Sona and Marana-11

1.6 rev 15 December 2022

User Guide

For model: 4.2B-11, 2.0B-11

Andor Technology 2022

andor.oxinst.com

Section 1 - Safety and Warning Information

Caution
PLEASE READ THIS INFORMATION FIRST BEFORE USING YOUR PRODUCT

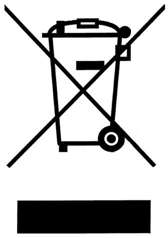
1. If the equipment is used in a manner not specified by Andor, the protection provided by the equipment may be impaired.
2. Do not position this product so that it is difficult to operate the mains disconnecting device. See "Emergency Mains Disconnection" on page 47.
3. Before using the product, please 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 in "Cooling Hoses and Connections" on page 89.
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. Any External AC/DC Power Supply used with this product must meet the requirements specified in "Power Supply Information" on page 97.

10. No parts should be replaced by the customer, except for the mains cables or the fuse, which must be of the same type and rating as that supplied and as specified in or "Fuse Replacement" on page 85, and certified in accordance with your region's safety regulations.
11. Make sure all cables are located so that they will not be subject to damage, especially the mains cable.
12. While running an experiment, keep room temperature as stable as possible.
13. Performance of the system may be adversely affected by rapidly changing environmental conditions or operation outside of the operating conditions specified in "Technical Specifications" on page 94.
14. Ensure that adequate ventilation is provided as specified in "Environmental Specifications" on page 96.
15. 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 "Technical Specifications" on page 94.
16. Medical Diagnosis: This equipment has not been designed and manufactured for the medical diagnosis of patients.
17. Electromagnetic Compatibility: This product was designed for and tested using the IEC/EN 61326-1 EMC standard for Class B emissions and a Basic immunity environment. Class B means that it is designed for a domestic or residential environment, and Basic immunity refers to the fact that it is not designed for a typical industrial environment.
18. 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.
19. Electromagnetic Compatibility: This product has been designed and tested to perform successfully in a normal (basic) electromagnetic environment, e.g. a typical life science test 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.

20. 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.
21. This product is a precision scientific instrument containing fragile components. Always handle it with care.
22. Do not wet or spill liquids on the product, and do not store or place liquids on the product.
23. If spillage occurs on the product, switch off power immediately, and wipe off with a dry, lint-free cloth.
24. If any ingress of liquids has occurred or is suspected, unplug the mains cables and do not use. Contact customer support.
25. See "General Cleaning & Decontamination Information" on page 84.
26. Do not expose the product to open flames.
27. Do not allow objects to fall on the product.

1.1 Label Symbols

	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 is 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

1.2 Unpacking Information

Carefully unpack the unit and retain the packaging materials to transport or return equipment if required:

- If the equipment appears damaged in any way, return it to sales outlet in its original packaging.
- No responsibility for damage arising from the use of non-approved packaging will be accepted.
- Ensure all items and accessories specified at the time of ordering and as detailed on the packing list are present: if any items are missing, please contact your sales representative.

1.3 Revision History

Version	Released	Description
1.0	04 Sep 2018	Initial Release
1.1	11 Apr 2019	Updated USA and Asia-Pacific addresses
1.2	19 Jun 2019	Updated altitude information on page 46, updated backplate images and mechanical drawings for Marana. USB terminology amended throughout.
1.3	29 July 2019	Updated China office address, table on page 39 and power supply information
1.4	1 Aug 2019	Updated power supply information
1.5	4 Dec 2019	Updated accessories table and model applicability of hardware guide
1.6	15 December 2022	Updated manual format for new standard camera manuals format. Updated images of camera for branding update. Added section for SRRF-Stream+. Added Reach statement and China ROHS.

1.4 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: andor.oxinst.com/downloads. If you find an issue in this manual, please contact your customer support representative with a description of the issue.

Section 2 - Introduction

This manual provides an overview of the Sona and Marana camera series. The Sona and Marana feature the latest back-illuminated sCMOS sensor technology for an exceptional sensitivity, speed and field of view. This makes it particularly suitable for demanding applications - **Sona for life science imaging**: such as live-cell imaging, embryo imaging; **Marana for physical science imaging**: such as space debris tracking and occultations. This manual includes a description of the main features of the cameras, their installation, routine operation and troubleshooting. It also provides a summary of some of the technical features of the Sona and Marana back-illuminated sCMOS camera series. For further information on operation and control of the camera refer to the relevant software guide e.g. Solis, and to the andor website for further technical information to help you get the best from your camera.

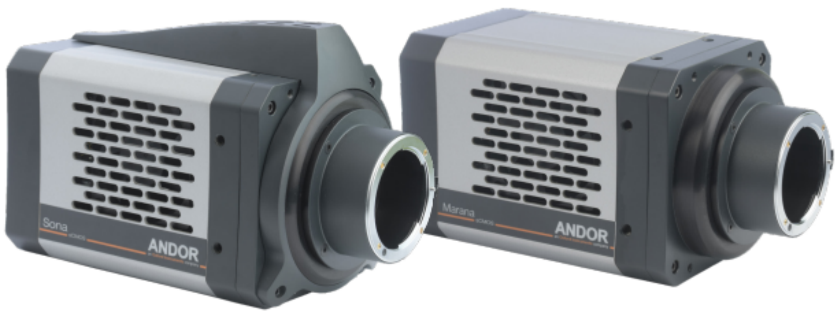


Figure 1:Sona (left) and Marana (right) back-illuminated sCMOS Cameras

2.1 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

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

300 Baker Avenue

Suite # 150

Concord

MA 01742

USA

Tel. +1 (860) 290-9211

Fax. +1 (860) 290-9566

Asia-Pacific

Andor Technology (Japan)

5F IS Building

3-32-42 Higashi-Shinagawa

Tokyo 140-0002

Japan

Tel: +81 (0)-3-6732-8968

Fax: +81 (0)-3-6732-8939

China

Andor Technology

Unit 1, Building A,

66 Zhufang Rd, Haidian Dist.

Beijing 100085

China

Tel: +86 (0)10 8271 9066

Fax. +86(0)10 8271 9055

The latest contact details for your local representative can be found on our website andor.oxinst.com/support

2.2 Copyright and Protective Notices

The publication of information in this documentation does not imply freedom from any patent or proprietary right of Andor Technology Ltd. or any third party.

2.3 Disclaimer

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IN NO EVENT SHALL ANDOR BE LIABLE FOR ANY LOSS OR DAMAGE, WHETHER DIRECT, INDIRECT, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR OTHERWISE HOWSOEVER CAUSED WHETHER ARISING IN CONTRACT TORT OR OTHERWISE, ARISING OUT OF OR IN CONNECTION WITH THE USE OF THE INFORMATION PROVIDED HEREIN.

2.4 Trademarks and Patent Information

Andor, Sona and Marana-11 and the Andor logo are trademarks of Andor Technology Ltd. Andor Technology Ltd. is an Oxford Instruments company. All other marks are property of their owners.

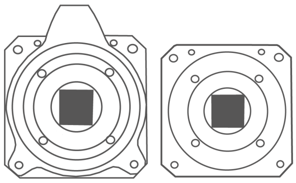
Manufacturers Information

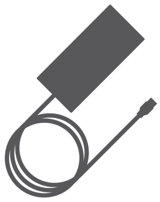
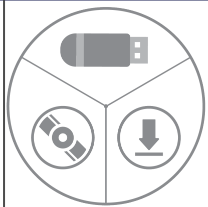
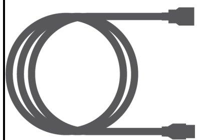
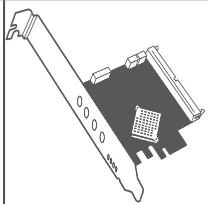
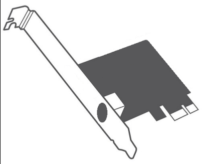
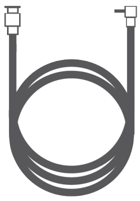
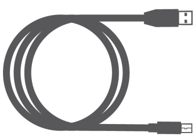
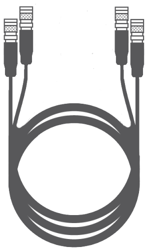
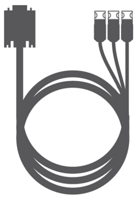
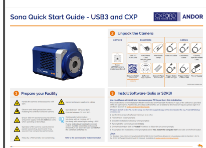
Andor Technology Ltd., Belfast, BT12 7AL, UK.

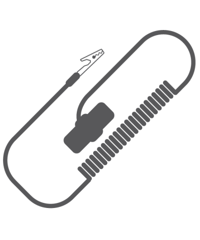
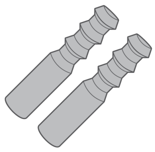
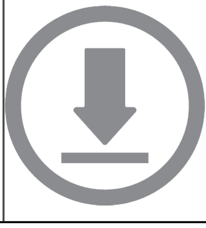
2.5 Supplied Components

The standard components supplied with the Sona and Marana-11 are shown below:

Table 1:Supplied components.

Description		Quantity
	Sona or Marana back illuminated sCMOS Camera (model as ordered)	1

Description		Quantity	Description		Quantity
	Power Supply 1 x 15 V	1		Software (if ordered)	1
	Power cable (country specific)	1		CoaXPress Card with ext. trigger input (CoaXPress variant only)	1
	USB 3 Card	1		Trigger Cable BNC to SMB (CoaXPress variant only)	1
	USB 3 Standard-A to Standard-B cable	1		CoaXPress Cable (CoaXPress variant only)	1
	Multi timing I/O cable, Trigger Cable BNC to D-type	1		Quick Start Guide	1

Description		Quantity	Description		Quantity
	Anti-static wrist band	1		Performance Sheet	1
	Coolant pipes (hose inserts, pair)	1		User Guide (electronic copy)	1

2.6 Camera Model Options

There are a number of models of Sona and Marana-11 camera based off of a common architecture and shared design. The differences for each model can be identified from the product codes and descriptions outlined below:

Table 2:Model options.

Model Type	Product Code	Sensor Type	Mounting
Sona 4.2B-11	**SONA-4BV11**	4.2 Megapixel Back-illuminated sCMOS: VIS/NIR optimized	F-mount
Sona 2.0B-11	**SONA-2BV11**	2.0 Megapixel Back Illuminated sCMOS: VIS/NIR optimized	C-mount
Marana 4.2B-11	**MARANA-4BV11**	4.2 Megapixel, Back-illuminated sCMOS: VIS/NIR optimized	F-mount
Marana 4.2B-11	**MARANA-4BU11**	4.2 Megapixel, Back-illuminated sCMOS: UV-optimized	F-mount

2.7 Optional Components

There are a range of optional and additional accessories available for Sona and Marana-11 including:

Table 3:Optional components.

Description	Order Code
MCU with 2x magnification for matching Sona to Leica microscopes	**MCU-SONA-LEI**
MCU with x2 magnification for matching Sona to Nikon Ti Series (TiE and Ti2) microscopes	**MCU-SONA-NIK-TI**
MCU with x2 magnification for matching Sona to Olympus microscopes	**MCU-SONA-OLY**
Re-circulator for enhanced cooling performance (supplied with 2x2.5 m tubing as standard)	**XW-RECR**
Oasis 160 Ultra compact chiller unit (tubing to be ordered separately)	**ACC-XW-CHIL-160**
6 mm tubing options for Oasis 160 Ultra compact chiller (2x2.5 m or 2x5 m lengths)	**ACC-6MM-TUBING-2X2.5** **ACC-6MM-TUBING-2X5M**
Pair of barbed hose inserts for 6 mm tubing	**6MM-HOSE-BARBS**

Please see the product specifications or contact Andor or your nearest Andor representative for further information.

Section 3 - Product Overview

This section provides an overview of the main features of the Sona and Marana-11. Please note that Sona configuration is shown below which will also cover the Marana model. Please refer to the additional information supplied for details of any model specific differences. As of January 2023 the camera body of the 4.2B-11 and 2.0B-11 were updated to new product branding which includes a blue casing, all specifications remain unchanged.

Figure 2:Sona sCMOS Camera

Lens Mount

The Sona and Marana 4.2B-11 feature an F-mount as standard, the Sona 2.0B-11 model features a C-mount (other adapters are available).

Sensor

The Sona and Marana feature high resolution sCMOS 4.2 Megapixel back illuminated sCMOS sensors. Andor's unique UltraVac® vacuum technology has been utilized. UltraVac® provides a permanent hermetically sealed enclosure so that the QE and cooling performance can be maintained over many years operation.

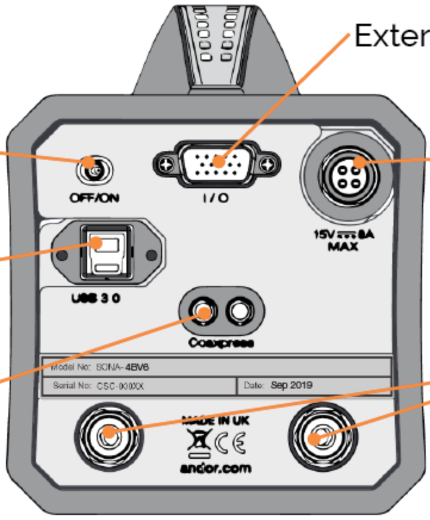
Camera Window

There is a single AR coated UV grade silica window for optimum transmission. For more information on camera windows please see andor.oxinst.com/learning/view/article/camera-windows.

Other Mountings

Four M4x 0.7 -6H, 8.0 [0.31] deep mounting holes on the front face (see "Mounting the Camera using the Mounting Flange" on page 32).

3.1 Rear Panel



USB Connectivity

USB 3 connection provides a robust high speed connection to the control PC.

CoaXPress Connectivity

CoaXPress connectivity, available on upgraded models only, provides a robust, high speed, 2-lane connection to the control PC.

External I/O: TTL / Logic

The TTL/Logic connection permits connection to other devices for synchronisation and control of fire, trigger and shutter operations. Connector type: D-type to BNC cable Fire (Output), External Trigger (Input), ARM.

Liquid Cooling Connections

Liquid cooling connections provide the facility for connection to a liquid cooling system. Refer to "Connecting a Cooling System" on page 33.

Power Connector

Power input connection (15 V DC) for connection to the PSU. Refer to "Power Supply Information" on page 97. An ON/OFF switch is also present.

