ANDOR
an Oxford Instruments company

iDus 416

Version 1.1 revised 05 Mar 2015

Hardware Guide

andor.com

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Revision History

Version	Released	Description
0.1	Internal use only 19 Feb 2013	Initial version- developed from iDus 401/420 generic User Guide
0.2	Internal use only 21 Feb 2013	Updated A2 Mechanical Dimensions to include with/without optional mounting foot information.
0.3	Internal use only 15 Mar 2013	Additional Safety Instructions added to Preface. Updated power supply instructions and information, Section 1.7. Added additional coolant pressure information Section 1.8.6.2
0.4	Limited release 05 Feb 2014	Added updated EMC statement regarding use of video mode (Section 1.8.4)
1.0	24 Feb 2014	Initial Release. Updated presentation (all sections)
1.1	05 Mar 2015	Updated presentation to Hardware Guide format. Software functionality covered in software guide provided and updated with control software (available separately).

Safety and Warning Information

PLEASE READ THIS INFORMATION BEFORE USE

1. To ensure correct and safe operation of this product, please read this guide before use and keep it in a safe place for future reference
2. If the equipment is used in a manner not specified by Andor, the protection provided by the equipment may be impaired
3. Before using the system, please follow and adhere to all warnings, safety, manual handling and operating instructions located either on the product or in this Hardware Manual
4. The Andor iDus 416 is a precision scientific instrument containing fragile components. Always handle with care
5. Do not expose the product to extreme hot or cold temperatures
6. Ensure that a minimum clearance of approximately 90mm (3.5”) is maintained in front of all ventilation slots and the fan inlet
7. Do not expose the product to open flames
8. Do not allow objects to fall on the product
9. Do not expose the product to moisture, wet or spill liquids on the product. Do not store or place liquids on the product. If a spillage occurs on the product, switch off power immediately, and wipe off with dry, lint-free cloth. If any ingress has occurred or is suspected, unplug mains cable, do not use, and contact Andor service
10. Electromagnetic Compatibility: This is a Class A product. In a domestic environment this product may cause electromagnetic interference, in which case the user may be required to take adequate measures.
11. The product contains components that are extremely sensitive to static electricity and radiated electromagnetic fields, and therefore should not be used, or stored, close to EMI/RFI generators, electrostatic field generators, electromagnetic or radioactive devices, or other similar sources of high energy fields
12. Operation of the system close to intense pulsed sources (e.g. plasma sources, arc welders, radio frequency generators, X-ray instruments, and pulsed discharge optical sources) may compromise performance if shielding of the iDus 416 is inadequate.
13. 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.
14. The iDus 416 is for indoor use only.
15. Pollution Degree 2. Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected
16. Overvoltage category CAT II- this means that the equipment is designed to cope with transient voltages above the rated supply that would be experienced by any product connected to a mains socket in a building.
17. Use only the power supply cord provided with the system for this unit. Should this not be correct for your geographical area, contact your local Andor representative
18. Only the correctly specified mains supply and fuse must be used.
19. Replace fuse with same type and rating.
20. Make sure the electrical cord is located so that it will not be subject to damage
21. There are no user-serviceable parts beyond the specified user accessible areas of the product and the enclosure must not be opened. Only authorised service personnel may service this equipment

Warning Labels and Symbols

The following labels and symbols are found on the product and in the supplied User Guides:

WARNING: Important safety information to ensure safe operation of the product.

This product requires a DC power supply.

SECTION 1: INTRODUCTION

1.1 Introduction

Thank you for choosing the Andor iDus 416. Andor's **CCD** (**C**harge **C**oupled **D**evice) exploits the processing power of today's desk-top computers. USB 2.0 connectivity ensures a seamless interface with the camera, as well as generating and receiving the signals you use to work with pulsed sources.

The system's hardware components and its comprehensive software provide speed and versatility that classical bench-top spectrometers cannot offer.

From the outset, the iDus has been designed for ease of use. The camera is compact, requires no maintenance, and fits easily to all Andor and other popular spectrographs.

Under Solis software control, it serves as both a multi-channel detector and a linear image sensor, catering for a broad range of spectroscopic applications.

Please refer to the Solis Software guide for further information.

1.2 About this Hardware Guide

This manual provides an overview of the iDus 416 Hardware features and functions and additional information that will help you get the best performance out of your camera. Information on controlling your iDus 416 through SDK or Solis is provided in the respective software guides. General software information for the iDus series is also available in the iDus User Guide.

1.3 Solis Help

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

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

1.4 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
www.andor.com/contact_us/support_request

USA
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425 Sullivan Avenue
Suite # 3
South Windsor
CT 06074
USA
Tel. +1 (860) 290-9211
Fax. +1 (860) 290-9566
www.andor.com/contact_us/support_request

Asia-Pacific
Andor Technology (Japan)
4F NE Sarugakucho Building
2-7-6 Sarugaku-Cho
Chiyoda-Ku
Tokyo 101-0064
Japan
Tel. +81-3-3518 6488
Fax. +81-3-3518 6489
www.andor.com/contact_us/support_request

China
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Luo Ke Time Square
No. 103 Huizhongli
Chaoyang District
Beijing,100101 P.R.
China
Tel: +86 (0)10 51294977
Fax. +86(0)10-6445-5401
www.andor.com/contact_us/support_request

* The latest contact details for your local representative can be found on our website.

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1.7 Trademarks and Patent Information

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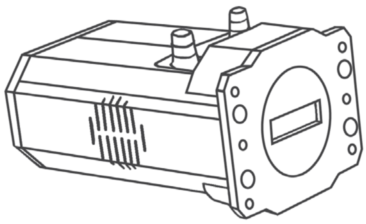
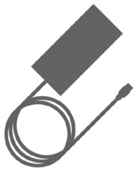
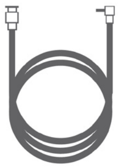
Changes are periodically made to the product and these will be incorporated into new editions of the manual. New versions of all Andor manuals will be made available through MyAndor http://my.andor.com/login.aspx. If you do not have an account please register at http://my.andor.com/Register.aspx.

1.8 Supplied Components

The standard components are outlined below. Please refer to the packing list and your order information to ensure that your camera and system options are present.

Description		Quantity
	iDus 416 CCD Camera	1
	USB 2.0 Cable	1
	Power Supply Unit (PSU) and Country Specific Power Cord	1
	BNC-SMB Cable	1
	Allen Key (x2)	1
	Quick Start Guide	1
	Product Manual CD	1

1.9 Optional Components

There are a range of optional components available including:

- Spectrographs such as Andor Shamrock and HoloSpec series
- Control Software e.g. Solis and SDK2
- Water Cooling systems (re-circulator or chiller) and accessories
- Additional PSU (for enhanced cooling option)
- Mounting Flanges
- Shutter and Shutter Driver

Please contact your nearest Andor Sales Representative for further information on these and other system components available.

