an Oxford Instruments company

Clara

Version 2.0 rev 24 Mar 2015

Hardware Guide

andor.com

CONTENTS

Page

SAFETY AND WARNING INFORMATION

PLEASE READ THIS INFORMATION FIRST BEFORE USING YOUR CLARA INTERLINE CAMERA.

1. To ensure correct and safe operation of this product, please read this guide before use and keep it in a safe place for future reference
2. If equipment is used in a manner not specified by Andor, the protection provided by the equipment may be impaired
3. Before using the system, please follow and adhere to all warnings, safety, manual handling and operating instructions located either on the product or in this manual
4. The Andor Clara is a precision scientific instrument containing fragile components. Always handle with care
5. Do not expose the product to extreme hot or cold temperatures
8. Do not expose the product to open flames
9. Do not allow objects to fall on the product
10. Do not expose the product to moisture, wet or spill liquids on the product. Do not store or place liquids on the product. If a spillage occurs on the product, switch off power immediately, and wipe off with dry, lint-free cloth. If any ingress has occurred or is suspected, unplug mains cable, do not use, and contact Andor service
11. The product contains components that are extremely sensitive to static electricity and radiated electromagnetic fields, and therefore should not be used, or stored, close to EMI/RFI generators, electrostatic field generators, electromagnetic or radioactive devices, or other similar sources of high energy fields
12. Operation of the system close to intense pulsed sources (e.g. plasma sources, arc welders, radio frequency generators, X-ray instruments, and pulsed discharge optical sources) may compromise performance if shielding of the Clara is inadequate
13. 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
14. The Andor Clara is for use in research laboratories and other controlled scientific environments
15. This equipment has not been designed and manufactured for the medical diagnosis of patients
16. Use only the power supply cord provided with the system for this unit. Should this not be correct for your geographical area contact your local Andor representative
17. Only the correctly specified mains supply and fuse must be used
18. Make sure the electrical cord is located so that it will not be subject to damage
19. There are no user-serviceable parts beyond the specified user accessible areas of the product and the enclosure must not be opened. Only authorised service personnel may service this equipment

Regulatory Compliance

CE The Clara complies with the requirements of the EU EMC and LV Directives through testing to EN 61326-1 and EN 61010-1.

This product requires a DC power supply

Revision History

Version	Released	Description
1.0	25 Oct 2011	Initial Release
2.0	24 Mar 2015	Presentation enhanced and minor edits throughout (all sections). Improved description of camera hardware (Section 2) Removal of Solis software content- obsolete replicated information. This is covered in full in the Solis in-application help. Specifications expanded (Section 7) Update to Terms and Conditions, CE and WEE Statements, providing link to latest up to date information on the Andor webpage (Appendix C).

SECTION 1: INTRODUCTION

Thank you for choosing the Andor Clara. Andor's **CCD** (**C**harge **C**oupled **D**evice) exploits the processing power of today's desk-top computers. USB 2.0 connectivity ensures a seamless interface with the camera, as well as generating and receiving the signals you use to work with most stanadrd pulsed sources. From the outset, the Clara has been designed for ease of use. Under Solis software control, it serves as both a multi-channel detector and a linear image sensor, catering for a broad range of imaging applications.

Figure 1: The Andor Clara Interline 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 Clara, camera please feel free to contact Andor directly, or via your local representative or supplier. The Clara is controlled through control software such as Andor Solis. Please refer to the software guide supplied with your software for further information.

1.1 Help and Technical Support

When the application is running, click the Button or press **F1** on the keyboard and the Andor Solis Help dialog box will open. Click on the area for which you require help and you will be provided with information relevant to the part of the application from which help was called.

In addition to the main On-Line Help, the system provides help that relates specifically to the **Andor Basic** programming language. If you are working in a Program Editor Window, context sensitive help is available on the 'reserved words' of the programming language. To activate, with the cursor on, or immediately after a reserved word, press **Ctrl + F1**.

So, whenever you're working with a particular window, you'll find a section in the User's Guide that sets that window in context, reminding you how the window is launched, letting you know what it can do, and telling you what other windows and operations are associated with it.

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

Europe

Andor Technology
7 Millennium Way
Springvale Business Park
Belfast
BT12 7AL
Northern Ireland
Tel. +44 (0) 28 9023 7126
Fax. +44 (0) 28 9031 0792

USA

Andor Technology
425 Sullivan Avenue
Suite # 3
South Windsor
CT 06074
USA
Tel. +1 (860) 290-9211
Fax. +1 (860) 290-9566

Asia-Pacific

Andor Technology (Japan)
4F NE Sarugakucho Building
2-7-6 Sarugaku-Cho
Chiyoda-Ku
Tokyo 101-0064
Japan
Tel. +81-3-3518 6488
Fax. +81-3-3518 6489

China

Andor Technology
Room 1213, Building B
Luo Ke Time Square
No. 103 Huizhongli
Chaoyang District
Beijing,100101 P.R.
China
Tel: +86 (0)10 5129 4977
Fax. +86(0)10-6445-5401

***NOTE: the contact details for your nearest representative can be found on our website:**

http://www.andor.com/ContactSupport.aspx?type=s

1.2 Disclaimer

1.3 Trademarks and Patent Information

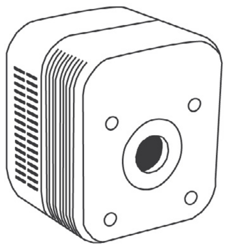
Andor, the Andor logo and Solis are trademarks of Andor Technology. Andor is an Oxford Instruments company. All other marks are property of their owners. Changes are periodically made to the product and these will be incorporated into new editions of the manual.

New releases of the manual are available through MyAndor: http://my.andor.com/login.aspx.

1.4 Components

The standard components supplied with the Clara are shown in **Table 1**:

Table 1: Standard Components supplied with the Clara

Description		Quantity
	Clara Interline CCD Camera	1

Description		Quantity
	USB 2.0 Cable	1 x 3 m
	Power Supply Unit (PS12) and Country specific Power Cord	1
	Product Manual on CD	1

1.4.1 Optional Accessories

There is a range of optional and additional accessories available for your Clara camera including:

- Mounting Flanges
- Multi I/O cable options
- Extension tubes
- Software: Solis, SDK and iQ

Please contact Andor or your nearest Andor representative for further information.

SECTION 2: PRODUCT OVERVIEW

This section provides an overview of the hardware and main features of the Clara. Further technical information is outlined in the Appendix A of this manual.

2.1 Front View

Figure 2: Clara Front View

2.1.1 CCD Sensor

The Clara features a high performance interline CCD Sensor. The sensor is 1392 x 1040 pixels (W xH) with a pixel size of 6.45 x 6.45 µm. A permanent vacuum, using the Andor “UltraVac” system enables deep cooling and elimination of dark current.

2.1.2 Camera Window

A single camera window protects the sensor and is part of the UltraVac system- refer to the Appendix in this manual for further information.

2.1.3 C-Mount

The C-mount enables simple and effective mounting of the camera to a wide range of standard lenses and devices. A further mount (¼ -20 UNC thread) is located on the baseplate of the Clara.

2.1.4 Cooling Slots

The Clara has a thermo-electric cooled and is air-cooled. A fan allows heat to be drawn away from the CCD sensor and into the surrounding air. It is therefore important that the cooling slots and fan are not obstructed.

