

NIRvana® HS System Manual



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Table of Contents

Chapter 1:	About this Document.....	11
1.1	Intended Audience.....	11
1.2	Intended Use of Equipment.....	11
1.3	Related Documentation.....	11
1.4	Document Organization.....	12
1.5	Safety Related Symbols Used in this Manual.....	13
1.6	Safety Related Symbols on Equipment.....	13
1.7	NIRvana HS Safety Information.....	14
1.7.1	Precautions.....	14
Chapter 2:	NIRvana HS Camera System.....	15
2.1	NIRvana HS Camera.....	16
2.1.1	Focal Plane Array (FPA) Sensor.....	16
2.1.2	Window.....	17
2.1.3	Cooling.....	17
2.1.3.1	Internal Fan.....	17
2.1.3.2	External Coolant Circulator.....	18
2.1.3.3	Coolant Ports.....	18
2.1.4	Rear-Panel Connectors.....	19
2.2	Power Supply.....	20
2.3	Standard Cables.....	21
2.4	Optical Mounts.....	22
2.5	Coolant Hoses.....	22
2.6	Certificate of Performance.....	22
2.7	Application Software.....	23
2.8	Accessories.....	23
2.9	Unpack the System.....	23
2.10	Care and Cleaning of a NIRvana HS System.....	24
2.10.1	Detector Window.....	24
2.10.2	Cleaning.....	24
2.10.2.1	Camera.....	24
2.10.2.2	Optical Surfaces.....	24
2.11	Repairs.....	24
Chapter 3:	Install LightField.....	25
3.1	Prerequisites.....	25
3.2	Installation Procedure.....	25
Chapter 4:	System Block Diagrams.....	27
Chapter 5:	Hardware Configuration.....	29
5.1	Attach Lens to the C-Mount Adapter.....	29
5.2	Adjusting the C-Mount Adapter.....	29
5.3	Mounting the Camera.....	31
5.4	External Coolant Circulator Use.....	32
5.4.1	Experiment Shutdown.....	33
Chapter 6:	First Light.....	35

6.1	Imaging Applications	37
6.1.1	Data Acquisition	39
6.1.2	Shut Down Procedure	40
6.2	Spectroscopy Applications	41
6.2.1	Rotational Alignment and Focus	44
6.2.1.1	Rotational Alignment	45
6.2.1.2	Focus	47
6.2.2	Acquire Data	48
6.2.3	Shut Down Procedure	48
Chapter 7:	Exposure	49
7.1	Exposure Time	49
7.2	Saturation	49
7.3	Noise Sources	50
7.3.1	Dark Charge	50
7.4	Sensor Temperature	50
Chapter 8:	Readout	53
8.1	Modes	53
8.1.1	Full Frame Readout	54
8.1.2	Expose During Readout	55
8.1.2.1	Exposure Time is Longer Than or Equal to Readout Time	56
8.1.2.2	Exposure Time is Shorter than Readout Time	57
8.1.3	Full Frame Readout versus Expose During Readout	58
8.1.4	Determine the Best Readout Mode for an Application	59
8.2	Region of Interest Strategy	59
8.2.1	Region of Interest Sizing Guidelines	59
8.2.2	Single Region of Interest Placement Guidelines	60
8.2.3	Two to Four Regions of Interest Placement Guidelines	60
8.2.4	Regions of Interest Impact on Frame Rate	60
8.2.5	Number of Regions of Interest	65
8.3	Analog Gain	66
8.4	Software Binning	66
8.5	Digitization	67
8.5.1	Speed	67
8.5.2	ADC Offset (Baseline Offset)	68
Chapter 9:	Data Correction	69
9.1	Non-Uniformity Correction (NUC): Gain and Offset	69
9.2	Background Subtraction	69
9.3	Flatfield Correction	70
9.4	Defect/Blemish Correction	71
Chapter 10:	Advanced Topics	73
10.1	Shutter Control Modes	73
10.2	Trigger Response Modes	74
10.2.1	External Trigger Input	74
10.2.2	No Response	75
10.2.3	Readout Per Trigger	75
10.2.4	Expose During Trigger Pulse	76
10.2.5	Start On Single Trigger	76
10.3	Output Signal Control	77
Appendix A:	Technical Specifications	79
A.1	System Dimensions and Weight	79

A.1.1	Vacuum Window	79
A.2	Camera Specifications	79
A.2.1	Thermal Characteristics	80
A.3	Power Specifications	80
A.4	Environmental Specifications	81
A.4.1	Ventilation	81
A.5	External Coolant Circulator Specifications	81
A.6	Minimum Host Computer Specifications	82
Appendix B:	Outline Drawings	83
Appendix C:	Optical Mount Removal and Replacement	85
C.1	Optical Mount Reference Drawings	87
Appendix D:	Calibration Charts	89
Appendix E:	Troubleshooting	93
E.1	Baseline Signal Suddenly Changes	93
E.2	Camera Stops Working	93
E.3	External Coolant Circulator: Low Coolant (Air in the Hoses)	94
E.4	Cooling Troubleshooting	95
E.4.1	Temperature Lock Cannot be Achieved or Maintained	95
E.4.2	Gradual Deterioration of Cooling Capability	95
E.5	Device Is Not Found	96
E.6	TEC Fault LED Comes On	96
	Warranty and Service	97
Limited Warranty		97
Basic Limited One (1) Year Warranty		97
Limited One (1) Year Warranty on Refurbished or Discontinued Products		97
XP Vacuum Chamber Limited Lifetime Warranty		97
Sealed Chamber Integrity Limited 12 Month Warranty		98
Vacuum Integrity Limited 12 Month Warranty		98
Image Intensifier Detector Limited One Year Warranty		98
X-Ray Detector Limited One Year Warranty		98
Software Limited Warranty		98
Owner's Manual and Troubleshooting		99
Your Responsibility		99
Contact Information		100

List of Figures

Figure 2-1:	NIRvana HS Camera System: Standard Items	15
Figure 2-2:	Typical NIRvana HS Camera	16
Figure 2-3:	NIRvana HS Rear-Panel Connectors	19
Figure 2-4:	Available Optical Adapters.	22
Figure 4-1:	Typical Imaging Experiment Layout: Air-cooled Camera	27
Figure 4-2:	Typical Spectroscopy Experiment Layout: Air-cooled Camera	27
Figure 4-3:	Typical Imaging Experiment Layout: Air/Liquid-cooled Camera.	28
Figure 4-4:	Typical Spectroscopy Experiment Layout: Air/Liquid-cooled Camera. . 28	
Figure 5-1:	Adjustable C-Mount Adapter	30
Figure 5-2:	Coolant Input/Output Port Identification	32
Figure 6-1:	Block Diagram: NIRvana HS Light Path.	35
Figure 6-2:	Typical Devices Tab: Imaging Application	37
Figure 6-3:	Typical Experiment Devices Area: Adding NIRvana HS Camera.	38
Figure 6-4:	Typical Workspace: NIRvana HS Camera	38
Figure 6-5:	Typical Imaging Application Workspace: View Tab	39
Figure 6-6:	Typical Imaging Application View Tab: Image Display.	39
Figure 6-7:	Typical Devices Tab: Spectroscopy Application	42
Figure 6-8:	Typical Experiment Devices Area: Adding NIRvana HS and Spectrograph42	
Figure 6-9:	Typical Workspace: NIRvana HS Camera with Spectrograph.	43
Figure 6-10:	Typical Spectroscopy Application Workspace: View Tab	45
Figure 6-11:	Experiment Options ► Align Spectrometer Selection	46
Figure 6-12:	Align Spectrometer: Pre-Rotational Alignment	46
Figure 6-13:	Align Spectrometer: Post-Rotational Alignment.	47
Figure 8-1:	Typical Readout Expander.	53
Figure 8-2:	Typical Analog to Digital Conversion Expander	54
Figure 8-3:	Timing Diagram: Full Frame Readout, $t_{exp} > t_{ro}$	55
Figure 8-4:	Timing Diagram: Expose During Readout, $t_{exp} \geq t_{ro}$	56
Figure 8-5:	Timing Diagram: Frame Transfer Readout, $t_{exp} < t_{ro}$	57
Figure 8-6:	Vertically Stacked ROIs with Small Vertical Gap	61
Figure 8-7:	Vertically Stacked ROIs with Large Vertical Gap	61
Figure 8-8:	Horizontally Aligned ROIs with Large Horizontal Gap	62
Figure 8-9:	Vertically Aligned ROIs with Small Horizontal Gap	62
Figure 8-10:	Vertically Aligned Mid-Sensor ROIs with Large Horizontal Gap	63
Figure 8-11:	Vertically Offset ROIs with Large Horizontal Gap, Overlapping Rows . 63	
Figure 8-12:	Vertically Offset ROIs with Large Horizontal Gap, No Vertical Gap or Row Overlap64	
Figure 8-13:	Vertically Offset ROIs with Large Horizontal Gap, 4 Row Vertical Gap . 64	
Figure 8-14:	Three ROIs with Horizontal Gaps and Overlapping Rows.	65
Figure 8-15:	Excessive Number of Small Regions of Interest	65
Figure 8-16:	Typical Analog to Digital Conversion Expander	67
Figure 9-1:	Typical Online Corrections Expander: Background Subtraction	70
Figure 9-2:	Typical Online Corrections Expander: Flatfield Correction	70
Figure 9-3:	Typical Star Defect (Not to Scale)	71
Figure 10-1:	NIRvana HS Camera: Rear Panel	74
Figure 10-2:	Timing Diagram: No Response Mode	75
Figure 10-3:	Timing Diagram: Readout Per Trigger.	75
Figure 10-4:	Timing Diagram: Expose During Trigger Pulse	76
Figure 10-5:	Timing Diagram: OUT 1/OUT 2 Control	77

Figure B-1:	Outline Drawing: NIRvana HS with C-Mount	83
Figure B-2:	Outline Drawing: NIRvana HS with Spectroscopy-Mount	84
Figure C-1:	NIRvana HS with Optical Mount Facing Up and Camera Bottom Identified 86	
Figure C-2:	Retaining Hardware Securing Optical Mount to Camera Chassis . . .	86
Figure C-3:	Optical C-Mount Reference Exploded View	87
Figure C-4:	Optical Spectroscopy-Mount Reference Exploded View	88
Figure D-1:	Hg Spectrum: NIRvana HS 1.7/SP-2500	90
Figure D-2:	Ne/Ar Spectrum: NIRvana HS 1.7/SP-2500	91
Figure E-1:	Typical Load Experiment: Devices Missing Dialog	96

List of Tables

Table 1-1:	Related Documentation	11
Table 2-1:	NIRvana HS Rear-Panel Connectors	19
Table 2-2:	Standard NIRvana HS Camera System Cables	21
Table 8-1:	Full Frame Readout vs. Expose During Readout Frame Rate Comparison 58	
Table A-1:	General System Specifications	79
Table A-2:	NIRvana HS FPA Specifications	79
Table A-3:	Operating Temperatures	80
Table A-4:	Power Specifications	81
Table A-5:	NIRvana HS Environmental Specifications	81
Table A-6:	External Coolant Circulator Specifications	81
Table E-1:	Issues with Recommended Troubleshooting Guidelines	93

Chapter 1: About this Document

Thank you for purchasing a NIRvana® HS camera system from Teledyne Princeton Instruments. The system has been thoroughly tested to meet Teledyne Princeton Instruments' exacting standards and to meet the demanding requirements of many low light level imaging applications.

This manual provides users with information necessary to install a NIRvana HS camera and place it in operation. Topics include a detailed description of the NIRvana HS camera family as well as the installation, applications, cleaning, and specifications of the camera system.

1.1 Intended Audience

This user manual is intended to be used by scientists and other personnel responsible for the installation, setup, configuration, and acquisition of imaging data being collected using the NIRvana HS camera system.

This document provides all information necessary to safely install, configure, and operate the NIRvana HS camera system beginning with the system's initial installation.

Please read this manual carefully before attempting to operate the camera. Doing so will help minimize the learning curve and optimize the many features of this camera to suit all research needs.

1.2 Intended Use of Equipment

The intended use of the NIRvana HS is to take images and/or measurements of light in the short wave infrared (SWIR) spectrum. It can be used for SWIR imaging and SWIR spectroscopy.

1.3 Related Documentation

[Table 1-1](#) provides a list of related documentation and user manuals that may be useful when working with the NIRvana HS camera system.

Table 1-1: Related Documentation

Document Number	Document Title
–	LightField Online Help
–	NIRvana HS Data Sheet

Current issues of Teledyne Princeton Instruments' manuals are available for download from:

ftp://ftp.piacton.com/Public/Manuals/Princeton_Instruments

Current issues of Teledyne Acton Research manuals are available for download from:

<ftp://ftp.piacton.com/Public/Manuals/Acton>

1.4 Document Organization

This manual includes the following chapters and appendices:

- [Chapter 1, About this Document](#)
This chapter provides information about the organization of this document, as well as related documents, safety information, and conventions used throughout the manual.
- [Chapter 2, NIRvana HS Camera System](#)
This chapter provides information about the NIRvana HS camera, interface card, cables, application software, and optional accessories.
- [Chapter 3, Install LightField](#)
This chapter provides information about the installation of Teledyne Princeton Instruments' LightField image acquisition software.
- [Chapter 4, System Block Diagrams](#)
This chapter provides system setup actions cross-referenced with the relevant manuals and/or manual pages. It also contains system layout diagrams.
- [Chapter 5, Hardware Configuration](#)
This chapter provides detailed directions for setting up the camera for imaging or spectroscopic applications and presents over-exposure protection considerations.
- [Chapter 6, First Light](#)
Discusses a number of topics, including cooling and effects of high humidity and includes a step-by-step procedure for verifying system operation.
- [Chapter 7, Exposure](#)
This chapter discusses factors that affect exposure and acquiring data.
- [Chapter 8, Readout](#)
This chapter discusses supported readout methods and how they can impact frame rates.
- [Chapter 9, Data Correction](#)
This chapter discusses how acquired data can be corrected.
- [Chapter 10, Advanced Topics](#)
Discusses the standard Trigger Response modes (No Response, Readout Per Trigger, and Clean Until Trigger), and Logic Output control.
- [Appendix A, Technical Specifications](#)
Provides camera and system specifications.
- [Appendix B, Outline Drawings](#)
Includes an outline drawing of the C-mount NIRvana HS camera and the power supply.
- [Appendix C, Optical Mount Removal and Replacement](#)
This appendix provides information necessary to replace the C-mount nose on a NIRvana HS camera with a spectroscopy-mount nose.
- [Appendix D, Calibration Charts](#)
This appendix provides the following calibration charts for use with the NIRvana HS camera
- [Appendix E, Troubleshooting](#)
Provides courses of action to take if you should have problems with your system.
- [Warranty and Service](#)
Provides warranty and customer support contact information.

1.5 Safety Related Symbols Used in this Manual



CAUTION!

The use of this symbol on equipment indicates that one or more nearby items should not be operated without first consulting the manual. The same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.



WARNING! RISK OF ELECTRIC SHOCK!

The use of this symbol on equipment indicates that one or more nearby items pose an electric shock hazard and should be regarded as potentially dangerous. This same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.

1.6 Safety Related Symbols on Equipment

CAUTION



The use of this symbol on equipment indicates that one or more nearby items should not be operated without first consulting the manual. The same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.

WARNING! RISK OF ELECTRIC SHOCK



The use of this symbol on equipment indicates that one or more nearby items pose an electric shock hazard and should be regarded as potentially dangerous. This same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.

1.7 NIRvana HS Safety Information

Before turning on the power supply, the ground prong of the power cord plug must be properly connected to the ground connector of the wall outlet. The wall outlet must have a third prong, or must be properly connected to an adapter that complies with these safety requirements.



WARNINGS!

1. If the NIRvana HS camera system is used in a manner not specified by Teledyne Princeton Instruments, the protection provided by the equipment may be impaired.
2. If the wall outlet is damaged, the protective grounding could be disconnected. Do *not* use damaged equipment until its safety has been verified by authorized personnel. Disconnecting the protective earth terminal, inside or outside the apparatus, or any tampering with its operation is also prohibited.

Inspect the supplied power cord. If it is not compatible with the power socket, replace the cord with one that has suitable connectors on both ends.



WARNING!

Replacement power cords or power plugs must have the same polarity and power rating as that of the original ones to avoid hazard due to electrical shock.

1.7.1 Precautions

To prevent permanently damaging the system, please observe the following precautions:

- If you are using high-voltage equipment (such as an arc lamp) with your camera system, be sure to turn the camera power ON LAST and turn the camera power OFF FIRST.
- When turning off and on the power supply, wait at least 10 seconds before switching it on. "TEC Fault" LED might come on if the power supply on/off state is switched too quickly.
- Use caution when triggering high-current switching devices (such as an arc lamp) near your system. The sensor can be permanently damaged by transient voltage spikes. If electrically noisy devices are present, an isolated, conditioned power line or dedicated isolation transformer is highly recommended.
- Do not block air vents on the camera. Preventing the free flow of air overheats the camera and may damage it.

91 9 1 9



- NIRvana HS Camera
- Power Supply;
- Line Cord;
- Coolant Hose Connectors;
- USB3 Cable;
- (3) MCX-to-BNC Adapter Cables;
- Certificate of Performance.

- LightField® Application Software;
- External Cooling Circulator;
- For spectroscopy applications requiring shutter control, Shutter Driver SHC-EXT is required
- Additional MCX-to-BNC cables.

Refer to [Table 2-2, Standard NIRvana HS Camera System Cables](#), on page 21 for ordering information.

Refer to [Section 2.8, Accessories](#), on page 23 for information about accessories.

2.1 NIRvana HS Camera

The NIRvana HS camera, shown in [Figure 2-2](#), is regulated by an internal controller which receives commands from the host computer/software and converts them to appropriate camera control signals, including synchronizing the operation of the NIRvana HS system with the rest of an experiment.

Figure 2-2: Typical NIRvana HS Camera



4411-0169_0002

In addition, the internal controller converts analog optical data acquired by the sensor into digital data which is then delivered to the host computer and data acquisition software being used. Read rate, exposure time, and regions of interest for NIRvana HS cameras are some of the parameters that are configured using the data acquisition software on the host computer.

This section provides detailed information about the NIRvana HS camera.

2.1.1 Focal Plane Array (FPA) Sensor

The NIRvana HS camera incorporates a 640 x 512 (20 x 20 μm pixels) InGaAs Focal Plane Array (FPA) that is equipped with four-port differential readouts. The sensor's excellent response and outstanding sensitivity in the 0.9 μm -1.7 μm spectrum make it particularly well suited for Near-InfraRed (NIR) imaging applications.

Additional key features of the FPA sensor include:

- Readout rates of 3.125 MHz, 12.5 MHz, and 25 MHz capable of 32, 129, and 258 frames per second, respectively;
- Deep cooling to -55°C which reduces the dark signal and enables long integration times.

2.1.2 Window

The NIRvana HS window is composed of AR-coated fused silica.

2.1.3 Cooling

Dark current is reduced in NIRvana HS camera systems by utilizing thermoelectric cooling of the sensors. Cooling by this method uses a Peltier cooler in combination with air-circulation (i.e., fan,) and/or circulating coolant. The NIRvana HS defaults to cooling set point of -50°C . Maximum cooling is -55°C with air or water.

To prevent condensation and contamination from occurring, cameras cooled in this manner are evacuated. Due to sensor size/packaging differences, the lowest achievable temperature varies by NIRvana HS model.



