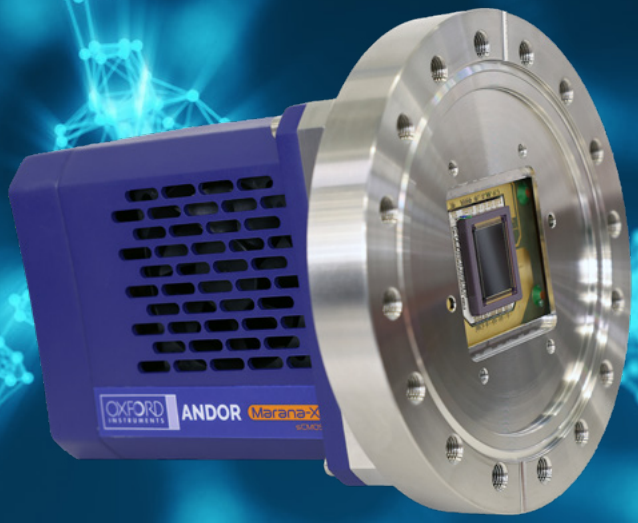
OXFORD INSTRUMENTS | ANDOR

Marana-X-6

Version 1.4 rev 18 February 2025



Hardware Guide

for Marana-X 4.2B-6 Models

andor.oxinst.com

Table of Contents

Revision History

Version	Released	Description
1.0	17 Nov 2020	Initial release of manual.
1.1	25 Nov 2020	Added information for replacement gasket. Corrected typographical errors.
1.2	04 Jul 2022	Updated mechanical drawings. Added China RoHS table. Added REACH statement. Updated packing list items. Updated software installation instructions. Added section on extensive binning.
1.3	04 Sept 2024	Updated frame rate tables. Added additional mechanical drawings. Updated specifications table. Updated introduction section.
1.4	18 Feb 2025	Added new image on cover and in Introduction section to include updated model with blue casing. Updated Minimum Computer Requirements to include Windows 11.

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 respresentative (Section 1.1) with a description of the issue.

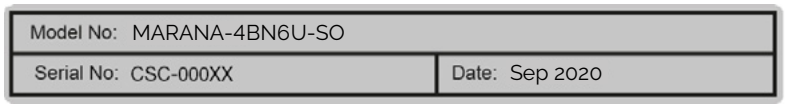
Safety and Warning Information

READ THIS INFORMATION FIRST

1. If the equipment is used in a manner not specified by Andor, the protection provided by the equipment may be impaired.
2. 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 Hardware Guide.
3. Users must be authorised and trained personnel only; otherwise this may result in personal injury, and/or equipment damage and impaired system performance.
4. There are no user-serviceable parts inside the product and the enclosure must not be opened. Only authorised service personnel may service this equipment.
5. Do not position this product so that it is difficult to operate the Mains disconnecting device. See SECTION 4.1, “Emergency Mains Disconnection”.
6. 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.
7. Only the correctly specified mains supply should be used.
8. Only the AC/DC external power supply provided with the product should be used.
9. Only the power supply cord provided with the product should be used. Should this not be correct for your geographical area, contact your local Andor representative.
10. Make sure the power supply cord is located so that it will not be subject to damage. If replacement of the detachable power supply cord is required, ensure replacement is of same type and rating.
11. Performance of the system may be adversely affected by rapidly changing environmental conditions or operation outside of the operating conditions specified in “TECHNICAL SPECIFICATIONS”
12. While running an experiment, try to keep temperature as stable as possible.
13. This equipment has not been designed and manufactured for the medical diagnosis of patients.
14. Electromagnetic Compatibility: This is a Class B product.
15. 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. Operating it in close proximity to devices that emit electromagnetic interference outside the normal range expected by the Directive may have adverse effects on performance.
16. 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.
17. Your product is a precision scientific instrument containing fragile components. Always handle it with care.
18. Do not wet or spill liquids on the product, and do not store or place liquids on the product.
19. If spillage occurs on the product, switch off power immediately, and wipe off with a dry, lint-free cloth.
20. If any ingress of liquids has occurred or is suspected, unplug the mains cables, do not use, and contact Andor Customer Support.
21. When using a liquid cooling system it is recommended that an overpressure device is fitted to avoid leaks that may find their way to the mains electricity supply and create a hazard. Refer to the information in SECTION 3.7 for general guidelines on the correct installation and use of a liquid cooling system.
22. See SECTION 5.1, “Cleaning and Decontamination”.
23. Do not expose the product to extreme hot or cold temperatures.
24. Do not expose the product to open flames.
25. Do not allow objects to fall on the product.
26. Keep this hardware guide in a safe place for future reference.

Warning and Safety Labels

The following warning labels appear on the product:



There are no user serviceable components inside.
The serial label of the camera (above) is located on the back of the camera. It shows the product model, serial number and the build date.

Unpacking Information

Carefully unpack the unit:

- If the equipment appears damaged in any way, return it to sales outlet.
- 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.

Section 1: Introduction

This manual provides an overview of the Marana-X camera series. The Marana-X features the latest back-illuminated sCMOS sensor technology optimised for exceptional sensitivity in the EUV/Soft X-Ray range, fast acquisition speeds, high dynamic range AND large field of view. This makes it particularly suitable for demanding applications such as extensive soft x-ray tomography and microscopy, as well as time-resolved soft x-ray absorption spectroscopy or High Harmonic Generation (HHG) source characterisation. This manual includes a description of the main features of the camera, installation procedures, routine operation and troubleshooting. It also provides a summary of some of the technical features of the Marana-X 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.

As of Summer 2024 the camera body of Marana-X-6 was updated to new product branding which includes a blue casing. The GS2020BSI sensor used by the Marana-X-6 cameras offers exceptional flexibility in its configuration. The latest specification Marana with the “Extreme performance updates package” is standard to cameras after Summer 2024. Cameras prior to this had 2 modes: low noise 2-CMS and High Dynamic Range modes. The latest update brings an additional High Speed Mode, as well as further image quality enhancements and reduced noise for low noise mode.

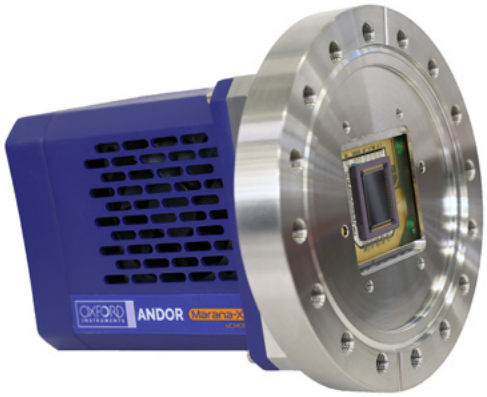


Figure 1: The Marana-X back-illuminated sCMOS Camera.

1.1 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 Ltd.
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)
5 Sumitomo Fudosan Osaki Twin Building East
5-1-18 Kita-Shinagawa,
Shinagawa-ku,
Tokyo 141-0001
Japan
Tel: +81(0)4510 3528
Fax: +81(0)4510 3518

China

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

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

1.2 Disclaimer

THE INFORMATION CONTAINED HEREIN IS PROVIDED "AS IS" WITHOUT WARRANTY, CONDITION OR REPRESENTATION OF ANY KIND, EITHER EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING BUT NOT LIMITED TO, ANY WARRANTY OF MERCHANTABILITY, NON-INFRINGEMENT OR FITNESS FOR A PARTICULAR PURPOSE.
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.

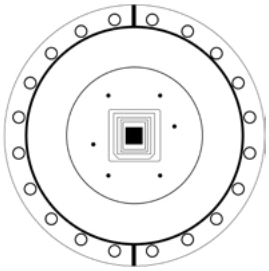
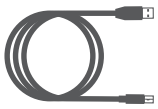
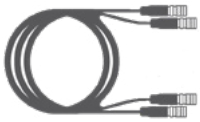
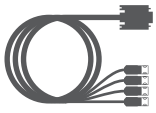
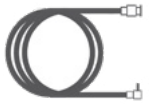
1.3 Copyright and Protective Notices

1.4 Trademarks and Patent Information

Manufacturers Information

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

1.5 Supplied Components

Description					Quantity
	Marana-X back illuminated sCMOS Camera				1
	Software (copy supplied if ordered)	1		Hardware Guide in electronic format andor.oxinst.com/downloads/	1
	Power Supply **1 x 15 V**	1		Power Cord (Country specific)	1
	USB 3 Card	1		Quick Start Guide	1
	USB 3 Standard-A to Standard-B cable	1		Anti-static Wrist band	1
	CoaXPress Card with ext. trigger input (CoaXPress variant only)	1		CoaXPress Cable (CoaXPress variant only)	1
	Multi timing I/O cable, Trigger Cable BNC to D-type	1		Trigger Cable BNC to SMB (CoaXPress variant only)	1
	Performance Sheet	1		Coolant pipes (hose inserts, pair)	1

1.5.1 Camera Model Options

There are a number of models of Marana-X camera based on a common architecture and shared design (see also Section 2.1). The differences for each model can be identified from the product codes and descriptions outlined below:

Model Type	Product Code	Sensor Type	Speed	Connection	Mounting
Marana-X 4.2B-6	**MARANA-4BN6U-SOI**	4.2 Megapixel Back-illuminated sCMOS EUV/soft X-ray optimised, 6.5 µm pixel, peak >99% QE	43 fps	USB 3.0	DN100CF 6" O.D. (ConFlat) fixed flange with 5/16 UNC threaded holes
Marana-X 4.2B-6	**MARANA-4BN6X-SOI**	4.2 Megapixel Back-illuminated sCMOS EUV/soft X-ray optimised, 6.5 µm pixel, peak >99% QE	74 fps	USB 3.0 & CoaXPress	DN100CF 6" O.D. (ConFlat) fixed flange with 5/16 UNC threaded holes
Marana-X 4.2B-6	**MARANA-4BN6U-SOM**	4.2 Megapixel Back-illuminated sCMOS EUV/soft X-ray optimised, 6.5 µm pixel, peak >99% QE	43 fps	USB 3.0	DN100CF 6" O.D. (ConFlat) fixed flange with M8 UNC threaded holes
Marana-X 4.2B-6	**MARANA-4BN6X-SOM**	4.2 Megapixel Back-illuminated sCMOS EUV/soft X-ray optimised, 6.5 µm pixel, peak >99% QE	74 fps	USB 3.0 & CoaXPress	DN100CF 6" O.D. (ConFlat) fixed flange with M8 UNC threaded holes

1.5.2 Optional Accessories

A range of accessories is available (see below). Marana-X is intended only for use with accessories supplied and recommended by Andor.

Description	Code
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**
Beryllium filter for Marana-X filter holder (250 µm thick)	**ACC-OPT-02839**

For **MARANA-4BN6U-SO** a simple in-field upgrade to CoaXPress capability is available using the **CHAM-UPG-CXP** code, if and when additional speed is needed. The upgrade includes CoaXPress card, cable and remote session to upgrade camera firmware and unlock CoaXPress capability. Please contact your local Andor representative if further information is required for any of the optional accessories.

