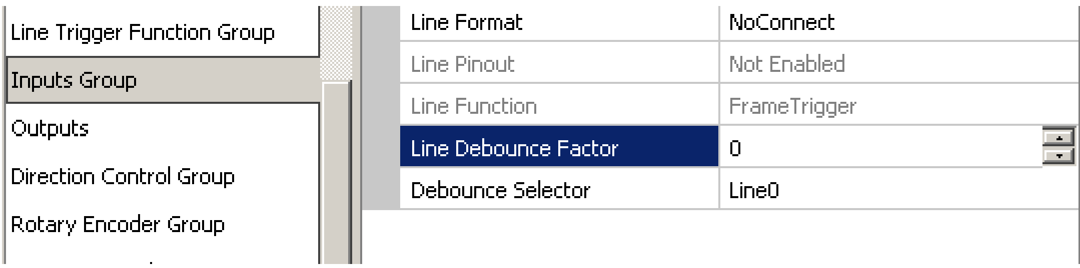
Indicates which label from the GPIO LUT that will be associated with the clear event input of the counter. Make sure you select an input label that is not being used for its default behavior. The possible values are: Q3, Q7, Q8, Q9, Q10, Q11, Q16, and Q17.

Current Counter Value

Displays the current counter value

Input Debouncing

The Debouncers tab is used to configure the debouncers of the camera. The debouncers are associated with the first and second PHYSICAL inputs of the software, usually Input 1 and Input 2.



The debouncers make sure that their corresponding inputs filter out bouncing effects. Bouncing is when there are a few very short pulses when the input signal transitions from low to high. Without debouncing, the controller may see these small pulses as real signals.
The debouncers make sure that the signal is truly high for the specified amount of time before it is declared as high. The same applies to the falling edge.

Input 0 Value

Indicates the debouncing value for input 0. Each unit is equal to 16 clock cycles (30ns each), or 480ns.

Input 1 Value

Indicates the debouncing value for input 1. Each unit is equal to 16 clock cycles (30ns each), or 480ns.

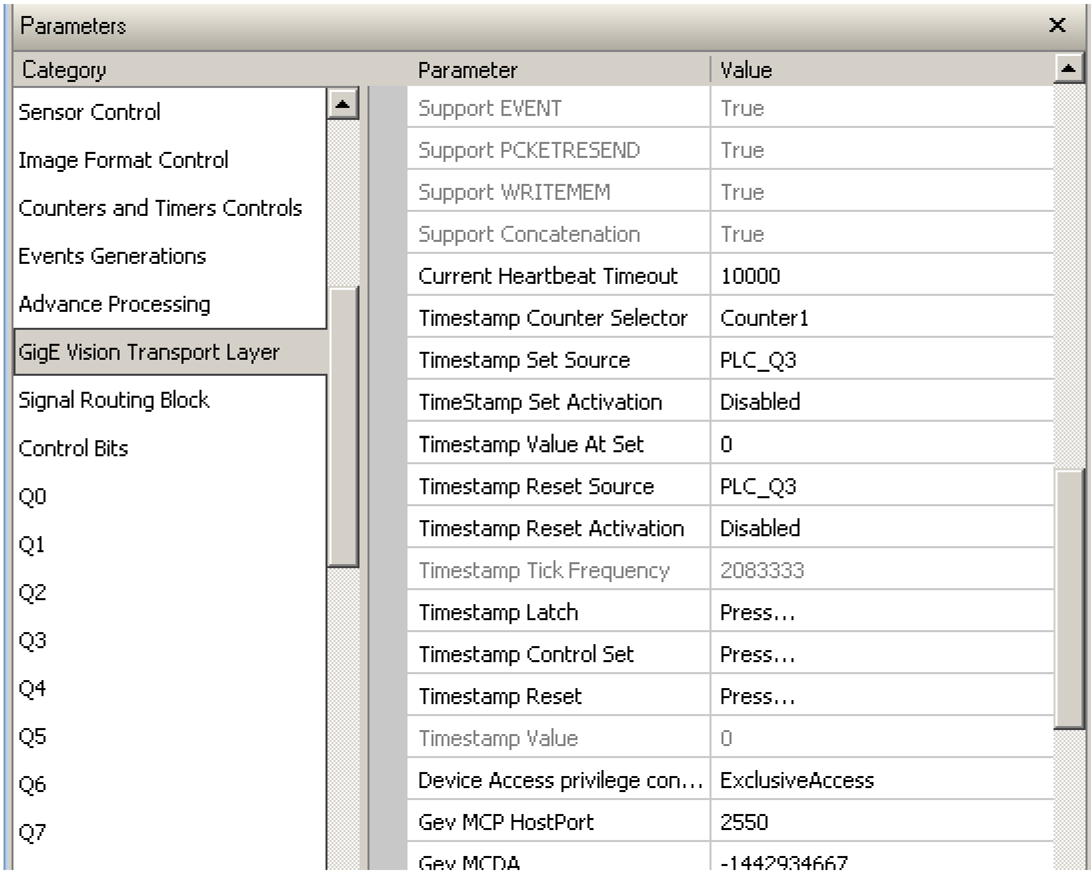
Input 2 Value

Indicates the debouncing value for input 2. Each unit is equal to 16 clock cycles (30ns each), or 480ns.

Input 3 Value

Indicates the debouncing value for input 3. Each unit is equal to 16 clock cycles (30ns each), or 480ns.

Timestamp Counter



Counter Select

Timestamp Counter (default), General Purpose Counter.

Granularity

Indicates the value of each timestamp unit of the timestamp counter. Available values are:480 nanoseconds, 1 microsecond, 100 microseconds, 10 milliseconds.

Set Mode

Indicates how the timestamp module handles the "set event". Possible values are:
Disabled
On Apply-The specified value is set when the user clicks the Apply button.
Rising edge input signal-When the signal on the "set event" input rises, the timestamp module applies the specified value.

Set Input

Indicates which label from the GPIO LUT that is associated with the "set event" input of the timestamp module. Make sure you select an input label that is not being used for its default behavior. The possible values are:
0: Q3
1: Q7
2: Q8

3: Q9
4: Q10
5: Q11
6: Q16
7: Q17

Clear Mode

Indicates how the timestamp module handles the "clear event". The possible values are:
Disabled
On Apply: The timestamp count is cleared when the user clicks the Apply button
Rising edge input signal: Then the signal on the clear event input rises, the timestamp module clears the timestamp counter value

Clear Input

Indicates which label from the GPIO LUT that is associated with the "clear event" input of the timestamp module. Make sure you select an input that is not being used for its default behavior. The possible values are:
0: Q3
1: Q7
2: Q8
3: Q9
4: Q10
5: Q11
6: Q16
7: Q17

Broadcast

When set to true, the operation is broadcasted to all other devices on the same network as the current device.

Set Value

The value assigned is used when the "set event" of the counter occurs.

Current Value

Displays the timestamp counter's current value.

Delayer

The delayer is used to delay an input signal. The output of the delayer is the delayed version of the input signal. A delayer is defined by:
Delay: The delay is a value expressed in the number of rising edges from the reference signal.
Reference Signal: A periodic input signal that is used to generate the delay from the input source. It is important that this reference signal be periodic. Also note that the pulse width of the signal you want to delay must be greater than the period of the reference signal.
Input Source Selection: The delayer does not have a pre-assigned label in the GPIO Look-Up Table (Qn). This parameter is used to select a label that **is not used** by another GPIO module.
The output of the delayer is considered an input for the GPIO Look-Up Table.
The labels for the output from the delayer in the GPIO Control Block programming languages depend on the LUT input configuration.