2.2 Rear panel

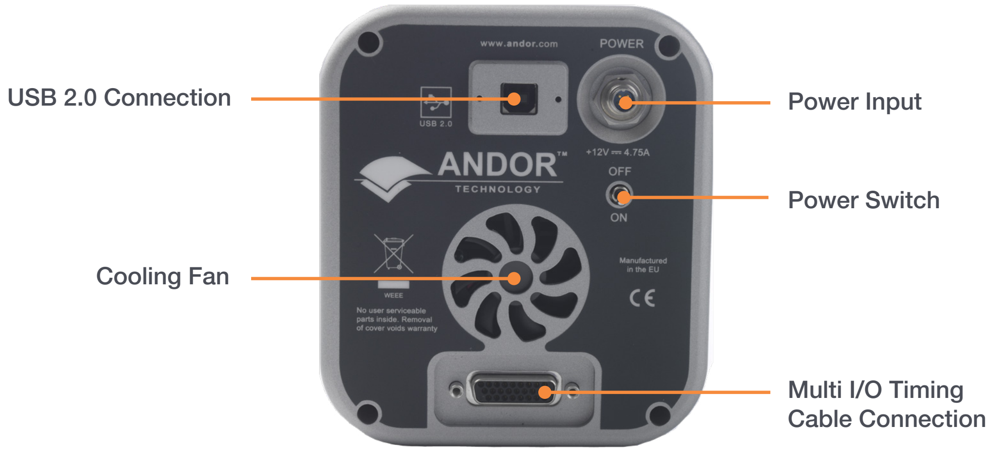


Figure 3: Clara Rear Plate Connections

2.2.1 USB 2.0 Connection

For connection of the Clara to the control PC.

2.2.2 Cooling Fan

A cooling fan draws heat from the CCD Sensor. Refer to Appendix A

2.2.3 Multi I/O Timing Cable Connection

The multi I/O connection enables interconnection, control and synchronisation between a range of devices. Pin-out information is provided in the following section.

2.2.3.1 Multi I/O Timing Cable Pin Outs

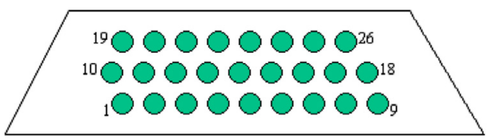


Figure 4: Multi I/O Cable Pin Outs

Table 2: Multi I/O Timing Cable Pinouts 26-way D type connector

1	External Trigger	**14**	I/O data bit 4
2	Trigger Invert Input	**15**	I/O data bit 5
3	GND	**16**	I/O data bit 6
4	OutputDAC1	**17**	I/O data bit 7
5	OutputDAC2	**18**	GND
6	GND	**19**	+5V Output
7	Frame Readout	**20**	GND
8	Fire	**21**	I^{2}C Data
9	Interline Shift	**22**	I2C Clock
10	I/O data bit 0	**23**	Shutter Output TTL
11	I/O data bit 1	**24**	Arm
12	I/O data bit 2	**25**	GND
13	I/O data bit 3	**26**	GND

- External trigger is a TTL input. By default it triggers on a rising edge. This can be inverted by tying Pin 2 to ground. Note that this can also be inverted in software.
- Frame Readout, Fire, Interline Shift and Shutter Output are all TTL timing outputs
- OutputDAC1 and OutputDAC2 are 16 bit DAC outputs which can be configured by the user to be up to approximately 10.1 Volts. Maximum output current which can be drawn is 10mA
- +5V Output is a 5V supply to signal to the user that the camera is powered up. Maximum current which can be drawn is 500mA
- I/O bits (8 off) are user programmable and can either be inputs or outputs. When being used as inputs these default to being weakly pulled high. The maximum low level input voltage is 1.5V and the minimum high level input voltage is 3.5V. As outputs the maximum “high” level output current drawn is 0.03mA and the maximum “low” level current which each output can sink is 10mA
- I^{2}C Clock and Data are available for user communication to other I^{2}C devices

2.2.4 Power Input

The Clara is powered via an external power supply unit (PSU). This is described in Section 2.2.6.

2.2.5 Power Switch

A power switch is located on the rear plate of the Clara for convenience.

2.2.6 Power Supply Unit (PSU)

The supplied external PSU (PS-12) requires an AC mains input of 100 - 240 V (± 10%), 50/60 Hz (± 10%). Maximum supply current = 1.4A, with typical power consumption of approximately 75 W.

The output of the PS-12 is 12V DC at 5.0A maximum. The PS-12 PSU is fitted with an IEC connector for the electrical supply input. The connection to the Clara is made via a 4-pin socket.

Figure 5: External Power Supply

The Clara PSU is for use with Telecommunications, Computer, Industrial Controller, and OA Systems and must only be used indoors

The Clara 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 240V 5A fuse.

If users use any other power supply, they do so at their own risk.

2.2.7 Power Connection Pin-outs

A 4 pin power connector is fitted for power connection, details are shown below:

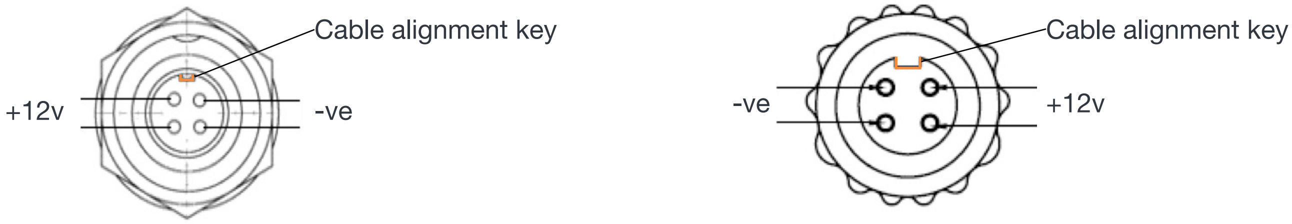


Figure 6: (Left, Camera Connection, Tyco Electronics Part # 6-1437719-4) and (Right, Connector socket Tyco Electronics Part # 3-1437719-3)

WARNING: Ensure that the power switch is in the 'OFF' position and the connector orientation is correct before inserting the power connector. The power connector is 'keyed' - Never forcibly insert the connector otherwise damage to the equipment may occur.

SECTION 3: INSTALLATION

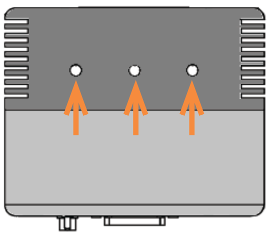
3.1 Safety Considerations

- Prior to commencing installation, please refer to the Safety and Warning Information at the preface of the manual and the Specifications in **Section 7** to ensure all requirements have been met.
- As part of the safety features of the product the Clara must be powered from an SELV (safety extra low voltage) source. In the case of the standard supplied power supply (PS-12) this unit provides an SELV output and is designed to have a protective earth connected via the earth pin on the mains plug of the unit. It is important to ensure that this is connected to the buildings protective earth system.
- The equipment should be positioned so that the mains supply plug/cord can be easily accessed for disconnection.