3.1.1 Multi I/O Timing Cable Pin Outs

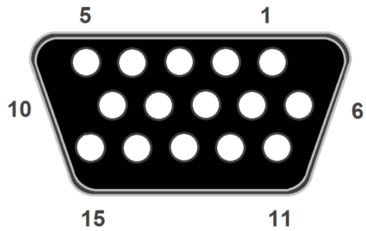


Table 4:Pinouts for the 15-way D type connector

Available using standard 3-way cable				Available using optional 7-way cable			
Pin	**3-way cable**	**Pin**	**3-way cable**	**Pin**	**7-way cable**	**Pin**	**7-way cable**
1	ARM	9	Reserved	1	ARM	9	Reserved
2	AUX_OUT_1	10	Reserved	2	AUX_OUT_1	10	Reserved
3	Reserved	11	Reserved	3	FIRE n	11	Reserved
4	Reserved	12	Reserved	4	FIRE	12	Reserved
5	Reserved	13	Reserved	5	AUX_OUT_2	13	Reserved
6	Ground	14	Reserved	6	Ground	14	Reserved
7	External Trig-ger	15	Reserved	7	External Trig-ger	15	Reserved
8	Reserved			8	Spare		

- **External Trigger** (and Spare inputs) are 5 V TTL input. By default they trigger on a rising edge.
- **ARM and AUX_OUT_1 (FIRE, FIRE n and AUX_OUT_2: for 7-way cable only)** outputs are all TTL timing outputs. These can be individually inverted via software (e.g. Solis or SDK).
- **AUX_OUT_1** supplies the 'FIRE ALL' output by default. This is the logical AND of the FIRE pulses associated with Row #1 and Row #n (the last row read out in the image frame). Therefore the FIRE ALL pulse represents the time within a frame when all rows on the sensor are simultaneously exposing.
- **AUX_OUT_1** is configurable for TTL timing outputs FIRE, FIRE n and FIRE ANY. The FIRE ANY pulse represents the time within a frame when any row of the image frame is exposing. Refer to "Trigger Modes" on page 66 for the behaviour of these signals and to the SDK3 manual for configuring the AUX_OUT_1 output.
- **AUX_OUT_2** output defaults to shutter control.

- **Optional 7-way multi I/O timing interface cable** (Andor part number ACC-ACZ-05612) gives access to all of the above I/O functions shown in the table above right (excluding Ground and Reserved pins).
- **Reserved pins** should not be used.

* using optional 7-way multi I/O timing cable only

3.1.2 Impedance Information

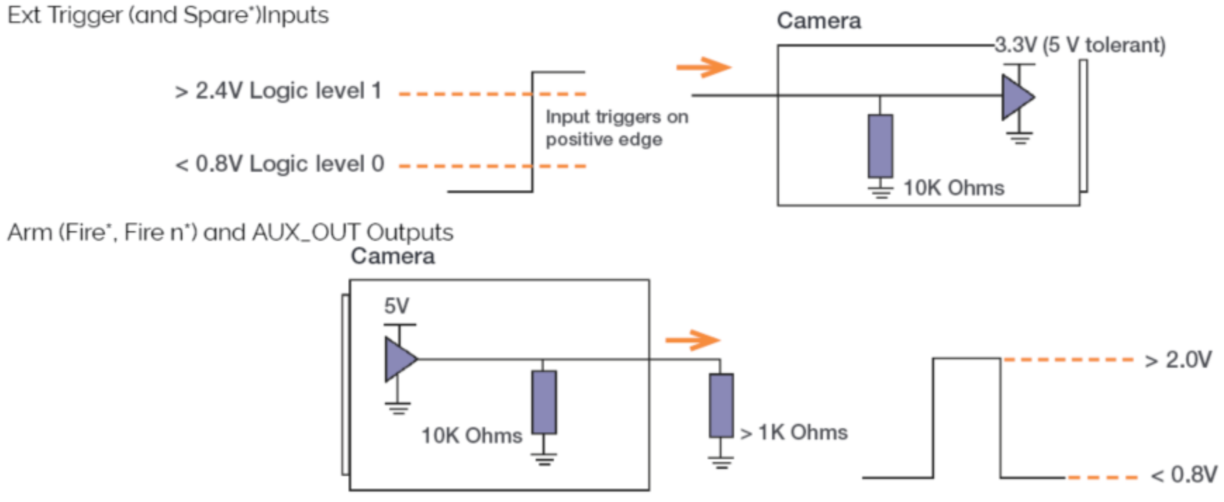


Figure 3:Sona and Marana-11 connection impedance information

3.2 Cooling Hose Connectors

There are two connectors to allow connection of Liquid Cooled Sona and Marana-11 models to a water cooler or re-circulator. Hose inserts are provided to enable connection to coolant hoses. On Sona and Marana the cooling hose connectors are available on the "Rear Panel" on page 20.

Please refer to "Connecting a Cooling System" on page 33 for details of connector and hose type compatibility and for connection and disconnection information.

3.3 Camera based Super Resolution (SRRF-Stream+)

Certain Andor cameras including Sona have been developed to enable super-resolution imaging to be achieved using a normal microscope. This technology is called SRRF-Stream+. It is a cell friendly and easy to use approach to achieving sub-diffraction limited resolutions. It is based on the SRRF (Super Resolution Radial Fluctuations) method of Gustafsson et al (2016). The benefits of this camera and software method are:

- Can use normal fluorophores and labelling protocols
- Use low illumination intensities e.g. LED illumination
- No need for specialised microscope: an existing microscope may be used with a suitable graphics card and compatible Andor camera

This makes it not only a cell-friendly way to perform super resolution imaging, but also makes high resolution imaging accessible a much wider range of researchers. There is little change to the existing imaging workflow. Resolutions down to ~100 nm may be obtained by this method depending on the specific microscope and labelling.

For full information on camera based super-based super resolution and camera compatibility please refer to SRRF-Stream+ Super Resolution.

If you have purchased a SRRF-Stream+ license for your camera please see our support documentation to get started:

- SRRF-Stream+ Quick Start Guide
- SRRF-Stream+ User Guide

Section 4 - Installation

Caution
Prior to commencing installation, the user should refer to the safety and warning information and unpacking instructions at the beginning of this manual.   **Due care must be taken when lifting the camera. Ensure that the mounting and connected assembly is secure and able to support the weight of the camera.**   **Power cabling and control cables should be routed to prevent accidents, damage and accidental unplugging while avoiding bend radii of less than 30 mm.**   **Temperature and humidity must meet the specifications defined in technical specifications.**

4.1 Transport and Storage

- The camera is packed in normal transport packaging for shipping.
- Allow the product to reach the ambient temperature after unpacking-especially if moving from a colder environment to a warm environment as this may lead to condensation.

Storage

- Temperature and humidity must meet the specifications defined in "Environmental Specifications" on page 96.
- If it is to be stored after use at a temperature below the coolant freezing point, ensure that all liquid coolant has been expelled from the camera.

4.1.1 Using Lens Mount Adaptors

An F-mount lens mounting system is present on the 4.2B-11 models, and a C-mount is present on the Sona/Marana 2.0B-11 model.

4.1.2 C-Mount Replacement

Note
C-Mount - Uses the inner set of mounting points

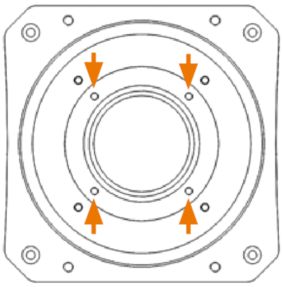


Figure 4:Inner mounting point locations

Removing the C-mount

Note
The use of nitrile gloves is recommended, when removing the C-Mount due to the proximity of the window.

1. Place the camera on its side (to prevent debris and dust landing on the window).
2. Use a 2 mm hex key/driver to loosen the 4xM3 CSK (countersunk) screws.
3. Remove the 4 screws and carefully remove the C-mount from the faceplate.

Fitting the C-mount

1. Ensure that the faceplate is clean and free from debris.
2. Ensure that the o-ring is fully seated in the groove.
3. Locate the C-Mount part into the faceplate aligning the 4xM3 CSK screw holes.
4. Using the M3 CSK screws provided, tighten the mount to 1.1 Nm onto the faceplate.

4.1.3 F-Mount and T-Mount Adaptors

Note
F-Mount and T-mounts- Use the inner set of mounting points see **"Inner mounting point locations" on the previous page**

Removing the F/T-mount

1. Place the camera on its side (to prevent debris and dust landing on the window).
2. Use a 2 mm hex key/driver to loosen the 4xM3 CSK (countersunk) screws.
3. Remove the 4 screws and carefully remove the F/T mount from the faceplate.

Figure 5:F-mount adaptor

Fitting the F/T-mount

1. Ensure that the faceplate is clean and free from debris.
2. Ensure that the o-ring is fully seated in the groove.
3. Locate the F/T-Mount part into the faceplate aligning the 4xM3 CSK screw holes.
4. Using the M3 CSK screws provided, tighten the mount to 1.1Nm onto the faceplate.

4.1.4 Using a Magnifying Coupler Unit

A magnifying coupler (e.g. Andor MCU) or lens tube may be used to match the large area sensor to the objective magnification and the aperture that is available from the microscope. These attach to the camera using a T-mount style connection (described in "F-Mount and T-Mount Adaptors" on the previous page). For further information on the magnifying coupler please refer to the instructions supplied with the MCU and your microscope

4.1.5 Mounting the Camera using the Mounting Flange

The camera mounting face features 4 off M4x0.7 -6H tapped holes x8.0 [0.31] deep. These can be used to secure the camera to an appropriate mounting as an alternative to using the lens mounts.

Caution
The weight of the camera is approx.2.7 kg ensure that the mounting and the system it is connected to provides adequate support.

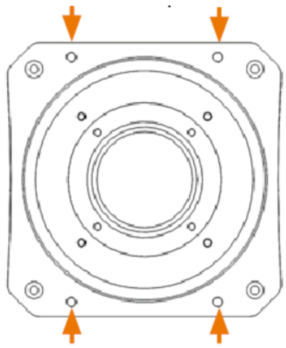


Figure 6:Alternative mounting points.

4.2 Connecting a Cooling System

The camera can use either air cooling to cool to 15°C or -25°C, or optional liquid cooling for deeper cooling to -45°C.

The camera will default to a Fan Setting of "Low" and will set the sensor temperature to 15°C as default following its initialisation (Audible double beep).

Important Considerations when using Liquid Cooling Systems

Caution
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 "Dew Point Graph" on page 101 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 as leaks may find their way to the mains electricity supply and create a hazard.** **The water cooling system of the camera is rated for operation up to 2 bar (200 kPa). If your water supply exceeds this value, then an overpressure safety device or regulator must be fitted to restrict the water pressure to less than or equal to this rating.** **In the event that replacement hose inserts/barbs are required, please place an order using the correct product code.** **Always remove residual coolant from the camera head if the camera is to be stored after operation especially if the storage conditions are below the freezing point of the coolant.**

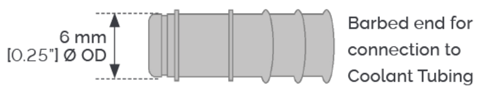
There are two cooling hose connectors located on the rear plate for the connection of the camera to a liquid cooling system. See "Rear Panel" on page 20.

Hose Inserts

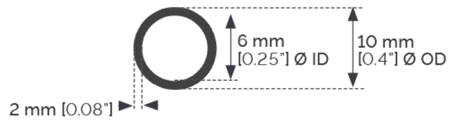
Hose inserts are provided to enable connection to coolant hoses.

- **Coolant Hose Inserts**: Two barbed coolant hose inserts (replacement part code 6MM-HOSE-BARBS) 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.



Coolant Hose Connector



Coolant Tubing

4.3 Coolant Recommendations

• **Coolant temperature**: Refer to the temperatures specified in Technical Specifications. Note that cooling performance may be affected by distance between camera head and cooler.

• **Recommended coolant**: water or water/glycol mix depending on the ambient environmental temperature during operation.

De-ionized water (without additives) may be used as the coolant. 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.

Caution
The liquid cooling system of the camera is rated to 2 bar (200 kPa). If your water supply exceeds this value, then an overpressure safety device or regulator must be fitted to restrict the water pressure to less than or equal to this rating.

4.3.1 Connecting the Coolant Hoses

1. Press the hose connector into the connection on the camera head, ensure it clicks into place and repeat for the second hose.

2. Confirm the hoses are connected securely by applying pressure on the top front of the camera body and pulling backwards on the hoses.

3. The coolant hoses are now connected.

4.3.2 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.

4.4 Connecting the Camera to the PC

The camera connects to a PC via USB 3 or via CoaXPress that provides a standard, robust and high-speed connection with the control PC. It is recommended to use the supplied PCIe card as this will ensure consistent performance. Other ports on the PC may share bandwidth with other devices and peripheral components. This may cause reduced, or inconsistent performance.

4.4.1 Installing the USB 3 Card or CXP Card in the PC (if required)

Note
Camera operation with PCIe cards not supplied by Andor cannot be guaranteed.

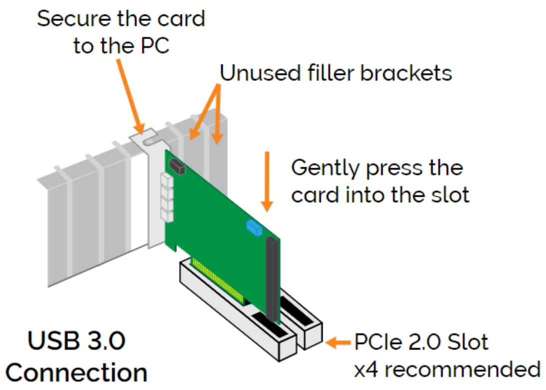


Figure 7:Left USB PCIe connection. Right CoaXPress PCIe connection.

1. Unplug all cables from the rear of the computer
2. Open the PC enclosure to gain access to the expansion slots.
3. Locate a suitable PCIe (2.0 or newer) slot:
   - **USB** Card operates in an x1 slot or one with a greater number of channels (i.e. x4, x8 or x16).
   - **CoaXPress** a minimum of x8 slot is required

   If you are unsure which slot is correct, please consult the PC user manual.
4. Remove the filler bracket corresponding to the slot you intend to use.
5. Remove the controller card carefully from its protective ESD packaging and insert the card connector fully into the expansion slot.
6. Ensure the card's mounting bracket is flush with any other mounting or filler brackets to either side of it, then secure the controller card in place.
7. Replace the computer cover and secure with mounting screws if applicable.
8. Reconnect any accessories you were using previously.