REFERENCES:

Refer to model-specific NIRvana HS data sheets for respective cooling specifications.

A feature of air-cooled NIRvana HS cameras is software control of the camera's internal fan. When fan vibration may affect results, the fan can be turned off and while coolant continues to be circulated through the camera, thus maintaining an adequate sensor cooling temperature.

If the NIRvana HS is operating inside an enclosure, the enclosure must have unrestricted air flow to an open environment.

2.1.3.1 Internal Fan

The NIRvana HS is equipped with an internal, low-vibration fan that:

- Removes heat from the Peltier device that cools the sensor; and
- Cools the electronics.

An internal Peltier device directly cools the cold finger on which the sensor is mounted. Air drawn into the camera through the back of the camera removes the heat produced by the Peltier device and then vents out through the slots on the side panels. By default, the fan is always in operation, and air-cooling of both the Peltier and the internal electronics takes place continuously.



CAUTION!

For the fan to function properly, free air circulation must be maintained between the sides of the camera and the laboratory atmosphere. A minimum of two (2) inches (50 mm) of clearance must be maintained around the camera's vented covers.

The low-vibration fan typically has no adverse affect on image quality. However, if the fan's vibration does reduce image quality and the NIRvana HS is also being cooled via an external coolant circulator, the fan may be turned off to reduce vibration.

2.1.3.2 External Coolant Circulator

NIRvana HS cameras are supplied with mating connectors for liquid cooling operation. The connectors for liquid cooling operation are designed for 1/4" ID hose and attach to the coolant ports located on the side of the camera.

Similar to air-cooled applications, circulating coolant removes heat that has been produced by the Peltier device. The primary advantage of circulating coolant is that it enables vibration-free data acquisition. For the circulating coolant to function properly, free air circulation must be maintained between the sides of the coolant circulator and the laboratory atmosphere.

The coolant circulator can be any commercially available circulator that is capable of continuously pumping a 50:50 mixture of room temperature (23°C) water and ethylene glycol at a rate of 2 liters per minute. NIRvana HS Refer to [Table A-6, External Coolant Circulator Specifications](#), on page 81 for additional information. If desired, contact Teledyne Princeton Instruments for additional recommendations. Refer to [Contact Information](#) on page 100 for complete information.



CAUTION!

Never set the coolant temperature below the dew point.

Coolant temperature should not be below the dew point of the ambient air. Internal condensation caused by operation below the dew point may damage the camera and will void the warranty. Additionally, the NIRvana HS monitors its internal temperature and will automatically restart its fan regardless of the software settings if it senses excessive internal heat buildup.

2.1.3.3 Coolant Ports

NIRvana HS cameras are equipped with cooling ports that allow it to be connected to an external coolant circulator. As is the case with circulating air, circulating coolant removes heat produced by the camera. This means of heat removal is designed for vibration-free data acquisition. For the circulating coolant to function properly, free air circulation must be maintained between the sides of the external circulator and the laboratory atmosphere.



WARNING!

NEVER apply negative pressure to the liquid circulator fittings on the NIRvana HS camera. Doing so may permanently damage the camera.



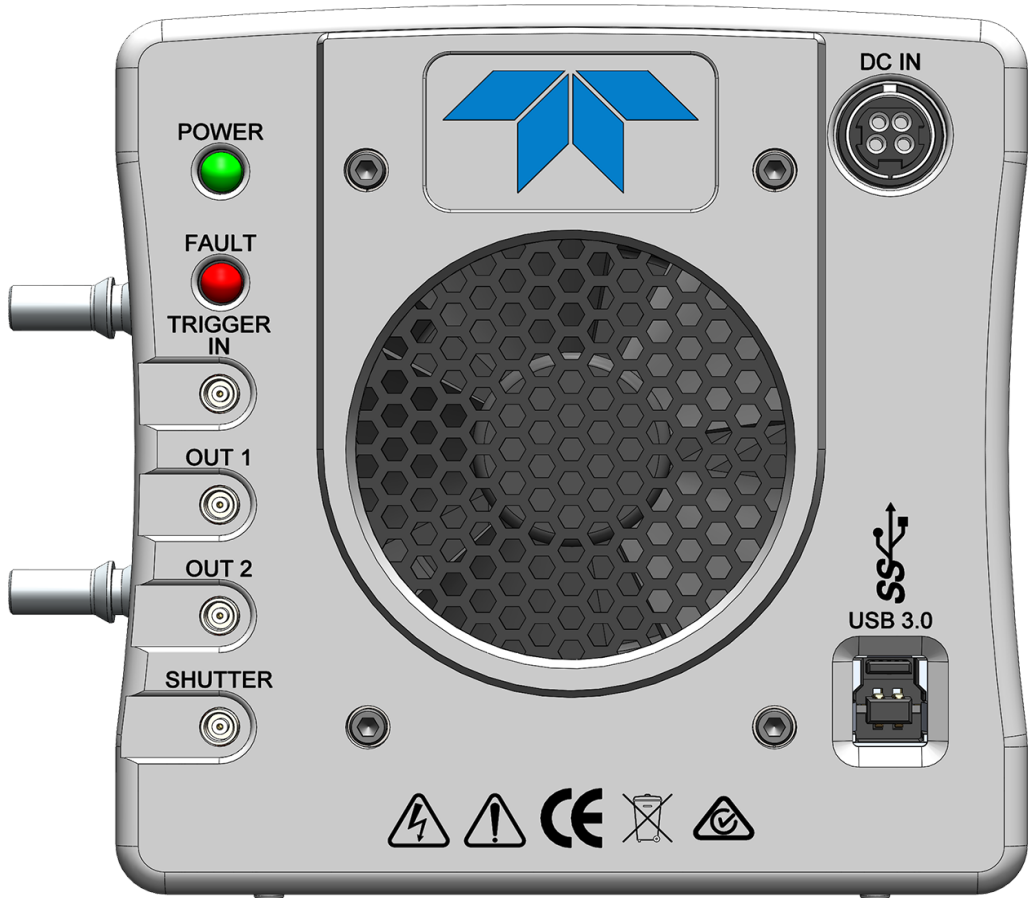
CAUTION!

The wetted areas of the NIRvana HS heat exchanger and fittings are nickel plated.

2.1.4 Rear-Panel Connectors

Figure 2-3 illustrates the rear-panel connectors on a NIRvana HS camera.

Figure 2-3: NIRvana HS Rear-Panel Connectors



4411-0169_0003

Refer to Table 2-1 for information about each rear-panel connector.

Table 2-1: NIRvana HS Rear-Panel Connectors (Sheet 1 of 2)

Label	Description
POWER	Green LED. When illuminated, indicates that the NIRvana HS is powered on.
DC IN	12 V _{DC} (11.5 A max) input and TEC control from power supply.
FAULT	This Red LED is normally extinguished. When illuminated or flashing, this LED indicates a fault within the system has been detected. Refer to Appendix E, Troubleshooting , on page 93 for additional information.
TRIGGER IN	0 to +5.0 V _{DC} TTL-compatible logic level input with a 10 k Ω pull-up resistor. Allows data acquisition and readout to be synchronized with external events. Positive or negative edge triggering is programmable. CAUTION: Do not apply a voltage greater than +5.0 V _{DC} to this input. Doing so may permanently damage the NIRvana HS camera.

Table 2-1: NIRvana HS Rear-Panel Connectors (Sheet 2 of 2)

Label	Description
OUT 1	0 to +5.0 V _{DC} programmable TTL-compatible logic level output capable of driving logic levels into 50 Ω . This output can be programmed and inverted via the application software.
OUT 2	0 to +5.0 V _{DC} programmable TTL-compatible logic level output capable of driving logic levels into 50 Ω . This output can be programmed and inverted via the application software.
Shutter	0 to +5.0 V _{DC} programmable TTL-compatible logic level output capable of driving logic levels into 50 Ω .
USB3	Control signals and data are transmitted between the NIRvana HS and Host Computer via this port.

2.2 Power Supply

All voltages required by NIRvana HS camera systems are generated and delivered by an external power supply included with each NIRvana HS camera. Refer to [Section A.3, Power Specifications](#), on page 80 for complete specifications.



CAUTION!

Use of a power supply other than that provided with the NIRvana HS camera will void the camera warranty. For specific power supply requirements, contact Teledyne Princeton Instruments. Refer to [Contact Information](#) on page 100 for complete information.

Each NIRvana HS camera system includes:

- An external power supply with spring-loaded, 4-pin DIN connector that connects to the rear of the NIRvana HS camera chassis.
See [Figure 2-3](#) and [Table 2-1](#) on page 19.



CAUTION!



When removing the DIN connector from the NIRvana HS, always grasp the connector by the black housing closest to the chassis and then pull straight out to disengage the connector from the camera chassis. Failure to do so may damage the connector and/or the camera. Such damage is not covered under warranty.

- A line cord to connect to an appropriate AC receptacle. Refer to [Table 2-2](#) on page 21 for complete information.
The receptacle on the line cord should be compatible with line-voltage line cords in common use in the region to which the system is shipped.
If the line cord's receptacle is incompatible, a compatible adapter should be installed on the line cord, taking care to maintain the proper polarity to protect the equipment and assure user safety.

2.3 Standard Cables

Table 2-2 describes the cables included with a standard NIRvana HS Camera System.

Table 2-2: Standard NIRvana HS Camera System Cables

Cable	Part Number	Description/Purpose	Length
MCX to BNC Adapter	6050-0540	<p>Two MCX to BNC adapter cables are provided with the NIRvana HS system. These connect to the TRIGGER IN, OUT 1, OUT2, and SHUTTER connectors on the rear of the NIRvana HS.</p>  <p>4411-0169_0004</p>	Varies
Line Cord	6050-0009	<p>Connects the NIRvana HS power supply to an appropriate AC power source.</p>  <p>4411-0169_0006</p>	3 m [9.8 ft]

2.4 Optical Mounts

Each NIRvana HS is equipped with:

- A C-mount Mount; or
- A Spectroscopy Mount.

[Figure 2-4](#) shows these two adapters.

Figure 2-4: Available Optical Adapters



If desired, the alternate mount can be ordered from Teledyne Princeton Instruments. Contact Customer Service for assistance. Refer to [Contact Information](#) on page 100 for complete information.

The Following adapters are available to convert from/to a different mount:

- 7607-8001 Spectrometer Nose Kit
- 7607-8002 C-Mount Nose Kit

Refer to Appendix C for installation instructions.

2.5 Coolant Hoses

There are (2) quick-disconnect fittings provided with the camera system. The fittings are compatible with 1/4" ID coolant hose such as Tygon 5624k51

2.6 Certificate of Performance

Each NIRvana HS camera is shipped with a Certificate of Performance which states that the camera system has been assembled and tested according to approved Teledyne Princeton Instruments procedures. It documents the camera's performance data as measured during the testing of the NIRvana HS and lists the following camera- and customer-specific information:

- Sales Order Number;
- Purchase Order Number;
- Camera Serial Numbers

This information is useful when contacting Teledyne Princeton Instruments Customer Support.

2.7 Application Software

Teledyne Princeton Instruments offers the following two data acquisition software packages for use with NIRvana HS camera systems:

- **LightField®**
LightField is Teledyne Princeton Instruments' 64-bit Windows compatible data acquisition and processing software package.
LightField combines complete control over Teledyne Princeton Instruments' cameras and spectrometers with easy-to-use tools for experimental setup, data acquisition and post-processing. LightField makes data integrity priority #1 via automatic saving to disk, time stamping, and retention of both raw and corrected data with full experimental details saved in each file. LightField works seamlessly in multi-user facilities, remembering each user's hardware and software configurations and tailoring options and features accordingly. The optional, patent-pending IntelliCal™ package is the highest-performance wavelength calibration software available, providing up to 10X greater accuracy across the entire focal plane than competing routines.
- **PICam**
PICam is Teledyne Princeton Instruments' standard 64-bit software interface for cooled cameras. PICam is an ANSI C library of camera control and data acquisition functions.
Refer to the PICam Programmer's Manual for supported operating systems.

**NOTE:**

NIRvana HS may be compatible with third-party data acquisition software packages. Check with individual providers for compatibility and support information.

2.8 Accessories

Teledyne Princeton Instruments offers a number of optional accessories that are compatible with NIRvana HS. For complete ordering information contact Teledyne Princeton Instruments. Refer to [Contact Information](#) on page 100 for complete information.

2.9 Unpack the System

All required items should be included with the shipment. The NIRvana HS system has been manufactured according to the camera options specified at the time of purchase, including the sensor window and coatings that were ordered.

When unpacking the system, examine the system components for any signs of shipping damage. If there are any, notify Teledyne Princeton Instruments immediately and file a claim with the carrier. Be sure to save the shipping carton for inspection by the carrier. If damage is not apparent but system specifications cannot be achieved, internal damage may have occurred in shipment.

Retain all original packing materials so that the NIRvana HS system can be easily and safely packaged and shipped to another location or returned for service if necessary. If assistance is required at any time, contact Teledyne Princeton Instruments Customer Support. Refer to [Contact Information](#) on page 100 for complete information.

2.10 Care and Cleaning of a NIRvana HS System

From time to time, NIRvana HS cameras may require minor cleaning.

2.10.1 Detector Window

- Never remove the detector's front window. Ice will form immediately, destroying the sensor.
- Never operate the detector cooled without proper evacuation. This could *destroy* the sensor!
- This fused silica window maintains the vacuum in the detector.

2.10.2 Cleaning



WARNING!

Turn off all power to the equipment and secure all covers before cleaning the units. Otherwise, damage to the equipment or injury to you could occur.

2.10.2.1 Camera

Although there is no periodic maintenance that *needs* to be performed on a NIRvana HS camera, users are advised to wipe it down with a clean damp cloth from time to time. This operation should only be done on the external surfaces and with all covers secured. In dampening the cloth, use clean water only. No soap, solvents or abrasives should be used. Not only are they not required, but they could damage the finish of the surfaces on which they are used.

2.10.2.2 Optical Surfaces

Optical surfaces may need to be cleaned due to the accumulation of atmospheric dust. We advise that the *drag-wipe* technique be used. This involves dipping a clean cellulose lens tissue into clean anhydrous methanol, and then dragging the dampened tissue over the optical surface to be cleaned. Do not allow any other material to touch the optical surfaces. Pay extra attention if the optical window is coated with AR (anti-reflection) materials as they can be susceptible to scratches. Please contact factory if you have any questions.

2.11 Repairs

Because the NIRvana HS camera system contains no user-serviceable parts, repairs must be performed by Teledyne Princeton Instruments. Should your system need repair, contact Teledyne Princeton Instruments customer support for instructions. For contact information, refer to [Contact Information](#) on page 100.

Save the original packing materials and use them whenever shipping the system or system components.

Chapter 3: Install LightField

This chapter provides the installation procedure for LightField application software.



NOTE:

If LightField version 6.11 or newer has already been successfully installed on the host computer, this chapter may be skipped.

If a LightField software license was not purchased with the camera system, installing LightField using the software CD included with the NIRvana HS will provide users with full software functionality for 45-days from the date of install.

Once the 45 day trial period has expired, available options are:

- Purchase a LightField license to continue using the instance on the current host computer;
- Install a new instance of LightField on a different host computer to begin another 45-days of full feature usage.

To purchase a LightField license, contact your sales representative.

3.1 Prerequisites

Before beginning to install LightField, verify that:

- The operating system on the desired host computer is Windows® 7/8/10 (64-bit);
- The host computer supports USB3;
If it does not support USB3, refer to the host computer manufacturer's instructions for installing a USB3 interface card;
- The installation disk and hardware key are available.

3.2 Installation Procedure

Perform the following procedure to install LightField on the host computer:

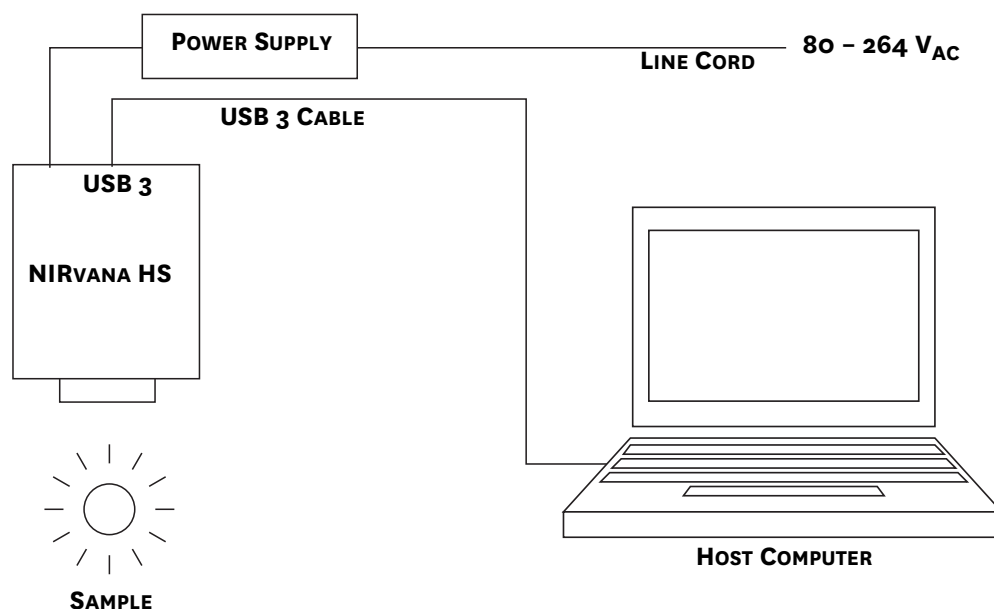
1. Insert the LightField Installation CD into the CD drive on the host computer, and follow the on-screen prompts.
2. After the installation has been completed, reboot the host computer.
3. Connect the NIRvana HS system components to the host computer and apply power.
4. Launch LightField, activate it, and begin experiment configuration.

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Chapter 4: System Block Diagrams

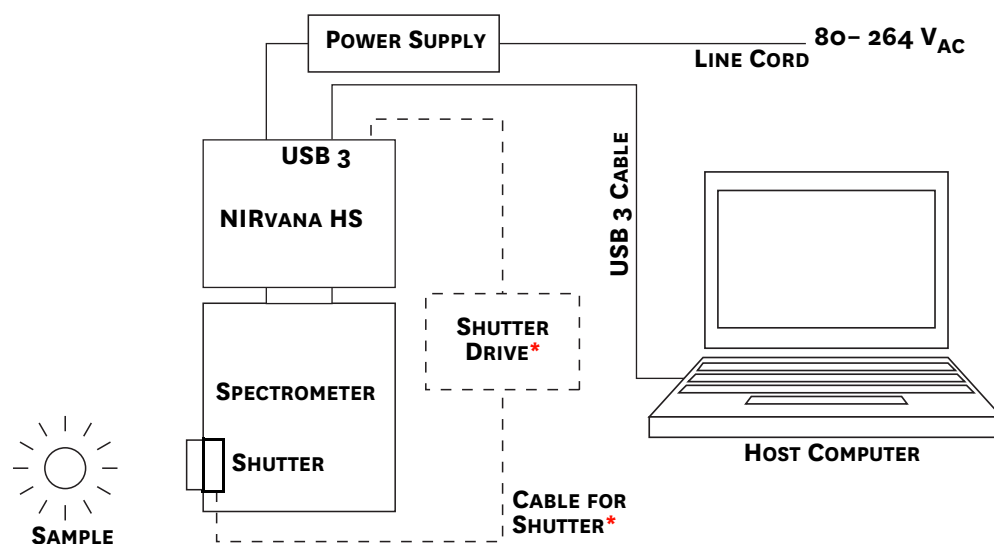
This chapter provides block diagrams of typical system configurations.