3.2 Mounting Instructions

To prevent damage to the Clara, other equipment and/or personnel the camera must be securely mounted before use. This can be using either one of the following points:

- The C-Mount on the front face of the camera
- The ¼ -20 UNC threaded holes on the Baseplate (underside of the unit)



Above: ¼ -20 UNC Threaded Mounting Holes (x3) - on baseplate

Figure 7: Mounting Locations for the Clara

3.3 Installing the Camera Drivers

1. Terminate & exit any programmes which are running on the PC.
2. Insert the Andor CD. The **InstallShield Wizard** starts. If it does not start automatically, run the file **setup.exe** directly from the CD then follow the on-screen prompts that then appear.
3. Follow the on-screen prompts and select “Clara” as the camera type.
4. Complete the InstallShieldWizard and restart the PC.

3.4 System Connection

Connect the elements of your system in the sequence that follows:

- Power up the PC
- Connect the USB cable between the USB connection on the rear plate and any available USB 2.0 port on the PC
- Connect the power supply to the **Power** connection point on the rear of the camera

3.5 Installing Software (Solis or SDK)

NOTE: You must have administrator access on your PC to perform this installation.

The same instructions cover the installation procedure for Andor's Solis software or Andor's SDK, which is used in conjunction with third party software. If you are planning to run your camera through a third party interface you will require the Andor Drivers, called SDK.

Switch on the PC, insert CD and run the "setup.exe" file on the CD or download location.

- Confirm the version of software.
- Follow the on screen prompts.
- Select the installation directory when prompted.

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.**
- **READ THE USER GUIDES SUPPLIED WITH YOUR SYSTEM COMPONENTS AND CONTROL 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

Once all system components are connected, the Clara may be turned on as follows:

1. Power up the PC
2. Power up the camera, ensuring that power is ON at the mains power socket.
3. Turn ON the rocker switch on the rear panel of the Clara.
4. Launch the camera control software e.g. Solis

4.3 Power-down Sequence

In order to turn the system off, proceed as follows:

1. Exit the software e.g. Solis
2. Switch the Clara off at the power switch located on the rear panel.
3. If the Camera will not be used for some time, switch off and disconnect the power at the mains power socket.

4.4 Risk Mitigation

4.4.1 Mechanical Housings

Once installed, the camera and any other system components form the protective housings of the product. No components, panels, connections or linkages should be loosened or removed to avoid exposure to any potentially hazardous radiation.

4.4.2 Hazards Due to Moisture or Liquids

Please do not put components including power cables or external power supply in places with high moisture or near water.

4.5 Using the Clara

- **The Clara is controlled through the control software, for example Solis. Please refer to your Solis Software Guide for the latest and complete guide to using Solis.**
- **The following information provides additional information specific to the Clara**

4.5.1 CCD Setup Options for the Clara

The clara has a range of setup options available under the Set-up CCD menu in Solis:

ACQUISITION MODE

- Single
- Accumulate
- Kinetic

TRIGGERING

- Internal
- External
- Fast External
- External Exposure

READOUT MODE

- Image
- Multi-Track
- FVB (Full Vertical Binning)

HORIZONTAL PIXEL SHIFT READOUT RATE

- 1MHz at 16-bit
- 10MHz at 14-bit
- 20MHz at 14-bit

HORIZONTAL PIXEL SHIFT PRE-AMPLIFIER GAIN

- 1x
- 2x

MODE

- Normal
- Extended NIR

The **Horizontal Pixel Shift Pre-Amplifier Gain** can be set as required for either lowest possible noise or maximum dynamic range. Depending on which combination of Acquisition, Readout & Triggering modes are selected, other additional Timings options become available. The following table lists the parameters for which you may enter a value in the appropriate text box. As you select an Acquisition Mode you will notice that you are able to enter additional exposure-related and timing parameters in a column of text boxes.

Certain text boxes become active as you select each Acquisition Mode. Minimum default values are also shown in the text boxes. **NOTE: The value you enter in one text box may affect the minimum permissible value in another text box. The system updates the display of minimum permissible values accordingly.**

Table 4: Acquisition Modes

Acquisition Mode (Readout Mode)	Exposure Time (secs)	No. of Accumulations	Accumulate Cycle Time (secs) (Internal Triggering)	Kinetic Series Length	Overlap*	Cosmic Ray Removal	Kinetic Cycle Time (secs)
Single Image	3						
Single (FVB)	3						
Accumulate (Image)	3	3	3		3	3	
Accumulate (FVB)	3	3	3			3	
Kinetic (Image)	3			3	3		3 3
Kinetic (FVB)	3			3			

***NOTE: Overlap function allows data to be read out whilst exposure is underway.**

4.5.2 Extended IR Mode

The Sony sensor used in the Clara offers the unique ability to switch to a mode whereby the QE of the sensor can be increased in the Near Infrared (NIR). Sony have increased the thickness of the silicon on which the CCD is formed and by manipulating the voltages applied to the silicon substrate, the depth of the region where red and NIR light can convert to photoelectrons is increased.

This in turn increases the response of the sensor to these wavelengths with a QE increase from 40% to 60% at 650 nm. For this mode to become fully active requires the first 1mS of the exposure, so it is not recommended for exposures of less than 10 mS. In this mode the amplifier is also powered down during the acquisition, thus eliminating the effect of amplifier glow. This mode is available in Solis by Selecting “Extended IR Mode”.

NOTE: In this mode it is not possible to read out the previous image during the exposure (overlap mode) as the amplifier is powered down.

4.5.3 Fan Settings

The speed of the cooling fan can also be controlled, useful if working in experimental configurations which are extremely sensitive to vibration. The vast majority of applications, including optical microscopy, can be used with the default highest fan speed, since the vibrations from the fan are minimal. However some applications can be extremely sensitive to even the smallest of vibrations (such as when combining an optical set-up with patch clamp electrophysiology or atomic force microscopy) and it can be useful to either select a slower fan speed, or to temporarily turn off the fan altogether for the duration of the acquisition.

If the fan is being turned off altogether, depending on the cooling temperature selected and on the ambient temperature, the acquisition duration can be as long as 15 - 20 minutes before temperature begins to rise. Then the fan must be turned on again to give the head time to re-stabilize (dissipate built-up excess heat from the Peltier TE cooler) before the next acquisition is begins.

4.5.4 Output DACs

Voltages to control external devices from the Clara can be chosen by selecting the **Output DACs** function from the **Hardware** drop-down menu.

- These DAC outputs allow the user to set an analogue voltage up for external devices.
- The resolution can be set to 8,10,12,14 or 16 bits. Both DAC outputs can then be scaled to a maximum of approximately 5V or 10V.
- These do not provide absolute outputs and there will be slight variations between the two outputs.
- Each voltage output can then be adjusted with up to 16 bit resolution. The maximum current which can be drawn from these outputs is 10mA

4.6 Timing Parameters

Depending on which combination of Acquisition, Readout & Triggering modes is selected, various timing parameters are available for the Clara as follows:

- **Exposure Time (secs)**
- **No. of Accumulations**
- **Accumulation Cycle Time (secs)**
- **Cosmic Ray Removal**
- **Kinetic Series Length**
- **Kinetic Cycle Time (secs)**

4.6.1 Using Shutters

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

You can use this to indicate when and how a hardware shutter should be used. With a CCD, the shutter is used for background shuttering. Certain settings (e.g. **Permanently OPEN & Permanently CLOSED**) take effect as soon as you close the Shutter Control dialog box. Other settings will be applied whenever you acquire data.

- **Fully Auto** is the simplest shutter mode, as it leaves all shuttering decisions to the system. When you perform Take Signal the shutter opens for the duration of the Exposure Time you have entered in the Setup Acquisition dialog box.