4.4.2 Connecting the Camera to the PCIe Card

4.4.2.1 Connecting via USB

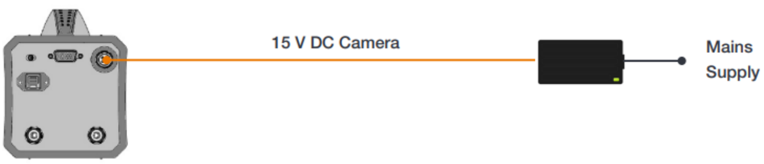
Connect the USB cable from the camera to the appropriate PCIe card on the control PC.

4.4.2.2 Connecting via CoaXPress

Connect the 2 Lane CoaXPress cable from the camera to the CXP (PCIe) card on the control PC

4.4.2.3 Connecting the Camera to the Power Supply

Connect the mains power cable between the camera power input (15 V DC) and the 15 V DC power supply unit. Route cables carefully so they do not pose a tripping hazard or at risk of being unplugged. Avoid tight bends or strain at the connections. Connect the power supply unit to the mains power supply.



4.5 Installing Software and Drivers

4.5.1 Minimum Computer Requirements

- 3.0 GHz single core or 2.4 GHz dual or quad core processor
- 4 GB RAM
- Hard drive: 850 MB/sec write speed recommended for the data rate associated with the max. frame rates. 100 MB free hard disc to install software
- For USB PCI Express x1 or greater (x4 recommended). For CoaXPress PCI Express x8 required
- Windows (8.1 and 10) or Linux

4.5.2 Installing Software or Drivers

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 Software Development Kit (SDK). For sCMOS cameras, SDK3 is required whereas, SDK2 is required for CCD and EMCCD cameras. If purchased please visit andor.oxinst.com/downloads to request a software or driver download.

Note
You must have administrator access on your PC to perform this installation

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

4.5.3 New Hardware Wizard

When the Sona and Marana-11 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 camera is correctly recognized and installed by opening the Device Manager (Devices and printers) in Windows, Control Panel. The camera will show under the Devices list.

4.5.4 Checking & Setting BIOS options (for PCs not supplied by Andor)

Enter the BIOS menu when starting PC. For Dell workstations, press F12 at start-up and select System Setup in the One Time Boot Menu. For Dell workstations 3 options in the Performance menu of the BIOS need to be checked/set:

- C-States Control – Disable C-States
- Intel Speed-step – Disable Speed-step
- Memory Node Interleaving – Set from NUMA to SMP. Note: This option is only available on larger workstations with 2 physical processors and may have a different name- ensure that NUMA is disabled

Section 5 - Operation

Caution
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 CAMERA CONTROL SOFTWARE PRIOR TO USE.**

5.1 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

5.2 Power Up Sequence

1. Ensure that the camera is powered on at the mains power supply. (There is an ON/OFF switch on the backplate of the camera).
2. Ensure that the USB or CXP cable is connected between the camera and the PC.
3. Switch on the camera using the ON/OFF switch at the rear panel of the camera.
4. Start up the PC.

Note
Wait until you hear a single beep followed by a double beep from the camera before you start up the camera software e.g. Solis or SDK. Otherwise the SW/SDK will not be able to connect to the camera.

5. Launch your camera control software e.g. Solis, Fusion or SDK3.
6. The camera will now start up under control of the software.

Note
It will take some time for the camera to reach the target cooling temperature (This is visible in the temperature status bar in Solis). Please wait until the camera has reached the target temperture before you start acquiring scientific grade images.

7. Refer to your software manual for set-up and image acquisition information.

5.3 Power Down Sequence

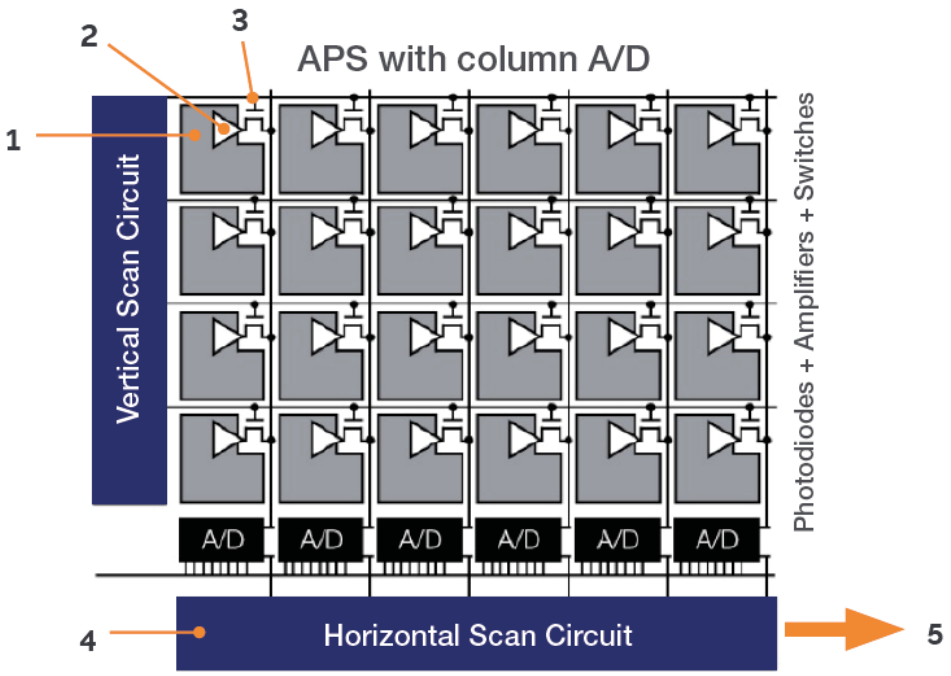
1. Exit the camera control software.
2. Switch the camera off using the switch on the rear panel .
3. If not using the camera for some time, disconnect from the mains power socket.

5.4 Using the Camera

Once set-up the camera is controlled through the camera control software. Please refer to the information supplied with the camera control software (available separately) for further details e.g. Andor Solis or SDK3. Some important features and concepts are outlined in the following sections.

5.5 sCMOS Structure and Operation

sCMOS technology has been developed specifically to overcome many of the limitations that have marred other scientific detector technologies, resulting in an imaging detector that provides exceptional performance for many applications.



As illustrated above, the CMOS sensor is an "Active Pixel Sensor" (APS) whereby each pixel has its own integral amplifier and the sequence of operation is as follows:

1. Light hits sensor and generates charge (electrons).
2. The photo-generated charge is converted to an analog voltage inside each pixel amplifier
3. Pixel voltage is transferred to the column bus via a row select signal
4. The analog voltage is then converted to a digital signal via columns of A/D (analog to digital) converters.
5. The final digitized signals are then read out sequentially at a pixel readout speed of up to 200 MHz.

Notes
The diagram, above is representative - the light sensitive area is contiguous as the photodiodes for each pixel are buried within the sensor. Each pixel also has a microlens to maximize sensitivity to light. **For Rolling Shutter mode operation, pixels in each row are exposed and the charge converted to a voltage simultaneously before being digitized then read out sequentially.**

5.6 Dual Amplifier Dynamic Range

The Dual Amplifier architecture of the sCMOS sensor in Sona and Marana-11 eliminates the need to choose between low noise or high capacity, in that signal can be sampled simultaneously by both high gain and low gain amplifiers. As such, the lowest noise of the sensor can be harnessed alongside the maximum well depth, affording the widest possible dynamic range. Traditionally, scientific sensors including CCD, EMCCD, ICCD and CMOS, demand that the user must select 'upfront' between high or low amplifier gain (i.e. sensitivity) settings, depending on whether they want to optimise for low noise or maximum well depth. Since the true dynamic range of a sensor is determined by the ratio of well depth divided by the noise floor detection limit, then choosing either high or low gain settings will restrict dynamic range by limiting the effective well depth or noise floor, respectively.

For example, consider a large pixel CCD, with 16-bit Analog to Digital Converter (ADC), offering a full well depth of 150,000 e- and lowest read noise floor of 3 e-. The gain sensitivity required to give lowest noise is 1 e-/ADU (or 'count') and the gain sensitivity required to harness the full well depth is 2.3 e-/ADU, but with a higher read noise of 5 e-. Therefore, it does not automatically follow that the available dynamic range of this sensor is given by 150,000/3 = 50,000:1. This is because the high sensitivity gain of 1 e-/ADU that is used to reach 3 e- noise means that the 16-bit ADC will top out at 65,536 e-, well short of the 150,000 e- available from the pixel. Therefore, the actual dynamic range available in 'low noise mode' is 65,536/3 = 21,843:1. Conversely, the lower sensitivity gain setting means that the ADC will top out at ~ 150,000 e-, but the higher read noise of 5 e- will still limit the dynamic range to 150,000/5 = 30,000:1 in this 'high well depth mode'. The sCMOS sensor offers a unique dual amplifier architecture, meaning that signal from each pixel can be sampled simultaneously by both high and low gain amplifiers. The sensor also features a split readout scheme in which the top and bottom halves of the sensor are read out independently. Each column within each half of the sensor is equipped with dual column level amplifiers and dual analog-to-digital converters, represented by the block diagram below:

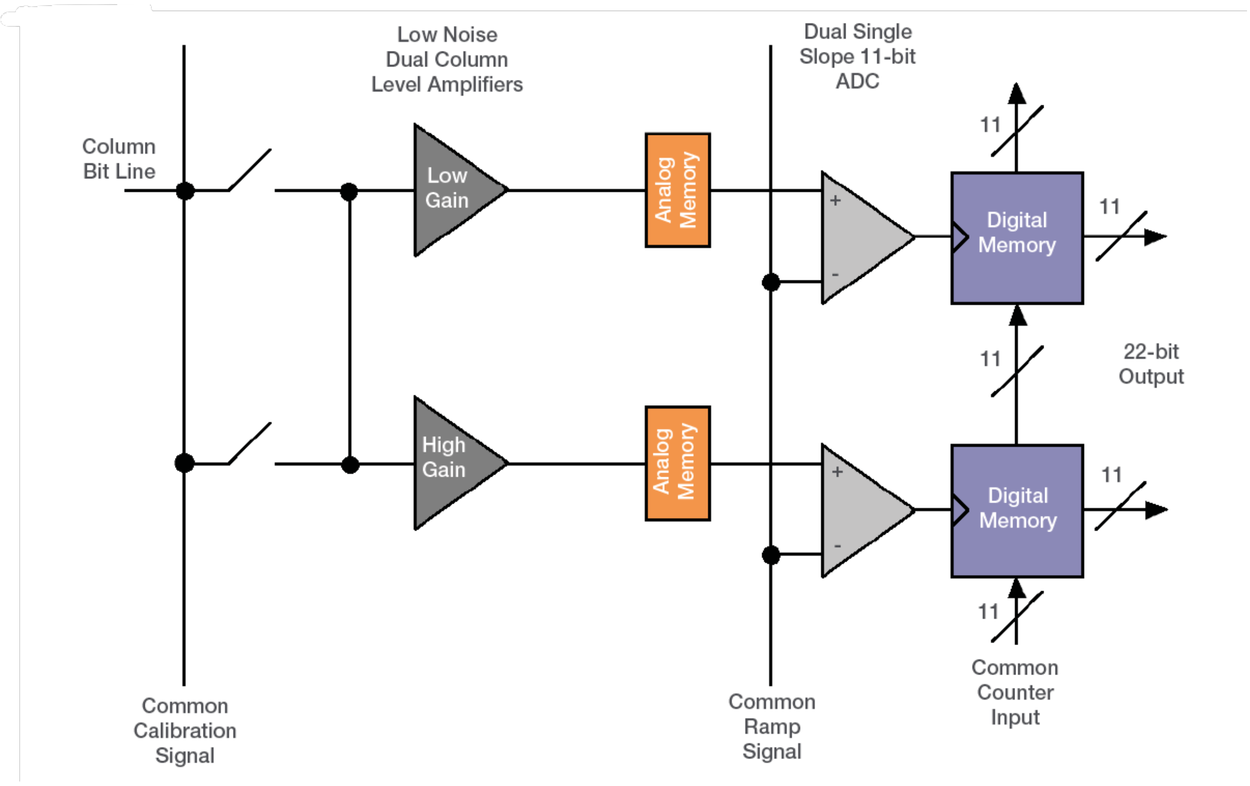


Figure 8:Amplifiers and ADC of the sCMOS Sensor

The dual column level amplifier/ADC pairs have independent gain settings, and the final image ("High contrast image of fixed labeled cell. Intensity line profile through single row demonstrates pixel regions that were sampled by high gain (low noise) and low gain (high capacity) amplifiers." on the next page) is reconstructed by combining pixel readings from both the high gain and low gain readout channels to achieve a wide intra-scene dynamic range, uniquely so considering the relatively small 6.5 µm pixel pitch.

The method of combining signals from two 11-bit ADCs can be divided into four basic steps.

1. At the end of the analog chain the “Signal” voltage is applied to two independent amplifiers: the high gain amplifier and the low gain amplifier. This results in two separate digital data streams from the sensor
2. The camera selects which data stream to use on a pixel per pixel, frame by frame basis using a threshold method
3. The data is then compensated for DC offset and gain. Again, this is done on a pixel by pixel basis using the compensation data associated with the data

stream. The gain corrects for pixel to pixel relative sensitivity, pixel node amplifier and the high and low amplifier relative gains

4. The pixels are then combined into a single 16-bit image for transfer to the PC

The user maintains the choice of opting to stay with 12-bit single gain channel data if dynamic range is not critical, resulting in smaller file sizes.