1.10 Transport and Storage Information

- The packaging used for the original delivery should be retained for further use.
- Storage/Transportation temperature range: -25°C to 50°C
- The packaging must be protected from excesses of weather.
- Relative humidity must not exceed 90% (non-condensing).

SECTION 2: PRODUCT OVERVIEW

This section provides an overview of the iDus 416.

2.1 Hardware Features

Figure 1: Main features of the iDus 416

CCD Sensor

The iDus 416 features a Back-illuminated, Deep Depletion CCD sensor with very low dark noise and very high Quantum Efficiency (QE). This sensor has been optimised for best performance in the near infra-red (NIR) spectrum. A thermoelectric cooler (TEC) is used to remove heat from the sensor and enable cooling down to -95°C (deep cooled version), eliminating dark current noise.

Camera Window

The camera windows primary function is to protect the sensor beneath. The camera window is a UV-grade, AR coated, fused silica optimised at 900 nm- matched to the sensor, specifically for best optical performance in the NIR region.

UltraVac™

The iDus 416 features Andor's proprietary UltraVac™ technology- the sensor is located within a permanent hermetically sealed vacuum head. This process ensures peak QE and maximal cooling will not degrade even after years of operation. For more information on UltraVac, please refer to Appendix C.

Mounting Flange

The mounting flange enables simple, direct and secure connection to the Andor Shamrock series of spectrographs. Additional mounting flanges are available to allow connection to a wide range of other spectrographs.

Cooling Fan

When running in normal air-cooled mode a cooling fan is used to dissipate heat from the sensor TEC. It is important to ensure that the ventilation slots on each side of the camera are kept clear of obstruction for effective cooling. For further information refer to Sections 2.5 and 2.6.

Power and Signal Connections

Refer to Section 2.1.1.

Water Pipe Connections

It is possible to use a water/liquid cooling system to enhance the cooling performance of the iDus 416. For further information on cooling refer to Section 2.6.

2.1.1 Power and Signal Connections

The power and signal connections are located on the back plate of the camera. These are outlined in the figure below.

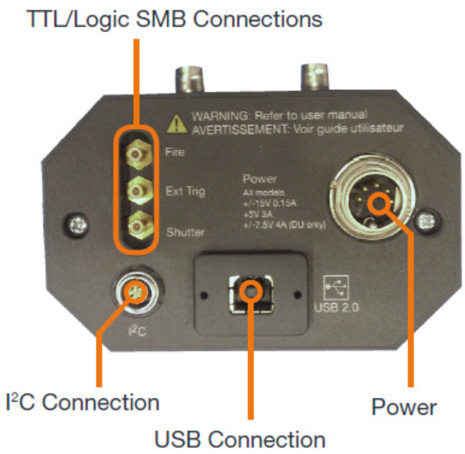


Figure 2:Power and Signal Connections of the iDus 416

TTL/Logic SMB Connections

3x are industry-standard SMB (Sub Miniature B) connectors labelled from top to bottom as follows:

- **Fire**
- **Ext Trig**
- **Shutter**

These are used to send or receive Triggering and Firing signals, which are described later in this manual. The SMB outputs (**Fire & Shutter**) are CMOS compatible & Series terminated at source (i.e. in the camera) for 50Ω cable.

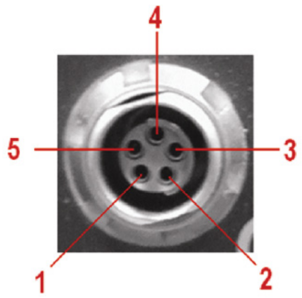
NOTE: The termination at the customer end should be high impedance (not 50Ω) as an incorrect impedance match could cause errors with timing and triggering. The SMB Ext Trig input is TTL level & CMOS compatible and has 470Ω impedance.

USB 2.0 Connection

A USB 2.0 compatible cable can be connected between the USB socket and a PC to enable control of the camera.

I^{2}C Connection

The pin connections for the five-way I^{2}C connector used on the iDus are shown below:



PIN	FUNCTION
1	SHUTTER (TTL)
2	I^{2}C CLOCK
3	I^{2}C DATA
4	+5V
5	GROUND
FISCHER CLIC-LOC™	

Power Connection

A 5-pin DIN plug is fitted for connection to the external PSU. Refer to Section 2.2.

2.2 Power Supply

The iDus 416 is supplied with an external PSU with a 5 pin DIN output plug. Do not use any other power supply unit with the iDus 416 other than those specified by Andor. The external power supply requirements are: 100-240 VAC, 50-60 Hz.

- **The iDus requires a Direct Current (DC) supply.**
- **The Electrical mains lead must be certified for use in your country. In applicable countries the plug must be fitted with a 240 V 5A fuse. In the UK this is a BS 1362, 6.3 × 25.4 mm (¼ × 1 inches) cartridge. Replace with same type and rating for continued protection.**
- **If Users use any other non-certified power supply, they do so at their own risk.**

2.3 Optional Power Supply for Additional Cooling

An optional power supply can be used to achieve maximum cooling. The connection to the iDus is also made via a 5-pin DIN socket. Refer to the Specifications below. For any further information on the power supply for your region please contact your local Andor Representative.

Input	100-240 VAC, 50-60Hz
Outputs:	
Pin 1	+5 VDC, 3.5 A
Pin 2	+7.5 VDC, 4 A
Pin 3	0 VDC, (Common)
Pin 4	+15 VDC, 100mA
Pin 5	-15 VDC, 100mA

2.3.1 Software

Software to control your iDus 416 camera is sold separately-please refer to you software guide for further information.

2.3.2 Manuals

A full set of current Andor product manuals is provided with each system on CD. New versions of manuals will be made available through MyAndor http://my.andor.com/login.aspx. If you do not have an account please register at http://my.andor.com/Register.aspx.

2.4 Working with Electronics

The computer equipment that is to be used to operate the iDus 416 should be fitted with appropriate surge/EMI/RFI protection on all power lines. Dedicated power lines or line isolation may be required for some extremely noisy sites. Appropriate static control procedures should be used during the installation of the system. Attention should be given to grounding. All cables should be fastened securely into place in order to provide a reliable connection and to prevent accidental disconnection.

The circuits used in the camera are extremely sensitive to static electricity and radiated electromagnetic fields, and therefore they should not be used, or stored, close to EMI/RFI generators, electrostatic field generators, electromagnetic or radioactive devices, or other similar sources of high energy fields. Types of equipment that can cause problems include the following:

- Arc welders
- Plasma sources
- Pulsed-discharge optical sources
- Radio frequency generators
- X-ray instruments

Operation of the system close to intense pulsed sources (lasers, xenon strobes, arc lamps, etc.) may also compromise performance, if shielding is inadequate.