NOTE: This option will automatically provide suitable shuttering for the majority of data acquisitions. The shutter will be closed for background data acquisitions and will be opened for all other data acquisitions.

- **If CLOSED for background** mode is selected, any shutter driven from the Shutter output will be closed as you perform Take Background. If you want the shutter to be open so that the Take Background function records genuine optical background data, deselect the option.

NOTE: Usually a background scan is used to subtract the dark signal and the Fixed Pattern Noise (FPN) of the sensor. For this reason the background scan is usually performed in darkness. A shutter may be used to stop light entering the spectrograph or other imaging system. Strictly speaking though, the background acquisition may be regarded as comprising all light with the single exception of the source. Thus, when you are working with a pulsed or independently shuttered source, it may be appropriate to have the mode deselected.

- In **Permanently OPEN** mode, the shutter will be open before, during and after any data acquisition.
- **Permanently CLOSED** mode can be useful if you want to take a series of acquisitions in darkness and do not require the shutter to open between acquisitions. You might, for example, wish to capture a sequence of background values. The shutter remains closed before, during and after any data acquisition.
- The TTL (Transistor-Transistor Logic) buttons, **TTL Low & TTL High**, let you instruct the system as to how it should control the opening and closing of the shutter.
  - If you select **TTL Low**, the system will cause the output voltage from the Clara to go 'low' to open the shutter.
  - If you select **TTL High**, the system will cause the output voltage from the Clara to go 'high' to open the shutter.

The documentation supplied by the shutter manufacturer will show whether your shutter opens at a high or a low TTL level.

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. Also there is no shutter pulse during the Take Signal and Take Reference data acquisitions.

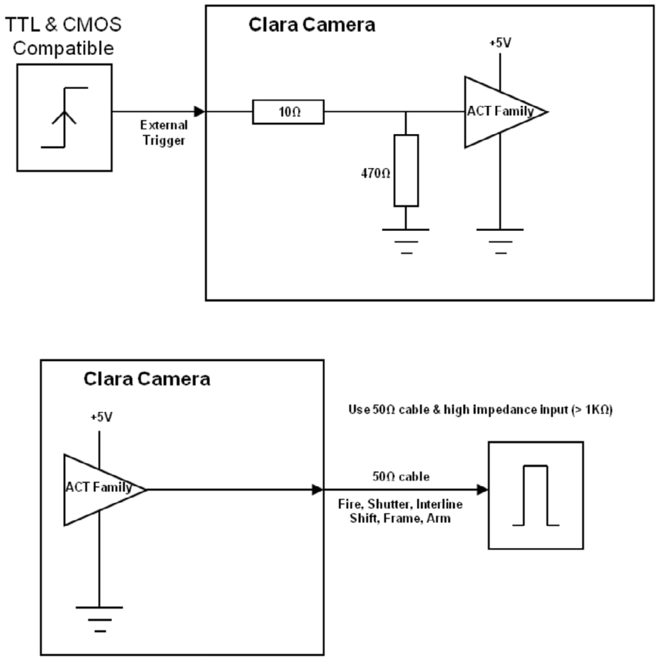


Figure 8: Using Clara with an External Shutter

4.6.2 Time to Open or Close

Shutters take a finite time to open or close and this is sometimes called the **S**hutter **T**ransfer **T**ime (**STT**). The documentation supplied by the shutter manufacturer should indicate the STT you can expect from your particular shutter. In the case of a CCD detector, the STT gives enough time for the shutter to open before acquisition starts and enough time to close after acquisition finishes and before readout commences.

Let us look at the STT in the context of the Andor system. By default, the value you enter in the Exposure Time text box in the **Setup Acquisition** dialog box determines the length of time the shutter will be in the open state. However, to accommodate the STT, the rising edge of the shutter output is sent before the FIRE output signal by an amount equal to the STT. You should set this value to the Transfer Time of your shutter.

The system also automatically adds the STT 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:

If you do not have a shutter connected, set the Time to open or close to 0. Setting the Time to open or close to any other value will insert extra delays into cycle time calculations.

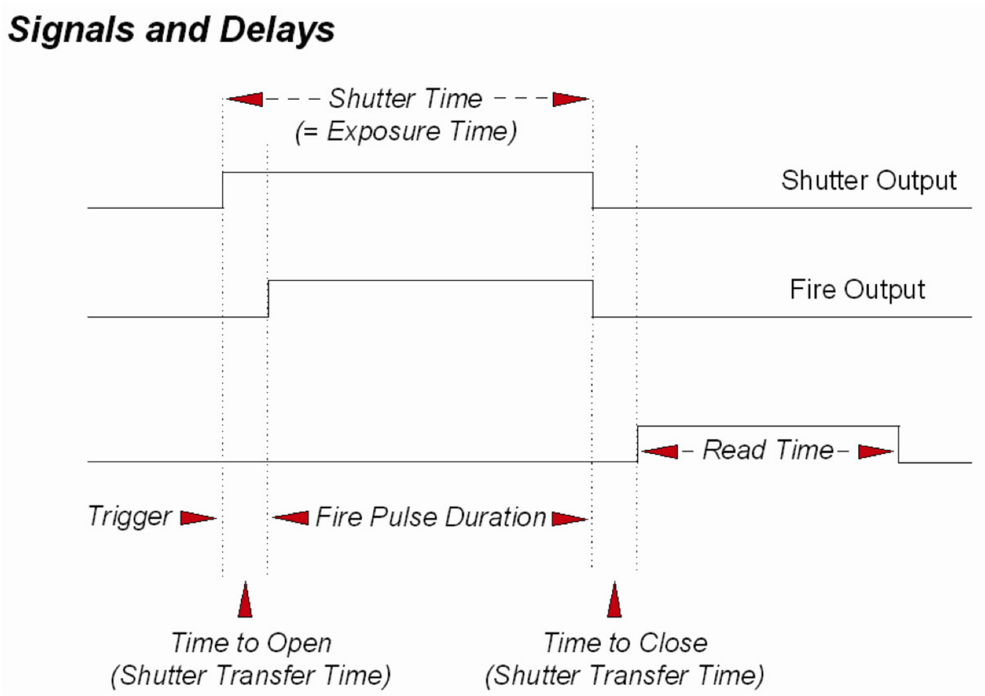


Figure 9: Example Illustration of Signals and delays for a typical Shutter

4.6.3 Exposure Time

As mentioned previously, Exposure Time (secs) is the time during which the CCD collects light prior to readout. The system will default to a minimum Exposure Time should you attempt to enter too low a value.

You will notice that the Exposure Time caption changes to Shutter Time if you have selected a Readout Mode other than Full Vertical Binning. The caption changes to reflect the fact that the CCD will be exposed to light for the duration of the Shutter Time (which includes any transfer time).

If your binning pattern is **Full Vertical Binning**, the shutter, if connected, will remain in the **Open** position at all times, except when background data are being acquired. If you want the equivalent of Full Vertical Binning but with shutter operations, choose Single Track, with the Track Height set to maximum.

4.6.4 Accumulate Cycle Time & No. of Accumulations

If you have selected Accumulate or Kinetic as the acquisition mode, with Internal triggering, you can also select the Accumulation Cycle Time and No. of Accumulations.

The Accumulation Cycle Time is the period in seconds between each of a number of scans, whose data are to be added together in computer memory to form an Accumulated Scan.

The Number of Accumulations indicates the number of scans you want to add together.