Section 2: Product Overview

This section provides an overview of the Marana-X.

2.1 External Features of the Camera

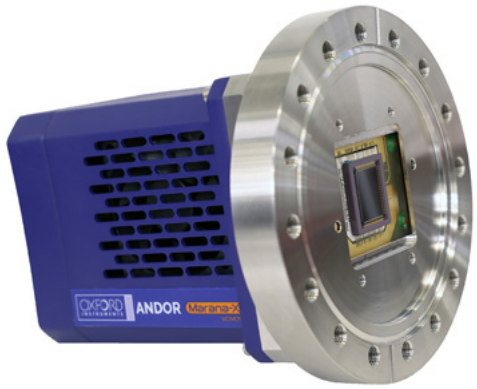


Figure 2: External Features (Marana-X)

Chamber Mount
The Marana-X 4.2B-6 features a DN100 ConFlat 6" O.D. as standard, with either Imperial or Metric mounting..
Sensor
The Marana-X features a high resolution sCMOS 4.2 Megapixel back illuminated sCMOS sensor "uncoated" for best response in EUV/Soft-Ray ray energy range.
Other Mountings
Four M4x 0.7 -6H, 8.0 [0.31] deep mounting holes on the front face (see section 3.4).
Copper Gasket
For recommended replacement please click here.

2.2 Rear Panel

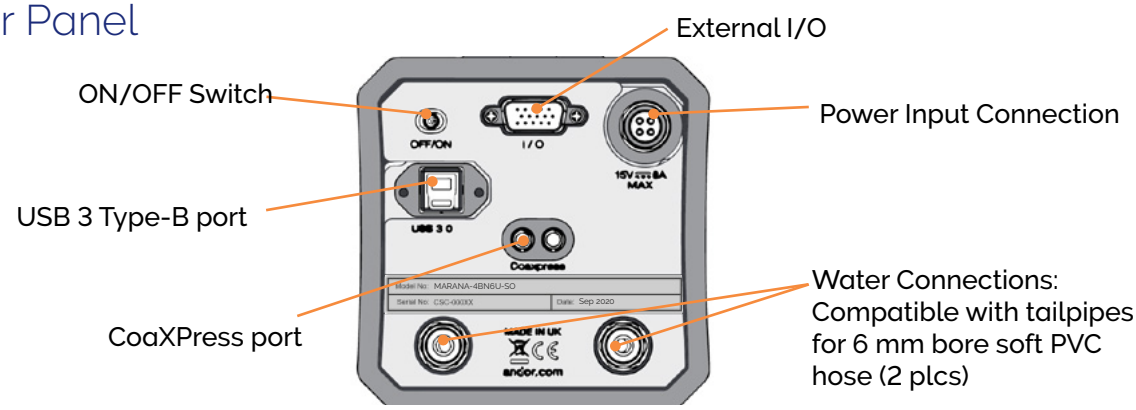


Figure 3: Rear Panel

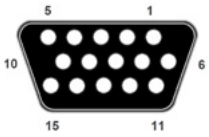
USB Connectivity
USB 3 connection provides a robust high speed connection to the control PC.

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.

Pinouts for the 15-way D type connector

Available using standard 3-way cable

Pin	3-way cable	Pin	3-way cable
1	ARM	9	Reserved
2	AUX_OUT_1	10	Reserved
3	Reserved	11	Reserved
4	Reserved	12	Reserved
5	Reserved	13	Reserved
6	Ground	14	Reserved
7	External Trigger	15	Reserved
8	Reserved		



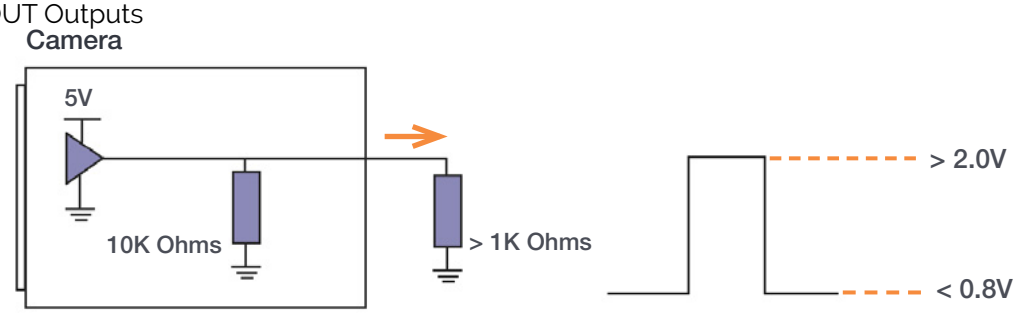
Available using optional 7-way cable

Pin	7-way cable	Pin	7-way cable
1	ARM	9	Reserved
2	AUX_OUT_1	10	Reserved
3	FIRE n	11	Reserved
4	FIRE	12	Reserved
5	AUX_OUT_2	13	Reserved
6	Ground	14	Reserved
7	External Trigger	15	Reserved
8	Spare		

- **External Trigger** (and **Spare** inputs) are 5V 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 **Section 2.6** 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.

Ext Trigger (and Spare*)Inputs

Arm (Fire*, Fire n*) and AUX_OUT Outputs



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

Liquid Cooling Connections
Liquid cooling connections provide the facility for connection to a liquid cooling system. Refer to Section 3.7.

Power Connector
Power input connection (15 V DC) for connection to the PSU. Refer to Section 2.3. An ON/OFF switch is also present.

Note: Minimum cable clearance required at rear of camera 150 mm.

2.3 Power Requirements

Ensure that the power connector for the camera is inserted securely. The connector is keyed to aid correct orientation. A 15 V DC External Power Supply supplies the camera. Refer to the Technical Specifications for the External Power Supply requirements.
Notes:

1. **The electrical mains lead should be certified for use in your country and in applicable countries the plug must be fitted with a 240 V 5 A fuse.**
2. **If users use any other power supply, they do so at their own risk.**

Section 3: Installation

WARNINGS:

- **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.**

3.1 Transport and Storage Information

- The camera is packed in a 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 (see Section 6.1 for further information).

Storage

- Storage Temperature: -10°C to 50°C.
- 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.

3.2 Mounting the Camera using the Mounting Flange

The Marana-X 4.2B-6 models have a DN100CF (ConFlat) 6"O.D. flange used to mount the camera to a mating flange on a vacuum chamber or spectrograph. The Marana-X flange is fixed with blind threaded holes. The threaded holes are metric or imperial depending on the camera variant. The mating flange should have through holes with adequate clearance for the mounting bolts.

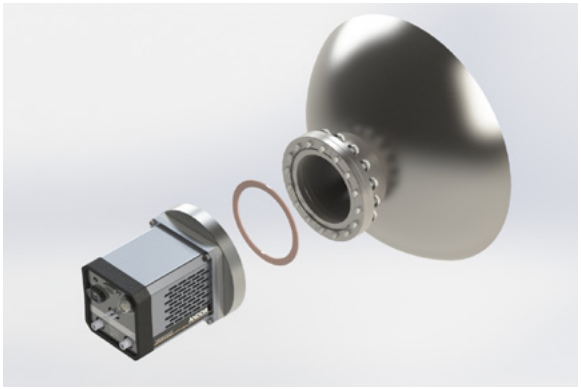


Figure 4: Expanded view of mounting components from left to right: Marana-X with DN100CF fixed flange / CF flange gasket / vacuum chamber with mounting bolts.

The seal mechanism is a knife-edge that is machined below the flange's flat surface. As the bolts of a flange-pair are tightened, the knife-edges make annular grooves on each side of a soft metal gasket. The extruded metal fills all the machining marks and surface defects in the flange, yielding a leak-tight seal.

When handling and installing CF components, Andor recommends the use of lint-free gloves during assembly. The slightest fingerprint or other residue can greatly influence the quality of vacuum. The knife edges on the mounting flanges can also be easily damaged by impacts, typically with other components or tools, e.g. stacking other components on top or accidentally dropping a screwdriver onto their face.

Prior to installation carefully inspect the flange mating surfaces for scratches and inspect the knife edges for any defects or residue that may affect vacuum integrity. **Follow vacuum chamber installation guidelines** to ensure that flanges are correctly attached and the gasket is seated properly.

To ensure that Electrostatic Discharge (ESD) does not adversely affect performance, it is important that if the open front of the camera is attached to a metal structure, there is complete conductive contact with the camera's conductive surface along the 360 degrees of the flange, and that any bolts and threaded holes used to attach it are free of insulating material, such as paint or anodisation, to allow good conduction. It is often when the electrical waves produced on the surface by the ESD event arc across insulating gaps that broad-spectrum radiowaves are produced that cause electromagnetic interference to electronic products.

Note: that the weight of the camera is approx. 5.4 kg [11.9 lbs] ensure that the mounting and the system it is connected to provides adequate support.

3.3 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.

3.3.1 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.

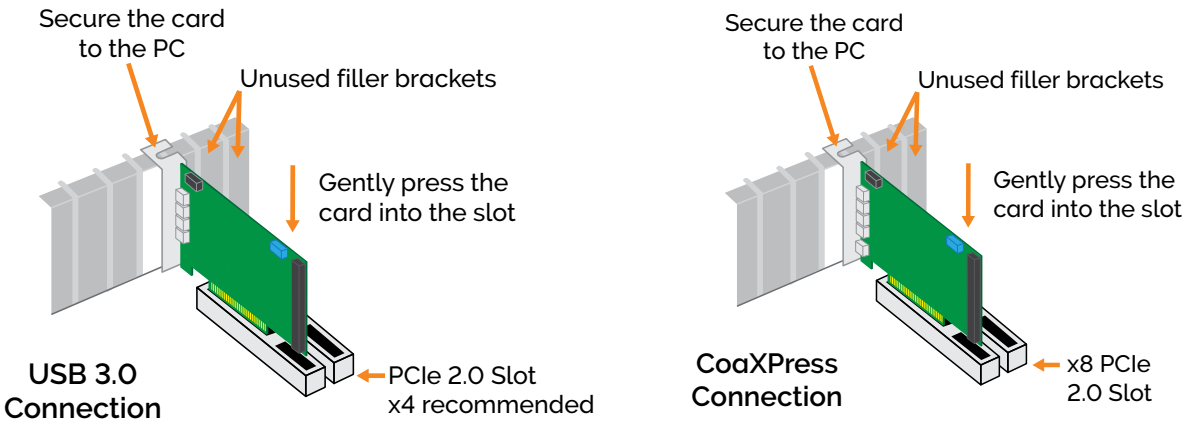


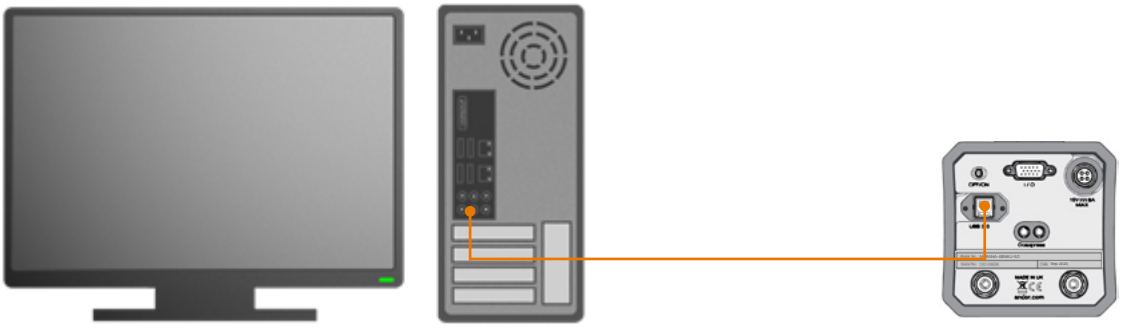
Figure 5: Left USB PCIe connection. Right CoaXPress PCIe connection.