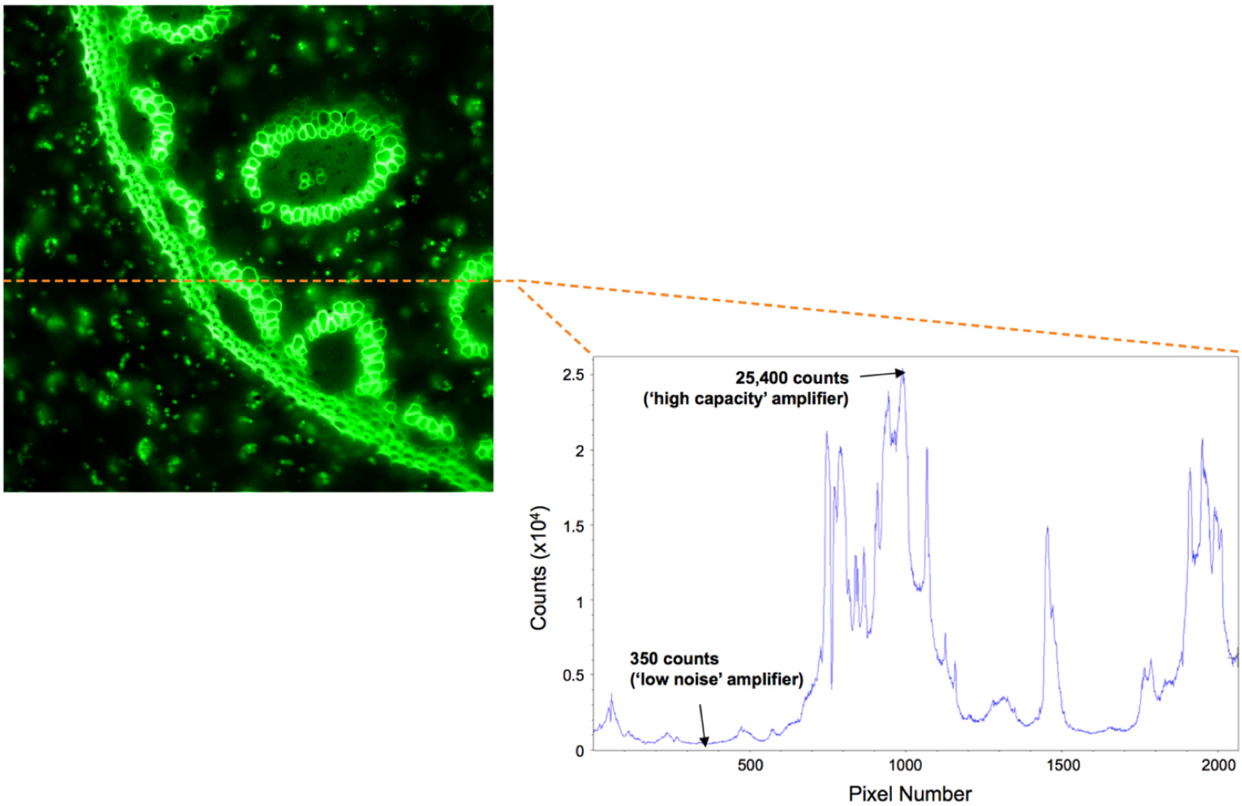


Figure 9:High contrast image of fixed labeled cell. Intensity line profile through single row demonstrates pixel regions that were sampled by high gain (low noise) and low gain (high capacity) amplifiers.

5.7 Imaging Modes

Sona and Marana provide an exceptional dynamic range on account of the combination of low noise floor and high signal handling provided by the large well depth capacity.

A dual amplifier architecture is utilised to enable both low noise, and maximum well depth to be used simultaneously. This delivers a very high linearity of >99.7% across this range allowing for quantitative analyses. When combined with the high frame rates and large sensor area this provides a lot of flexibility for how the camera may be used.

For dynamic images - Use 16-bit mode to provide the data range required to capture full range images. Frame rates will be lower than for 12-bit- however you can use Region of Interest (ROIs) to boost frame rates.

For the fastest frame rates - Use 12-bit mode for applications in which time resolution is the most critical parameter. 12-bit mode allows frame rates 2 times faster than 16-bit mode at the expense of a reduced dynamic range. ROIs can also be used to further increase frame rates

5.7.1 Sona and Marana-11 Maximum Frame rates

Max Frame Rate (fps)	Marana and Sona 4.2B-11		Sona 2.0B-11 model	
ROI Size (W x H)	16-bit	12-bit	16-bit	12-bit
2048 x 2048	24	48	-	-
1608 x 1608	30	61	-	-
1400 x 1400	35	70	35	70
1200 x 1200	41	81	41	81
1024 x 1024	48	95	48	95
512 x 512	95	190	-	-
256 x 256	190	378	-	-
128 x 128	378	750	-	-
2048 x 8	5415	9747	-	-
1200 x 8	5415	9747	5415	9747
2048 x 2	16244	24367	-	-
2048 x 1	24367	24367	-	-

Another consideration is data storage. High frame rate, full frame images at 16-bit can quickly generate many gigabytes worth of data. Using 12-bit, smaller ROIs or frames rates can help to reduce the amount of image data produced.

5.7.2 Using ROIs (AOIs)

Region of Interest (ROI) also called Area of Interest (AOI) can be selected so that only a defined region of the sensor is used. When a sub image has been defined, only data from the selected rows will be digitized.

This smaller “cropped” region of the sensor can subsequently be read out much faster than the full sensor area so that frame rates may be significantly higher (see "Imaging Modes" on page 56). Preset ROIs may be selected as well as manually defined ROIs with a 1 pixel granularity [min size. 1 (h) x 25 (w)].

5.8 Understanding Read Noise in sCMOS

sCMOS technology boasts an ultra-low read noise floor that significantly exceeds that of even the best CCDs, and at several orders of magnitude faster pixel readout speeds. For those more accustomed to dealing with CCDs, it is useful to gain an understanding of the nature of read noise distribution in CMOS imaging sensors.

CCD architecture is such that the charge from each pixel is transferred through a common readout structure, at least in single output port CCDs, where charge is converted to voltage and amplified prior to digitization in the Analog to Digital Converter (ADC) of the camera. This results in each pixel being subject to the same readout noise. However, CMOS technology differs in that each individual pixel possesses its own readout structure for converting charge to voltage. In the sCMOS sensor, each column possesses dual amplifiers and ADCs at both top and bottom (facilitating the split sensor readout). During readout, voltage information from each pixel is fed directly to the appropriate amplifier/ADC, a row of pixels at a time .

5.8.1 Binning

Binning is a process used for both CCD and sCMOS sensors in which the signal for a number of pixels is combined into a single array with a single signal output. For CCD sensors combining the charge from arrays of pixels e.g. 4 pixels (2x2 binning) into single larger "super-pixels" allows the read noise (the dominant noise source in CCDs) to be reduced since there are less read events. Binning is therefore commonly used for CCD cameras to increase the signal to noise ratio and speed of readout, at the expense of lower resolution. For further information refer to the technical note: CCD Binning.

However, for cameras with sCMOS sensors such as in the Andor ZL41, Zyla, Neo, Sona and Marana models, the binning process is performed slightly differently. Binning is processed by the FPGA after the pixels have been readout- therefore there is not the speed increase observed in CCD cameras from the reduced number of pixels being read out. After FPGA processing the pixel information is transmitted to the control PC - this may be faster when binning is applied under some conditions. For further information refer to the technical note: Binning in sCMOS cameras.

5.8.2 Spurious Noise Filter

The Spurious Noise filter corrects for pixels that would otherwise appear as spurious 'salt and pepper' noise spikes in the image. The appearance of such noisy pixels is analogous to the situation of Clock Induced Charge (CIC) noise spikes in EMCCD cameras, in that the overall noise of the sensor has been reduced to such a low level, that the remaining small percentage of spurious, high noise pixels can become an aesthetic issue. The filter actively corrects such high noise pixels, replacing them with the mean value of the neighbouring pixels The filter can be switched on and off by the user prior to data acquisition.

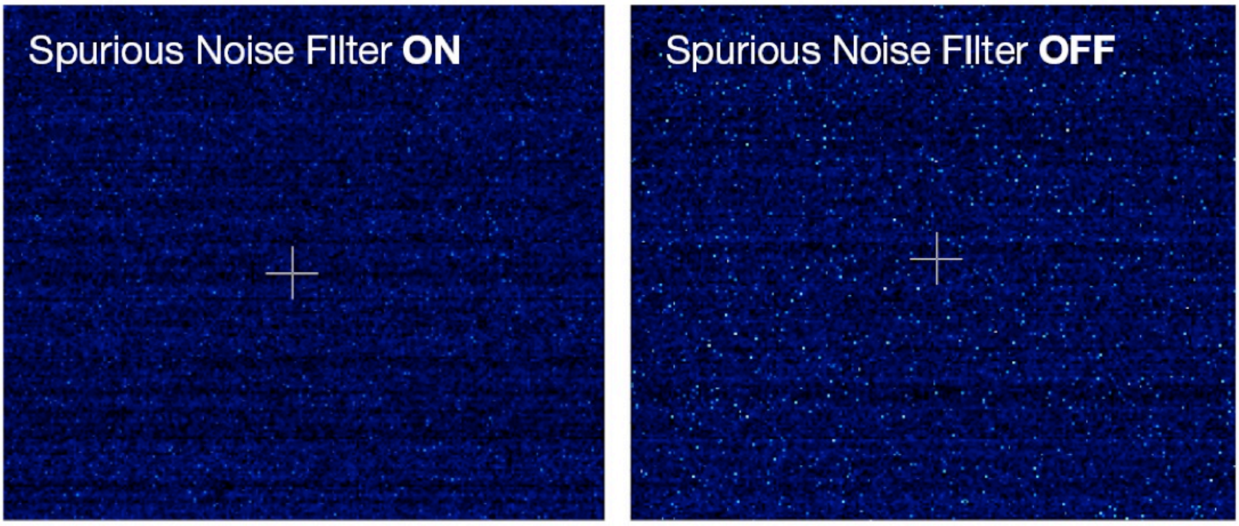


Figure 10:Demonstration of Spurious Noise Filter (Filter On left, Filter Off, Right) on a dark image, 20 ms exposure time, 200 MHz (x2 halves) readout speed

5.8.3 Blemish Correction Filter

This Blemish Correction filter identifies and compensates for three types of blemishes during the FPGA processing step:

1. Hot pixels
2. Noisy pixels
3. Unresponsive pixels

sCMOS sensors are particularly susceptible to hot pixel blemishes. These are spurious noise pixels that have significantly higher darkcurrent than the average. Through deep TE cooling of the sensor (e.g. -45^{o}C for Sona/Marana), it is possible to dramatically minimize the occurrence of such hot pixels within the sensor, meaning that these pixels can still be used for useful quantitative imaging. However, if deep cooling cannot be achieved it is necessary to use interpolative filters to minimize the hot pixel blemishes. These filters work by taking the mean of the surrounding 8 pixel values and replacing this hot pixel blemish with this mean value. Such interpolation over pixel blemishes can be detrimental in some applications that depend on total quantitative integrity over a limited set of pixels, for example in localization based super-resolution microscopy (such as PALM and STORM techniques) and astronomy. In these applications it is essential for the user to be able to switch off interpolative corrections. Furthermore, having access to the location of these blemishes allows an accurate map of 'good' pixels to be determined by the user. A new service allows the end user to request a 'hot pixel map' of their sCMOS sensor from Andor. This map will be generated based on the experimental conditions outlined by the end user. From the latest general release of Andor SDK3 (version 3.7.30004) and Solis (version 4.24.30004) blemish correction can be switched on and off by the user. Refer to the SDK and Solis User Guide and help information for instructions.

5.9 Rolling Shutter

The Sona and Marana function in what is termed Rolling Shutter operation. This describes the sequence in which the lines of the pixels are read from the sensor array in a "rolling wave" effect. In Rolling Shutter, adjacent rows of the array are exposed at slightly different times as the readout waves sweep through the sensor. Each row will start and end its exposure slightly offset in time from its neighbour. The rolling shutter readout mechanism is illustrated below.

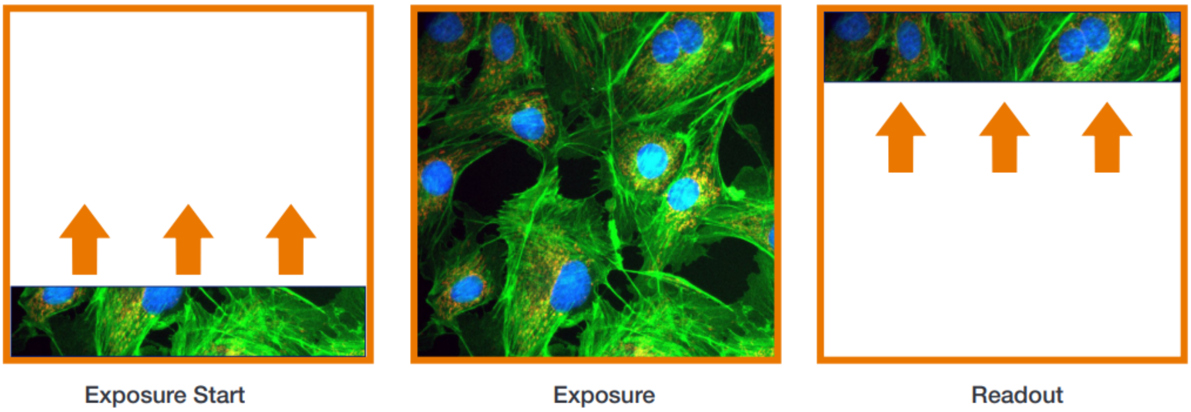


Figure 11:Rolling Shutter

- At the start of an exposure, the "Reset" wave sweeps through the sensor clearing any accumulated charge from the pixels. The pixels then start accumulating light induced charge.
- At the end of the exposure, the "readout" wave sweeps through the sensor, transferring the charge from each row into the readout node of each pixel.

So, whilst each row of pixels is exposed for exactly the same length of time they do not all start and end at exactly the same time i.e. the row at the top edge of the sensor would have started and ended its exposure after the rows at the bottom of the sensor.

Rolling shutter can be operated in a 'continuous' mode when capturing a kinetic series of images, whereby after each row has been read out it immediately enters its next exposure. This ensures a 100% duty cycle, meaning that no time is wasted between exposures and, perhaps more importantly, no photons are wasted. At the maximum frame rate for a given readout speed the sensor is continuously reading out, so as soon as the readout fronts reach the top of the sensor, they immediately return to the bottom to start readout of the next exposure.

Note: Rolling Shutter enables readout speeds to be maximised and the noise minimised - however a potential complication of this readout type is spatial distortion. This was more commonly associated with older CMOS

Exposure Start Exposure Readout camcorders were the image readout rate was not fast enough to keep up with a panned image. In modern sCMOS cameras however, the readout speeds are faster and rolling shutter is suitable for the majority of scientific applications. Some sCMOS cameras such as Neo and ZL41 Cell 5.5 can operate in a mode called Global Shutter as well as Rolling Shutter. Global Shutter which can be thought of as a “snapshot” as all pixels of the array are exposed simultaneously. This avoids spatial distortion, however frame rates are reduced and noise is higher when compared to operation in Rolling Shutter mode.