4.6.5 Kinetic Series Length & Kinetic Cycle time

When Kinetic is selected as the acquisition mode, with Internal triggering you can also select the Kinetic Series Length and Kinetic Cycle Length (secs).

- **Kinetic Series Length**: the number of scans you require in your series
- **Kinetic Cycle Length**: the interval (in seconds) at which each scan (or accumulated scan) in your series begins

SECTION 5: MAINTENANCE

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

5.1 Cleaning and Decontamination

The most critical aspect of maintenance by the user is to ensure that the system is in a clean environment that is suitable for sensitive electro-optical equipment. The laboratory should be free of dust, fumes and other materials that could affect the system.

- To clean the product, turn off power to the camera and only use a damp, lint-free cloth on the external surfaces. Do not wet the connectors.
- Use water only- do not use solvents, cleaning agents, or aerosols.

5.2 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

5.3 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

5.4 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

SECTION 6: 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.

6.1 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

6.2 Camera is not recognized by PC

1. Ensure the camera is switched on
2. Check the Camera to PC connection.

6.3 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. Ensure fan vents are not obstructed
3. Check the camera is operating within the specified environmental conditions shown in this manual.

6.4 Fan not operating as expected

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

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.

6.5 Camera does not cool to the required temperature

1. Check that the operating ambient temperature is within allowable limits.
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 in the software if using deep air cooling.

SECTION 7: SPECIFICATIONS

7.1 Camera Technical Specifications

	Clara	Clara E
Active pixels [W x H]	1392 x 1040	
Pixel size	6.45 x 6.45 μm	
Image area [W x H]	8.98 x 6.71 mm	
Pixel readout rate (MHz)	20, 10, 1	
Read noise (e-) Typical	1 MHz 10 MHz 20 MHz 2.4 5 6.5	1 MHz 10 MHz 20 MHz 3.0 5 6.5
Minimum temperature air cooled (fan on) @ 25°C ambient	-55°C	-20°C
Minimum temperature 'vibration free mode' (fan off) @ 25°C ambient	-40°C	Mode not available
Dark current, e-/pixel/sec @ minimum temperature	0.0003	0.0015
Maximum frame rate	11 frames per second @ 20 MHz	
Pixel well depth (typical)	18,000 e-	
Well depth with binning (typical)	30,000 e-	
Maximum dynamic range	> 6,500:1 @ 1MHz; 12,500 with binning	
Linearity	Better than 99%	
Dual digitization	16 bit @ 1 MHz; 14-bit @ 10 MHz & 20 MHz	
Baseline (bias) offset clamp	Yes	
Timestamp accuracy	12.5 ns	
System window type	UV-grade fused silica 'Broadband VUV-NIR', unwedged	

7.2 Camera

Dimensions (D x W x H) mm [inches]	96.1 [3.84] x 112 [4.41] x 127 [5.00]
Weight	Weight: 2.2 kg [4 lb 13 oz]
Interface	USB-2.0
Lens Mount	C-mount
Power Requirements	100-240 VAC, 50-60 Hz 12 V@4.75 A (DC)
Regulatory Compliance	Compliant with the requirements of the EU EMC and LV Directives through testing to EN 61326-1 and EN 61010-1 Compliant with the North American Safety Standards: UL 61010-1 and CAN/ CSA-C22.2 No. 61010-1-04
Computer Requirements	3.0 GHz single core or 2.4 GHz multi core processor, 2 GB RAM, 100 MB free hard disc to install software (at least 1GB recommended for data spooling) USB 2.0 High Speed Host Controller capable of sustained rate of 40MB/s Windows (XP, Vista, 7 and 8) or Linux

7.3 Environmental

Usage	Indoor use only
Altitude	Up to 2000 m
Operating Temperature	0°C to 30°C ambient
Storage Temperature	-25°C to 50°C
Operating Relative Humidity	<70% (non-condensing)
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 mains socket in a building.
Rated Pollution	Pollution Degree 2. Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.
Ventilation and clearance Requirements	Do not cover during operation. Do not block cooling fan or vents. Allow 135 mm at rear of camera for cable clearance.

Further technical specifications are available from our website at:

http://www.andor.com/scientific-cameras/clara-interline-ccd-series

APPENDIX A: GLOSSARY

If this is the first time you have used Andor's CCD, the glossary that follows will help familiarize you with its design philosophy and some of its key terminology.

CCD

A Charge Coupled Device (CCD) is a silicon-based semiconductor chip bearing a two-dimensional matrix of photo-sensors, or pixels. This matrix is usually referred to as the '**image area**'. The pixels are often described as being arranged in rows and columns (rows running horizontally, columns vertically). A typical CCD-chip may comprise 256 rows and 1024 columns, or 578 rows and 385 columns.

The CCD in your camera is a scientific slow scan device (in contrast to the fast scan CCD used in video cameras to capture moving images). An example of a typical layout is shown here:

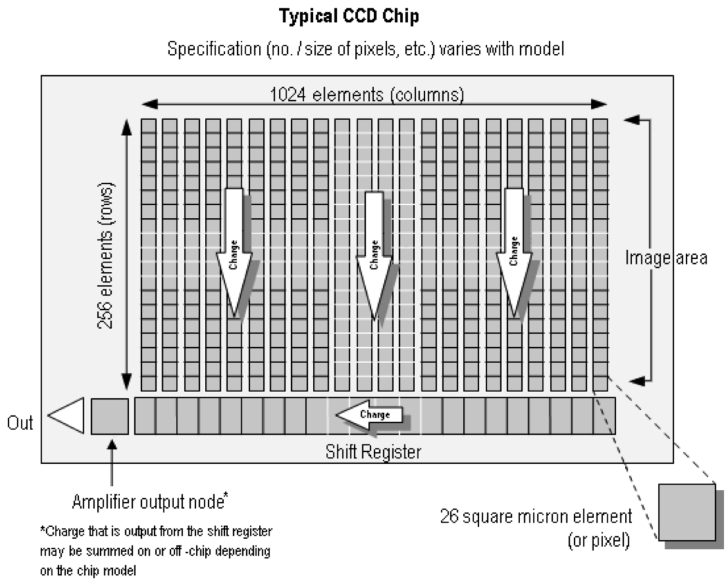


Figure 10: An example of the structure of a typical CCD

The **Shift Register** runs below and parallel to the light collecting rows. It has the same number of pixels as a light-collecting row, but is itself masked, so that no light can fall on it. When light falls on an element, electrons (photoelectrons) are produced and (in normal operation), these electrons are confined to their respective elements. Thus, if an image (or any light pattern) is projected on to the array, a corresponding charge pattern will be produced. To capture the image pattern into computer memory, the charge pattern must be transferred off the chip, and this is accomplished by making use of a series of horizontal (i.e. parallel to the rows/shift register) transparent electrodes that cover the array.

By suitable 'clocking', these electrodes can be used to shift (transfer) the entire charge pattern, one row at a time, down into the shift register. The shift register also has a series of electrodes (which are vertical, i.e. parallel to the columns) which are used to transfer the charge packets, one element at a time, into the output node of the 'on-chip' amplifier. The output of the amplifier feeds the Analog-to-Digital (A/D) converter, which in turn converts each charge packet into a 14-bit or 16-bit binary number.