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). For CoaXPress please note that a minimum of x8 slot is required
4. If you are unsure which slot is correct, please consult the PC user manual.
5. Remove the filler bracket corresponding to the slot you intend to use.
6. Remove the controller card carefully from its protective ESD packaging and insert the card connector fully into the expansion slot.
7. 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.
8. Replace the computer cover and secure with mounting screws if applicable.
9. Reconnect any accessories you were using previously.

3.3.2 Connecting the Camera to the PCIe Card

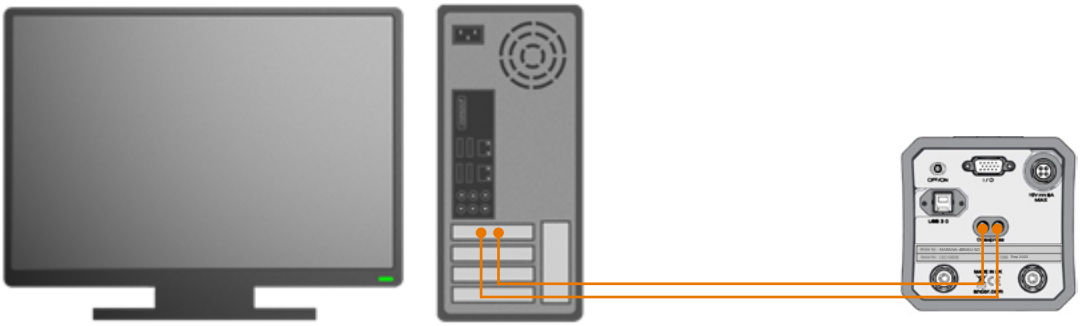
3.3.2.1 Connecting via USB

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



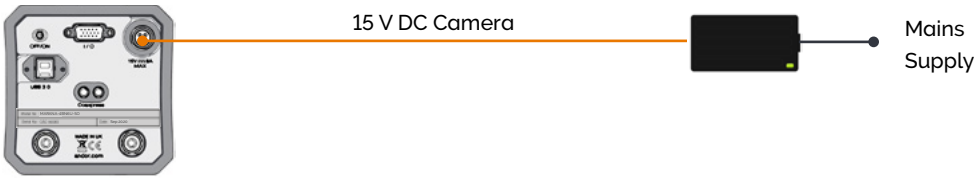
3.3.2.2 Connecting via CoaXPress

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



3.4 Connecting the Camera to the Power Supply

- Connect the DC 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 PSU to the mains power supply.



3.5 Connecting a Cooling System

The camera can use either air cooling to cool to 0°C or -25°C, or optional liquid cooling for deeper cooling to -45°C.

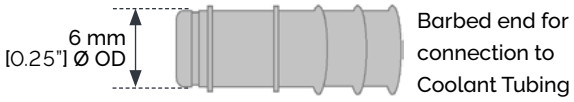
Note: the camera will default to a Fan Setting of "Low" and will set the sensor temperature to 0°C as default following its initialisation (Audible double beep)

3.5.1 Important Considerations when using Liquid Cooling Systems

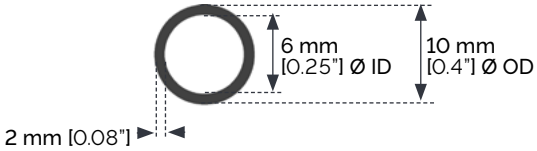
- Before attempting to insert or remove the coolant hose connections, ensure that all coolant has been drained from the hoses and integral coolant channel within the camera head.
- Care must be taken to avoid permanent damage to the camera system resulting from either leakage of coolant during connection/removal of hoses or spillage of any residual coolant contained within the camera head once the hoses have been removed.
- Always ensure that the temperature of the liquid coolant circulated through the camera head is above the dew point of the camera ambient temperature and humidity conditions. Refer to the Dew Point graph in **Appendix C** 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 on page 14.
- 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.

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

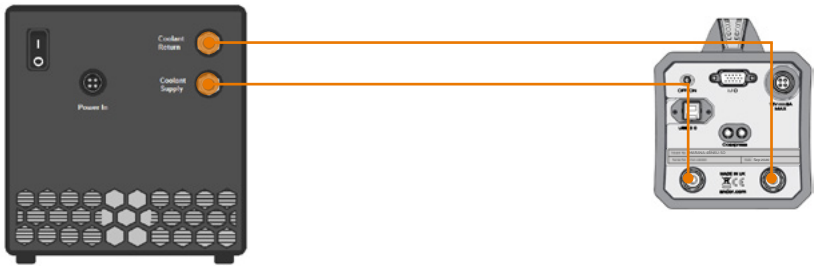


Coolant Tubing

3.6 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.



Connect the coolant hoses between the camera and the liquid cooling system

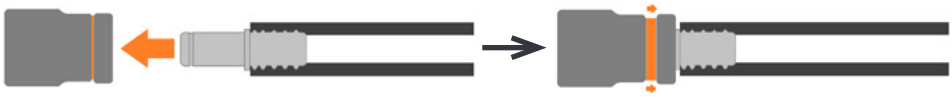
Note: The liquid cooling system of the camera is rated to 2 bar (200 kPa). If your water supply exceeds this value, then an overpressure safety device or regulator must be fitted to restrict the water pressure to less than or equal to this rating.

3.7 Connecting the Liquid Cooling System

An overview for connecting a liquid cooling system is outlined below- please refer to the information supplied with your cooling system for further information.

3.7.1 Connecting the Coolant Hoses

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



2. Press the hose connectors into the connections on the camera head, ensure they click into place.
3. Confirm the hoses are connected securely by applying pressure on the front of the camera body and pulling backwards on each hose.
4. Connect the other ends of the coolant hoses to the cooling system- refer to the cooling system manual.

3.7.2 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.

3.8 Installing Software and Drivers

3.8.1 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, 8.1, 10 and 11) or Linux

3.8.2 Installing Solis Software and Drivers

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 the provided copy of Andor Solis. 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/Marana.
5. Continue installation and restart your computer - when prompted - to successfully complete the installation.
6. The shortcut icon for Solis will appear on the desktop on re-start.
7. The camera is now ready to be connected to a PC / laptop and powered on.

3.8.3 New Hardware Wizard

When the Marana-X 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.

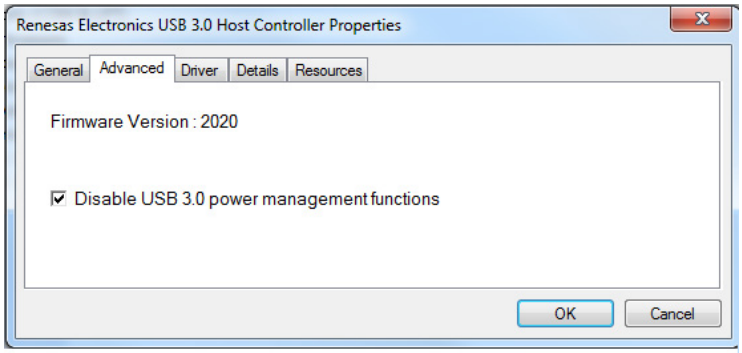
A system message will appear to indicate that the device has been successfully installed.

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.

3.8.4 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 4: Operation

WARNINGS:

- **IF THE EQUIPMENT IS USED IN A MANNER NOT SPECIFIED BY ANDOR OR ITS DISTRIBUTORS, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.**
- **PLEASE READ THE USER GUIDES SUPPLIED WITH YOUR SYSTEM COMPONENTS AND CAMERA CONTROL SOFTWARE PRIOR TO USE.**
- **CAMERA MUST BE ATTACHED TO A VACUUM CHAMBER AND PUMPED DOWN TO <10^{-4} mBar BEFORE BEING CONNECTED TO A POWER SUPPLY AND TURNED ON.**

4.1 Emergency Mains Disconnection

In case of emergency, the disconnecting points of the equipment are the mains power cords connected to the external power supply, or the mains socket switches.

WARNING: SWITCH OFF THE POWER AT THE MAINS SOCKET AND REMOVE THE MAINS LEAD FROM THE EXTERNAL POWER SUPPLIES.

4.2 Power-up Sequence

1. Ensure that the camera is powered on at the mains power supply. (Note that 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 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 temperature before you start acquiring scientific grade images.

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

4.3 Power-Down Sequence

1. Exit the camera control software.
2. Switch the camera off using the switch on the rear panel (Section 2.2).
3. If not using the camera for some time, disconnect from the mains power socket.

4.4 Using the Marana-X

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.

4.4.1 sCMOS Sensors

An sCMOS sensor is an "Active Pixel Sensor" in that each pixel has its own integral amplifier. The basic operation is as follows:

1. Light (photons) hits the sensor and generates charge (electrons).
2. The photo-generated charge is converted to an analog voltage for each pixel amplifier.
3. These pixel voltages are transferred to the column bus via a row select signal.
4. The analog voltages are then converted to digital signals via columns of analog to digital (A/D) converters.
5. The final digitized signals are then read out sequentially at a pixel readout speed of up to 310 MHz.

sCMOS sensors provide benefits over more traditional CCD sensors in terms of speed and sensor size, making them ideal for many scientific applications. The latest sensors, such as that of the Marana-X also now provide low noise, and very high quantum efficiency (QE) through use of a back-illuminated design. Please refer to the Andor website for a range of technical articles on sCMOS.

4.4.2 Extended Dynamic Range (EDR)

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

Dynamic Range = well depth/noise floor

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.

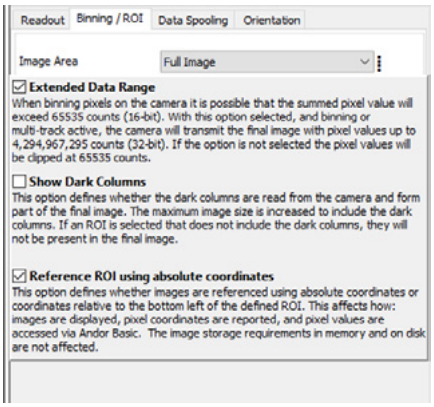
For dynamic images - Use 16-bit mode to provide the data range required to capture full range images. Frame rates will be lower than for 12-bit- however you can use Region of Interest (ROIs) to boost frame rates.