Our testing shows that this product exceeds the international EMC and ESD susceptibility requirements in its normal operating modes. However, during installation, “video” mode is sometimes used to set the camera up, and this particular mode can be subject to interference from electrostatic discharge. This effect is difficult to reproduce and we consider it to be a permissible loss of performance under EN 61326-1:2013.

2.5 Prevention of Camera Overheating

Care should be taken to ensure that the camera does not overheat, as this can cause system failure. Overheating may occur if either of the following situations arises:

- The air vents on the sides of the camera are accidentally blocked or there is insufficient or no water flow
- The ambient air temperature is more than 30°C.

To protect the camera from overheating, a thermal switch has been attached to the heat sink. If the temperature of the heat sink rises above predefined limit then the current supply to the cooler will cut out and a buzzer will sound. The cut-out will automatically reset once the camera has cooled. It is not recommended that you operate in conditions that would cause repeated cut-outs as the thermal switch has a limited number of operations.

2.6 Cooling

The CCD detector is cooled using a thermoelectric (TE) cooler. TE coolers are small, electrically powered devices with no moving parts, making them reliable and convenient. A TE cooler is actually a heat pump, i.e. it achieves a temperature difference by transferring heat from its 'cold side' (the CCD-chip) to its 'hot side' (the built-in heat sink). Therefore the minimum absolute operating temperature of the CCD depends on the temperature of the heat sink. Our vacuum design means that we can achieve a maximum temperature difference of over 110ºC (DU models with optional power supply), a performance unrivalled by other systems. The maximum temperature difference that a TE device can attain is dependent on the following factors:

- Heat load created by the CCD
- Number of cooling stages of the TE cooler
- Operating current.

The heat that builds up on the heat sink must be removed and this can be achieved in one of two ways:

1. **Air cooling**: a small built-in fan forces air over the heat sink.
2. **Water cooling**: external water is circulated through the heat sink using the water connectors on the top of the camera.

All Andor CCD systems support both cooling options. Whichever method is being used, it is not desirable for the operating temperature of the CCD detector simply to be dependant on or vary with the heat sink temperature. Therefore a temperature sensor on the CCD, combined with a feedback circuit that controls the operating current of the cooler, allows stabilisation of the CCD to any desired temperature within the cooler operating range.

As well as a choice of cooling method there is also a choice of performance versus compactness. This arises from the Power Supply Unit options that are available for supplying power to the temperature control circuit, i.e. the standard supplied PSU (and optional PSU).

2.6.1 Air Cooling

Air cooling is the most convenient method of cooling, but it will not achieve as low an operating temperature as is possible by water cooling (see below). Even with a fan (see **NOTE** immediately below), a heat sink typically needs to be 10ºC hotter than the air (room) temperature to transfer heat efficiently to the surrounding air. Therefore the minimum CCD temperature that can be achieved will be dependent on the room temperature.

NOTE: The fan does not operate until the heat sink temperature has reached between 20ºC and 22ºC. It is therefore normal for the fan not to operate when the system is first switched on.

2.6.2 Water Cooling

A flow of water through the heat sink removes heat very efficiently, since the heat sink is never more than 1ºC hotter than the water. With this type of cooling, the minimum temperature of the CCD will be dependent only on the water temperature and not on the room temperature.

Water cooling, either chilled though a refrigeration process or re-circulated (which is water forced air cooled then pumped) allows lower minimum operating temperatures than air cooling. However, there is a very important point relating to water cooling. If the water temperature is lower than the dew point of the room, condensation will occur on the heat sink, the water taps and other metal parts of the camera. This will quickly destroy the camera and must never be allowed to happen (Refer to the dew point graph in Appendix D). This is not an issue when using a Recirculator which eliminates the dew point problem.

WARNINGS

- NEVER USE COOLING WATER THAT IS COLDER THAN THE DEW POINT OF THE AIR IN THE ROOM. DAMAGE CAUSED IN THIS WAY IS NOT COVERED BY THE WARRANTY.
- RECOMMENDED COOLING SUPPLY PRESSURE: MAX 2 BAR (30 PSI)

NOTES:

- **The relationship between the air temperature and the minimum CCD temperature in the table is not linear. This is because TE coolers become less efficient as they get colder.**
- **Systems are specified in terms of the minimum dark current achievable, rather than absolute temperature. For dark current specifications, please refer to the specification sheet for your camera.**

2.6.3 Fan Settings

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

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

NOTE: If water cooling is being used, the fan can be turned off and exceptional cooling performance maintained indefinitely.

SECTION 3: INSTALLATION

3.1 Computer Requirements

The minimum computer requirement for correct iDus operation is as follows:

- 3.0GHz single core or 2.4GHz multi core Processor with 2GB RAM
- Windows (XP, Vista, 7 or 8) or Linux
- USB 2.0 High Speed Host Controller capable of sustained rate of 40 MB/s
- 100MB of free hard disc space (at least 1GB recommended for data spooling)

3.2 Installing the Camera Control Software

Note: You must have administrator access on your PC to install software on your PC.

Refer to your software e.g. Solis or SDK2 for installation instructions.

3.3 Installing the Software & USB Driver

1. Terminate & exit any programmes which are running on the PC.
2. Insert the Andor CD. The **Install Wizard** now starts. If it does not start automatically, run the file **setup.exe** directly from the CD then follow the on-screen prompts that then appear, as appropriate for your operating system.
9. If prompted, select the '**Yes, I want to restart my computer now**' option then click **Finish** to complete the installation of the camera software.

3.4 Connecting the iDus 416 to a Spectrograph

Notes:

- **Refer also to your Spectrograph User Guide.**
- **If an Andor Spectrograph was ordered with your iDus 416, the iDus 416 should come ready to use and aligned on the Spectrograph. If the camera needs to be aligned, refer to the alignment section of your Spectrograph user guide.**

3.4.1 Attach the iDus 416 to the Spectrograph

1. Carefully remove the protective film from the front face of the camera.
2. Remove the blanking plate from the Spectrograph mounting plate.
3. Align the camera to the mounting plate of the Spectrograph as shown below.