Readout Sequence of a CCD

In the course of readout, charge is moved vertically into the shift register, and then horizontally from the shift register into the output node of the amplifier. The readout sequence illustrated below (which corresponds to the default setting of the Full **Resolution Image** binning pattern) allows data to be recorded for each individual element on the CCD-chip. Other binning patterns are achieved by summing charge in the shift register and/or the output node prior to readout (please refer to **Vertical Binning** and **Horizontal Binning**).

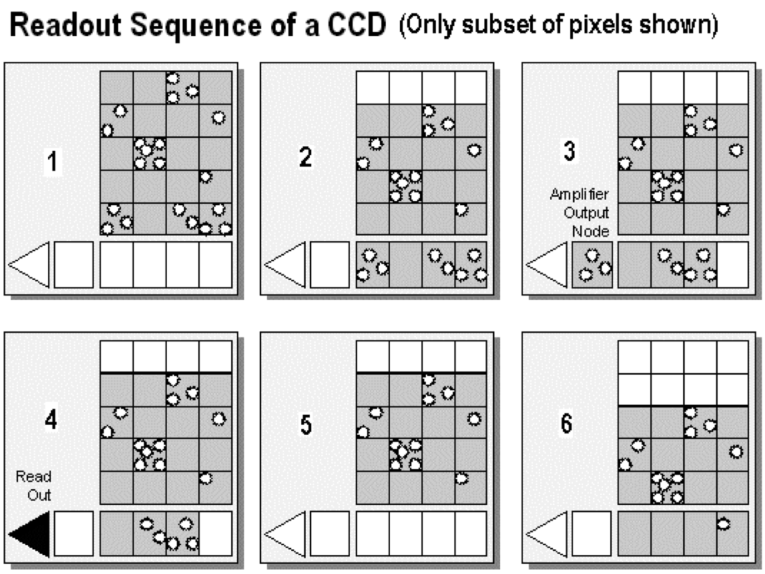


Figure 11: A representation of the readout sequence of a CCD

1	Exposure to light causes a pattern of charge (an electronic image) to build up on the frame (or 'image area') of the CCD-chip.
2	Charge in the frame is shifted vertically by one row, so that the bottom row of charge moves into the shift register.
3	Charge in the shift register is moved horizontally by one pixel, so that charge on the endmost pixel of the shift register is moved into the output node of the amplifier.
4	The charge in the output node of the amplifier is passed to the analog-to-digital converter and is read out.
5	Steps 3 & 4 are repeated until the shift register is emptied of charge.
6	The frame is shifted vertically again, so that the next row of charge moves down into the shift register. The process is repeated from Step 3 until the whole frame is read out.

Interline CCD

An Interline CCD is designed to compensate for some of the shortcomings of standard Frame Transfer (FT) CCD's. Instead of having a storage area of similar dimensions directly below the active region, an interline sensor has optically masked columns of pixels adjacent to each active column. This therefore means that the image can be moved behind the masked region in a single horizontal shift. This shift is known as the interline transfer and is extremely fast (~10μsec) therefore minimising the time between exposures. The image can then be read out, in the normal way, during the acquisition of the following image. A pictorial illustration of this process is shown below:

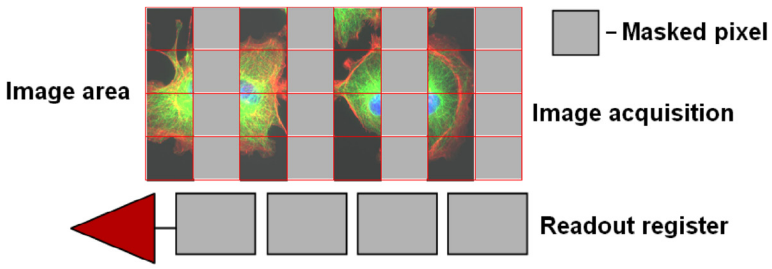


Figure 12: Image is acquired in the active pixels

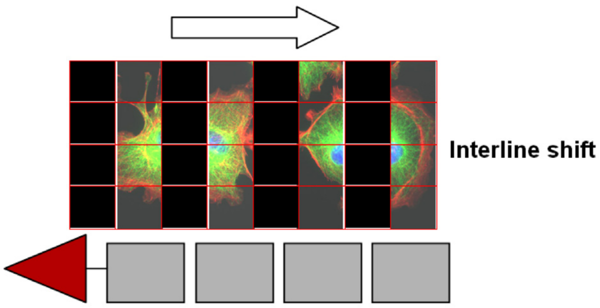


Figure 13: Image is shifted behind the masked region in one simultaneous horizontal shift. Once complete, acquisition of the next image can begin.

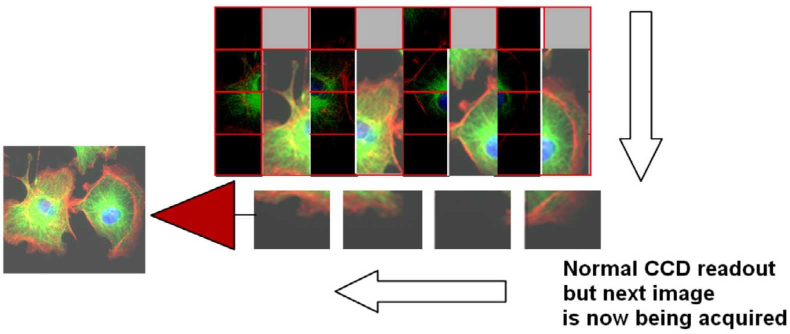


Figure 14: Image is vertically shifted behind the mask, one row at a time, into the readout register as with a conventional CCD

Because of the rapid simultaneous shift, it is not necessary to use a shutter, or light source synchronisation, without introducing image smearing. This single shift also provides an added boost to the frame rate over and above that of Frame Transfer devices. An obvious drawback of an interline sensor is that half of the image area is obscured. This is compensated for by fabricating a microlens array over the sensor surface. These tiny lenses focus the light that is incident on both the active and masked regions, onto the active pixels. In doing so the fill factor is increased to above 70%.

Accumulation

Accumulation is the process by which data that have been acquired from a number of similar scans are added together in computer memory. This results in improved signal to noise ratio.

Acquisition

An Acquisition is taken to be the complete data capture process.

A/D Conversion

Charge from the CCD is initially read as an analog signal, ranging from zero to the saturation value. **A/D** (**A**nalog to **D**igital) conversion changes the analog signal to a binary number which can then be manipulated by the computer.

Background

Background is a data acquisition made in darkness. It is made up of fixed pattern noise, and any signal due to dark current.

Binning

Binning is a process that allows charge from two or more pixels to be combined on the CCD-chip prior to readout (please see **Readout Sequence of a CCD**). Summing charge on the CCD and doing a single readout results in better noise performance than reading out several pixels and then summing them in the computer memory. This is because each act of reading out contributes to noise.

The two main variants of the binning process are vertical binning and horizontal binning, which are individually described in the pages that follow. In addition there are several binning patterns that tailor the main binning variants to typical application usage.

Vertical Binning

In Vertical Binning, charge from two or more rows of the CCD-chip is moved down into the shift register before the charge is read out. The number of rows shifted depends on the binning pattern you have selected. Thus, for each column of the CCD-chip, charge from two or more vertical elements is 'summed' into the corresponding element of the shift register. The charge from each of the pixels in the shift register is then shifted horizontally to the output node of the amplifier and read out.