For the fastest frame rates - 16-bit mode is the most flexible and suitable for most applications offering a high frame rate as well as a high dynamic range. High speeds of up to 74 fps can be achieved using CoaXPress which is up to 20% faster than other cameras that use the same sensor.

For the highest sensitivity and the lowest noise - a low noise mode (12-bit mode) can be enabled that uses a two times correlated multisampling (2-CMS) approach, so that a low noise floor can be achieved without sacrificing frame rate, or the need to increase exposure times.

Marana-X provides on-head binning capabilities that conveniently process images or spectra before being sent to the computer for further analysis.

Extensive binning - where data range can exceed 16-bit, the Marana-X offers a mode where data bit depth can be extended to 32-bit to preserve the integrity of the extended data range.



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.

Marana-X 4.2B-6 Frame Rates

S Spectroscopy Mode 4.2B-6

Vertically binned tracks (overlap ON)

Array Size (W x H)	Max Spectra Rate USB 3.0 (CXP)		
	16-bit Mono16	12-bit (Low Noise) Mono12 Packed	11-bit (High Speed) Mono12 Packed
any x 1	11511 (9760)	11478 (9720)	11378 (9800)
any x 2	10744 (9130)	11774 (9714)	11204 (9870)
any x 8	6368 (8922)	7609 (7520)	7445 (9107)
any x 1200	73 (126)	74 (74)	98 (230)
any x 2048	43 (74)	43 (43)	57 (135)

I Imaging Mode 4.2B-6

Frame rate table (overlap ON)

ROI Size (W x H)	Max Frame Rate (fps) USB 3.0 (CXP)		
	16-bit Mono16	12-bit (Low Noise) Mono12 Packed	11-bit (High Speed) Mono12 Packed
2048x2046	43 (74)	43 (43)	58 (135)
1400x1400	92 (108)	63 (63)	120 (198)
1200x1200	125 (126)	74 (74)	164 (230)
1024x1024	147 (147)	86 (86)	231 (270)
512x512	294 (294)	173 (173)	536 (539)
256x256	582 (582)	343 (343)	1061 (1061)
128x128	1148 (1148)	676 (676)	2073 (2073)

M Multi-track Mode 4.2B-6

Vertically binned tracks (overlap ON)

Number of Tracks	Track height (h)		Track separation (d)		Max Acquisition Rate: USB (CXP)		
	Pixels	µm	Pixels	µm	16-bit Mono16	12-bit (Low Noise) Mono12 Packed	11-bit (High Speed) Mono12 Packed
2	10	65	10	65	6313 (6313)	3720 (3720)	10600 (9900)
2	10	65	0	0	6313(6313)	3720 (3720)	10600 (9900)
2	20	130	10	65	3443 (3443)	2029(2029)	6038 (6038)
6	50	325	40	260	498 (498)	293 (293)	907 (907)
10	10	65	0	0	1456 (1456)	858 (858)	2620 (2620)
10	20	130	0	0	742 (742)	437 (437)	1348 (1348)
10	30	195	30	195	498 (498)	293 (293)	907 (907)
50	20	130	0	0	151 (151)	89 (89)	276 (276)
60	20	130	0	0	125 (125)	74 (74)	230 (230)
100	20	130	0	0	75 (75)	44 (44)	138 (138)

Note: Frame/spectral rates do not differ whether partial or full rows are selected.

4.4.3 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. 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 the preceding table). Preset ROIs may be selected as well as manually defined ROIs with a 1 pixel granularity [min size. 1(h) x 25 (w)].

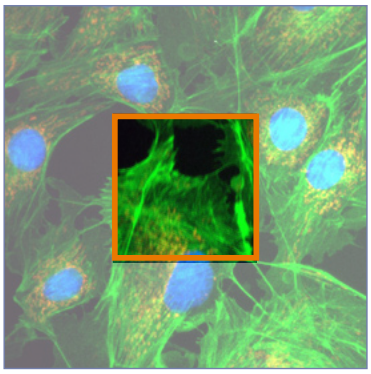


Figure 6: ROIs can be used to focus on a sub-region of an image.

4.4.4 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 Zyla, Neo, Sona, Marana and Marana-X 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.

4.4.5 Spurious Noise Filter

The overall noise of the sensor is at such a low level, that under some conditions, the remaining small percentage of spurious, high-noise pixels can become an aesthetic issue. The **Spurious Noise Filter** actively corrects such high noise pixels, replacing them with the mean value of the neighbouring pixels. The filter can be switched off by the user prior to data acquisition experiments.

4.4.6 Blemish Correction Filter

The **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°C), it is possible to dramatically minimize the occurrence of such hot pixels within the sensor, and still use them for 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 can be detrimental in some applications that depend on total quantitative integrity over a limited set of pixels (e.g. PALM and STORM techniques) as well as 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. The end user can 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.

4.5 Trigger Modes

Marana-X 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 Table X 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 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.

Note: 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.

4.6 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.

4.7 Rolling Shutter

Marana-X functions 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.

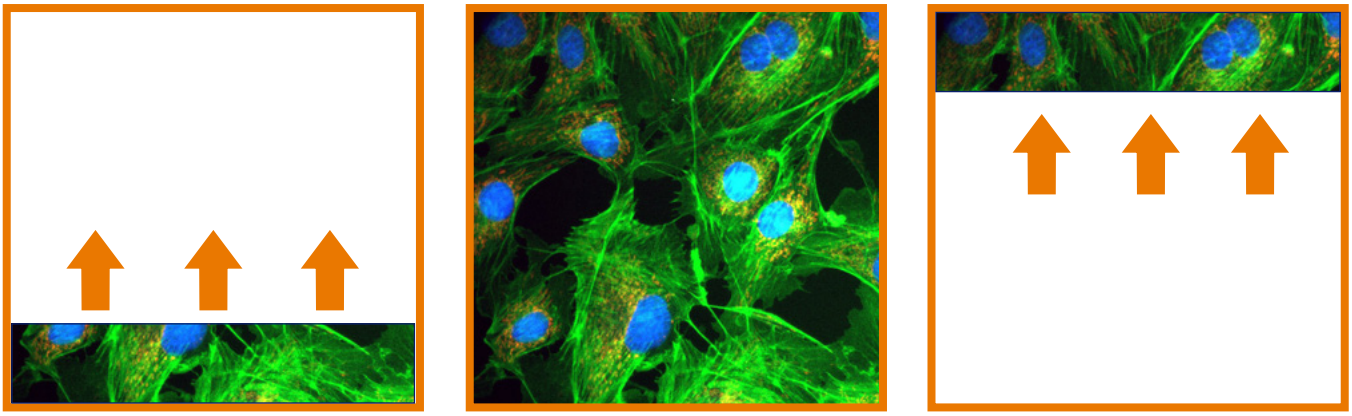


Figure 7: Rolling Shutter Operation

- 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 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 are faster and rolling shutter is suitable for the majority of scientific applications. Some sCMOS cameras such as Neo and Zyla 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.

4.7.1 Rolling Shutter Mechanism

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 sampled
3. Charge is transferred from photodiode to node
4. The node level (signal level) is sampled
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.

4.7.2 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.

4.7.3 Timing Parameters and External Triggering

The timing tables accompanying each of the triggering diagrams that follow indicate the exposure and cycle times achievable in each triggering mode. These are based on Frame and Row Periods as shown below.
Timing Parameters based on Sensor Clock Speed:

1 Row	6.6 µs (16-bit)	11.2 µs (12-bit)
1 Full Frame (2048 rows)	13.5 ms (16-bit)	22.9 ms (12-bit)

Note: A single row can be read in 16-bit mode.

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

Minimum EXT Trigger Width

EXT Trig Pulse Width	10 ns

4.7.4 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 as shown in Figures 8 and 9. 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.

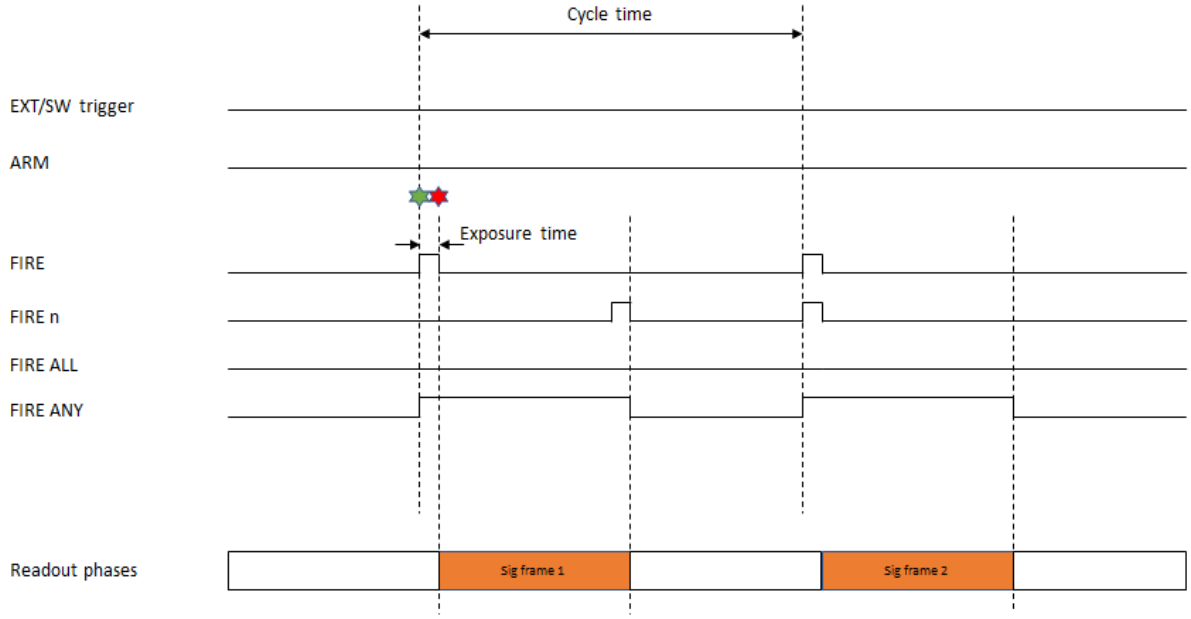


Figure 8: Internal Triggering "short" (non-overlap)