Figure 4-1: Typical Imaging Experiment Layout: Air-cooled Camera



4411-0169_0008

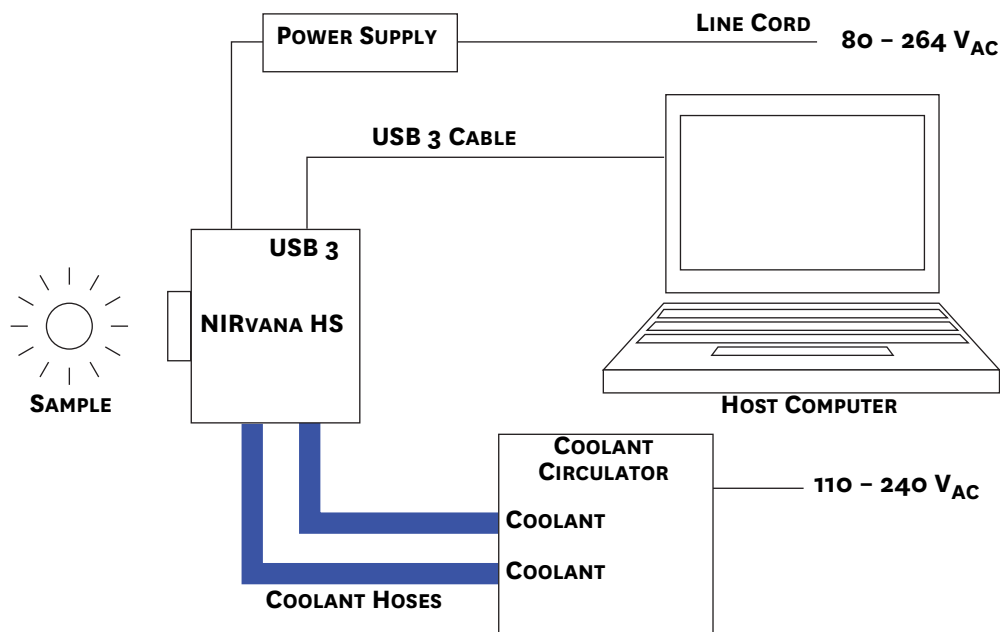
Figure 4-2: Typical Spectroscopy Experiment Layout: Air-cooled Camera



4411-0169_0009

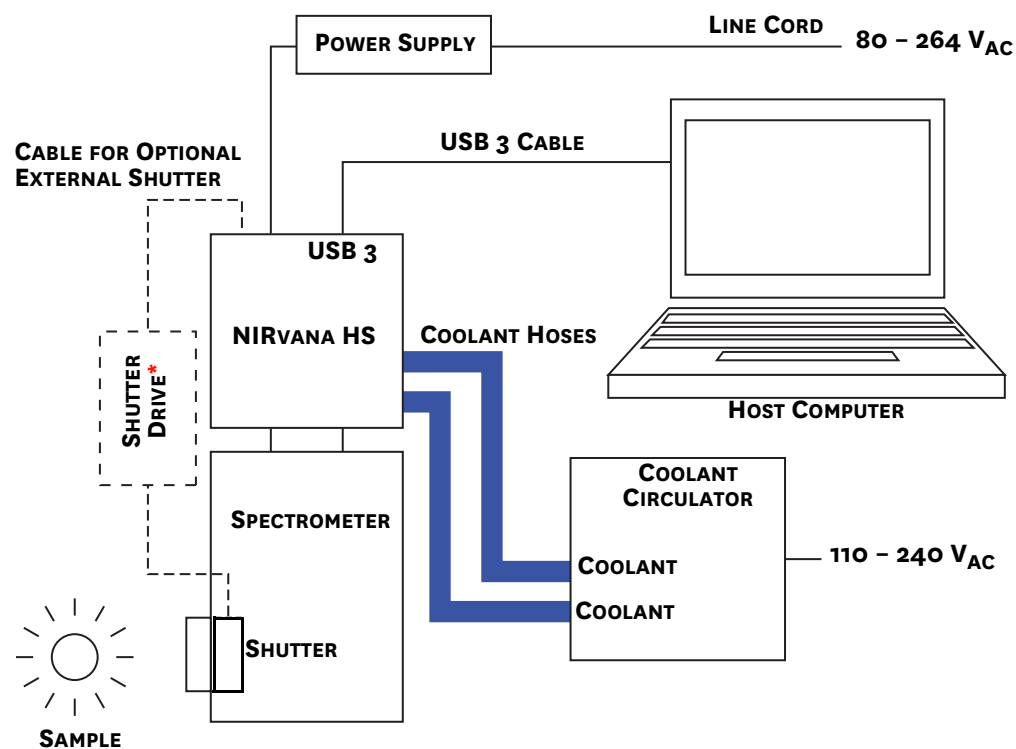
* CUSTOMER SUPPLIED

Figure 4-3: Typical Imaging Experiment Layout: Air/Liquid-cooled Camera



4411-0169_0010

Figure 4-4: Typical Spectroscopy Experiment Layout: Air/Liquid-cooled Camera



4411-0169_0011

* CUSTOMER SUPPLIED

Chapter 5: Hardware Configuration

This chapter provides information about the installation and configuration of a NIRvana HS camera system.



CAUTION!

Overexposure Protection: Cameras that are exposed to room light or other continuous light sources will quickly become saturated. Set the lens to the smallest aperture (i.e., highest f-number,) and cover the lens with a lens cap to prevent overexposure. Saturation is not harmful to a non-intensified camera, but it should be avoided.

5.1 Attach Lens to the C-Mount Adapter

NIRvana HS cameras for imaging applications incorporate an integrated C-mount adapter.

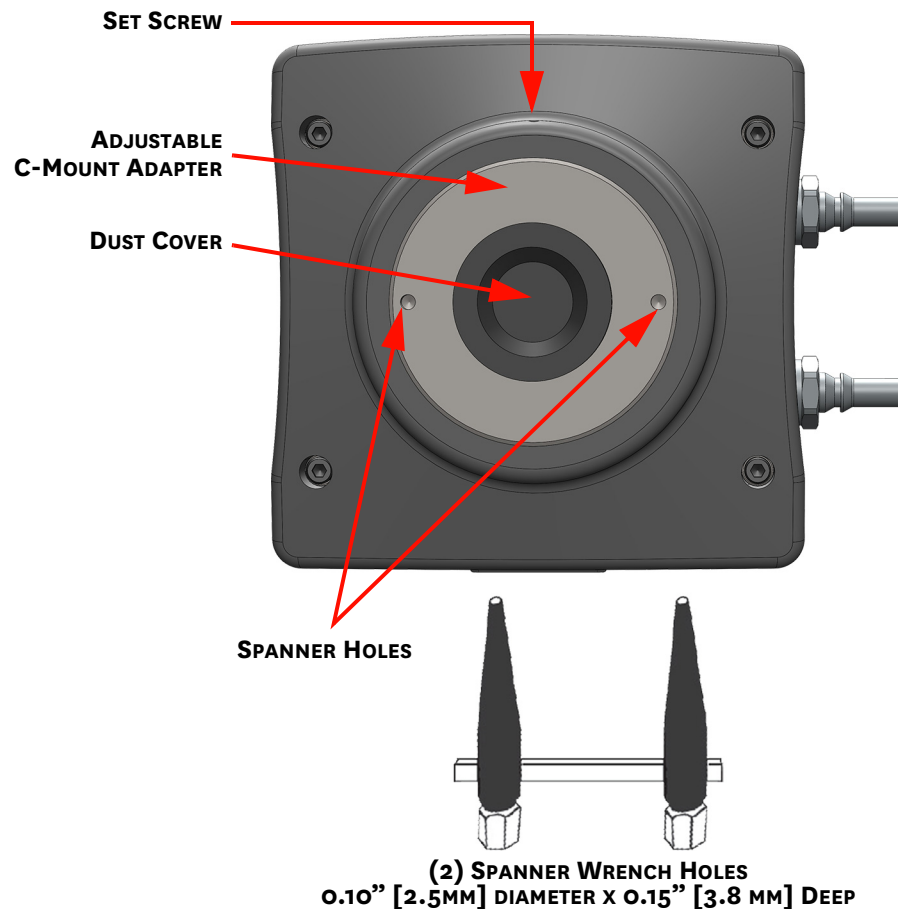
Each NIRvana HS camera is shipped with a protective dust cover screwed into the C-mount adapter opening. Simply unscrew the dust cover, store it, and then screw the desired lens in. Tighten the lens by hand only.

5.2 Adjusting the C-Mount Adapter

The NIRvana HS features an adjustable C-mount adapter that allows the focal depth to be changed.

Perform the following procedure to adjust the C-mount adapter:

1. Using the hex wrench supplied with the system (or a 0.050" hex wrench) loosen the setscrew securing the adapter. See [Figure 5-1](#).

Figure 5-1: Adjustable C-Mount Adapter

4411-0169_0012

2. Using a spanner wrench (or equivalent,) rotate the ring to the desired height.

**NOTE:**

The distance between the two adapter holes is 3.85" [97.8 mm].

3. Use the hex wrench to tighten the setscrew to lock the adapter in place.

**NOTE:**

To lock the setscrew, the face of the adapter should be no more than 0.1" (2.5 mm) out from the front surface of the camera nose.

**CAUTION!**

The C-mount lens thread-depth should be 0.21" (5.33 mm) or less. Otherwise, depending on the adapter in-out location, the lens could bottom out and damage the glass. If you are not certain of the thread depth, remove the adapter from the camera nose, thread the lens into the adapter until the lens threads are flush with the back surface of the adapter. Note the depth at the front surface, remove the lens, and then re-insert the adapter into the camera nose.

5.3 Mounting the Camera

The NIRvana HS is equipped with a 1/4-20 mounting hole on the bottom of the camera (see Appendix B). This allows the camera to be mounted in any orientation

5.4 External Coolant Circulator Use

For liquid-cooled cameras, an external coolant circulator provides a vibration-free method of heat removal. Perform the following procedure to connect an external coolant circulator to a liquid-cooled NIRvana HS camera:

**NOTE:**

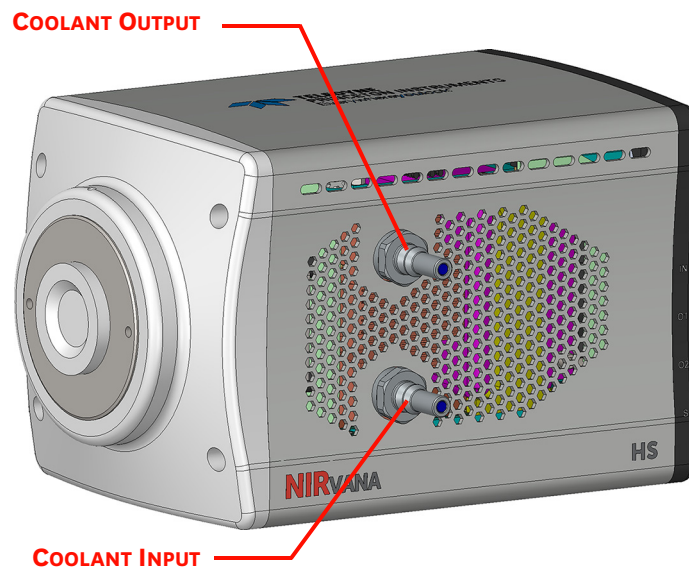
For specific configuration information, refer to the manufacturer-supplied documentation included with the external coolant circulator.

1. Verify the camera and the circulator power switches are turned off.
2. Verify the coolant circulator is positioned a minimum of 6 inches (150 mm) below the NIRvana HS camera. The vertical distance should not exceed 10 feet (3 m). Typically, the camera is at table height and the circulator is on the floor.
3. Connect the two coolant ports on the external coolant circulator to the two coolant ports on NIRvana HS as shown in [Figure 5-2](#).

**NOTE:**

In [Figure 5-2](#), coolant input and output flows are relative to the NIRvana HS, not the external coolant circulator.

Figure 5-2: Coolant Input/Output Port Identification



4411-0169_0026

**CAUTION!**

Verify there are no kinks in hoses that may impede coolant flow. Lack of sufficient flow can seriously harm the detector. Any resulting damage is not covered under warranty.

**NOTE:**

Damage caused by water leaking into the NIRvana HS voids the warranty.

4. Verify that the reservoir on the external coolant circulator contains sufficient coolant as specified by its manufacturer. If additional coolant is required, use a 50:50 mixture of water and ethylene glycol based commercial antifreeze to add sufficient coolant.
5. Replace the reservoir cap.
6. Plug the external circulator into a 100-240 V_{AC}, 47-63 Hz power source.
7. Turn the coolant circulator on.

**CAUTION!**

When configuring an external coolant circulator, adhere to the following:

- Minimum coolant flow rate is 2.0 liter/minute [0.55 gallon/minute].
- Coolant pressure should never exceed 25 psi.
- Never set the circulator temperature below the dew point.

8. Verify there are no leaks or air bubbles in the hoses.

**NOTE:**

Small air bubbles (approximately the size of bubbles in soda) are common, particularly immediately following start up. These bubbles do not prevent proper operation.

- If no problems are observed, proceed to step 9.
 - If there are leaks or air bubbles, turn the circulator off and correct the problem(s) by securing the hoses or adding more coolant to the reservoir. Turn the circulator back on. Recheck and if there are no problems, proceed to step 9.
9. Turn on the NIRvana HS.
 10. Launch LightField.

5.4.1 Experiment Shutdown

Following the completion of a liquid-cooled experiment, perform the following procedure:

1. Turn off the NIRvana HS power supply.
2. Turn off the coolant circulator according to all manufacturer-supplied documentation and procedures.
3. If desired, carefully disconnect the coolant hoses from the NIRvana HS.

**WARNING!**

If the NIRvana HS is to be shipped, to avoid potential catastrophic damage to the camera, all coolant must be drained from it.

Chapter 6: First Light

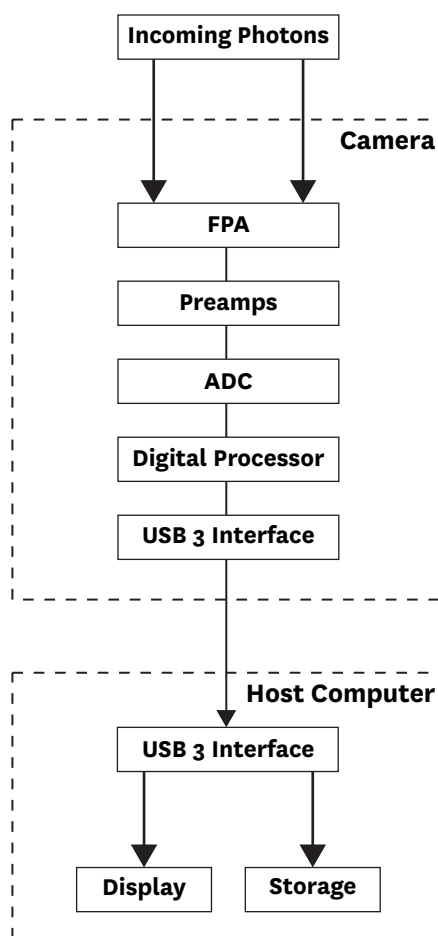
Once the NIRvana HS camera hardware has been configured as described in [Chapter 5, Hardware Configuration](#), operation of the camera is straightforward. For most applications simply:

- Establish optimum performance using Preview mode;
- Set a target temperature for the NIRvana HS system;
- Wait until the system's temperature has stabilized;
- Acquire live data in Acquire mode.

Additional considerations regarding experiment setup and equipment configuration are addressed in LightField's Online Help.

During data acquisition, the sensor is exposed to a source and charge accumulates in the pixels. After the defined exposure time, the accumulated signal is readout of the array, digitized, and then transferred to the host computer. Upon data transfer, the data are displayed and/or stored via the application software. This sequence is illustrated by the block diagram shown in [Figure 6-1](#).

Figure 6-1: Block Diagram: NIRvana HS Light Path



4411-0169_0013

Whether data are displayed and/or stored depends on the data collection operation that has been selected in the application software:

- **Preview**

This mode is typically used when setting up the system during First Light procedures.

In Preview mode, the number of frames is ignored. A single frame is acquired and displayed, another frame is acquired and overwrites the currently displayed data, and so on until Stop is selected. This frame cannot be stored. Preview mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible, achieved by operating with axes and cross-sections off, and with Zoom 1:1 selected.

- **Acquire**

This mode is typically used for the collection and storage of data.

In Acquire mode, every frame of data collected can be automatically stored so the completed dataset may include multiple frames with one or more set of accumulations. This mode is typically selected during actual data collection.

One limitation of Acquire mode operation is that if data acquisition continues at too fast a rate for it to be stored, data overflow may occur.



REFERENCES:

For information about synchronizing data acquisition with external devices, refer to [Chapter 10, Advanced Topics](#).

The following sections provide the step-by-step procedures to verify initial NIRvana HS system operation using LightField for both imaging and spectroscopic applications.

6.1 Imaging Applications

This section provides step-by-step instructions for acquiring an image in LightField for the first time. The intent of this procedure is to help gain basic familiarity with the operation of the system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

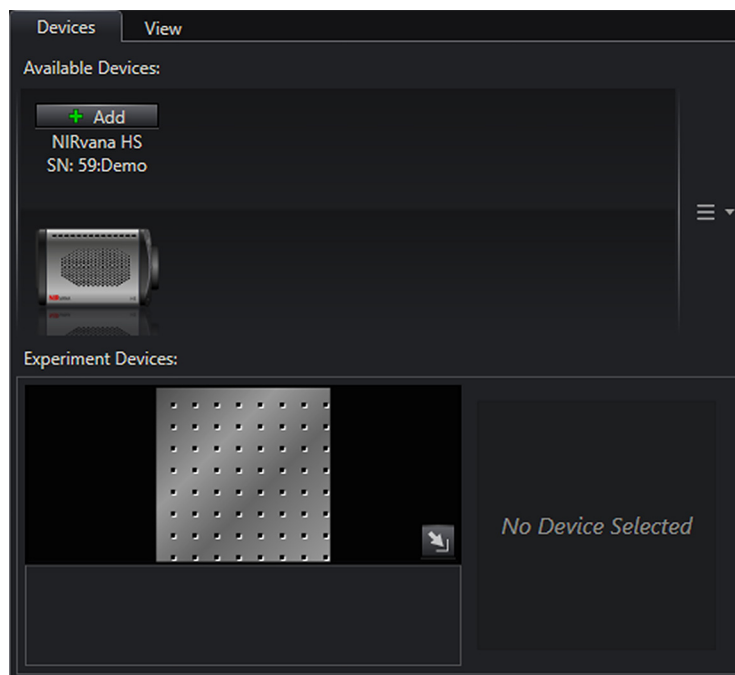
This procedure assumes:

- The system has been set up in accordance with the instructions in previous chapters;
- Familiarity with LightField;
If this is not the case, refer to the online help while performing this procedure.
- The system is being operated in imaging mode.
- The target is a sharp image, text, or drawing that can be used to verify that the camera is seeing and can be used to maximize focus.

Perform the following procedure to set up and configure the system to acquire an image:

1. Mount a test target in front of the camera.
2. Turn on the NIRvana HS.
3. Turn on the host computer.
4. Launch LightField.
5. Once LightField has launched, a NIRvana HS camera icon will be shown in the Available Devices area. See [Figure 6-2](#).