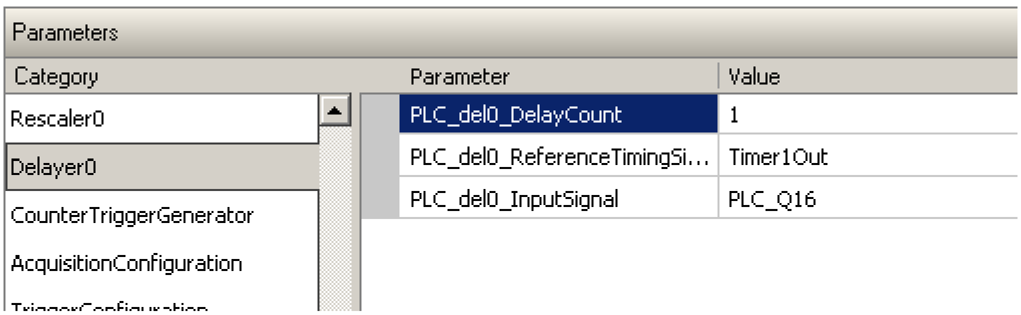


Figure 62: Delayer

The following sections provide details on the LUT control block, the LUT programming language and the advanced features of the GPIO.

PLC Control

PLC control allows very precise control of the camera. Most users do not need to access the PLC functions as the Beginner level and Guru level functions are adequate for the majority of use-cases. However, Spyder provides a PLC and LUT programming for users who require highly specialized control of the camera functions.

In general, to configure the PLC, you need to accomplish three main tasks:

- Assign a physical camera pin and signal to a GPIO Input number.
- Map the GPIO Input or Output using the parameters located in the Line Trigger Function, Inputs, Outputs, Direction Control, and Sensor Control groups. (NOTE: This will override the factory default in beginner level.)
- Use the LUT programming language to map the GPIO Input Configuration to the GPIO Output in Guru level.

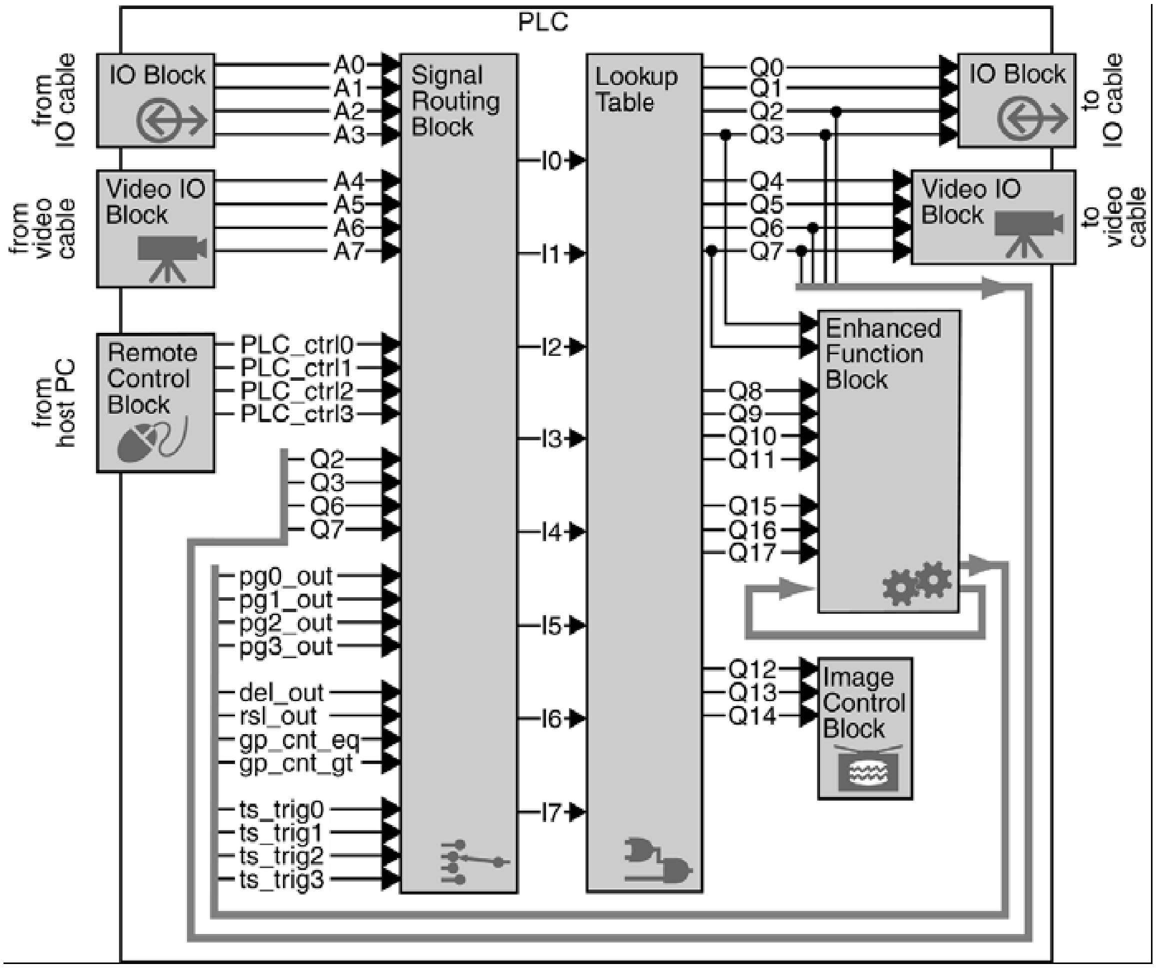
The following sections provide details on the LUT control block, the LUT programming language and the advanced features of the PLC.

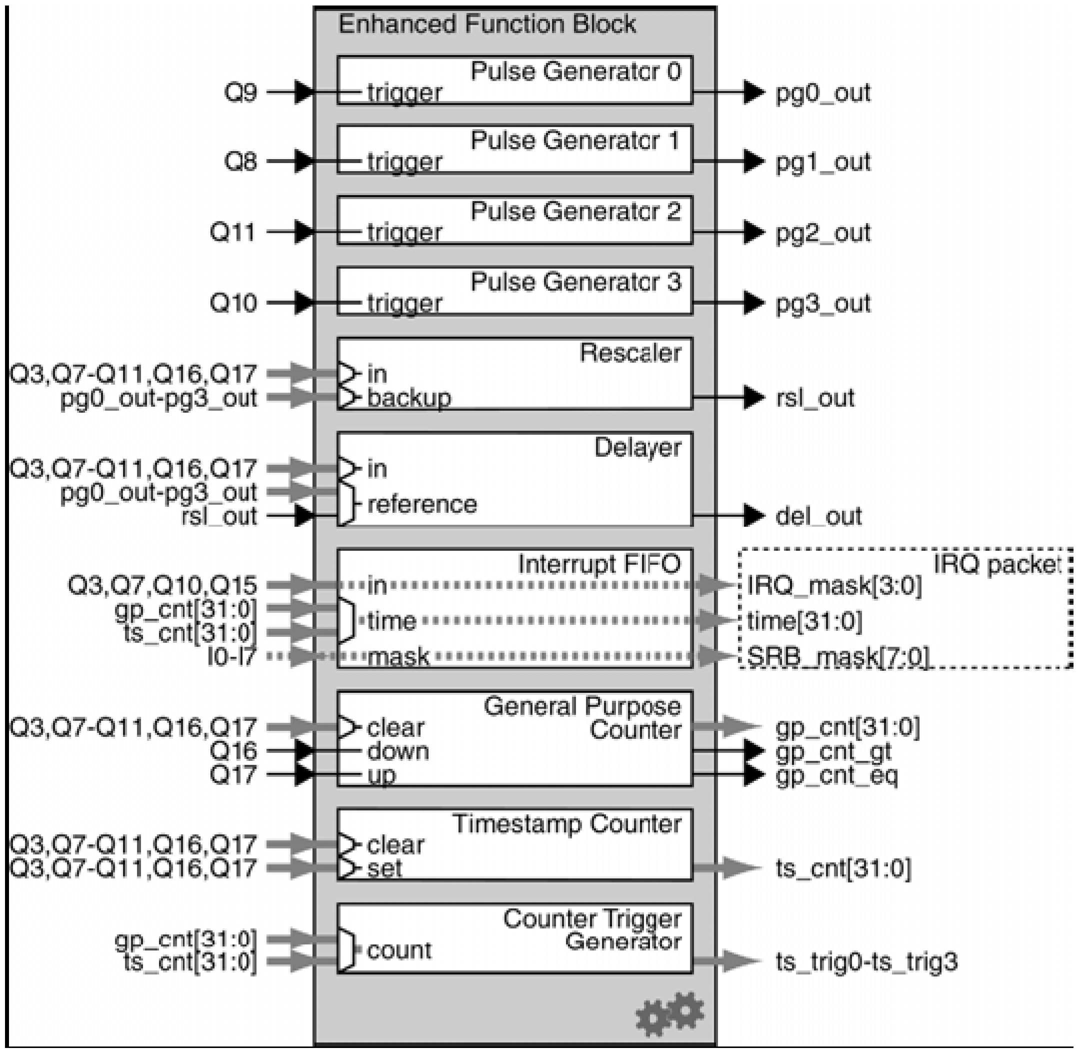
Note: the screenshots in this section are from the CamExpert GUI. Other GUI's should contain a similar arrangement to what is shown.