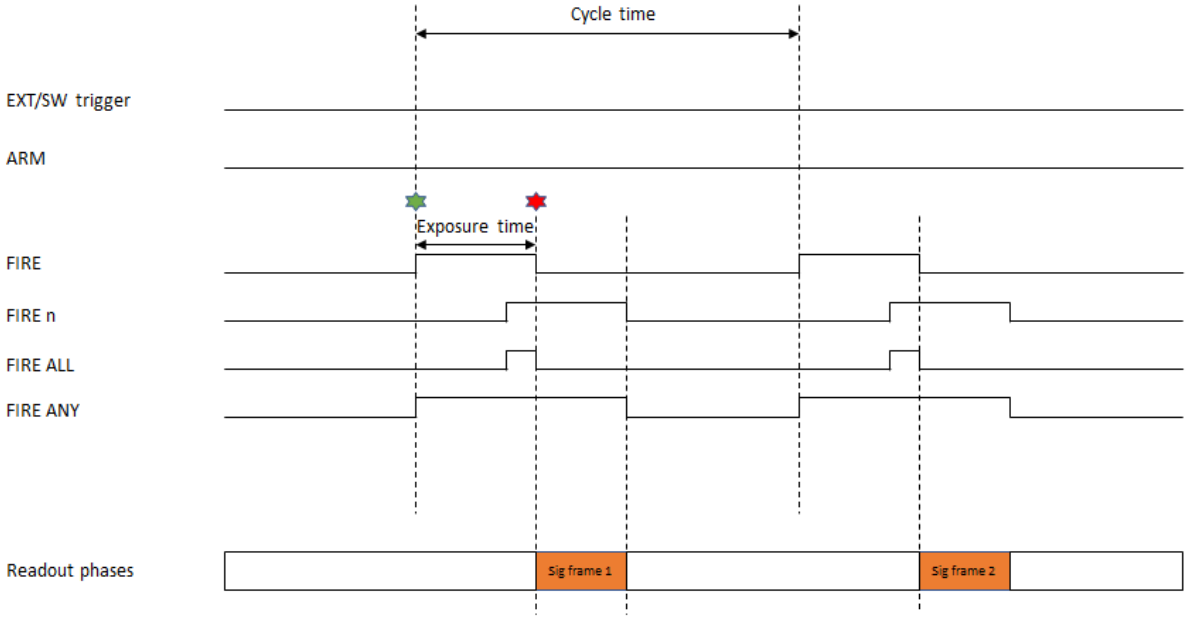


Figure 9: Internal triggering "long" (non-overlap)

Parameter	Minimum	Maximum
Exposure	4 Rows	600 s
Cycle Time (1/Frame Rate)	Exposure + 1 Frame + 2 Rows	-

Note: actual minimum Exposure time is 11.2 µs in 12-bit mode and 6.6 µs in 16-bit mode. The exposure time is incremented in 1 Row time steps.

4.7.5 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 figure 10 below.

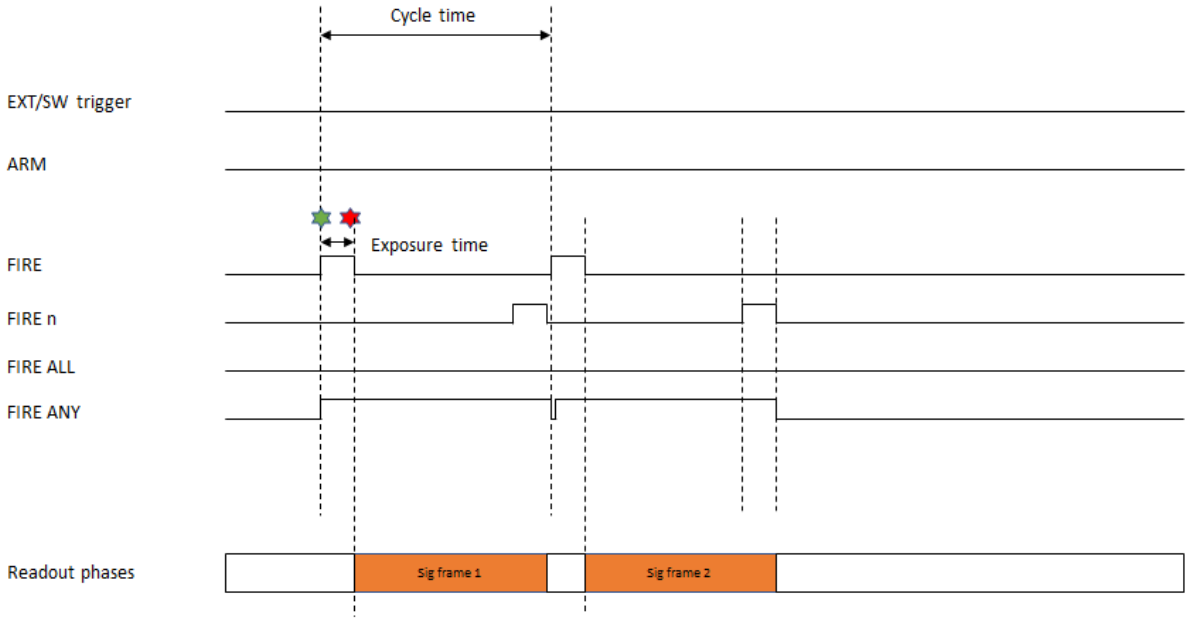


Figure 10: Internal Triggering "short" (overlap)

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 + 2 Rows time. See figure 11 below:

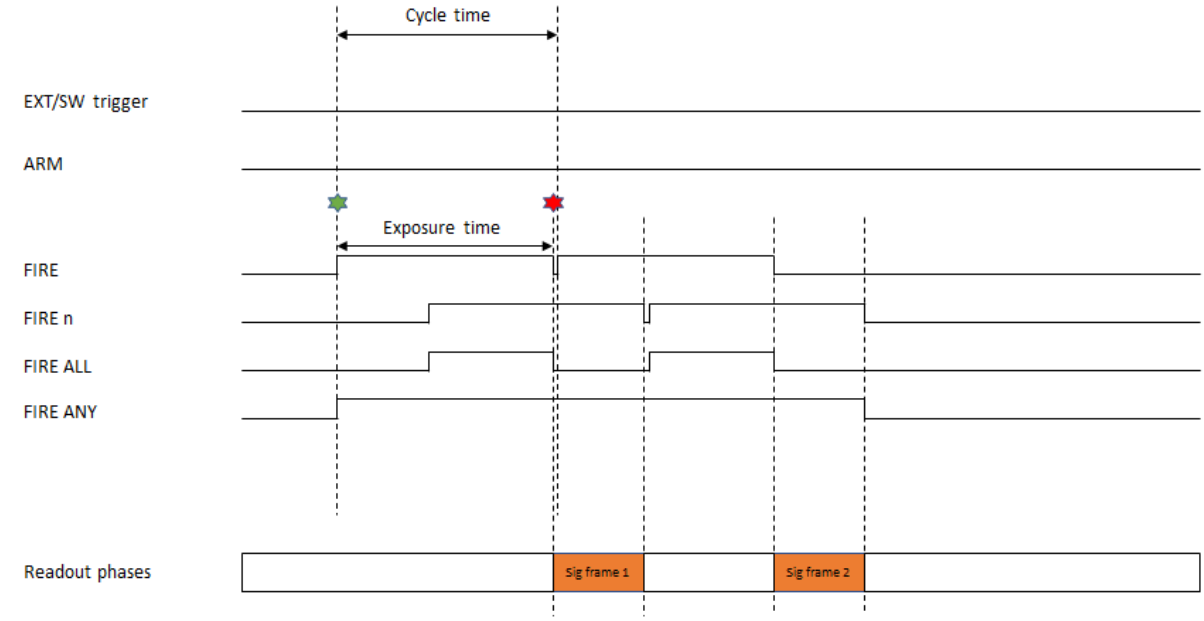


Figure 11: Internal Triggering "long" (overlap)

Parameter	Minimum	Maximum
Exposure	4 Rows	600 s
Cycle Time (1/Frame Rate)	Short Exposure: 1 Frame + 2 Rows Long Exposure: Exposure + 2 Rows	
FIRE Any low period	~5.6 µs in 12-bit and ~9.8 µs in 16-bit (1 Row)	

4.7.6 Rolling Shutter External / Software 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.

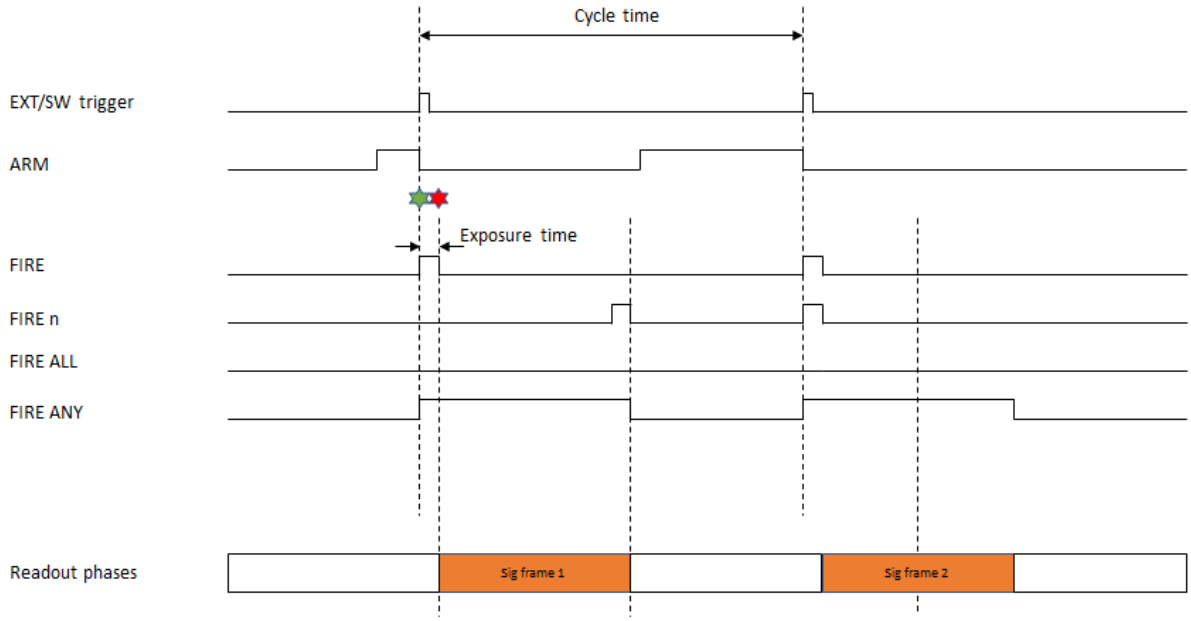


Figure 12: External Triggering “short” (non-overlap)