5.9.1 Rolling Shutter Mechanisms

In Rolling Shutter mode, charge transfer happens on a per row basis whilst in global shutter charge transfer happens for the whole sensor or globally. To read out a pixel in Rolling Shutter mode, the following occurs within the analog circuitry:

1. The read out node is reset
2. The node level (reference level) is measured
3. Charge is transferred from photodiode to node
4. The node level (signal level) is measured
5. Reference level (step 2) is subtracted from signal level (Step 4) to get real signal

This process is commonly referred to as CDS (Correlated Double Sampling) and is done in the analog domain before digitization. The reason it is required is due to what is known as reset noise, this arises because every time the node is reset it does not settle at exactly the same level and hence the actual level must be measured (Step 2.) and subtracted from the signal level (Step 4) to get the real signal.

5.10 Trigger Modes

The Sona and Marana-11 camera has the following triggering modes:

- **Internal Trigger** - the camera determines the exact time when an exposure happens based on the acquisition settings entered by the user. This is the most basic trigger mode and requires no external intervention.
- **External Trigger** - the camera and software are in a high state of readiness to accept a trigger from an external source. Refer to "Minimum EXT Trigger Width" on page 70 for the minimum pulse width required to guarantee a trigger. The external trigger is fed via the External Trigger input on the I/O Connector on the camera head.
- **Software Trigger** works in the a similar manner to External Trigger mode whereby the camera and software are in a high state of readiness and can react extremely quickly to a trigger event issued via software. This mode is particularly useful when the user needs to control other equipment between each exposure and does not know in advance how long such control will take or if the time taken changes randomly.
- **External Start** is a mode where the camera will wait for one external trigger event to occur after the acquisition sequence has been started. Once this external trigger event is detected, the camera will start the Internal Trigger read out process and will progress as if the camera was in internal trigger mode.
- **External Exposure Trigger** is a mode of operation where the exposure time and cycle time are controlled by the external trigger input.

The TTL inputs and outputs may be used to synchronize the camera operation with external events or equipment.

The individual outputs are described in the following sections.

The AUX_OUT_1 output can be configured via software (Solis or SDK) to provide one of the following outputs: FIRE, FIRE n, FIRE ALL, or FIRE ANY.

The default state provides 'FIRE ALL on this output.

The polarity of the TTL inputs and outputs can also be inverted (individually) via either Solis or SDK.

Note
'Row 1' is the first row read out in the image frame. 'Row n' is the last row read out in the image frame. **The trigger diagrams in the following sections are for outlining the events and timing of outputs in the various trigger modes and not to scale.**

5.10.1 Software Acquisition Events

Software Acquisition Events are only accessible via SDK- these are not available in Solis, Fusion, iQ or other software but may be used internally. Refer to the SDK3 manual for further information on configuration of Software Acquisition Events.

If Acquisition Events are not used, the user must wait until the image frame has been completely transferred to the PC before they receive any notification that the exposure has completed. With Acquisition Events and in particular the ExposureEndEvent the user will be notified as soon as the exposure is complete in advance of readout completion. This in conjunction with SW trigger, means that the next acquisition can be started much sooner, resulting in an improvement in frame rate.

5.10.2 Signal Information

The Rolling Shutter signals in the diagrams are as follows:

- **FIRE**: (Exposure for Row 1): In Rolling Shutter mode, the FIRE output from the camera indicates to the user the exposure time for the first row
- **FIRE Row n**: (Exposure for Row n): The exposure for Row 2 is delayed by one row time relative to Row 1, Row 3 is delayed by one row time relative to Row 2, etc. for all rows in the frame (up to Row n). This signal is connected to an external output from the camera known as FIRE Row n.
- **FIRE ALL**: The Fire ALL output from the camera indicates when all rows within a frame are being simultaneously exposed.
- **FIRE ANY**: The FIRE ANY output indicates when any row within a frame is being exposed.
- **ARM**: The ARM output from the camera is used in external and software triggering modes to indicate when the camera is ready to accept an incoming trigger. If ARM is low when a trigger event occurs, it will be ignored
- **Frame Readout Phase**: This signal shows the period during which the signal frame is read out from the sensor
- * : Marks the start of an exposure.
- * : Marks the end of exposure.

Throughout this section exposure times are referred to as either "Short" or "Long".

Short refers to when the required exposure time is less than the time it takes to read out a frame.

Long refers to when the required exposure time is greater than the time it takes to read out a frame

5.10.3 Timing Parameters and Ext Triggering

The timing tables accompanying each of the triggering diagrams that follow indicate the exposure and cycle times achievable in each triggering mode for the Sona and Marana-11. These are based on Frame and Row Periods as shown below.

Table 5:Timing Parameters based on Sensor Clock Speed:

	16-bit	12-bit
1 Row	20.52 µs	
1 Full Frame (2048 rows)	42.025 ms	21.012 ms

Note
Due to the architecture of the sensor in a "Row Time" in 16-bit mode a single row from the sensor can be read, however, in 12-bit 2 rows are read out within this period. The definition of the term Row time used here is because all actions with the sensor are synchronised to this Row time.

In External and External Start Triggering Modes, the minimum trigger pulse width detected by the camera is:

Table 6:Minimum EXT Trigger Width

EXT Trig Pulse Width	6.6 ns

5.10.4 Rolling Shutter Internal Triggering (Non-Overlap Mode)

Internal Trigger Mode allows the user to configure an exposure time and cycle time. For Internal Triggering Non-overlap mode, the exact acquisition sequence depends on the exposure time and cycle time set . The following diagrams show the behaviour of TTL outputs **'Fire'**, **Fire n'**, **'Fire ALL'** and **'Fire ANY'**.

Fire ALL indicates the time period within a frame during which all rows are exposing simultaneously.

Fire ANY indicates the time period within a frame during which any row is exposing.

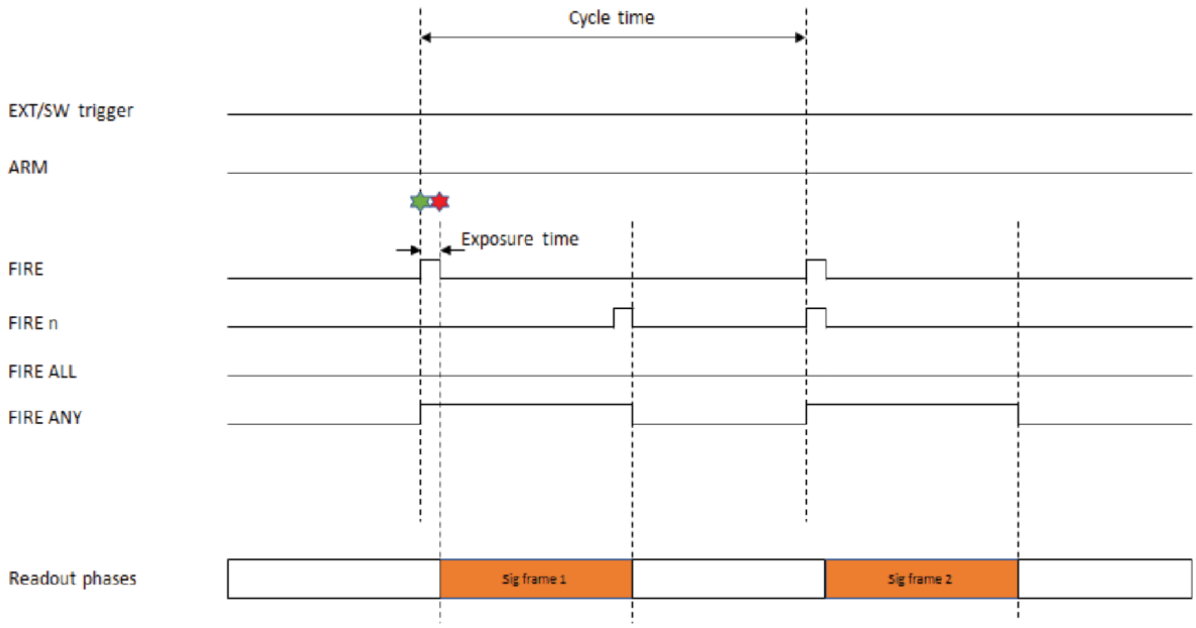


Figure 12:Internal Triggering "short" (non-overlap)

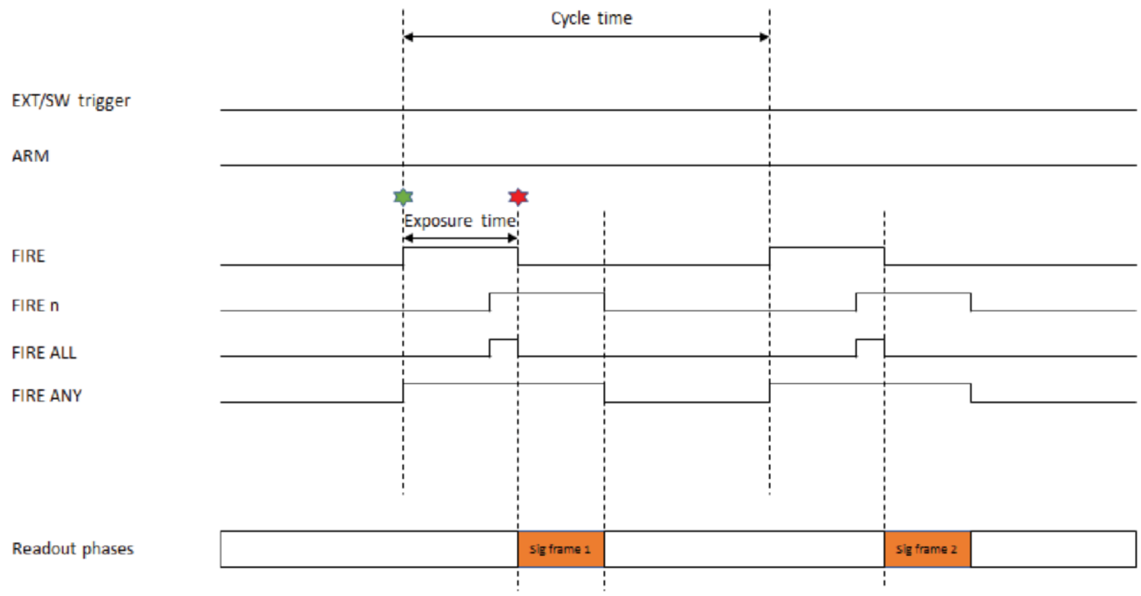


Figure 13:Internal triggering "long" (non-overlap)

Parameter	Minimum	Maximum
Exposure	1 Row	30 s
Cycle Time (1/Frame Rate)	Exposure + 1 Frame + 1 Row	44,000 s

Note
Actual minimum Exposure time is 15 µs in 12-bit mode and 9.48 µs in 16-bit mode. The exposure time is incremented in 1 Row time steps

5.10.5 Rolling Shutter Internal Triggering (Overlap Mode)

Internal Triggering in Overlap Mode allows the user to perform an exposure and acquire images from the sensor simultaneously. This is achieved by starting a new exposure for a new frame while the current frame's exposure is being read out from the sensor.

When the required exposure time is less than the time it takes to read out a frame (Short Exposures), the cycle time is always defined by the time taken to read out a frame + 1 Row time. See below.

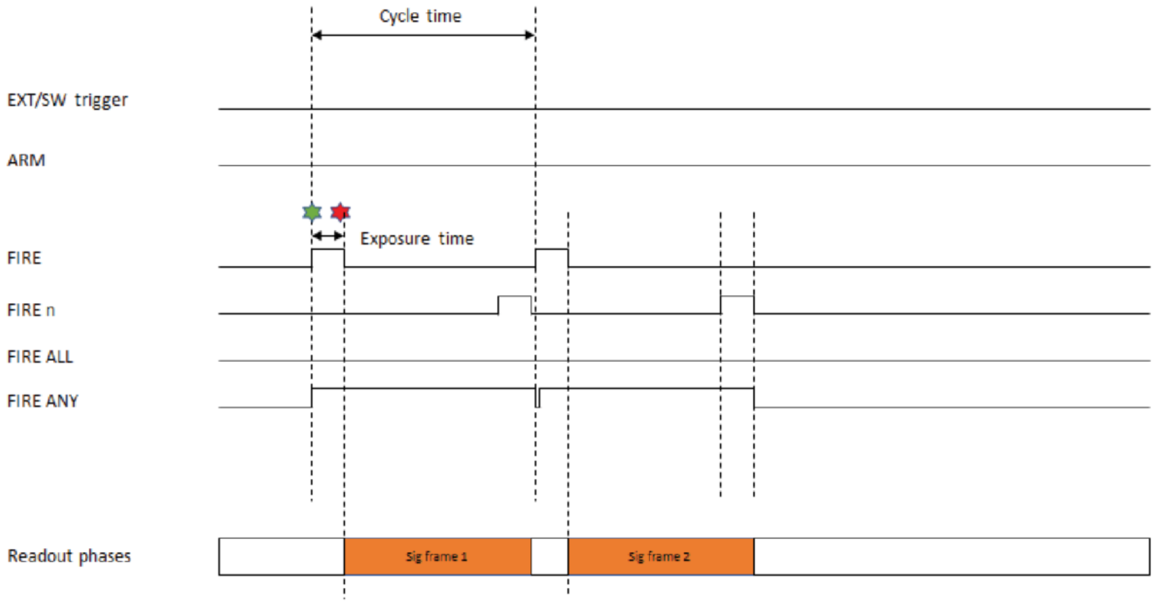


Figure 14:Internal Triggering "short" (overlap)

When the required exposure time is greater than the time it takes to read out a frame (Long Exposures), the cycle time is defined by the Exposure time + 1 Row time. See below.