The PLC Control Block

All signals pass through the PLC Control Block. Depending on its programming, the PLC Control Block generates output signals that can be redirected to various camera outputs.

The PLC control block uses a look up table (LUT) to generate the outputs. This LUT contains eight different inputs, each of which can generate 18 different outputs, resulting in 256 entries of 18 bits.





Note that all external inputs (from the camera, TTL inputs, and PLC controls) are resynchronized. The outputs from the look-up table are synchronous.
The LUT is programmed using a simple language. This language allows you to create logical equations that specify the conditions that set particular outputs

Note: There is a delay of two clock cycles between the inputs of the LUT and its outputs. A clock cycle has a period of 30 nanoseconds, so the delay is 60 nanoseconds.
The signals in the PLC Control Block are defined in the tables below.
Inputs to CamExpert are labeled I*n* (where n is an integer from 0 to 7) and outputs are labeled Q*n* (where n is an integer from 0 to 15).

PLC Input Signal Routing Block

The following code sets the first entry in the PLC's signal routing block: Setting the Signal Routing Block is complicated by the fact that each entry in the table has a different set of enumerated inputs. So for example, a value of 0 for **i0**(i.e. GPIO Input 0) means something different for **i6** (i.e. Pulse Generator 1 Output). Below is a table of enumerated values with respect to each entry.

For more information on the Signal Routing Block, refer to the section below, Signal Routing Block on page 89.

Value	i0	i1	i2	i3	i4	i5	i6	i7
0	GPIO Input 0	GPIO Input 1	GPIO Input 2	GPIO Input 3	GPIO Control Bit 1	GPIO Control Bit 0	Pulse Generator 1 Output	Pulse Generator 0 Output
1	Frame Valid	Line Valid	GPIO Control Bit 3	GPIO Control Bit 2	Data Valid	Spare	Rescaler 0 Output	Pulse Generator 2 Output
2	GPIO Input 1	GPIO Input 0	GPIO Input 0	GPIO Input 0	GPIO Input 0	GPIO Input 0	GPIO Input 0	GPIO Input 0
3	GPIO Input 2	GPIO Input 3	GPIO Input 1	GPIO Input 1	GPIO Input 1	GPIO Input 1	GPIO Input 1	GPIO Input 1
4	Line Valid	Frame Valid	Frame Valid	Reserved	GPIO Input 2	GPIO Input 3	Reserved	GPIO Input 3
5	Data Valid	Spare	Reserved	Line Valid	Reserved	Frame Valid	Frame Valid	Frame Valid
6	GPIO Control Bit 0	GPIO Control Bit 0	Reserved	Reserved	Line Valid	Reserved	Reserved	Line Valid
7	GPIO Control Bit 1	GPIO Control Bit 1	GPIO Control Bit 0	GPIO Control Bit 0	Timestamp Trigger 3	Timestamp Trigger 2	Data Valid	Spare
8	GPIO Control Bit 2	GPIO Control Bit 3	GPIO Control Bit 1	GPIO Control Bit 1	GPIO Control Bit 2	GPIO Control Bit 3	Timestamp Trigger 1	GPIO Control Bit 0
9	Q2 (feedback)	Q3 (feedback)	Q2 (feedback)	Q3 (feedback)	Q2 (feedback)	Q3 (feedback)	GPIO Control Bit 1	GPIO Control Bit 1
10	CC3 (feedback)	CC4 (feedback)	CC3 (feedback)	CC4 (feedback)	CC3 (feedback)	CC4 (feedback)	GPIO Control Bit 2	Timestamp Trigger 0
11	Pulse Generator 0 Output	Pulse Generator 2 Output	Pulse Generator 0 Output	Pulse Generator 2 Output	Pulse Generator 0 Output	Pulse Generator 2 Output	Q2 (feedback)	Q3 (feedback)
12	Pulse Generator 1 Output	Pulse Generator 3 Output	Pulse Generator 1 Output	Pulse Generator 3 Output	Reserved	Reserved	CC3 (feedback)	CC4 (feedback)
13	Rescaler 0 Output	Rescaler 0 Output	Rescaler 0 Output	Rescaler 0 Output	Rescaler 0 Output	Rescaler 0 Output	Pulse Generator 3 Output	Reserved
14	Reserved	Reserved	Delayer 0 Output	Delayer 0 Output	Delayer 0 Output	Delayer 0 Output	Delayer 0 Output	Reserved
15	Reserved	Reserved	Counter 0 Equal	Counter 0 Greater	Counter 0 Equal	Counter 0 Greater	Counter 0 Equal	Counter 0 Greater

GPIO Output Labels

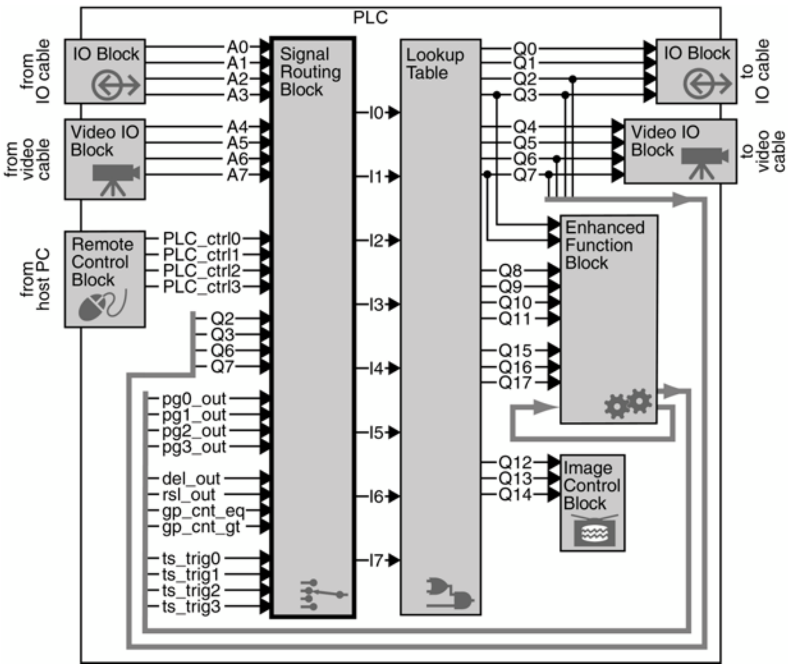
Signal	Label	Description
GPIO OUTPUT 0	Q0	GPIO output 0
GPIO OUTPUT 1	Q1	GPIO output 1
GPIO OUTPUT 2	Q2	GPIO output 2
GPIO OUTPUT 3	Q3	GPIO output 3