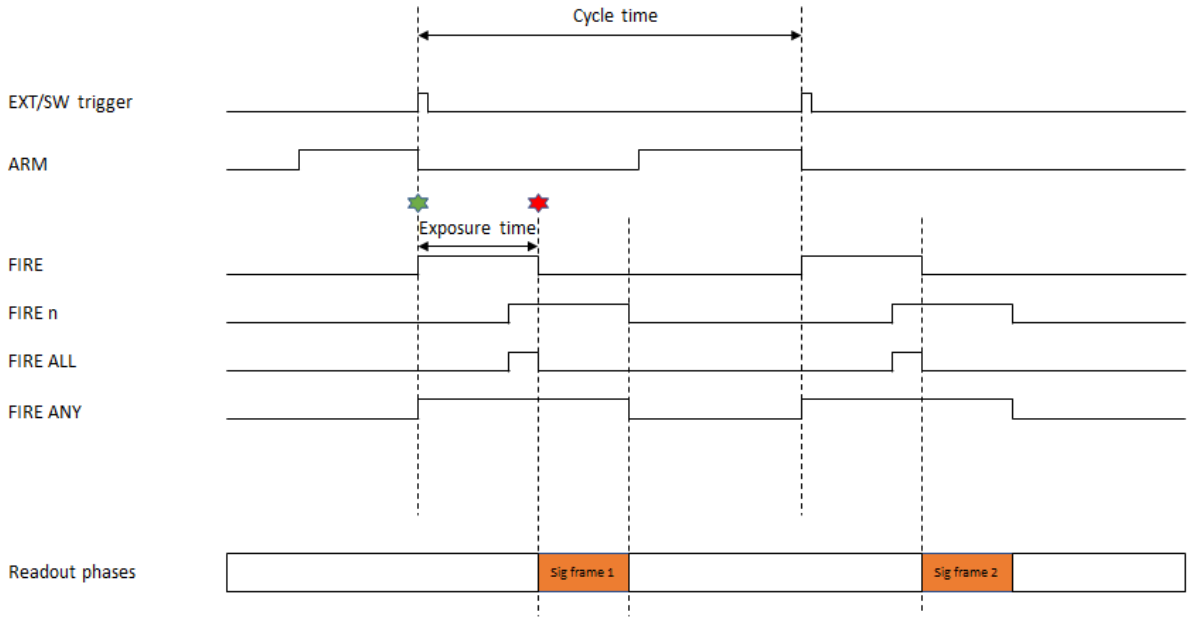


Figure 13: External Triggering "long" (non-overlap)

Parameter	Minimum	Maximum
Exposure	4 Rows	600 s
Cycle Time (1/Frame Rate)	Exposure + 1 Frame + 2 Rows	-
External Start Delay	1 Rows	2 Rows
EXT Trig Pulse Width	10 ns	-

4.7.7 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 4 Rows the falling edge will be missed, and a subsequent falling edge will be required to end the exposure.

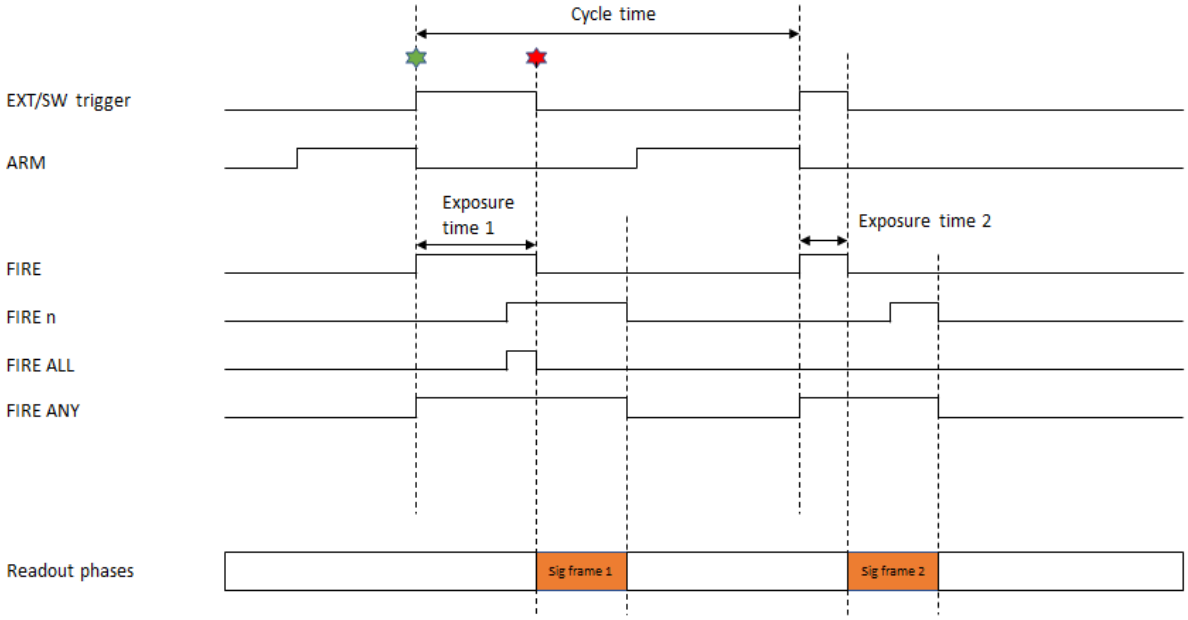


Figure 14: External Exposure “long” (non-overlap)

Parameter	Minimum	Maximum
Exposure	4 Rows	600 s
Cycle Time (1/Frame Rate)	Exposure + 1 Frame + 1 Row	-
External Start Delay	1 Rows	2 Rows
EXT Trig Pulse Width	10 ns	600 s

4.7.8 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.

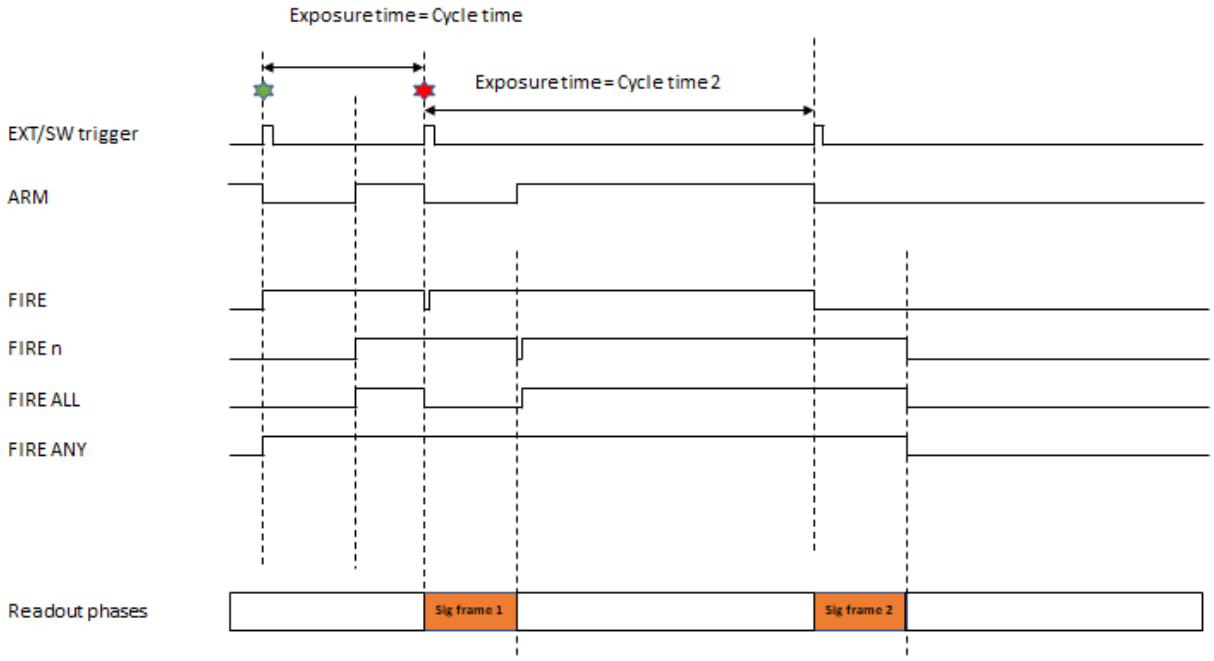


Figure 15: External Exposure "long" (overlap)

Parameter	Minimum	Maximum
Exposure	2 Frames + 1 Row	-
Cycle Time (1/Frame Rate)	Exposure	Exposure
External Start Delay	2 Rows	3 Rows
EXT Trig Pulse Width	10 ns	-
FIRE low period	2 Rows	-

4.7.9 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 Section 4.7.4 and 4.7.5). The ARM signal indicates to the user when the camera is ready to detect an External Start Trigger. The following figure 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.

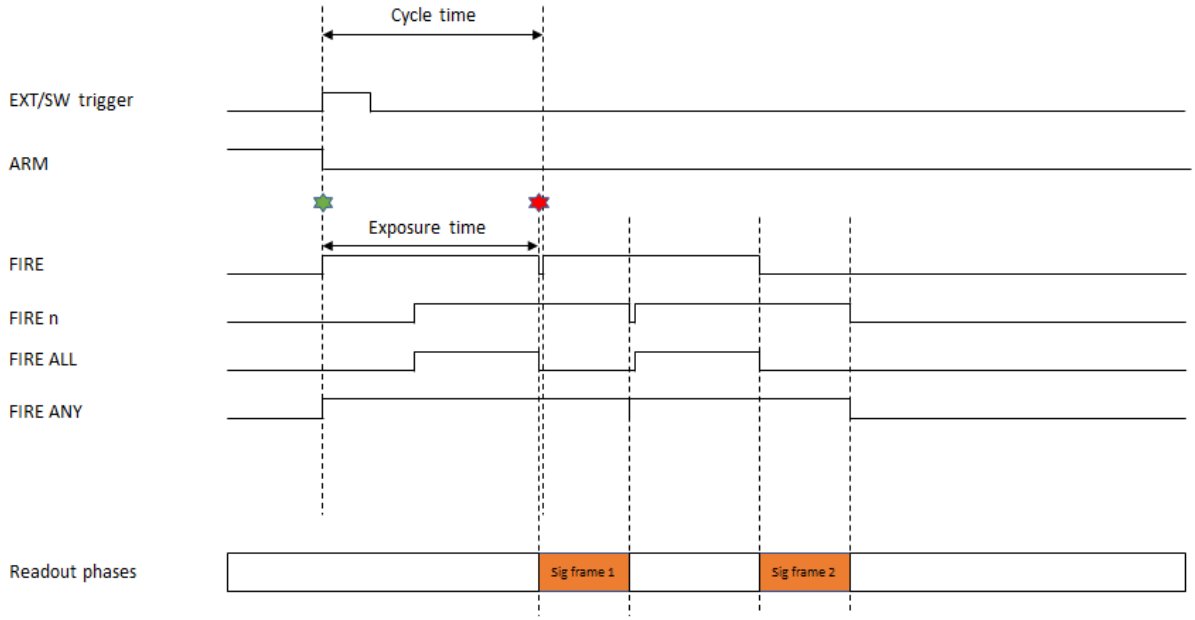


Figure 16: External Start Triggering "long" (non-overlap)

4.7.10 Rolling Shutter Triggering Constraints

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

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.	4 Rows to 600 s	-	-	✓
Internal (Overlap On)	User settable exposure time.	4 Rows to 600 s	-	-	✓
External (Non Overlap)	Exposure time user settable. Cycle Time controlled via external trigger pulse	4 Rows to 600 s	1 row	5 ns	✓
Software (Non Overlap)	Exposure time user settable. Cycle Time controlled via software trigger function	4 Rows to 600 s	1 row	5 ns	✓
External Exposure (Non Overlap)	Exposure Time controlled by width of external trigger pulse. Cycle Time controlled via period of external trigger pulse.	4 Rows to 600 s	1 row	4 Rows	×
External Exposure (Overlap On)	Exposure time controlled by period of external trigger pulse	(2 Frames + 5 Rows) to 600 s	1 row	5 ns	×
External Start (Non Overlap)	User settable exposure time. User settable Cycle Time.	4 Rows to 600 s	1 row	5 ns	✓

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 Regular Checks

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

5.2 Annual Electrical Safety Checks

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

5.3 General Maintenance & Decontamination Information

Sensor Specific Instructions

Note: Do not attempt to clean the sensor face or blow with pressurised air. It is highly sensitive and easily damaged. Do not attempt to clean inside the flange sensor aperture.