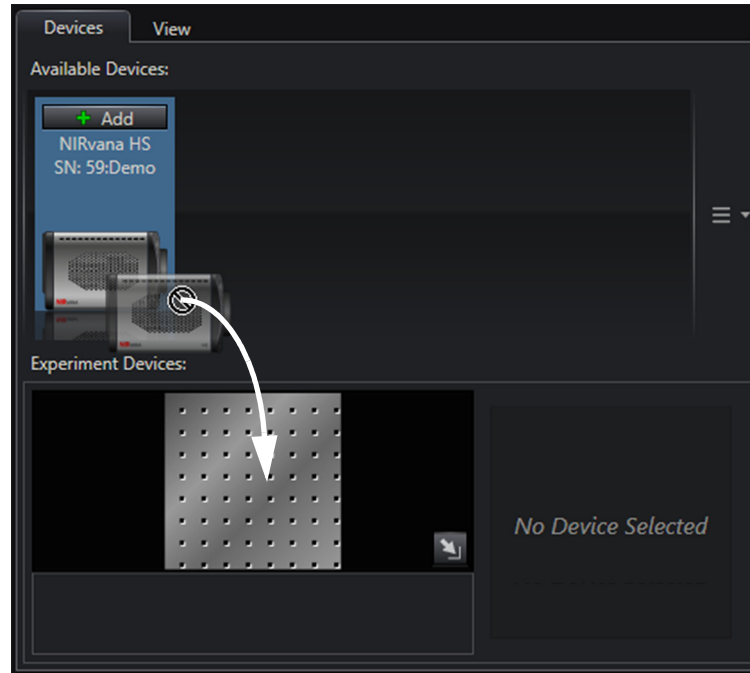
Figure 6-2: Typical Devices Tab: Imaging Application



4411-0169_0014

6. Drag the NIRvana HS camera icon into the Experiment Devices area. See [Figure 6-3](#).

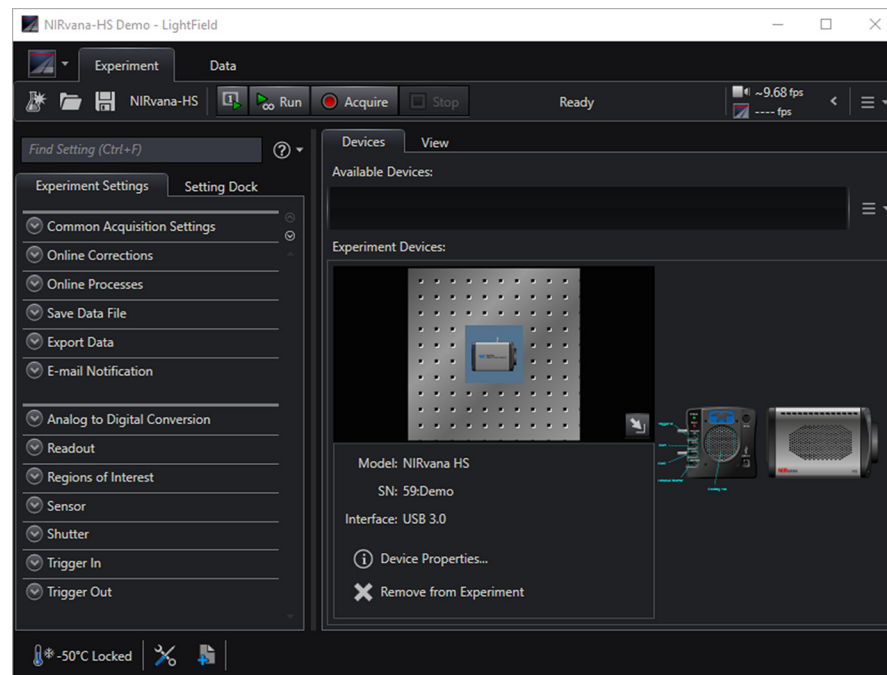
Figure 6-3: Typical Experiment Devices Area: Adding NIRvana HS Camera



4411-0169_0015

The Experiment Settings stack on the left now includes expanders. See [Figure 6-4](#).

Figure 6-4: Typical Workspace: NIRvana HS Camera



4411-0169_0016

Since this is a new experiment, default values for the NIRvana HS configuration parameters will be used.

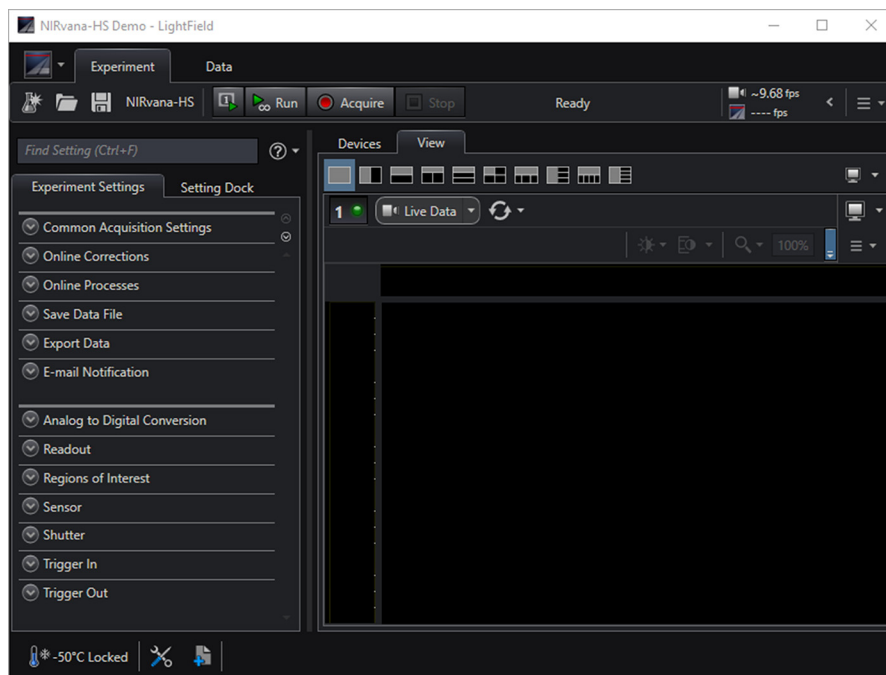
The Status Bar across the bottom of the workspace includes an icon for Temperature Status. Temperature Status reports the current system temperature and if the configured temperature has been reached. Clicking on the icon opens the Sensor expander where the set temperature can be changed.

6.1.1 Data Acquisition

Perform the following procedure to acquire data:

1. Click on the View tab to change to the display area. See [Figure 6-5](#).

Figure 6-5: Typical Imaging Application Workspace: View Tab



4411-0169_0017


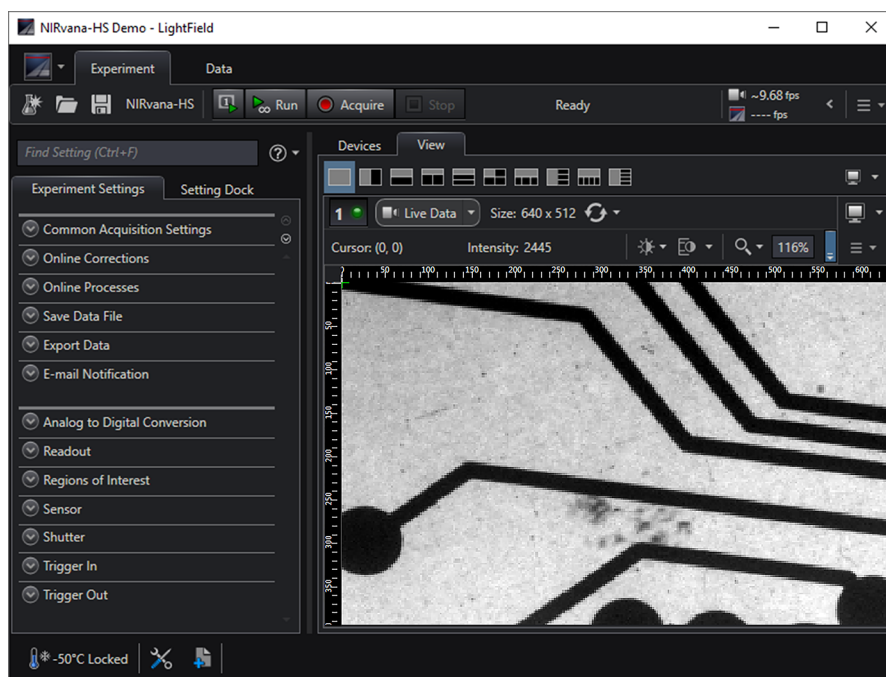
2. Click Run  to start Preview mode. In this mode, images are continuously acquired and displayed. See [Figure 6-6](#).

Figure 6-6: Typical Imaging Application View Tab: Image Display



4411-0169_0018

3. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor. Imaging tips include:
 - Begin with the lens blocked off and then set the lens to the smallest possible aperture (i.e., the greatest f-stop number.)
 - Verify there is a suitable target in front of the lens. An object with text or graphics works best.
 - Check the brightest regions of the image to determine if the A/D converter is at full-scale. A 16-bit A/D is at full scale when the brightest parts of the image reach an intensity of 65535. Adjust the aperture so that it is just slightly smaller (i.e., a greater f-stop,) than the setting where maximum brightness on any part of the image occurs.
 - Set the focus adjustment of the lens for maximum sharpness in the viewed image.
4. After the camera has been focused, stop Preview mode, continue Preview mode, begin Acquire mode, wait for the sensor to reach the operating temperature before going to Acquire mode, or shut down the system. Refer to [Section 6.1.2, Shut Down Procedure](#), for the proper shut down procedure.

6.1.2 Shut Down Procedure

Perform the following procedure to safely shut down a LightField experiment:

1. Close LightField.
2. Turn off the camera power.

6.2 Spectroscopy Applications

This section provides step-by-step instructions for acquiring a spectrum in LightField for the first time. The intent of this procedure is to help gain basic familiarity with the operation of the system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

This procedure assumes:

- The system has been set up in accordance with the instructions in previous chapters;
- Familiarity with LightField;
If this is not the case, refer to the online help while performing this procedure.
- The system is being operated in spectroscopy mode with a spectrograph (e.g., a Teledyne Acton Research IsoPlane spectrograph,) on which it has been properly installed.
- A suitable light source (e.g., mercury pen-ray lamp) has been mounted in front of the entrance slit of the spectrograph.

Any light source with line output can be used. Standard fluorescent overhead lamps have good calibration lines as well. If there are no line sources available, it is possible to use a broadband source for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.



CAUTION!

Overexposure Protection: Cameras that are exposed to room light or other continuous light sources will quickly become saturated. If the camera is mounted to a spectrograph, close the entrance slit of the spectrograph to reduce the incident light.

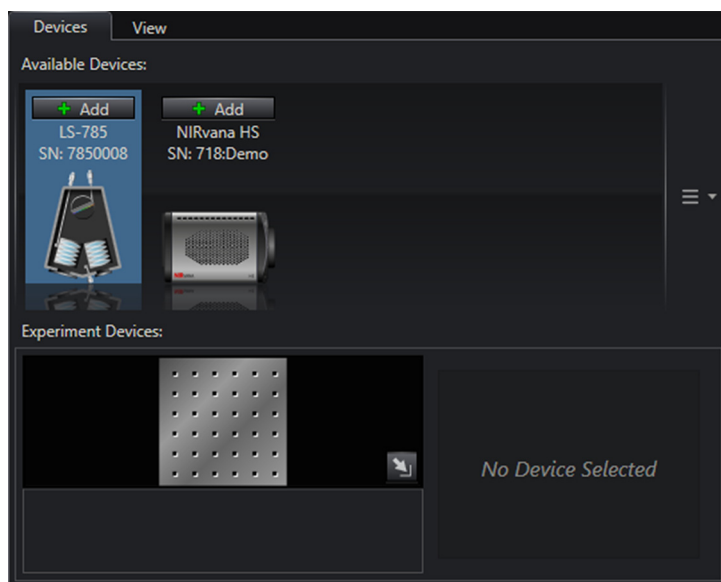
- The customer has installed a compatible shutter driver, such as the SHC-EXT from Princeton Instruments.
- The spectrograph has an entrance slit shutter that is being controlled by the NIRvana HS via the Shutter connector.

Perform the following procedure to configure LightField for the first time:

1. Set the spectrograph entrance slit width to minimum (10 μm if possible).
2. Turn on the spectrograph.
3. Mount a light source such as a Teledyne Princeton Instruments IntelliCal[®] Hg/Ne-Ar Dual Switchable light source in front of the entrance slit.
4. Connect the Shutter connector on rear of the NIRvana HS to the shutter driver.
5. Connect the shutter driver to the entrance slit shutter which may be:
 - An External Slit Shutter
A shutter assembly mounted externally to the spectrograph has shutter cable that plugs into the Shutter driver.
 - An Internal Slit Shutter
A shutter mounted internally has an external shutter connector in the sidewall of the spectrograph.
6. Mount the camera to the spectrograph exit port.
7. Turn on the NIRvana HS.
8. Turn on the host computer.
9. Launch LightField.

10. After LightField has launched, icons representing the camera and spectrograph are shown in the Available Devices area. See [Figure 6-7](#).

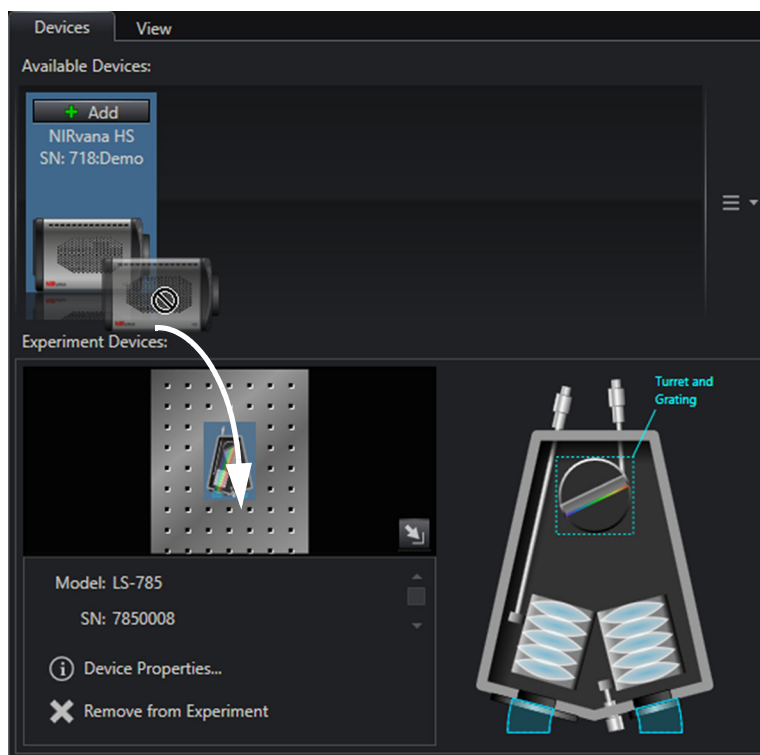
Figure 6-7: Typical Devices Tab: Spectroscopy Application



4411-0169_0019

11. Drag each icon into the Experiment Devices area. See [Figure 6-8](#).

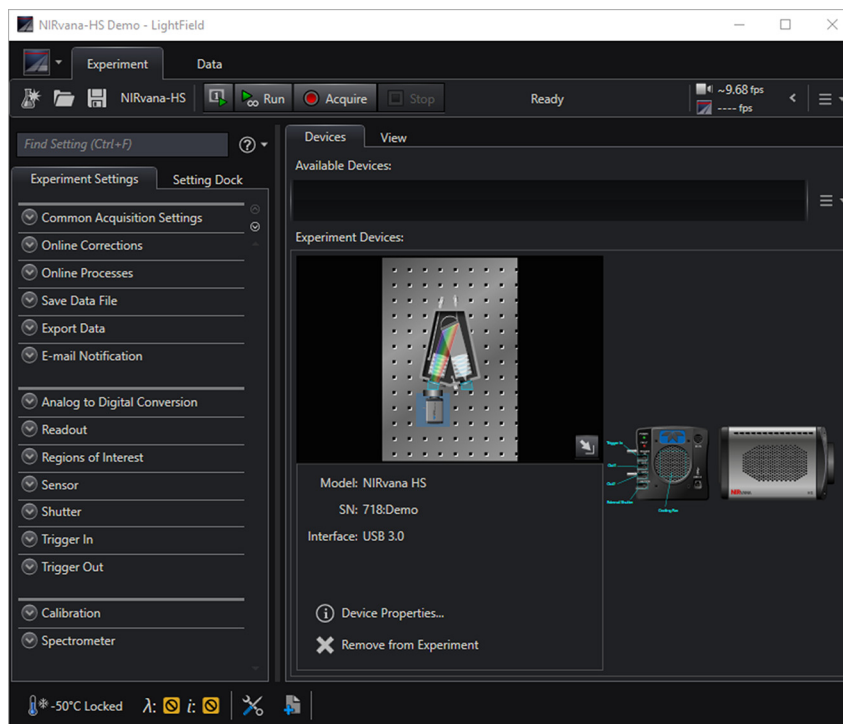
Figure 6-8: Typical Experiment Devices Area: Adding NIRvana HS and Spectrograph



4411-0169_0020

The Experiment Settings stack on the left now includes expanders. See [Figure 6-9](#).

Figure 6-9: Typical Workspace: NIRvana HS Camera with Spectrograph



4411-0169_0021

Since this is a new experiment, default values for the NIRvana HS and spectrograph configuration parameters will be used.

The Status Bar across the bottom of the workspace includes an icon for Temperature Status. Temperature Status reports the current system temperature and if the configured temperature has been reached. Clicking on the icon opens the Sensor expander where the set temperature can be changed.

12. On the Shutter expander, select Shutter Mode: Normal.
13. Open the Spectrometer expander and select the appropriate grating.

**NOTE:**

When using a broadband source, select 0.0 nm.

14. Turn on the shutter driver.
15. Turn on the light source at the spectrograph's entrance slit.
16. Click Run to begin previewing data.

Depending on the display settings, you should see either a spectral band (image) or a graph. Background noise will decrease as the camera cools to its default temperature.

17. Turn off the light source.

The data display should change to a background noise pattern or low intensity graph. If this occurs you have confirmed that light entering the spectrograph is being seen by the camera. Proceed to [Section 6.2.1, Rotational Alignment and Focus](#), on page 44.

18. If there is little or no difference between the data displayed when the light source is on or off:
 - a. Verify that the light source has power and is turned on.
 - b. Verify that the entrance slit is open a minimum of 10 μm .
 - c. Check the Exposure Time (Common Acquisition Settings expander).
 - d. Verify that Shutter Mode is set to Normal (Shutter expander).
 - e. Check the shutter cable connections.
 - f. Verify shutter operation. You should hear the shutter open and close while Run is active.

If you hear a shutter operating and you have performed step a through step e, turn the light source on, wait a minute, and then turn the light off while you view the data display.

 - If the problem is fixed, stop acquisition or proceed to [Section 6.2.1, Rotational Alignment and Focus](#), on page 44.
 - If you do not hear a shutter operating and you have performed step a through step e, stop data acquisition and proceed to step g.
 - g. Verify that the spectrograph has an entrance slit shutter.

An externally mounted shutter is easily confirmed.

Verifying an internally mounted shutter requires access to the inside of the spectrograph. Refer to the spectrograph manual for information.
19. If additional assistance is required, contact Customer Support. Refer to [Contact Information](#) on page 100 for complete contact information.