Signal	Label	Description
EXSYNC	Q4	EXSYNC
PRIN	Q5	PRIN
DIRECTION	Q6	Camera forward and reverse control.
CAM_CTRL (NOT USED_	Q7	• CC4 signal. Not used.
PULSE_TRIG1	Q8	Trigger for pulse generator 1. Used only when the pulse generator is in triggered mode. If available, can be used by one of the following modules: • Rescaler 0 input • Delayer 0 reference signal • Counter 0 clear event input • Timestamp counter set event input • Timestamp counter clear event input
PULSE_TRIG0	Q9	Trigger for pulse generator 0. Used only when the pulse generator is in triggered mode. If available, can be used by one of the following modules: • Rescaler 0 input • Delayer 0 reference signal • Counter 0 clear event input • Timestamp counter set event input Timestamp counter clear event input
PULSE_TRIG3	Q10	Trigger for pulse generator 3. Used only when the pulse generator is in triggered mode. If available, can be used by one of the following modules: • Rescaler 0 input • Delayer 0 reference signal • Counter 0 clear event input • Timestamp counter set event input Timestamp counter clear event input
PULSE_TRIG2	Q11	Trigger for pulse generator 2. Used only when the pulse generator is in triggered mode. If available, can be used by one of the following modules: • Rescaler 0 input • Delayer 0 reference signal • Counter 0 clear event input • Timestamp counter set event input Timestamp counter clear event input
GPIO_FVAL	Q12	Output to the internal grabber to replace or mix with the camera's FVAL signal. Depending on the camera, the FVAL signal can be replaced or combined with the signal of this output.
GPIO_LVAL	Q13	Output to the internal grabber to replace or mix with the camera's LVAL signal. Depending on the cameral, the LVAL signal can be replaced or combined with the signal of this

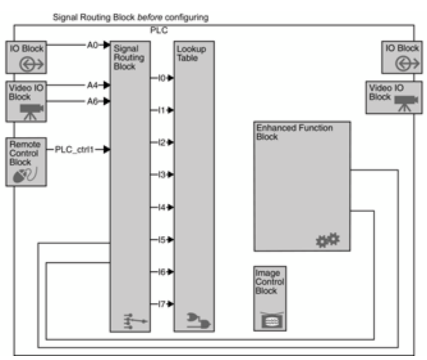
Signal	Label	Description
		output.
GPIO_TRIG	Q14	Trigger of image grabber when configured to use hardware trigger.
GPIO_IRQ	Q15	Trigger for an application callback. When the callback is invoked, it provides the following information: • A bit mask of the 8 LUT inputs at the time the interrupt was generated. • The timestamp value at the time of the interrupt.
CNT_DOWN	Q16	Trigger for the down event of counter 0. If available, can be used by one of the following modules: • Rescaler 0 input • Delayer 0 references signal • Counter 0 clear event input • Timestamp counter set event input • Timestamp counter clear event input
CNT_UP	Q17	Trigger for the up event of counter 0. If available, can be used by one of the following modules: • Rescaler 0 input • Delayer 0 references signal • Counter 0 clear event input • Timestamp counter set event input • Timestamp counter clear event input

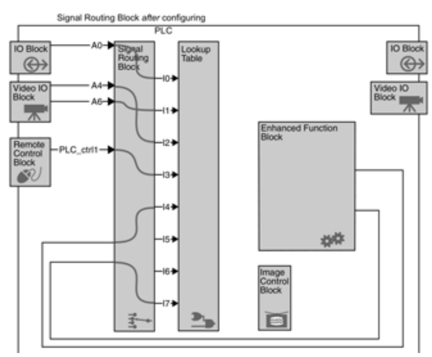
Signal Routing Block

In its simplest terms, the Signal Routing Block is a group of switches that let you route signals to the Lookup Table. You can direct PLC inputs and feedback inputs to signals I0 through I7.



The Signal Routing Block lets you redirect signals from the IO Block, the Video IO Block, Lookup Table, and the Enhanced Function Block back into the Lookup Table for further processing. Because most of the other blocks in the PLC use preconfigured inputs and outputs, the Signal Routing Block is the primary method of routing a signal from one block to another.



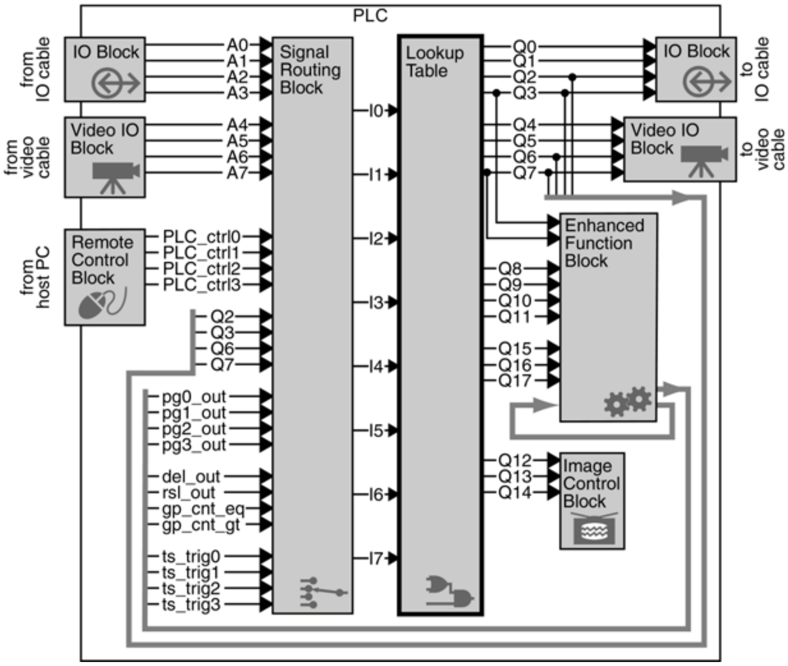


How the Signal Routing Block Works

The Signal Routing Block has 8 outputs (I0 - I7). Each output uses a 16:1 multiplexer that connects to 16 inputs.

The Signal Routing Block has more than 16 input signals, so not every input can be connected to every one of signals I0 - I7. However, signals I0 - I7 are functionally identical, so connecting to a specific one isn't important. If you can't route the input with your first choice, simply choose another.

The Lookup Table lets you connect any input signal I0-I7 to any Lookup Table output signal Q0-Q17



You can manipulate your inputs using simple or complex Boolean expressions. The following expressions are both valid:

Q0 = I6

Q6 = !(I4 & I6) & ((I2 ^ I5) | I1)

<table>
<tr><th colspan="3">Correct Lookup Table Syntax</th></tr>
<tr><th>Syntax</th><th>Valid Construction</th><th>Sample Line</th></tr>
<tr><td>Line</td><td>Output = Expression EOL (end of line)</td><td></td></tr>
<tr><td>Output</td><td>Q0, Q1, Q2, ..., Q16, Q17</td><td></td></tr>
<tr><td>Input</td><td>I0, I1, I2, ..., I6, I7</td><td></td></tr>
<tr><td>Expression</td><td>Input
Not Input
Boolean constant</td><td>Q1=I5
Q1=!I5
Q1=FALSE</td></tr>
<tr><td>Combined Expression</td><td>Expression Boolean operator Expression</td><td>Q1=I5 & I3
Q16 = I8 | I6</td></tr>
<tr><td>Boolean Operators</td><td>& (and)
| (or)
^ (xor)</td><td>Q14 = I4 & I6
Q15 = I3 | I5
Q9 = I1 ^ I8</td></tr>
<tr><td>Not</td><td>!</td><td>Q0=!I0
Q10= !(I8 & I5)</td></tr>
<tr><td>Delimiter</td><td>()</td><td>Q0 = !(I0)
Q3 = !(I1 | (I7 ^ I5))
Q6 = (I3 | I5) ^ (I1 & I2)</td></tr>
<tr><td>Boolean Constants</td><td>1, true, TRUE
0, false, FALSE</td><td>Q0 = 1
Q3 = TRUE Q6 = I3 ^ true</td></tr>
<tr><td>EOL</td><td>\ r
\ n
\ r\ n
\ n\ r</td><td>(used only for SDK, not Coyote)</td></tr>
</table>