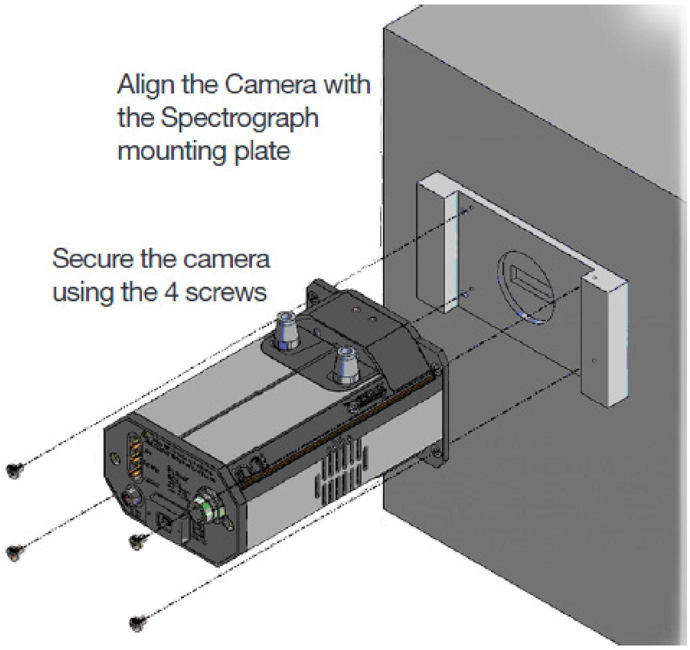


Figure 3: Connecting the iDus 416 to a spectrograph

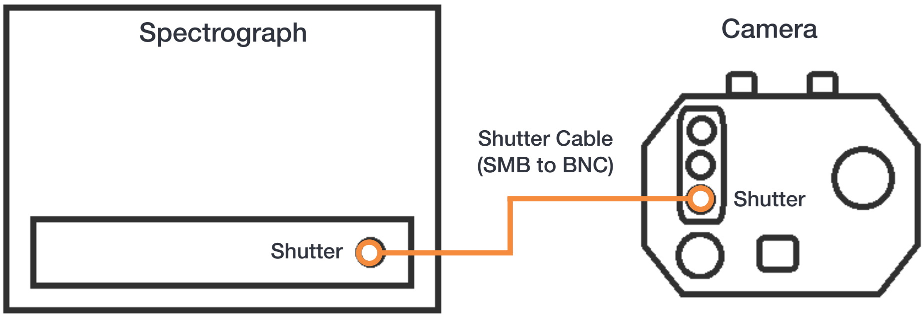
4. Secure the camera to the Spectrograph as shown, using the 4 screws provided.

3.4.2 Connecting the Signal Cables between the iDus 416 and the Spectrograph

The Spectrograph can be controlled through either the SMB or I²C (where available) connections. Both options are shown below:

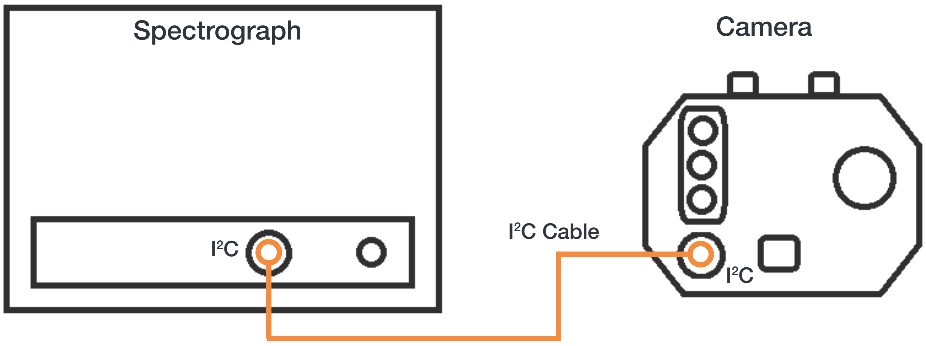
3.4.2.1 SMB

1. Connect the SMB to BNC cable to the camera SMB Shutter connection.
2. Connect the other end of the SMB to BNC cable to the Spectrograph Shutter BNC connection.



3.4.2.2 I²C

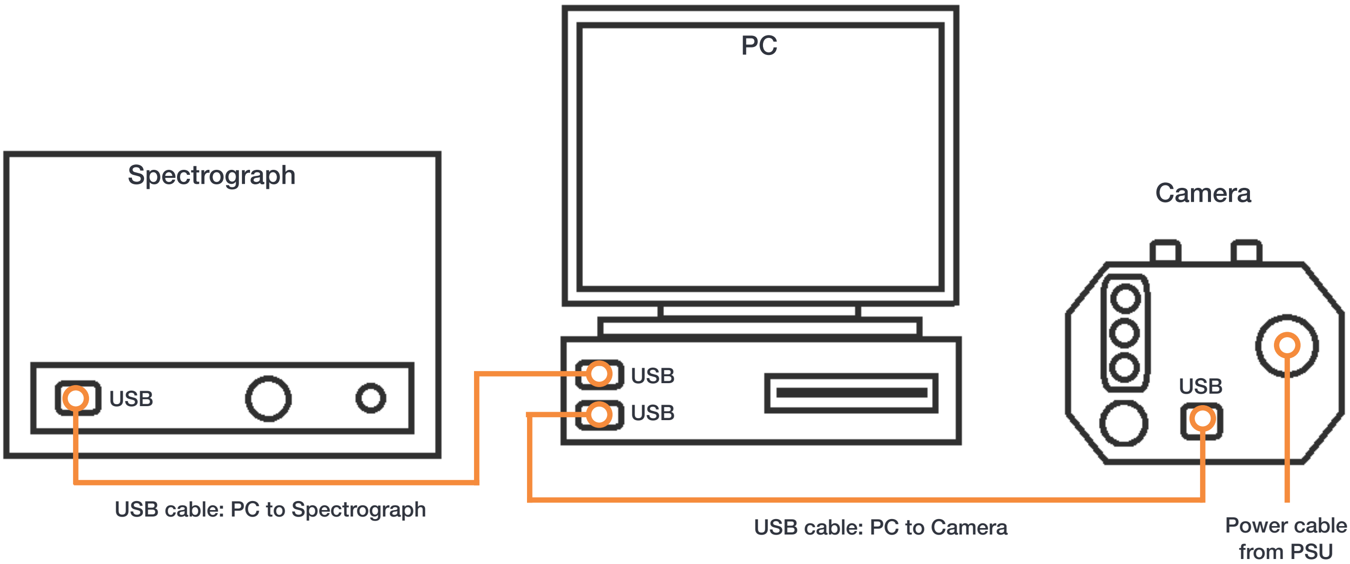
1. Connect the I²C cable to the I²C connection on the camera.
2. Connect the other end of the I²C cable to the I²C connection on the Spectrograph.
3. The SMB to BNC cable is not required when using the I²C connection.



3.5 Connecting the iDus 416 to the Control PC

Ensure the mains power cable is not inserted before attaching the PSU to the camera.

1. Insert the power cable from the power supply into the 5-way DIN power connector at the rear of the camera. Secure in position using the screw-lock.
2. Insert the mains cable into the camera power supply unit.
3. Connect the USB cable to the camera and an available USB port on the PC. Note: the PC is connected to both the spectrograph and the camera by USB connections.



4. Ensure the camera and spectrograph cable connections have been made as shown in Section 3.4.
5. Connect the Camera PSU to the power supply.

3.6 Optional Mounting Flanges

Mounting Flanges (or face plates) are metal plates which allow the camera to be positioned at the focal plane of a spectrograph.

