iStar CCD

Version 2.3 rev 18 February 2025

Hardware Guide

for the iStar Intensified CCD camera

andor.oxinst.com

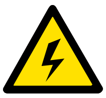
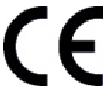
SAFETY AND WARNING INFORMATION

PLEASE READ THIS INFORMATION FIRST BEFORE USING YOUR PRODUCT.

1. If the equipment is used in a manner not specified by Andor, the protection provided by the equipment may be impaired.
2. Do not position this product so that it is difficult to operate the mains disconnecting device. See page 27, "Emergency Mains Disconnection".
3. Before using the product, please follow and adhere to all warnings, and safety, manual handling, and operating instructions located either on the product, or in this manual.
4. Keep this manual in a safe place for future reference.
5. Users must be authorised and trained personnel only; otherwise, this may result in personal injury, and/or equipment damage and impaired system performance.
6. There are no user-serviceable parts inside the product and the enclosure must not be opened. Only authorised service personnel may service this equipment.
7. If using liquid cooling, ensure that the coolant supply is connected prior to powering the camera. Please also read all of the information relating to the use of coolant on page 23.
8. Protective earth is an integral part of the protection against electric shock in this product and is provided via the earth pin of the external power supply. Ensure that this is plugged into the building earth system via the mains socket. Do not tamper with any of the earthing measures.
9. The product uses a low voltage D.C. connector with a pin that is longer than the other two to act as an early earth pin for protective earth as it will make contact before the camera receives power. We thus strongly advise that you use the supplied External AC/DC power Supply, but if this is not used then ensure that the earth stud is used an alternative Protective Earth Terminal as documented on page 115.
10. Any External AC/DC Power Supply used with this product must meet the requirements specified on page 115.
11. No parts should be replaced by the customer, except for the mains cables, which must be of the same type and rating as that supplied (and as specified in "Electrical Power Specifications" on page 115) and certified in accordance with your region's safety regulations.
12. Fuse: Only replace the fuse with one that meets the requirements specified on page 108.
13. Make sure all cables are located so that they will not be subject to damage, especially the mains cable.
14. While running an experiment, keep room temperature as stable as possible.
15. Performance of the system may be adversely affected by rapidly changing environmental conditions or operation outside of the operating conditions specified in "Appendix A: Technical Specifications".
16. Ensure that adequate ventilation is provided as specified in "Appendix A: Technical Specifications".
17. This product is designed to be used in an indoor environment. If the customer chooses to use this outside, then it is their responsibility to provide adequate protection. Andor assumes no liability for damage or obligation to repair under warranty relating to use outside of the environmental requirements specified in "Appendix A: Technical Specifications".
18. Medical Diagnosis: This equipment has not been designed and manufactured for the medical diagnosis of patients.
19. Electromagnetic Compatibility – Caution: This product was designed for and tested using the IEC/EN 61326-1 EMC standard for Class A emissions and a Basic immunity environment. Class A means that it is not designed for a domestic or residential environment, and Basic immunity refers to the fact that it is not designed for a typical industrial environment. This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

20. Electromagnetic Compatibility: As required by IEC/EN 61326-1, we must inform you that electromagnetic emissions in excess of that required by that EMC standard for the emissions class of this product can in theory occur due to its connection to other equipment.
21. Electromagnetic Compatibility: This product has been designed and tested to perform successfully in a normal (basic) electromagnetic environment, e.g. a typical physics research laboratory, as per the EU EMC Directive. It is not designed to operate in a harsh electromagnetic environment, e.g. close to the following equipment: EMI/RFI generators, electrostatic field generators, electromagnetic or radioactive devices, plasma sources, arc welders, x-ray instruments, intense pulsed sources, or other similar sources of high energy fields whose emissions are not within the normal range expected under the EU EMC Directive.
22. Ionising Radiation: Please note that this product is not designed to provide protection from ionising radiation. Any customer using this product in such an application should provide their own protection.
23. This product is a precision scientific instrument containing fragile components. Always handle it with care.
24. Do not wet or spill liquids on the product, and do not store or place liquids on the product.
25. If spillage occurs on the product, switch off power immediately, and wipe off with a dry, lint-free cloth.
26. If any ingress of liquids has occurred or is suspected, unplug the mains cables and do not use. Contact customer support.
27. See “Cleaning and Decontamination” on page 108.
28. Do not expose the product to open flames.
29. Do not allow objects to fall on the product.

Symbols on Product

	Electric Shock Hazard: This product contains hazardous live circuits and must not be opened by users
	General Warning Symbol: See the section on liquid coolant use on page 23
	Protective Earth Terminal: This is an additional earth stud that can be used to provide protective earth in accordance with safety standards. See ‘Alternative Protective Earth via Earth Stud’ on page 22
	EU CE Mark by which we indicate that this product meets the requirements all the relevant EU Product Directives that require this mark, including the Low Voltage Directive for safety (as this product in manufactured in Northern Ireland, it does not require the UKCA Mark)
	EU WEEE (Waste Electrical and Electronic Equipment) Mark which indicates that this should not be disposed of in domestic waste but at a suitable recycling site
	China EPUP (Environmental Protection Use Period) Mark that indicates that this product is expected to last for 20 years approximately before ending-up in the waste and recycling system
	D.C. Voltage Symbol

ADDITIONAL NOTES - AVOIDING DAMAGE TO THE IMAGE INTENSIFIER

An image intensifier is a very sensitive component, best practice should be applied to maximise its usability and lifetime..

1. There are three major potential forms of damage to be considered:

    - **Bleaching of the photocathode** brought about by over-illuminance of this photo-sensitive material. Bleaching reduces the effective Quantum Efficiency (QE) of the photocathode over time (it can ultimately render it unresponsive to light) and may permanently increase the background noise of the Image Intensifier.
    - **Ion damage of the photocathode –** If the Multichannel Plate (MCP) is overloaded with incoming photoelectrons accelerated by the electric field between the photocathode and the MCP, it is much more likely for positive ions to be knocked out of the walls of the MCP. These ions are in turn accelerated towards the photocathode and can do considerable mechanical damage. Excessive incoming photoelectron signal can also increase the outgassing rate inside the tube to the point where the vacuum is seriously diminished.
    - **Photoelectron damage to Phosphor screen and MCP** - Excessive numbers of photoelectrons in the MCP can be brought about by excessive input light levels, or moderate light levels and excessive gain. These can damage both the MCP or the phosphor screen. The protection circuitry in the iStar CCD monitors the current drawn by the phosphor, which is indirectly linked to the incident signal intensity as seen through the MCP gain chain. Above a certain level the high voltage power supply at the MCP shuts down to prevent damage. However, when only a sub-section of the Phosphor / photocathode is illuminated, damage can occur without the high voltage supply shutting down. Applications involving focusing of strong spectral line features, or confined bright spots in a imaging scenario must therefore be treated with appropriate caution (including the possible use of Neutral Density filters).
    - As a general rule of thumb, when the sensor is already saturated, this type of damage is liable to occur.

    The following best practices should be observed:
    Always maintain the measured signal below the saturation level of the sensor. This should constitute a safe operating condition in most circumstances.

    - Do not focus features of <50 µm on the photocathode (i.e. stay around the resolution limit of the ICCD camera). For example, a 10 µm feature might be sufficiently intense to damage the photocathode but, when it is smeared out to ~ 50 µm, it may not be saturating the sensor and therefore satisfies the general guideline above. This applies to images and to spectra. Be particularly careful with automatic spectrographs that reset themselves with the brighter zero order on the center of the focal plane.
    - Always keep the photocathode covered when the detector is not in use (the photocathode will degrade even when switched off). This can be facilitated by using a mechanical shutter whenever possible.
    - If you are unsure of the signal levels to be detected, one should start with low signal levels and build up by using a series of neutral density filters. If necessary, use a CCD detector to check the signal level.
    - Protect the iStar CCD from mechanical shock both in use, and in transit, as damage to the intensifier tube may result from sharp jolts.

2. To remove dirt or fingerprints on the input window of the image intensifier, please contact your local Andor representative for advice on how to best clean this interface.

3. Turning off the iStar CCD camera through mains or camera On/Off switch during acquisition or cooling may result in damage to the camera. When possible, ensure sensor cooling temperature should be > 0°C (after switching Off the cooler) before turning off the camera.

4. Prior to mounting the camera on an optical system, the black grommet which covers the image intensifier and protects it from unwanted photo-bleaching must be carefully removed without the use of any tools such as screwdrivers.

Revision History

Version	Released	Description
1.0	31 Aug 2011	Initial Release (adapted from iStar Classic manual)
1.1	01 Nov 2012	Updated presentation and format.
2.0	04 July 2022	Updated to current format. Added China RoHS table to Appendix.
2.1	26 June 2023	Extensive edit. Changes on file.
2.2	27 Sept 2024	Image Intensifier footnotes added due to obsolescence.
2.3	18 Feb 2024	Added Windows 11 mention to Minimum Computer Requirements.

Updates to the Manual

Changes are periodically made to the product and these will be incorporated into new editions of the manual. Please check for new releases of the manual at: https://andor.oxinst.com/downloads. If you find an issue in this manual please contact your customer support representative (Section 1.1) with a description of the issue.

Section 1: Introduction

Thank you for choosing the **iStar intensified Scientific CCD camera**. You are now in possession of a state-of-the-art, cutting-edge platform new intensified camera which combines the ultra-fast, gated image intensifier technology of the Andor iStar with a range of high-performance CCD sensors for imaging and spectroscopy. For applications requiring simultaneously high aquisition rates and high dynamic range please also check our Scientific CMOS (sCMOS)-based iStar range.

Figure 1: The iStar CCD Camera

This manual contains useful information and advice to ensure you get the optimum performance from your new system. If you have any questions regarding your iStar CCD camera please feel free to contact Andor directly, or via your local representative or supplier.

1.1 Help and Technical Support

If you have any questions regarding the use of this equipment, please contact the representative* from whom your system was purchased, or:

Europe

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Building B2 West,
No.11 West Third Ring North Road,
Haidian District,
Beijing,
100089
China
Tel: +86 (0) 10 5884 7900
Fax. +86 (0) 10 5884 7901

* The latest contact details for your local representative can be found on the Contact and Support page of our website.

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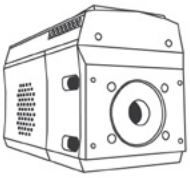
Manufacturers Information

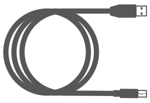
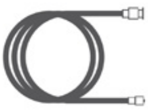
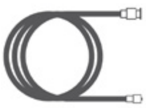
Andor Technology Ltd., Belfast, BT12 7AL, UK.

1.4 Components

The standard components supplied with the iStar CCD are shown in **Table 1**. Note that the iStar CCD camera requires camera control software e.g. Solis, supplied separately.

Table 1: Standard Components supplied with the iStar CCD

Description		Quantity
	iStar Intensified CCD Camera	1

Description		Quantity
	PCIe Card	1
	Camera to PC USB Inter-face cables (s)	1 x 3 m
	Power Supply Unit and Country specific Power Cord	1
	SMA - BNC Cable	2 x 3 m
	Gate Monitor Cable	1
	Performance sheet	1

Description		Quantity
	Anti-static Strap	1
	Hex Key (7/64, 3/32, 3.0mm & 2.5mm)	4
	Software supplied in electronic format	1
	User guide andor.oxinst.com/downloads/	1
	Hose inserts (for connection to cooling system)	2

1.4.1 Accessories

A range of optional accessories are available to order, please contact your local sales representative for further information.

Description	Order Code
C-mount lens adaptor	**ACC-LM-C**
F-mount lens adaptor	**ACC-LM-NIKON-F**
Oasis 160 Ultra compact chiller unit (tubing to be ordered separately)	**ACC-XW-CHIL-160**
6 mm tubing options for ACC-XW-CHIL-160 (2x2.5 m or 2x5 m lengths)	**ACC-6MM-TUBING-2X2.5/ ACC-6MM-TUBING-2X5M**
I^2C to BNC cable for Kymera and Shamrock shutter control	**ELC-05323**
Metric Bracket, converts ¼-20 mounting points to M6	**ACC-ISTAR-METRIC ADP**
UV-VIS 105 mm SLR lens, 250 - 650 nm transmission, F-mount	**OL-AF10-F45-#UV2**

Note: The use of a mechanical shutter is recommended. Although Image Intensifiers act as efficient optical shutters, the use of a mechanical shutter is recommended when the camera is not used to protect the photocathode from "passive" photo-bleaching.

Section 2: Product Overview

2.1 Hardware Description

This section provides an overview of the external and other features of the iStar CCD camera.

Figure 2: External features of the iStar CCD Camera

Intensifier Input Window
The input window is the substrate on which the photocathode is deposited and typically dictates the lowest photon wavelengths that can be detected by the ICCD. It also seals the image intensifier internal vacuum chamber and is designed to prevent contaminants and moisture impacting the performance and lifetime of this device.

Mounting Flange
The mounting flange enables the iStar CCD to be mounted to a wide range of optical components. Refer to mechanical drawings in Appendix A.

Sensor
The iStar CCD features a range of CCD sensors (refer to the specification sheet for model performance data).

Gate Monitor Socket
The gate monitor socket is located behind the grommet.

Ventilation Slots
There are two sets of ventilation slots. At the top of the camera, air is taken in through the top grill and passed out through the side grills. At the side of the camera, air is taken through the side shown above, and passed out through the opposite side. Ensure that there is sufficient space (>100 mm) to enable adequate ventilation.

Dry Gas Purge Port
Dry gas purge for intensifier input window to help reduce Electron Background Illumination (EBI) noise in photon counting applications. It is a push fit for 6.0 mm [0.24] O.D. plastic hose (vent on opposite side).

2.2 Power And Signal Connections

2.2.1 Connector Plate

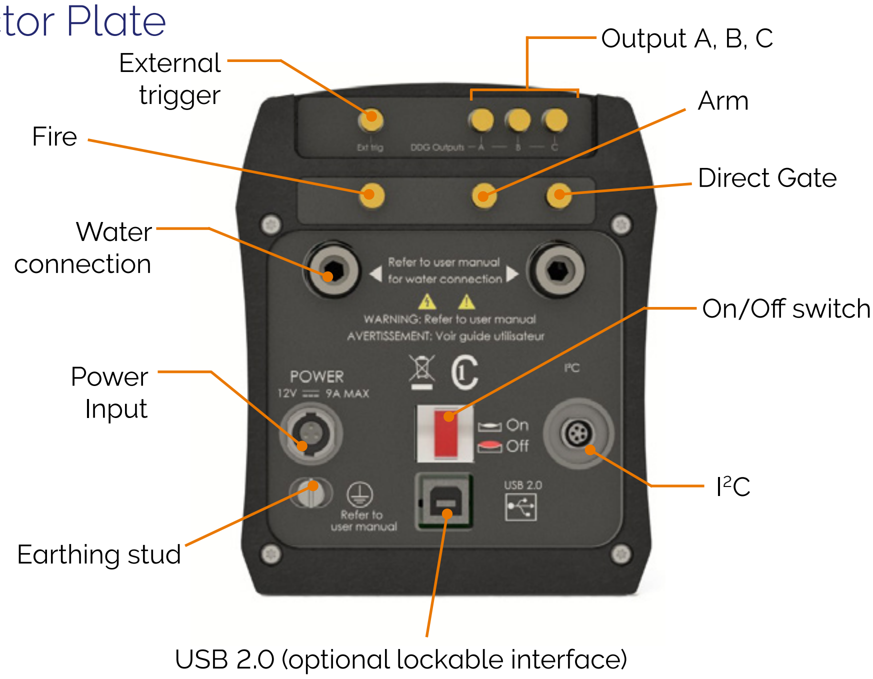


Figure 3: iStar Connections

Power Input
For connection to the external PSU (refer to Section 2.2.2). An On/Off switch is also present (shown above).

USB
A USB 2.0 compatible cable can be connected between the USB socket and a PC. An optional locking interface is also available.

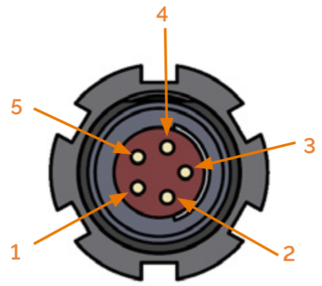
Direct gate
TTL compatible input used to directly gate the photocathode of the image intensifier tube, i.e. bypassing the iStar internal Digital Delay Generator (DDG) to switch it On and Off. The photocathode is On when the input TTL signal is high. User should provide (electrical) pulse width and appropriate gate pulse delay.

Logic Input / Output (SMA) Connections
The user can synchronize the readout of the iStar CCD camera to external events / equipment by means of the SMA connections. The functions of each are detailed below:

- **Ext Trig (External Trigger)**: TTL compatible input which is used to initiate data acquisition by the camera.
- **Digital Delay Generator Outputs A, B & C:** Programmable 5V CMOS level outputs used to synchronize external events / equipment with operation of the iStar.
- **Fire:** 5 V CMOS level reference signal relating to the sensor exposure time. This output remains high during the charge / signal accumulation period, i.e. the time during which charge from the image area is not being read-out
- **Arm:** 5 V CMOS level reference signal to indicate when system is ready to accept External Triggers. Signal goes high when system is ready to accept External Triggers after a readout sequence has finished.
- **Aux Out** (external mechanical shutter output) Configured by default to a 5V CMOS level with 50 Ω impedance shutter output for controlling Andor Shamrock and Kymera spectrograph mechanical shutters.

I²C

Compatible with Fischer SC102A054-130, pin-outs as follow: 1 = Shutter (5 V CMOS level with 50 Ω impedance), 2 = I²C Clock (5 V), 3 = I²C Data (5 V), 4 = +5 Vdc, 5 = Ground. The pin-outs of this connector are shown below:



Pin	Function
1	SHUTTER (TTL)
2	I²C CLOCK
3	I²C DATA
4	+5 V
5	GROUND

Figure 4: Pin outs of the I²C connector

Earthing Stud

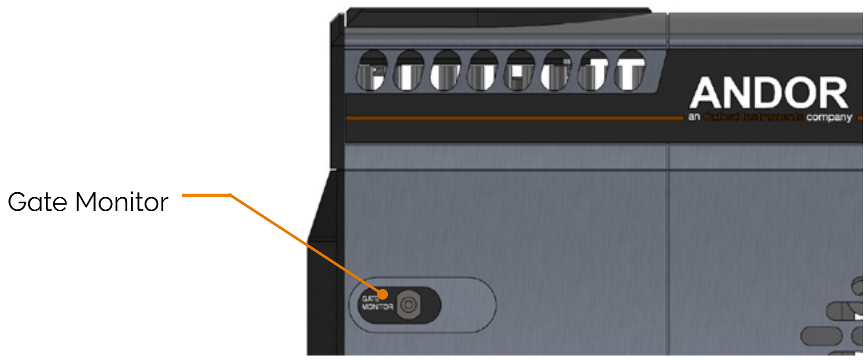
Enables the iStar CCD to be connected to an external earthing point to maintain low noise and/or is used as an alternative Protective Earth Connector Terminal in the event that the Andor-supplied External Power Supply is not used, e.g. in an OEM application (see Section 3.1.4 for further details).

Water/Liquid Cooling Connections

Refer to Section 3.2 for information on the use of water/liquid cooling.

Gate Monitor

Enables user to monitor the accurate, actual On and Off switching of the photocathode (connection shown below).



2.2.2 Power Supply Unit (PSU)

Ensure that the power connector is inserted correctly. Never forcibly insert the connector otherwise damage to the equipment may occur. Please see "External Power Supply Requirements" on page 115.

The iStar CCD requires a Direct Current (DC) supply. The electrical mains lead should be certified for use in your country and in applicable countries the plug must be fitted with a 240 V, 5 A fuse.

Section 3: Installation

WARNING: Prior to commencing installation, the user should refer to the safety and warning information at the beginning of this manual.

3.1 Connecting the iStar CCD to other Equipment

3.1.1 Attaching to a Spectrograph

The iStar CCD can be easily connected to an Andor **spectrograph.** If the iStar CCD and Andor's spectrograph have been ordered at the same time, the system will arrive already pre-aligned and integrated. If this is not the case, such as matching the iStar CCD to an existing, or third-party spectrograph - the following general guidelines should be observed. Refer also to the instructions supplied with other system components for mounting cameras and detectors.

1. Bolt the **detector** to the **camera mounting flange**, ensuring that the head is correctly orientated and that the appropriate **O-ring** is inserted at the front of the detector head.
2. Attach the **camera mounting flange** to the spectrograph, ensuring that the appropriate **O-ring** is in place between both detector flange and spectrograph flange.
3. Secure all four attachment screws so that the detector head, the flanges and the spectrograph are fitted together securely in order to allow correct grounding through the connector cable. Good grounding maintains the low noise performance of the detector, and in severe environments may prevent the instrument from damage.

3.1.2 Attaching to a Lens System

The iStar CCD can also be easily connected to a **lens system** for imaging purposes. Your local Andor representative can supply details of the available adaptors for connecting the **iStar CCD** to various manufacturers' lenses.
The following general instructions should be followed:

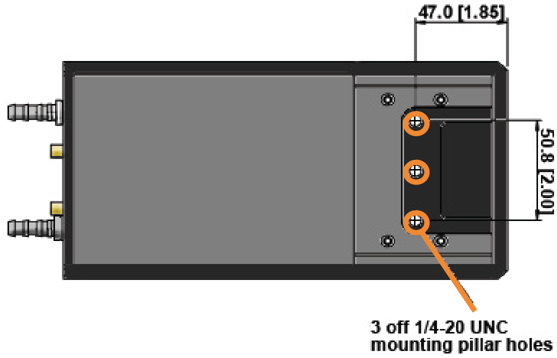
1. When attaching the iStar CCD to a **lens adaptor** (C-Mount or F-Mount for example), make sure that the adapter thread is free of dust ot debris that could fall onto the intensifier window. Then ensure that the adapter is correctly orientated and aligned. Ensure that the appropriate **O-ring** is inserted between the camera front plate and the **lens adaptor** plate. In the case of the C-Mount, place the side of the adaptor that is flush with the metal insert towards the iStar CCD front plate.

   Ensure that all four attachment screws are secured to the adaptor.
2. Attach the appropriate lens into the metal insert (C-Mount) or bayonet interface (F-Mount) of the lens adaptor.

3.1.3 Attaching to Mounting Posts

Three ¼ -20 UNC threaded holes are located on the underside of the camera as shown below. For further information, refer to the mechanical drawings in **Appendix A**.



3.1.4 Alternative Protective Earth via Earth Stud

As the main Protective Earth is provided via the Andor-supplied External Power Supply, then if this is not used, the alternative Earth Stud (see Figure 3, section 2.2.1) must be used instead as follows:

- A double-crimped, M4 Ring Terminal with 10AWG (6 mm^2) or larger, green and yellow striped, insulated wire must be connected and it is the responsibility of the customer that it is suitably and reliably connected at the other end to the building's protective earth system.

3.1.5 Connecting the iStar CCD Camera to the PC

Connect the USB 2.0 cable from the iStar CCD Camera to a suitable USB 2.0 slot on the control PC

USB connection between camera and PC

3.2 Cooling

The iStar CCD can use either air cooling, or optional water/liquid cooling.

3.2.1 Important Considerations when using Liquid Cooling Systems

- Before attempting to insert or remove the coolant hose connections, ensure that all coolant has been drained from the hoses and integral coolant channel within the camera head.
- Care must be taken to avoid permanent damage to the camera system resulting from either leakage of coolant during connection / removal of hoses or spillage of any residual coolant contained within the camera head once the hoses have been removed.
- Always ensure that the temperature of the liquid coolant circulated through the camera head is above the dew point of the camera ambient temperature and humidity conditions. Refer to the Dew Point graph in **"Appendix C: Dew Point Graph" on page 117** for guidance.
- Use of coolant at or below the dew point can result in permanent damage to the camera head, due to formation of condensation on internal components.
- Never use damaged, split or worn hoses.
- In the event that replacement hose inserts / barbs are required, please contact your local Andor representative.

3.3 Cooling Hose Connectors

There are two connectors to allow connection of the iStar CCD to a water cooler, or re-circulator. Hose inserts are provided to enable connection to coolant hoses.

Coolant Hose Connectors: Two barbed coolant hose inserts are supplied as standard, suitable for connection to 6 mm (0.25") internal diameter soft PVC tubing / hose.
Recommended tubing: 10 mm (0.4") outside diameter, i.e. a wall thickness of 2 mm (0.08"). Alternative hose dimensions and materials should be thoroughly tested to ensure a leak tight seal is achieved with the barbed inserts.

3.3.1 Coolant Recommendations

Is recommended that de-ionized water (without additives) is used as the coolant to prevent deposits forming. Some mains supply water is heavily mineralized (i.e. "Hard") which could cause deposits in the water circuit inside the camera. This can reduce the flow-rate and cooling efficiency.
The specified cooling performance of the camera can be achieved with coolant flow rates of 2 litres per minute, the maximum recommended pressure of coolant circulating through the camera head is 2 bar (30 PSI). In the event that replacement hose inserts / barbs are required, please contact your local Andor representative.

3.4 Connecting the Liquid Cooling System

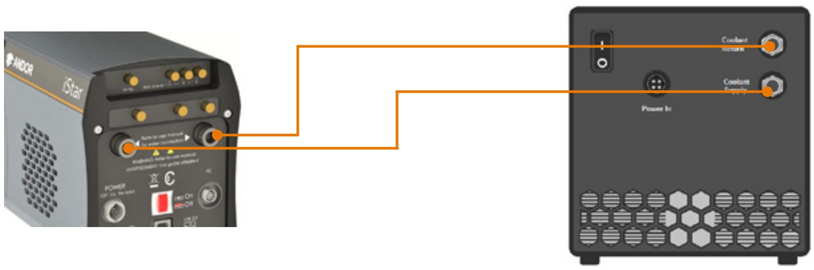
An overview for connecting an liquid cooling system is outlined below- please refer to the information supplied with your cooling system for information specific to its operation.

3.4.1 Connecting the Coolant Hoses

1. Press the hose insert into the coolant hose, and repeat for the second hose.

2. Press the hose connectors into the connections on the camera head, ensure they click into place.

3. Confirm the hoses are connected securely by applying pressure on the front of the camera body and pulling backwards on each hose.
4. Connect the other ends of the coolant hoses to the cooling system- refer to the cooling system manual.



3.4.2 Disconnecting the Coolant Hoses

1. Press the latch on the camera hose connection away from the hose.
2. Hold the latch in and pull the hose backwards.

3. The hose should release from the camera connection with little resistance.

NOTE: If the hose does not release, ensure that the latch on the camera connection is pressed in fully as shown above.

3.5 Installing Software and USB Drivers

3.5.1 Minimum Computer Requirements

- 3 GHz Quad Core or 2.4 GHz multi core processor
- 4 GB RAM
- Hard drive capable of sustained rate of 450 MB/s
- USB 3.0 High Speed Host Controller
- Windows (8.1, 10 or 11) or Linux

3.5.2 Installing Solis Software and USB Driver

If ordered, Solis software is available for download from the Andor download area at https://andor.oxinst.com/downloads/.

1. Terminate & exit any applications which are running on the PC.
2. Insert or run the copy of Andor Solis. The InstallShield Wizard should now start. If it does not start automatically, run the file setup.exe directly.
3. Select appropriate location for installation of software and drivers on your computer / network.
4. When prompted, select iStar CCD.
5. Continue installation and restart your computer - when prompted - to successfully complete the installation.
6. The shortcut icon for Solis will appear on the desktop on re-start.
7. The iStar is now ready to be connected to a PC / laptop and powered on.

3.5.3 New Hardware Wizard

When the iStar camera is connected to a PC for the first time, the **New Hardware Wizard** screen will appear.

1. Select the '**No, not this time only'** option then click **Next>**.
2. Select the **'Install from a list or specified location (Advanced)** option then click **Next**>.
3. Navigate to the directory where the Andor Solis software was installed to on the PC, then click **Next> so that the Installation Wizard can start.**
4. Click the **Finish** button to complete the installation.

Note: If the camera is connected to a different USB port, steps 1 – 4 will have to be repeated on the first connection only.

5. A system message will appear to indicate that the device has been successfully installed.

   Note: You can check that the iStar CCD is correctly recognized and installed by opening the Device Manager (Devices and printers) in Windows, Control Panels. The iStar CCD will show under the Devices list.

Section 4: Operation

WARNINGS:

- **IF THE EQUIPMENT IS USED IN A MANNER NOT SPECIFIED BY ANDOR OR ITS DISTRIBUTORS, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.**
- **PLEASE READ THE USER GUIDES SUPPLIED WITH YOUR SYSTEM COMPONENTS AND SOFTWARE PRIOR TO USE**

4.1 Emergency Mains Disconnection

In case of emergency, the disconnecting point of the equipment is the mains power cord connected to the external power supply, or the mains socket switch.
WARNING: SWITCH OFF THE POWER AT THE MAINS SOCKET AND REMOVE THE MAINS LEAD FROM THE EXTERNAL POWER SUPPLY.

4.2 Power-up Sequence

1. Ensure that the camera is powered on at the mains power supply.
2. Ensure that the USB cable is connected between the camera and the PC.
3. Start up the PC.
4. Ensure the On/Off switch on the camera is set to On.
5. Launch your camera control software e.g. Solis or SDK.
6. The camera will now start up under control of the software and you are ready to use the camera.
7. Refer to your software manual for set-up and acquisition information.

4.3 Power-Down Sequence

1. Exit the camera control software.
2. The camera cooler will automatically switch off.
3. Switch off power to the camera throught he on/off switch at the back of the detector and/or at the mains power socket.

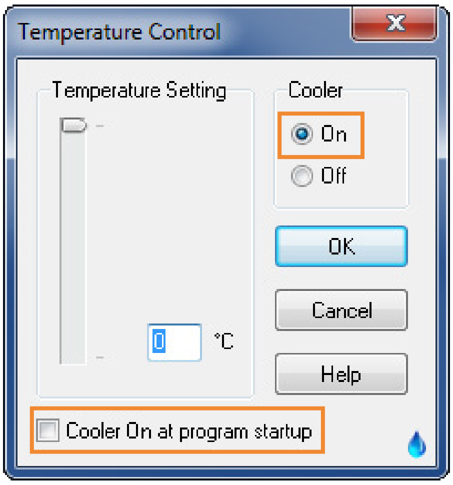
4.4 Using the iStar CCD Camera

The following sections provide an overview of how to set up and use the basic functions of the iStar CCD camera in Solis. Online help is built into Solis and available through the Solis Help Menu. This provides a full description of the features available. For other software, please refer to the software guide provided with your software.

4.5 Pre-Acquisition Setup

4.5.1 Setting The Cooling Temperature

For accurate readings, the detector should first be cooled, as this will help reduce dark signal and associated shot noise. To do this, either select the **Temperature** option from the **Hardware** drop-down menu on the main window or click the OFF button in the bottom-left of the screen. This will open up the **Temperature** dialog box. Select the **On** radio button in the **Cooler** area.
The degrees (C) field in the Temperature Setting section will now be highlighted in blue and the Cooler will be indicated as On.
To adjust the temperature, either type in the new figure in the Degrees (C) box or move the slider bar down or up. Once the desired temperature has been selected, click OK. The dialog box will disappear and the Temperature Control button in the bottom-left of the screen will show the current temperature highlighted in red e.g.: -45°C

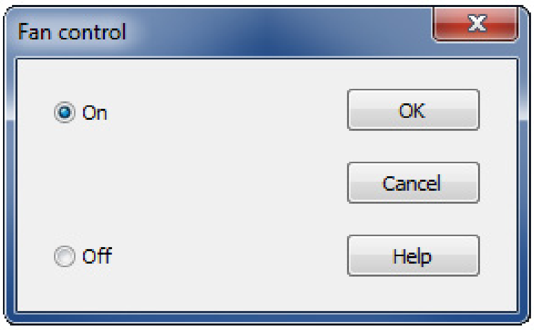


This figure will change as the camera cools. Once the sensor has reached the desired temperature, the highlighted area changes to blue.
You can also select the option to have the Cooler switched on as soon as you start the application. This is selectable in the bottom-left of the Temperature dialog box (shown above).

4.5.2 Fan control

The cooling fan can also be turned Off or On in the software for applications sensitive to fan vibration or where camera air flow is obstructed, meaning that only water cooling can be used.

1. Select Fan Control from the Hardware drop-down menu.
2. Select whether fans should be activated, or deactivated during cooling and/or acquisition.

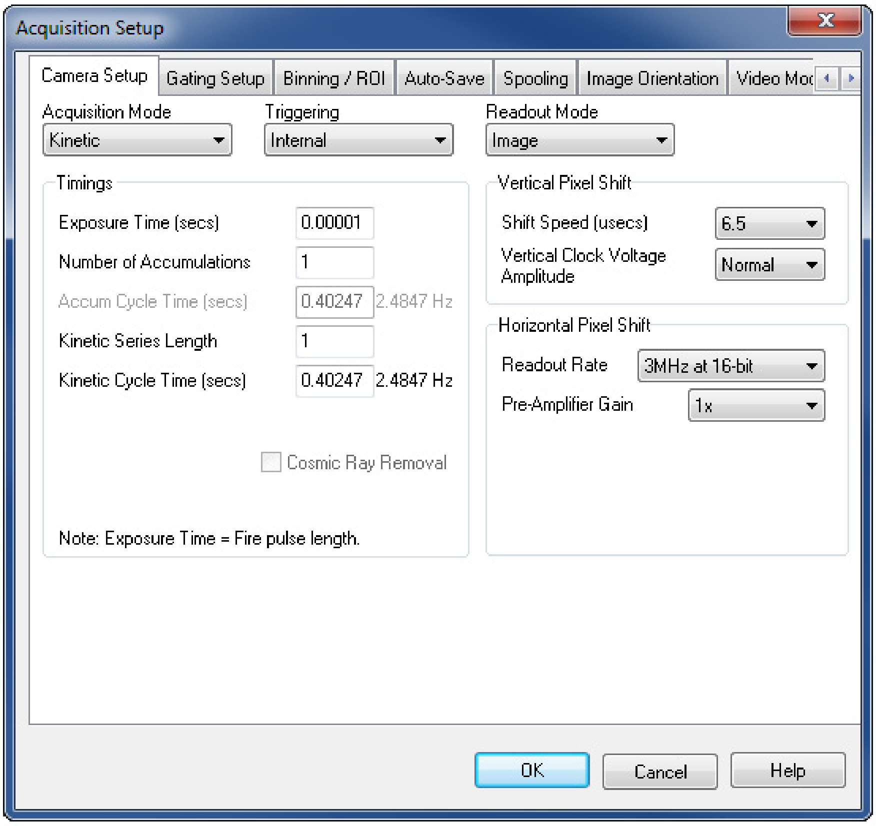


4.6 CCD Setup Acquisition

To select the mode of acquisition prior to data capture, the following steps should be followed:

- Click the  button
- Key in **Ctrl+A**
- Select **Setup Acquisition** from the **Acquisition** drop-down menu:

The Setup Acquisition dialog box appears, e.g.:



As user selects an acquisition mode, additional acquisition-related parameter fields will appear. The following matrix lists the acquisition modes and the key set-able parameters:

Mode	Exposure Time	Accumulate Cycle Time	No. Of Accumulations	Kinetic Cycle Time	No. in Kinetic Series
Single Scan	✓	-	-	-	-
Accumulate	✓	✓	✓	-	-
Kinetic	✓	-	✓	✓	✓

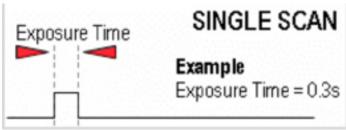
Note: The value entered in one field (e.g. exposure time) may affect the value in another field (e.g. acquisition cycle time)
Note: Other modes such as photon counting or fast kinetics will be detailed specifically in following sections of this user guide

4.7 Acquisition Modes and Timing

An acquisition is taken to be the complete data capture process that is executed whenever user selects **Take Signal**, **Take Background**, or **Take Reference** from the acquisition menu, or whenever user clicks the **Take Signal** button. By contrast, a scan (an “acquired scan” in the definitions that follow) is a single readout of data from the CCD-chip. Several scans may be involved in a complete data acquisition. The minimum time required for an acquisition is dependent on a number of factors, including the exposure time (i.e. the time in seconds during which the CCD collects light prior to readout) and the triggering mode. Triggering modes are described in more detail later in this section.