<table>
<tr><th colspan="3">Incorrect Lookup Table Usage</th></tr>
<tr><th>Rule</th><th>Incorrect Syntax</th><th>Correct Syntax</th></tr>
<tr><td>The output must be on the left hand side of the equation
(the value is being assigned to Q4, not I5).</td><td>I5 = Q4</td><td>Q4 = I5</td></tr>
<tr><td>Outputs may not be on the right hand side of the equation.</td><td>Q1 = I7 & I8
Q2 = Q1 | I5</td><td>Q1 = I7 & I8
Q2 = (I7 & I8) | I5</td></tr>
<tr><td>Equations must be separated by a carriage return or an EOL symbol.</td><td>Q3 = I7,Q15=I8</td><td>Q3 = I7
Q15 = I8</td></tr>
</table>

How the Lookup Table Works

The Lookup Table has 8 inputs (I0 - I7) capable of two states each (true, false). Thus, the outputs have a total number of 256 input combinations. The result of each combination can be 1 or 0.

When you modify the equations in the Lookup Table, the controller calculates the results of all 256 input combinations and stores the result of each output as a 256-bit lookup table (hence the name). There are 18 outputs (Q0 - Q17), so the controller calculates 18 different lookup tables.

The controller then passes the resulting 18 lookup tables to the IP Engine. Knowing the value of the 8 inputs, the PLC needs only look up the value of the resulting output (for each output), rather than calculate it. Thus, the Lookup Table can achieve a propagation delay of only one system clock cycle (30 ns), regardless of the complexity or number of Boolean expressions.

Appendix D: EMC Declaration

We, TELEDYNE DALSA
605 McMurray Road
Waterloo, Ontario
CANADA N2V 2E9

Declare under sole responsibility that the cameras:
Brand Name: Spyder3 GigE

Models: SG-14-04K80, SG-14-02k40, SG-14-02k80, SG-14-01k40, and SG-14-01k80

The CE Mark, FCC Part 15, and Industry Canada ICES-003 evaluation of the Teledyne DALSA Spyder3 GigE cameras, which are manufactured by Teledyne DALSA Inc., satisfied the following requirements:

EN 55022 Class A (1998) and EN 61326 (1997) Emissions Requirements
EN 55024 (1998) and EN 61326 (1997) Immunity to Disturbances

Place of issue: Waterloo, Ontario, Canada

Date of Issue: August 28, 2006

Hank Helmond
Director of Quality, TELEDYNE DALSA Corp.

Appendix E: Setting up the FVAL

This setup only works with fixed frame trigger mode.

Setup Signal Routing Block

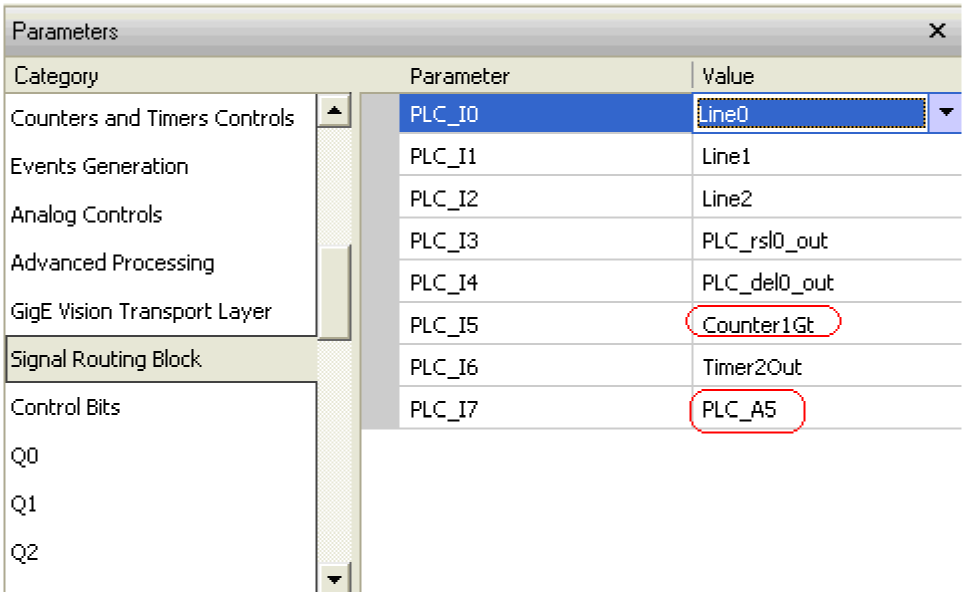


Figure 63: Signal Routing Block

Step 1

Match counter duration with image height

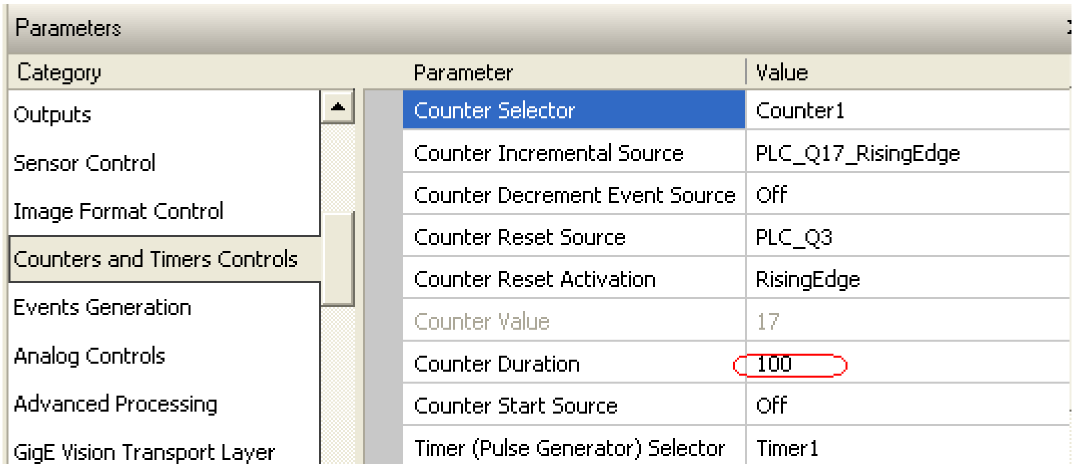


Figure 64: Setting counter duration, under Counters and Timers Controls

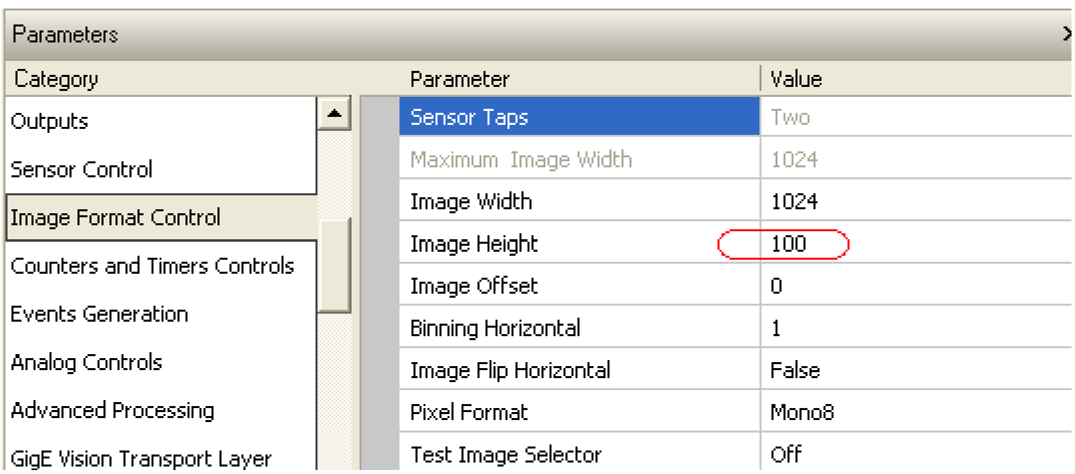


Figure 65: Setting image height, under Image Format Controls

Step 2

Setup counter incremental source to line valid (PLC_A5)