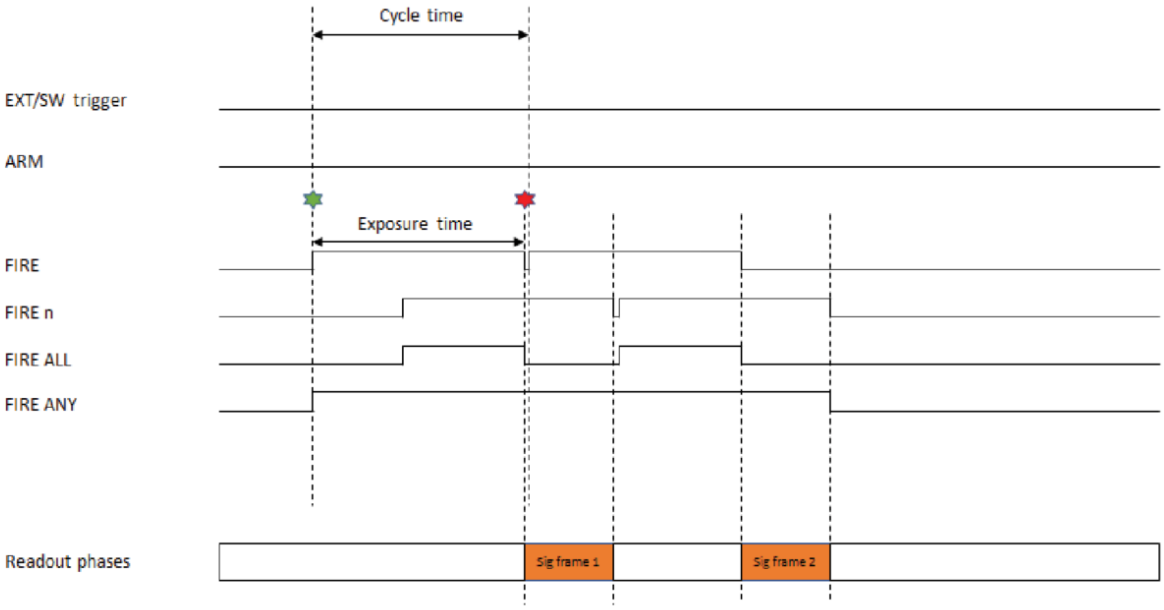


Figure 15:Internal Triggering “long” (overlap)

Parameter	Minimum	Maximum
Exposure	1 Row	30 s
Cycle Time (1/Frame Rate)	Greater of: 1 Frame + 1 Row or Exposure time + 1 Row	
FIRE Any low period	~5 µs in 12-bit and ~10 µs in 16-bit (1 Row)	

5.10.6 Rolling Shutter External Triggering (Non Overlap Mode)

In this section, both External and Software Trigger are described in the same diagram as the acquisition sequence is the same. The trigger event can either be from the EXT Trigger input or sent via software. The ARM signal is asserted to indicate it is ready to detect an incoming trigger input.

Once the trigger event is detected a rolling reset is initiated, this effectively begins a new exposure. When the exposure period has completed, a signal frame read out phase begins. Once the frame has been read out completely the Arm signal goes high and the camera waits for the next trigger event to be detected.

The external trigger is fed via the EXT Trigger input on the I/O Connector on the camera head.

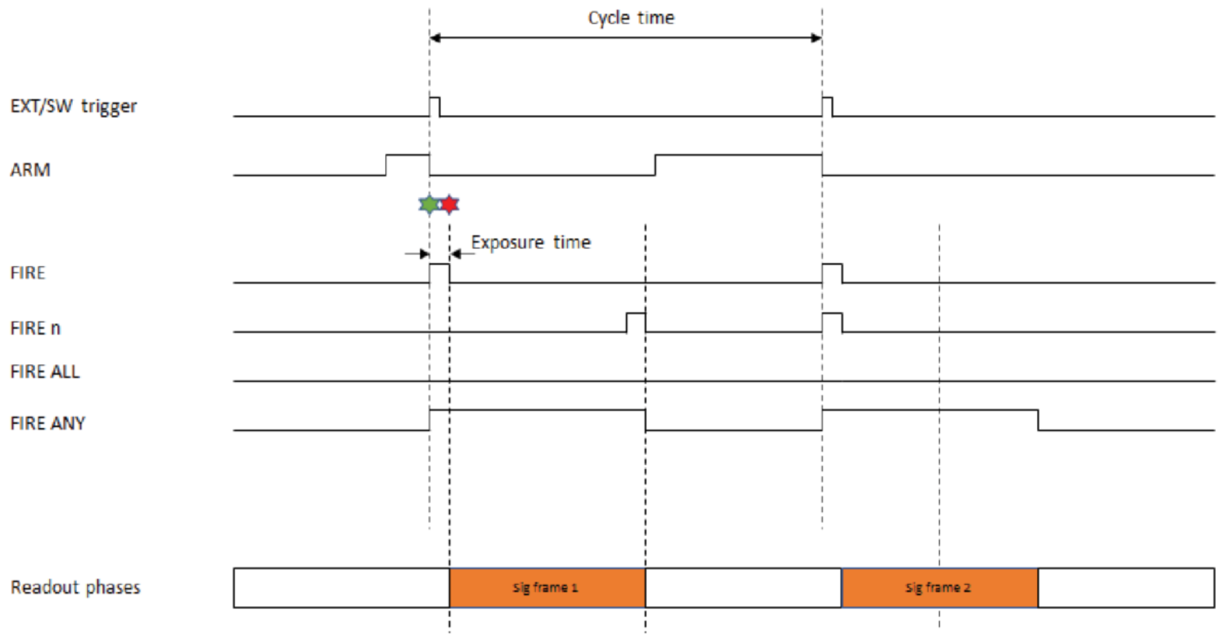


Figure 16:External Triggering "short" (non-overlap)

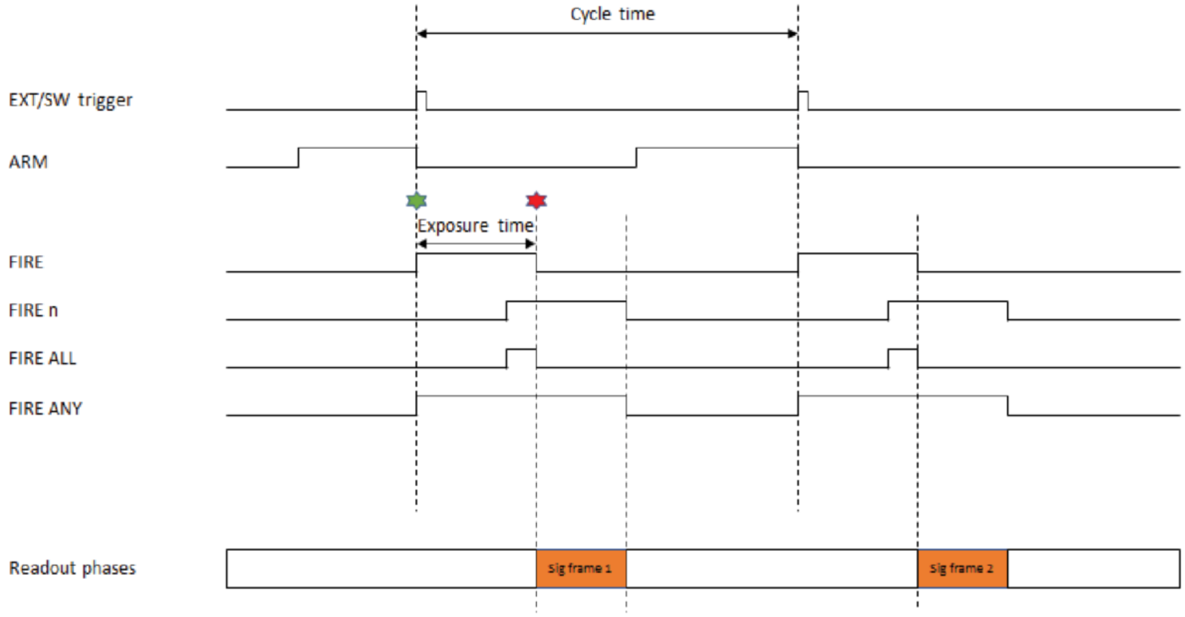


Figure 17:External Triggering "long" (non-overlap)

Parameter	Minimum	Maximum
Exposure	3 Rows	30 s
Cycle Time (1/Frame Rate)	Exposure + 1 Frame + 1 Row	-
External Start Delay	0	1 Row
EXT Trig Pulse Width	6.6 ns	-

5.10.7 Rolling Shutter External Exposure Triggering (Non-Overlap Mode)

On detection of the trigger event a reset read out is initiated, this effectively begins a new exposure. When the external trigger input goes LOW, a signal frame read out phase begins. When the frame has been read out completely, the Arm goes high and the camera waits for the next trigger event to be detected.

The external trigger pulse width defines the exposure time for all rows but is only coincident with the exposure time for Row 1. The exposure for Row 2 will be delayed by one row time relative to Row 1 and so forth.

The period of the external trigger pulse defines the overall cycle time. If the width of the trigger event is less than 3 Rows the falling edge will be missed, and a subsequent falling edge will be required to end the exposure

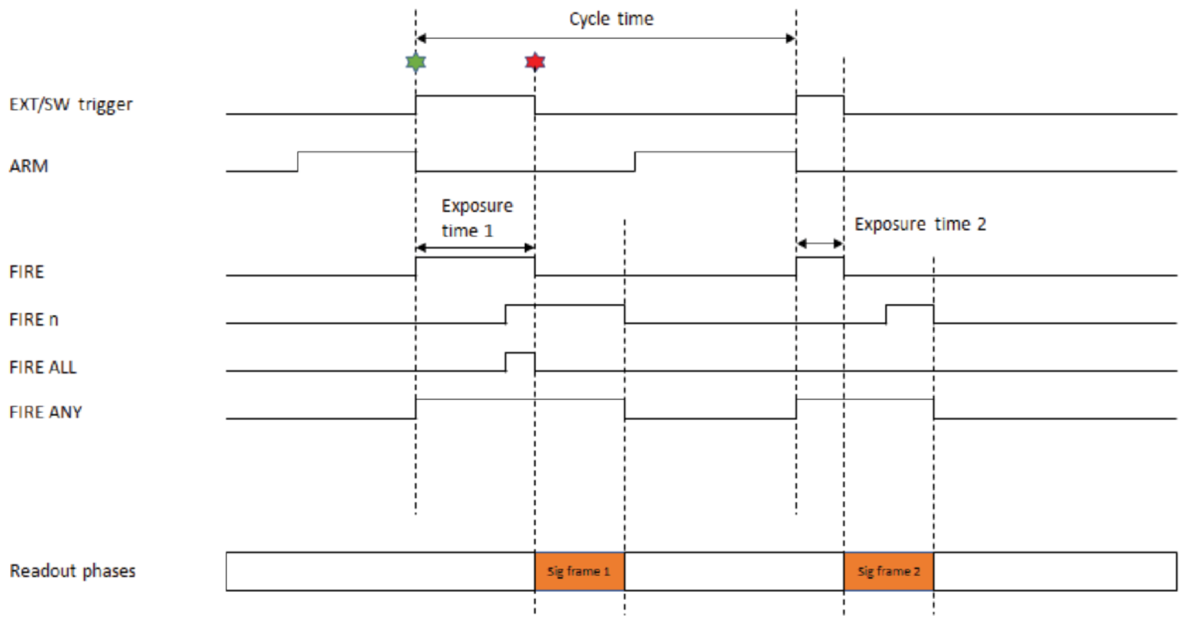


Figure 18:External Exposure "long" (non-overlap)

Table 7:Rolling Shutter External Exposure Triggering (Non Overlap Mode) Timing Parameters

Parameter	Minimum	Maximum
Exposure	3 Rows Fire = 2R + 15 µs (12-bit) = 2R + 10 µs (16-bit)	30 s
Cycle Time (1/Frame Rate)	Exposure + 1 Frame + 1 Row	-
External Start Delay	0	1 Row

Parameter	Minimum	Maximum
EXT Trig Pulse Width	2 Rows	30 s

5.10.8 Rolling Shutter External Exposure Triggering (Overlap Mode)

In overlap mode, every positive edge of an external trigger will trigger a frame read out and start a new exposure for the next frame. The period of external trigger pulse defines exposure and cycle time for each frame read out.

On detection of the positive edge a frame read out is initiated at the start of the next Row read period. This frame is discarded as it does not contain the correct exposure period. Reading out this first frame effectively begins the first exposure. When the next positive edge of the external trigger is detected, a signal frame read out is initiated at the start of the next Row read period. As each row is read out, the new exposure for that row begins.

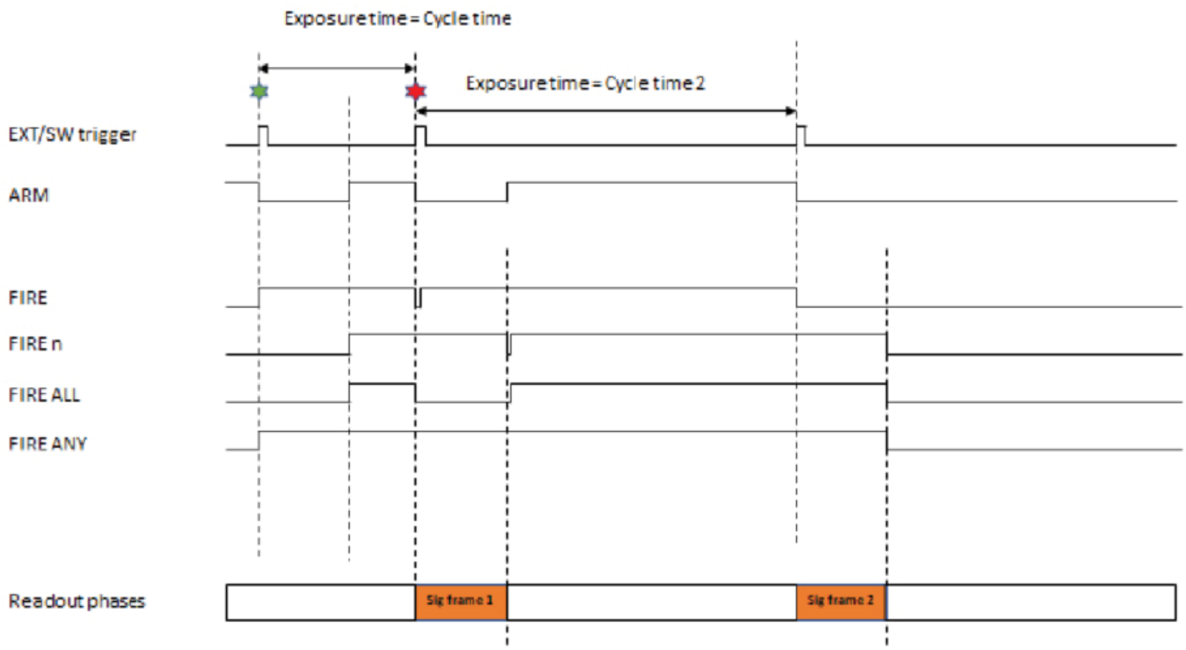


Figure 19:External Exposure "long" (overlap)

Parameter	Minimum	Maximum
Exposure	1 Frame + 2 Row	30 s
Cycle Time (1/Frame Rate)	Exposure	Exposure
External Start Delay	6.6 ns	1 Row
EXT Trig Pulse Width	2 rows	-
FIRE low period	6 μs (12-bit) 11 μs (16-bit)	-

5.10.9 Rolling Shutter External Start Triggering

In this mode the camera will wait for a single external trigger event. Once this external trigger event is detected, the camera will progress as if the camera was in internal trigger mode (see "Rolling Shutter Internal Triggering (Overlap Mode)" on page 73 and "Rolling Shutter Internal Triggering (Non-Overlap Mode)" on page 71. The ARM signal indicates to the user when the camera is ready to detect an External Start Trigger. "Rolling Shutter External Start Triggering (Non Overlap)" below shows the External Start used in Non-overlap Mode, Long Exposure. The delay from the External Trigger to start of exposure is between 0 and 1 Row.