Andor can provide mounting flanges for a wide range of spectrographs, in imaging and non-imaging format, with focal lengths ranging from 125cm to 1m if required.

Please consult your spectrograph instruction manual to ensure that you are using the correct flange.

SECTION 4: USING THE IDUS 416

The iDus 416 is controlled through the software and the options and functions available will depend on which software is used. Please refer to your control software e.g. Solis or SDK2.

WARNINGS:

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

4.1 Emergency Mains Disconnection

In case of emergency, the disconnecting point of the equipment is the mains power cord connected to the external power supply, or the mains socket switch.

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

4.2 Power up Sequence

1. Switch on your PC.
2. Switch on power to other system components as described in their user guides.
3. Start your software (refer to your software manual).
4. Start acquiring data.

4.3 Power down Sequence

1. Close down the software.
2. Switch off power to other system components as described in their user guides.
3. Switch off power to the system at the power supply if the units will not be used for some time.

4.4 Risk Mitigation

4.4.1 Mechanical Housings

Once installed the Camera, Spectrograph and any other system components form the protective housings of the product. No components, panels, connections or linkages should be loosened or removed.

4.4.2 Hazards Due to Moisture or Liquids

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

SECTION 5: MAINTENANCE

WARNINGS:

- **THERE ARE NO USER MAINTENANCE PROCEDURES REQUIRED FOR THE IDUS 416.**
- **THE SYSTEM SHOULD BE POWERED-DOWN PRIOR TO USER PERFORMING ANY SYSTEM CHECKS.**
- **DO NOT USE EQUIPMENT THAT IS DAMAGED.**
- **CONTACT YOUR ANDOR REPRESENTATIVE IF THERE ARE ANY QUERIES OR ISSUES WITH YOUR SYSTEM.**

5.1 Cleaning and Decontamination

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

- To clean the product, only use a damp, lint-free cloth on the external housing of the unit. Do not wet the connectors.
- Use water only- do not use solvents, cleaning agents, or aerosols.

5.2 Regular Checks

The state of the product should be checked regularly, especially the integrity of the enclosure and the mains cable.

On a Daily Basis:

- Visually inspect the system.
- Perform any maintenance activities suggested in the user documentation supplied with your system

On a Weekly Basis:

- Ensure that all power cables are firmly in place.
- Check cables and connections to ensure that no damage has occurred to the cables connecting the various elements of the system.

5.3 Replacement Parts

There are no user replaceable parts in the camera- please contact your nearest Andor representative (see Section 1.1) if required.

5.4 Fuse Replacement

The camera itself does not have a fuse. However, if a U.K. (BS 1362) mains lead has been supplied, it contains a fuse, whose characteristics are as follows:

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

For continued protection, always replace with a fuse of the same type and rating.

SECTION 6: TROUBLESHOOTING

6.1 Unit does not switch on

- Check power cord is plugged in and connected correctly to mains supply
- If applicable, replace fuse in the supplied mains cable (Section 5.4).
- If the unit still does not switch on after the checks above have been carried out, contact Andor Technical Support

6.2 Device not recognised when plugged into PC

- Choose another USB port
- Check connections

6.3 Temperature Trip Alarm sounds

To protect the camera from overheating, a thermal switch has been attached to the heat sink. If the temperature of the heat sink rises above the predefined limit, the power supply to the cooler will cut off and a buzzer will sound. Should the buzzer sound ensure the following:

Air Cooling

- Check that the air vents on the sides of the camera are not blocked
- The ambient air temperature is not above 30°C
- The fan has not been deactivated (or the speed set too low) in software
- Check that no foreign bodies are obstructing the fan's rotation

Water Cooling

- That there is sufficient water flow through the cooling system

NOTE: When using water cooling, always use water that is above the dew point of the ambient environment to prevent condensation from occurring.

The thermal cut-out will not reset until the camera has been powered off and the temperature of the metalwork reaches a predefined limit. Operation of the camera under conditions that cause repeated cut-outs is not recommended, as thermal cycling will unnecessarily cycle the components and solder joints in the system.

SECTION 7: TECHNICAL SPECIFICATIONS

7.1 General

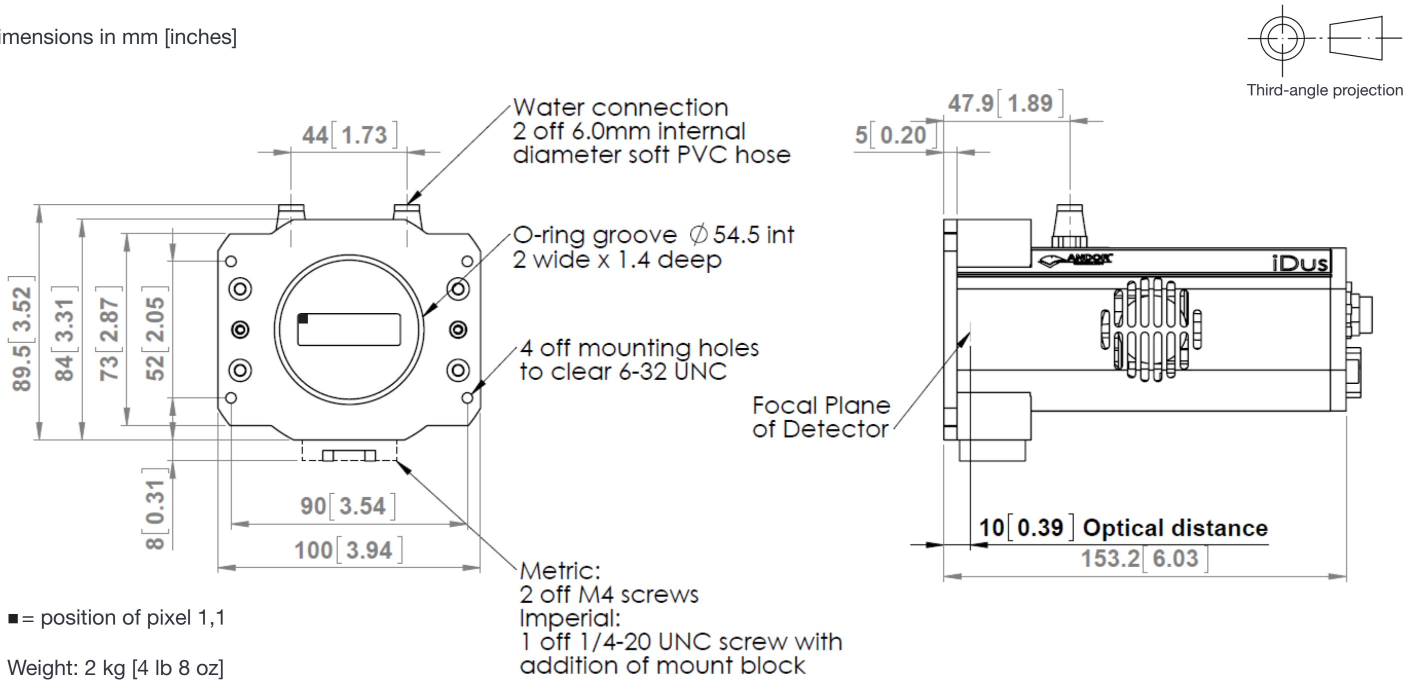
Model	Standard Cooling: DV416A-LDC-DD	Deep Cooling: DU416A-LDC-DD
Sensor	LDC-DD: Back-Illuminated CCD, Deep-Depletion with anti-fringing, low dark current	
Active pixels	2000 x 256	
Pixel size (W x H)	15 x 15 µm	
Image area	30 x 3.8 mm	
Register well depth (typical)	300,000 e-	
Minimum temperatures:		
Air cooled	-55°C	-80°C
Coolant recirculator	-65°C	-90°C
Coolant chiller, coolant @ 10 °C, 0.75 l/min	-70°C	-95°C
Cooling type	Thermoelectric (with forced air cooling, or optional water cooling)	
Max. Spectra per second	30 (Full Vertical Binning)	
Camera control	USB 2.0	
Signal connections	SMB: provided with SMB - BNC cable, Fire (Output), External Trigger (Input), Shutter (Output) I^2C connector: Compatible with Fischer SC102A054-130 1 = Shutter (TTL), 2 = I^2C Clock, 3 = I^2C Data, 4 = +5 Vdc, 5 = Ground	
Power Requirements	100-240 VAC, 50-60 Hz	
Dimensions (approx) L x W x H mm [inches]	153.2 [6.03] x 100 [3.94] x 89.5 [3.52]	
Weight	2 Kg [4 lb 8 oz]	