Variants of Vertical Binning are used to affect a variety of binning patterns and they are as follows:

- **Single-Track**: charge is vertically binned and read out from a number of complete, adjacent rows of pixels on the CCD-chip. The rows form a single track across the full width of the CCD-chip. A value is taken for each column in the track.
- **Multi-Track**: Multi-Track mode differs from Single-Track in that you may now define two or more tracks from which to read out charge. In processing terms, each track is treated as in Single-Track above.
- **Full Vertical Binning (FVB)**: charge from each complete column of pixels on the CCD is 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-chip.

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

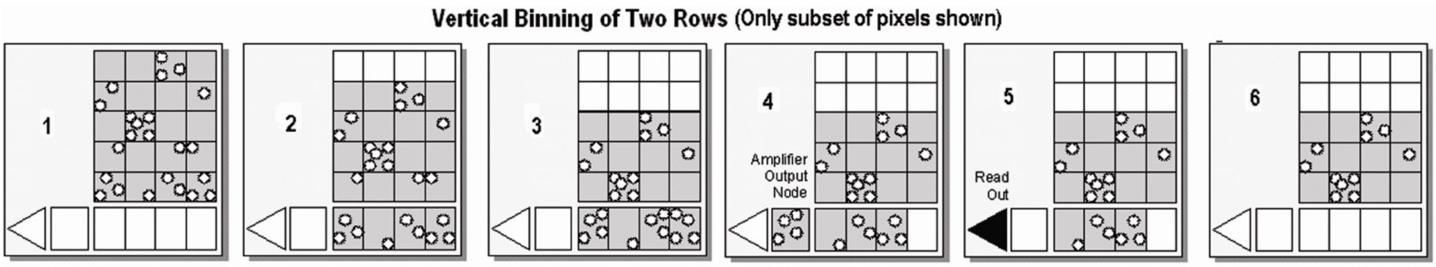


Figure 15: Vertical Binning of two rows

1	Exposure to light causes a pattern of charge (an electronic image) to build up on the frame (or Image Area) of the CCD-chip.
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 charge from two rows - i.e. the charge is vertically binned
4	Charge in the shift register is moved horizontally by one pixel, so that charge on the endmost pixel of the shift register is moved into the output node of the amplifier.
5	The charge in the output node of the amplifier is passed to the analog-to-digital converter and is read out.
6	Steps 4 & 5 are repeated until the shift register is empty. The process is repeated from Step 2 until the whole frame is read out.

Horizontal Binning (Creating Superpixels)

Shifting the charge horizontally from several pixels at a time into the output node is known as horizontal binning.

Horizontal binning in combination with vertical binning allows you to define so-called superpixels that in Image Display Mode represent as a single picture element charge that has been binned from a group of pixels. For example, charge that is binned vertically from two rows and horizontally from two pixels before being read out is displayed as a superpixel of dimensions 2 x 2 pixels.

On the one hand, superpixels (by comparison with single pixels) result in a more coarsely defined image when the data are displayed in **Image** misplay mode. On the other hand, superpixels offer the advantages of summing data on-chip prior to readout. In the example below, where each superpixel is of dimensions 2 x 2 pixels, charge from two rows is first binned vertically into the shift register; then charge from two pixels of the shift register is binned horizontally into the output node of the amplifier. The effect of the combined binning processes is a summed charge 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 shown in **Steps 1 - 4** of **Vertical Binning of Two Rows** then horizontal binning begins.

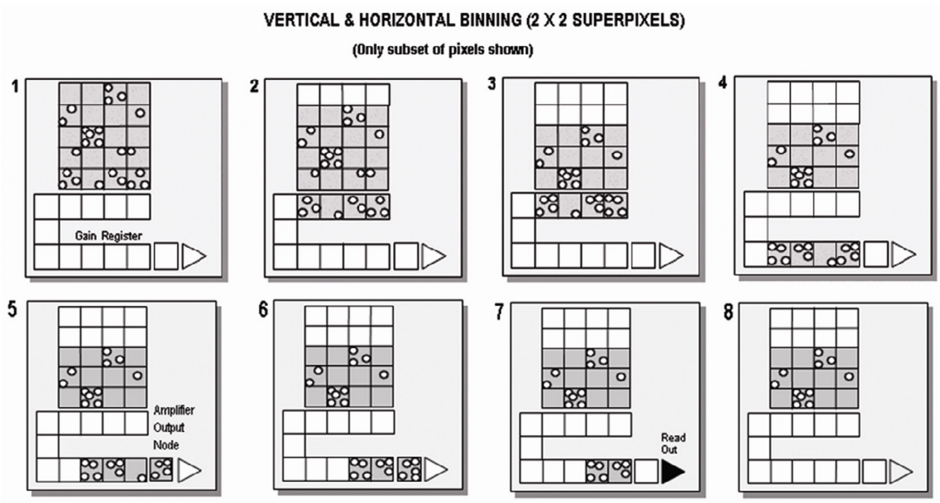


Figure 16: Superpixels

…5	Charge from two rows has already been vertically binned into the shift register (see Vertical Binning of Two Rows on page 126). Now charge in the shift register is moved horizontally by one pixel, so that charge on the endmost pixel of the shift register is moved into the output node of the amplifier.)
6	Charge in the shift register is again moved horizontally, so that the output node of the amplifier now contains charge from two pixels of the shift register - i.e. the charge has been horizontally binned.
7	The charge in the output node of the amplifier is passed to the analog-to-digital converter and is read out.
8	Steps 4 - 6 are repeated until the shift register is empty. The process is repeated from Step 2 until the whole frame is read out.

Counts

Counts refer to the digitization by the A/D conversion and are the basic unit in which data are displayed and processed. Depending on the particular version of the detection device, one count may, for example, be equated with a charge of 10 photoelectrons on a pixel of the CCD.

Dark Signal

Dark signal, a charge usually expressed as a number of electrons, is produced by the flow of dark current during the exposure time. All CCD's produce a dark current, an actual current that is measurable in (typically tenths of) milliamps per pixel. The dark signal adds to your measured signal level, and increases the amount of noise in the measured signal. Since the dark signal varies with temperature, it can cause background values to increase over time. It also sets a limit on the useful exposure time.

Reducing the temperature of the CCD reduces dark signal (typically, for every 7°C that temperature falls, dark signal halves). CCD readout noise is low, and so as not to compromise this by shot noise from the dark signal, it is important to cool the detector to reduce the dark signal. If you are using an exposure time of less than a few seconds, cooling the detector below 0°C will generally remove most of the shot noise caused by dark signal.

Detection Limit

The Detection Limit is a measure of the smallest signal that can be detected in a single readout. The smallest signal is defined as the signal whose level is equal to the noise accompanying that signal, i.e. a signal to noise ratio (S/N) of unity.

Sources of noise are:

- **Shot noise of the signal itself**
- **Shot noise of any dark signal**
- **Readout noise**

If the signal is small, we can ignore its shot noise.

Furthermore, if a suitably low operating temperature and short exposure time can be achieved, the lowest detection limit will equal the readout noise.

Exposure Time

Exposure Time is the period during which the CCD collects light prior to readout.

Noise

Noise is a complex topic, the full exploration of which is beyond the scope of this glossary. Noise may, however, be broken down into two broad categories as follows:

- **Pixel Noise**
- **Fixed Pattern Noise**

These two categories are described in the paragraphs that follow.