4.7.1 Single Scan

Single Scan refers to an acquisition in which only one user frame is transmitted from the camera.
A user frame is output from the sensor on receipt of a valid trigger of the selected type and then transmitted from the camera. Note that any subsequent triggers within the same acquisition are ignored.



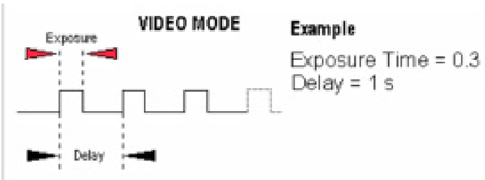
The following parameters can be changed:

- **Exposure Time**

Note: Should user attempt to enter too low a value, the system will default to a minimum exposure time.

4.7.2 Video

If user selects the  button, the system repeatedly performs a single scan and updates the data display.



Note: This is a useful mode for focusing the New CCD and for watching experimental events happening in real-time. However, this mode will not allow to save any of the acquired images or data, except for the last frame of the sequence.

When the **Video Mode** tab on the setup acquisition dialog box is selected, the video mode dialog interface appears.

The following parameters can then be set:

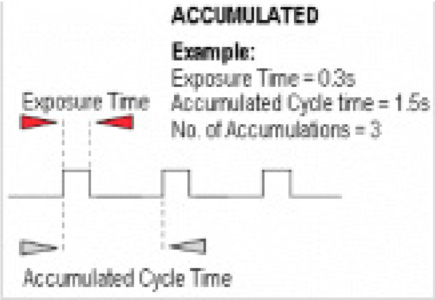
- **Exposure Time**
- **Delay:** The interval required between scans.
  Note: When entering too low a value, the system will default to a minimum delay.
- **Resolution (sub-image area):** Size of the sub-image (in pixels).
- **Binning pattern:** Super pixel size (in pixels).
  Note: When the ‘Use Settings From Standard Setup’ option is selected, these parameters cannot be altered.

The system will acquire data only as quickly as these can be displayed. If **Take Background** or **Take Reference** in video mode are the chosen mode of operation, the system will perform one scan only. New data will continue to be acquired and displayed until one of the following actions is being carried out:

- Select **Abort Acquisition** from the **Acquisition Menu**
- Click the  button
- Press the **<ESC>** key

4.7.3 Accumulate

Accumulate mode allows user to 'add together' in the computer memory the data from a number of scans to create an 'accumulated scan' e.g.:



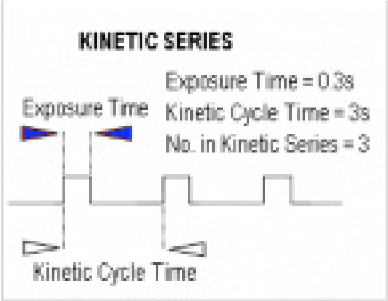
The following parameters can be entered in the **Setup Acquisition** dialog box:

- **Exposure Time**
- **Accumulated Cycle Time**: The period in seconds between each scan. This parameter is only available when internal triggering is selected
- **No. of Accumulations**: The number of scans to be added together

Note: This mode can be used to effectively improve the acquisition signal to noise ratio.

4.7.4 Kinetic Series

Kinetic series mode allows user to run, record and save a sequence of consecutive acquisitions in a single working window. The following parameters are used to configure the acquisition:



- **Exposure Time**
- **Kinetic Cycle Time:** The time between the start of two consecutive scans within a kinetic series
- **Number in Kinetic Series:** The number of scans taken in the kinetic series

This mode is particularly well suited to recording the temporal evolution of a process, and can also be used in conjunction with accumulation mode for further signal-to-noise ratio enhancement.

Note: If External Trigger is selected the Kinetic Cycle dialog box will indicate the maximum achievable frame rate.

4.7.5 Fast Kinetics

Fast Kinetics mode allows access to exposure times (and time resolution) on a microsecond timescale, i.e. in the order of magnitude of the CCD vertical shift speeds. However, in the case of ICCDs, the ultimate time-resolution will be dictated by the photocathode gate time.

In Fast Kinetics the signal to be recorded is imaged across a certain section of the CCD, typically across the top rows of the CCD sensor. The non-illuminated part of the CCD is used for storage of the consecutive images part of the same acquisition sequence before readout. The overall sequence is recorded in one single acquisition window.

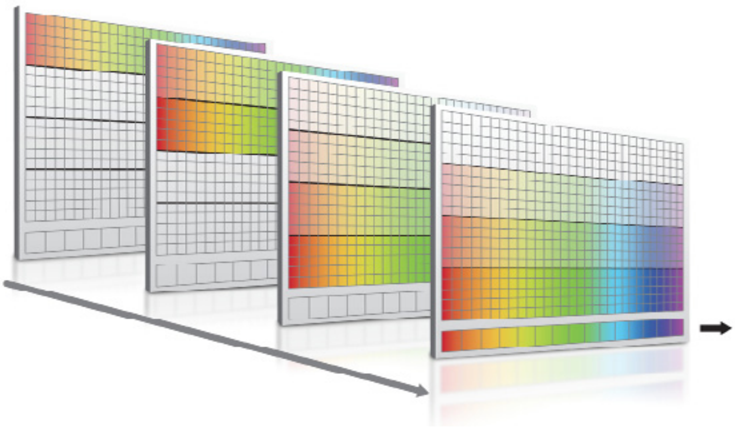
T1 - CCD keep clean sequence is interrupted, and useful signal builds-up on the user-defined top portion of a sensor

T2 - At the end of the exposure time, signal is rapidly shifted down by a pre-defined number of rows, and a second exposure takes place

T3 - This process is repeated until the number of acquisitions equals the series length set by user

T4 - The sequence moves into the readout phase by shifting in turn the individual acquisitions to the readout register, which is then read out

From the **Setup Acquisition** dialog box, the following parameters can be configured:



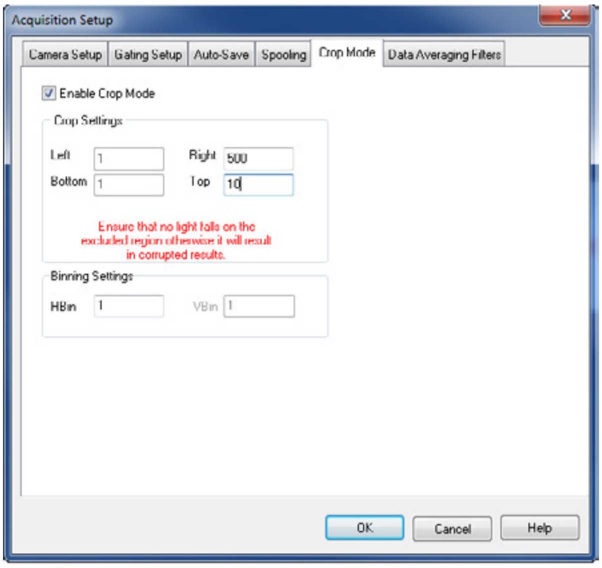
- **Exposure time:** the exposure time also represents the cycle time of the Fast Kinetics series. There is no separate parameter for a fast kinetics cycle time.
- **Sub Area Height:** in rows.
- **Number in Series:** the number of time-sampled acquisitions in the series to be stored on the sensor. These will depend on the sensor height and number of active rows selected.
- **Binning**
- **Offset**: of the active area from the bottom of the detector

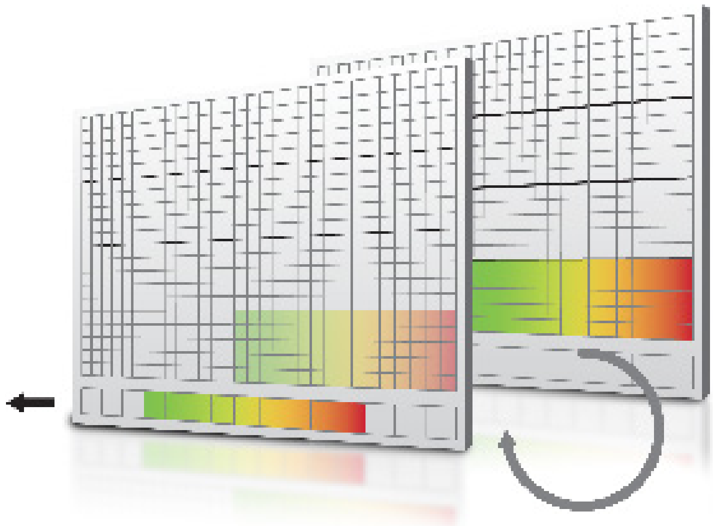
Notes:

- Special offset flanges for Andor spectrographs are available so that active area of the sensor is positioned across the spectrograph optical axis, where best optical performance can be achieved.
- When using fast kinetics mode, care should be taken to avoid (or greatly minimize) stray light falling on the bottom of the sensor, i.e. outside the active area of the sensor, in order to avoid useful, stored signal corruption.
- The use of Andor's Optomask for imaging applications should be considered to physically block unwanted light falling on to the storage part of the sensor.

4.7.6 Cropped Sensor Mode

If an experiment demands the fastest image or spectrum acquisition rates, but cannot be constrained by the maximum storage size of the sensor (as is the case for 'Fast Kinetics Mode'), a specific 'Cropped Sensor Mode' can be set up through the main acquisition set up window, e.g.





In this mode, the user defines a 'sub-array' size from within the full image sensor area, such that it encompasses the region of the image where change is rapidly occurring. The sensor subsequently 'imagines' that it is of this smaller defined array size, achieved through software executing special readout patterns, and reads out at a proportionally faster rate. The smaller the defined array size, the faster the acquisition rates achievable.
The cropped area must be positioned in the bottom-left of the sensor, thus the subject of study should be first positioned in this area rather than centrally located.

Notes

- Special offset flanges for Andor spectrographs are available so that crop area of the sensor is positioned across the spectrograph optical axis, where best optical performance can be achieved.
- When using crop mode, care should be taken to avoid (or greatly minimize) stray light falling on the top of the sensor, i.e. outside the active 'cropped' area of the sensor, in order to avoid useful signal corruption.
- The use of Andor's Optomask for imaging applications should be considered to physically block unwanted light falling on to the upper part of the sensor.

4.7.7 Photon Counting

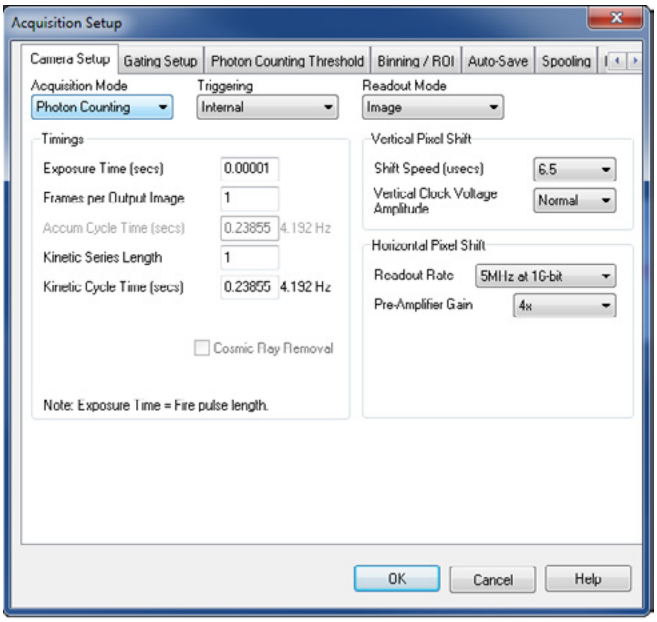
Photon Counting can only be successfully carried out with very weak signals, because as the name suggests, it involves counting only single photons per pixel. If more than one photon falls on a pixel during the exposure, an ICCD cannot distinguish the resulting signal spike from that of a single photon event, and thus the dynamic range of a single frame exposure is restricted to one photon.
Under such ultra-low light conditions, 'photon counting mode' imaging carries the key benefit that it is a means to **circumvent the Multiplicative Noise**, also known as '**Noise Factor**'. Multiplicative noise is a by-product of the Electron Multiplication process and affects both EMCCDs and ICCDs. This gives the new 'effective shot noise' that has been corrected for multiplicative noise.

Photon Counting mode does not measure the exact intensity of a single photon spike, but instead registers its presence above a threshold value. It does this for a succession of exposures and combines the individual 'binary' images to create the final image. As such, this mode of operation is not affected by the multiplication noise (which otherwise describes the distribution of multiplication values around the mean multiplication factor chosen). The end result is that low light images acquired through this mode of acquisition are improved by a factor of ~x2-2.5 Signal-to-Noise, compared to a single integrated image with the same overall exposure time.

To successfully photon count with ICCDs, there has to be a significantly higher probability of seeing a 'photon spike' than seeing a darkcurrent/EBI 'noise spike'. The lower the contribution of this dark noise sources to a single exposure within the accumulated series, the lower the detection limit of photon counting and the cleaner the overall image will be. The probability for the photocathode to generate an unwanted EBI event can be minimised to an extent by flushing the window of the intensifier constantly with dry gas (see "Figure 2: External features of the iStar CCD Camera" on page 17 to locate the dry gas interface)

4.7.7.1 Photon Counting in Real-Time

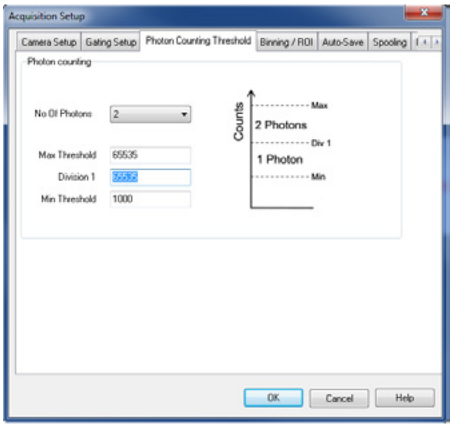
As the ICCD is continually scanned, the signal builds up in computer memory and can be viewed live on the screen.
Photon Counting can be selected and configured from the **Acquisition Mode** drop-down menu of the dialog box, e.g.:



Parameters to be set are:

- **Exposure Time** per acquisition
- Number of **Acquisitions per Output Image or spectrum**
- **Kinetic Series Length** required.

The **Photon Counting Threshold** tab provides the following interface:
Min.Threshold and **Max. Threshold** values can be set to define the signal intensity range considered for the detection of the single photons events. The iStar CCD photon counting mode allows selection of several 'counting levels' to especially differentiate several photons from a single pixel or column - the latter is especially useful when working in FVB mode. Each level is defined by a signal intensity in counts.



The **histogram** option selectable from the quick access button on the main window allows easy visualization of signal intensities brackets population.

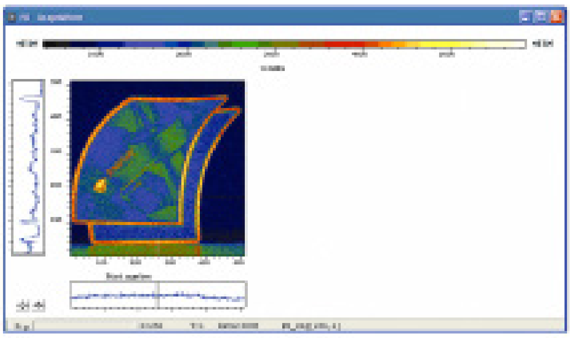
4.8 Readout Modes

The signal captured by a 2D CCD sensor can be read in several different ways, adapted to specific experimental configurations. The main options available are:

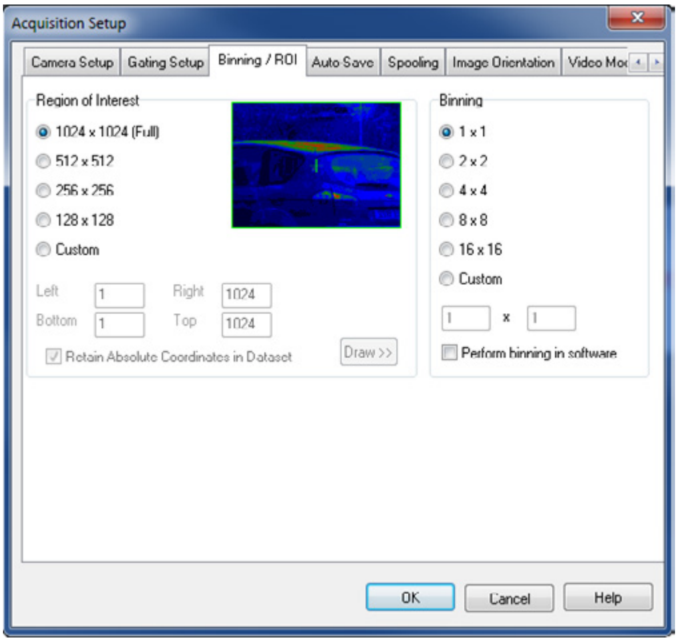
- **Image** (including sub-array and binning)
- **Multi-Track**
- **Full Vertical Binning (FVB)**

4.8.1 Image Mode

The default image display mode is referred to as 'full resolution image', whereby signal information (in counts) of each individual pixel of the CCD is reported and accessible, e.g.:

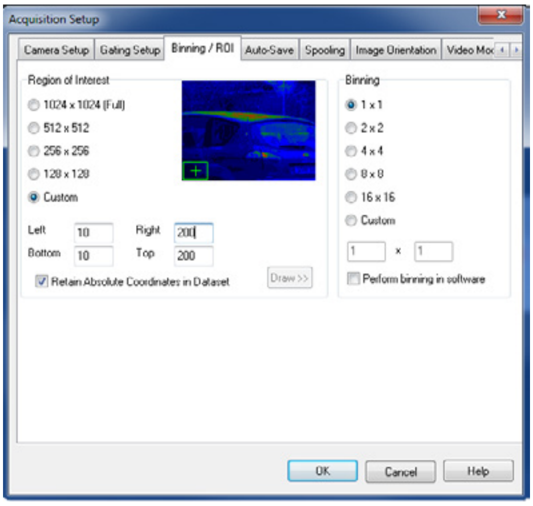


By selecting the **Binning/ROI** tab in the setup acquisition interface the following options appear:
This interface allows the user to tailor the image display through sub-arrays/sub-images, or binning.



4.8.1.1 Sub Image

For the purpose of initial focusing and alignment of the camera, or to increase the frame or spectral rate, user may select a sub-image of the CCD chip. When the camera is running in sub-image mode, only data from the selected pixels will be read out, and data from the remaining pixels will be discarded. To read out data from a selected area (or sub-image) of the CCD, the radio buttons should be toggled to select the required resolution as shown below:



Note: The standard choices of sub-image configuration will vary with the CCD matrix used.
A custom sub-image can also be used to set a specific size and location of the desired acquisition area on the CCD chip. To user-define a sub-image, the custom radio button should be selected so that the co-ordinate fields appear.

Draw

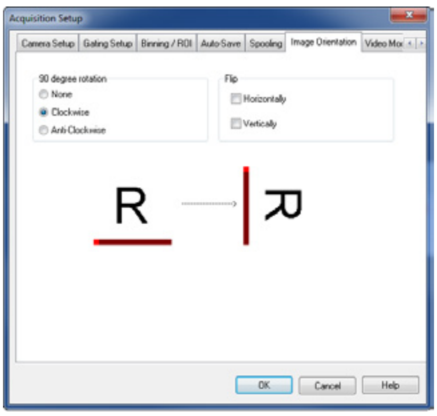
In addition to the previous methods of defining a sub-image on the sensor, a **Draw** option can be used to graphically select the size and location of the sub-image. A full resolution image must first be acquired to provide the template on which the sub-image will be drawn. The 

button displays the Draw tool on the full resolution image.

Note: 'Restore Absolute Co-ordinates in Data Set' allows user to retain actual pixel X-Y co-ordinates on the CCD

4.8.1.2 Image orientation

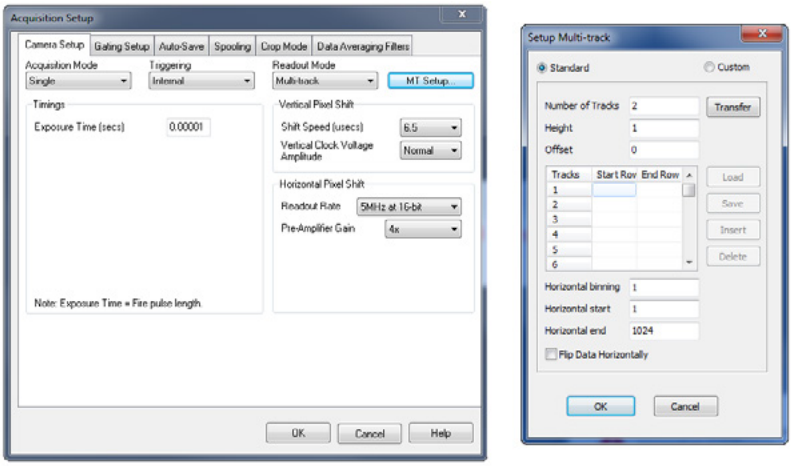
In image mode, the data can also be orientated in a specific way as they are acquired. The orientation of the image data is accessible from the **Image Orientation** tab on the **Setup Acquisition** dialogue box e.g.:



4.8.2 Multi-track Mode

Multi-track mode allows creation of one or more individual acquisition tracks that can be defined (in rows) by the height of each track, and the offset on the CCD-chip, which in effect 'raises' or 'lowers' the pattern of tracks from which the charges will be read out.
In this way, the position of the tracks can be adjusted to match a light pattern produced on the CCD-chip by a fibre-optics bundle for example. To define multiple tracks on the CCD-chip can be defined under the **Multi-track** section from the **Readout Mode** drop-down menu in the **Setup Acquisition** dialog box:

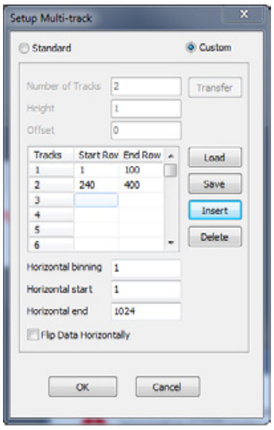
By clicking the MT Setup... button, the following **Setup Multi-track** dialog box opens:



There are two modes of operation, i.e. **Standard** or **Custom**.

- In **Standard** mode, the user defines the **Number of tracks**, the **Height** & **Offset**. The software automatically calculates the position of the tracks by distributing them evenly across the sensor.
- In **Custom** mode, the user has the ability to define the tracks as required.

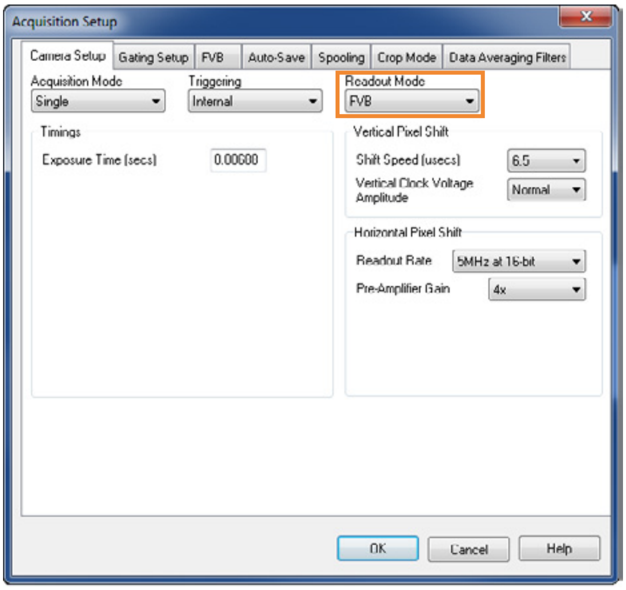
The user can also save the position of the individual tracks to a file that can be reloaded later. The **Load** and **Save** buttons are used to achieve this. The user can also utilize the **Insert** and **Delete** buttons to define or remove tracks.



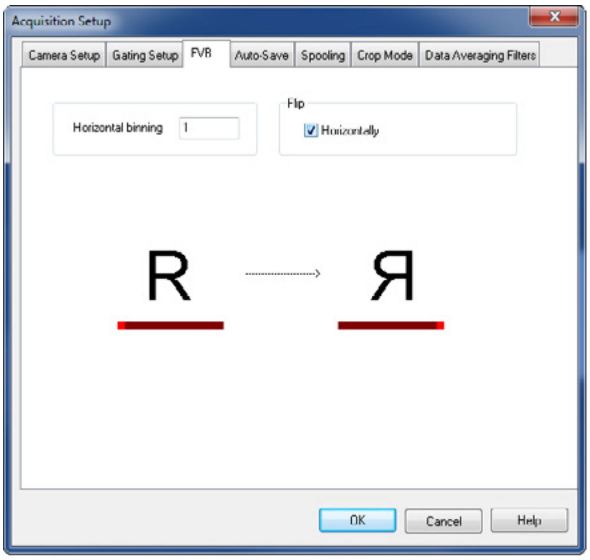
The user can also define the horizontal binning and position of all the tracks. The **Transfer** button can be used to quickly load the automatically calculated tracks from the standard mode setup into custom mode.

4.8.3 Full Vertical Binning (FVB)

FVB allows the user to operate the CCD-chip as a linear image sensor (a photodiode array), typically for spectroscopy applications. The charges from each column of pixels (each column being the chip height) are combined, or binned, on the chip to give one single signal value per column. **FVB** mode is selected in the **Setup Acquisition** dialog box as shown below:



For some spectrographs, it may be necessary to change the direction in which the data is displayed on screen. This is accessible in the setup acquisition dialogue, in the FVB tab as shown below:
In some instances spectral rate can be more important than spatial/spectral resolution. For such applications, horizontal binning can be applied by setting the desired binning format in the **Horizontal Binning** section of the acquisition setup interface to a value greater than one.



4.8.4 Binning

Binning is a process that allows charge from two or more **pixels** to be combined on the **CCD**-chip prior to readout. Summing charges on the CCD and doing a single readout gives better noise performance than reading out several pixels and then summing them in computer memory. This is because each act of reading out charges from the CCD contributes to noise.
Combining both the vertical and horizontal binning methods produces '**superpixels**'. These consist of two or more individual pixels that are binned and read out as one large pixel. Thus the whole CCD, or a selected sub-area becomes a matrix of superpixels.
On the one hand superpixels result in a loss of spatial resolution when compared to single pixel readout, but on the other hand they offer the advantage of summing data on-chip prior to readout, thereby producing a better signal-to-noise ratio and a higher frame rate.

4.8.4.1 Vertical Binning

Charges from two or more rows of the CCD-chip are moved down into the shift register before the charges are read out. The number of rows shifted depends on the binning pattern selected. Thus, for each column of the CCD-chip, charges from two or more vertical elements are **summed** into the corresponding element of the shift register. The charges from each of the pixels in the shift register are then clocked horizontally to the output amplifier and read out.

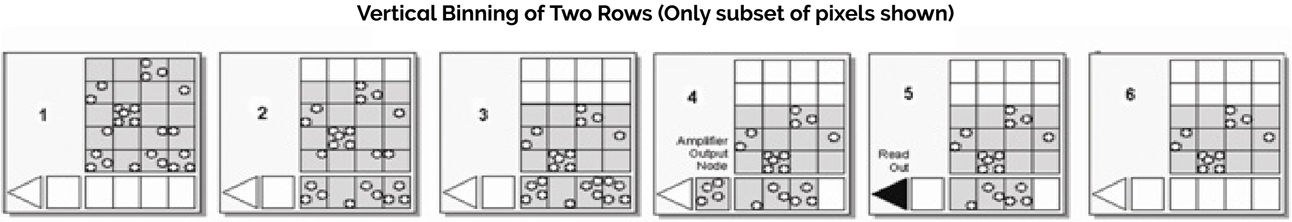
1. **Single-Track**: Charges are vertically binned and read out from a number of user-selected adjacent rows of pixels on the CCD-sensor. The rows form a single track across the full width of the CCD-sensor.

2. **Multi-Track**: This mode differs from single-track in that user now defines two or more tracks (groups of rows) on the CCD from which to read out charges. In processing terms, each track is treated as in single track.

3. **Full Vertical Binning (FVB)**: Charges from each complete column of pixels on the CCD are moved down and summed into the shift register, and the charge is then shifted horizontally one pixel at a time from the shift register into the output node - in effect a value is read out for each complete column of the CCD-sensor. This mode is typically used for spectroscopy (please refer to section 5.3.3.3).

The example below illustrates readout of data from adjacent tracks, each track comprising two binned rows of the sensor.

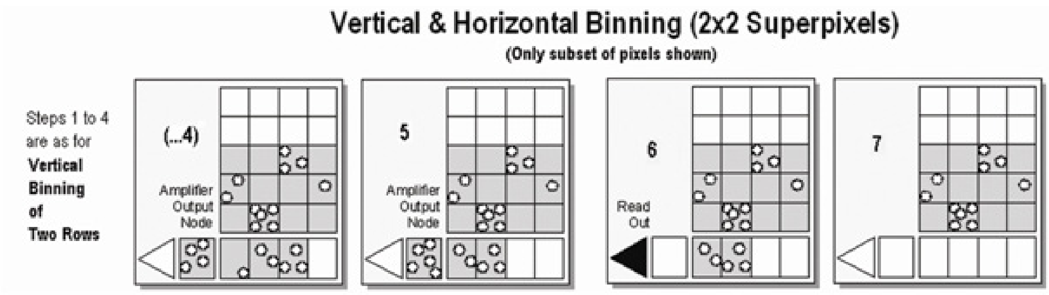
Vertical Binning of Two Rows (Only subset of pixels shown)



1	Exposure to light causes a pattern of charge (an electronic image) to build up on the frame (or 'image area') of the CCD-sensor.
2	Charge in the frame is shifted vertically by one row, so that the bottom row of charge moves down into the shift register.
3	Charge in the frame is shifted vertically by a further row, so that the next row of charge moves down into the shift register, which now contains charges from two rows - i.e. the charges are vertically binned.
4	Charges in the shift register are moved horizontally by one pixel, so that charges on the endmost pixel of the shift register are moved into the output node of the amplifier.
5	The charges in the output node of the amplifier are passed to the analogue-to-digital converter and are read out (digitized).
6	Steps 4 and 5 are repeated until the shift register is empty. The process is repeated from Step 2 until the whole frame is read out.

4.8.4.2 Horizontal Binning

In this configuration, charges from two or more pixels in the serial register are transferred into the output amplifier and read out as one combined data value. Thus the charges from two or more of the horizontal elements are effectively summed into the output amplifier before being readout.
In the example below (where each superpixel is of dimensions 2 x 2 pixels) charges from two rows is first binned vertically into the shift register; then charges from two pixels of the shift register are binned horizontally into the output node of the amplifier. The effect of the combined binning processes is a summed charges equating to a 2 x 2 **'superpixel'**.
Since this example initially involves binning charge from two rows, the process begins in the same way as the previous example (see **Steps 1 - 4** of **Vertical Binning** section).



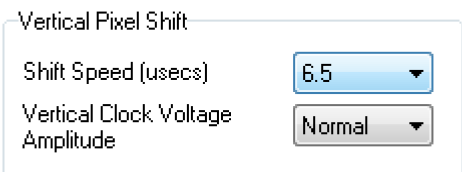
(...4)	Charges from two rows have already been vertically binned into the shift register. Charges in the shift register are now moved horizontally by one pixel, so that charges on the endmost pixel of the shift register are moved into the output node of the amplifier.
5	Charges in the shift register are again moved horizontally, so that the output node of the amplifier now contains charges from two pixels of the shift register - i.e. the charges have been horizontally binned.
6	The charges in the output node of the amplifier are passed to the analogue-to-digital converter to be read out.
7	Steps 4 to 6 are repeated until the shift register is empty. The process is repeated from Step 2 (in Vertical Binning section) until the whole frame is read out.

4.9 CCD Clocking Speed

4.9.1 Vertical Pixel Shift

Shift speed

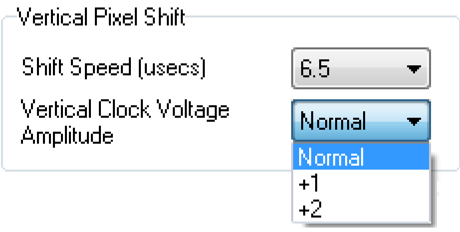
Shift Speed (µsecs) specifies the time taken clock (shift) charges from one row on the CCD sensor to the next. Speeds which appear un-bracketed in the drop-down list are guaranteed to meet all the system specifications. In some instances, using a slightly slower vertical shift speed may result in a slight increase in the single well capacity for imaging applications. However it may also reduce the maximum frame/spectral rates achievable.



Bracketed vertical shift speed values are also available (CCD-model dependent) to achieve even faster acquisition rates. However, with this setting the pixel well depth and charge transfer efficiency may be impacted.

Vertical Clock Amplitude Voltage

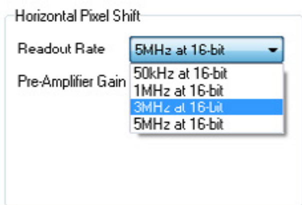
The vertical clock voltage amplitude can be used to increase the amplitude of the clock pulses used to perform row shifts on the CCD. The normal setting is the default amplitude which has been set at the factory during the optimization and testing of the camera. The other settings (if available) specify the voltage increase to be applied to this clock amplitude. In some imaging applications, increasing this voltage can provide a slightly higher single pixel well depth and improve charge transfer efficiency, at the expense of slightly higher Clocking Induced Discharge (CIC) noise.
Application of higher voltage may be required in combination with the fastest of the bracketed vertical pixel shift speeds in order to overcome image distortion effects that result from reduced charge transfer efficiency. Best practice is to select the fastest vertical shift speed, then step the vertical clock voltage 1 unit at a time until distortive effects disappear from the image.