7.2 Environmental

Usage	Indoor use only
Altitude	Up to 2000 m
Operating Temperature	0°C to 30 °C ambient
Storage Temperature	-25°C to 50 °C ambient
Operating Relative Humidity	<70% (non-condensing)
Overvoltage Category	CAT II An overvoltage category of CAT II means that the equipment is designed to cope with transient voltages above the rated supply that would be experienced by any product connected to a mains socket in a building.
Rated Pollution	Pollution Degree 2. Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.
Ventilation Requirements	Allow 90mm space at the rear for signal and power connections. Ensure ventilation slots at both side of the camera are clear of obstruction to allow normal cooling in air-cooled mode.

APPENDIX A: MECHANICAL DRAWINGS

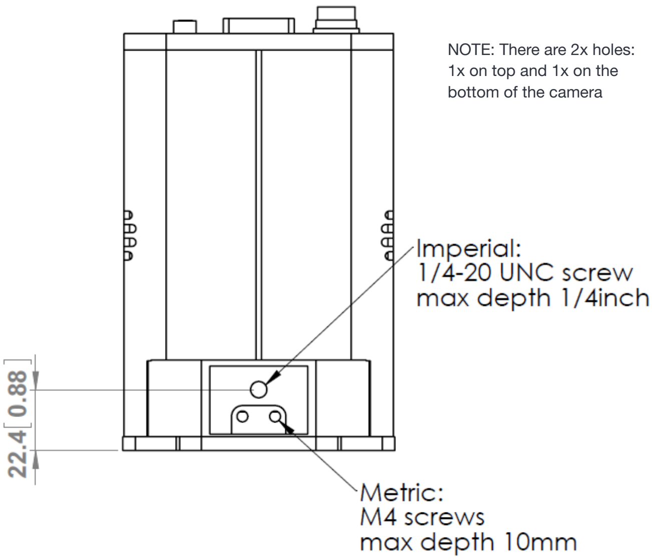
Dimensions in mm [inches]



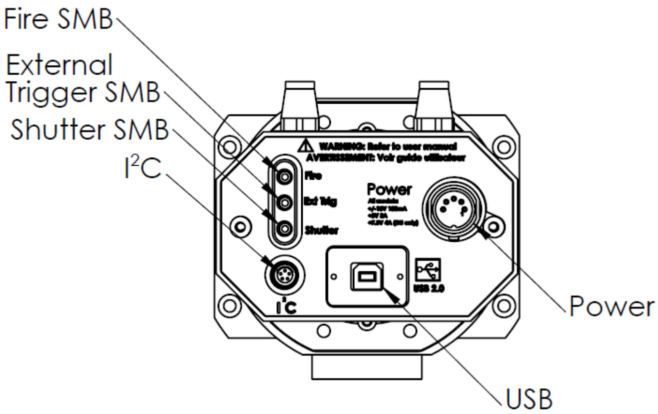
■= position of pixel 1,1

Weight: 2 kg [4 lb 8 oz]

Mounting hole locations



Rear connector panel



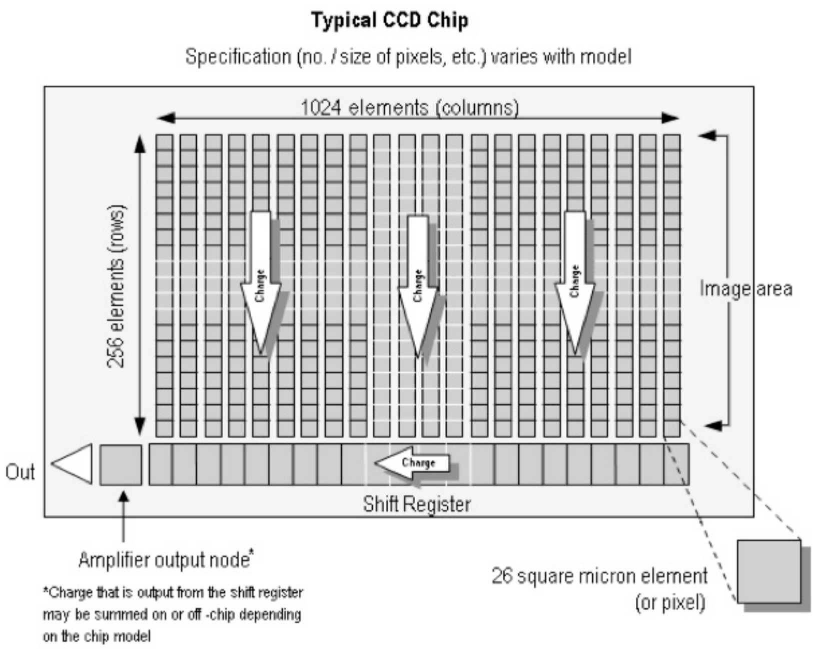
APPENDIX B: GLOSSARY

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

B1.1 - CCD

A **Charge Coupled Device (CCD)** is a silicon-based semiconductor chip bearing a two-dimensional matrix of photo-sensors, or pixels. This matrix is usually referred to as the '**image area**'. The pixels are often described as being arranged in rows and columns (rows running horizontally, columns vertically). A typical CCD-chip may comprise 256 rows and 1024 columns, or 578 rows and 385 columns (the iDus 416 has a 256 x 2000 array).