Pixel Noise

Let us first attempt to define pixel noise. Assume that a light signal is falling on a pixel of the CCD. If the charge on the pixel is read, and the read process is repeated many times, the noise may be taken as the variation in the values read. The Root Mean Square (r.m.s.) of these variations is often used to express a value for noise. As a rule of thumb, the r.m.s. is four to six times smaller than the peak to peak variations in the count values read from the pixel. Pixel noise has three main constituents:

- **Readout noise**
- **Shot noise from the dark signal**
- **Shot noise from the light signal itself**

Shot noise cannot be removed because it is due to basic physical laws. Most simply defined, shot noise is the square root of the signal (or dark signal) measured in electrons.

Readout Noise

Readout noise (which in our cameras is, in any case, low) is due to the amplifier and electronics: it is independent of dark signal and signal levels; it is only very slightly dependent on temperature; and it is present on every read, as a result of which it sets a limit on the best achievable noise performance.

Shot noise from the dark signal is dependent on the exposure time and is very dependent on the temperature; shot noise from the signal is additionally dependent on the signal level itself. If either the signal or the dark signal falls to zero, their respective shot noise also falls to zero.

The total pixel noise is not, however, simply the sum of the three main noise components (readout noise, shot noise from the dark signal, and shot noise from the signal).

Rather, the Root Sum Square (r.s.s.) gives a reasonable approximation - thus:

total = sqrt (readnoise² + darkshot² + sigshot²)

$$\text{total} = \sqrt{\text{readnoise}^2 + \text{darkshot}^2 + \text{sigshot}^2}$$

where:

- **total** is the pixel noise
- **readnoise** is the readout noise
- **darkshot** is the shot noise of the dark signal
- **sigshot** is the shot noise of the signal

Shot Noise

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

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.

Fixed Pattern Noise

Fixed Pattern Noise (FPN) consists of the differences in count values read out from individual pixels, even if no light is falling on the CCD detector. These differences remain constant from read to read. The differences are due in part to a variation in the dark signal produced by each pixel, and in part to small irregularities that arise during the fabrication of the CCD.

Since fixed pattern noise is partly due to dark signal, it will change if the temperature changes, but because it is fixed, it can be completely removed from a measurement by background subtraction.

Pixel

A Pixel is an individual photosensor (or element) on a CCD.

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 CCD 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 **Quantum Efficiency** (**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

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**'.

Saturation

Saturation is the largest signal the 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-chip. A number of factors determine the maximum amount of charge that the CCD can handle.

Scan Types: Keep Clean & Acquired

The CCD is continually being ‘**scanned**’ to prevent its becoming saturated with dark current (see dark signal). 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** above). In this User’s Guide ‘**scan**’ generally refers to an acquired scan - unless the context specifically indicates otherwise.

Signal to Noise Ratio

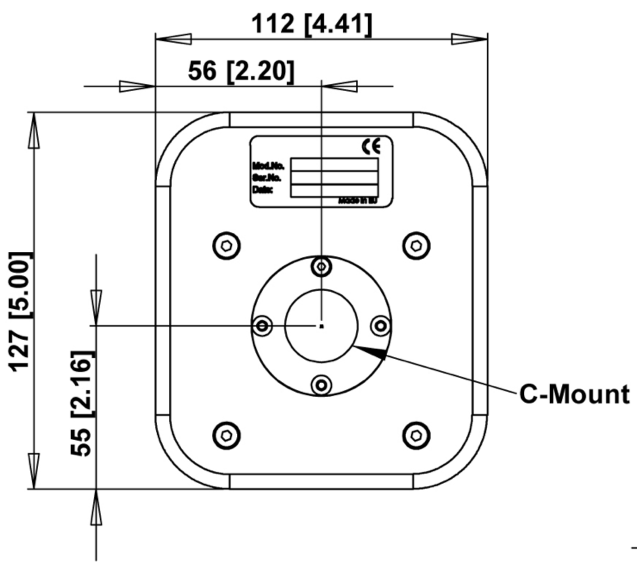
The **S**ignal to **N**oise **R**atio (commonly abbreviated as **S/N** or **SNR**) is the ratio between a given signal and the noise associated with that signal. Noise has a fixed component, and a variable component (shot noise) which is the square root of the signal. Thus, the SNR usually increases (improves) as the signal increases.

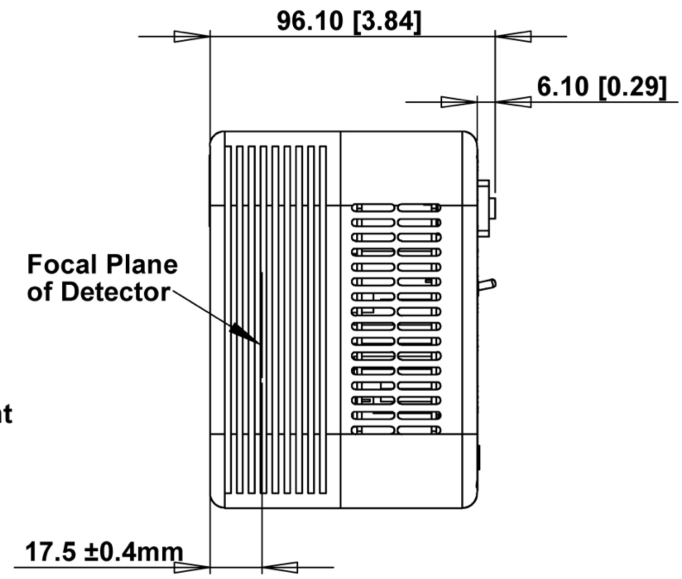
The maximum SNR is the ratio between the maximum signal (i.e. the saturation level) and the noise associated with that signal. At near saturation levels the dominant source of noise is the shot noise of the signal.

APPENDIX B: MECHANICAL DRAWINGS

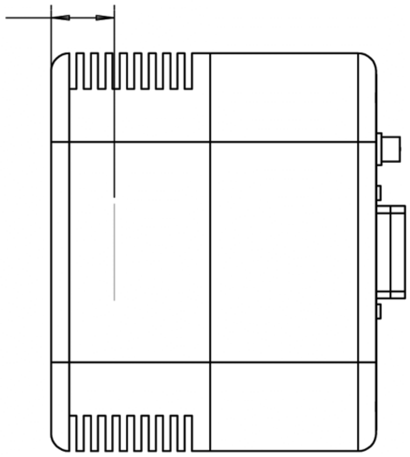
Dimensions in mm [inches]

Front and side view

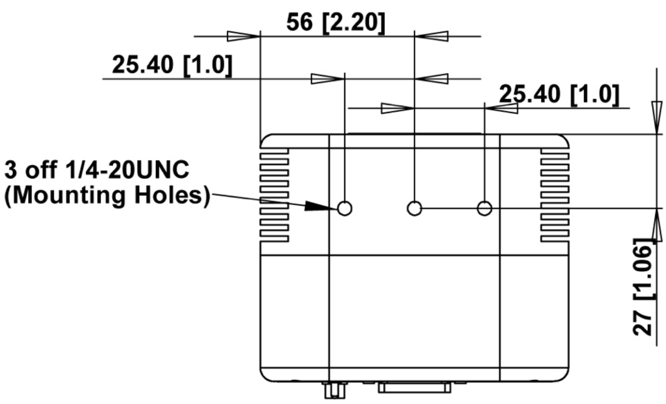




Focal Plane Distance



Mounting Hole locations



APPENDIX C: OTHER INFORMATION

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 may be viewed at: http://www.andor.com/pdfs/literature/Andor_Standard_Warranty.pdf

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.