4.9.2 Horizontal Pixel Shift

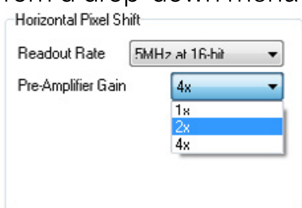
Readout Rate

Horizontal pixel shift readout rate defines the rate at which pixels are read (or digitized) from the shift register. The faster the horizontal readout rate the higher the frame or spectral rate that can be achieved. Slower readout rates will generate less noise in the data as it is read out, meaning that less MCP gain will be required to overcome the sensor noise floor and hence maximise the acquisition dynamic range. The available rates are system-dependent, and can be selected from a drop-down list on the **Setup Acquisition** dialog box, of which an example is shown below:



Pre-Amplifier Gain

Pre-amplifier gain determines the amount of gain applied to the video signal emerging from the CCD and allows the user to control the sensitivity of the camera system. Depending on the system there are up to three options available. They are again selected from a drop-down menu on the **Setup Acquisition** dialogue box:

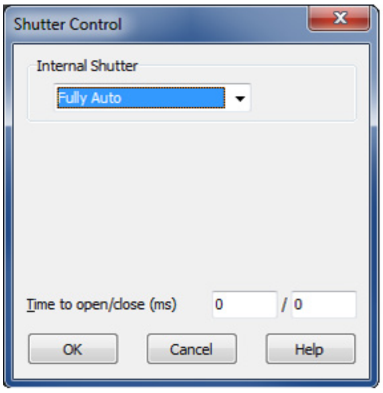


These normalized gain settings will correspond to system sensitivities specified on the performance sheets (in terms of electrons per A/D count) which accompany the system.
Selecting higher pre-amplifier gain values (i.e. x2 or x4) will increase the sensitivity of the camera (i.e. fewer electrons will be required to produce one A/D count) and provide the lowest readout noise performance. However this may result in the A/D converter saturating before the single pixel / register capacity of the CCD sensor is reached.

4.10 Shutter

With an ICCD, a mechanical shutter can be used for background acquisition in complement of the image intensifier optical shuttering (photocathode gating). Indeed the photocathode may exhibit some light leakage during exposure to bright light source even when 'Off'. But it is essentially used to protect the photocathode from unnecessary photo-bleaching between acquisitions or during storage of the equipment.
A shutter can be used to take a reference or background if FVB is selected. For either multi-track or image mode, the shutter may be required to avoid unnecessary signals/light falling on the photocathode or CCD during the readout process.

When the **Shutter Control** option is selected from the **Hardware** drop-down-menu, or the  button is clicked, the shutter control dialog box opens:



Note: Certain settings (e.g. Permanently OPEN & Permanently CLOSED) take effect as soon as the Shutter Control dialog box is closed. Other settings will be applied whenever data acquisition is started.

- In **Permanently OPEN** mode, the shutter will be open before, during and after any data acquisition. However if the camera is to be left unattended for long periods, it is recommended that the shutter is closed.
- **Permanently CLOSED** mode can be useful for taking a series of acquisitions in darkness (background) and do not require the shutter to open between acquisitions. The shutter remains closed before, during and after any data acquisition.
- **Fully Auto** is the simplest shutter mode, as it leaves all shuttering decisions to the system. When a Take Signal operation is performed, the shutter opens for the duration of the CCD exposure time.
- If **CLOSED for background** mode is selected, any shutter driven from the shutter output of the camera will be closed during background acquisition only.
- The **TTL** (Transistor-Transistor Logic) buttons, TTL Low & TTL High, allow user to instruct the system as to how it should control the opening and closing of the shutter i.e. open or closed status during high or low TTL states.

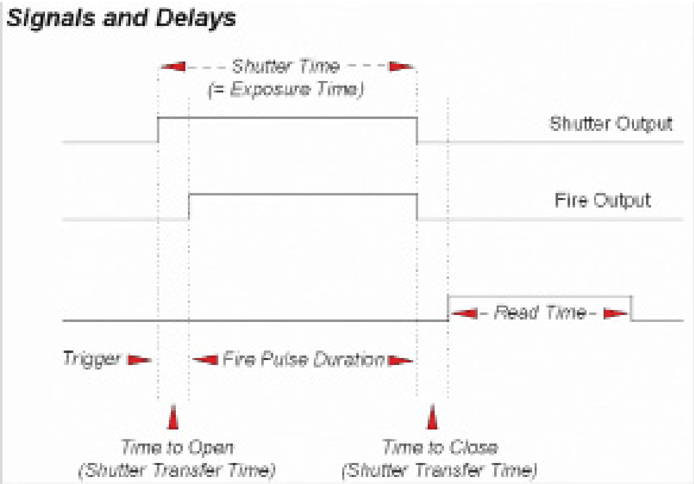
Note: The shutter pulse is not capable of driving a shutter. It is only a 5V pulse designed to trigger TTL & CMOS compatible shutter drivers. The shutter pulse from the camera can be directly connected to Andor Kymera or Shamrock spectrographs in order to control the internal shutter of these instruments, or to external standalone shutter and shutter driver.

4.10.1 Shutter Transfer Time

Shutters take a finite time to open or close and this is sometimes called the **S**hutter **T**ransfer **T**ime **(STT**). This is typically in the order of a few tens of milliseconds, and will vary from one shutter type to the other. The STT should give enough time for the shutter to open before acquisition starts, and enough time to close after acquisition finishes and before readout commences.

Note: Mechanical shutters are limited to repetition rates of a few Hz for correct 'opening' and 'closing' operation. This frequency will vary from one shutter type to the other. If acquisition rate of the CCD exceeds the maximum recommended shutter rate, then this will cause partial operation of the shutter blades and potential damage to the device. At that stage, shutter should either be left fully opened (and image intensifier photocathode becomes the sole signal shuttering interface in the system), or CCD acquisition rate should be decreased.

By default, the value entered in the exposure time text box on the Setup Acquisition dialog box determines the length of time the shutter will be in the open state. However, to accommodate the transfer time, the rising edge of the shutter output is sent before the Fire output signal by an amount equal to the preset STT. The system automatically adds the transfer time to the end of the acquisition sequence, introducing an appropriate delay between the start of the shutter closed state and the commencement of the data being read out as shown in the following example diagram:



Important note: If no shutter is connected, the time to open or close should be set to 0. Setting the Time to open or close to any other value will insert extra delays into cycle time calculations.

4.11 Acquisition and Data Types Selection

Some acquisitions, such as quantitative measurements or absorption / transmission / reflection require a degree of data processing which can be executed and displayed seamlessly in Solis.

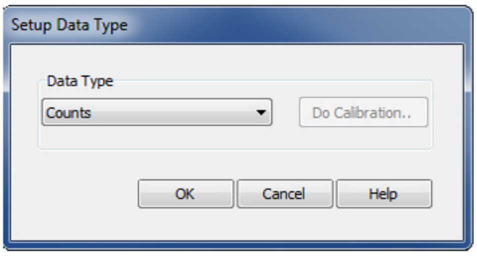
4.11.1 Definitions of Data Types

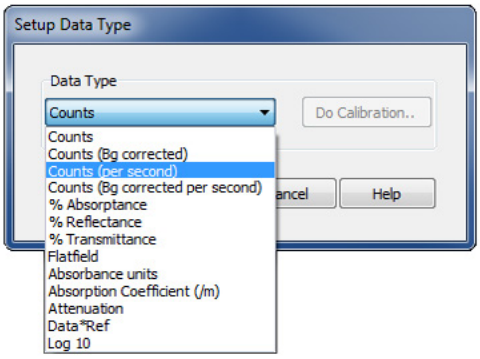
Data processing and display involves the following baseline information:

- **Signal:** Uncorrected raw data acquired via **Take Signal**. 'Signal', as used in the definitions of the calculations, refers to 'raw' data from the detector and should not be confused with the possibly 'processed' data to be found under the **Sig** tab of the **Data** window.
- **Background:** Data in uncorrected counts, acquired in darkness.
- **Reference:** Background corrected data. Reference data is normally acquired from the light source, without the light having been reflected from or having passed though the material being studied.

4.11.2 Data Display and Processing Modes

The data processing and display formats can be selected from the **Acquisition** drop down menu under **Setup Data Type,** e.g.:



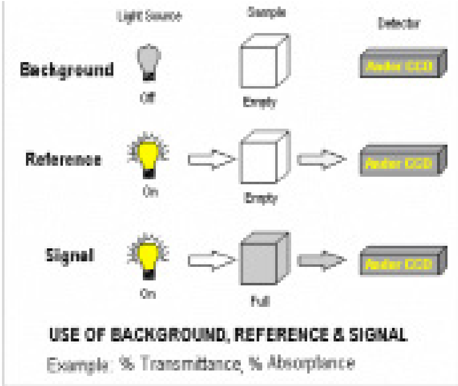


The descriptions of the different available data display and processing types are shown in **Table 3**.

Table 3: Data type and display available in Solis

OPTION	FUNCTION
Counts (per second)	Counts ÷ Exposure Time.
Count (Bg corrected per second)	Counts (Bg corrected) ÷ Exposure Time.
%Absorptance	Represents the light absorbed by an object. If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has passed through the material being examined), then: % Absorptance = 100 x (1 - (Signal - Background) / Reference)
%Reflectance	Represents the light reflected by an object. If Reference is the background corrected incident intensity, and Signal - Background the reflected intensity (i.e. the intensity of light which has been reflected from the material being examined), then: % Reflectance = 100 x (Signal - Background) / Reference
%Transmittance	Represents the light transmitted through an object. If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has been transmitted through the material being examined), then: % Transmittance = 100 x (Signal - Background) / Reference
Flatfield	Flatfield is used to remove any pixel-to-pixel variations that are inherent in the ICCD sensor. If Reference is the background corrected incident intensity, the Signal is divided by the Reference so: Flatfield = M x Signal / Reference Where M is the Mean of Reference.
Absorbance units	A measure of light absorbed by an object (i.e. they represent the object's Optical Density - OD). If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has passed through the material being examined), then Transmission = (Signal - Background) / Reference. Absorbance Units are defined as Log10 (1 / Transmission). Therefore: Absorbance Units = Log10 (Reference / (Signal - Background)).
Absorption Coefficient (/m)	Indicates the internal absorptance of a material per unit distance (m). It is calculated as -loge t, where t is the unit transmission of the material and loge is the natural logarithm. If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has passed through the material being examined), then: Transmission = (Signal - Background) / Reference and: Absorption Coefficient = -loge ((Signal - Background) / Reference)
Attenuation	A measurement, in decibels, of light absorbed due to transmission through a material - decibels are often used to indicate light loss in fibre optic cables, for instance. If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has passed through the material being examined), then: Attenuation = 10 x Log10 ((Signal - Background) / Reference)
Data*Ref	Allows you to 'custom modify' the background corrected signal: Data x Ref = (Signal - Background) x Reference Store Value See the Andor Basic Programming Manual for similar operations.
Log 10	Calculates the logarithm to the base 10 of the background corrected signal counts. Log Base 10 = Log10 (Signal - Background)
Radiometry (Optional Add-on)	Provide a tool to calculate values for Radiance or Irradiance. The system requires that you supply calibration details. This option must be ordered separately.°

The illustration below shows a typical use of Background, Reference and Signal for computations such as %Absorptance or %Transmittance:



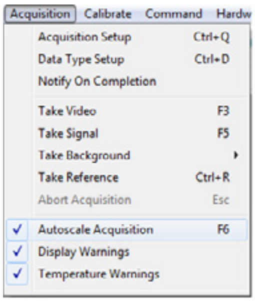
For example, the % Absorption will be computed as:
100 x (1 - (Signal - Background) / Reference))

The default data type (used when capturing data and having not explicitly made a selection from the **Data Type** dialog box) is **counts**.

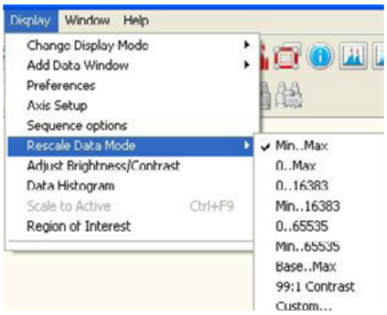
If any data type other than counts or counts (Bg Corrected) are selected, user will have to perform **Take Background** and **Take Reference** (in that order) before performing **Take Signal**.

4.11.3 Autoscale Acquisition

Prior to the **Take Signal** function being activated, autoscale acquisition can be selected from the **Acquisition** drop-down menu as shown below (or F6 on the keyboard):



- With autoscale acquisition deselected, the display will remain the same size regardless of brightness settings, etc. When not selected, the button appears.
- With autoscale acquisition selected, the system will configure the acquisition window (if necessary adjusting its scales in real-time) so that all data values are displayed as they are acquired. The button appears when selected on. The data are displayed in accordance with the selection made on the **Rescale Data Mode** on the **Display** Menu:



Different scaling modes are available as follows:

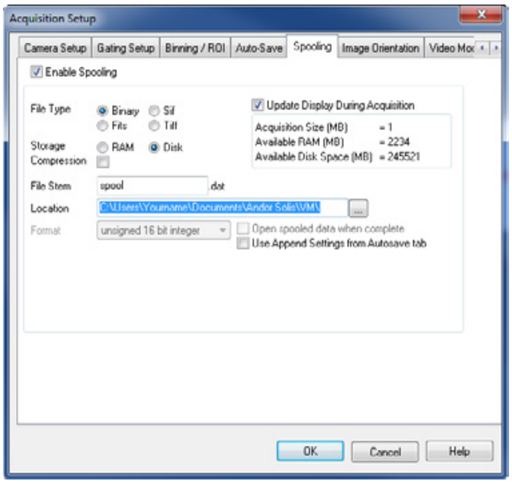
- Minimum & maximum **(Min..Max)**
- Zero & maximum **(0..Max)**
- Zero & 16383 **(0..16383)**
- Minimum & 16383 **(Min..16383)**
- Zero & 65535 **(0..65535)**
- Minimum & 65535 **(Min..65535)**
- Custom setting as required - user selectable min and max display range

Note: The histogram icon can be used to adjust conveniently and in real-time signal display scaling.

4.11.4 Data File Handling

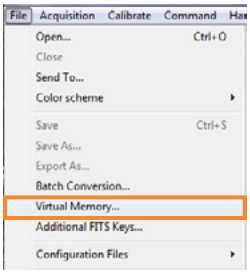
4.11.4.1 Spooling (Data Spooling)

Andor Solis software has an extensive range of options that allows user to spool acquisition data direct to the hard disk of your PC. This is particularly useful when acquiring a series of many images. The amount of data generated by a kinetic series of, for example 1,000 acquisitions, is huge and more than most PC RAM can handle.
To select click on the **Data Spooling tab** and the **Spooling** dialog box appears.
With the spooling function enabled, data is written directly to the hard disk of you PC, as it is being acquired. The **Enable Spooling** function should be selected as shown below, and user should enter the relevant stem name and location root.
Note: Andor recommends only very high-speed hard disk drives be used for this type of operation and these need to be dedicated for spooling.



4.11.4.2 Virtual Memory

In addition to the spooling function, it can also be useful to have the Virtual Memory (VM) function enabled. This will speed up the retrieval of large data sets and allow larger data sets to be acquired. This works by buffering data in the hard drive of the PC. The **Virtual Memory**… option is selected from the **File** menu.

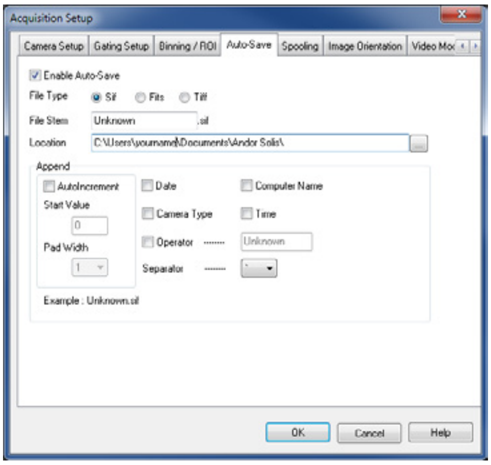


This will open the **Virtual Memory** dialog box.

User should select the **Enable** box and the required **Threshold** level. The data is normally saved to the default directory shown in the **Location** field. Alternatively, user can click on the  button and choose a different area to save the data.
Note: It is recommended to have the option activated for images > 50 MB.

4.11.4.3 Auto-Save

Auto-Save allows user to set parameters and controls for the auto saving of acquisition files thus removing the worry of lost data and files. Selection of this mode is accessible under the **Auto-Save** tab on the **Setup Acquisition** dialog box. The **Auto-Save** dialog box appears.



If selected, acquisitions will be saved automatically after each individual one is completed. Each subsequent auto-saved file will over-write the previously auto-saved one.
In the Auto-Save dialog box, a **Stem Name** may be entered. This is the main root of the name that the acquisition is to be saved as.
The Stem Name can be appended with a number of details, e.g.:

- Operator name (supplied by user)
- Computer name
- Camera type
- Date
- Time

An auto-increment On/Off tick box allows a number to also be entered to the main stem name. This number is automatically incremented each time a file is saved.
Any combination of these may be selected by activating the relevant tick box.

Note: This function will only auto-save single scan, kinetic series or accumulated images.

4.12 Gating and Image Intensifier Settings (Gating)

This section details the different image intensifier modes of operation relative to ‘gating’ and signal amplification that are found under the Gating tab.

4.12.1 Gate Modes

In the Acquisition Setup interface, under the Gating tab, a drop-down menu allows the user to select the gate mode, valid options are:

GATE MODE	DESCRIPTION
CW On	*The photocathode is continuously in the ON state*
CW Off	*The photocathode is continuously in the OFF state.*
Fire only	*Photocathode is switched on only when the Fire pulse is high.*
Gate only	*Photocathode is switched on only when the Direct Gate input is high.*
Fire and Gate	*Photocathode is switched on only when both the Fire & Direct Gate inputs are high.*
DDG	*The photocathode is switched on only when the Gate pulse from the DDG is high.*

Note: For direct gate input, the maximum safe levels are -0.5 to +5.75 V. The input impedance is 50 Ω termination to ground. The minimum high logic level is 1.7 V and maximum low logic level is 0.8 V.

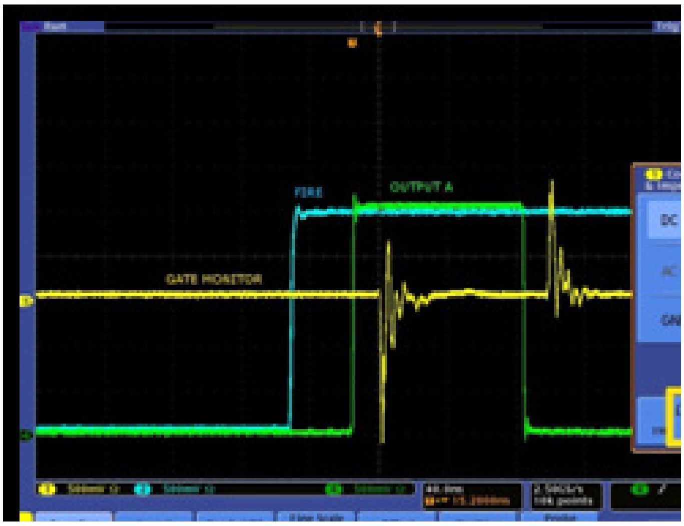
4.12.2 Using the Gate Monitor

The gate monitor connection, on the side of the main block of the iStar CCD enables the temporal position of the photocathode switching On (negative spike) and Off (positive spike) to be monitored. A cable is supplied with the iStar CCD, which has a BNC connector on one end for attaching to an oscilloscope.
When Intelligate is selected an additional gate monitor spike precedes the spike from the photocathode. This spike corresponds to the MCP switching on.
The oscilloscope should be set to trigger on the steepest part of Output A, this is typically ½ of the peak amplitude. The Fire pulse may also be used, but its jitter performance with respect to the gate pulse will not be as good.
The following plots show the preferred oscilloscope settings for working with short and long gate widths.

Fire Pulse (Blue)

Gate Monitor (Yellow)

Output A (Green)

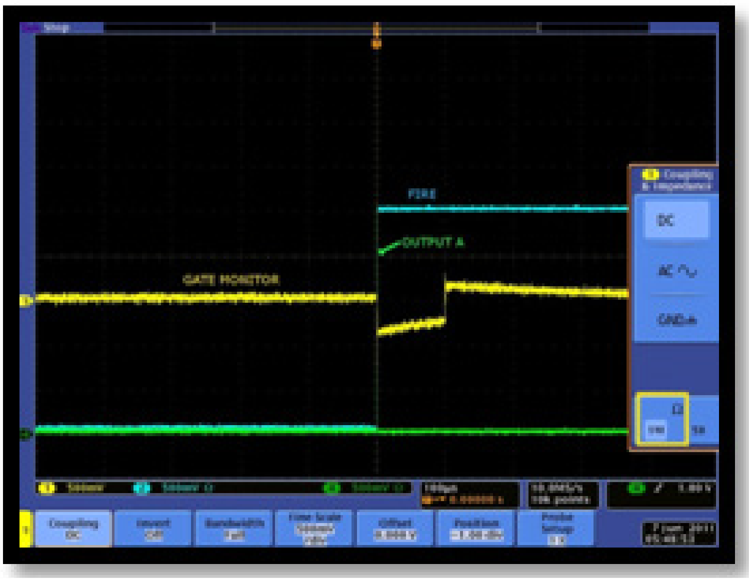


Short Gate Widths (<1 us)
For example: 100 ns gate width:
Set input impedance on oscilloscope to 50 Ω.
Set Voltage amplitude to 500 mV

Fire Pulse (Blue)

Gate Monitor (Yellow)

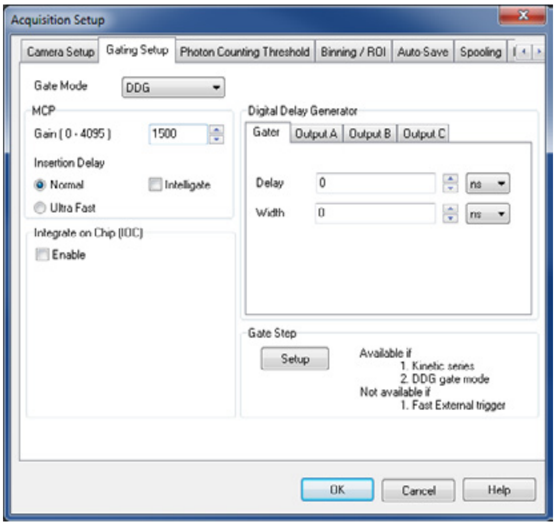
Output A (Green)



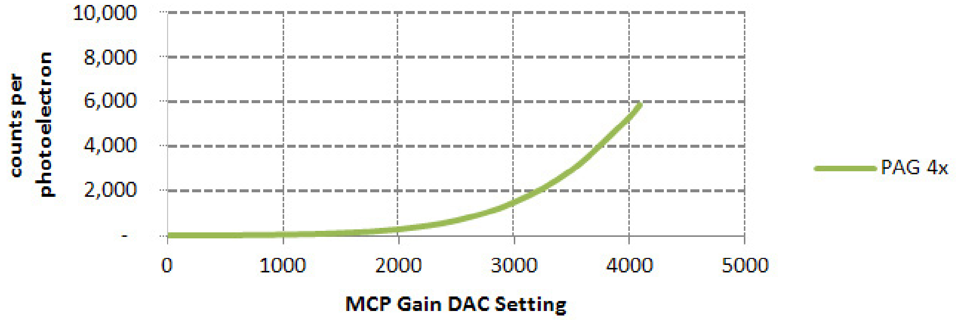
Long Gate Widths (>1 us)
For example: 100 us gate width:
Set input impedance on oscilloscope to 1 MΩ.
Set Voltage amplitude to 500 mV

4.12.3 MCP Gain

The gain of the Micro-Channel Plate (MCP) in the image intensifier can be varied through software from a setting of 0 to 4,095. By increasing the gain, the voltage across the MCP is increased and hence the signal reaching the sensor is amplified. The value can be entered in the MCP Gain text box of the 'Gating' tab of the Acquisition Setup interface. It can also be controlled by the slider.



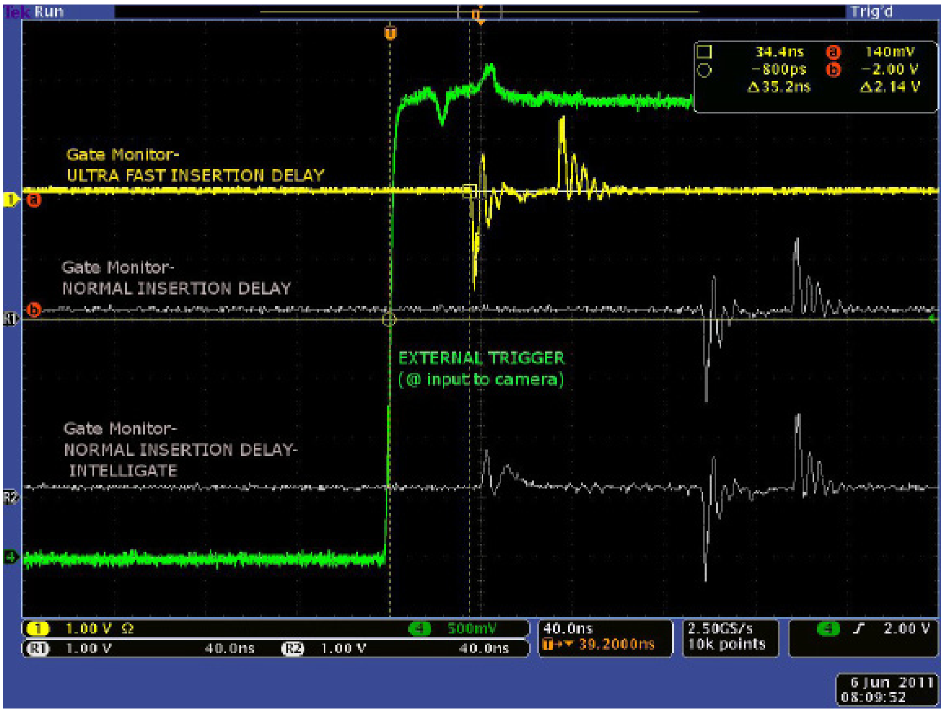
The graph below shows typically how the signal level on the CCD sensor varies with increasing gain setting.



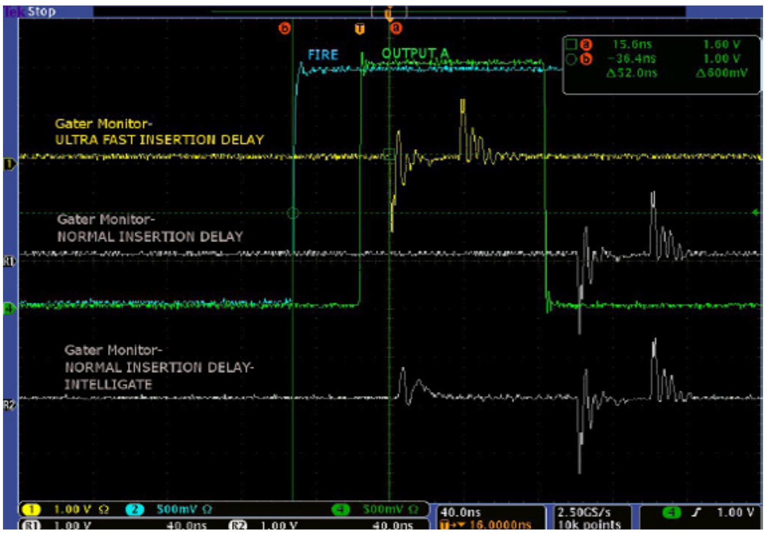
Note: MCP gain versus DAC settings is reported for each system on the associated performance sheet.

4.12.4 Insertion Delay

Insertion delay refers to the propagation delay of a trigger source (External Trigger, Internal Trigger (Fire pulse) or Direct Gate) to travel through the electronics and open the image intensifier. A radio button allows the user to select between 'Normal' and 'Ultra Fast' options. Switching from 'Ultra Fast' to 'Normal' adds 100 ns delay to the gate pulse. This allows the MCP voltage to rise and settle when using Intelligate before opening the photocathode. Intelligate is not available when using 'Ultra Fast' insertion delay.

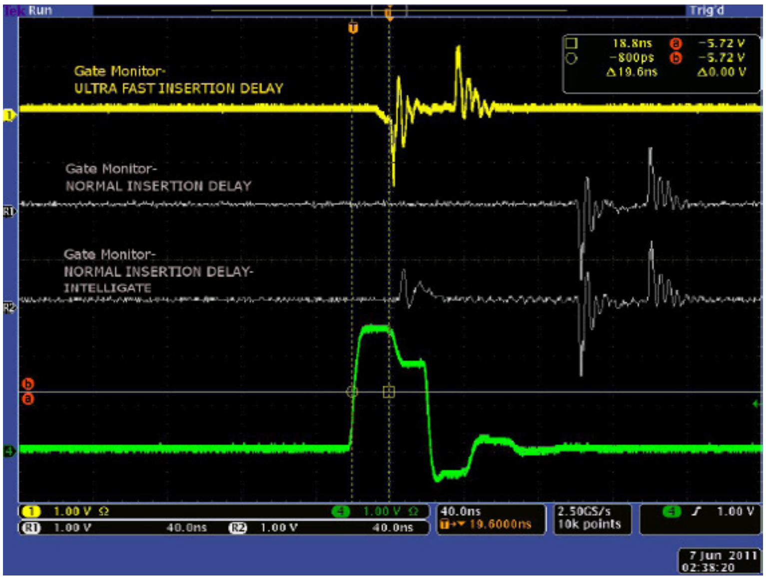


External Trigger to intensifier opening using DDG
Ultra Fast ≈ 35 ns
Normal ≈ 135 ns



Fire pulse to intensifier opening using DDG
Ultra Fast ≈ 50 ns
Normal ≈ 150 ns

Direct Gate (Green)



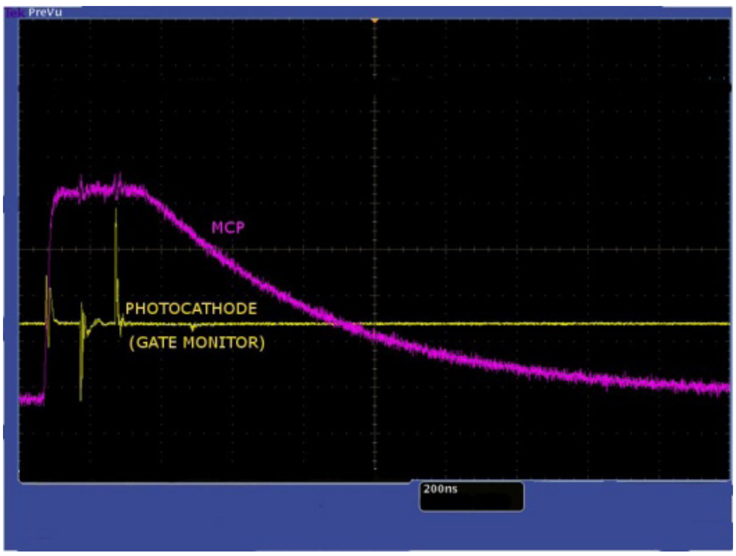
Direct Gate to intensifier opening
Ultra Fast ≈ 20 ns
Normal ≈ 120 ns

4.12.5 Intelligate

With traditional Image Intensifier gating the photocathode of the tube is switched on and off. But even when the photocathode is switched off, some photons can still leak through it and reach the Microchannel Plate (MCP). UV photons can be energetic enough to generate photoelectrons at the MCP input that will be amplified (as the MCP amplification chain is always “on”), and that will then be detected by the sensor. The ability of the Image Intensifier to reject photons when it is switched off becomes worse in the UV, so the On/Off ratio of the tube is compromised. The solution to this, as utilized by Andor’s Intelligate™ function, is to gate the MCP as well as the photocathode.

A checkbox is accessible under the ‘Gating’ tab of the Acquisition Setup interface allows the user to apply the Intelligate function.

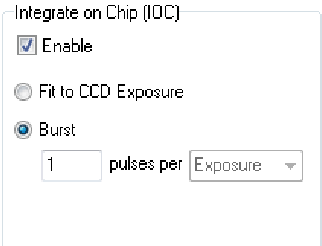
The gating electronics will output a fast rising edge that is sent to the MCP. After a 100 ns delay, which allows the MCP voltage to rise and settle, the photocathode will open. The MCP will remain at the gain value (as set by the user in the software) for the duration of the gate width, and then be switched off leading to the rapid decrease of the gain. This method of gating eliminates the need for a pre-pulse or anticipator circuit and results in photoelectron rejection of better than 10^7:1, below 200 nm.



MCP Gating in practice

4.12.6 Integrate On Chip (IOC)

IOC is a function that enables the image intensifier to be opened and closed a number of times while the sensor makes a single acquisition. Light signal passes through the intensifier while it is open (or switched on) and reaches the sensor. The sensor accepts the light continuously for the entire duration of the acquisition while the intensifier is opening and closing. Charges are built up on the sensor or 'integrated' until the acquisition is complete. Then all the charges that have been built up are read out in the normal way.



IOC greatly improves the signal-to-noise ratio achievable, since the signal is being integrated on the sensor itself while being read out once. Hence noise will only be generated from a single readout. The signal-to-noise ratio achieved while operating the iStar CCD's IOC function is better than that obtained while operating the system in accumulate acquisition Mode. This is because during accumulate mode, the sensor is read out a number of times and accumulated in the computers memory. So the signal-to-noise ratio in this case will include noise generated from each read out that occurs.

This mode also minimizes the dark current contribution by filling up the exposure time with multiple useful signal contributions, further enhancing the overall signal-to-noise performance.

A checkbox, accessible on the 'Gating' tab of the Acquisition Setup interface, allows the user to apply the Integrate On Chip function and is only available in DDG gate mode.

IOC allows several gate pulses, as well as outputs A/B/C synchronization signals, to be generated within the exposure. When outputs A, B, or C are enabled, the first set of pulses is determined by the delay and width of these outputs as set by the user. The delay applies from the rising edge of the Fire pulse for internal trigger or rising/falling edge (user selected) for External Trigger. This delay is in addition to the inherent insertion delay.

Once the first set of pulses is finished, subsequent sets are spaced out by the period/frequency pre-set in the IOC section. Since subsequent sets cannot start before the first set is finished, the software automatically adjusts the period/ frequency according to the time from the start of the first pulse to the end of the last pulse. The start of the first pulse could be the delay value in gater or output A/B/C, and the end of the last pulse could be the delay plus width of gater or output A/B/C.

Please refer to the following page for detailed setting of these modes under different trigger conditions.

INTERNAL TRIGGER	
IOC OPTIONS	**DESCRIPTION**
Fit to Exposure	Software calculates the maximum number of pulses that can fit into the exposure. The Fire pulse generates the first pulse determined by the delay and width fields, subsequent pulses are generated internally in the DDG by a user defined period/ frequency.
Number of Pulses	Same as "Fit to Exposure" but the user can chose the number of gate pulses per exposure.
Note: A default minimum of 20 ns delay applies when Integrate on Chip is selected and when the DDG generates the pulse train internally by a user-defined frequency or period. This is a characteristic of the DDG and it is related to its ability to set the period between pulses in 20 ns intervals. This delay is in addition to the inherent insertion delay.	

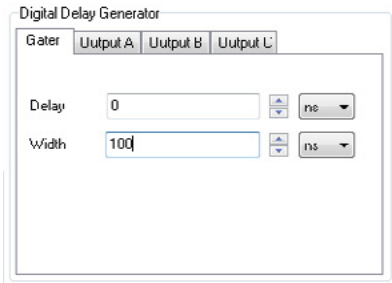
External Trigger	
IOC OPTIONS	**DESCRIPTION**
Number of Pulses = 1	Every External Trigger within the exposure will generate only one gate pulse.

4.12.7 Digital Delay Generator (DDG) Step (including Gate Step)

The DDG Step feature is available for use with the kinetic series acquisition mode. A check box under the heading "Step" is use to determine which signals (Gater and/or Output A/B/C) use the DDG step feature.