- When not in use, the sensor chamber should be covered and sealed.
- Due to the exposed nature of the sensor, extreme care should be taken with the camera, as damage can easily occur through mishandling or by contamination.
- If the sensor becomes contaminated, due to accident or misuse, please contact Andor immediately for advice on cleaning.

Camera Body Instructions

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

5.4 Cleaning the Camera Flange

Note: Do not attempt to clean the sensor face or blow with pressurised air. It is highly sensitive and easily damaged. Do not attempt to clean inside the flange sensor aperture.

When handling and installing CF components, Andor recommends the use of lint-free gloves during assembly. The slightest fingerprint or other residue can greatly influence the quality of vacuum. The knife edges on the mounting flanges can also be easily damaged by impacts, typically with other components or tools, e.g. stacking other components on top or accidentally dropping a screwdriver onto their face.

The camera sensors are **STATIC SENSITIVE**, therefore, ensure all ESD precautions are followed when handling and cleaning.

To clean the stainless steel flange use cotton buds dipped in acetone paying particular attention to the knife edge. The surfaces should be thoroughly cleaned until no more dirt comes off on the cotton buds. Do not touch the internal surfaces once they have been cleaned.

Once cleaned inspect the knife edge for any defects or residue that may affect vacuum integrity.

5.5 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:

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

5.6 Cooling Hoses and Connections

The user should routinely check all cooling 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.

5.7 Vacuum Operations

- Do not operate the Marana-X in a vacuum that exceeds (i.e. lower pressure) 1.33 x 10^{-8} mb (10^{-8} Torr)
- Ensure that the vacuum environment to which the camera is fitted is free of water vapour and other contaminants.
- Care should also be taken to control pressure change, as sudden pressure changes can potentially cause damage to the sensor assembly.

Please refer to the Andor Technical Note: Open-front camera flanges for further details.

Section 6: Troubleshooting

6.1 Preventing Condensation

It is strongly advised that the camera should not be used in a condensing atmosphere. If used in a condensing atmosphere the sensor MUST be protected, and the use of a cold finger is strongly recommended.

Key Risks

- 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.

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

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

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

Refer to Appendix C for a Dew Point Graph.

6.2 Quick Troubleshooting Guide

Issue	Possible Cause	Action
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.
	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.	Check section 2.2 of this manual.
External Trigger input not functioning correctly.	This is a 5 V TTL input which should be driven from a 5 V TTL compatible source.	Check section 2.2 of this manual.
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 aquisition settings.

Appendix A: Technical Specifications [1]

Model	Marana-X 4.2B-6
Sensor Type	Back-Illuminated Scientific CMOS
Array Size	2048 (W) x 2048 (H) 4.2 Megapixel
Pixel Size	6.5 x 6.5 µm
Image Area	13.3 mm x 13.3 mm (18.8 mm diagonal)
Readout Modes	Rolling Shutter
Pixel Readout Rates	310 MHz (Fast High Dynamic Range mode, 16-bit) 180 MHz (Low Noise mode, 12-bit) 570 MHz (High Speed 11-bit)
Quantum Efficiency [2]	up to 99%
Read Noise (e-) median [3]	1.0 e- (Low Noise, 12-bit) 1.6 e- (High Dynamic Range, 16-bit) 1.9 e- (High Speed, 11-bit)
Sensor operating temperature [4] Air cooled Water/liquid cooled	 -25°C (up to 30°C ambient) -45°C (@16°C water)
Dark Current Air cooled (@-25°C) Water/liquid cooled (@ -45°C)	 0.15 e^-/pixel/s 0.10 e^-/pixel/s
Active area pixel well depth	42 000 e^- (Fast High Dynamic Range mode, 16-bit) 2100 e^- (Low Noise mode, 12-bit, bit depth limited) 2100 e- (High Speed, 11-bit)
Dynamic Range	34 000:1 (Fast High Dynamic Range mode, 16-bit)
Data Range	16-bit (Fast High Dynamic Range mode) 12-bit (Low Noise mode) 11-bit (High Speed Mode)
Linearity [5]	> 99.7%
PRNU	< 0.5% (@ half-light range)
Region of Interest (ROI)	User-definable, 1 pixel granularity, min. size 9 (w) x 1 (h)
Pre-defined ROI	1608 x 1608, 1200 x 1200, 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

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•6	Start exposure - End exposure (row 1), Start exposure - End exposure (row n)
Image Timestamp Accuracy	25 ns
PC Interface	USB 3.0•7 and CoaXPress (2-lane CXP-6)
Mounting Flange	DN100CF (ConFlat) 6" O.D. fixed flange available with M8 or 5/16 UNC threaded holes

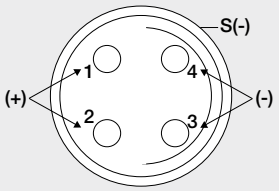
Environmental Specifications

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.
Ingress protection rating	IP20
Electromagnetic compatibility	This is a Class B product.
Cooling vent clearance	100 mm minimum

Footnotes

1. Figures are typical and target specifications and therefore subject to change.
2. Quantum efficiency as supplied by the sensor manufacturer.
3. Read noise measured at 0°C (Marana-X 4.2B-6).
4. Coolant temperature must be above dew point.
5. Linearity is measured from a plot of Signal vs. Exposure Time over the full dynamic range.
6. Software Exposure Events provide rapid software notification (SDK only) of the start and end of acquisition.
7. Marana-X 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.

External Power Supply Requirements

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 Connector Pin Connections	Pins 1 & 2: +15 V Pins 3 & 4: 0 V Shield: 0 V
Low Voltage Supply Cable Connector Solder-side 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 an appropriate IEC standard, e.g. IEC 60950-1, and meet the reinforced insulation from mains requirement of IEC 61010-1
Environmental	Ensure that the EPS meets the environmental specification of the overall product (see above)

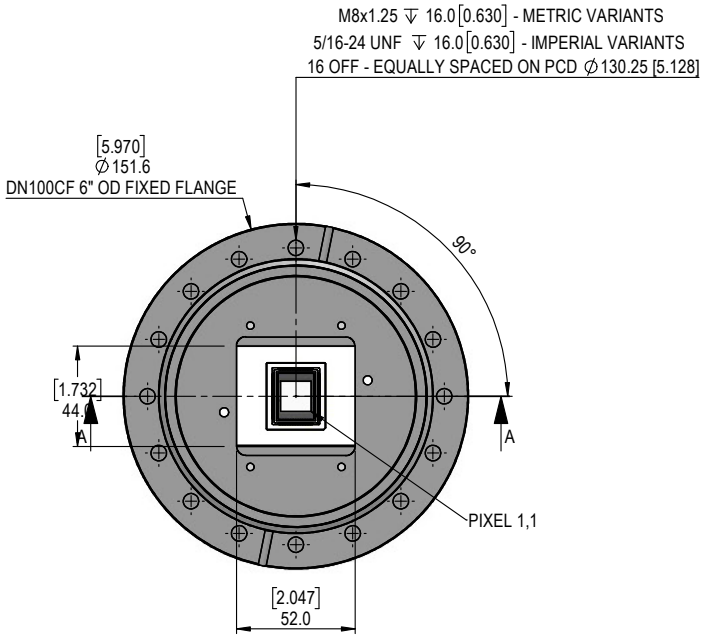
Camera Power Specifications

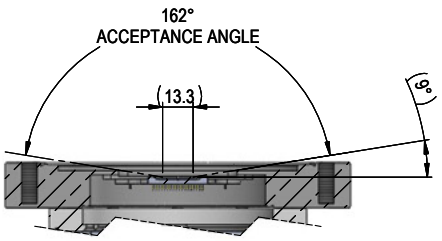
Mains Input for Supplied External Power Supply	100-240 VAC, 50-60 Hz
Power Consumption	Camera + External Power Supply: Air cooling of sensor to -25˚C: 46 W typical/ 114 W max Water cooling of sensor to -45˚C: 57 W typical/ 114 W max Camera Only: Air cooling of sensor to -25˚C: 40 W typical / 100 W max Water cooling of sensor to -45˚C: 50 W typical/ 100 W max
Voltage Rating	15 V
Current Rating	8 A