6.2.1 Rotational Alignment and Focus

The camera mounting hardware provides two degrees of freedom:

- Rotation;

Rotation relates to the physical rotation of the camera while watching a live display on the monitor so that spectral lines will be perpendicular to the rows on the array.
- Focus.

In this context, focus means to physically move the camera back and forth through the focal plane of the spectrograph while watching a live display until the optimal focus is achieved.

**NOTE:**

When aligning accessories such as fibers, lenses, and optical fiber adapters, first align the spectrograph to the slit. Then align the accessory without disturbing the camera's position.

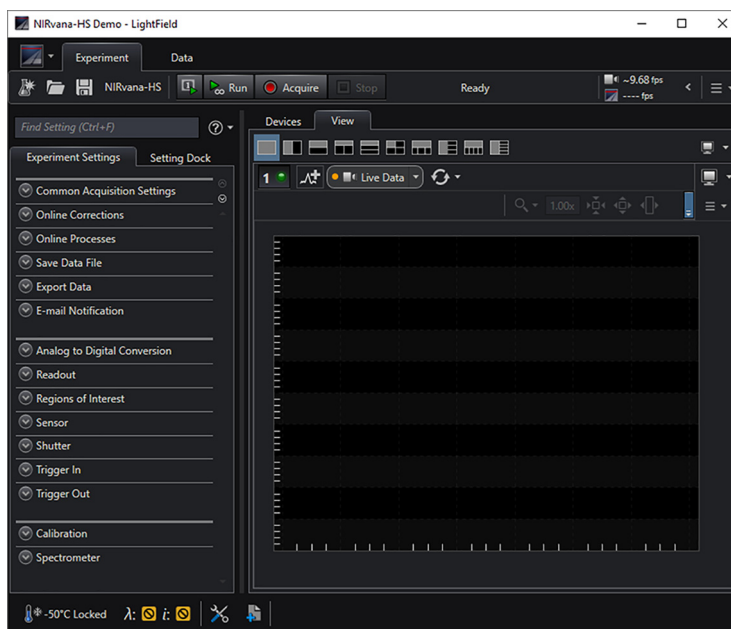
The following sections provide information and procedures necessary to rotationally align and focus a NIRvana HS system.

6.2.1.1 Rotational Alignment

Perform the following procedure to rotationally align the system:

1. Click on the View tab located just above Experiment Devices to change to the display area. See [Figure 6-10](#).

Figure 6-10: Typical Spectroscopy Application Workspace: View Tab



2. If you have not already done so, mount a light source (e.g., Neon, Argon, or Xenon,) to the front of the entrance slit.
3. Open the Spectrometer expander, select the grating, and select the center wavelength.
4. Set the slit to 10 μm . If necessary, adjust the Exposure Time to maintain optimum (i.e., near full-scale,) signal intensity.
5. Wait until the camera temperature locks at its default temperature.
6. Verify that the spectroscopy-mount adapter moves freely at the spectrograph.

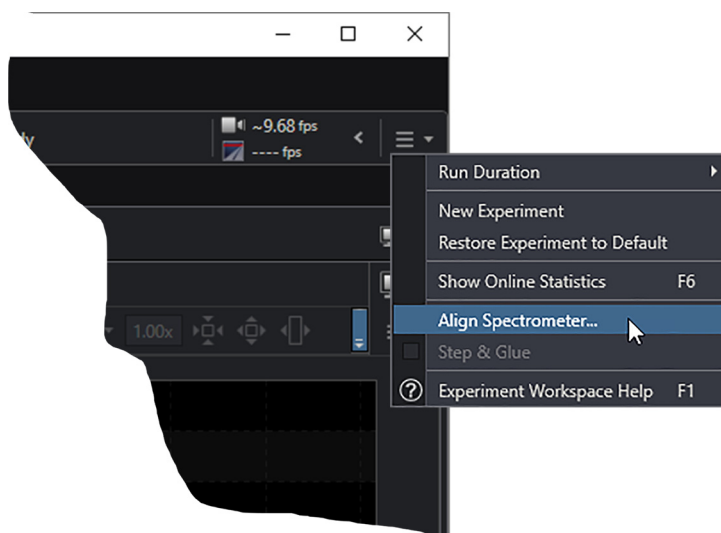


NOTE:

It may be necessary to loosen the two set screws that lock the sliding tube in place.

7. Select Align Spectrometer... from the Experiment Options menu. See [Figure 6-11](#).

Figure 6-11: Experiment Options ► Align Spectrometer Selection



4411-0169_0023

8. The Spectrometer Alignment dialog is displayed in which changes to be made to the NIRvana HS system configuration parameters are outlined. Review the information and click Begin.

Typically, three 1-row high Regions of Interest (ROIs) are created:

- One near the top of the sensor;
- One in the middle of the sensor;
- One near the bottom of the sensor.

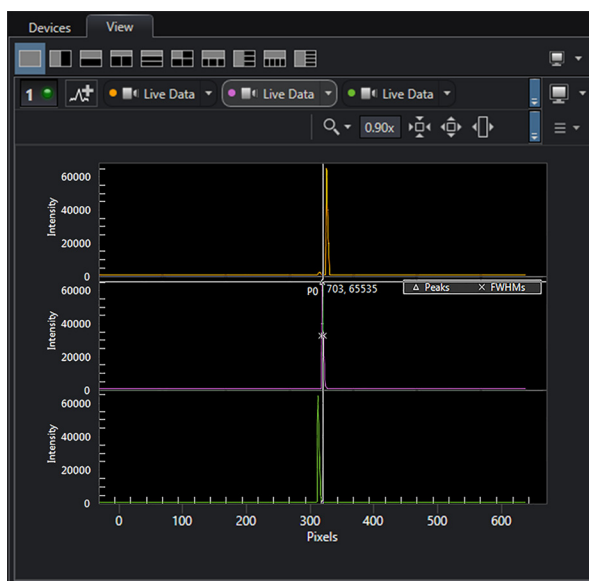
See [Figure 6-12](#).



NOTE:

Data is acquired and displayed, but NOT stored.

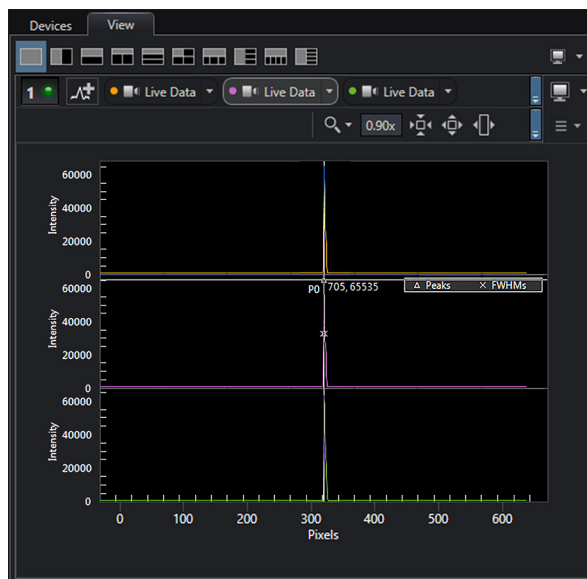
Figure 6-12: Align Spectrometer: Pre-Rotational Alignment



4411-0169_0024

9. Adjust the rotational alignment by rotating the camera while watching a live display of the line. Click on a peak to monitor during the rotational alignment. This positions the large cursor to provide a vertical reference line across all of the ROIs. Rotate the camera until the selected peak is aligned horizontally in all of the ROIs. See [Figure 6-13](#).

Figure 6-13: Align Spectrometer: Post-Rotational Alignment



4411-0169_0025

Alternatively, capture an image, display the horizontal and vertical cursor bars, and compare the vertical bar to the line shape on the screen. Rotate the camera until the line shape on the screen is parallel with the vertical bar.

6.2.1.2 Focus

Perform the following procedure to focus the system:

1. Slowly move the camera in and out of focus. The spectral peak(s) should go from broad to narrow and back to broad. Maximize the intensity level and minimize the FWHM of the selected peak(s).



NOTE:

The Peak Finding function is active for the center graph so that FWHM information can be monitored to achieve the narrowest line width.

Focusing is accomplished depending on the spectrograph being used as follows:

- Long focal-length spectrographs (e.g., a Teledyne Acton Research SP-2300)
The mounting adapter includes a tube that slides inside another tube to move the camera in or out as required to achieve optimum focus.
 - Short focal-length spectrographs
There is generally a focusing mechanism on the spectrograph itself which, when adjusted, will move the optics as required to achieve proper focus.
 - No focusing adjustment
If no focusing adjustment is provided by the spectrograph or by the mounting hardware the only option is to adjust the spectrograph's focusing mirror.
2. Tighten the two spectrograph set screws to secure the spectrograph sliding tube.
 3. Halt data acquisition.

6.2.2 Acquire Data

After the system has been successfully aligned and focused, perform the following procedure to acquire data:

1. Stop running in Alignment mode.
2. Make any required changes to the experiment setup and/or software parameters. Changes might include adjusting exposure time, setting up an entrance slit shutter, changing the timing mode to External Sync, or lowering the temperature.
3. Begin running Acquire mode. Data will be acquired and displayed/stored based on the experiment's settings.
4. Once data collection has been completed, the camera may remain powered on so the array temperature will remain locked or the system may be shut down. Refer to [Section 6.2.3, Shut Down Procedure](#), for the proper shut down procedure.

6.2.3 Shut Down Procedure

Perform the following procedure to safely shut down a LightField experiment:

1. Close LightField.
2. Turn off the light source and the spectrograph.
3. Turn off the camera power.

Chapter 7: Exposure

This chapter discusses factors that affect exposure and the accumulation of charge on the FPA sensor.

A Focal Plane Array (FPA) such as the one in NIRvana HS is a matrix of photodiodes bonded to a readout circuit on an IC chip. The photodiodes are sensitive to NIR wavelengths in which they absorb NIR radiation, convert it into electrons, and send a voltage signal in response to form an image. NIR imaging FPA photodiodes are composed of materials sensitive to NIR radiation.

Each cell on an FPA is connected to its own charge storage well. These cells respond to the intensity of light or NIR radiation falling on their collection areas and store a proportional amount of charge in their associated wells. Once charge accumulates for the specified Exposure Time the charge in each well is read out serially through four video output ports.



REFERENCES:

Refer to [Chapter 8, Readout](#), on page 53 for complete information.

7.1 Exposure Time

Exposure Time is configured in LightField on the Common Acquisition Settings expander and is the time between commands sent to start and stop signal accumulation on the sensor.

7.2 Saturation

When signal levels in a region of the image are very high, charge generated in one pixel may exceed the well capacity of the pixel, spilling over into adjacent pixels in a process called blooming. In this case, a shorter exposure time is advisable, with signal averaging to enhance Signal-to-Noise (S/N) Ratio accomplished through the software.

For signal levels low enough to be read-noise limited, longer exposure times, and therefore longer signal integration on the sensor, will improve the S/N Ratio approximately linearly with the length of exposure time. There is, however, a maximum time limit for on-chip accumulation which is determined by either the saturation of the sensor by the signal or the loss of dynamic range due to the buildup of dark signal.

7.3 Noise Sources

Primary noise sources include:

- **Dark Charge**
NIR signal from the environment and leakage current.
- **Input Signal**
Photon shot noise.
- **Readout**
Noise generated when the multiplexers are read out.

An ideal detector contains no noise sources and is limited only by the photon shot noise. Unfortunately, there are always noise sources that will contribute noise of one kind or another to the total signal. The methods used to reduce the noise depend on the noise component being addressed. Infrared noise from the detector and the environment can be reduced by lowering the temperature of the detector and environment, respectively.

7.3.1 Dark Charge

Dark charge (also known as dark current) is the thermally induced buildup of charge in the sensor over time. The statistical noise associated with this charge is known as dark noise. Dark charge values vary widely from one sensor to another and are temperature dependent.

With the light into the camera completely blocked, the sensor pixels accumulate thermally generated electrons, dependent on the exposure time and camera temperature. The longer the exposure time and the warmer the camera, the less uniform this background will appear. Thus, to minimize dark-charge effects, the camera should be operated at its default sensor temperature.



CAUTION!

If a sudden change is observed in the baseline signal, there may be excessive humidity in the camera vacuum enclosure. Turn off the camera and contact Teledyne Princeton Instruments Customer Support. Refer to [Contact Information](#) on page 100 for complete contact information.

7.4 Sensor Temperature

Lowering the temperature of the sensor generally enhances the quality of an acquired signal by lowering dark noise. In LightField, temperature control is achieved on the Sensor expander. Initially, the default temperature appropriate for the specific model is used.

Once the temperature set point has been set, the software controls the camera's cooling circuits to reach set sensor temperature. Upon reaching that temperature, the control loop locks to that temperature for stable and reproducible performance. When temperature lock has been reached (i.e., the temperature is within 0.05°C of the set value,) the current temperature is Locked. The on-screen indication allows easy verification of temperature lock.

The time required to achieve lock can vary considerably depending on factors such as camera type, sensor type, ambient temperature, etc. Once lock occurs, focus may begin. However, waiting an additional twenty minutes before taking quantitative data is recommended so that the system has time to achieve optimum thermal stability.

When vibration may affect results, fan operation can be turned off while making sure that the coolant is circulating through the camera to maintain the sensor cooling temperature. If the fan is turned off and there is no coolant circulating through the camera, the built-in thermo-protection switch may shut the camera down to prevent thermal damage. In the event that this occurs, wait approximately ten minutes, correct the situation that caused the shutdown, and re-power the camera.

The deepest operating temperature for a system depends on the sensor size and packaging. Refer to [Table A-3, Operating Temperatures](#), on page 80 for default cooling temperatures.

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Chapter 8: Readout

This chapter discusses topics related to the reading out of data that have been acquired by a NIRvana HS camera.

8.1 Modes

NIRvana HS supports two Readout Modes:

- The first and most common mode is **Full Frame Readout**, also referred to as **Integrate Then Read (ITR)**. This is the default Readout Mode for the NIRvana HS.
- The second mode is **Expose During Readout**, or **Integrate While Read (IWR)**.

Following integration, acquired data must be read out.



NOTE:

Integration Time is the **Exposure Time**, the period of time during which the sensor is actively collecting incoming signal.

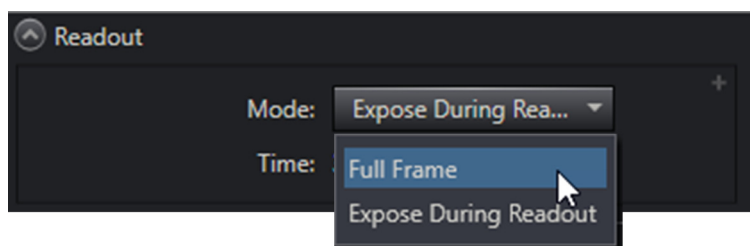
Readout is the process of transferring the data collected during integration.

Depending upon experiment conditions and requirements, users should select the most appropriate mode:

- Full Frame Readout (ITR) provides the lowest noise readout;
- Expose During Readout (IWR) provides the fastest Frame Rate.

In LightField, **Readout Mode** is configured on the **Readout** expander via the **Mode** parameter. See [Figure 8-1](#).

Figure 8-1: Typical Readout Expander



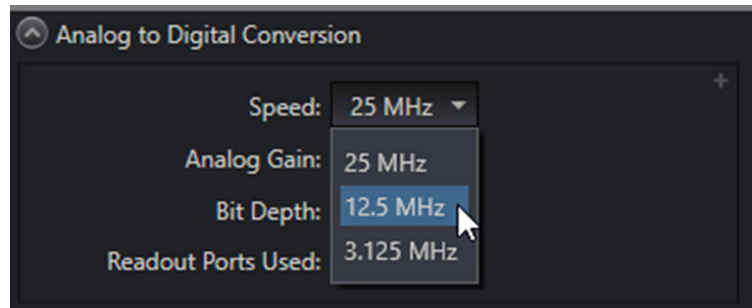
Readout rates are determined by the camera's clocking frequency and the camera's resolution. The NIRvana HS provides three clock frequencies:

- 3.125 MHz;
- 12.5 MHz;
- 25 MHz.

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Readout rate is configured in LightField on the **Analog to Digital Conversion** expander via the **Speed** parameter. See [Figure 8-2](#).

Figure 8-2: Typical Analog to Digital Conversion Expander



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Using the full camera resolution of 640 x 512, the readout times of the camera are approximately 31 ms, 8 ms, and 4 ms respectively.

These options and techniques are discussed in this chapter.

8.1.1 Full Frame Readout

In general, Full Frame Readout is the simplest method of reading out acquired data. Data readout for a frame of data begins when the frame's exposure cycle has ended. Similarly, once data readout has been completed, the next exposure cycle begins, and so on, until the programmed number of frames has been completely acquired and read out.

When using Full Frame Readout, Frame Rate is always determined by:

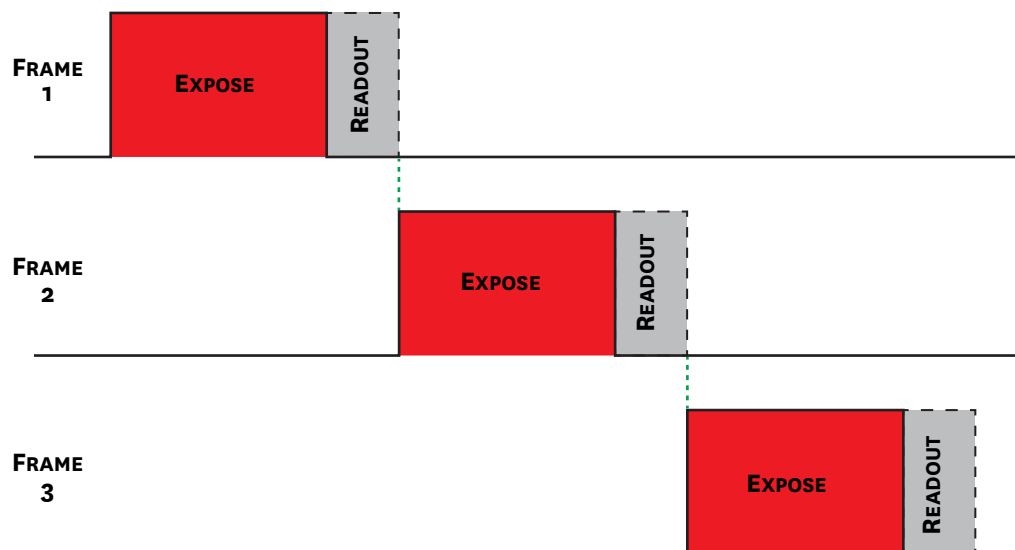
$$t_{\text{exp}} + t_{\text{ro}}$$

[Figure 8-3](#) illustrates the timing diagram for three frames of data being acquired and read out using Full Frame Readout.



NOTE:

Although the Exposure Time is illustrated as being longer than Readout Time, the same timing relationship applies for all relative Exposure/Readout Times.

Figure 8-3: Timing Diagram: Full Frame Readout, $t_{exp} > t_{ro}$ 

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8.1.2 Expose During Readout

Using Expose During Readout generally yields faster Frame Rates with no gaps in acquired data as well as less lag time. Expose During Readout is particularly useful when Exposure Time and Readout Time are in the same magnitude.