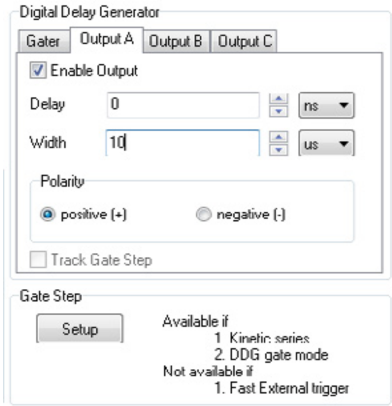
The first exposure in a kinetic series will use the delay/width specified for the Gater and/or Output A/B/C. For every successive exposure in the series, the delay/width applied is adjusted by the DDG step value determined by the corresponding DDG step mode selected. If the Gater DDG step delay is enabled this will cause the image intensifier to be 'gated on' progressively later (or earlier, if a negative DDG Step is configured) for each acquisition in the series.

4.12.7.1 Gater



Gate Delay: The user can introduce a delay to the gate pulse from an internal or External Trigger event in order to synchronise the opening of the image intensifier with an optical pulse. The range can be set from 0 to 10 s.
Gate Width: The user can enter the length of time the image intensifier is switched (or gated) On. Optical signal falls on the CCD sensor during this time. The range can be set from 0 to 10 s.
Resolution: 10 ps.

4.12.7.2 Output A, B & C



The DDG can send out auxiliary output pulses called Output A, Output B, and Output C. These outputs are +5 V CMOS level with 50 Ω source impedance. They can drive 5 V into a non-terminating load or 2.5 V into 50 Ω load. The outputs can be used to synchronize triggers for auxiliary equipment, e.g. lasers, flash lamps or National Instrument™ hardware. It is recommended that these outputs be use as a trigger sources, rather than the Fire pulse, since they have better jitter performance with respect to the gate pulse. Fire pulse is best used as an indication of when the CCD expects to be exposed to light.
Delay: The user can configure the delay individually for each output - The range can be set from 0 to 10 s.
Width: The user can configure the width individually for each output - The range can be set from 2 ns to 10 s.
Resolution: 10 ps.

Polarity: Positive (low-high-low) or negative (high-low-high).

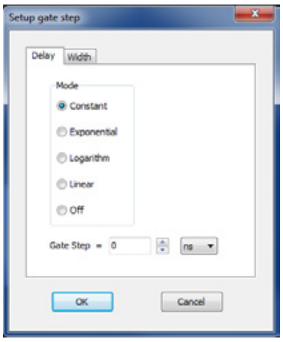
4.12.7.3 Track Gate Step (Optical Width)

When this option is selected in the **Gater** tab of the **Setup Acquisition** interface, the gate width becomes the factory measured actual optical gate width.

Note: Optical width versus electrical TTL widths is reported individually on the performance sheet of every IStar CCD.

4.12.7.4 Gate Step Configuration (Setup gate step)

The **Gate Step** feature is available for use with the kinetic, photon counting, and fast kinetics acquisition modes. The first exposure in a series will use the gate delay specified. For every successive exposure in the series, the gate delay applied is incremented by the gate step value. In this way the **Gate Step** feature causes the image intensifier to be 'gated on' progressively later (or earlier, if a negative value is entered) for each acquisition in the series.



Delay Mode

The user can select the mode and gate step interval variable settings for a time delay to be added (or subtracted) incrementally to the gate delay during a series of acquisitions.

Gate Width

The user can also set up the gate width from the mode and gate step variable options.

Three options are selectable:

- Exponential
- Logarithmic
- Linear

If, for example, the user sets up a Kinetic Series to acquire four scans during the series, with an initial gate delay of 10,000 ps and with variable gate step conditions as shown below, then:

Gate Step = 100 + (5000x) (ps)

The gate pulse delay will be increased by a gate step of:

*1,000 + 5,000 * 1 = 6,000 ps after the first scan in the kinetic series (i.e. the gate delay changes to 16,000 ps)*

The Gate Delay will be increased by a further:

*1,000 + 5,000 * 2 = 11,000 ps after the second scan (i.e. the gate delay changes to 27,000 ps)*

and by:

*1,000 + 5,000 * 3 = 16,000 ps after the third scan (i.e. the gate delay changes to 43,000 ps)*

This means that the gate delay for the final scan in the series is 33,000 ps (6,000 + 11,000 + 16,000) larger than the gate delay for the first scan in the series.

Notes:

- In fluorescence lifetime measurements, gate delay and gate step parameters can be set to allow a series of decay curves to be built up automatically.
- The Andor Basic command 'KineticSlice' allows the extraction of pixel/column signal intensity throughout a kinetic series, and plots this intensity versus time in a separate display window.

4.13 Triggering modes

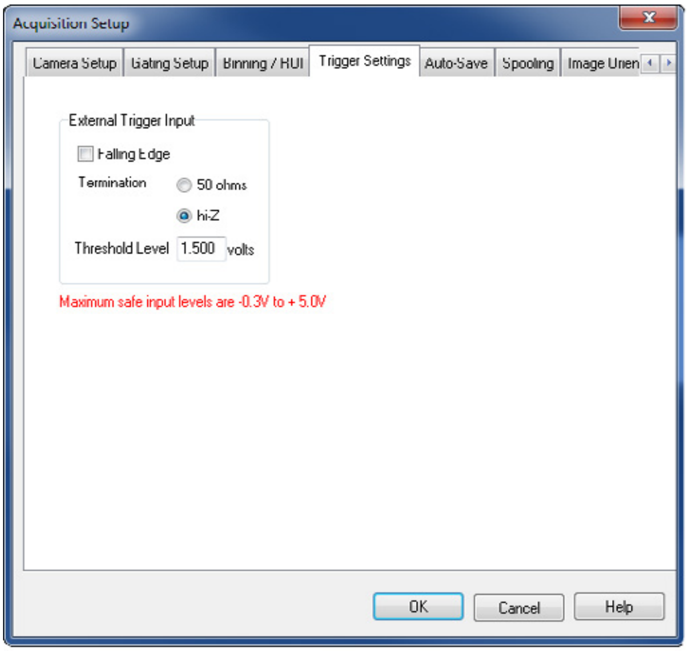
Note: The triggering modes are selected from a drop-down list on the Setup Acquisition dialog box.

4.13.1 Internal Trigger

Camera acts as a primary timing for any external device, and also triggers both CCD and intensifier simultaneously. The camera determines the exact time when an exposure happens, based on the acquisition settings entered by the user.
To control an external device in time (e.g. a laser) output A, B or C from the DDG should be used (see section 6 for details on setup).

4.13.2 External Trigger

Camera waits for a trigger from an external device to perform the acquisition sequence, hence acting as a secondary timing; both CCD and intensifiers are triggered simultaneously. Once an acquisition has been started, the camera is placed into a special cleaning cycle called "**External Keep Clean Cycle**" which ensures that charge build up on the CCD is kept to a minimum while waiting for the External Trigger event. The external keep clean consists of a continuous sequence of one vertical shift followed by one horizontal shift. Once the External Trigger is received the current keep clean sequence is completed and the exposure phase initiated. The exact nature of the acquisition will depend on the user settings and is explained in more detail in a subsequent section. The External Trigger is fed via the Ext Trig input on the camera head.
The maximum safe input levels are -0.3 to +5.0 V. The user can configure the following settings under the **Trigger** settings tab:



Termination: The input impedance can be change between High Impedance and 50 Ω.
Rising or Falling Edge Triggered: The system can be set to respond to rising edge or falling edge triggers.
Threshold Level: The trigger threshold can be programmed from +0.25 to +3.3 V.

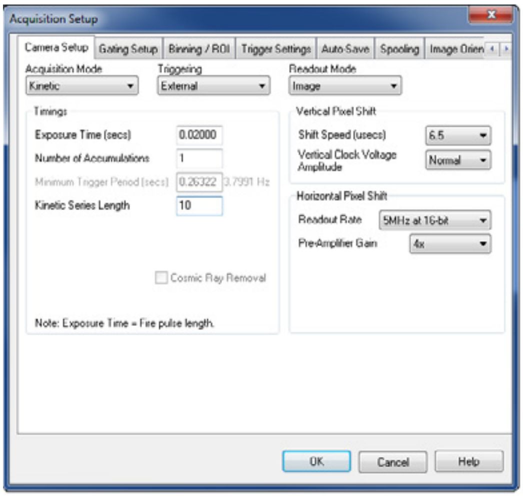
When using External Trigger the user may find it useful to monitor the Arm output at back of the detector head. When the Arm is high the system will accept External Triggers.
For lowest jitter, the user may need to adjust the input impedance and/or trigger threshold to set the trigger level to the steepest part the input edge, typically 1/3 to 1/2 of the peak amplitude.

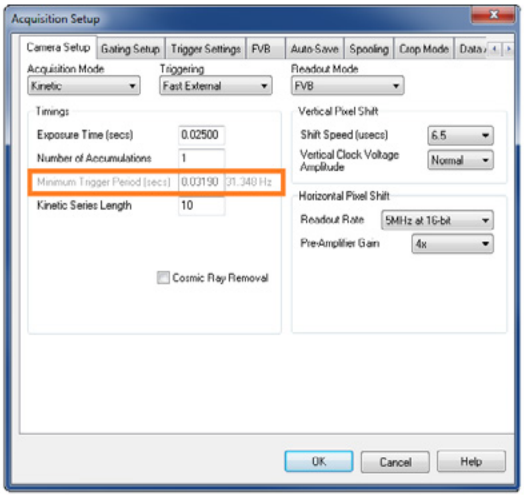
4.13.3 Fast External

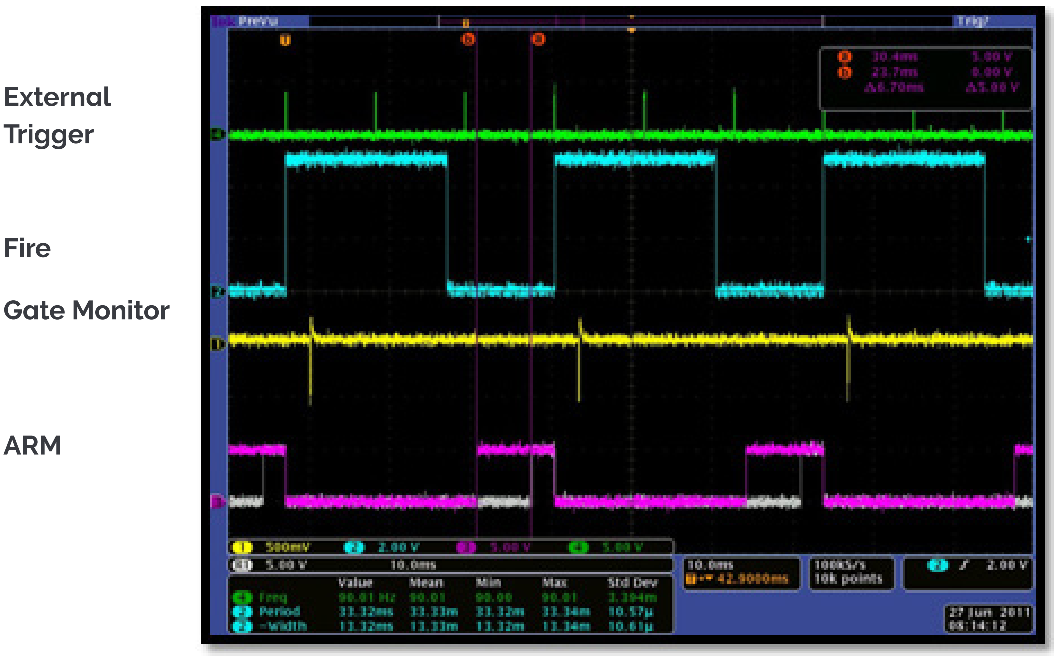
Fast External Trigger is for the most part identical to External Trigger. It differs in only one key aspect. In fast External Trigger the camera will not wait for a sufficient number of keep clean cycles to have been completed to ensure the image area is completely clean of charges before accepting an External Trigger event. It will instead allow a trigger event to immediately start the acquisition process after performing a '1 vertical-1 horizontal, keep clean cycle'. As a result, Fast External Trigger allows a higher frame/spectral rate than standard External Trigger.

The Arm is set low and the Fire pulse high approximately one 'keep clean cycle' later. If one is monitoring on the oscilloscope the External Trigger with respect to the Fire pulse, the jitter of one 'keep clean cycle' will be seen. Note that the intensifier will open in response to that first External Trigger and the jitter in the Fire pulse is not important. Also note that output A/B/C are available to offer lowest jitter between them and the External Trigger and gate pulse.

The timings are the same as in External Trigger mode, except that by removing the keep clean cycle the CCD can be triggered earlier as shown by the Arm waveform below.







4.13.4 External Start

External Start is a mixture of External and Internal Trigger. In this mode the camera will perform a sequence of External Keep Clean Cycles while waiting for one External Trigger event to occur and then start the acquisition process going. Once this External Trigger event has occurred the camera will switch to internal trigger and the acquisition will progress as if the camera was in internal trigger mode.

Section 5: Gating, Triggering and Synchronisation

5.1 Triggering: Internal

5.1.1 Acquisition Mode: Single

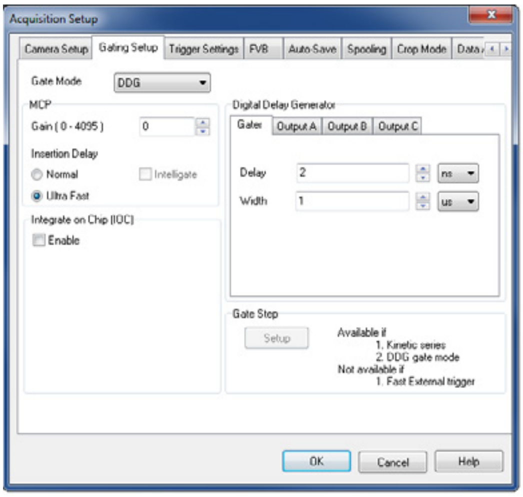
5.1.1.1 Standard Operation (IOC Disabled)

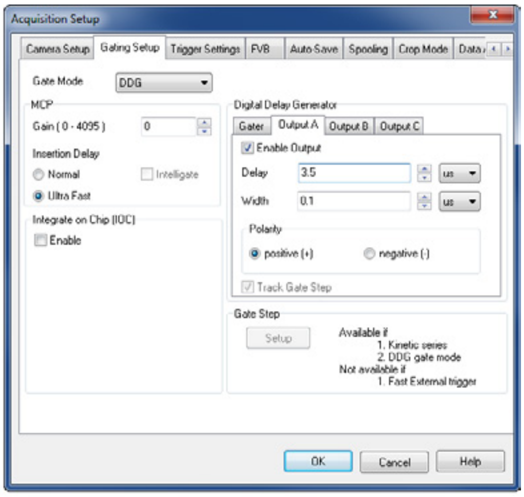
Description

One gate pulse is generated within the exposure. A delay relative to the rising edge of the Fire pulse can be applied to the Gate pulse (and output A/B/C).

Setup

IOC disabled, output A enabled.



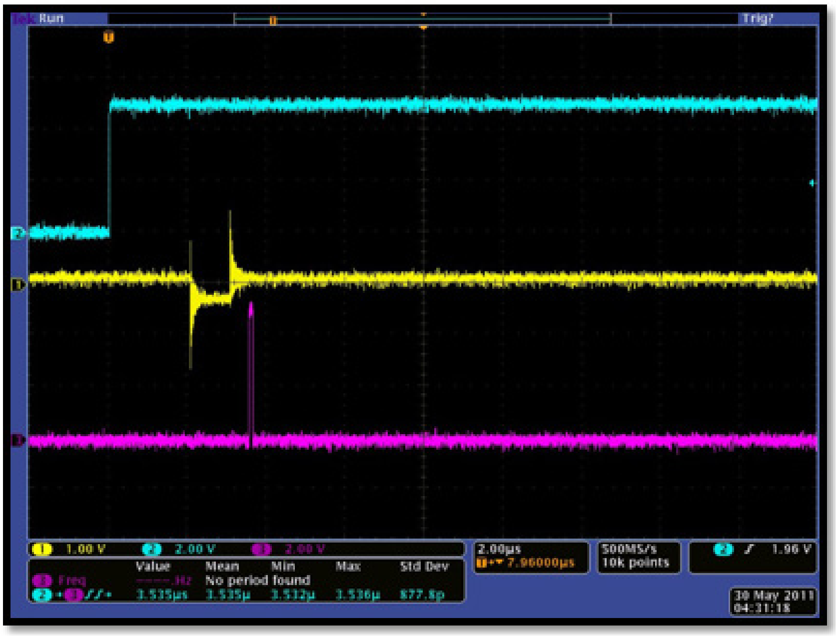


Waveforms

Fire

Gate Monitor

Output A



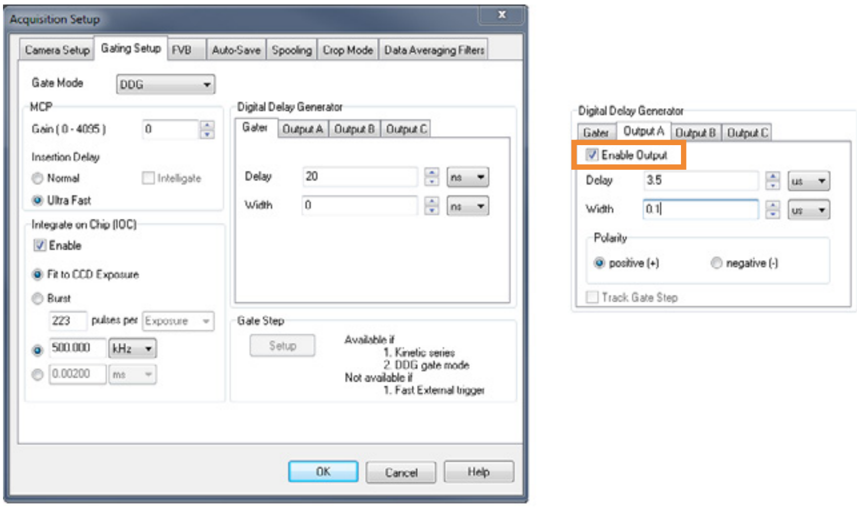
5.1.2 Integrate On Chip (IOC) Enabled

Description

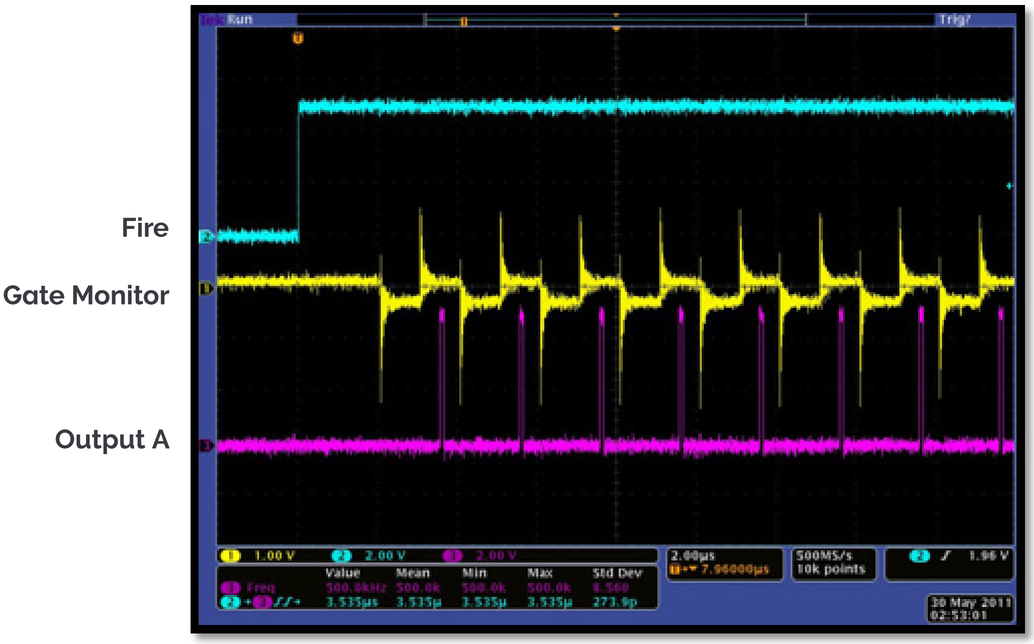
Several gate pulses are generated within the exposure. A delay relative to the rising edge of the Fire pulse can be applied to the gate pulse (and output A/B/C).

Setup

IOC enabled, output A enabled.

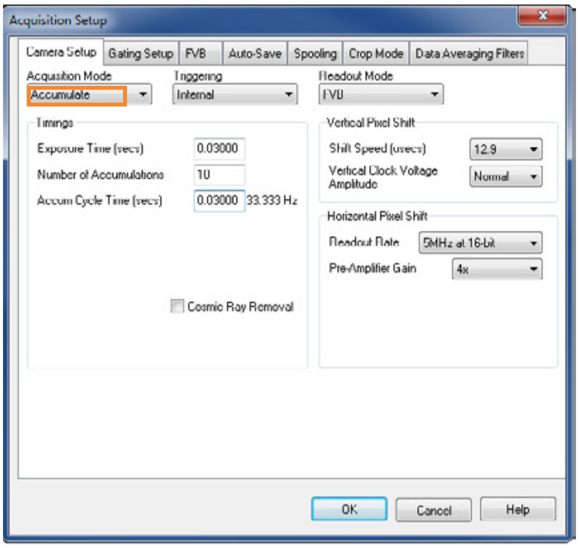


Waveforms



5.1.3 Acquisition Mode: Accumulate

A number of individual frames will be added together to produce the final accumulated image.



5.1.3.1 Standard Operation (IOC Disabled)

Description

One gate pulse is generated within an exposure. The gate delay is the same for each of the exposures involved.

Setup

IOC disabled, gate step disabled, output A enabled.

Waveforms

Timings are the same as in kinetic series: 1 accumulation, standard operation (IOC disabled and gate step disabled).

5.1.3.2 Integrate on Chip (IOC)

Description

Several gate pulses are generated within each exposure. The gate delay is the same for each of the exposures.

Setup

IOC enabled, output A enabled.

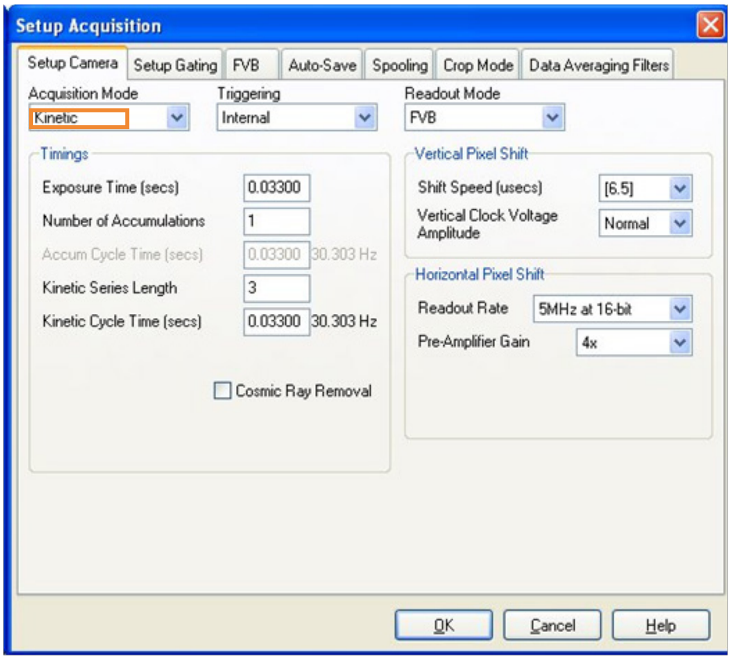
Waveforms

Timings are the same as in kinetic series: 1 accumulation, IOC enabled.

5.1.4 Acquisition Mode: Kinetic

5.1.4.1 Number of Accumulations = 1

A number of single images will be acquired in the series.



5.1.4.2 Standard Operation (IOC Disabled and Gate Step Disabled)

Description

One gate pulse is generated within an exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC disabled, gate step disabled, output A enabled.

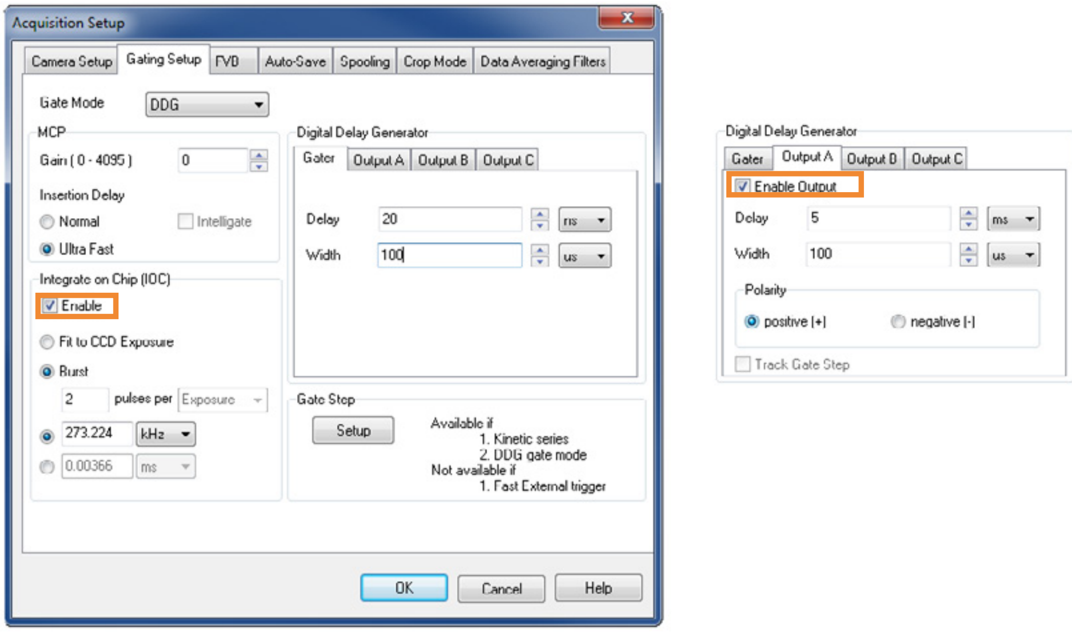
5.1.4.3 Integrate on Chip (IOC) Enabled

Description

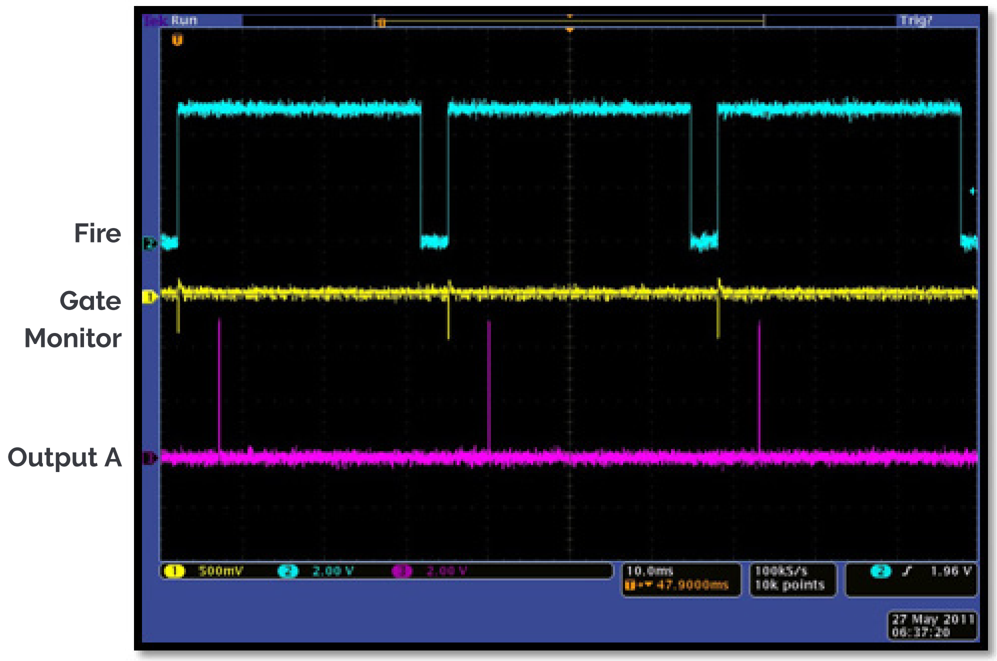
Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC enabled, Output A enabled.



Waveforms



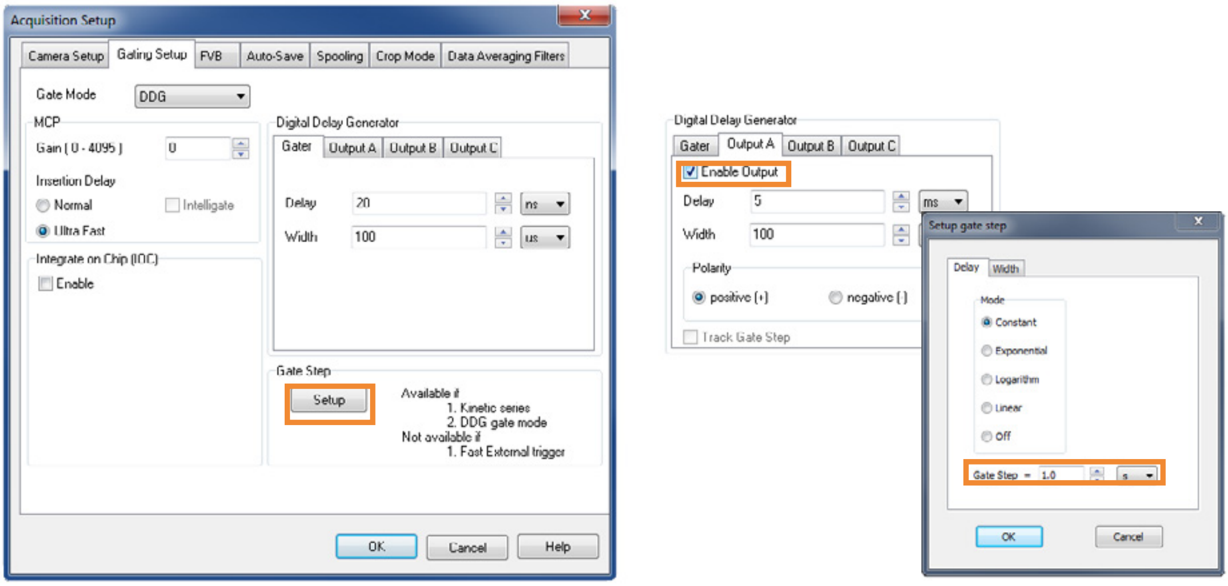
5.1.4.4 Gate Step Enabled

Description

One gate pulse is generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

Setup

Gate step enabled, Output A enabled (trackstep disabled).



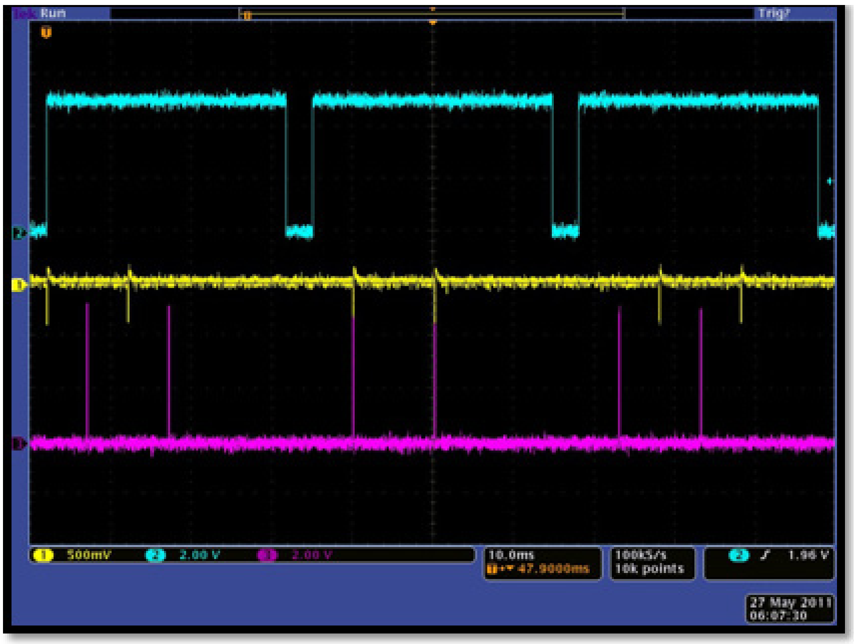
Waveforms

Fire

Gate

Monitor

Output A



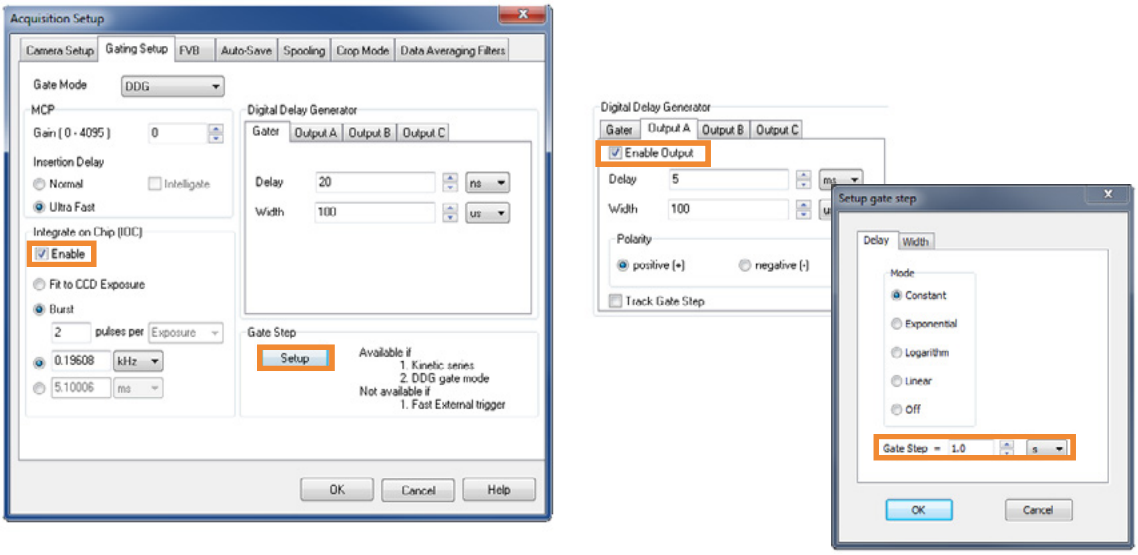
5.1.4.5 IOC and Gate Step Enabled

Description

Several gate pulses are generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

Setup

IOC enabled, gate step enabled, output A enabled (trackstep disabled).