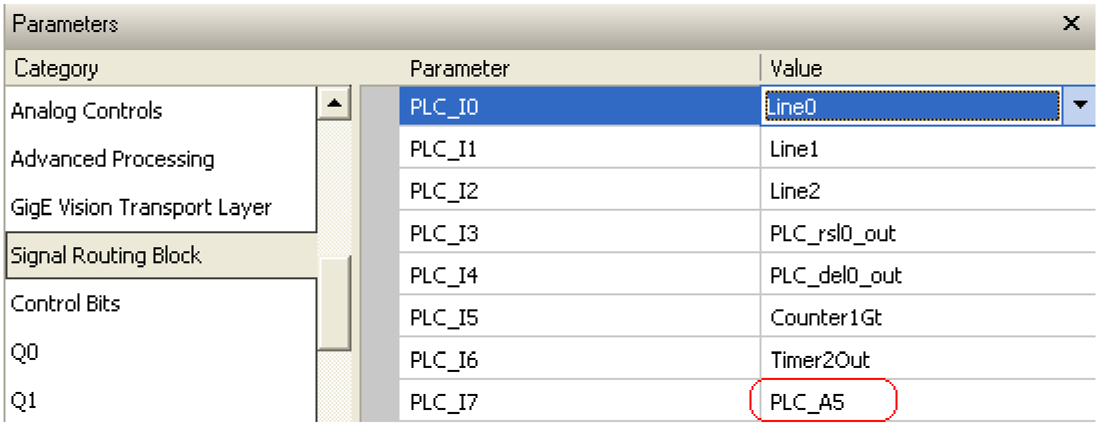


Figure 66: Setting PLC_I7 to PLC_A5 under Signal Routing Block

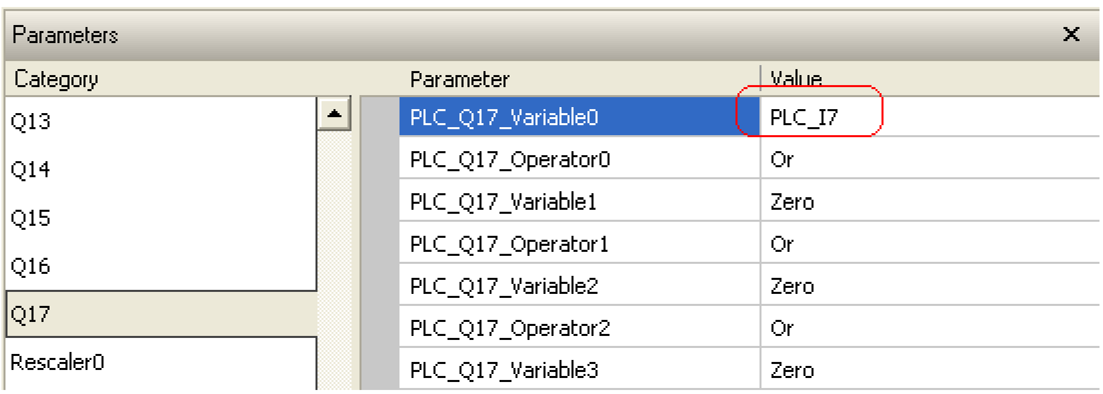


Figure 67: Setting PLC_Q17_Variable0 to PLC_I7 under Q17

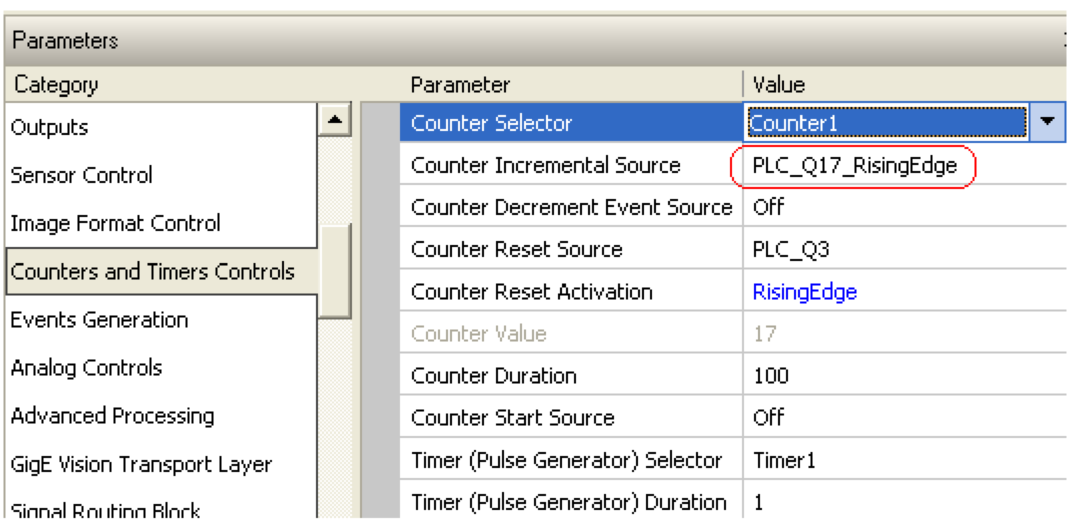


Figure 68: Setting Counter Incremental Source to PLC_Q17_RisingEdge under Counters Timers Control

Step 3

Setup Counter Reset Source to external fixed frame trigger.