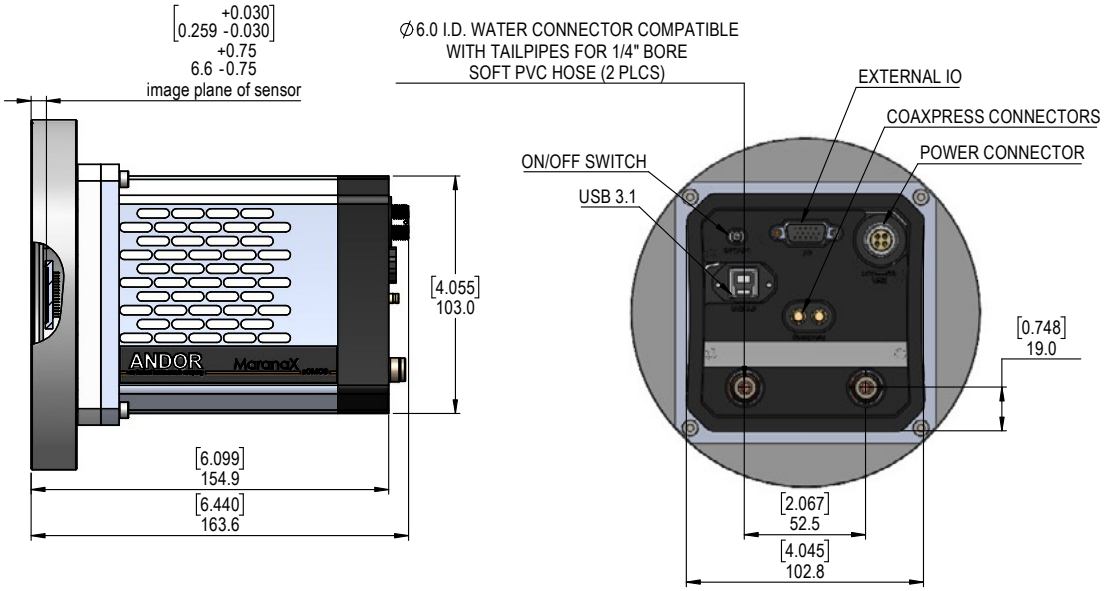
Appendix B: Mechanical Drawings

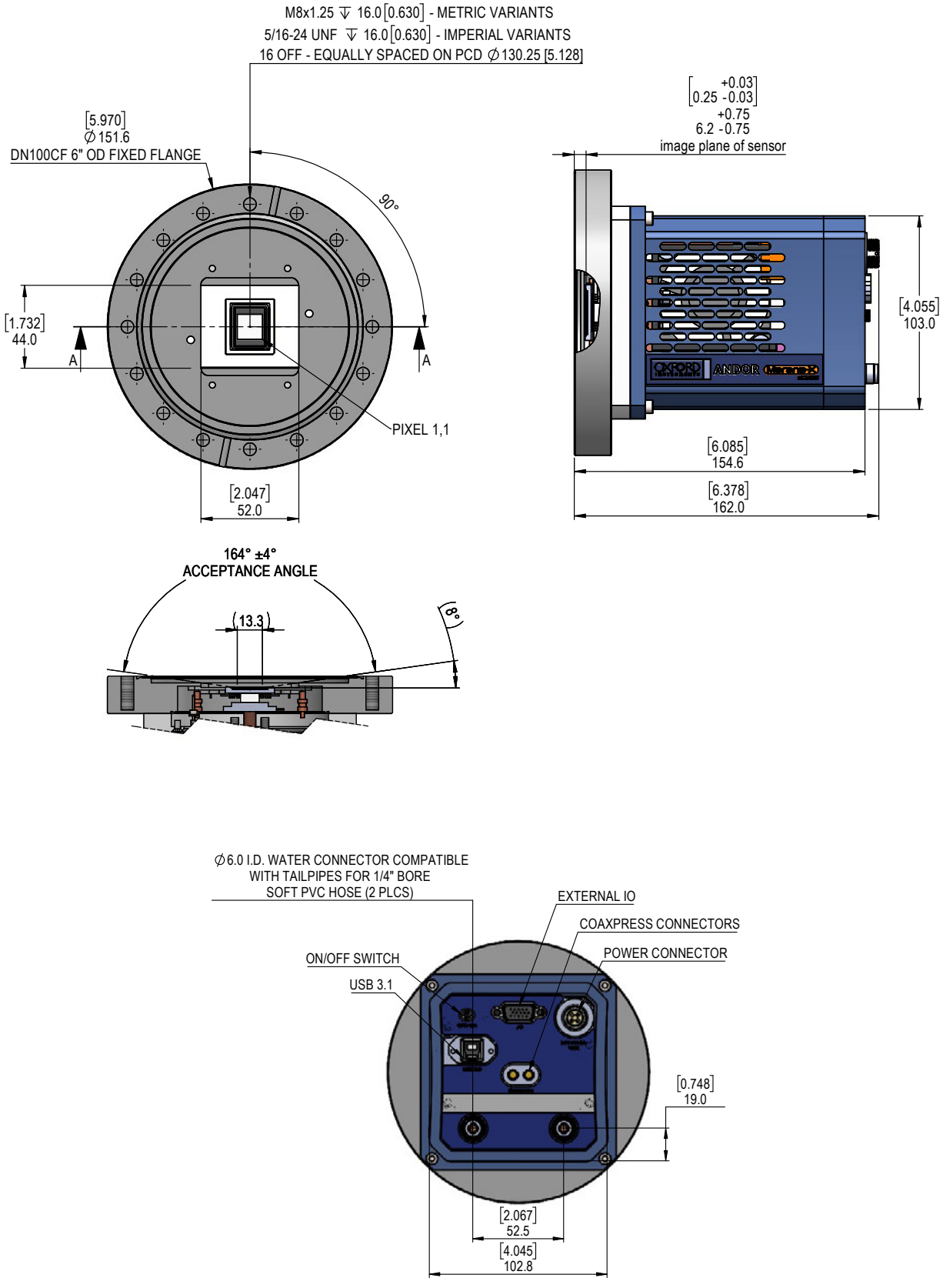
Dimensions in mm [inches]

Weight (approx): ~5.4 kg





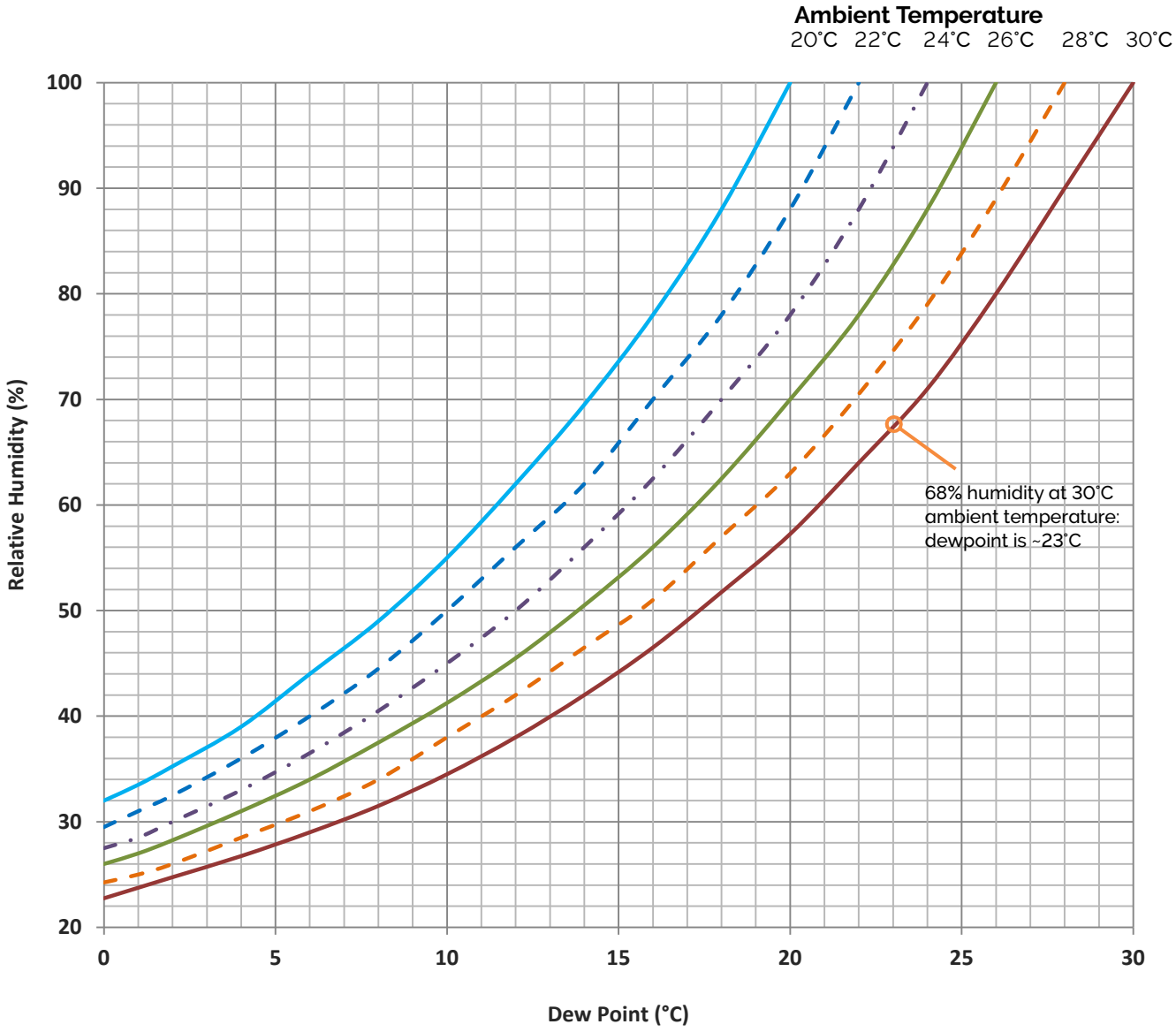



M8x1.25 ↧ 16.0 [0.630] - METRIC VARIANTS
5/16-24 UNF ↧ 16.0 [0.630] - IMPERIAL VARIANTS
16 OFF - EQUALLY SPACED ON PCD ∅130.25 [5.128]
[5.970]
∅151.6
DN100CF 6" OD FIXED FLANGE
90°
[1.732]
44.0
A
A
PIXEL 1,1
[2.047]
52.0
[+0.03
0.25 -0.03]
+0.75
6.2 -0.75
image plane of sensor
[4.055]
103.0
[6.085]
154.6
[6.378]
162.0
164° ±4°
ACCEPTANCE ANGLE
(13.3)
8°
∅6.0 I.D. WATER CONNECTOR COMPATIBLE
WITH TAILPIPES FOR 1/4" BORE
SOFT PVC HOSE (2 PLCS)
EXTERNAL IO
COAXPRESS CONNECTORS
POWER CONNECTOR
ON/OFF SWITCH
USB 3.1
[0.748]
19.0
[2.067]
52.5
[4.045]
102.8

Appendix C: Dewpoint Information

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

The first signs that condensation is forming will be on the coolant connections entering and exiting the camera. Use of coolant at or below the dewpoint can result in permanent damage to the camera head due to formation of condensation on internal components. It is therefore very important to ensure that coolant temperature is above the dewpoint. Further guidelines are provided in **Section 6.1**. The relationship between Relative Humidity and dewpoint at varying ambient temperature is shown below. Solis features a dewpoint calculator and there are also a range of dewpoint calculators on-line that you can enter ambient temperature and relative humidity to calculate the dewpoint for your conditions.



Appendix D: Other Information

D.1 Terms and Conditions of Sale and Warranty Information

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

D.2 EU/UK REACH Regulation Statement

Andor's EU/UK REACH Regulation statement is available here.

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

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

Appendix E: Marana-X China RoHS Hazardous Substances Declaration

Name and Content of Hazardous Substances in the Product for Marana-X-6
产品中有害物质的名称及含量 产品中有害物质的名称及含量

Component Name 部件名称	Hazardous Substance: 有害物质					
	Lead (Pb) 铅	Mercury (Hg) 汞	Cadmium (Cd) 镉	Chromium VI Compounds (Cr^{6+}) 六价铬化合物	Polybrominated Biphenyls (PBB) 多溴化联苯	Diphenyl Ethers (PBDE) 多溴联苯醚
Sensor 芯片	O	O	O	O	O	O
Printed Circuit Board Assemblies 路板组件 电路板组件	X	O	O	O	O	O
Fan Assembly 风扇	O	O	O	O	O	O
Cooling Assembly 制冷系统	O	O	O	O	O	O
Heatsink 散热片	O	O	O	O	O	O
Metal Parts 金属部件	O	O	O	O	O	O
Solder 焊接物	O	O	O	O	O	O
Power Supplies 电源	O	O	O	O	O	O
Accessories 配件	X	O	O	O	O	O
Label 标签	O	O	O	O	O	O

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