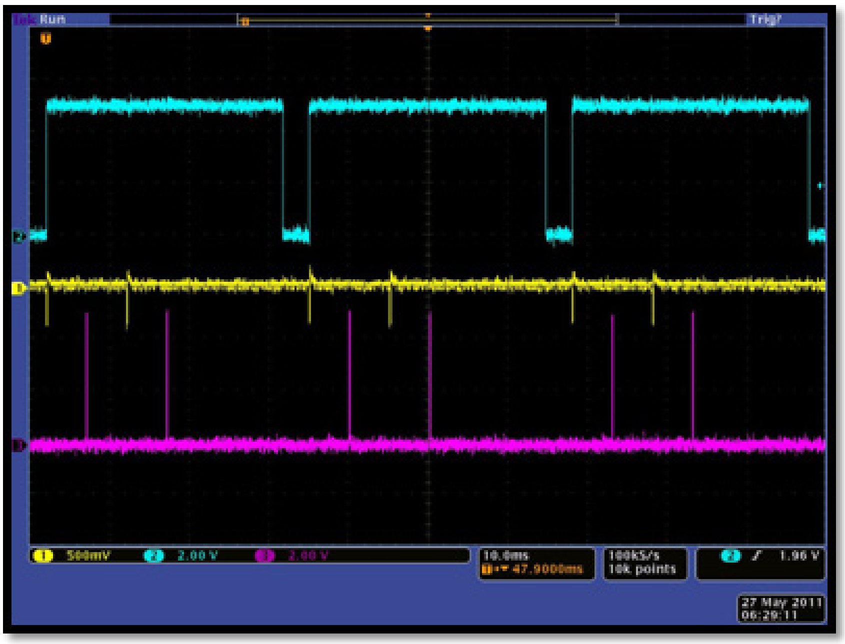


Waveforms

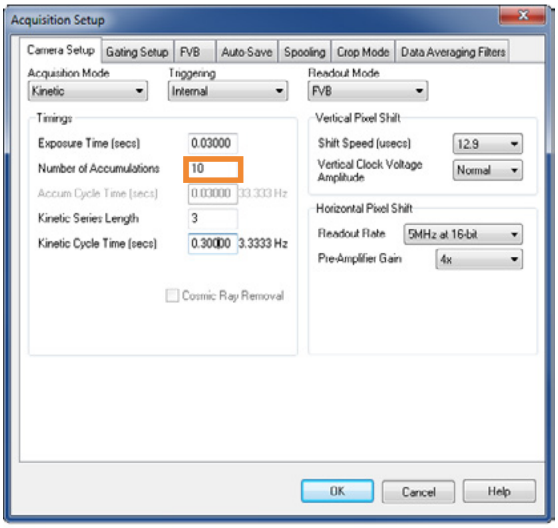
Fire

Gate Monitor

Output A



5.1.5 Number of Accumulations > 1



A number of accumulated images will be acquired in the series.

5.1.5.1 Standard Operation (IOC Disabled and Gate Step Disabled)

Description

One gate pulse is generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is also the same for every accumulated image that is returned.

Setup

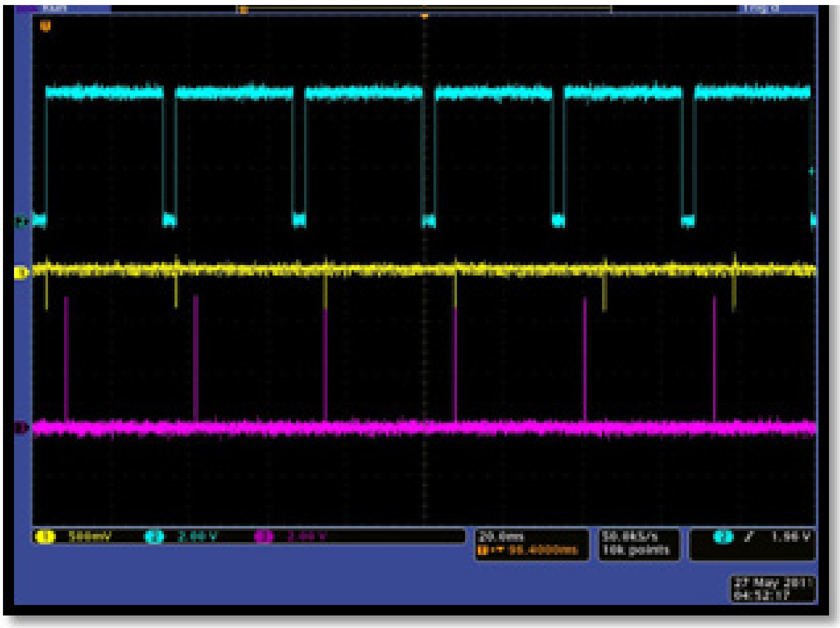
IOC disabled, gate step disabled, Output A enabled.

Waveforms

Fire

Gate Monitor

Output A



5.1.5.2 Integrate on Chip (IOC) Enabled

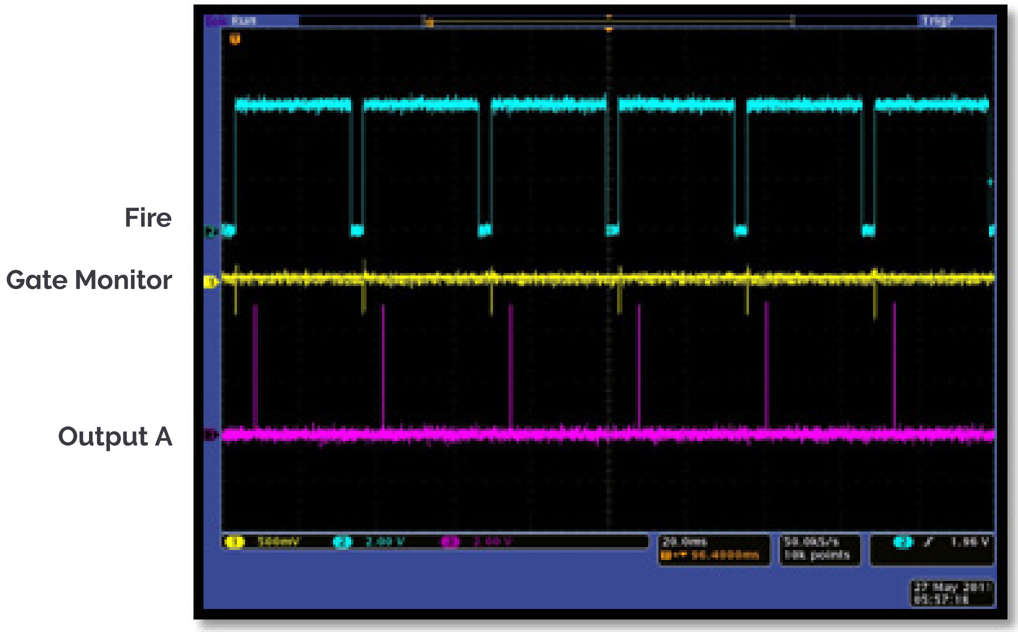
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is also the same for every accumulated image that is returned.

Setup

IOC enabled, Output A enabled.

Waveforms



5.1.5.3 Gate Step Enabled

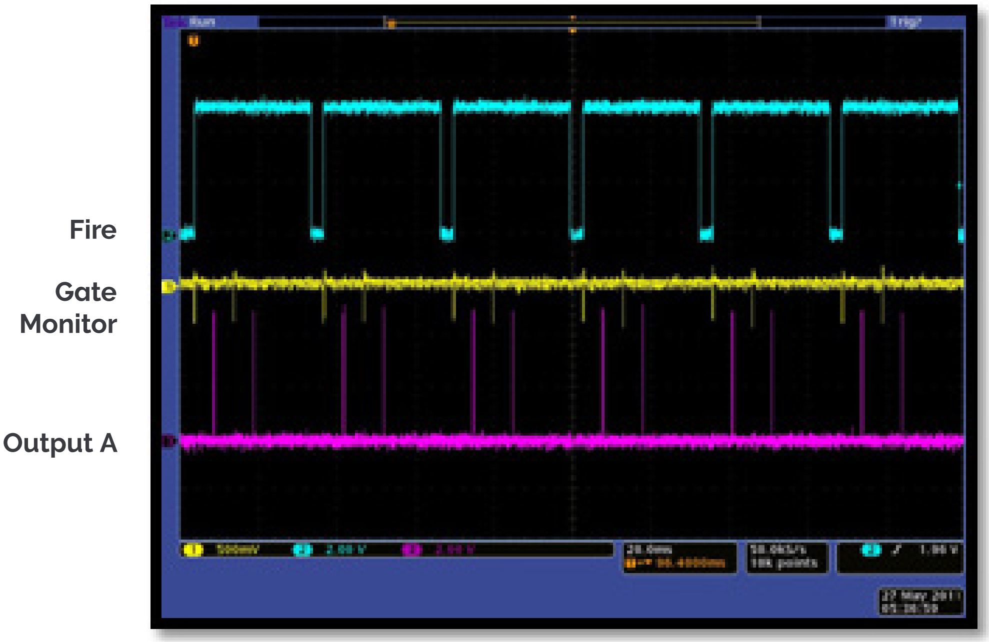
Description

One gate pulse is generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is incremented for every accumulated image that is returned.

Setup

Gate step enabled, Output A enabled (trackstep disabled).

Waveforms



5.1.5.4 IOC and Gate Step Enabled

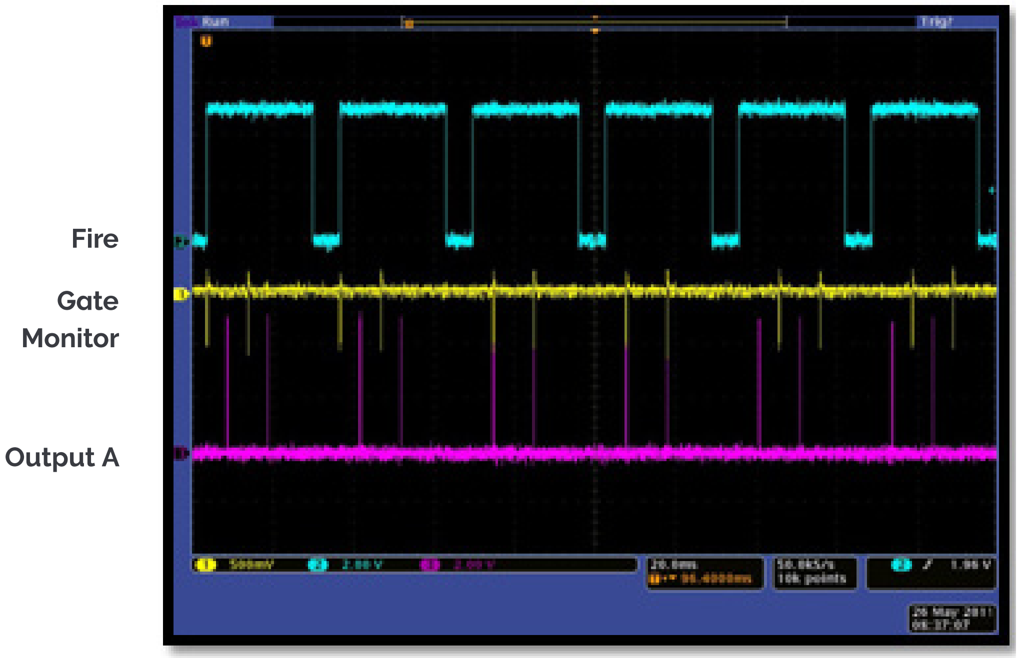
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is incremented for every accumulated image that is returned.

Setup

IOC enabled, gate step enabled, output A enabled (trackstep disabled).

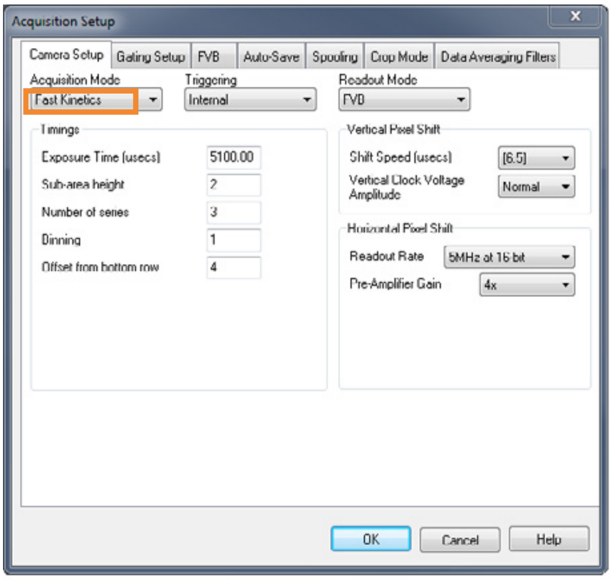
Waveforms



5.1.6 Acquisition Mode: Photon Counting

Same as Acquisition Mode: Kinetic operation.

5.1.7 Acquisition Mode: Fast Kinetics



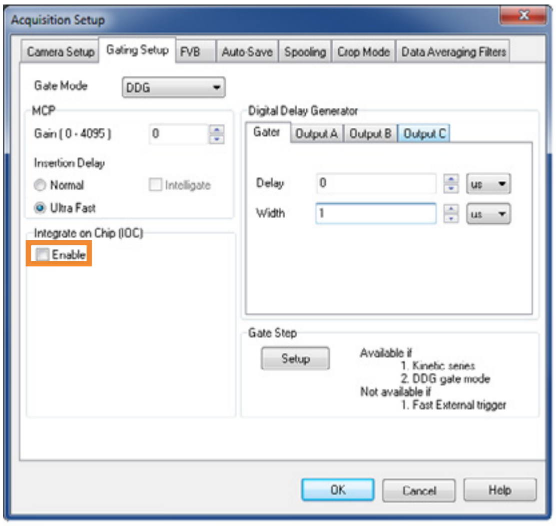
5.1.7.1 Standard Operation (IOC Disabled and Gate Step Disabled)

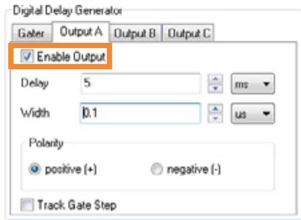
Description

One gate pulse is generated within an exposure. A gate delay is applied that is the same for each exposure in the series.

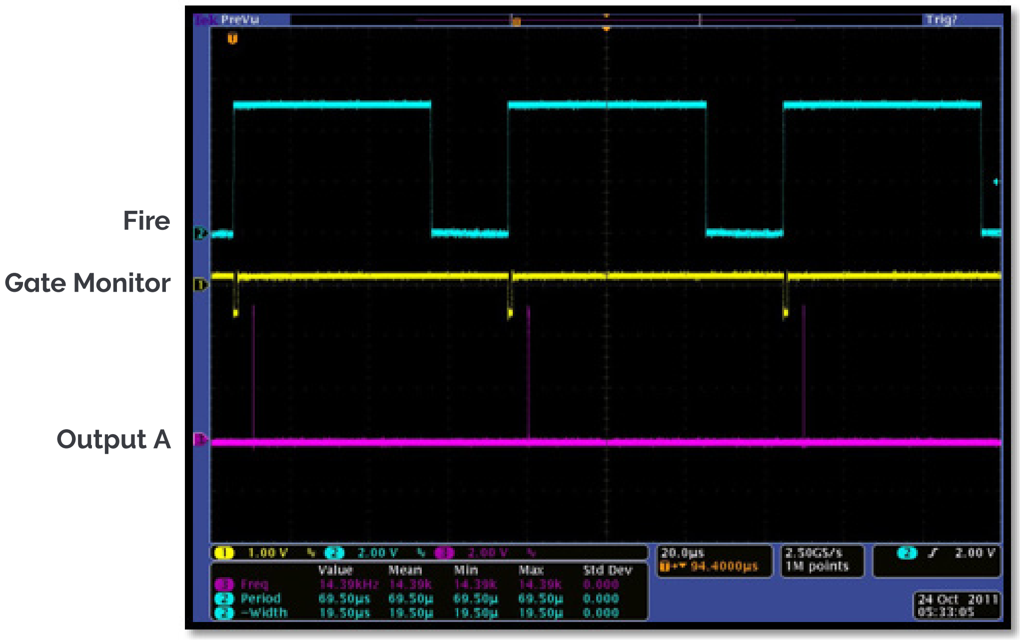
Setup

IOC disabled, gate step disabled, Output A enabled.





Waveforms



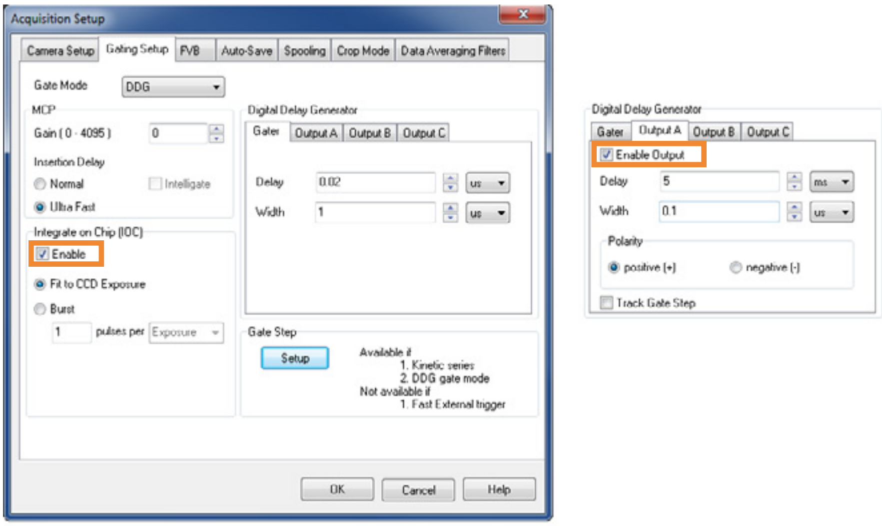
5.1.7.2 Integrate on Chip (IOC) Enabled

Description

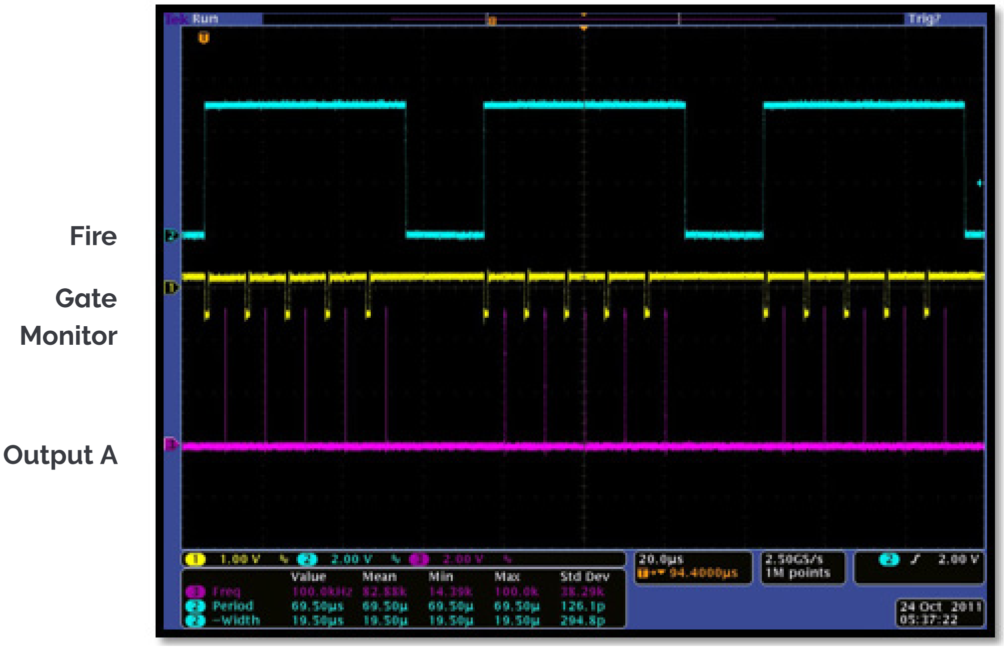
Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC enabled, Output A enabled.



Waveforms



5.1.7.3 Gate Step Enabled

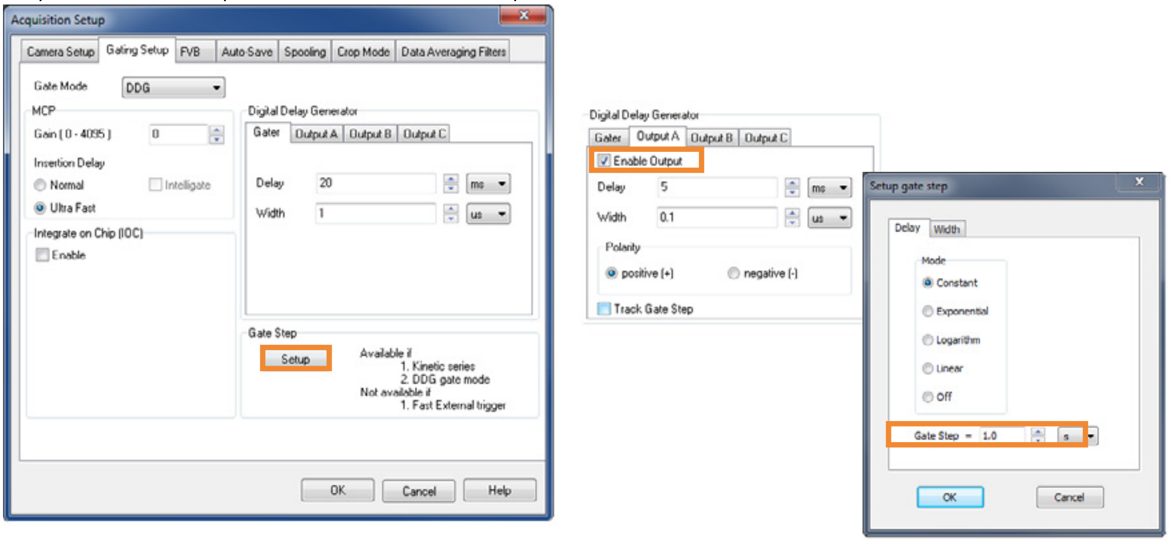
Description

One gate pulse is generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

Note: The fire pulse rate cannot exceed 15 kHz in this particular mode.

Setup

Gate step enabled, Output A enabled (trackstep disabled).

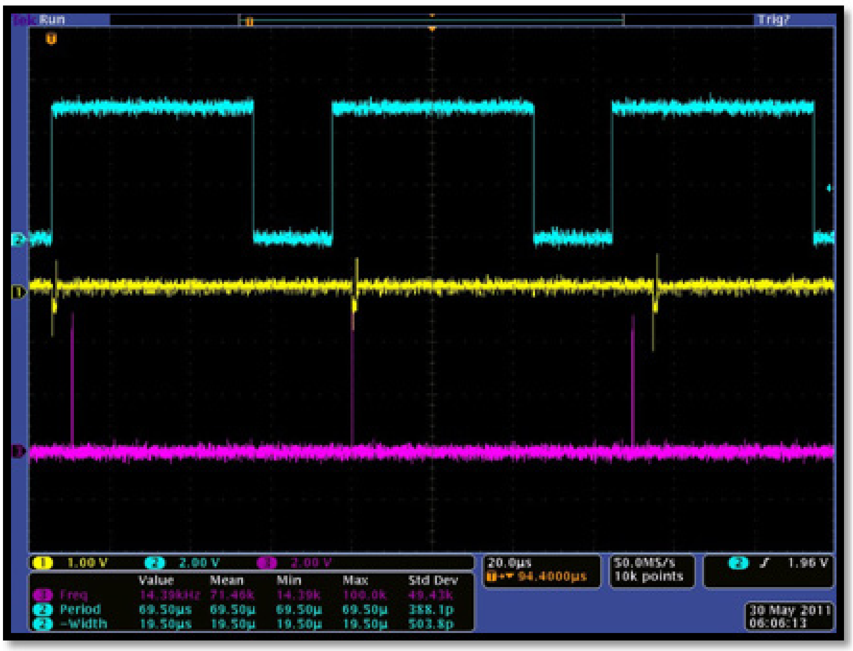


Waveforms

Fire

Gate Monitor

Output A



5.1.7.4 IOC and Gate Step Enabled

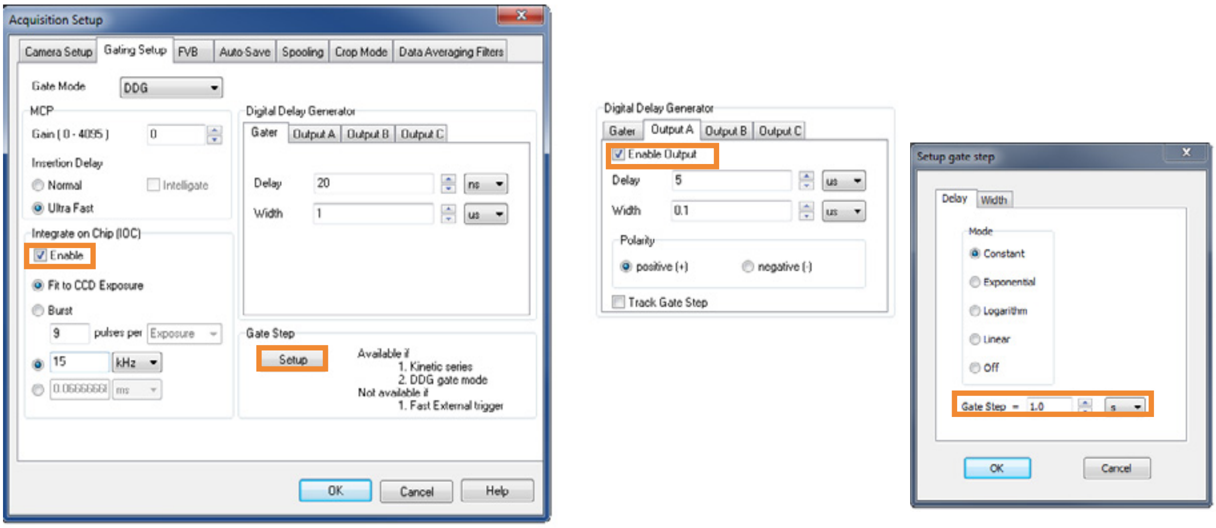
Description

Several gate pulses are generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

Note: The fire pulse rate cannot exceed 15 kHz in this particular mode.

Setup

IOC enabled, gate step enabled, Output A enabled (trackstep disabled).

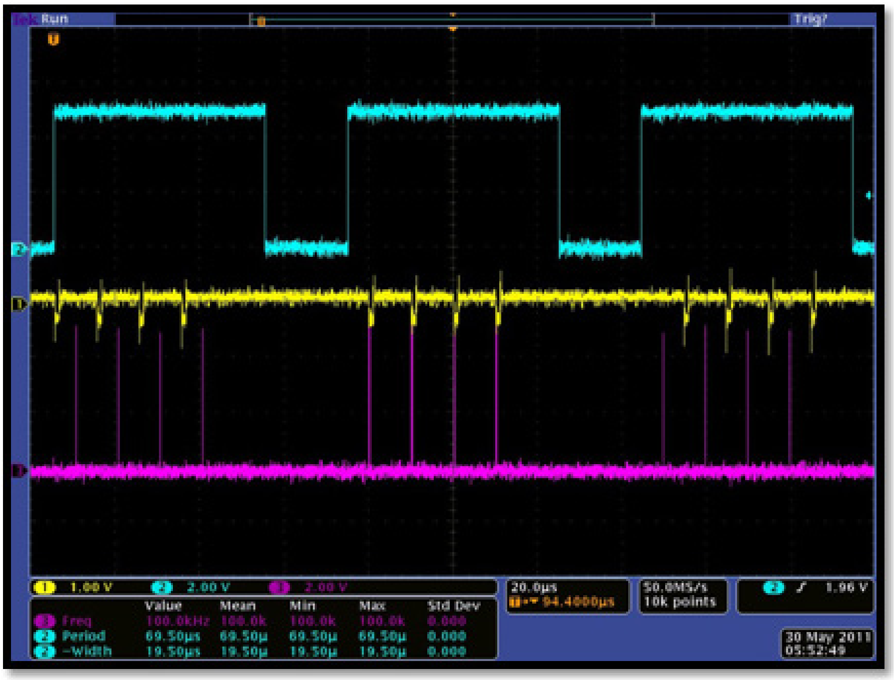


Waveforms

Fire

Gate Monitor

Output A



5.2 Triggering: External

5.2.1 Acquisition Mode: Single

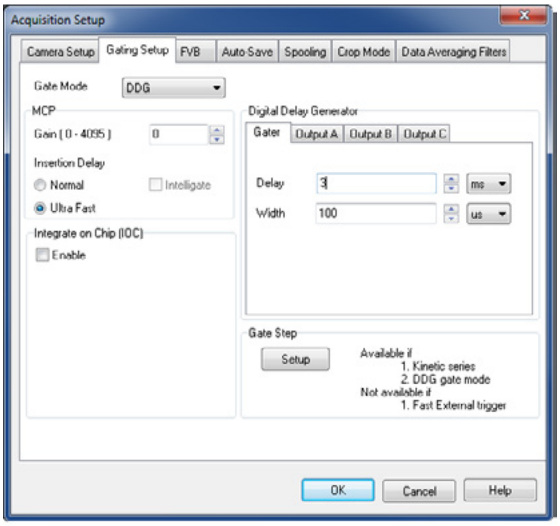
5.2.1.1 Standard Operation (IOC Disabled)

Description

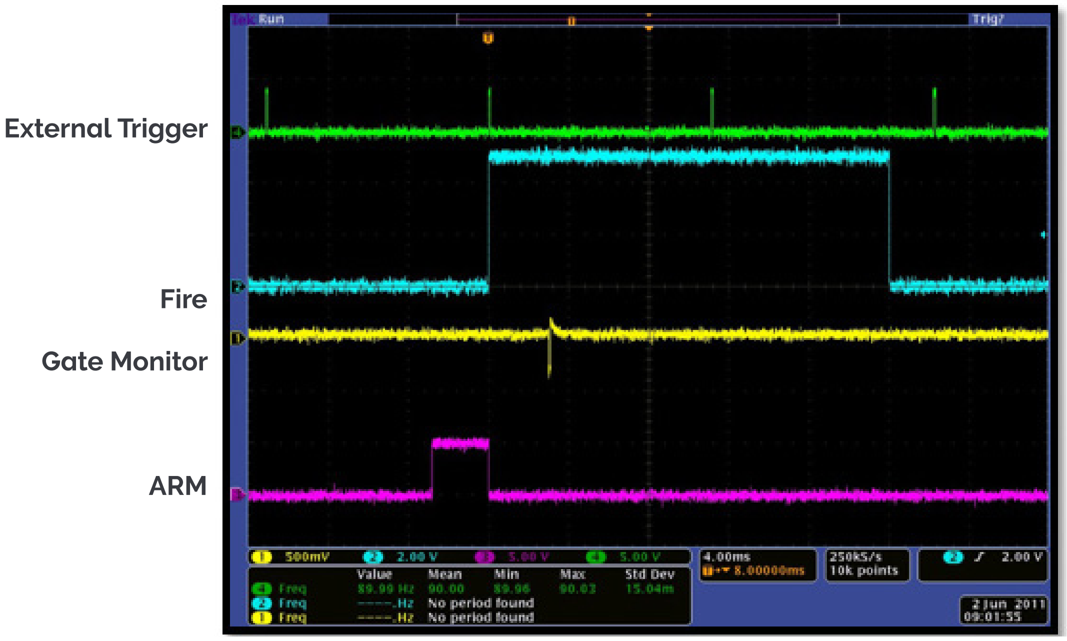
The External Trigger generates one gate pulse per exposure. A delay relative to the trigger can be applied to the gate pulse (and output A/B/C). Any subsequent triggers that arrive during the exposure are ignored.

Setup

IOC disabled.



Waveforms



5.2.2 Integrate on Chip (IOC) Enabled

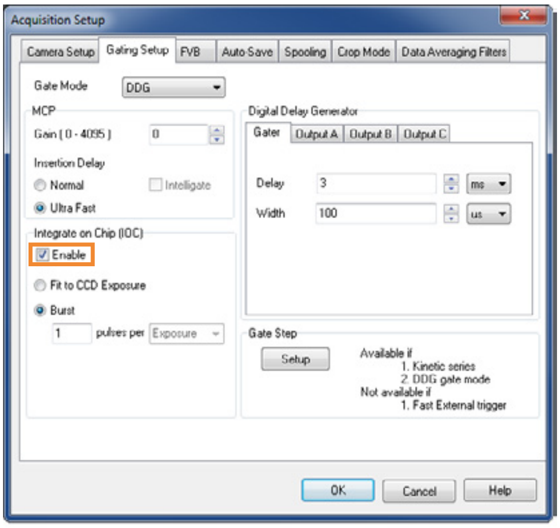
5.2.2.1 Default: One Pulse per Trigger

Description

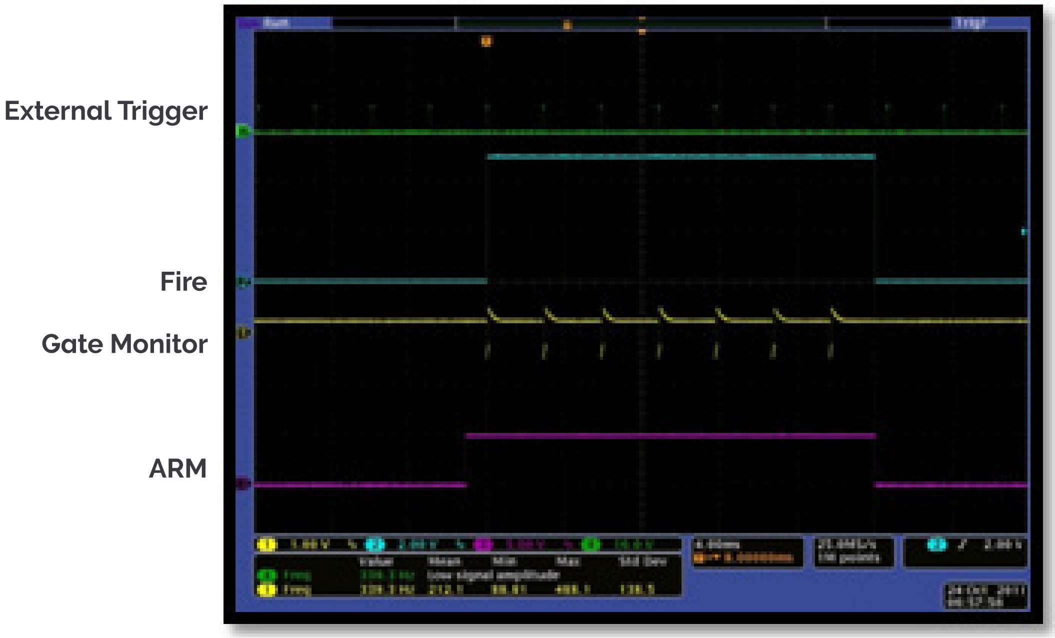
This is the standard mode of operation in External Trigger. Every External Trigger within an exposure will generate only one gate pulse. A gate delay is applied that is the same per every trigger within an exposure.

Setup

IOC enabled, output A/B/C disabled.



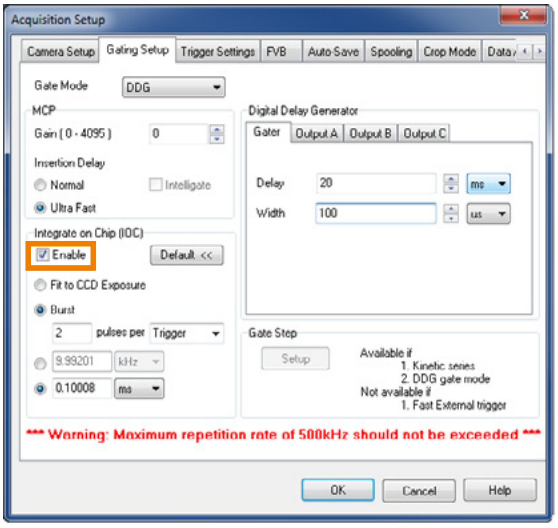
Waveforms



5.2.2.2 Advanced: Burst of Pulses per Trigger

Description

The user can select for multiple pulses per trigger. The External Trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency.