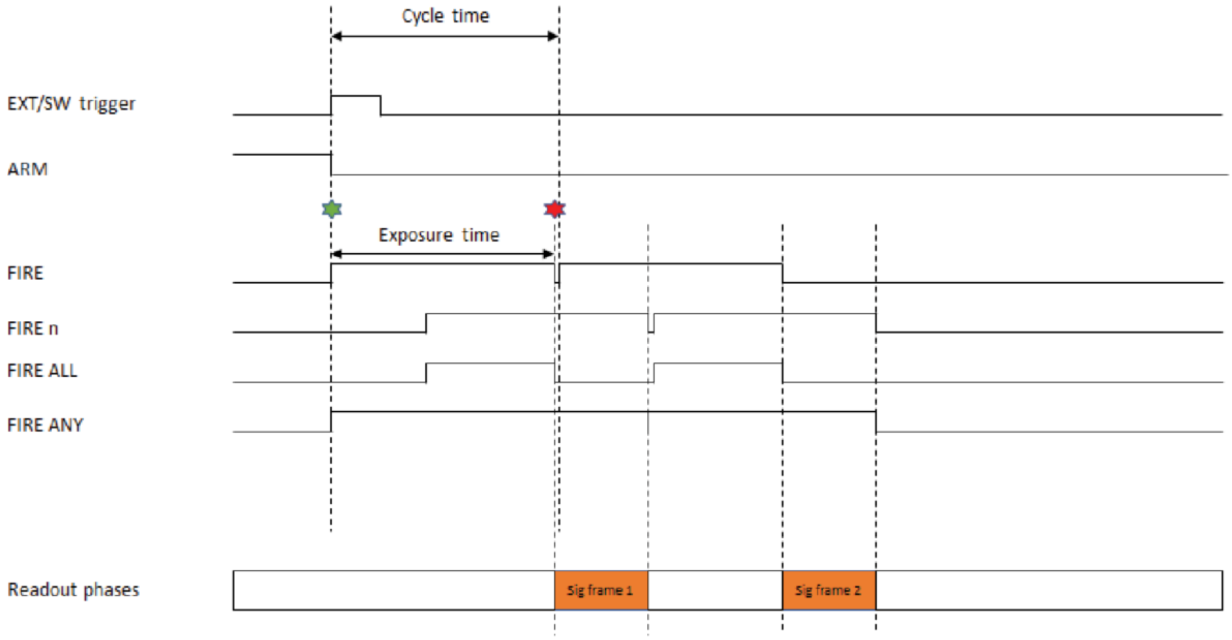


Figure 20:Rolling Shutter External Start Triggering (Non Overlap)

5.10.10 Rolling Shutter Triggering Constraints

The table below shows a summary of constraints when operating in Rolling Shutter mode:

Table 8:Rolling Shutter Mode Triggering Constraints

Rolling Shutter Triggering Modes		Exposure Range	Max Trigger Jitter	Min Trigger Pulse Width	Fast Exposure Switching Supported
Internal (Non-Overlap)	User settable exposure time. User settable Cycle Time.	1 Row to 30 s	-	-	Yes
Internal (Overlap On)	User settable exposure time.	1 Row to 30 s	-	-	Yes
External (Non Overlap)	Exposure time user settable. Cycle Time controlled via external trigger pulse	3 Rows to 30 s	1 row	6.6 ns	Yes
Software (Non Overlap)	Exposure time user settable. Cycle Time controlled via software trigger function	3 Rows to 30 s	1 row	6.6 ns	Yes
External Exposure (Non Overlap)	Exposure Time controlled by width of external trigger pulse. Cycle Time controlled via period of external trigger pulse.	3 Rows to 30 s	1 row	2 rows	No
External Exposure (Overlap On)	Exposure time controlled by period of external trigger pulse	(1 Frame + 2 Row) to 30 s	1 row	6.6 ns	No
External Start (Non Overlap)	User settable exposure time. User settable Cycle Time.	1 Row to 30 s	1 row	6.6 ns	Yes

Section 6 - Maintenance

Caution
There are no user-servicable 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.
- Ensure that the AC mains plug in connection to building power outlet remains readily accessible to facilitate disconnection from the power supply.
- Do not use equipment that is damaged.

6.2 General Cleaning & Decontamination Information

- The product body can be cleaned with a soft cloth and dampened by water or glass cleaner.
- Never spray liquids directly on the product; apply cleaning solution to the cloth, then wipe the product body with the dampened cloth.
- Do not use abrasive or other detergents to clean the product.
- Decontamination: In the event any product must be returned the customer must complete a decontamination form to declare the equipment is contamination free and safe for Andor employees to work on: andor.oxinst.com/rma

6.3 Fuse Replacement

In the U.K., Ireland and some other countries, the supplied mains cable has a BS 1363/A (also known as ITA 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:

- **Rating:** 5 A, 240 VAC
- **Type:** BS 1362, size: ¼ × 1" (6.3 × 25.4 mm) cartridge

6.4 Annual Electrical Safety Checks

- It is advisable to check the integrity of the insulation and protective earth of the product on an annual basis, e.g. U.K. PAT testing. However over time the repetition of dielectric strength tests can damage safety insulation.
- Do not use equipment that is damaged.

6.5 Cleaning the Camera Window

At some point, it may become necessary to clean debris that may have settled on the sCMOS imaging sensor window. Cleaning the camera window can provide effective results providing you carefully follow these step-by-step directions.

Caution
Only open the shutter (if present) using camera control software.
Do not attempt to manually open the shutter (if fitted) with your fingers or other objects.
Scratching the window may require the window to be replaced which is not covered under the product warranty
Cleaning the window is done entirely at the customers risk, window replacement is not covered under the warranty. It's better to under-clean than to over-clean.

Tools Required

- Compressed Air Can (or source of clean compressed air)
- Optics Brush

Window Cleaning Procedure

1. Remove the camera from your microscope (or other optical equipment) and place it on a clean dry surface.
2. Use the camera control software to open the shutter (if fitted).

   If your program does not have this feature, try starting a long exposure. Over exposing the sensor to room light will not damage the sensor.

   #### Guidelines for using Compressed Air

   If you are using a compressed air can always test-blast away from window before blowing air on the window. When you test-blast, you'll notice a spray of condensation shoot out from the can.

   • If condensation does form on the window, do not wipe it off. Allow it to fully dry before proceeding.

   • Always orient the compressed air can in an upright position before spraying.

• A clean source of compressed air such as an air can is recommended- do not use a compressor that may spray fine droplets of oil, or an unfiltered air supply that may spray dust particles onto the camera window.

3. With the shutter (if present) open, turn the camera on its side making it easier for particles to fall out of the camera head face the window toward you at the edge of a table.
4. Give the window short blasts of compressed air to work dust particles out of the camera head.
5. If there are still particles stuck on the window use an optics brush to very carefully dislodge them from the window surface. Then spray the dust particles out of the camera head with compressed air.
6. Make sure to use compressed air to clean your adapter tubes and focal reducers as well so you don't get more dust once everything's assembled.

6.6 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

Preventing Condensation

- Take special care during installation as the temperature of the camera may be low from shipping or storage. When moved to a warmer environment such as a lab, there is a higher risk of condensation forming. Therefore, ensure that sufficient time is allowed for the product to reach the ambient temperature of the operating environment before use (this may take several hours).
- Never use water that has been chilled below the dew point of the ambient environment to cool the camera.

How may Condensation be detected?

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.

   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.

Refer to "Dew Point Graph" on page 101

Fault	Cause	Solution
Camera buzzer does not sound on start-up.	Communication error.	Ensure that power is connected to the camera and the On/Off switch is set to On
Camera is not recognized by PC.	Camera not switched on.	Ensure the camera is switched on.
	USB cable not connected.	Check that USB cable is connected between the camera and the USB port on the PC.
	CXP cable not connected.	Check that CXP cable is connected between the camera and the PCIe card on the PC.
Camera not recognized by camera control software.	Camera control software has been started before camera has finished initialisation.	Wait until you hear a single beep followed by a double beep from the camera before the software is started (Otherwise the camera control software will not be able to connect to the camera).
Buzzer sounds continuously.	Over temperature condition (overheating).	Power off the camera to allow it to cool down. Check camera is operating within the specified temperature range. Check fan vents not obstructed. Check water cooling system is functioning. If trying to cool to -45°C please ensure liquid cooling system is connected and running.
Fan not operating as expected.	Fans rotate at full speed if temperature gets too high.	Check settings. Check fans and vents are rotating and free of obstruction.
Camera does not cool to the required temperature	Ambient temp is above specified operating range.	Check ambient temp is with specified range.
	Fans may be obstructed	Check fans and vents are rotating and free of obstruction.

Fault	Cause	Solution
	Liquid cooling system not functioning correctly	Check cooling system.
Camera image quality not as expected: e.g. image noise.	The sensor must cool down to the target temperature before scientific grade images are taken. It may still be possible to image before this happens.	Ensure that the camera has reached target temperature before acquiring images. This can be checked in the camera control software: e.g. in Solis in the temperature status bar.
Fire, Aux_Out and Arm outputs not functioning correctly	These are 5 V TTL outputs which should not be used to drive low impedance loads	See "Multi I/O Timing Cable Pin Outs" on page 21
External Trigger input not functioning correctly.	This is a 5 V TTL input which should be driven from a 5 V TTL compatible source.	See "Multi I/O Timing Cable Pin Outs" on page 21
Frame rates do not match expected rates.	If using standard USB card installed on PC/laptop resource may be split between components, reducing performance.	Use supplied USB 3 card to ensure performance.
	Camera settings do not match those required for best performance.	Check camera acquisition settings.

Appendix

The following sections contain information on product specifications, including technical, environmental, mechanical and electrical specifications. In addition, detailed mechanical drawings are presented.

Appendix A: Technical Specifications

Model Specific Specifications[1]

Model	Sona/Marana-11 (32 mm)	Sona/Marana -11 (22 mm)
Sensor Type	Back-Illuminated Scientific CMOS	
Array Size	2048 (W) x 2048 (H) 4.2 Megapixel	1400 (W) x 1400 (H) 2.0 Megapixel
Pixel Size	11 x 11 µm	
Image Area	22.5 mm x 22.5 mm (31.9 mm diagonal)	15.5 mm x 15.5 mm (21.8 mm diagonal)
Readout Modes	Rolling Shutter	
Pixel Readout Rates	100 MHz (High Dynamic Range, 16-bit) 200 MHz (Fast Speed, 12-bit)	
Quantum Efficiency[2]	up to 95%	
Read Noise (e-) median	1.6 e- (at any readout rate)	
Sensor operating temperature[3] Air cooled Water/liquid cooled	+15°C, -25°C +15°C, -25°C, -45°C	
Dark Current Air cooled (@-25°C) Water/liquid cooled (@ -45°C)	0.7 e-/pixel/s 0.3 e-/pixel/s	
Active area pixel well depth	85000 e- (High Dynamic Range, 16-bit) 2600 e- (Fast Speed, 12-bit, bit depth limited)	
Dynamic Range	53000:1 (High Dynamic Range, 16-bit)	
Data Range	16-bit (High Dynamic Range) 12-bit (Fast Speed)	
Linearity[4]	> 99.7%	
PRNU	< 0.5% (@ half-light range)	
Region of Interest (ROI)	User-definable, 1 pixel granularity, min. size 25 (w) x 1 (h)	
Pre-defined ROI	1608 x 1608, 1200 x 1200, 1024 x 1024, 512 x 512, 128 x 128	1024 x 1024, 512 x 512, 128 x 128
Pixel Binning (on FPGA)	2 x 2, 3 x 3, 4 x 4, 8 x 8 (user-definable binning also available)	

General Specifications[1]

Model	Sona and Marana-11
I/O	O: Fire Row 1, Fire Row n, Fire All, Fire Any, Arm, I: External
Trigger Modes	Internal, External, External Start, External Exposure, Software
Software Exposure Events[5]	Start exposure - End exposure (row 1), Start exposure - End exposure (row n)
Image Timestamp Accuracy	25 ns
PC Interface	USB 3.0[6] and CoaXPress
Camera Window	AR coated UV grade fused silica window
Lens Mount	F-mount (Sona and Marana-11 (32 mm)) C-mount (All other models)

1. Figures are typical unless otherwise stated.
2. Quantum efficiency as supplied by the sensor manufacturer.
3. Coolant temperature must be above dew point.
4. Linearity is measured from a plot of Signal vs. Exposure Time over the full dynamic range.
5. Software Exposure Events provide rapid software notification (SDK only) of the start and end of acquisition.
6. The Sona connects to your control PC using a USB 3.0 connection. This may also be referred to as USB 3.1 (Gen 1). Andor provide a USB 3.0 card and cable, and recommend that these are used to ensure optimum performance.

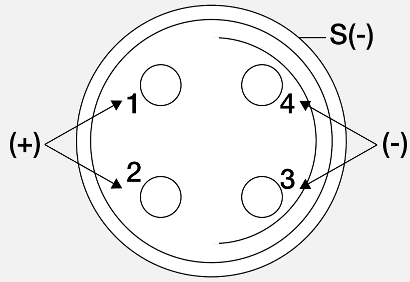
Environmental Specifications

Location to be used	Indoor use only
Altitude Limit for Air-cooling	Up to 2000 m
Altitude Limit for Water-cooling	Up to 6000 m
Operating temperature	0°C to +30°C ambient (non-condensing)
Storage temperature	-10°C to 50°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.
Cooling vent clearance	Do not cover during operation. Allow 100 mm clearance at air vents.