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

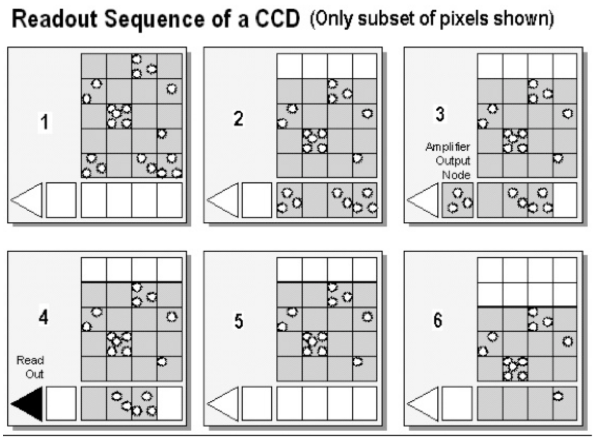


The **Shift Register** runs below and parallel to the light collecting rows. It has the same number of pixels as a light-collecting row, but is itself masked, so that no light can fall on it. When light falls on an element, electrons (photoelectrons) are produced and (in normal operation), these electrons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

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

B1.1.1 - Readout Sequence of a CCD

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



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

B1.2 - Accumulation

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

B1.3 - Acquisition

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

B1.4 - A/D Conversion

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

B1.5 - Background

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

B1.6 - Binning

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

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

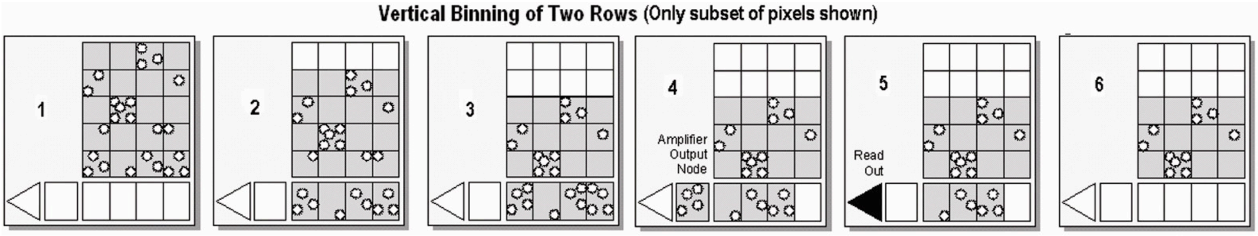
B1.6.1 - Vertical Binning

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

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

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

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



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

B1.6.2 - Horizontal Binning (Creating Superpixels)

Shifting the charge horizontally from several pixels at a time into the output node is known as horizontal binning. This is not available for the iDus 416 in Solis, but may be enabled in SDK.

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

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

Since this example initially involves binning charge from two rows, the process begins in the same way as shown in **Steps 1 - 4 of Vertical Binning of Two Rows** then horizontal binning begins.

...5	Charge from two rows has already been vertically binned into the shift register (see Vertical Binning of Two Rows on page 150). Now charge in the shift register is moved horizontally by one pixel, so that charge on the endmost pixel of the shift register is moved into the output node of the amplifier.)
6	Charge in the shift register is again moved horizontally, so that the output node of the amplifier now contains charge from two pixels of the shift register - i.e. the charge has been horizontally binned.
7	The charge in the output node of the amplifier is passed to the analog-to-digital converter and is read out.
8	Steps 4 - 6 are repeated until the shift register is empty. The process is repeated from Step 2 (again, please refer to page 150) until the whole frame is read out.

B1.7 - Counts

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

B1.8 - Dark Signal

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

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

B1.1.9 - Detection Limit

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

Sources of noise are:

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

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

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

B1.10 - Exposure Time

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

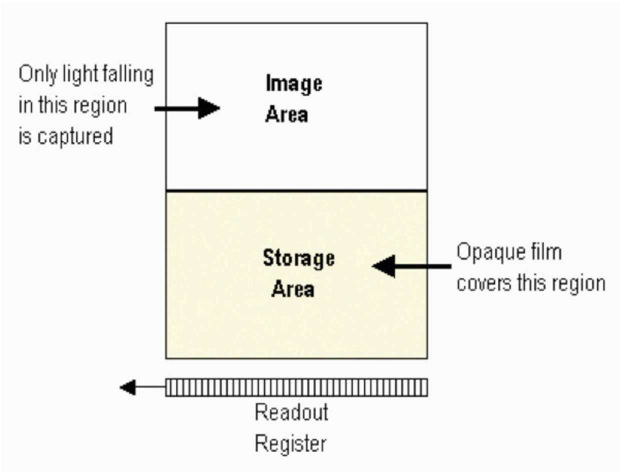
B1.11 - Frame Transfer

Frame transfer is a mode of operation of the chip. It can be switched on for any acquisition mode. It is only available if your system contains a **F**rame **T**ransfer **CCD (FT CCD)**. This mode is not applicable to the iDus 416.

An FT CCD differs from a standard CCD in 2 ways:

1. Firstly, an FT CCD contains 2 areas, of approximately equal size (see **figure** below).
    - The first area is the **Image** area, this area is at the top and farthest from the read-out register. It is in this area that the CCD is sensitive to light.
    - The second area is the **Storage** area and sits between the Image area and the read-out register. This area is covered by an opaque mask, usually a metal film, and hence is not sensitive to light.
2. The second way in which an FT CCD differs from a standard CCD is that the **Image** and the **Storage** areas can be shifted independently of each other.

These differences allow an FT CCD to be operated in a unique mode where one image can be read out while the next image is being acquired. It also allows an FT CCD to be used in imaging mode without a shutter.



B1.12 - Noise

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

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

These two categories are described in the paragraphs that follow.

B1.12.1 - Pixel Noise

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

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

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

B1.12.1.1 - Readout Noise

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

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

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

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

total = sqrt (readnoise^2 + darkshot^2 + sigshot^2)

where:

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

B1.12.1.2 - Shot Noise

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

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

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

B1.12.1.3 - Fixed Pattern Noise

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

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

B1.13 - Pixel

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

B1.14 - Quantum Efficiency / Spectral Response

The glossary refers to signals as a number of electrons. More strictly speaking these are ‘photoelectrons’, created when a photon is absorbed. When a UV or visible photon is absorbed by the CCD detector it can at best produce only one photoelectron. Photons of different wavelengths have different probabilities of producing a photoelectron and this probability is usually expressed as Quantum **E**fficiency (**QE**) or **Spectral Response**.