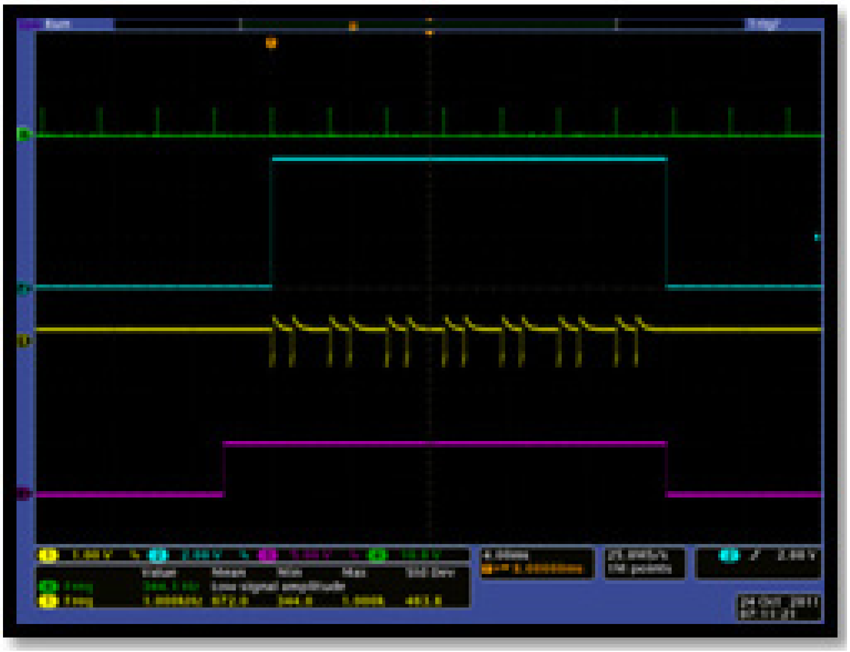
Waveforms

External Trigger

Fire

Gate Monitor

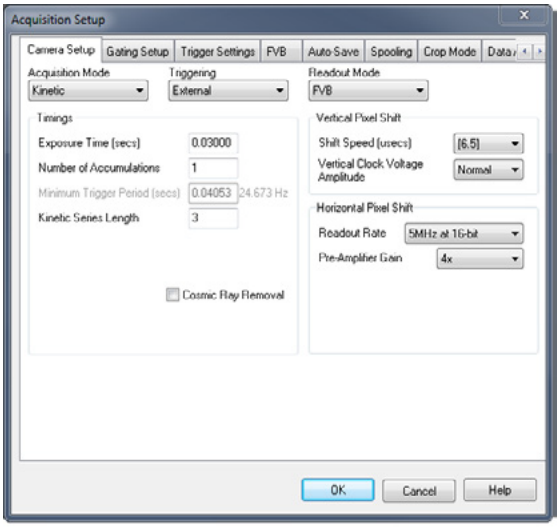
ARM



5.2.3 Acquisition Mode: Kinetic

5.2.3.1 Number of Accumulations = 1

A number of single images will be acquired in the series.



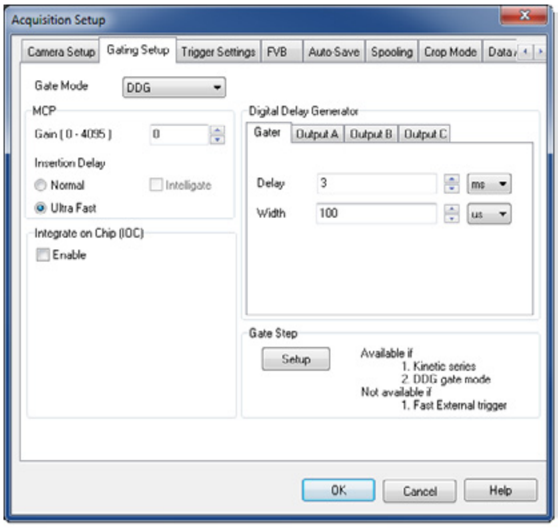
5.2.3.2 Standard Operation (IOC Disabled and Gate Step Disabled)

Description

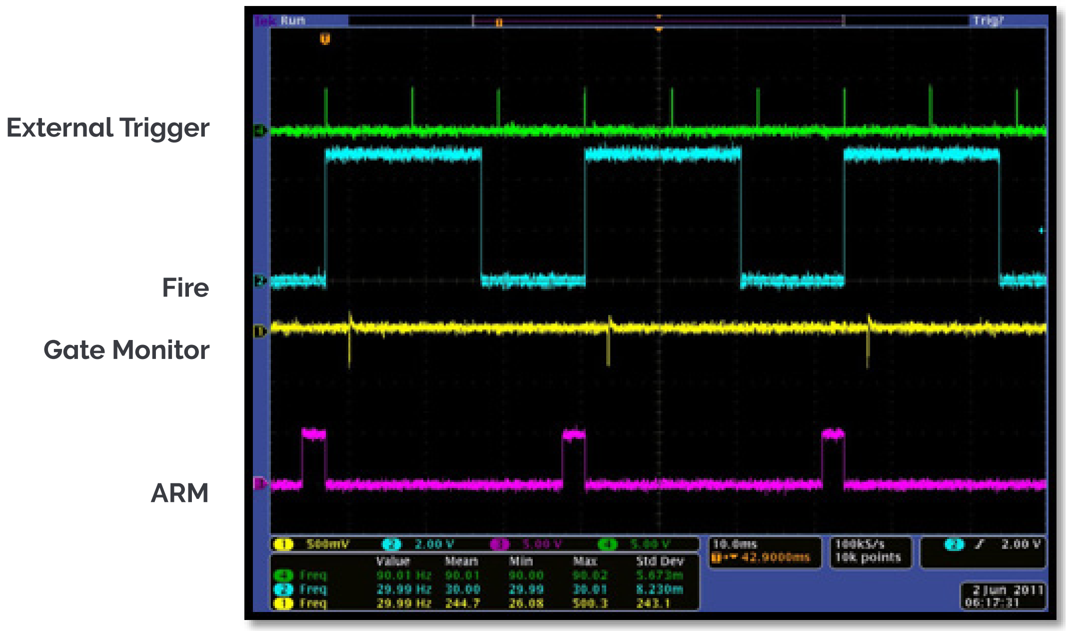
The External Trigger generates one gate pulse per exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC disabled, gate step disabled, output A/B/C disabled.



Waveforms



5.2.4 Integrate on Chip (IOC) Enabled

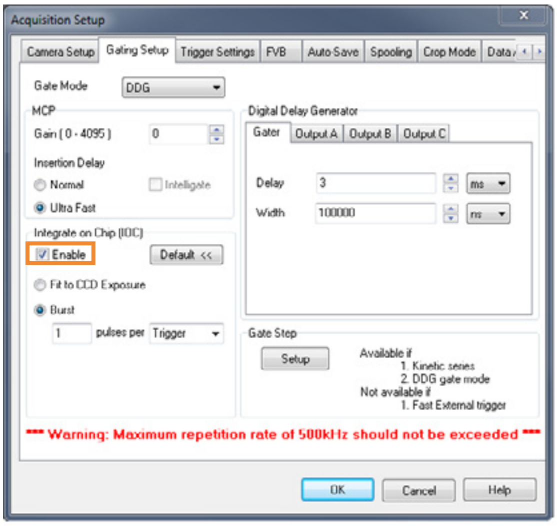
5.2.4.1 Default: One Pulse per Trigger

Description

Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an exposure. Every External Trigger within an exposure can generate only one gate pulse.

Setup

IOC enabled, output A/B/C disabled.



Waveforms

External Trigger

Fire

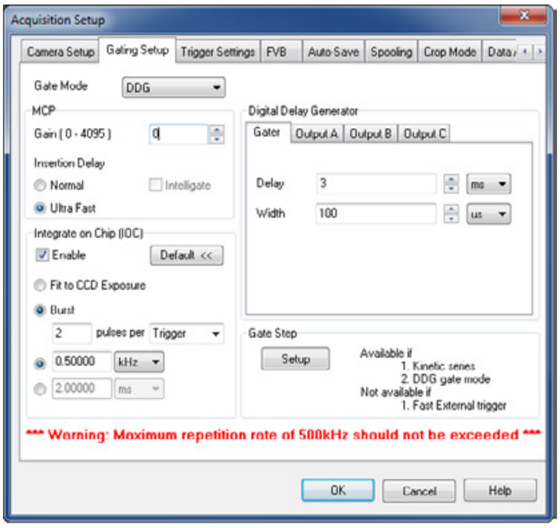
Gate Monitor

ARM

5.2.4.2 Advanced: Burst Pulses per Trigger

Description

The user can select multiple pulses per trigger. The External Trigger generates the first pulse, and subsequent pulses are generated internally by a user defined period/frequency.



Waveforms

External Trigger

Fire

Gate Monitor

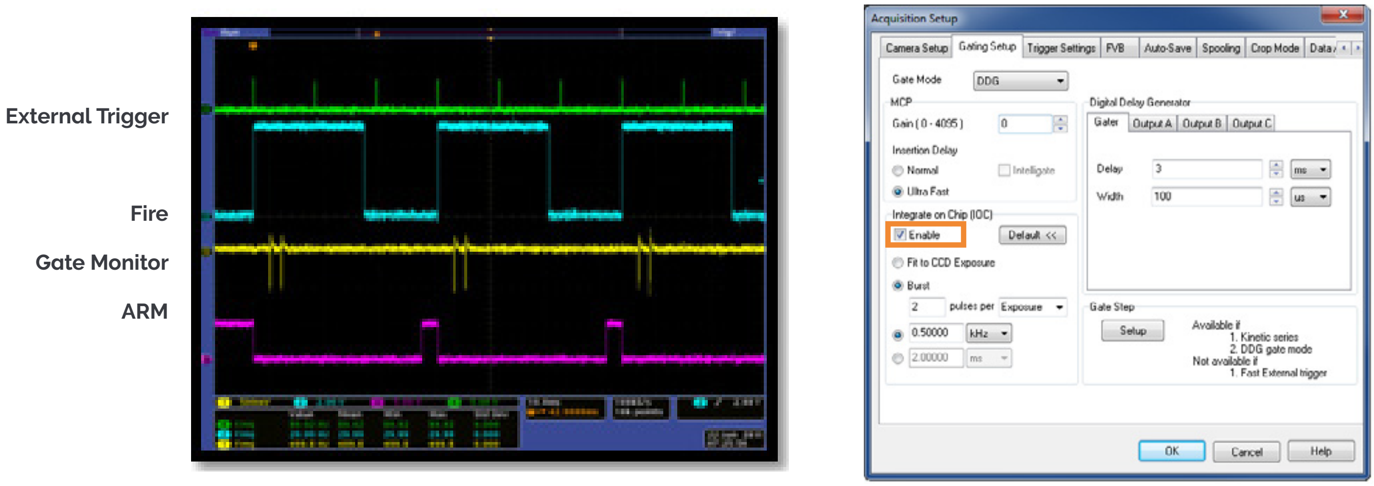
ARM

5.2.4.3 Advanced: Burst/Fit Pulses per Exposure

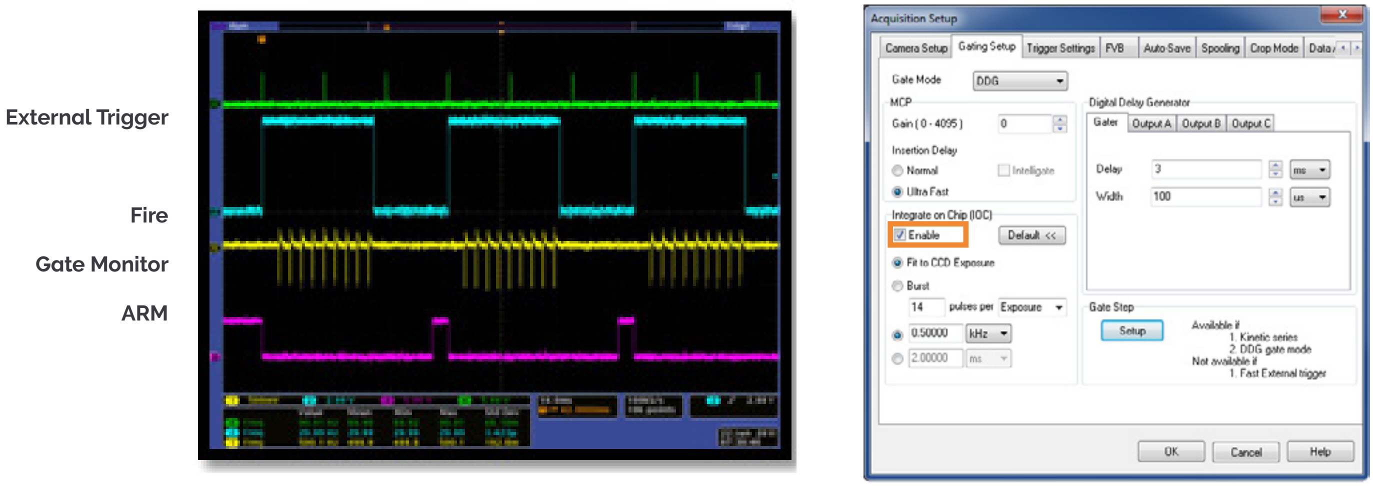
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure in the series. For each exposure, the External Trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses is applied that can fit into the exposure or the user defines the number of pulses per exposure. Any subsequent triggers that arrive during the exposure are ignored.

Waveforms



Burst per Exposure



Fit to CCD Exposure

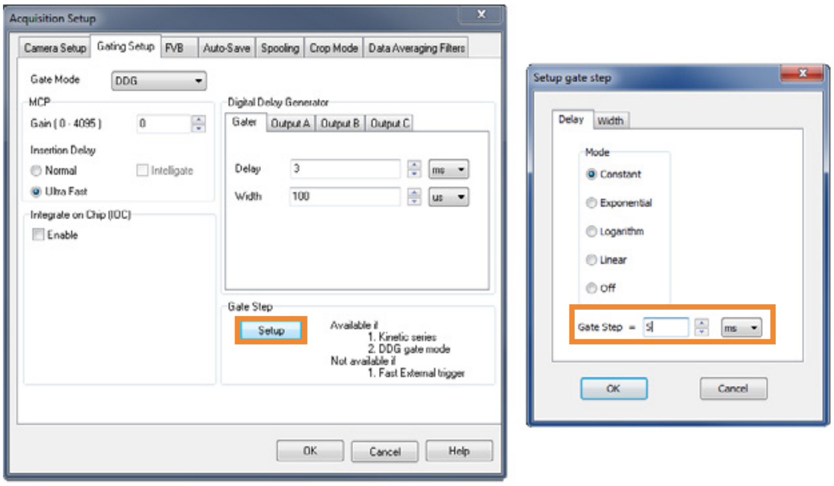
5.2.4.4 Gate Step Enabled

Description

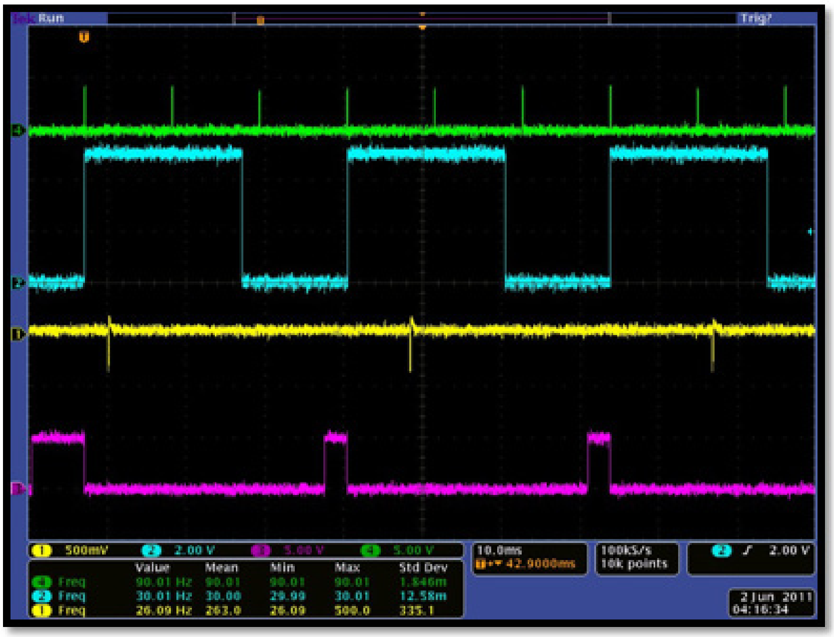
The External Trigger generates one gate pulse per exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

Setup

Gate step enabled, output A/B/C disabled.



Waveforms



5.2.5 IOC and Gate Step Enabled

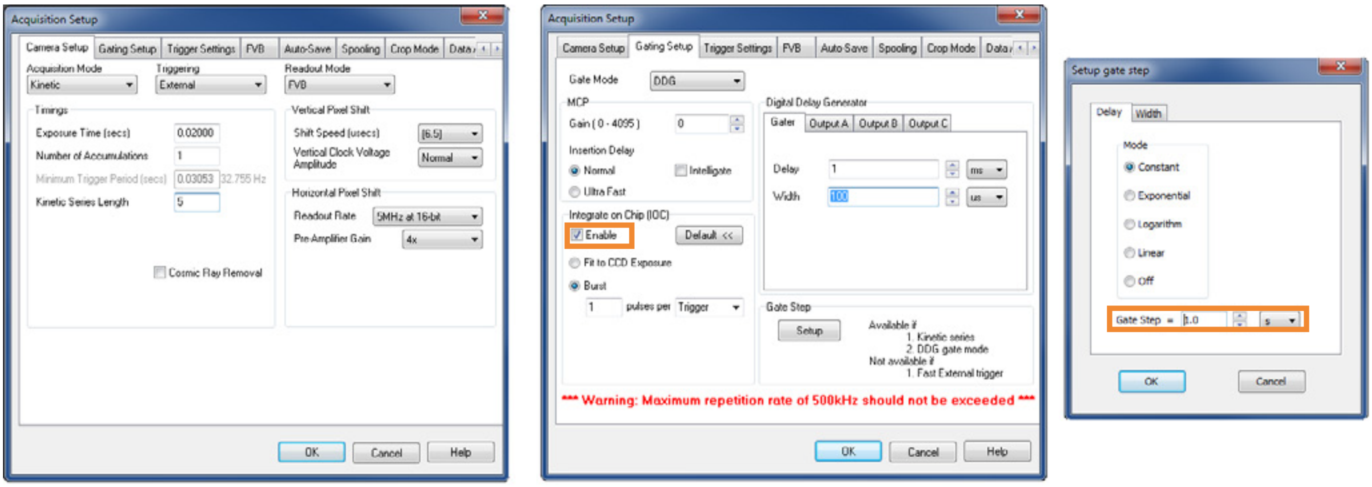
5.2.5.1 Default: One Pulse per Trigger

Description

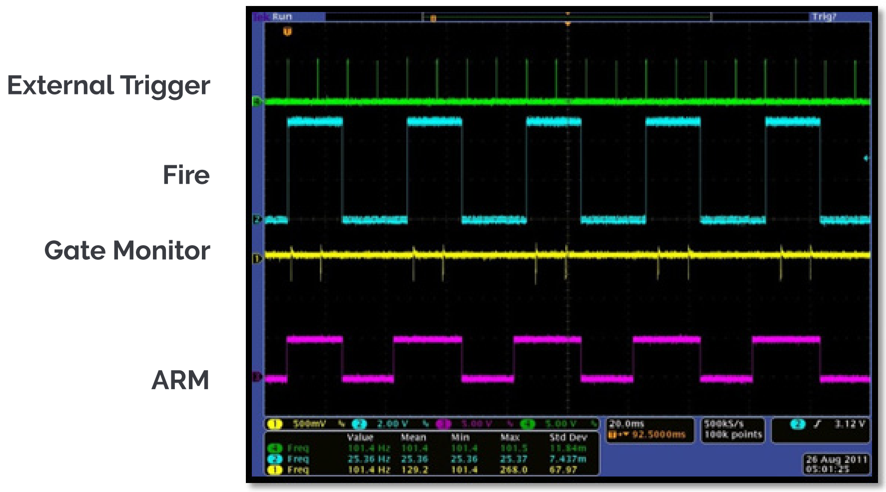
Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value. Every External Trigger within an exposure can generate only one gate pulse.

Setup

IOC enabled, gate step, output A/B/C disabled.



Waveforms



One Pulse per Trigger

Limitations

WHEN USING EXTERNAL TRIGGER WITH IOC AND GATE STEP THE SOFTWARE HAS TO COMMUNICATE TO THE DDG IN BETWEEN SCANS IN ORDER TO INCREMENT THE GATE DELAY. THE TIME NEEDED IS :

- **7.5 ms** when incrementing the gate delay
- **11.5 ms** when incrementing the gate delay, output A delay, output B delay, output C delay (if track gate step is enabled)

This time is in most cases less than the time it takes to clean out the image area before each exposure. **Therefore precautions only need to be taken when the time to clean out the image area is less than 7.5 ms (or 11.5 ms if other channels are tracking the gate step)**. Since this clean cycle depends on the sensor and vertical shift speed combination the table below shows the recommended settings. Unless stated otherwise the maximum trigger rate is to 500 kHz (5 kHz for Intelligate).

a) When incrementing the gate delay only:
When using trigger rates **less than 133 Hz,** the recommended setup is:

	Vertical Shift Speed (µsecs)
DH334T (47-10 sensor)	6.5
DH320T (30-11 sensor)	11.3
DH340T (42-10 sensor)	12.9

When using trigger rates **greater than 133 Hz,** the recommended setup is:

	Vertical Shift Speed (µsecs)	Clean Cycle (msecs) for information only
DH334T (47-10 sensor)	6.5	13.5
DH320T (30-11 sensor)	22.5	9.3
DH340T (42-10 sensor)	12.9	10

b) When incrementing the gate delay, output A delay, output B delay, output C delay, and track gate step is enabled
When using trigger rates **less than 87 Hz**, the recommended setup is:

	Vertical Shift Speed (µsecs)
DH334T (47-10 sensor)	6.5
DH320T (30-11 sensor)	11.3
DH340T (42-10 sensor)	12.9

When using trigger rates **greater than 87 Hz**, the recommended setup is:

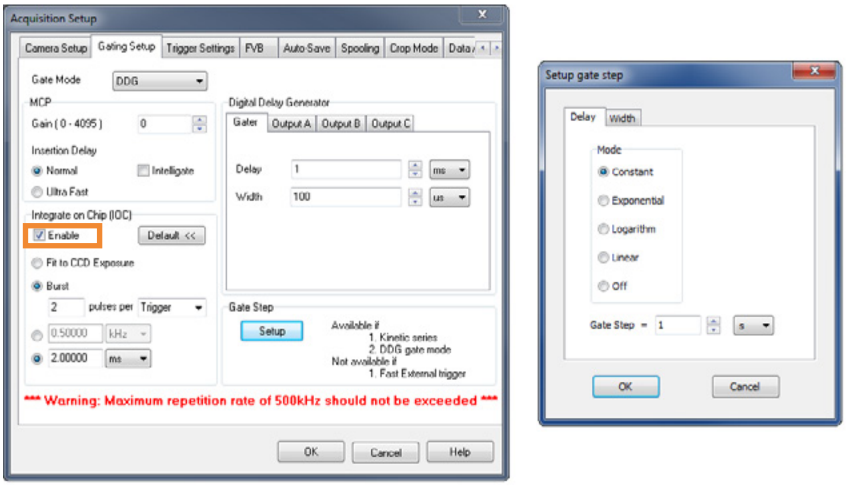
	Vertical Shift Speed (µsecs)	clean cycle (msecs) for information only
DH334T (47-10 sensor)	6.5	13.5
DH320T (30-11 sensor)	22.5 (107 Hz maximum)	9.3
DH340T (42-10 sensor)	25.7	16.6

Note: This mode is not supported in fast External Trigger or when using fast kinetics. However IOC and gate step are available in internal trigger mode.

5.2.5.2 Advanced: Burst Pulses per Trigger

Description

The user can select for multiple pulses per trigger. The External Trigger generates the first pulse, subsequent pulses are generated internally by a user defined Period/Frequency. A gate delay is applied that is the same per every trigger within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.



Waveforms

External Trigger

Fire

Gate Monitor

ARM

Burst per Exposure

5.2.5.3 Advanced: Burst/Fit Pulses per Exposure

Description

Several gate pulses are generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value. For each exposure, the External Trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses is applied that can fit into the exposure, given the final gate delay in the series, or the user defines the number of pulses per exposure. Any subsequent triggers that arrive during the exposure.

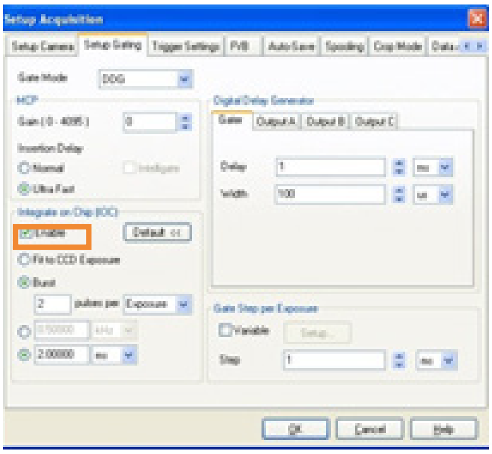
Waveforms

External Trigger

Fire

Gate Monitor

ARM



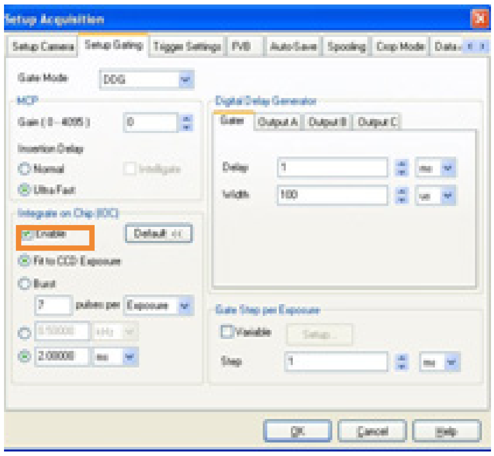
Burst per Exposure

External Trigger

Fire

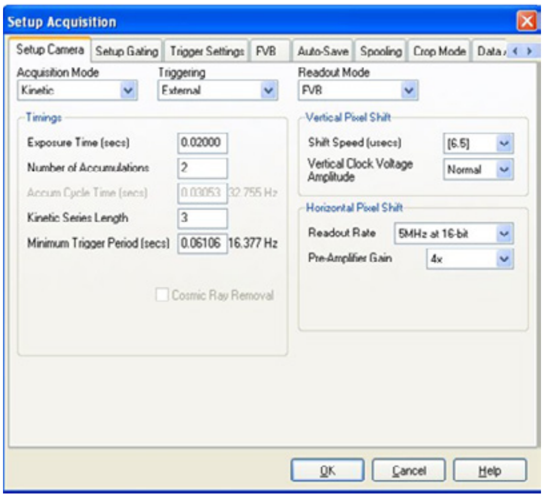
Gate Monitor

ARM



Fit to CCD Exposure

5.2.6 Number of Accumulations > 1



5.2.6.1 Standard Operation (IOC Disabled and Gate Step Disabled)

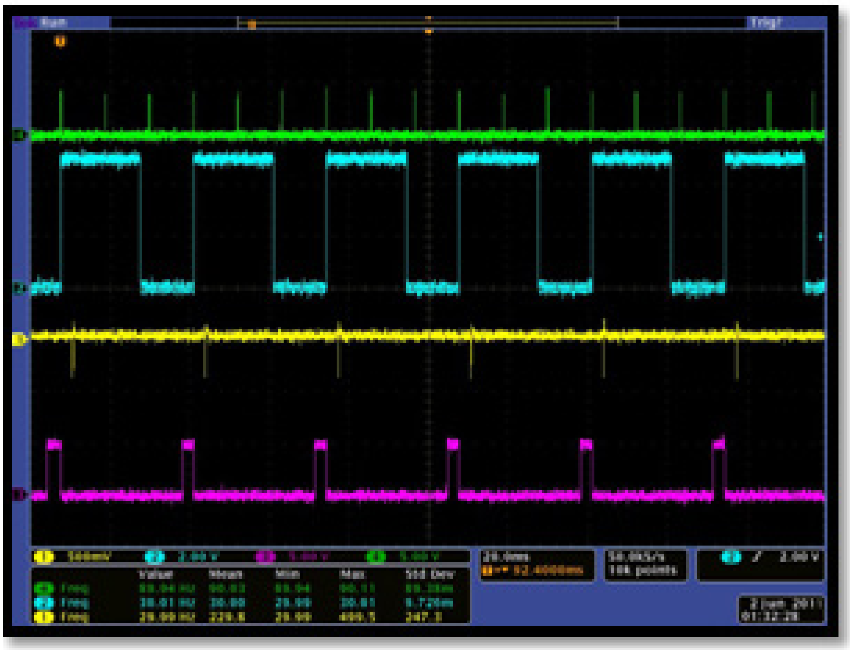
Description

The External Trigger generates one gate pulse per exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is also the same for every accumulated image that is returned.

Setup

IOC disabled, gate step disabled, output A/B/C disabled.

Waveforms



5.2.7 Integrate on Chip (IOC) Enabled

5.2.8 Default: One Pulse per Trigger

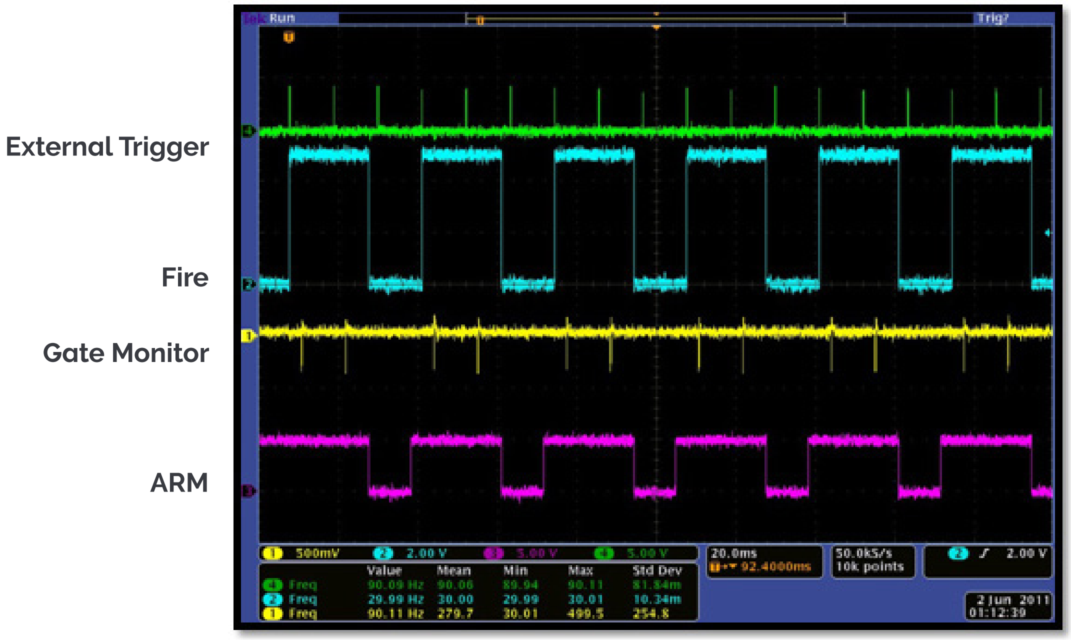
Description

Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an accumulated image. The gate delay is also the same for every accumulated image that is returned. Every External Trigger within an exposure will generate only one gate.

Setup

IOC enabled, output A/B/C disabled.

Waveforms

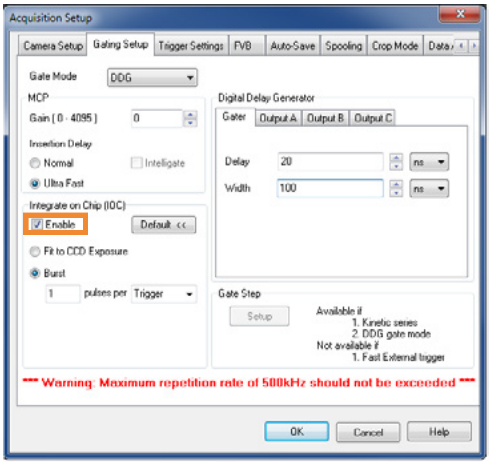


One Pulse per Trigger

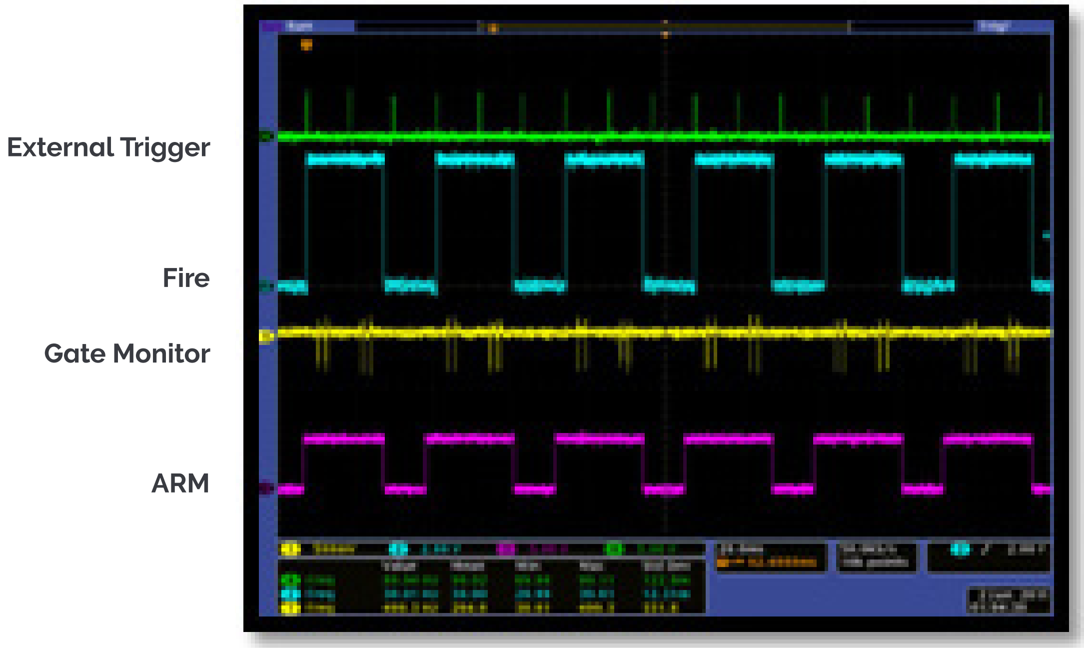
5.2.8.1 Advanced: Burst Pulses per Trigger

Description

The user can select for multiple pulses per trigger. The External Trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency.