For Expose During Readout, the relationship between Exposure Time and Readout Time may be as follows:

- Exposure Time is longer than or equal to Readout Time [$t_{exp} \geq t_{ro}$];
- Exposure Time is shorter than Readout Time [$t_{exp} < t_{ro}$].

Simplified timing diagrams illustrating each of these scenarios are presented in the following sections, and associated Frame Rate implications are discussed.

8.1.2.1 Exposure Time is Longer Than or Equal to Readout Time

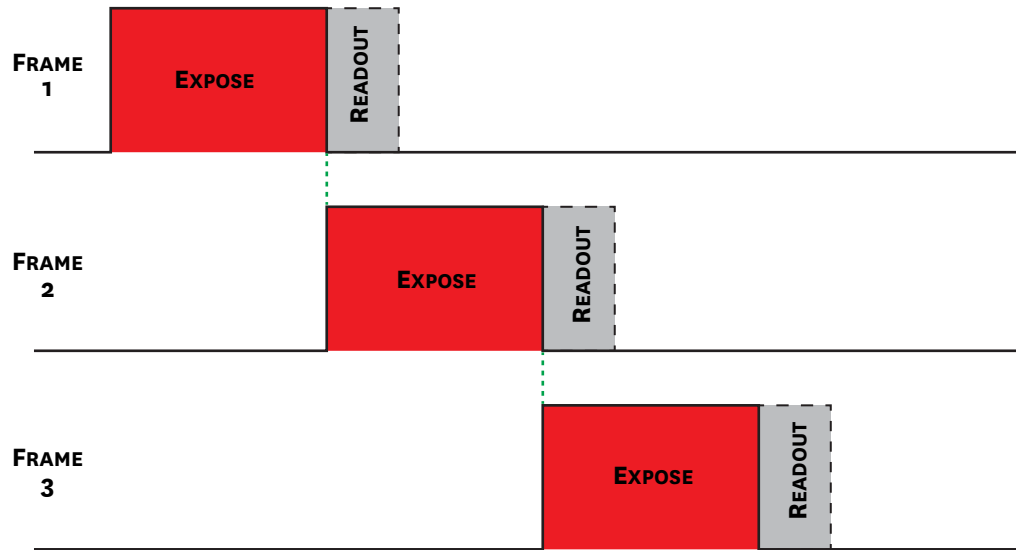
Figure 8-4 illustrates the timing diagram for Expose During Readout when Exposure Time is longer than Readout Time.



NOTE:

Figure 8-5 also applies to applications when Exposure Time equals Readout Time.

Figure 8-4: Timing Diagram: Expose During Readout, $t_{\text{exp}} \geq t_{\text{ro}}$



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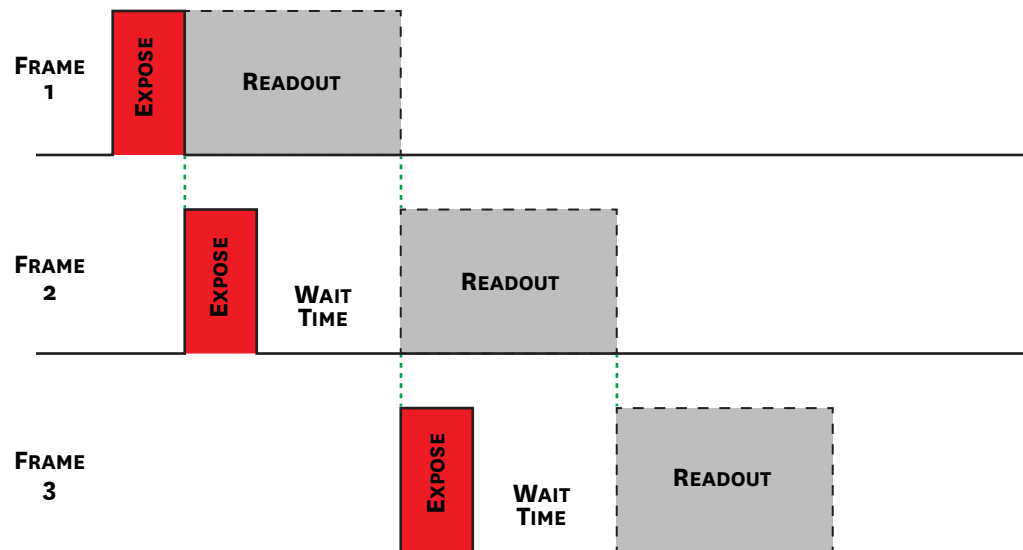
For this application, each successive frame's expose cycle begins as the prior frame's Expose cycle ends and Readout cycle begins.

Therefore, the Frame Rate is defined by the Exposure Time.

8.1.2.2 Exposure Time is Shorter than Readout Time

Figure 8-5 illustrates the timing diagram for Expose During Readout when Exposure Time is shorter than Readout Time.

Figure 8-5: Timing Diagram: Frame Transfer Readout, $t_{\text{exp}} < t_{\text{ro}}$



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However, there are a number of caveats associated with this timing situation, primarily a risk of overexposure. This is due to the fact that the sensor is collecting signal while readout is occurring, which is illustrated by the **Wait Time** periods in Figure 8-5.

Overexposure can be avoided by turning the light source off (or blocking it) during the wait time. One way to do this is to control the light source via TTL with the Exposing Output Signal.



NOTE:

The first frame in Figure 8-5 is never overexposed.

For this application, regardless of when a frame's exposure starts or ends, the reading out of data cannot begin until the prior frame's data have been completely read out. Therefore, the effective Exposure Time is actually equal to the Readout Time.

Consequently, the Frame Rate for these scenarios is defined by the Readout Time.

8.1.3 Full Frame Readout versus Expose During Readout

When deciding on the readout mode to be used, keep in mind that:

- Expose During Readout provides the fastest Frame Rate;
- Full Frame Readout provides the lowest noise readout.

Table 8-1 compares frame rates for these two Readout modes for a variety of Exposure Times and Readout Rates.

Table 8-1: Full Frame Readout vs. Expose During Readout Frame Rate Comparison

Expose Time	Full Frame Readout			Expose During Readout		
	Clock (MHz)			Clock (MHz)		
	3 MHz	12 MHz	25 MHz	3 MHz	12 MHz	25 MHz
	Readout Time (ms)			Readout Time (ms)		
	31	7.8	3.9	31	7.8	3.9
100 μ s	32.3	128.9	257.7	32.3	129.0	258.4
500 μ s	32.2	128.2	255.1	32.3	129.0	258.4
1 ms	31.3	114.3	205.3	32.3	129.0	258.4
5 ms	27.8	78.4	112.7	32.3	129.0	200.0
10 ms	24.4	56.3	72.1	32.3	100.0	100.0
50 ms	12.3	17.3	18.3	20.0	20.0	20.0
100 ms	7.6	9.3	9.6	10.0	10.0	10.0
500 ms	1.9	2.0	2.0	2.0	2.0	2.0
1 sec	1.0	1.0	1.0	1.0	1.0	1.0
5 sec	0.2	0.2	0.2	0.2	0.2	0.2
10 sec	0.1	0.1	0.1	0.1	0.1	0.1

EDR Compared with FFR

	Increase < 3%
	Increase 3% – 10%
	Increase 11% – 25%
	Increase > 26%

8.1.4 Determine the Best Readout Mode for an Application

When deciding on the best readout mode for an application, consider the following:

- For the lowest noise possible, use the 3.125 MHz clock and Full Frame readout mode.
- The benefit of Expose During Readout is maximized when Exposure time and Readout time are similar. See [Table 8-1](#).
- If Regions of Interest are not utilized, exposure times less than 1 ms or greater than 500 ms result in nearly identical frame rates in either readout mode based on full 640 x 512 resolution.
- In Expose During Readout mode, when expose is much shorter than readout, the sensor will accumulate signal during the prior frame readout. See [Figure 8-5](#). This mode can be used during strobed light applications, or when the event is much shorter than readout and no additional signal is present.

8.2 Region of Interest Strategy

NIRvana HS supports user-defined Regions of Interest (ROI) which specifies one or more areas on the sensor from which acquired data will be readout. Depending on the number, size, and proximity of the defined ROIs on the sensor, decreased Readout Times may be achieved resulting in an effective increase in Frame Rate.

When designing an ROI strategy, there are a sizing and placement factors to consider in order to realize the greatest Readout Time/Frame Rate benefits.

8.2.1 Region of Interest Sizing Guidelines

For imaging applications, when sizing Regions of Interest, the maximum benefit to readout times/frame rates is achieved when:

- The width of each ROI is a multiple of 16 columns;
The minimum width of an ROI is 32 columns.
- The height of each ROI is a multiple four (4) rows.
The minimum height of each ROI is four (4) rows.

For spectrographic applications, when sizing Regions of Interest, the maximum benefit to readout times/frame rates is achieved when:

- The width of each ROI is the full width of the sensor;
- The height of each ROI is a multiple four (4) rows.
The minimum height of each ROI is four (4) rows. Creating an ROI that is less than four (4) rows in height yields no improvement in Readout Time/Frame Rate.

8.2.2 Single Region of Interest Placement Guidelines

For imaging applications, when positioning/placing a single Region of Interest the greatest improvement in Readout Time/Frame Rate is achieved when the ROI is positioned such that, referencing a standard (**x, y**) coordinate system, its corners are placed such that:

- The x-coordinates are multiples of 16;
For example, 0, 16, 32, 48, ...
- The y-coordinates are multiples of 4.
For example, 0, 4, 8, 12, ...

For spectrographic applications, by default the full width of the sensor is required. Therefore, when positioning/placing a single Region of Interest the greatest improvement in Readout Time/Frame Rate is achieved when the full-width ROI is positioned such that its top and bottom boundaries fall on rows that are multiples of 4 (i.e., 0, 4, 8, 12, ...)

8.2.3 Two to Four Regions of Interest Placement Guidelines

When positioning two to four ROIs on a sensor, in addition to the guidelines detailed in [Section 8.2.2, Single Region of Interest Placement Guidelines](#), there are additional placement guidelines which should be followed in order to achieve the maximum benefit in Readout Times/Frame Rate improvements.

For imaging applications:

- Regions of Interest should not share rows;
- Adjacent edges of vertically stacked ROIs must be separated by a multiple of 4 rows.

For spectroscopic applications:

8.2.4 Regions of Interest Impact on Frame Rate

This section compares experimentally obtained Frame Rates for a series of imaging application Regions of Interest geometries.

Unless otherwise or explicitly stated:

- The entire sensor area is included for relative positioning of Regions of Interest;
- Each geometry is comprised of two (2) Regions of Interest;
- Each Region of Interest measures 200 x 200 pixels;
- Each Region of Interest has been color-coded for ease of identification only;
- Where applicable, identified gaps between Regions of Interest are expressed in Rows or Columns (as appropriate.)

As a point of reference, the base frame rate (i.e., when no Regions of Interest have been defined,) is 32.3 fps using a clock speed of 3.125 MHz.

Figure 8-6 illustrates two vertically stacked Regions of Interest with a small vertical gap. The measured readout rate is 96.3 fps.

Figure 8-6: Vertically Stacked ROIs with Small Vertical Gap

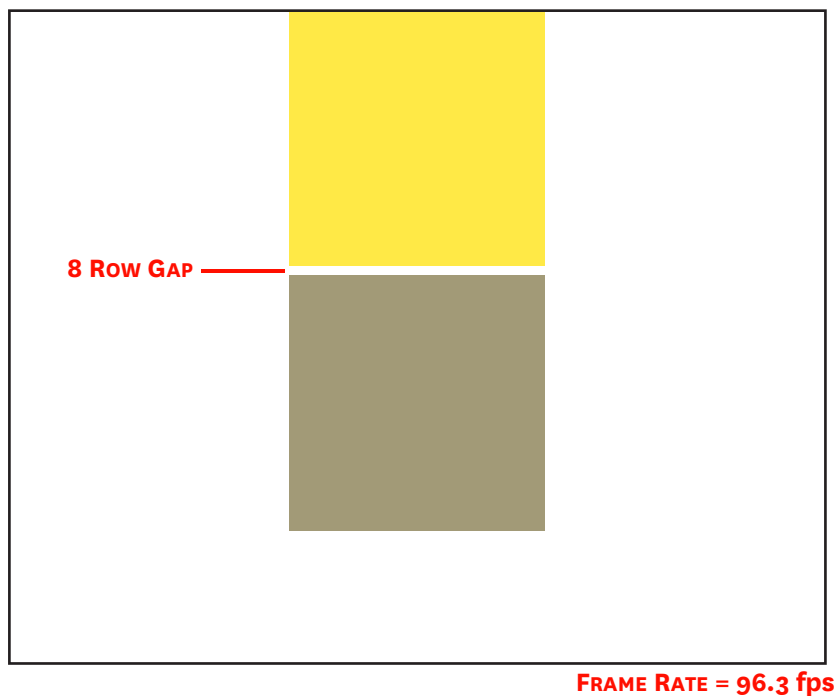


Figure 8-7 illustrates two vertically stacked Regions of Interest with a large vertical gap. The measured readout rate is 96.3 fps.

Figure 8-7: Vertically Stacked ROIs with Large Vertical Gap

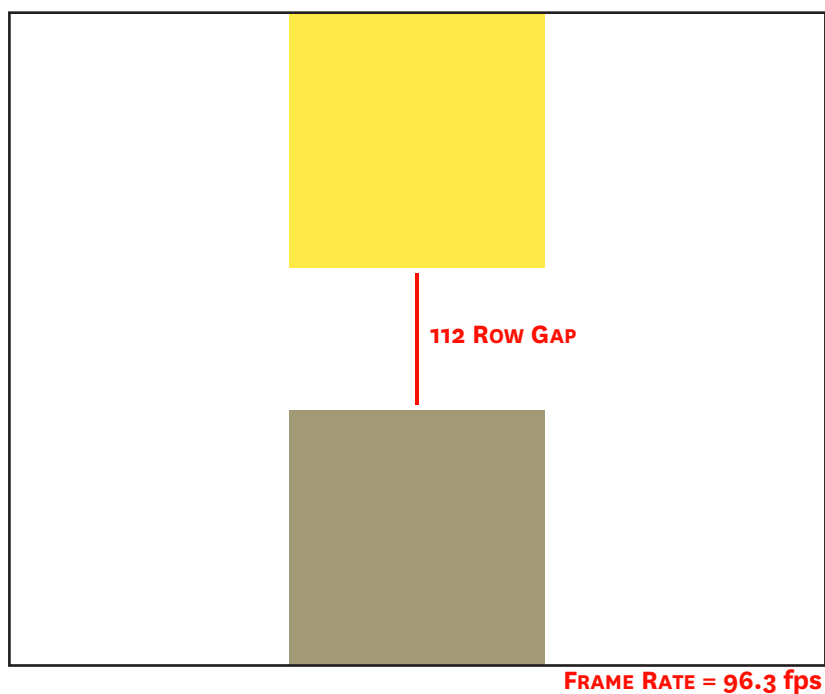
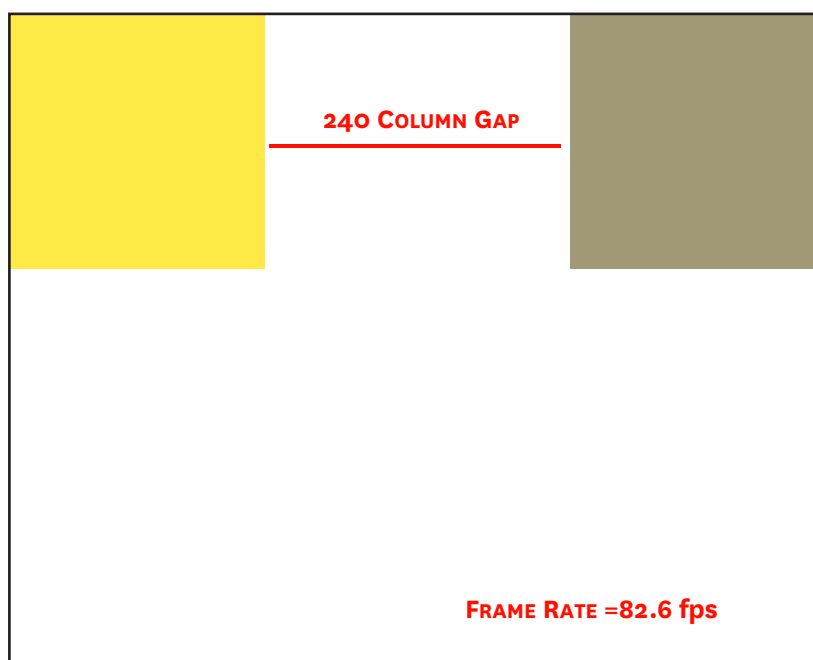


Figure 8-8 illustrates two vertically aligned Regions of Interest with a large horizontal gap. The measured readout rate is 82.6 fps.

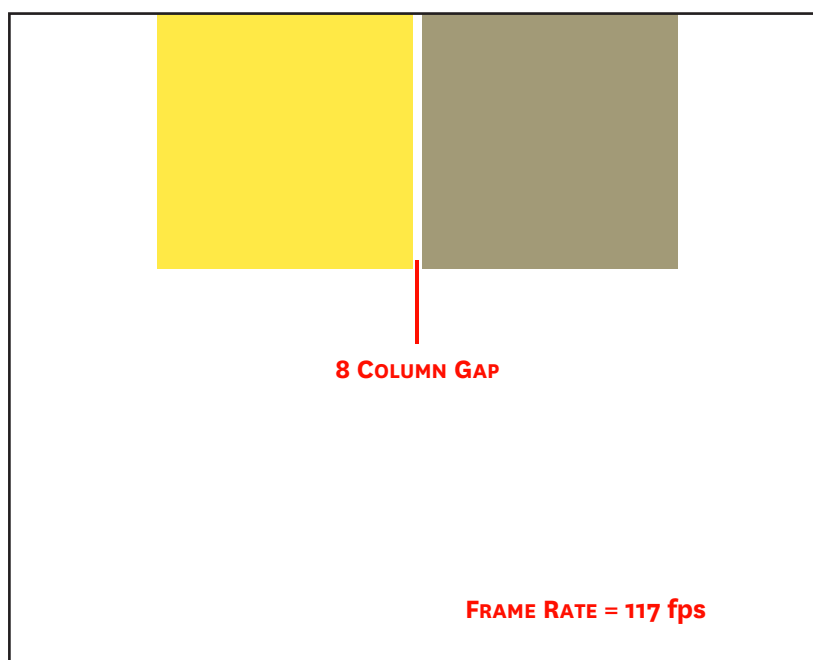
Figure 8-8: Horizontally Aligned ROIs with Large Horizontal Gap



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Figure 8-9 illustrates two vertically aligned Regions of Interest with a small horizontal gap. The measured readout rate is 117 fps.