QE is a percentage measure of the probability of a single photon producing a photoelectron, while spectral response is the number of electrons that will be produced per unit photon energy. Many factors contribute to the QE of a CCD, but the most significant factor is the absorption coefficient of the silicon that serves as the bulk material of the device

B1.1.15 - Readout

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

B1.16 - Saturation

Saturation is the largest signal the CCD can measure. A signal is measured in terms of the amount of charge that has built up in the individual pixels on the CCD-chip. A number of factors determine the maximum amount of charge that the CCD can handle.

B1.17 - Scan Types: Keep Clean & Acquired

The CCD is continually being ‘**scanned**’ to prevent its becoming saturated with dark current (see dark signal). If the Scan is being used simply to ‘clean’ the CCD (i.e. it is a keep-clean scan), the charge from the CCD is discarded.

In an acquired scan, however, the charge undergoes A/D conversion and is acquired into computer memory so that it can be used for subsequent processing and display: it is ‘**read out**’ (see **Readout** previously). In this User’s Guide ‘scan’ generally refers to an acquired scan - unless the context specifically indicates otherwise.

B1.18 - Signal to Noise Ratio

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

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

APPENDIX C: CCD TECHNOLOGY

This section provides some further information on the technology that is used in Andor CCD cameras such as the iDus 416.

Vacuum Housing

Unless protected, cooled CCD sensors will condense moisture, hydrocarbons and other gas contaminants that will attack the CCD surface. If that happens, CCD performance will decline proportionally and will eventually fail.

Fortunately, the integrity of the sensor can be preserved by housing it in a protective enclosure. However, it is important to understand that all such environments are not the same and the underlying technology used can seriously impact camera life (and performance).

Outgassing

Outgassing is the release of a gas trapped in a material. It is a problem encountered in high-vacuum applications. Materials not normally considered absorbent can release enough molecules to contaminate the vacuum and cause damage to optical sensors, window coatings, etc.

Even metals and glasses can release gases from cracks or impurities but sealants, lubricants and adhesives are the most common cause. Left unchecked, cooling performance would steadily degrade and therefore lead to increased dark current. Furthermore, resulting electrochemical reactions would eventually destroy the sensor.

UltraVac™

A permanent hermetic vacuum head is an essential component of high-end imaging and spectroscopy cameras. A permanent vacuum requires not only a hermetic seal, but also low outgassing- which sets the real limit on long-term performance. These criteria are what Andor's UltraVac™ vacuum process uniquely ensures.

Andor's proprietary UltraVac™ process minimizes outgassing, ensuring peak quantum efficiency and cooling will not degrade, even after years of operation. Temperature of the sensor can be reduced significantly (down to -95°C with an enhanced thermoelectric Peltier design) translating into substantially lower darkcurrent and fewer blemishes.

Elimination of condensation and outgassing means that the system can also use only a single entrance window, with antireflection coating so that QE of the system is maximized. All vacuum processes are carried out in a Class 1,000 clean room. Andor's UltraVac™ is a proven solution with many years of supplying vacuum systems to the field with a negligible failure rate (Mean Time Between Failure (MTBF) of 100 years).

Thermoelectric Cooler

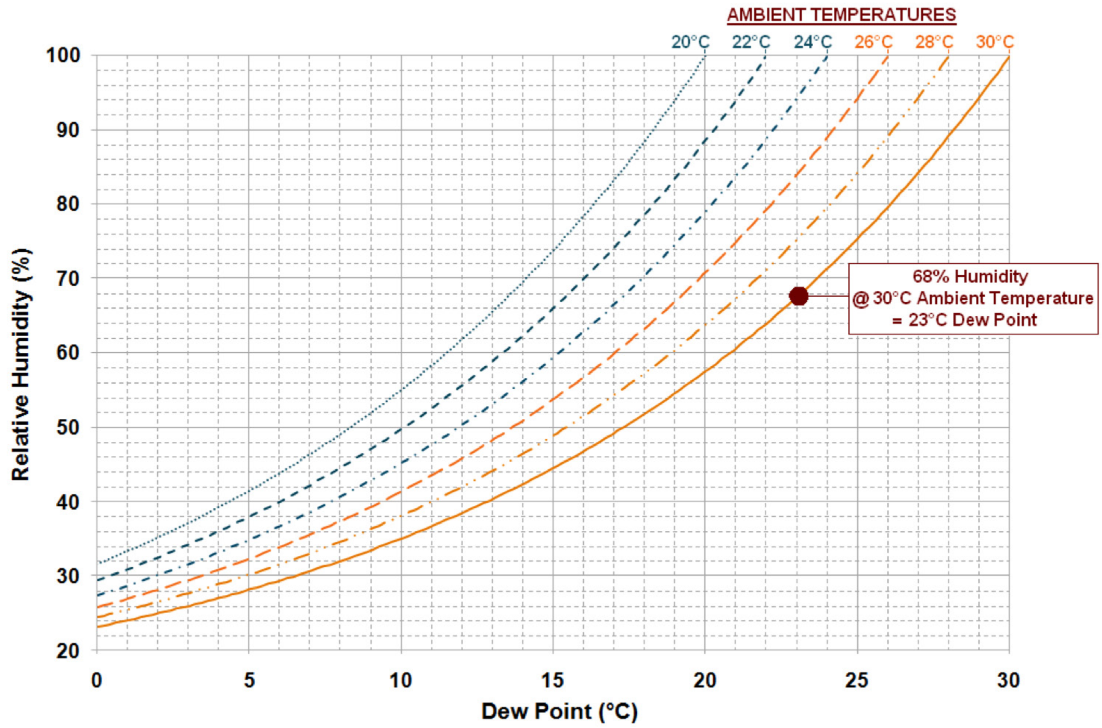
The iDus 416 features a Peltier cooling assembly, which utilizes the thermoelectric effect to rapidly cool the sensor down to the stable operating temperature. TE coolers have a cold side (in contact with the sensor) and a hot side. Heat must be efficiently dissipated from the TE cooler for effective cooling of the sensor.

The iDus 416 is designed to yield maximum heat dissipation, via either forced air cooling (in-built fan) or water cooling which, in combination with Andor's UltraVac™ vacuum process, results in exceptional cooling performance. A recirculator or a chiller can be purchased from Andor to provide convenient and effective heat dissipation through water cooling.

The iDus 416 camera also contains temperature control components, which regulate the cooling of the camera and ensure that a stable temperature is maintained between and throughout measurements.

APPENDIX D: DEW POINT GRAPH

The graph below plots the relationship between Relative Humidity and Dew Point at varying ambient temperatures. This can be used to calculate the minimum temperature the cooling water should be set to.



In the relatively dry atmosphere of an air-conditioned lab, cooling water at 10°C should not present any problems. However, in some humid conditions condensation may occur, resulting in damage to the camera. In such conditions you will have to use warmer water (20°C or even higher if it is very humid). The minimum CCD temperature in this example would then be limited to between -90°C to -95°C.

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

Waste Electronic and Electrical Equipment Regulations 2006 (WEEE)

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