Waveforms



Burst per Trigger

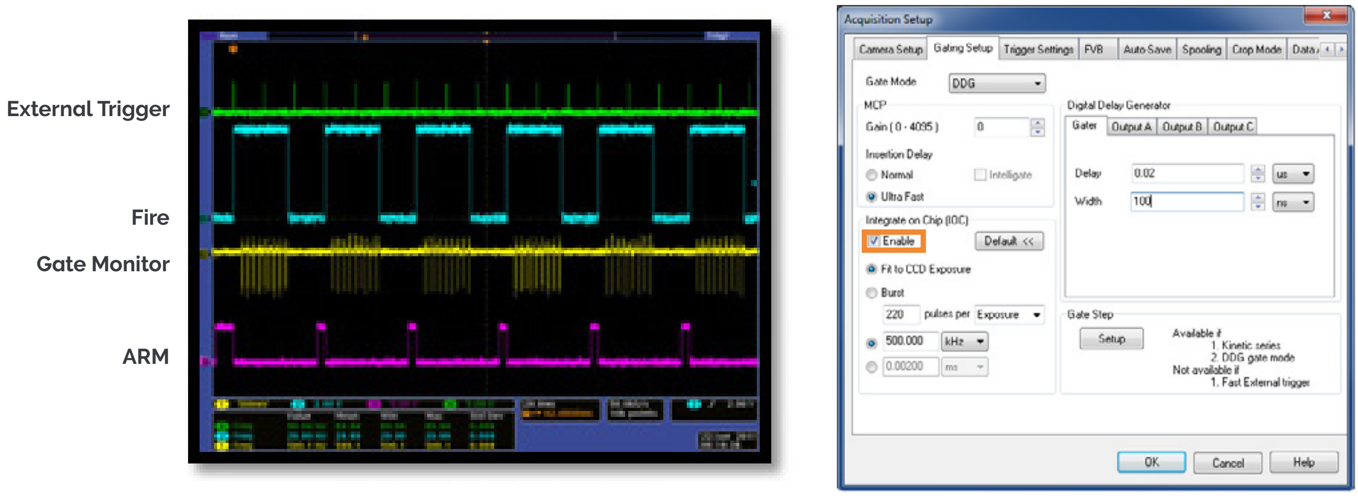
5.2.8.2 Advanced: Burst/Fit Pulses per Exposure

Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is also the same for every accumulated image that is returned. For each exposure, the External Trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses that can fit into the exposure is applied, or alternatively the user defines the numbers of pulses per exposure. Any subsequent triggers that arrive during the exposure are ignored.

Waveforms

Burst per Exposure



Fit to CCD Exposure

5.2.8.3 Gate Step Enabled

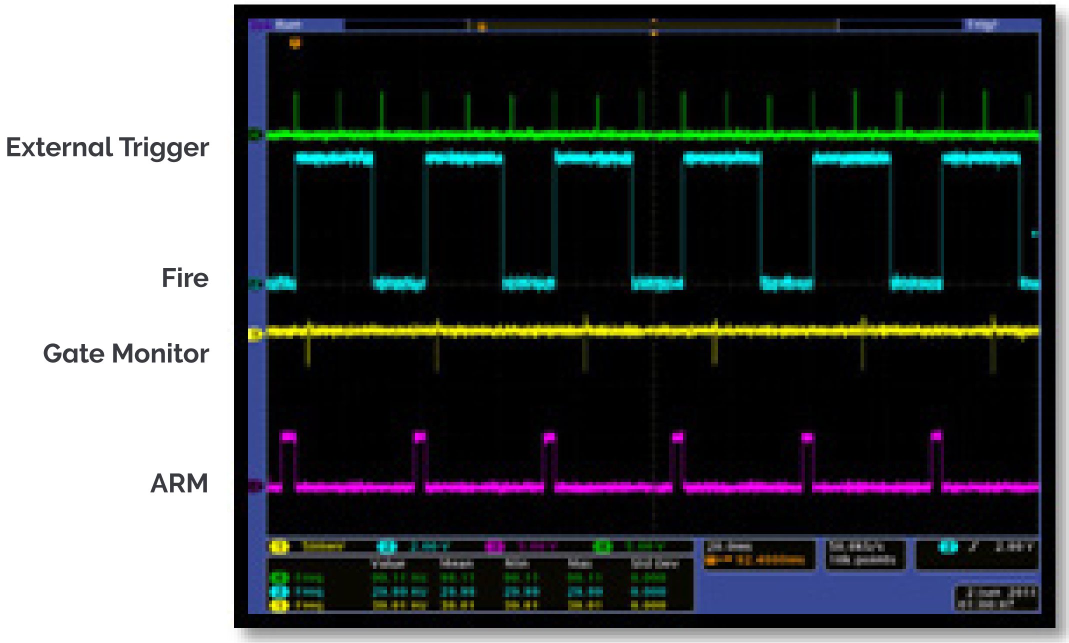
Description

The External Trigger generates one gate pulse per exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is incremented for every accumulated image that is returned.

Setup

Gate step enabled, output A/B/C disabled.

Waveforms



5.2.9 IOC and Gate Step Enabled

5.2.9.1 Default: One Pulse per Trigger

Description

Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an accumulated image. The gate delay is incremented for every accumulated image that is returned. Every External Trigger within an exposure can generate only one gate pulse.

Setup

IOC enabled, gate step enabled, output A/B/C disabled.

Waveforms

External Trigger

Fire

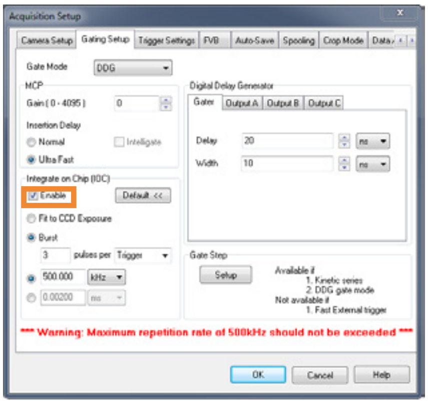
Gate Monitor

ARM

5.2.9.2 Advanced: Burst Pulses per Trigger

Description

The user can select for multiple pulses per trigger. The External Trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency. A gate delay is applied that is the same per every trigger within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.



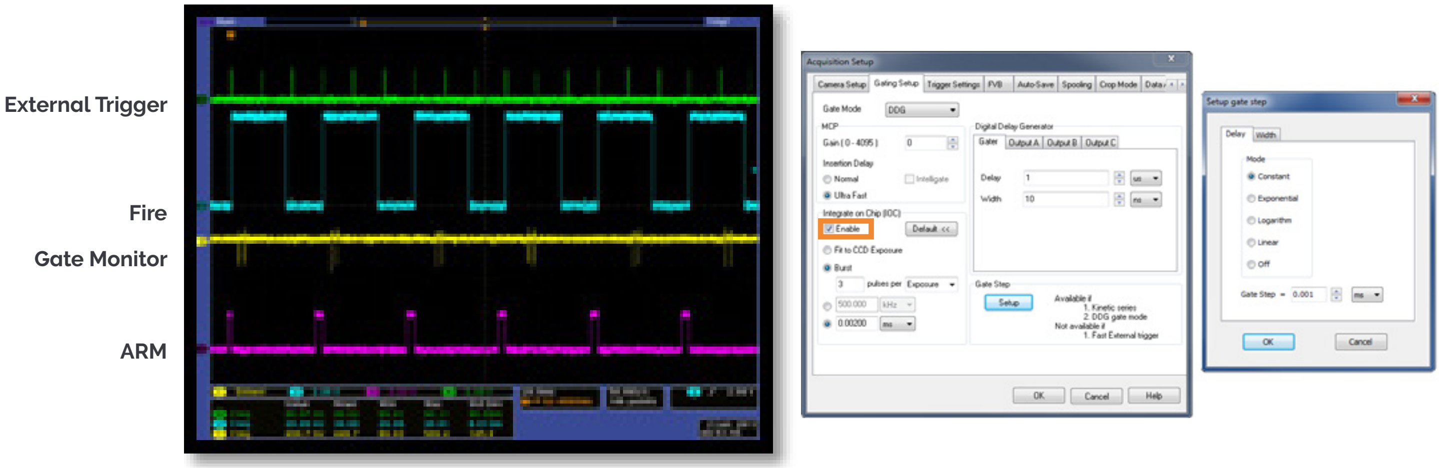
Burst per Trigger

5.2.9.3 Burst/Fit Pulses per Exposure

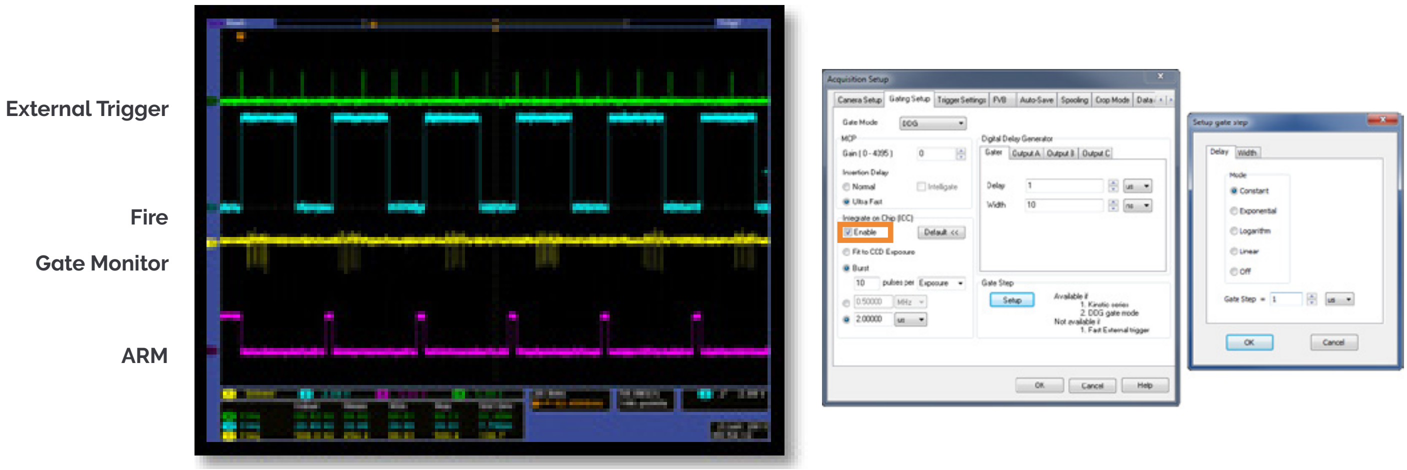
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is incremented for every accumulated image that is returned. For each exposure, the External Trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses is applied that can fit into the exposure, given the final gate delay in the series, or the user defines the numbers of pulses per exposure. Any subsequent triggers that arrive during the exposure are ignored.

Waveforms



Burst per Exposure



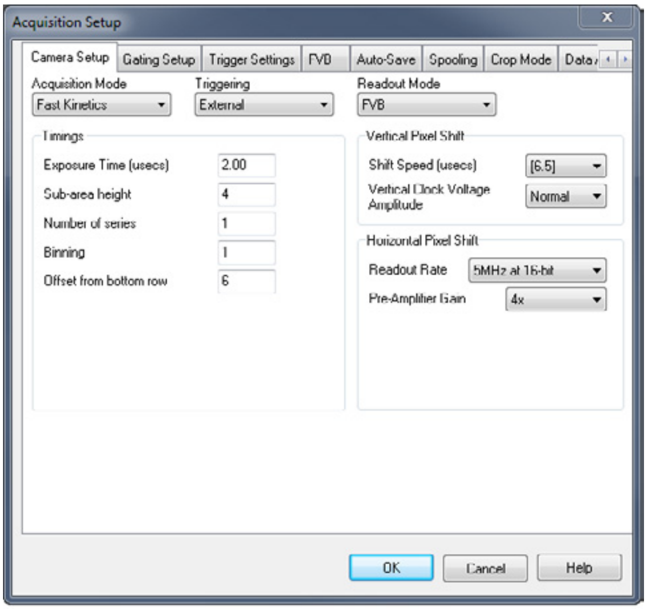
Fit to CCD Exposure

5.2.10 Acquisition Mode: Photon Counting

Same as Acquisition Mode: Kinetic.

5.2.11 Acquisition Mode: Fast Kinetics

Allows the user to acquire a short kinetics series with a rapid cycle time. The image is captured on a sub section of the sensor array, with the remainder of the array being used as a storage area until the data series is readout. The user can specify the exposure time for each frame within the series (in seconds), the size of the sub-section capturing the image (in rows) and the binning pattern. The number in the series can also be entered but is limited to a maximum value equal to the number of rows in the sensor array divided by the number of rows specified in the sub section.



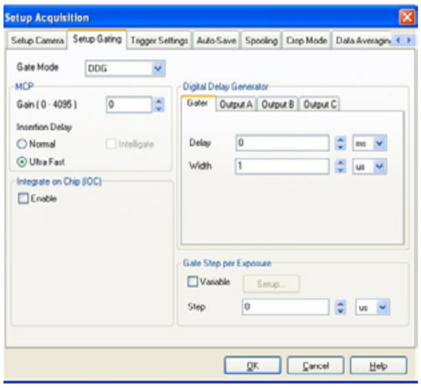
5.2.11.1 Standard Operation (IOC Disabled and Gate Step Disabled)

Description

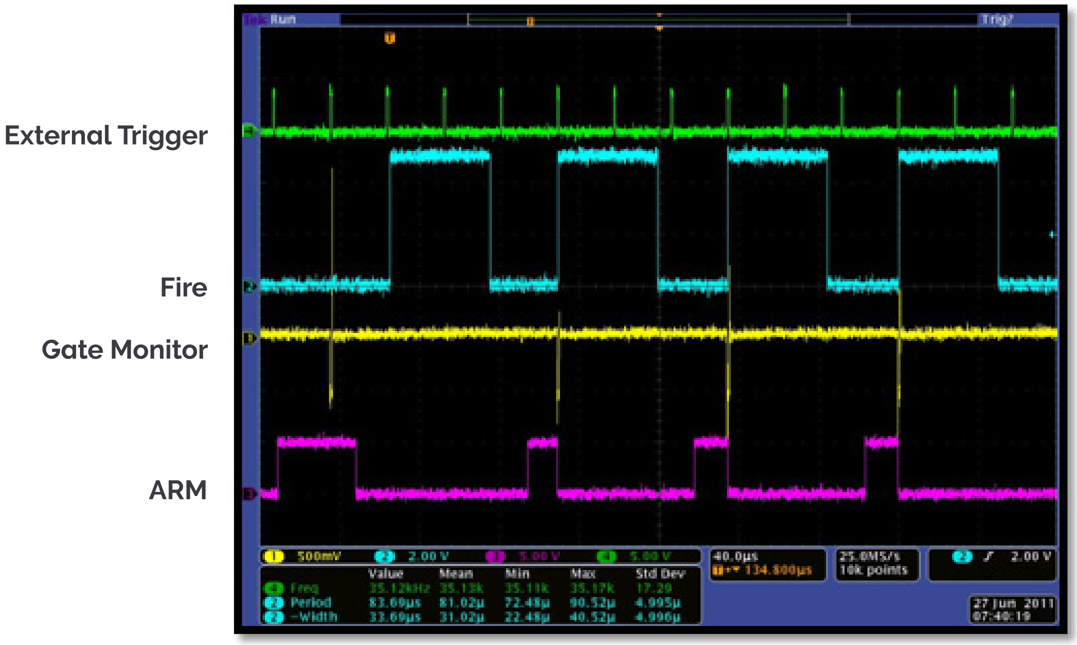
The External Trigger generates one gate pulse per exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC disabled, gate step disabled, output A/B/C disabled.



Waveforms



5.2.12 Integrate on Chip (IOC) Enabled

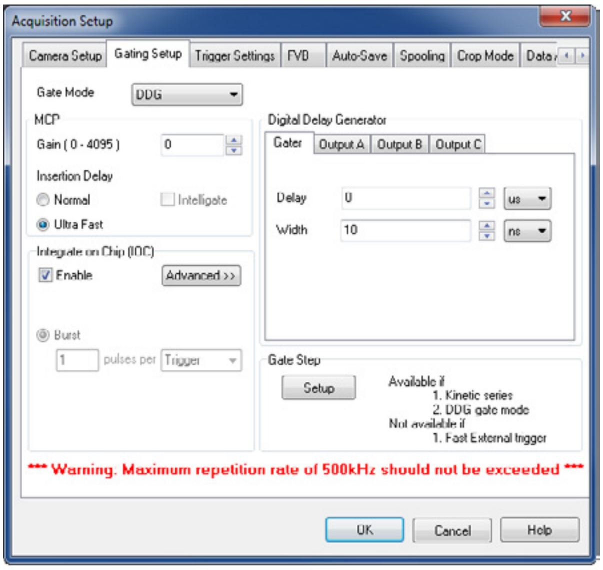
5.2.12.1 Default: One Pulse per Trigger

Description

Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an exposure. Every External Trigger within an exposure can generate only one gate pulse.

Setup

IOC enabled, output A/B/C disabled.



Waveforms

External Trigger

Fire

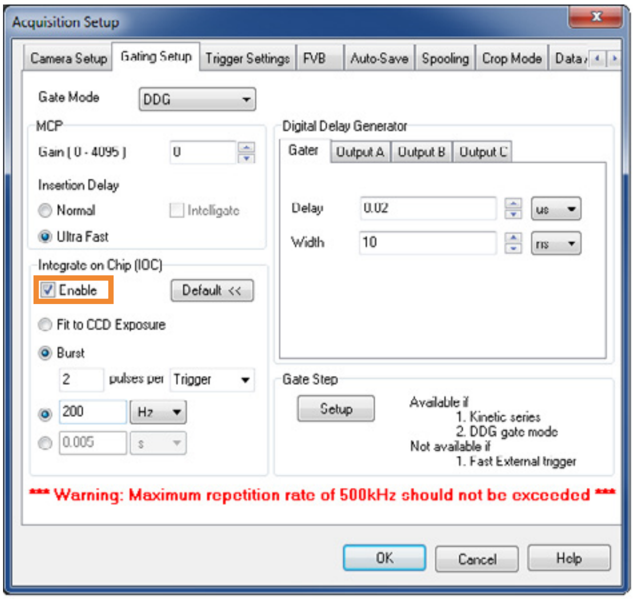
Gate Monitor

ARM

5.2.12.2 Advanced: Burst pulses per trigger

Description

The user can select for multiple pulses per trigger. The External Trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency.



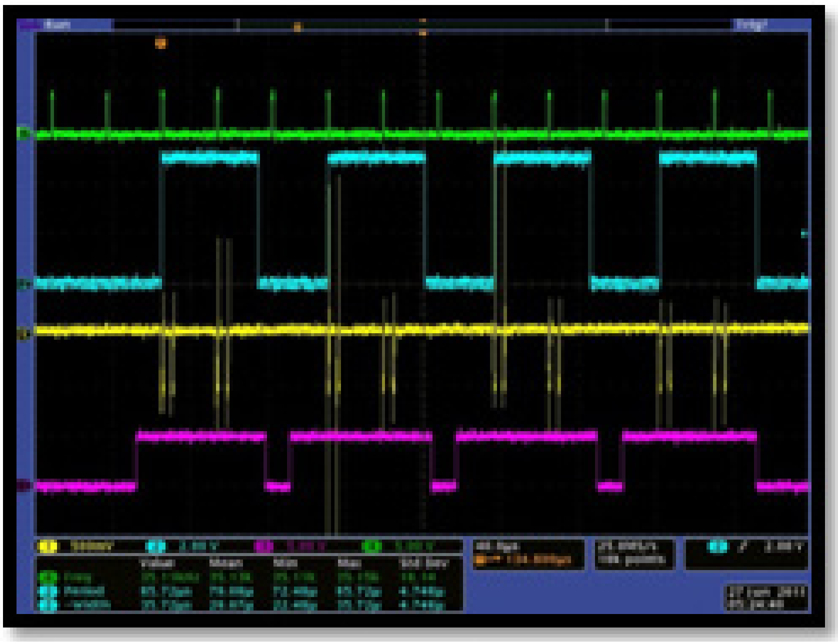
Waveforms

External Trigger

Fire

Gate Monitor

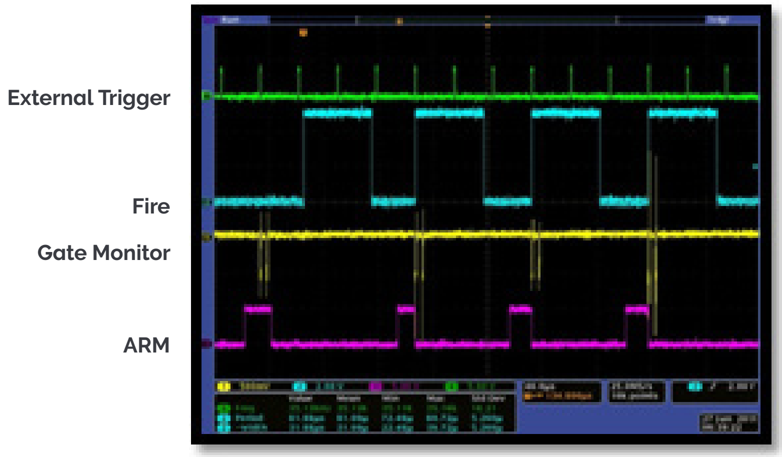
ARM

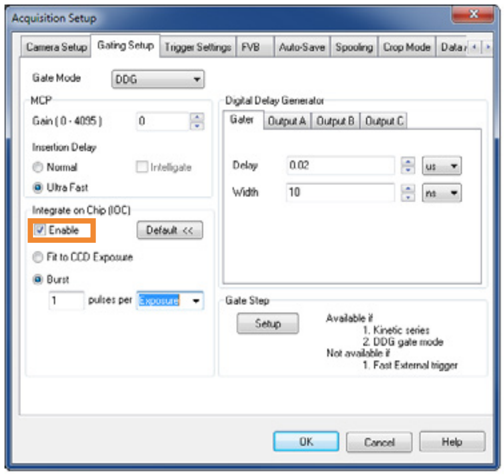


5.2.12.3 Advanced: Burst/Fit Pulses per Exposure

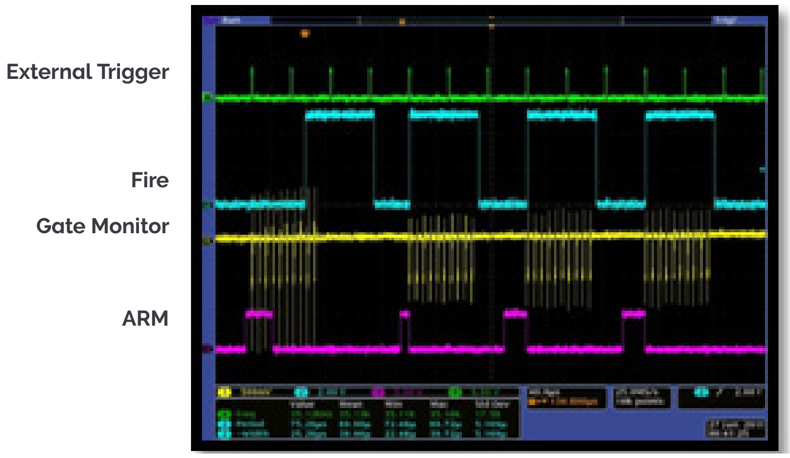
Description

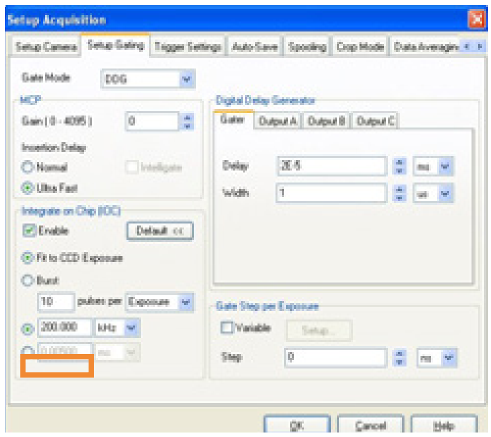
Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure in the series. For each exposure, the External Trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses is applied that can fit into the exposure or the user defines the number of pulses per exposure. Any subsequent triggers that arrive during the exposure are ignored.





Burst per Exposure





Fit to CCD Exposure

5.2.12.4 Gate Step Enabled

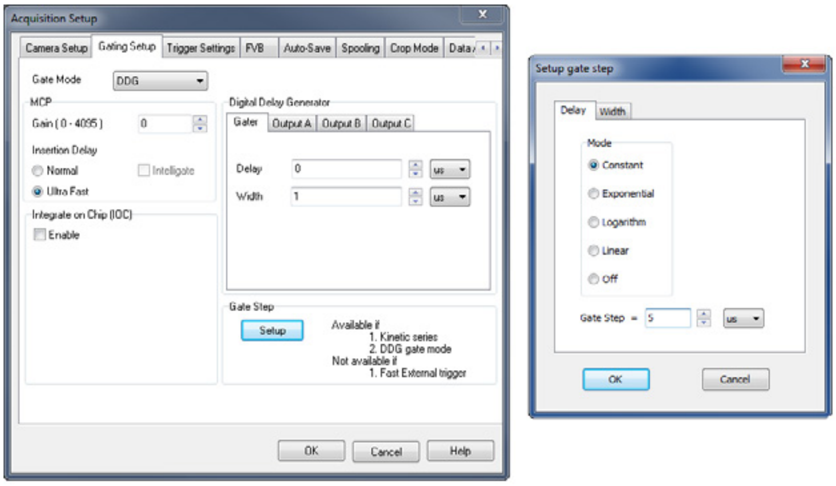
Description

The External Trigger generates one gate pulse per exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

Note: The External Trigger rate can not exceed 15 kHz.

Setup

Gate step, output A/B/C disabled.



Waveforms

External Trigger

Fire

Gate Monitor

ARM

5.2.13 IOC and Gate Step Enabled

5.2.13.1 Default: One Pulse per Trigger

This mode is not supported by fast kinetics. However IOC and gate step is available in internal trigger mode.

5.2.13.2 Advanced: Burst Pulses per Trigger

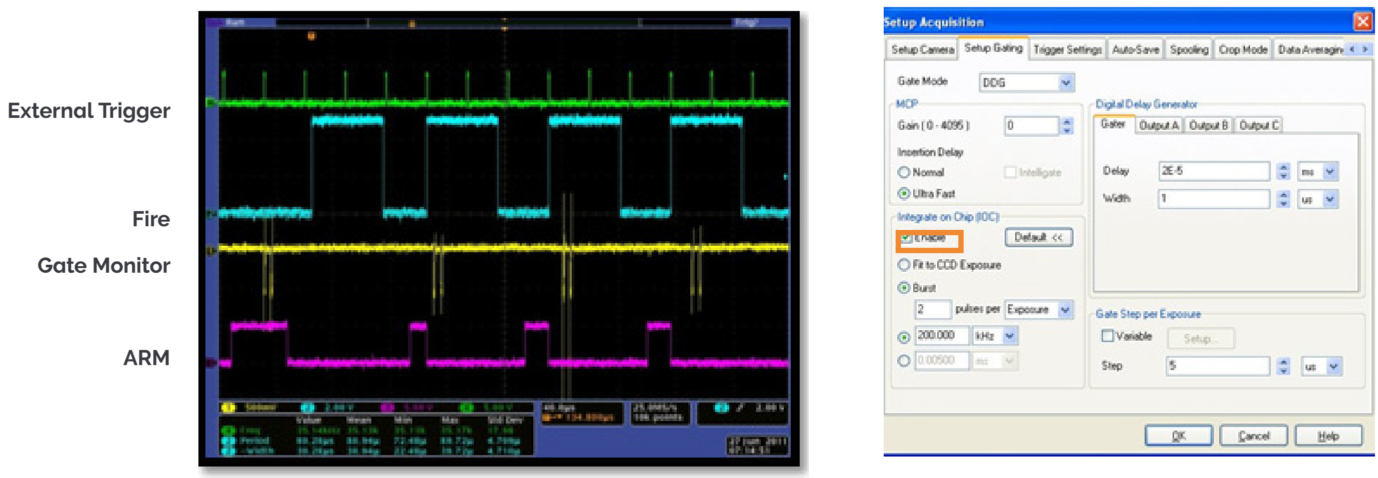
This mode is not supported with by kinetics. However IOC and gate step is available in internal trigger mode.

5.2.13.3 Advanced: Burst/Fit Pulses per Exposure

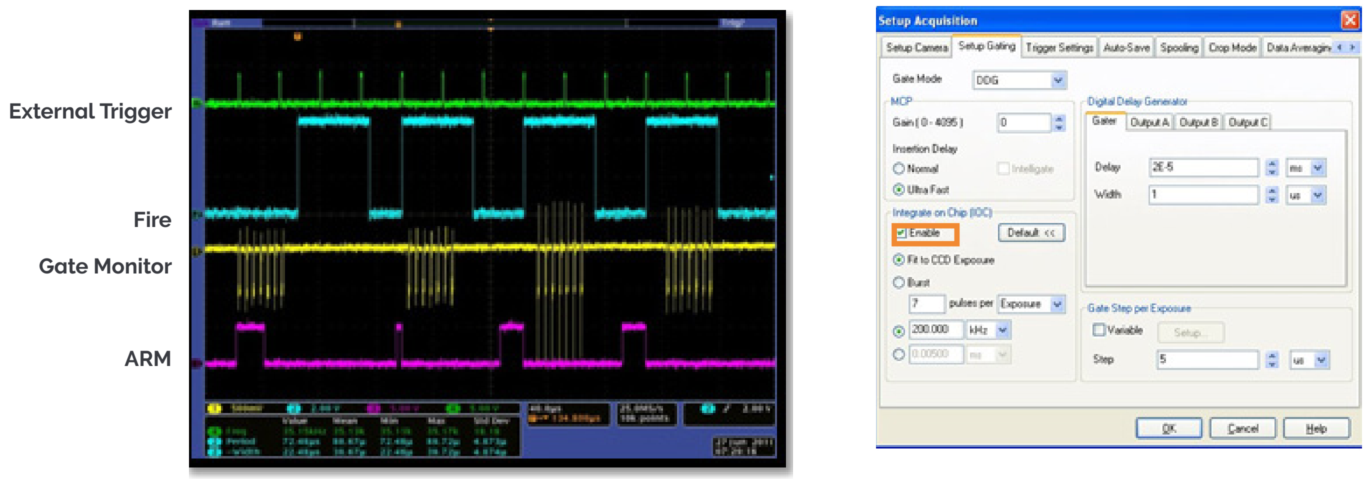
Description

Several gate pulses are generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value. For each exposure, the External Trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period, or the user defines the number of pulses per exposure. The maximum number of pulses is applied that can fit into the exposure, given the final gate delay in the series. Any subsequent triggers that arrive during the exposure are ignored.

Note: The External Trigger rate cannot exceed 15 kHz.



Burst per Exposure



Fit to CCD Exposure

Section 6: Maintenance

THERE ARE NO USER-SERVICEABLE PARTS INSIDE THE CAMERA. DAMAGE CAUSED BY UNAUTHORISED MAINTENANCE OR PROCEDURES WILL INVALIDATE THE WARRANTY.

6.1 Regular Checks

- The state of the product should be checked regularly, especially the integrity of the External Power Supply and the mains cable.
- Do not use equipment that is damaged.

6.2 Annual Electrical Safety Checks

- It is advisable to check the integrity of the insulation and protective earth of the AC/DC converter on an annual basis, e.g. U.K. PAT testing.
- Do not use equipment that is damaged.

6.3 General Cleaning & Decontamination Information

- The camera body can be cleaned with a soft cloth and dampened by water or glass cleaner.
- Never spray liquids directly on the camera; apply cleaning solution to the cloth, then wipe the camera body with the dampened cloth.
- Do not use abrasive or other detergents to clean the camera.

6.4 Fuse Replacement

In the U.K, Ireland and some other countries, the supplied mains cable has a BS 1363 (or Type G) plug that includes an integrated fuse. Only replace with fuse of the same type and rating for continued protection. The characteristics of a replacement fuse are as follows:

- **Rated Current**: 5 A
- **Rated Voltage**: 240 VAC
- **Size**: ¼ × 1" (6.3 × 25.4 mm) cartridge
- **Type**: BS 1362

6.5 Cooling Hoses and Connections

The user should routinely check all coolant hoses and connections for signs of leakage, damage or wear. All seals must be intact before powering on camera system and any worn / damaged items must be replaced immediately.

Section 7: Troubleshooting

This section provides useful information and solutions for some troubleshooting scenarios. If you have an issue that you are unable to rectify using this section, please contact Andor Technical Support for further advice.

7.1 Camera buzzer does not sound on start-up

1. The camera buzzer should be audible momentarily when the camera is switched on.
2. If this does not occur, ensure that power is connected to the camera and the On/Off switch is set to On.

7.2 Camera is not recognized by PC

1. Ensure the camera is switched on.
2. Check the Camera to PC connection.
3. Check that the iStar is correctly recognised and installed by opening the Device Manager (Devices and Printers) in Windows, Control Panels. The iStar will show under the Devices list.

7.3 Buzzer sounds continuously

This indicates that an "over temperature" condition has occurred within the camera. Follow the instructions below to rectify this situation:

1. Power the camera off and allow it to cool down.
2. For air-cooled models, ensure fan vents are not obstructed.
   For water-cooled models, ensure that water coolant supply is connected and that chiller/re-circulator is operational.
3. Check the camera is operating within the specified environmental conditions (see **Section 1.4**).

7.4 Fan not operating as expected

- To protect the internal electronics, the fan defaults to full speed if the camera heat-sink temperature exceeds 50°C.

NOTE: The fan will continue to run even if the user has switched it off via software, until the correct heat-sink temperature has been reached.

7.5 Camera does not cool to the required temperature

1. Check that the operating ambient temperature is within allowable limits (see **Specifications**) when cooling the sensor.
2. Check that the camera vents are not blocked and have sufficient clearance to allow air flow.
3. Check that the fan is switched on (or for water cooled models, the coolant system is operating correctly).

7.6 Preventing Condensation

NEVER USE WATER THAT HAS BEEN CHILLED BELOW THE DEW POINT OF THE AMBIENT ENVIRONMENT TO COOL THE CAMERA.

You may see condensation on the outside of the camera body if the cooling water is at too low a temperature or if the water flow is too high. The first signs of condensation will usually be visible around the connectors where the water tubes are attached. If this occurs carry out the following actions:

1. Switch off the system.
2. Wipe the camera with a soft, dry cloth.

NOTE: It is likely there will already be condensation on the cooling block and cooling fins inside the camera.

3. Set the camera aside to dry for several hours before you attempt reuse.
4. Before reuse blow dry gas through the cooling slits on the side of the camera to remove any residual moisture.

Use warmer water or reduce the flow of water when you start using the device again.

NOTE: This is not an issue when using a Re-circulator which eliminates the dew point problem.

Refer to Appendix B for a Dew Point Graph.