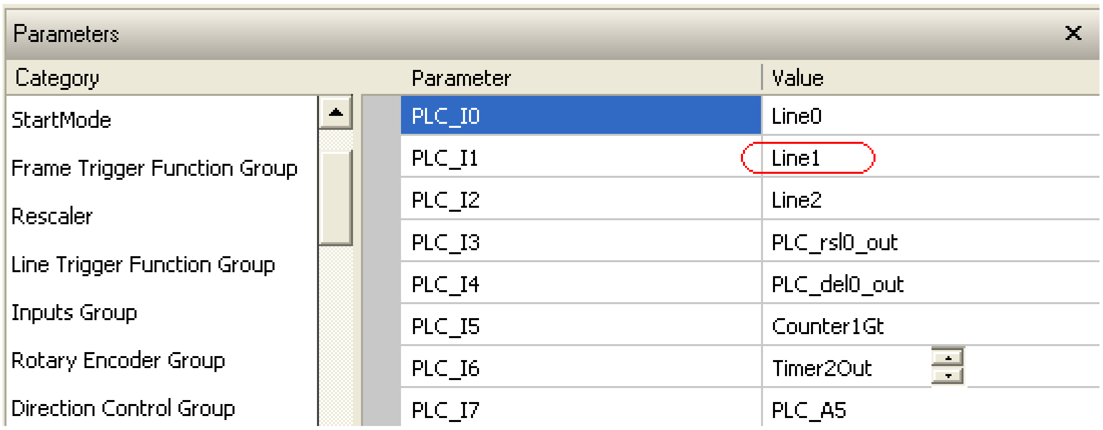


Figure 69: Setting PLC_I1 to Line1

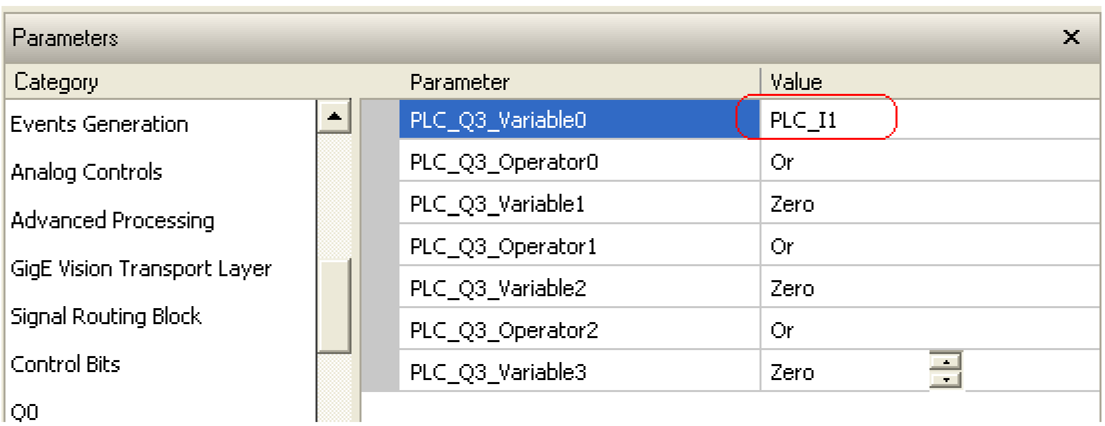


Figure 70: Setting PLC_Q3_Variable0 to PLC_I1

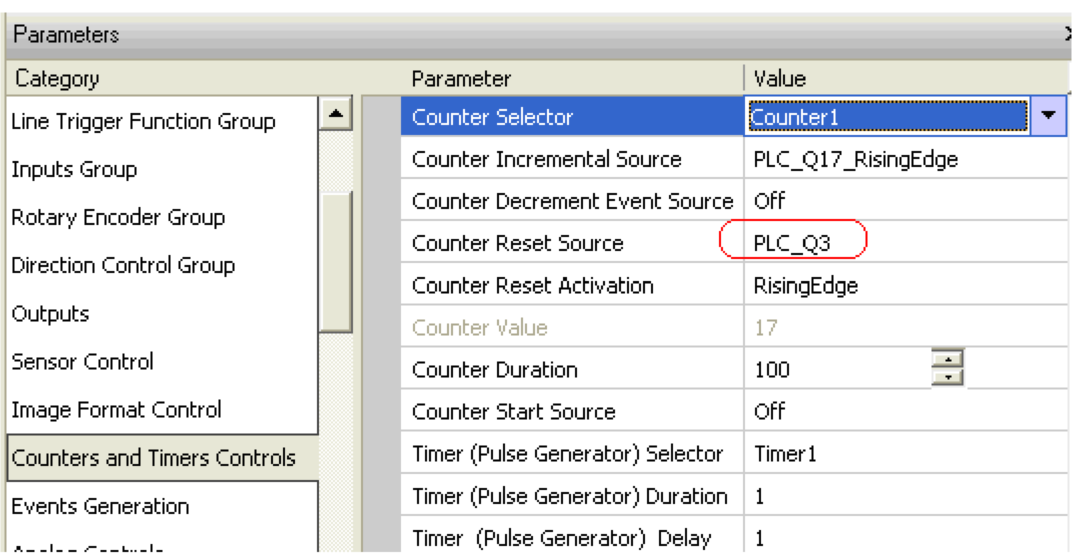
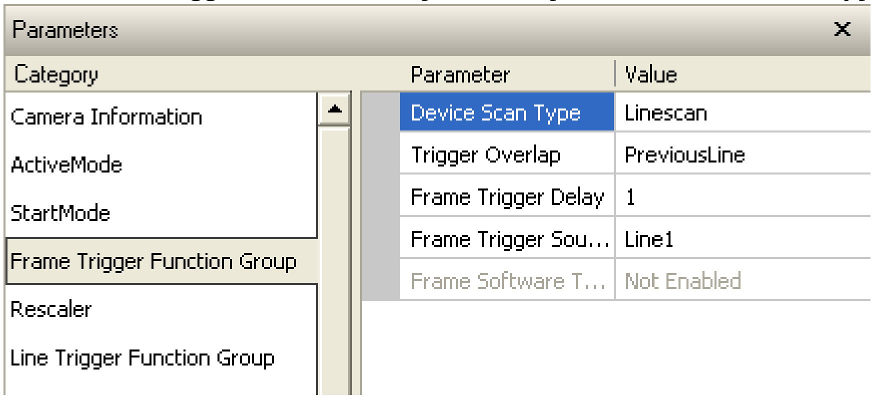


Figure 71: Setting Counter Reset Source to PLC_Q3

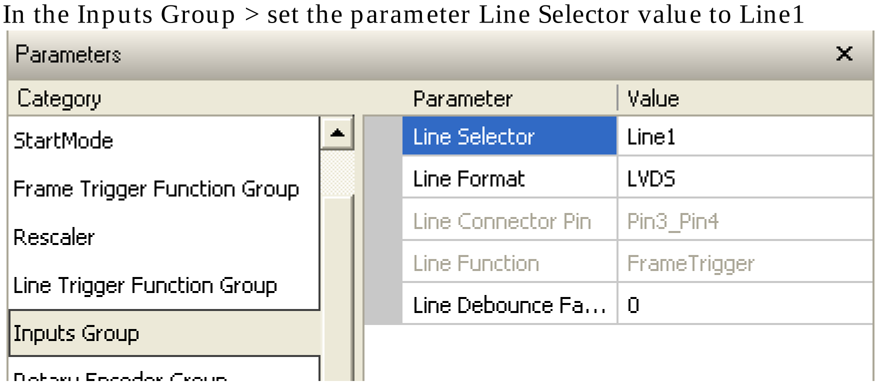
Examples: Setting the FVAL

line rate 5000, image height 100, input frequency is 40 hz.

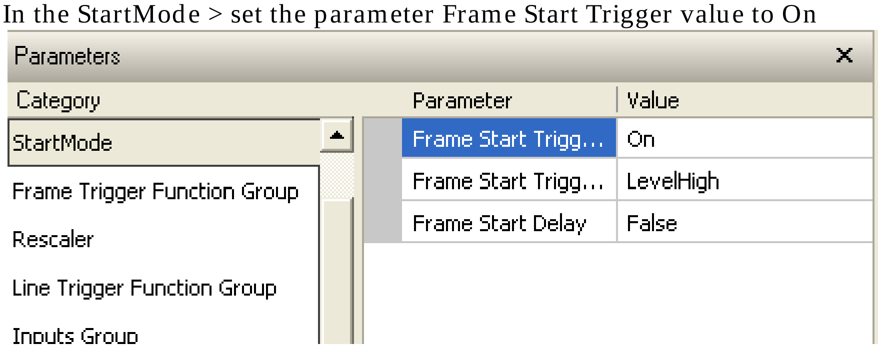
In the Frame Trigger Function Group > set the parameter Device Scan Type value to Linescan