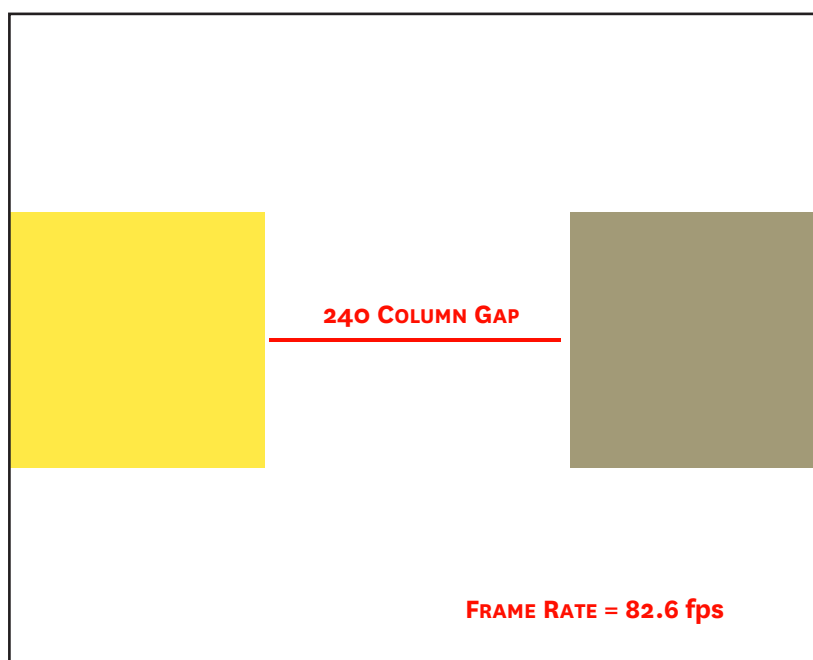
Figure 8-9: Vertically Aligned ROIs with Small Horizontal Gap



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Figure 8-10 illustrates two vertically aligned Regions of Interest with a large horizontal gap. The regions are vertically mid-sensor. The measured readout rate is 82.6 fps.

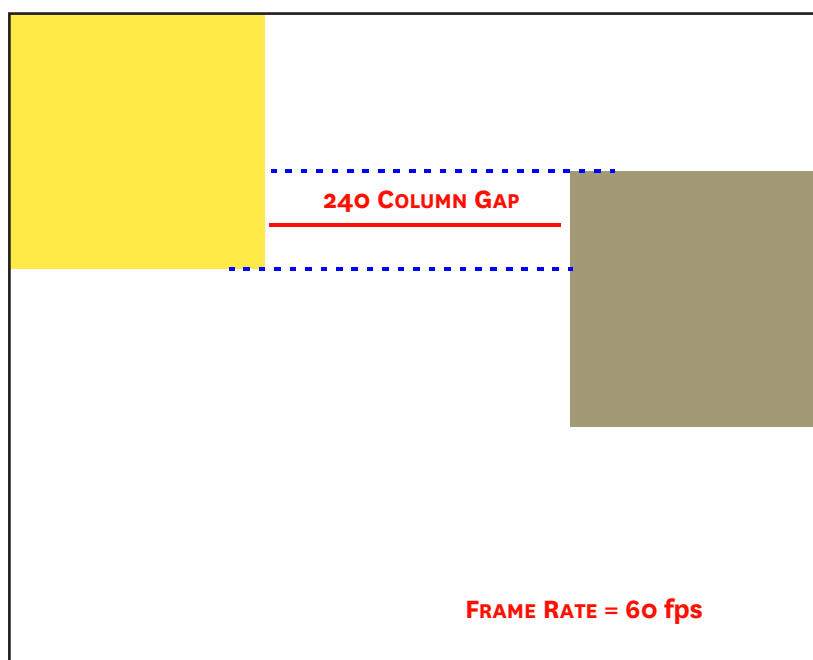
Figure 8-10: Vertically Aligned Mid-Sensor ROIs with Large Horizontal Gap



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Figure 8-11 illustrates two vertically offset Regions of Interest with a large horizontal gap and several overlapping rows. The measured readout rate is 60 fps.

Figure 8-11: Vertically Offset ROIs with Large Horizontal Gap, Overlapping Rows



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Figure 8-12 illustrates two vertically offset Regions of Interest with a large horizontal gap, no overlapping rows, and no vertical gap. The measured readout rate is 41 fps.

Figure 8-12: Vertically Offset ROIs with Large Horizontal Gap, No Vertical Gap or Row Overlap

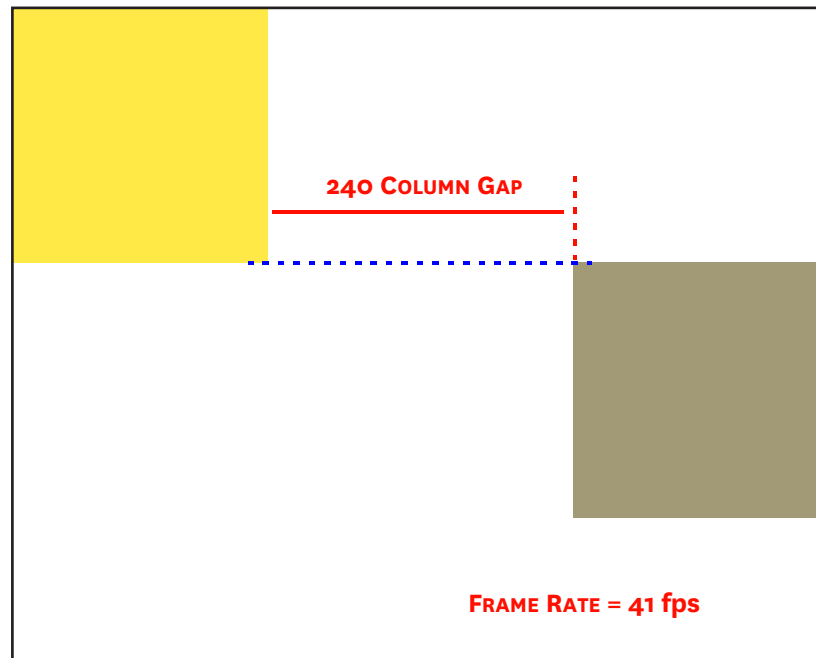


Figure 8-13 illustrates two vertically offset Regions of Interest with a large horizontal gap and the minimal vertical gap (i.e., 4 rows.) The measured readout rate is 82.6 fps.

Figure 8-13: Vertically Offset ROIs with Large Horizontal Gap, 4 Row Vertical Gap

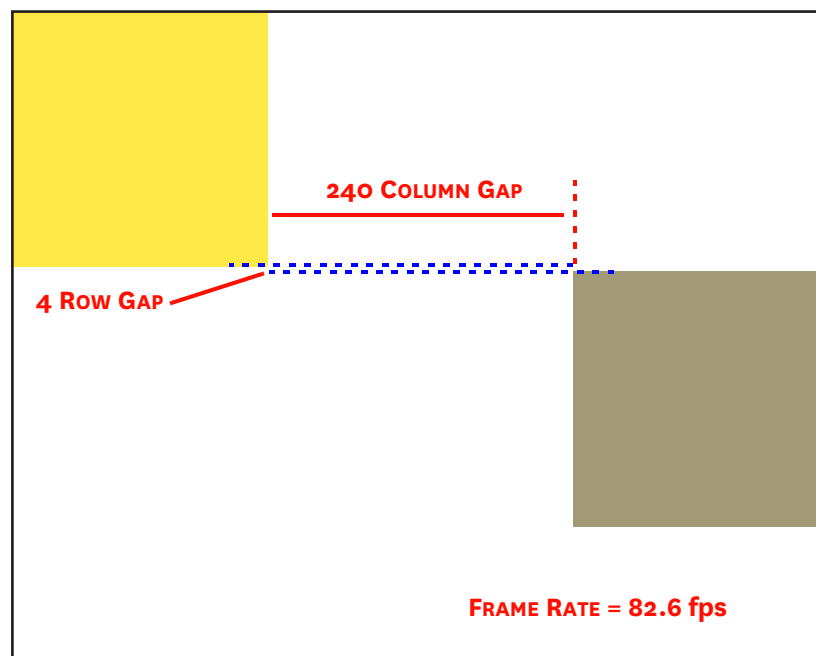
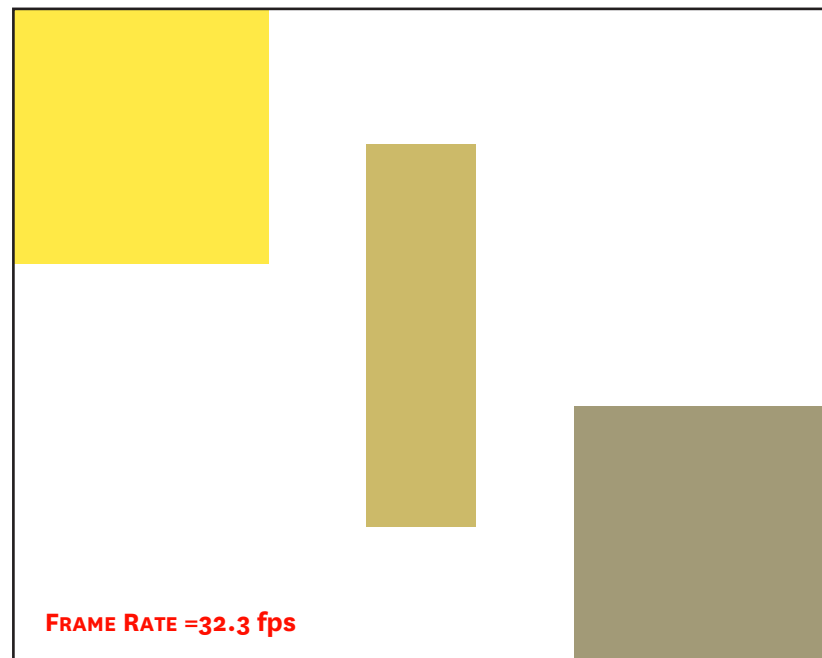


Figure 8-14 illustrates three Regions of Interest with horizontal gaps and multiple overlapping rows. The measured readout rate is 32.3 fps.

Figure 8-14: Three ROIs with Horizontal Gaps and Overlapping Rows



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8.2.5 Number of Regions of Interest

When it comes to the creation of ROIs, more is not always better, and creating an excessive number of smaller ROIs may yield minimal frame rate increase. See Figure 8-15.

Figure 8-15: Excessive Number of Small Regions of Interest



NOTE:

When using ROI for high speed imaging, performance is computer dependent. Frame rates above 10 kHz may result in data overload and early stoppage of the system.

8.3 Analog Gain

Analog Gain is used to change the number of electrons required to generate an Analog-to-Digital Unit (ADU,) also known as a count.

The Analog Gain is configured on the Analog to Digital Conversion expander.

Analog Gain Control determines how many photons are required to generate an analog-to-digital unit. The gain selection should be based on the signal intensity.

Available Analog Gain options are:

- Low;
Low is appropriate for applications measuring high-level signals. This setting allows the digitization of larger signals.
- High.
High is appropriate for applications consistently measuring low-level signals. This setting requires fewer electrons to generate an ADU and reduces some sources of noise. This is a particularly important consideration in absorbance measurements.

Example

The following descriptions assume that the actual incoming light level is identical in both instances. The numbers used do not reflect the actual values for NIRvana HS and do not reflect actual detector performance.

- Low requires 1750 electrons to generate one ADU.
Strong signals can be acquired without flooding the sensor. If the gain is set to Low and the spectra or images appear weak, the gain setting should be changed to High.
- High requires 65 electrons to generate one ADU. Some noise sources are reduced.
Because fewer electrons are needed to generate an ADU, weaker signals can be more readily detected. Lower noise further enhances the ability to acquire weak signals. If the sensor appears to be flooded with light, change the setting to Low.

This technique is also useful in high light level experiments where the detector is again photon shot-noise limited. Summing multiple pixels in software corresponds to collecting more photons, and results in a better S/N Ratio for the measurement.

8.4 Software Binning

Software Binning allows software averaging which can improve the S/N Ratio by as much as the square-root of the number of scans. Unfortunately, with a high number of scans, (i.e., greater than 100,) camera 1/f noise may reduce the actual S/N Ratio to slightly below this theoretical value. Also, if the light source used is photon-flicker limited rather than photon shot-noise limited, this theoretical signal improvement cannot be fully realized. Again, background subtraction from the raw data is necessary.

This technique is also useful in high light level experiments where the camera is again photon shot-noise limited. Summing multiple pixels in software corresponds to collecting more photons, and results in a better S/N Ratio for the measurement.

Software Binning is configured on the Region of Interest expander as well as the associated Edit ROIs... window.

Software Binning occurs after a signal has been read out of the sensor and combines signals in adjacent pixels to create super pixels.

8.5 Digitization

After gain has been applied to the signal, the Analog-to-Digital Converter (ADC) converts the analog information (continuous amplitudes) into digital data (quantified, discrete steps) that can be read, displayed, and stored by the application software. Digitization Resolution is 16 bits.

Factors associated with digitization include the digitization rate and baseline signal. Depending on the detector model, you may be able change the speed at which digitization occurs and/or offset the baseline. These factors are discussed in the following sections.

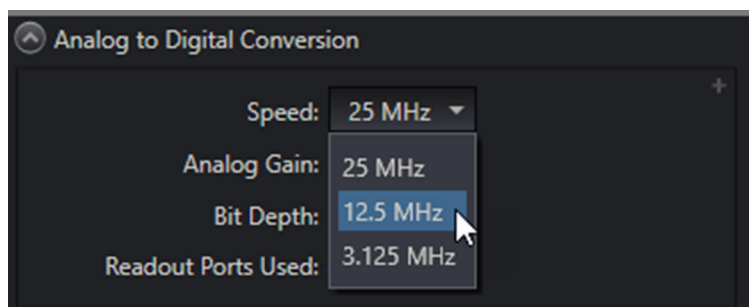
8.5.1 Speed

After readout, an analog signal representing the charge of each pixel is digitized to 16 bits. NIRvana HS supports three user-configurable digitization speeds:

- 3.125 MHz;
- 12.5 MHz;
- 25.0 MHz.

Speed is configured on the **Analog to Digital Conversion** expander. See [Figure 8-16](#).

Figure 8-16: Typical Analog to Digital Conversion Expander



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Because sensor readout noise increases with readout rate, it may be beneficial to sacrifice speed for data quality.

- When speed of data acquisition and conversion is critical, select 25 MHz.
- Selecting a speed of 3.125 MHz produces the lowest read out noise.

Switching between conversion speeds is under software control for total experiment automation.

8.5.2 ADC Offset (Baseline Offset)

ADC offset (also known as baseline offset) provides another way of dealing with dark charge. Refer to [Section 7.3.1, Dark Charge](#), on page 50 for additional information. By offsetting the baseline signal, much of the background is ignored during conversion.

During the exposure time, the sensor collects a charge pattern and an NIR signal in addition to the signal of interest. The longer the exposure time and the warmer the detector and the environment, the larger and less uniform this background will appear.



CAUTION!

If a sudden change in the baseline signal is observed, there may be excessive humidity in the detector vacuum enclosure. Turn off the camera and contact Teledyne Princeton Instruments Customer Support for instructions.

Chapter 9: Data Correction

This chapter discusses the methods incorporated by NIRvana HS for correcting data. For each individual camera, specific correction data are determined during the manufacturing process. All necessary correction data are stored within the camera's non-volatile flash memory (NVRAM.) During camera start-up, the available correction data are copied from the flash memory onto the correction data memory for real time access. The correction data transfer is synchronized with the transfer of image data from the sensor. A correction module may also write back to the correction data memory, depending on its functionality. The specific image correction modules are described in the following sections.

9.1 Non-Uniformity Correction (NUC): Gain and Offset

Each pixel of an InGaAs sensor includes two sources of signal non-uniformity:

- Dark Signal Non-Uniformity (DSNU);
This is the inherent level of dark charge associated with all sensor pixels.
- Photo Response Non-Uniformity (PRNU);
This is the sensitivity of each pixel to light.

The interaction and combination of these two sources yields an underlying, sensor-specific, static pattern which can be identified/characterized, and then compensated for using Non-Uniformity Correction techniques.

The NIRvana HS camera is factory calibrated at a default temperature for all speeds and gains to perform column-by-column gain and offset correction. NUC removes the vertical fixed-pattern in an image due to column amplifier differences. If improved pixel-by-pixel correction is desired, refer to [Section 9.2, Background Subtraction](#) and [Section 9.3, Flatfield Correction](#).

9.2 Background Subtraction

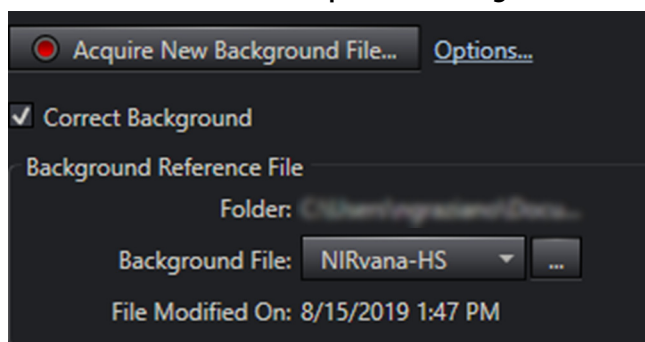
To compensate for remaining non-uniformity, background subtraction can be used to remove or reduce the impact of fixed pattern noise when acquiring data. The technique requires that a live background image be acquired, stored, and selected as the background file to be used in background-subtracted data acquisition. This background image is subtracted from the live image to reduce the fixed pattern noise.



NOTE:

The background image should be acquired with the NIRvana HS at cooling set point, the lens cover installed/in place, and little or no ambient light in the area. All camera configuration settings should be the same as for the experiment to be performed.

Background Subtraction is enabled and configured on the Online Corrections expander within LightField. The Background Reference Image is also acquired from within this same expander. See [Figure 9-1](#).

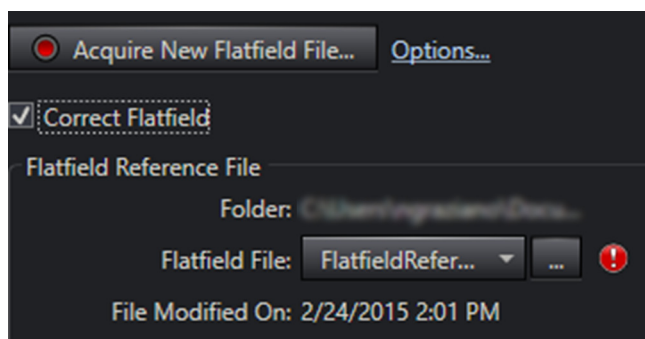
Figure 9-1: Typical Online Corrections Expander: Background Subtraction

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9.3 Flatfield Correction

Non-uniformity of illumination sources, optical non-uniformity (i.e., vignetting,) and/or the non-uniformity of the InGaAs detector can be compensated for by applying Flatfield Correction. This procedure is performed by first setting up the experiment parameters, waiting until the detector has reached operating temperature to ensure stability, and taking a Flatfield Reference image of the illumination source (without the sample.)

Flatfield Correction is enabled and configured on the Online Corrections expander within LightField. The Flatfield Reference File is also acquired from within this same expander. See [Figure 9-2](#).

Figure 9-2: Typical Online Corrections Expander: Flatfield Correction

4411-0169_0056

After the flatfield image has been acquired, select Automatic Flatfield Correction and specify the data file to be used. Then, configure the experiment with the sample in place and acquire data. The Flatfield data will automatically be applied to the raw data and the resulting data will be displayed and/or stored.

9.4 Defect/Blemish Correction

All NIRvana HS cameras have a defect map pre-loaded into camera NVRAM. LightField creates a Blemish Definition file to correct for any inherent defects/blemishes that have been identified on the sensor by Teledyne Princeton Instruments. If additional corrections are required, customers can manually edit this Blemish Definition File.

Defects in general are outlying pixels whose sensitivity to light is too low (dark defects) or too high (white defects). These pixels may have static behavior or vary over time (e.g. flicker) and may depend on speed or gain.



REFERENCES:

Refer to the LightField Online Help for complete information about how to modify and store the Blemish Defect File.