Appendix A: Specifications

For the latest information please refer to the specifications for your model. available from andor.oxinst.com/products/istar-intensified-cameras

	DH320T	DH334T	DH340T
Array format	1024 x 255 26 µm pixels	1024 x 1024 13 µm pixels	2048 x 512 13.5 µm pixels
Fibre optic taper magnification	1:1	Ø18 mm: 1:1 Ø25 mm: 1.5:1 (effective pixel size 19.5 x 19.5 µm)	1:1
Read noise / e^-, typ. (max) 50 kHz 1 MHz 3 MHz 5 MHz	 7 (9) 12 (13) 19 (20) 25 (32)	 5 (7) 8 (12) 14 (18) 20 (50)	 6 (8) 9 (12) 12 (18) Focusing mode only
Register well depth	550,000 e^-	150,000 e^-	150,000 e^-
Minimum cooling temperature [dark current, e^-/pix/s] Air cooled Coolant chiller @ 10°C, 0.75 l/min	Ø18 mm: -30°C [0.4], -40°C [0.1] Ø25 mm: -25°C [0.8], -35°C [0.2]	Ø18 mm -30°C [0.15] -40°C [0.04]	Ø18 mm: -30°C [0.15], -40°C [0.04] Ø25 mm: -25°C [0.3], -35°C [0.08]
Vertical shift speeds	5.7 to 22.5 µs	6.5 to 12.9 µs	6.5 to 27.5 µs
Sensitivity	2 to 10 e^-/count	1 to 5 e^-/count	1 to 5 e^-/count
Sensor linearity •3	Better than 99%		
Digitization	16-bit		

Driving the Absolute Best Spectral Acquisition Rates

	DH334T
Sensor array size	1024 x 1024
Pixel size	13 x 13 µm
Max. readout speed	5 MHz
Frame rates 1x1 full frame 2x2 binning	 4.2 fps 7.3 fps
Spectral rates (FVB)	145 sps
Crop mode rates (spectral, binned) [number of rows equivalent to a 130 µm high channel]	3,450 sps [10 rows]
Fast Kinetics rates vs. channel heights 26 µm 50 µm 100 µm 200 µm	 48,780 Hz [2 rows] 29,850 Hz [4 rows] 16, 805 Hz [8 rows] 9,525 Hz [15 rows]

Specifications: Gen 2 Image Intensifiers•[1]

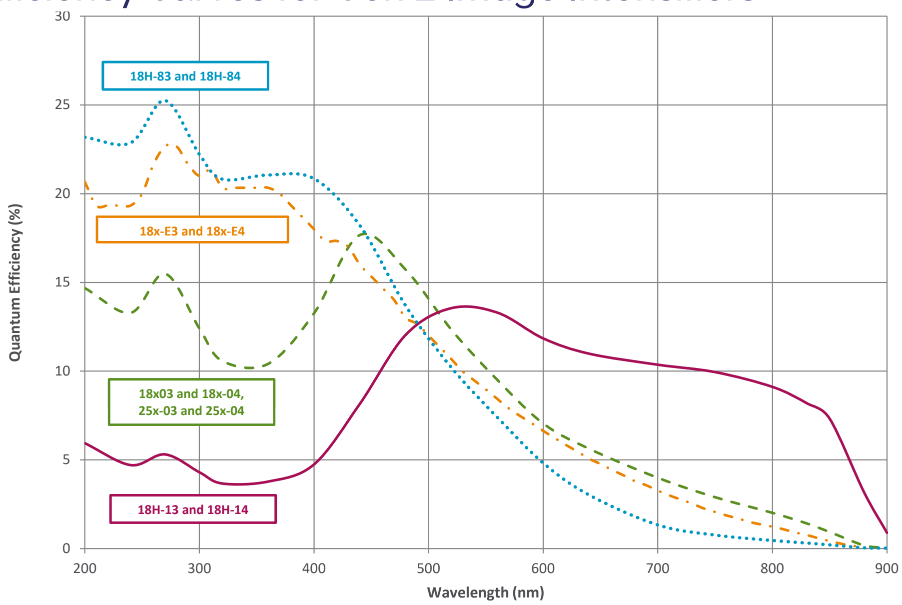
Photocathode model	18*-03	18*-05 ǂ•[11]	18H-13•[11]	18H-83•[11]	18*-E3•[4]
Useful aperture	Ø18 mm				
Input window	Quartz	MgF_2	Quartz	Quartz	Quartz
Photocathode type	W-AGT	W-AGT	WR	UW	WE-AGT
Minimum guaranteed QE at room temperature •[5]	13.5%	11%	7%	20%	15%
Typical peak QE at room temperature •[5]	>18%	>15%	>13.5%	>25%	>22%
Wavelength range	180 - 850 nm	120 - 850 nm	180 - 920 nm	180 - 850 nm	180 - 850 nm
Image intensifier resolution limit •[6]	25 µm	25 µm	25 µm	25 µm	25 µm
Phosphor type [decay time to 10%] Standard Optional*	 P43 [2 ms] P46 [200 ns]				
Image intensifier resolution limit •[6] P43 (Standard) P46 (Optional)	 25 µm 30 µm [-04 model]	 25 µm 30 µm	 25 µm 30 µm [-14 model]	 25 µm 30 µm [-84 model]	 25 µm 30 µm [-E4 model]
Minimum optical gate width (ns) •[7, 8] U (Ultrafast) F (Fast) H (High QE)	 < 2 < 5 -	 < 5 < 10 -	 - - < 50	 - - < 100	 < 2 < 5 -
Maximum relative gain •[9]	> 1000 [P43] > 500 [P46]	> 1000	> 850	> 500	> 300
Maximum photocathode repetition rate (with Intelligate™ OFF)	500 kHz (continuous)				
Maximum photocathode repetition rate (with Intelligate™ ON)	5 kHz (continuous)				
Equivalent Background Illuminance (EBI)	< 0.2 photoe⁻/pix/sec		< 0.4 photoe⁻/pix/sec	< 0.2 photoe⁻/pix/sec	

* Substitute with appropriate gate width option, e.g. 18F-03 (please refer to page 9 for detailed ordering information)

** All photocathode types can be combined with a fast-decay P46 phosphor – please contact your local Andor representative for further information.

ǂ Available with VUV-compatible spectrograph interface

Quantum Efficiency Curves for Gen 2 Image Intensifiers•[5]



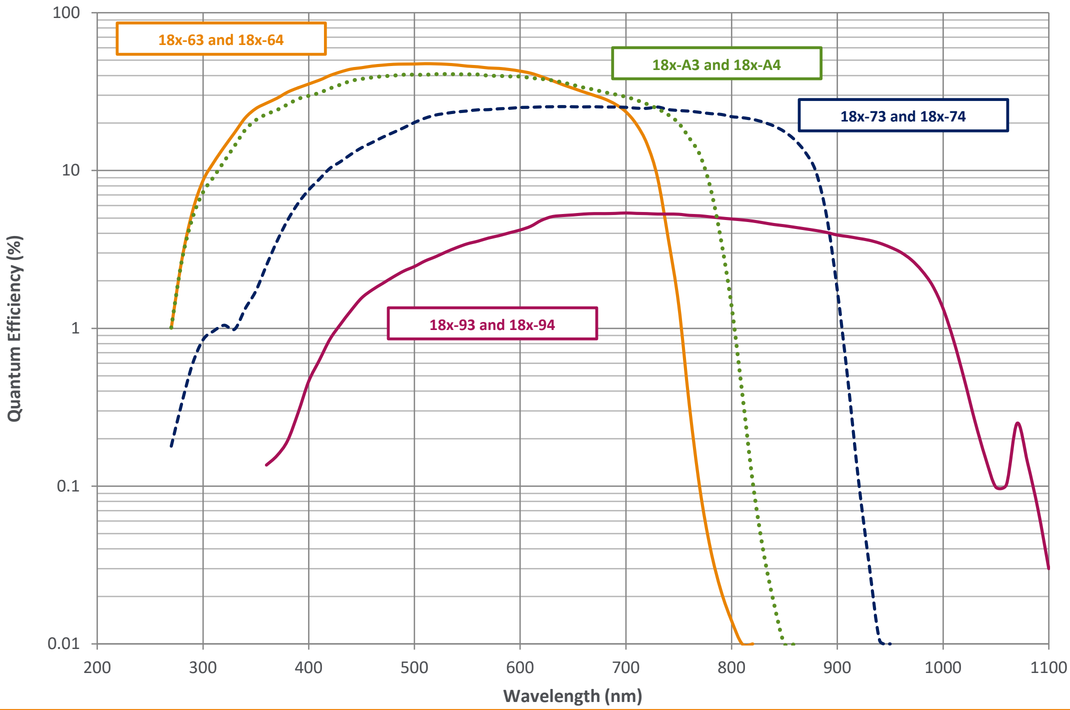
Specifications: Gen 3 Image Intensifiers[•1]

Photocathode model	18*-63	18*-73	18*-93[•11]	18*-A3
Useful aperture	Ø 18 mm			
Input window	Glass	Glass	Glass	Glass
Photocathode type	HVS	VIH	NIR	EVS
Minimum guaranteed QE at room temperature •5	38%	23%	0.10%	35%
Typical peak QE at room temperature •5	> 50%	> 30%	> 5%	> 40%
Wavelength range	280 - 760 nm	280 - 910 nm	380 - 1090 nm	280 - 810 nm
Phosphor type [decay time to 10%] Standard Optional**	P43 [2 ms] P46 [200 ns]			
Image intensifier resolution limit •6 P43 (Standard) P46 (Optional)	30 µm 35 µm [-64 model]	30 µm 35 µm [-74 model]	30 µm 35 µm [-94 model]	30 µm 35 µm [-A4 model]
Minimum optical gate width (ns) •8 U (Ultrafast) F (Fast)	< 2 < 5	< 2 < 5	< 3 < 5	< 2 < 5
Maximum relative gain •9	> 200			
Maximum photocathode repetition rate (with Intelligate™ OFF)	500 kHz (continuous)			
Maximum photocathode repetition rate (with Intelligate™ ON)	5 kHz (continuous)			
Equivalent Background Illuminance (EBI)	< 0.1 photoe⁻/pix/sec	< 0.3 photoe⁻/pix/sec	< 2 photoe⁻/pix/sec	< 0.2 photoe⁻/pix/sec

* Substitute with appropriate gate width option, e.g. 18U-63 (please refer to page 9 for detailed ordering information)

** All photocathode types can be combined with a fast-decay P46 phosphor – please contact your local Andor representative for further information.

Quantum Efficiency Curves for Gen 3 Image Intensifiers[•5,10]



Mechanical Specifications

	iStar CCD
Weight (Camera Only*)	4.5 kg [9 lb 15 oz]
Weight (External Power Supply)	0.65 kg

* The camera weight is the head only with no cables or pipes attached and without water or coolant.

Environmental Specifications

	iStar CCD
Location to be used	Indoor
Altitude	Up to 2000 m
Operating temperature	0°C to 40°C
Storage temperature	-20°C to +55°C
Operating relative humidity	< 70% (non-condensing)
Pollution degree	Pollution degree 2. Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.
Ingress protection rating	IP20
Electromagnetic compatibility	This is a Class A product. In a domestic environment this product may cause electromagnetic interference, in which case the user may be required to take adequate measures
Cooling vent clearance	100 mm minimum

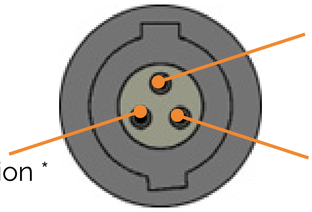
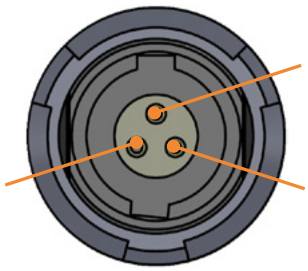
Footnotes:

1. Figures are typical unless otherwise stated.
2. Measured for the entire system. Combination of CCD readout noise and A/D noise - measurement is for single pixel readout with -30°C CCD cooling and at minimum exposure time under dark conditions. Values quoted are measured with highest available PAG setting.
3. Linearity is measured from a plot of counts vs exposure time under constant photon flux up to the saturation point of the system.
4. The On/Off ratio of the 'E3' image intensifier in the UV with MCP gating is typically 10^5.
5. Typical photocathode Quantum Efficiency and input window transmission as measured by the tube manufacturer.
6. Typical resolution of the image intensifier tube only, not the overall resolution of the system. As a rough guide, the smallest resolvable FWHM feature will be approximately 2x the CCD pixel size. This is a very important consideration for optical resolution calculations in spectrograph-based systems.
7. Gen 2 High QE (H) option – Photocathode QE is inherently linked to the gating speed of the intensifier. High QE option (H) offers higher peak QE than Ultrafast (U) or Fast (F) intensifiers, while exhibiting minimum gating speed one order of magnitude slower.
8. Actual measured minimum optical gating of the photocathode, reflecting not only the electrical pulse width applied to the photocathode but also its inherent irising time.
9. Gain is software-selectable through a 12-bit DAC and varies exponentially with DAC setting. Value refers to the ratio of max to min intensifier gain as measured for individual cameras. Actual optical gain (counts/photoe$^-$) for a DAC setting is accessed by the multiplication of the relative gain (at that DAC value) by the minimum system gain (at DAC = 0, CCD e$^-$ /photoe$^-$) and divided by the sensitivity (CCD e$^-$/count) at a given CCD PAG. Sensitivities are individually measured and reported for each system.
10. Specifications are subject to change without notice
11. 18*-05, 18H-13, 18H-83 and 18*-93 image intensifiers are available through our Customer Special Request process - please contact your sales representative.

Camera Power Specifications

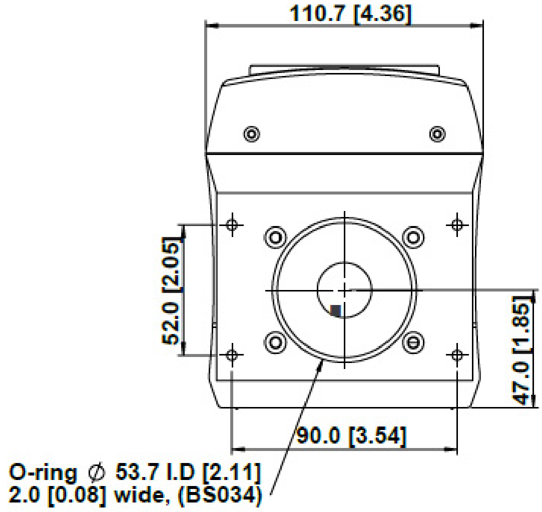
	iStar CCD
Mains Input for Supplied External Power Supply	100 - 240 VAC, 43 - 67 Hz
Power Consumption	Camera + External Power Supply: 66.7 W Typ. / 82.8 W Max. Camera Only: 36.6 W Typ. / 45.7 W Max.
Voltage Rating	12 V
Current Rating	9 A
Mains Overvoltage category	CAT II. An overvoltage category of CAT II means that the equipment is designed to cope with transient voltages above the rated supply that would be experienced by any product connected to a standard single-phase mains socket in a building.

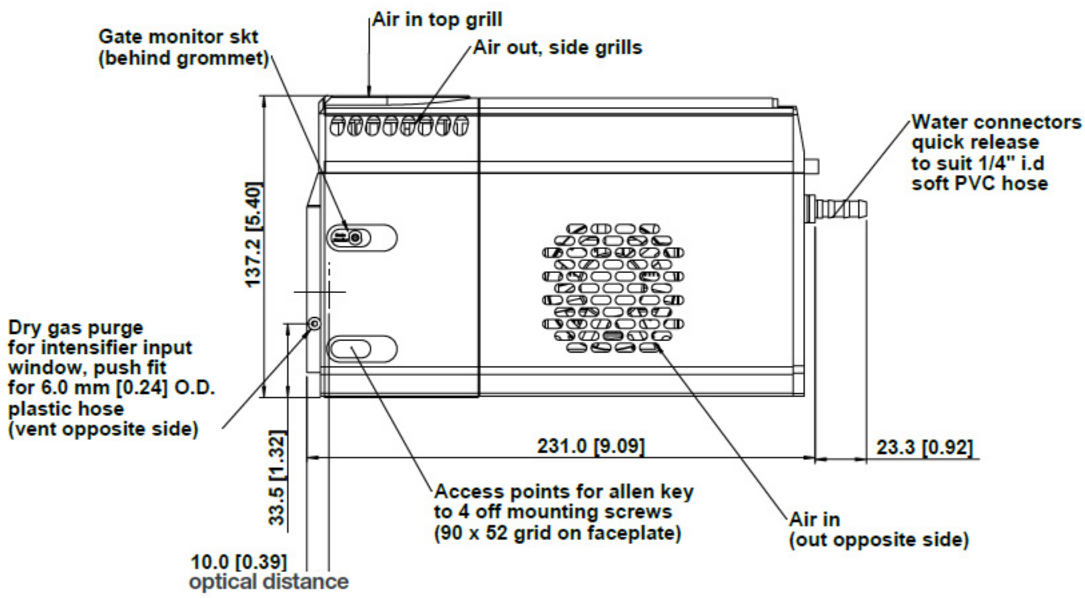
External Power Supply Requirements

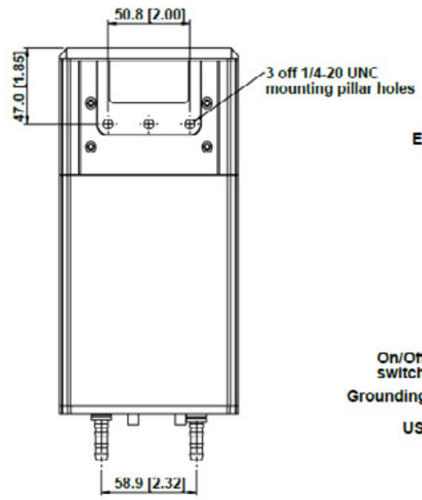
	PS-90
Low Voltage Supply	12 V d.c. ± 5%
Low Voltage Supply Current	9 A
Low Voltage Supply Cable Plug	Lemo Redel 1P Series 3-pin Female Plug with 170° keying (Part No. PAH.N0.3GL.LC65GZ)
Low Voltage Supply Cable Plug Insertion View	
Low Voltage Supply Product Socket	Lemo Redel 1P Series 3-pin Male Socket with 170° keying (Part No. PKH.N0.3GL.AG)
Low Voltage Supply Product Socket Insertion View	
Ripple	120 mV max.
Safety	Certified to an appropriate IEC standard, e.g. IEC 60950-1, and meet the reinforced insulation from mains requirement of IEC 61010-1
Environmental	Ensure that the EPS meets the environmental specification of the overall product (see above)

* Ideally also connected to 0 V Return and Protective Earth, but not essential. Not connected on supplied PS-90.

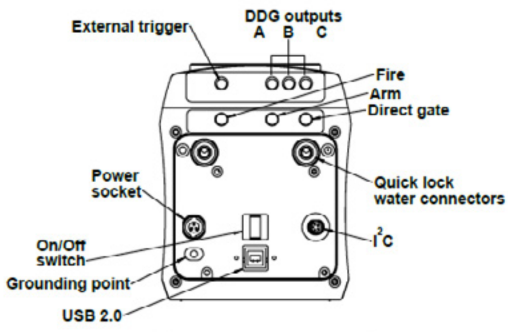
Appendix B: Mechanical Drawings







Mounting hole locations

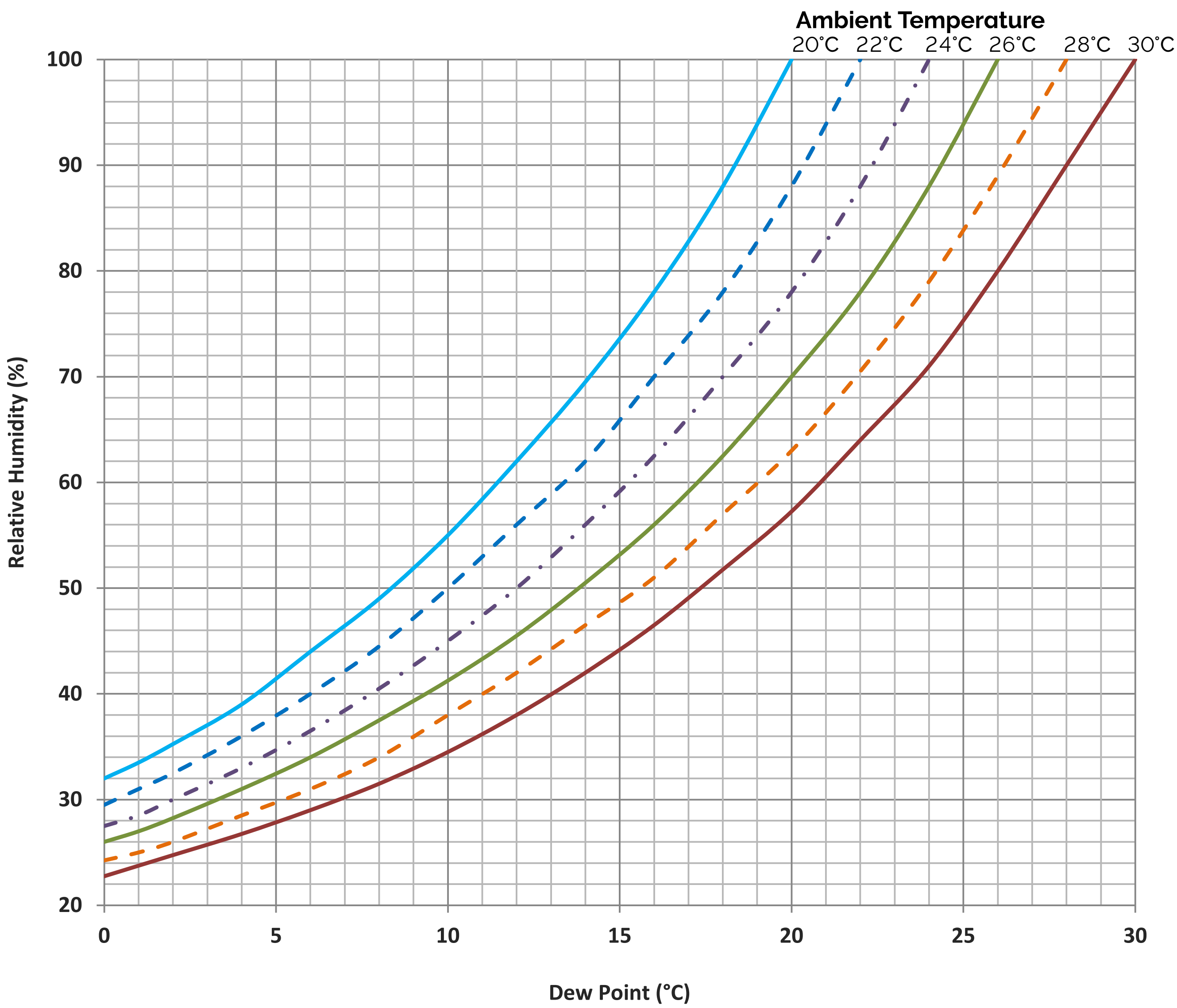


Rear connector panel

Appendix C: Dew Point Graph

To avoid issues with condensation the coolant temperature must be set above the dewpoint- the temperature at which condensation (dew) will form. In the relatively dry conditions of an air conditioned lab, or a cool dry climate, use of a coolant temperature of 10°C should not cause any problems. As relative humidity or ambient temperature increase however, the dewpoint temperature will also increase so that the minimum coolant temperature that can be used will have to increase accordingly. This will therefore limit the maximum cooling performance that can be achieved.

The first signs that condensation is forming will be on the coolant connections entering and exiting the camera. Use of coolant at or below the dewpoint can result in permanent damage to the camera head due to formation of condensation on internal components. It is therefore very important to ensure that coolant temperature is above the dewpoint. The relationship between Relative Humidity and Dew Point at varying Ambient Temperature is shown below. There is an inbuilt dewpoint calculator in Solis as well as various calculators available on-line that you can enter ambient temperature and relative humidity to calculate the dewpoint for your conditions.



Appendix D: DDG Information

The iStar CCD holds a fully integrated software-controlled digital delay generator (DDG) with the following specifications:

Gate pulse delay & width	• Adjustable from 0 ns to 10 s in 10 ps steps • Software controlled, pre-programmed or real-time
Trigger Outputs	
Output A, B and C	• 3x output, +5 V CMOS level with 50 Ω source impedance; can drive 5 V into a non-terminating load or 2.5 V into 50 Ω load; output synchronized triggers for auxiliary equipment, e.g. lasers, flash lamps, or National Instrument™ hardware • Individual delays control from 0 ns to 10 s in 10 ps steps • Configurable polarity • Software controlled, pre-programmed or real-time
Fire	• 5 V CMOS level reference signal for beginning and end of individual sensor exposure
Arm monitor	• 5 V CMOS level reference signal to indicate when system is ready to accept External Triggers. Signal goes high when system is ready to accept External Triggers (after a complete readout has finished) including keep clean and goes low when the exposure is finished
Gate & output A, B and C jitter	• 35 ps rms (relative to External Trigger signal)
Trigger Inputs	
External Trigger	• Trigger input for sensor and Digital Delay Generator • Up to 500 kHz for Integrate-On-Chip mode • Software-configurable polarity, termination and trigger threshold • Fast external software option for most rapid camera response to External Trigger (keep clean interruption) – no need for pre-trigger pulse
Direct gate	• TTL input for exact external control of photocathode width and timing with smallest insertion delay.
Additional Controls	
Gate monitoring	• AC coupling from photocathode to monitor exact photocathode On/Off switching and timings
Insertion delay	• < 19 ns in direct gate operation

D.1 Image Intensifiers

An Image intensifier is an evacuated, proximity-focus device that amplifies the intensity of an incoming signal. The device is small, typically (25-50 mm) 1-2 inches in diameter and 25mm (1 inch) thick. As well as amplifying incoming signal, an image intensifier can rapidly be switched on and off, allowing it to be used as a very fast optical shutter in the nanosecond time regime. The image intensifier used in the system can either be of 2nd generation ('Gen 2') or 3rd generation ('Gen 3').

There are three major elements in an image intensifier :

- The photocathode
- The Micro-Channel Plate (MCP)
- The output Phosphor screen

D.2 Photocathodes and Windows

The photocathode is deposited on the inside surface of an input window, typically made of silica, MgF_2, Borosilicate glass of fibre-optic plate. The input window typically set the lower wavelength detection limit, while the photocathode set the upper detection wavelength.

When an incoming photon strikes the photocathode, a photoelectron may be emitted, depending on the QE of the photocathode. This photoelectron is drawn across a small gap towards the MCP by an electric field.

'Gen 2' refers to multi-alkali based photocathodes that present a wide wavelength coverage from UV up to ~ 900 nm, with moderate peak QE up to ~25-30%. The lower detection limited is set by the photocathode substrate, typically Silica of Magnesium Fluoride (MgF_2). These photocathode are quite resistive, and require a metallic underlay (full or grid-type) to achieve nanosecond gating times (at the expense of a few percent QE).

'Gen 3' refers to Gallium-Arsenide (GaAs) – based photocathodes. These are typically deposited on glass - which set the lowest detection limit at ~ 350 nm, and are sensitive up to ~900 nm. They present peak QE of up to 50%.

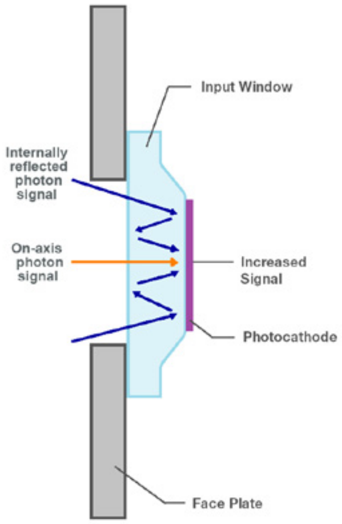
Gating - The voltage on the photocathode in relation to the input of the MCP can be rapidly toggled between 2 levels. If the voltage of the photocathode is made positive relative to the input of the MCP, then the photoelectrons will not have sufficient energy to leave the photocathode and the image intensifier will effectively be OFF. By switching the voltage the intensifier can be turned ON and OFF. This process is referred to as "Gating". Gating periods in the nanosecond scale (billionth of a second) can be readily achieved, making the image intensifier, one of the fastest optical shutters available.

D.3 Internal Reflection in the Input Window

Data acquired with a 25 mm intensifier tube may exhibit an artifact due to light that has entered the camera obliquely and has been internally reflected in the input window. The effect is generally not significant, but a brief explanation may be appropriate nonetheless.

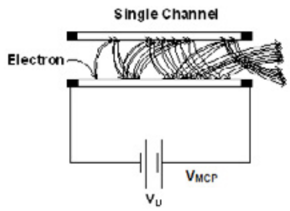
At the center of the photocathode the internally reflected rays may coincide with each other and with light falling on the photocathode directly. The result is a signal around 5% higher than average at the center of the photocathode. The phenomenon appears as a slight peak in the middle of a 2D trace, or as a slight cone in the middle of an image.

The aperture in the faceplate is left deliberately large to fully accommodate the light cone from lenses and spectrographs. If an aperture of 25-26 mm diameter is placed in front of the input window, the range of angles at which light can enter is reduced and the peak or cone effect disappears. There may then, however, be a vignette effect as light from the outside of the light cone emerging from lenses or spectrographs is blocked.



D.4 Micro Channel Plate (MCP)

The MCP is a thin disk (~1 mm) of honeycomb glass. Each of the ~10 µm honeycomb channels is coated with a resistive material.
The MCP plate has a high potential across it (500 V to 1 kV) so that an incoming photoelectron will cascade down the channel, producing secondary electrons by impact ionization. Typical gain for single stage MCP can be as high as 10^4 – gain can be adjusted by varying the voltage potential across the MCP. This is typically achieved through a software-controlled DAC in research-grade Intensified CCDs.



D.5 Phosphors

The function of the Phosphor on the inside of the intensifier's fibre optic exit window is to convert the incident electron pattern into a visible light pattern that can be detected by the sensor. For best efficiency, it is important that the emission of the phosphor is matched to the response of the sensor.

Phosphor type	Color	Emission peak (nm)	Decay time (to 10%)	Composition	Relative light output
P46	Yellow/Green	530	200 ns	$Y_3Al_5O_{12}$:Ce	$^1/_3$
P43	Yellow/Green	545	2 ms	Gd_2O_2S:Tb	1

Our systems use either **P46** or **P43** Phosphor as standard (details are shown in the table above). P46 is used for applications requiring fast scan rates (> 300 Hz). If these speeds are not required then the more efficient P43 is preferable. P43 is used in preference to the more commonly used P20 because of superior linearity. See the specification supplied with your system for more details.

D.6 Coupling to the sensor

The **output** of the image intensifier is coupled to a **sensor** via either a lens - with possible vignetting and lower throughput, or a fibre-optic plate for low distortion and maximum throughput. The high efficiency fibre optic coupling is important because it means that the image intensifier can be operated at lower gains, which results in better dynamic range and linearity. Andor also produce the iStar sCMOS to further extend sensitivity through the use of a sCMOS detector. This enables higher speeds at high resolution and with high dynamic range capacity. Andor CCD-based iStar iStar series is complemented by sCMOS-based iStar options to access higher frame and spectral rates while maintaining high dynamic range and linearity.

D.7 Quantum Efficiency/Spectral Response

The glossary refers to signals as a number of electrons. More strictly speaking these are "photoelectrons", created when a photon is absorbed. When a UV or visible photon is absorbed by the detector it can at best produce only one photoelectron. Photons of different wavelengths have different probabilities of producing a photoelectron and this probability is usually expressed as **Q**uantum **E**fficiency **(QE**) or spectral response.
QE is a percentage measure of the probability of a single photon producing a photoelectron, while spectral response is the number of electrons that will be produced per unit photon energy. Many factors contribute to the QE of a CCD, but the most significant factor is the absorption coefficient of the silicon that serves as the bulk material of the device.

D.8 Readout

Readout is the process by which data are taken from the pixels of the **CCD** and stored in computer memory. The pixels, which are arranged in a single row, are read out individually in sequence. Readout involves amplifying the charge on each pixel into a voltage, performing an **A/D conversion**, and storing the data in computer memory. The time taken to perform this operation is known as the **Read Time.**

D.9 Saturation

Saturation is the largest signal a CCD can measure. A signal is measured in terms of the amount of charge that has built up in the individual pixels on the CCD-sensor. A number of factors determine the maximum amount of charge that the CCD can handle.
Each **pixel** is ultimately limited in the amount of charge it can hold (its "well depth"), in other words, is finite. This maximum charge, or well depth, is generally quoted in electrons. The well depth of a single pixel in the CCD detector is typically in the order of 300,000 electrons, but is ultimately dependent on the sensor.

D.10 Scan Types: Keep Clean & Acquired

The CCD is continually being **"scanned"** to keep it maintained in a **"ready state".** If the **Scan** is being used simply to "clean" the CCD (i.e. it is a **keep-clean scan**), the charge from the CCD is discarded.
In an **acquired scan**, however, the charge undergoes A/D conversion and is acquired into computer memory so that it can be used for subsequent processing and display: it is "read out" (see **Readout** previously). In this **User's Guide** "scan" generally refers to an acquired scan - unless the context specifically indicates otherwise.

D.11 Shift Register

The **Shift Register** usually consists of a single row of elements (or **pixels**) running parallel to and below the bottom row of light-gathering pixels (the image area) on the CCD-sensor. The shift register is protected from light by an aluminium mask. The elements in the shift register have a greater capacity to store charge (a greater '**well depth**') than the other pixels on the CCD-sensor.

D.12 Shot Noise

Shot Noise is due to basic physical laws and cannot be removed. Any signal, whether it be a dark signal or a light signal, will have shot noise associated with it. Most simply defined:

- If the signal or **dark signal = N electrons,** the **shot noise** is the square root of N.

You can do nothing about the shot noise of your signal, but by choosing minimum exposures and operating the CCD at suitably low temperatures, the dark signal, and hence the noise from the dark signal, can be reduced.

D.13 Signal to Noise Ratio

The **Signal to Noise Ratio (S/N**) is the ratio between a given signal and the **noise** associated with that signal. Noise has a fixed component, and a variable component **(shot noise**) which is the square root of the signal. Thus, the Signal to Noise Ratio usually increases (improves) as the signal increases.
The maximum Signal to Noise Ratio is the ratio between the maximum signal (i.e. the **saturation** level) and the noise associated with that signal. At near saturation levels the dominant source of noise is the shot noise of the signal.

Appendix E: Other Information

E.1 Terms and Conditions of Sale and Warranty Information

The terms and conditions of sale, including warranty conditions, will have been made available during the ordering process. The current version for the US is available here, for all other regions (except Japan) please click here.

E.2 EU/UK REACH Regulation Statement

Andor's EU/UK REACH Regulation statement is available at the following link.

E.3 Waste Electronic and Electrical Equipment Regulations 2006 (WEEE)

The company's statement on the disposal of WEEE can be found in the Terms and Conditions.

Appendix F: iStar CCD China RoHS Hazardous Substances Declaration

Name and Content of Hazardous Substances in the Product
产品中有害物质的名称及含量 产品中有害物质的名称及含量

Component Name 部件名称	Hazardous Substance: 有害物质					
	Lead (Pb) 铅	Mercury (Hg) 汞	Cadmium (Cd) 镉	Chromium VI Compounds (Cr^{6+}) 六价铬化合物	Polybromi-nated Biphenyls (PBB) 多溴化联苯	Diphenyl Ethers (PBDE) 多溴联苯醚
Printed Circuit Board Assemblies (Surface-mount Resistors and Capacitors, and Brass Connectors) 路板组件 电路板组件 (表面贴装电阻器和电容器，以及黄铜连接器)	X	O	O	O	O	O
Hex Stand-offs (see image in table below) 六角隔撑	X	O	O	O	O	O
Screw Locks (see image in table below) 螺丝锁定	X	O	O	O	O	O
All other parts 其余配件	O	O	O	O	O	O

This table was developed according to the provisions of SJ/T 11364
本表格依据SJ/T 11364 的规定编制
O - The content of such a hazardous substance in all homogeneous materials of such a component is below the limit required by GB/T 26572
O -表示该有害物质在该部件所有均质材料中的含量均在GB/T 26572 规定的限量要求以下
X - The content of such a hazardous substance in a certain homogeneous material of such a component is above the limit required by GB/T 26572
X - 表示该有害物质至少在该部件的某一均质材料中的含量超出GB/T 26572 规定的限量要求

This table shows images for parts within the iStar CCD Instrument.

Hex Stand-offs 六角隔撑	
Screw Locks 螺丝锁定