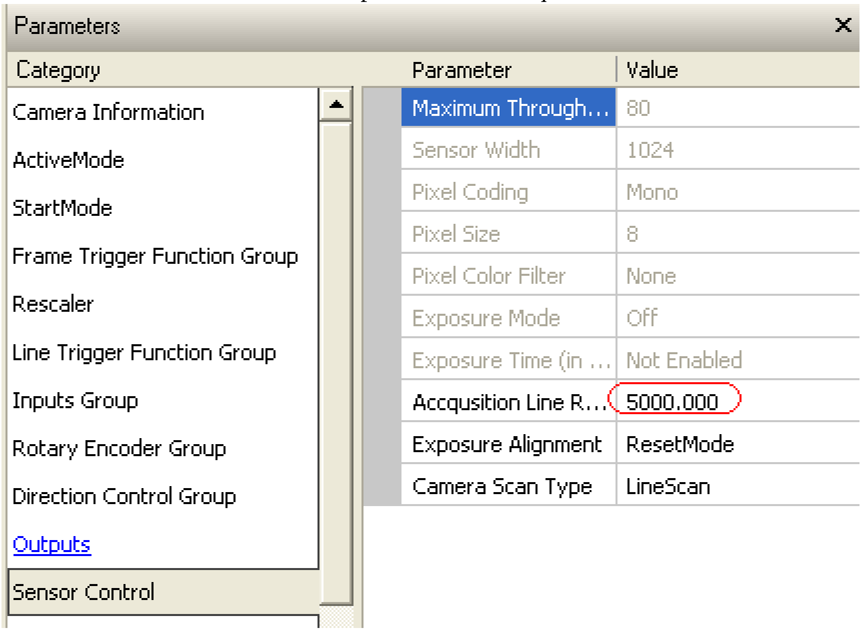
In the Inputs Group > set the parameter Line Selector value to Line1



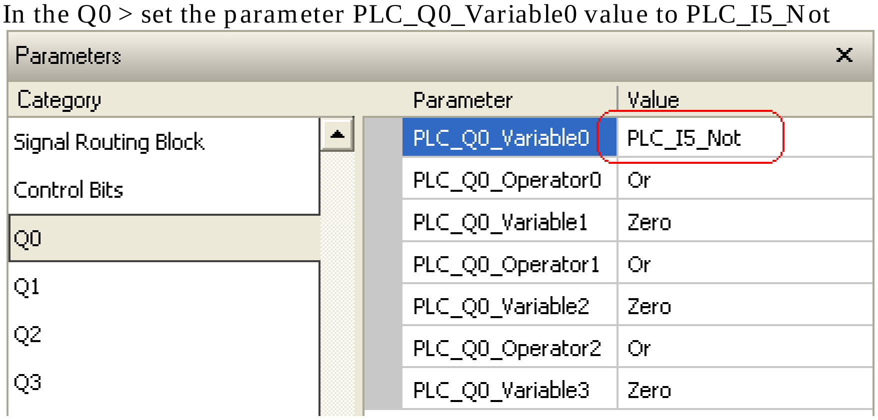
In the StartMode > set the parameter Frame Start Trigger value to On



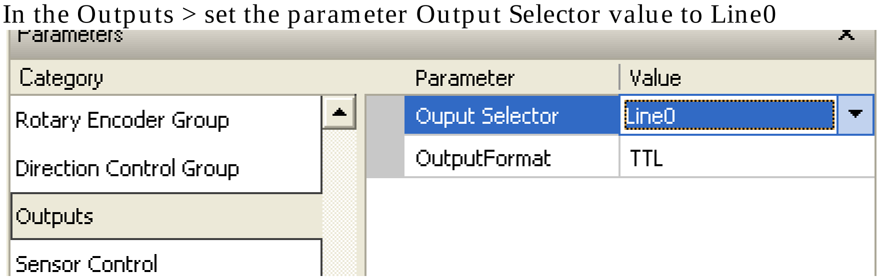
In the Sensor Control > set the parameter Accqusition Line value to 5000.000



In the Q0 > set the parameter PLC_Q0_Variable0 value to PLC_I5_Not



In the Outputs > set the parameter Output Selector value to Line0



The output from GPIO output line0 is shown below:

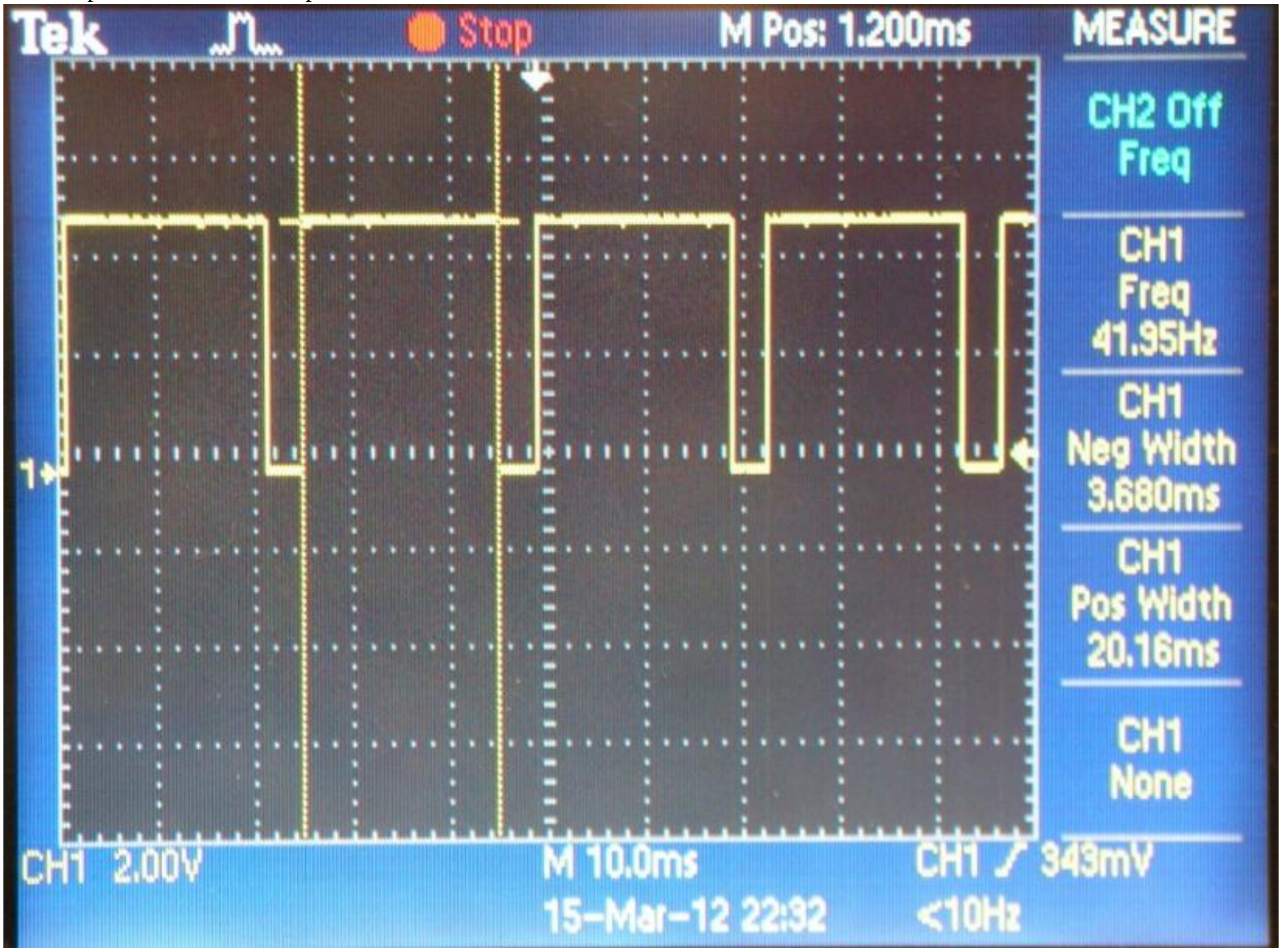


Figure 72: FVAL signal waveform

Revision History

Revision Number	Change Description	Revision Date
00	Beta release.	February 1 2012
01	- Added Appendix E: Setting Up the FVAL - Revision to the Clearing Dark Current section. - Revised EMC Declaration section.	May 31 2013

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