Power Supply Information

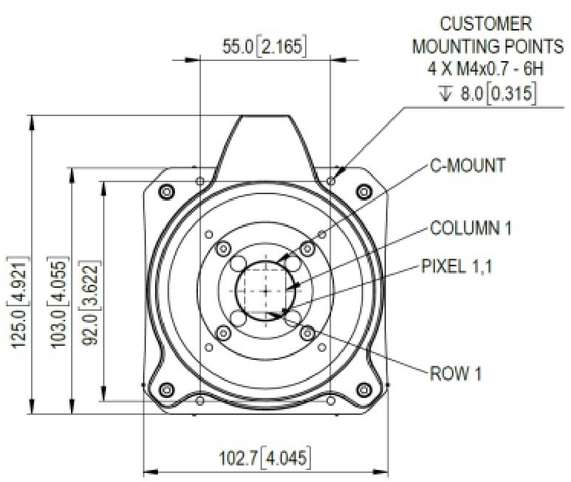
	Sona and Marana-11
Mains Input for Supplied External Power Supply	100 – 240 VAC, 50 – 60 Hz
Power Consumption (inc. External Power Supply)	Camera + External Power Supply: Air cooling of sensor to -25°C: 40 W typical/ 114 W max Water cooling of sensor to -45°C: 40 W typical/ 114 W max Camera Only: Air cooling of sensor to -25°C: 35 W typical / 100 W max Water cooling of sensor to -45°C: 35 W typical/ 100 W max
Voltage Rating	15 V
Current Rating	8 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.

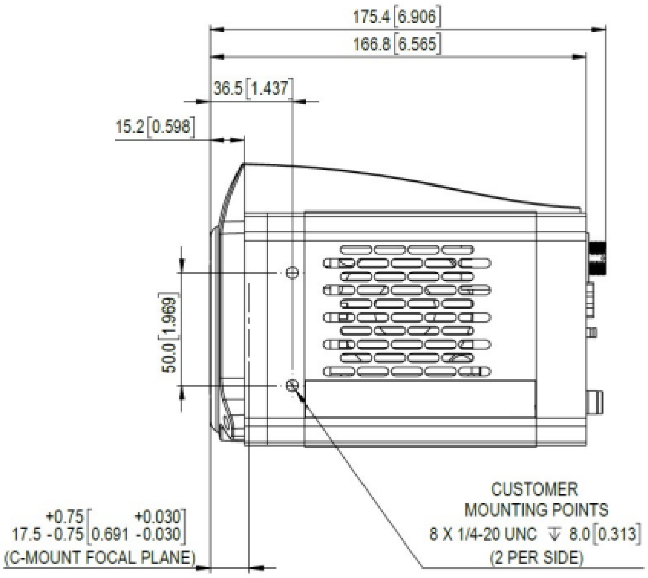
External Power Supply Specifications

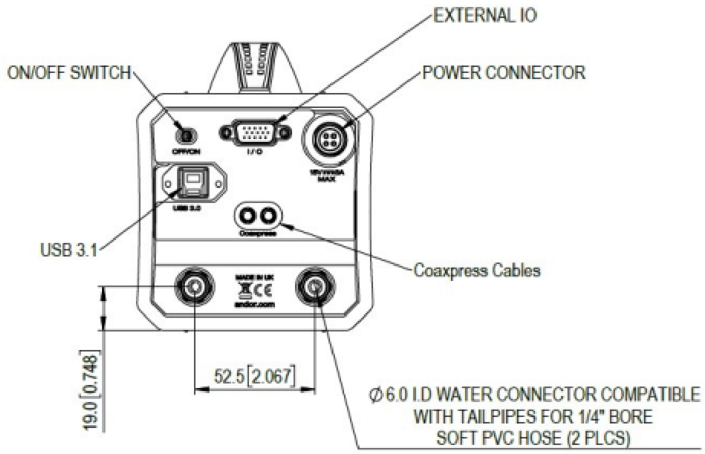
	Sona and Marana-11
Low Voltage Supply Input	15 V +/- 5%
Low Voltage Supply Current	8 A
Low Voltage Supply Cable Connector	Right-angle Plug: Fischer WSO 104 A037-130+ Straight Plug: Fischer S 104 A037-130+ Required Cable Clamp Set: Fischer E3 104.3/6.7+B
Low Voltage Supply Pin Connections	Pins 1 & 2: +15 V Pins 3 & 4: 0 V Shield: 0 V
Low Voltage Supply Cable Plug Insertion View	
Ripple	150 mV peak-to-peak
In-rush Current Capability	Shall start up a load whose in-rush current from a 0.15 Ω source resistance is 2.7 A min. peak and a pulse width of 15 ms min. measured at half the peak.
Safety	Certified to IEC 62368-1 in accordance with local safety regulations and meets the reinforced insulation from mains requirement of IEC 61010-1
Environmental	Ensure that the EPS meets the environmental specification of the overall product

Appendix B: Mechanical Drawings

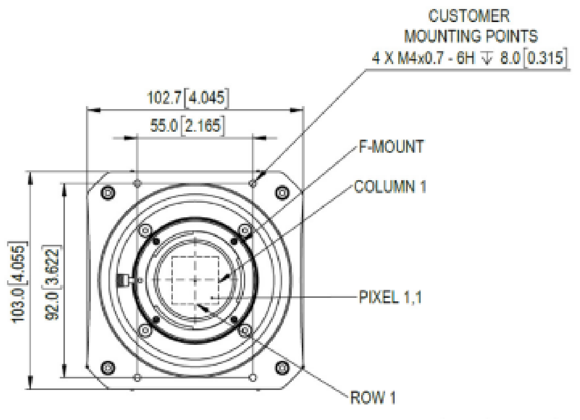
Sona Mechanical Drawings

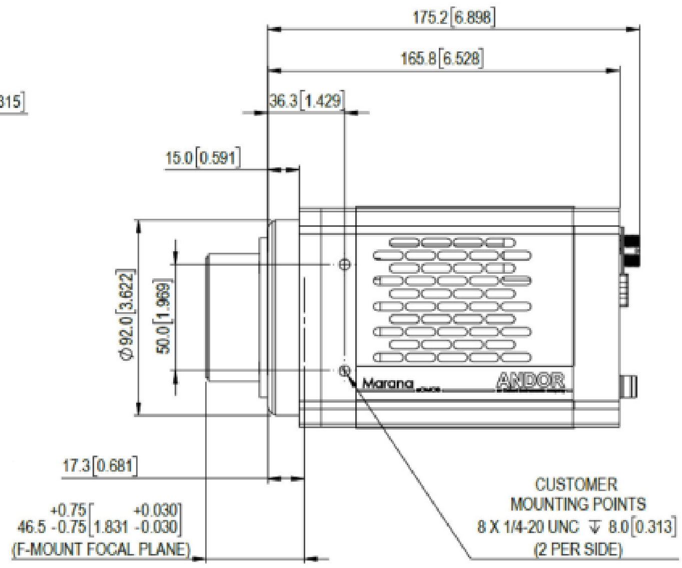


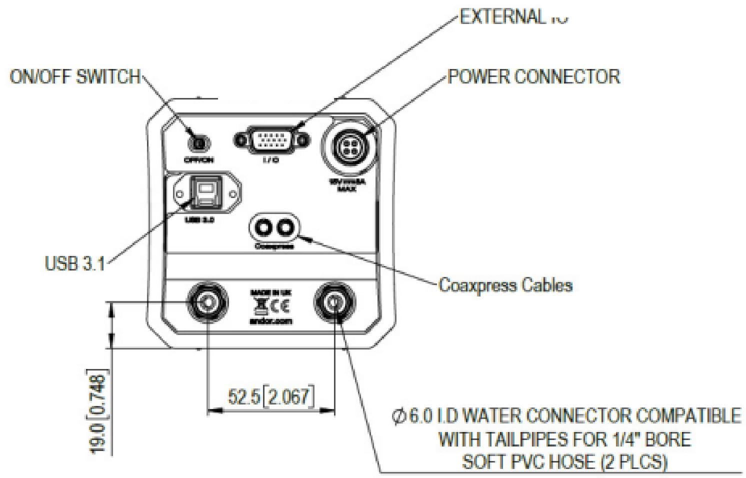




Marana Mechanical Drawings

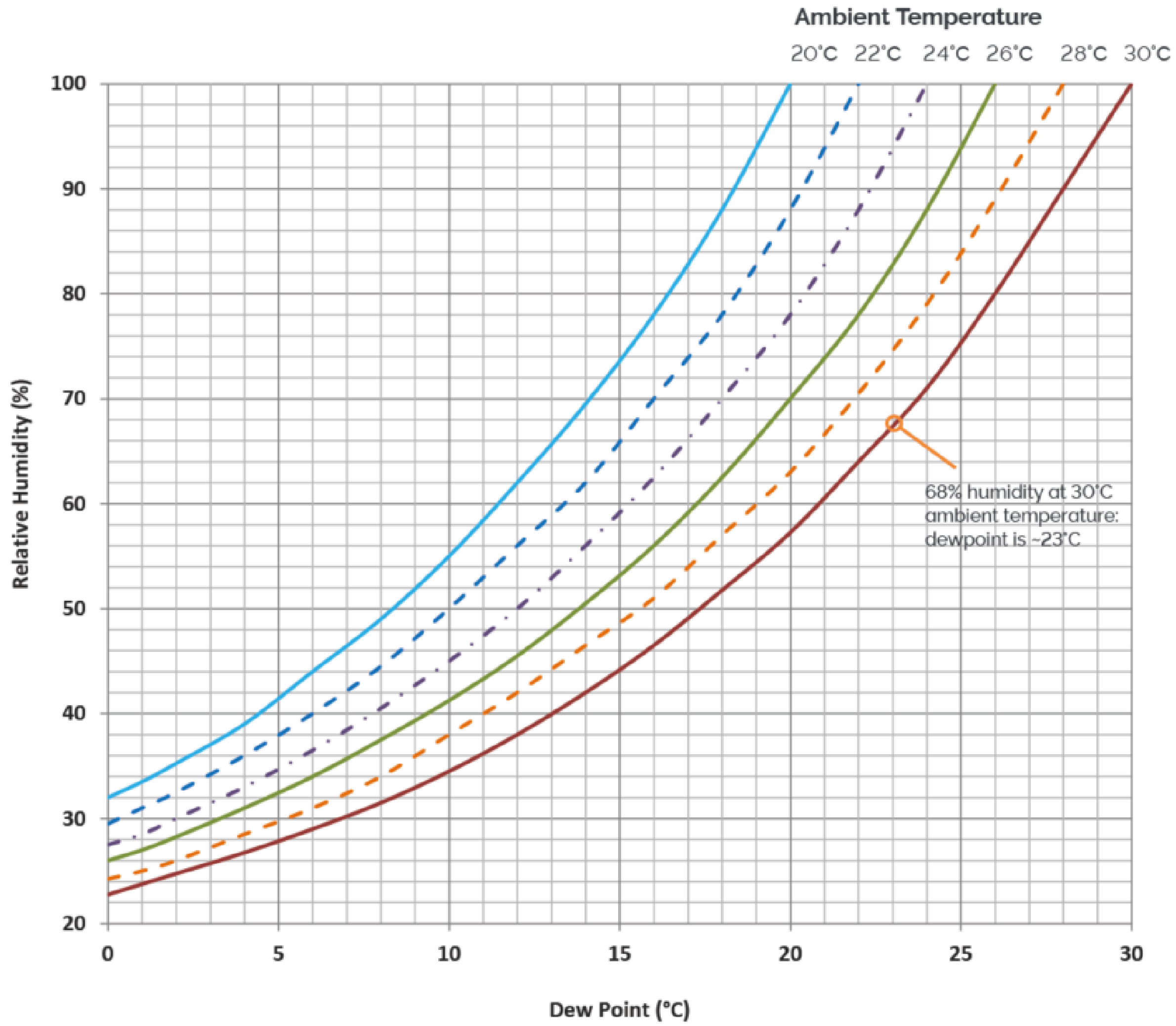






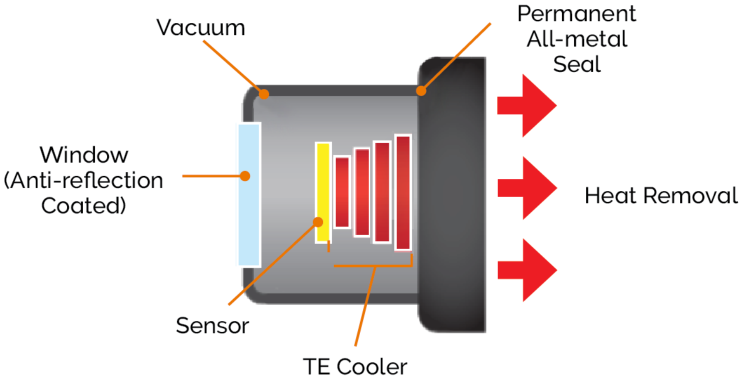
Appendix C: Dew Point Graph

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.



Appendix D: UltraVac Technology

UltraVac is Andors proprietary vacuum technology that provides a permanent, hermetically sealed enclosure (without O-rings) for the sensor. This ensures maximum cooling performance, with a reliability proven through years of use in Andor cameras such as the iXon EMCCD, iKon and Newton series- the Mean Time Between Failure (MTBF) value is > 100 years.



Outgassing is minimized through assembly in a state of the art facility, with a stringent protocol and use of proprietary materials (Outgassing is the release of trapped gasses that would otherwise degrade cooling performance and potentially cause sensor failure). UltraVac also features a single camera window for the best optical performance. For more information about our UltraVac technology, please visit our website and view the technical article on UltraVac.

Appendix E: Other Information

Terms and Conditions of Sale and Warranty Information

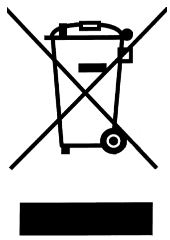
The terms and conditions of sale, including warranty conditions, will have been made available during the ordering process. The current version for the US is available here, for all other regions (except Japan) please click here.

EU/UK REACH Regulation Statement

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

Waste Electronic and Electrical Equipment

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



Appendix F: China RoHS Hazardous Substances Declaration

Component Name 部件名称	Hazardous Substance: 有害物质					
	Lead (Pb) 铅	Mercury (Hg)汞	Cadmium (Cd)镉	Chromium VI Compounds (Cr6+)	Polybrominated Biphenyls (PBB)	Diphenyl Ethers (PBDE)
Printed Circuit Board Assemblies (Surface-mount Resistors and Capacitors, and Brass Connectors) 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

表示该有害物质在该部件所有均质材料中的含量均在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

Component Name 部件名称	
Hex Stand-offs 六角隔撑	
Screw Locks 螺丝锁定