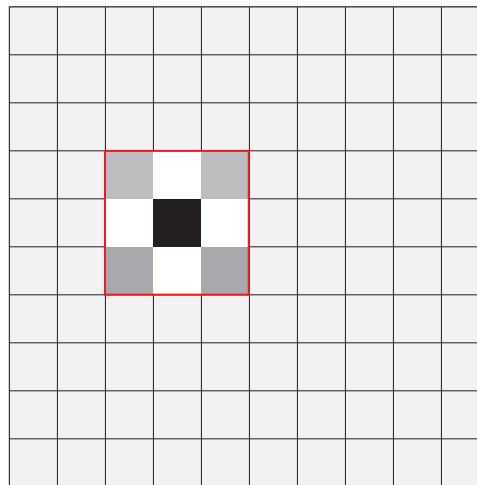
The following types of defects/blemishes are corrected:

- Row;
- Column;
- Point; and
- Cluster.

Beginning with NIRvana HS, a new geometry of sensor defect, called a Star defect, is now able to be identified and corrected.

A Star defect is a square 3 x 3 pixel region described as a white cross with a black center pixel. The four corners of the 3 x 3 matrix may be fuzzy/gray. This defect is caused by charge that cannot be absorbed by a dead pixel and ultimately spills into surrounding pixels in a star pattern. See [Figure 9-3](#) for a simplified representation of a Star defect.

Figure 9-3: Typical Star Defect (Not to Scale)



4411-0169_0063

Using a complex series of correction algorithms, LightField is able to create an accurate approximation of acquired image data for this region.

Although theoretically possible, unlike with the simpler geometric defects (e.g., row, column, etc.) Teledyne Princeton Instruments discourages the manual modification of the NIRvana HS Defect Map for any Star Defects that have not previously been identified by the factory. Contact Teledyne Princeton Instruments Customer Support for guidance if additional Star Defects must be corrected. Refer to [Contact Information](#) on page 100 for complete information.

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Chapter 10: Advanced Topics

Previous chapters discussed the configuration of hardware and software for basic operation. This chapter discusses the following topics associated with experiment synchronization:

- Shutter Control Modes;
- Trigger Response Modes;
- Output Signal Control.



NOTE:

Configuration parameters discussed in this section are found on the following expanders:

- Shutter;
- Trigger In;
- Trigger Out.

10.1 Shutter Control Modes

Shutter Control mode is configured on the Shutter expander.

Available operating modes are:

- Normal;
In this mode, the shutter opens during exposure and then closes.
- Always Closed;
When selected, the shutter will not operate during the experiment and remains in the closed position. This option is useful when making dark charge measurements.
- Always Open;
When selected, the shutter will not operate during the experiment and remains in the open position.
- Open Before Trigger
In this mode, the shutter is opened before an external trigger is received.



NOTE:

When using **Expose During Readout**, neither Normal mode nor Open Before Trigger mode is available.



REFERENCES:

Refer to [Section 10.2, Trigger Response Modes](#), on page 74 for additional information.



NOTE:

Shutter timing is included in the appropriate timing diagrams supplied in [Section 10.2, Trigger Response Modes](#).

10.2 Trigger Response Modes

NIRvana HS's Trigger Response modes for Full Frame operation are:

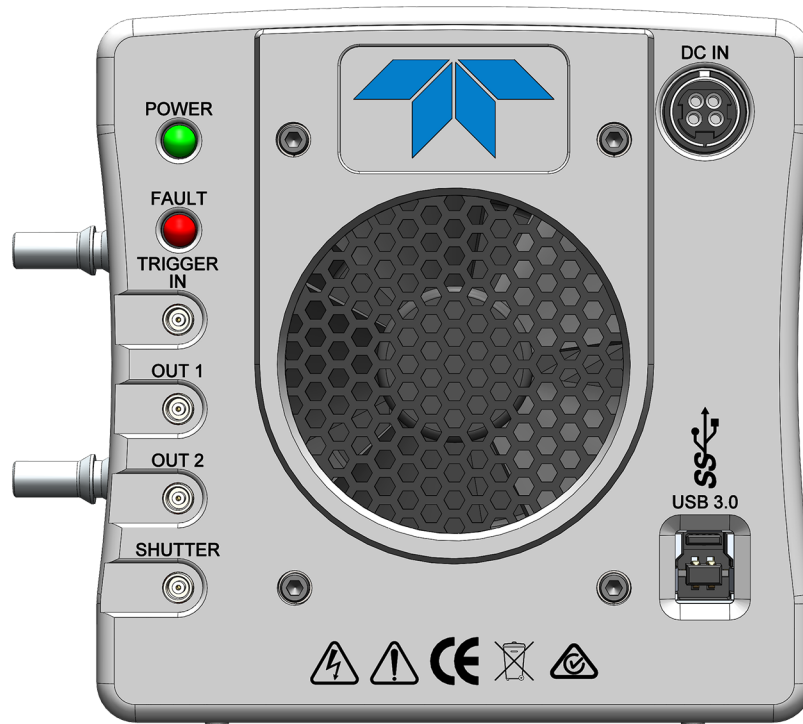
- No Response;
- Start On Single Trigger;
- Readout Per Trigger;
- Expose During Trigger Pulse.

Timing mode, when combined with the Shutter Mode options, provide the widest variety of modes for precision experiment synchronization.

10.2.1 External Trigger Input

The selected Trigger Response determines how the camera will respond to an External Sync pulse supplied to the camera by the TRIGGER IN connector on the rear of the camera. See [Figure 10-1](#).

Figure 10-1: NIRvana HS Camera: Rear Panel



Things to keep in mind when setting up the External Sync pulse input include:

- Pulse Height: 0 to +3.3 VDC logic levels (TTL-compatible.)
- Pulse Width (trigger edge frequency): The time between trigger edges.
- TRIGGER IN Connector Impedance: High impedance (~5 k Ω pull-up to +3.3 V.)
- Trigger Polarity: Rising (+) or falling (-) must be indicated on the Trigger expander.

10.2.2 No Response

In this mode, the camera ignores any external triggers and all settings are obtained from the setup parameters, making the duration of each exposure time constant and the interval times between exposures constant.



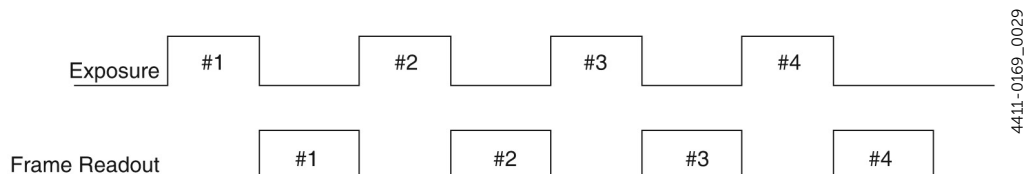
NOTE:

Open Before Trigger mode is not permitted in this triggering mode.

All other shutter modes behave the same way in this triggering mode.

See [Figure 10-2](#) for the timing diagram for this mode.

Figure 10-2: Timing Diagram: No Response Mode



10.2.3 Readout Per Trigger

In this mode, each frame within a sequence requires a trigger. Each frame is exposed for the length of time specified within the software and is then read out. If a trigger arrives during the exposure-readout cycle for the previous frame, it is ignored.

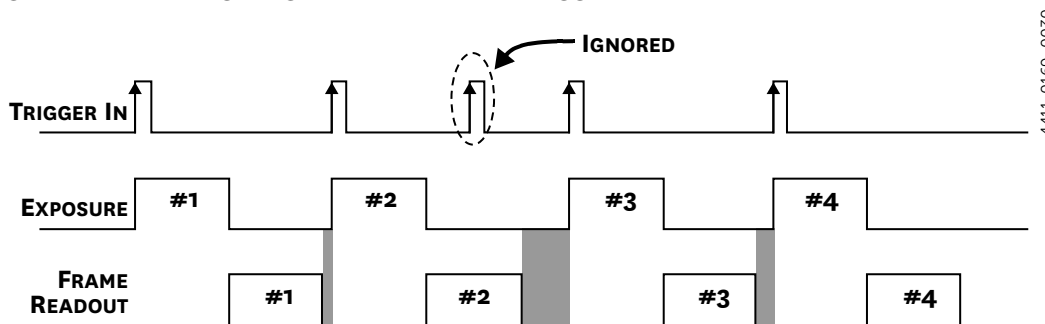


NOTE:

For sequences comprised of a single frame, Start on Single Trigger mode is equivalent to Readout Per Trigger mode.

[Figure 10-3](#) illustrates the timing diagram for this mode. Shaded areas indicate the idle time between exposures.

Figure 10-3: Timing Diagram: Readout Per Trigger



10.2.4 Expose During Trigger Pulse

When Expose During Trigger Pulse timing is selected, the camera exposure is determined by the TRIGGER IN input on the camera (see [Figure 10-1](#)) which allows an external timing generator to control the exposure time for the camera.

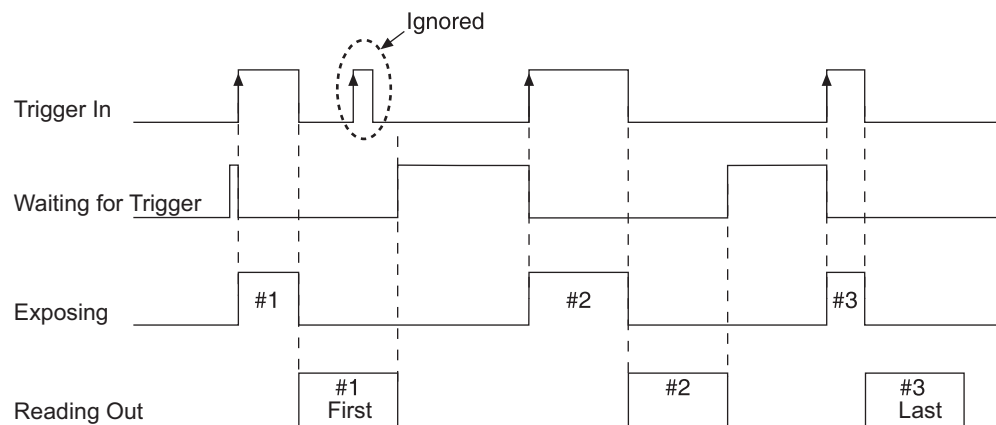
The transition from the inactive state to the active state of the input at the TRIGGER IN connector starts the exposure, while the transition from the active state to the inactive state ends the exposure.

When the camera is ready to accept input through its external trigger connector, the Waiting For Trigger (WFT) signal at the OUT 1/OUT 2 connector is high (if WFT is the selected output signal): WFT goes HIGH immediately after readout (or after Open Before Trigger if it is active). It goes LOW when an active edge (+ or – edge depending on your setting) occurs and the exposure begins.

[Figure 10-4](#) illustrates the timing diagram for Expose During Trigger Pulse mode with the following configuration settings:

- Three exposure sequence;
- No Open Before Trigger.

Figure 10-4: Timing Diagram: Expose During Trigger Pulse



4411-0169_0034

10.2.5 Start On Single Trigger

In this mode, the camera requires only one trigger to acquire a sequence of frames. Once the initial trigger has been received, the camera ignores any additional triggers until the entire exposure/readout sequence has been completed.

10.3 Output Signal Control

This section provides information about the use of the OUT1 and OUT 2 connectors on the rear of the NIRvana HS. The signals at these connectors can be used to monitor camera operation or synchronize with external equipment.

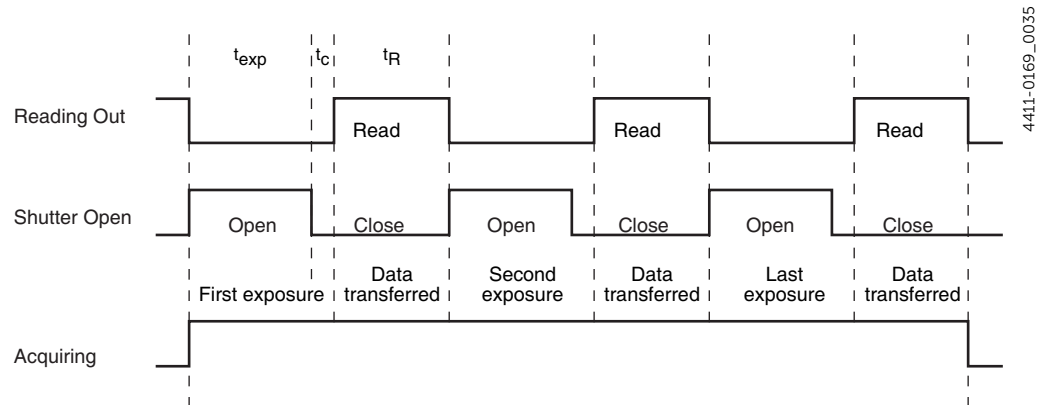
The TTL-compatible logic level output (i.e., 0 to +3.3 V_{DC}) from the OUT 1/OUT 2 connectors on the rear panel can be used to monitor camera status and control external devices. By default, the logic output level is high while the action is occurring.

The timing of the level changes depends on the output type selected on the Trigger expander.

The timing diagram shown in [Figure 10-5](#) compares timing for the following three signals:

- **Reading Out**
It is at a logic high when the sensor is being read; otherwise low.
- **Shutter Open**
This level is at a logic high when the shutter is open. The output precisely brackets shutter-open time (exclusive of shutter close delay time, t_{c1}) and can be used to control an external shutter or to inhibit a pulser or timing generator.
- **Acquiring**
Initially low, this signal goes high to mark the beginning of the first exposure. It remains high until the system is halted. If a specific number of frames have been programmed, it remains high until all have been taken and then returns low. The timing diagram in [Figure 10-5](#) assumes three frames have been programmed.

Figure 10-5: Timing Diagram: OUT 1/OUT 2 Control



Additional related signals and configuration settings include:

- **Exposing**
This level is at a logic high during the programmed exposure time (i.e., the time configured in the software.)
- **Effectively Exposing**
This level is at a logic high during the effective exposure time. This exposure time equals the read out time in Expose During Readout mode when the exposure time is less than the readout time. Otherwise, Effective Exposing and Exposing are identical.
- **Always High**
The level at the connector is high.
- **Waiting For Trigger**
This level is at a logic high when the camera is ready to acquire and is waiting for an external trigger (through the TRIGGER IN connector) before exposing the sensor. The level goes low when a trigger is detected: exposure begins. The Wait for Trigger (WFT) signal goes high immediately after readout or after Open Before Trigger (if it is active).

**NOTE:**

When the Invert Output Signal check box is checked, the output is at a logic low when the action is occurring.

Appendix A: Technical Specifications



CAUTION!

All specifications are subject to change.

This appendix provides some technical information and specifications for NIRvana HS cameras and optional accessories. Additional information may be found on data sheets available on the Teledyne Princeton Instruments website (www.princetoninstruments.com).

A.1 System Dimensions and Weight

Refer to [Table A-1](#) for system dimensions and weight.

Table A-1: General System Specifications

Dimension	Specification	
	C-Mount	Spec-Mount
Length	7.3 in [18.6 cm]	7.3 in [18.6 cm]
Width	4.5 in [11.4 cm]	4.5 in [11.4 cm]
Height	4.5 in [11.4 cm]	4.5 in [11.4 cm]
Weight	7.3 lbs [3.3 kg]	7.1 lbs [3.2 kg]

A.1.1 Vacuum Window

SI-UV fused-silica quartz (0.125"/3.17 mm thick)

A.2 Camera Specifications

Refer to [Table A-2](#) for FPA specifications for NIRvana HS detectors.

Table A-2: NIRvana HS FPA Specifications (Sheet 1 of 2)

Specification	NIRvana HS
FPA	Teledyne Princeton Instruments Proprietary
Resolution	640 x 512
Pixel Size	20 μm x 20 μm
Imaging Area	12.8 mm x 10.24 mm
Readout Amplifiers (Ports)	1
ADC Speed/16 bits	3.125 MHz, 12.5 MHz, 25 MHz

Table A-2: NIRvana HS FPA Specifications (Sheet 2 of 2)

Specification	NIRvana HS
Frame Rate	32 fps @ 3.125 MHz 129 fps @ 12.5 MHz 258 fps @ 25 MHz
Read Noise	60 e-Typical ^a
Non-linearity (High Gain)	<2% ^b
Optical Focal Distance	17.526 mm Nominal for C-mount

a. Measured with 1 μ s exposure time.

b. Linearity for exposure > 20 ms to 1 minute.

A.2.1 Thermal Characteristics

Refer to [Table A-3](#) for specific thermal information.

Table A-3: Operating Temperatures

Specification	Cooling Medium	Specification
Default Operating Temperature	Air	-50°C
	Liquid ^a	-55°C
Deepest Cooling Temperature	Air	-55°C
	Liquid ^a	-55°C
Precision	–	$\pm 0.05^\circ\text{C}$

a. External coolant circulator required.

A.3 Power Specifications

All voltages required by NIRvana HS cameras are generated and delivered by an external power supply included with each NIRvana HS camera.



WARNING!

In case of a fire or other emergency, immediately remove the power supply's line cord AC plug from the wall receptacle.



CAUTION!

Use of a power supply other than that provided with the NIRvana HS camera will void the camera warranty. For specific power supply requirements, contact Teledyne Princeton Instruments. Refer to [Contact Information](#) on page 100 for complete information.

Refer to [Table A-4](#) for power specifications for the external NIRvana HS power supplies.

Table A-4: Power Specifications

Parameter	Specification
Input Voltage	80 - 264 V _{AC}
Input Frequency	43 - 63 Hz
Output	12 V _{DC} at 11.5 A

A.4 Environmental Specifications

Refer to [Table A-5](#) for environmental specifications.

Table A-5: NIRvana HS Environmental Specifications

Parameter	Specification		
	Minimum	Nominal	Maximum
Storage Temperature	-10°C		+50°C
Operating Temperature	0°C		+35°C
Operating Ambient Relative Humidity Non-condensing	10%		95%
Operating Ambient Temperature	0°C		+35°C

A.4.1 Ventilation

Allow at least two (2) inches (50.8 mm) clearance around all vented covers.

The ambient air temperature must be less than 25°C. When operating in ambient air temperatures greater than 25°C, the sensor temperature can begin to degrade.

When the camera is operating inside an enclosure, the enclosure must have unrestricted flow to an open environment. The camera vents heat through vents near the nose, while its air intake is near the rear of the camera.

A.5 External Coolant Circulator Specifications



CAUTION!

Never set the coolant temperature below the dew point.

Refer to [Table A-6](#) for external coolant circulator specifications.

Table A-6: External Coolant Circulator Specifications

Parameter	Specification
Coolant Flow Rate @ 20°C (minimum)	2.0 liter/minute 0.55 gal/minute
Coolant Pressure (maximum)	25 psi
Minimum Heat Load	160 W

A.6 Minimum Host Computer Specifications

**NOTE:**

Computers and operating systems experience frequent updates. Therefore, the following sections are intended to provide minimum system requirements for operating a NIRvana HS camera.

A faster computer with a minimum of 16 GB memory (RAM) will greatly enhance the software performance during live mode operations.

Contact the factory to determine specific requirements.

The minimum system requirements for LightField are:

- Windows 7/8/10 (64-bit)
- 2 GHz dual core processor
- 8 GB RAM (or greater)
- CD-ROM drive
- Hard disk with a minimum of 2 GB available for installation. Additional space is required for data storage: the amount of space required depends on the number and size of images/spectra collected.
- Mouse or other pointing device.

Appendix B: Outline Drawings


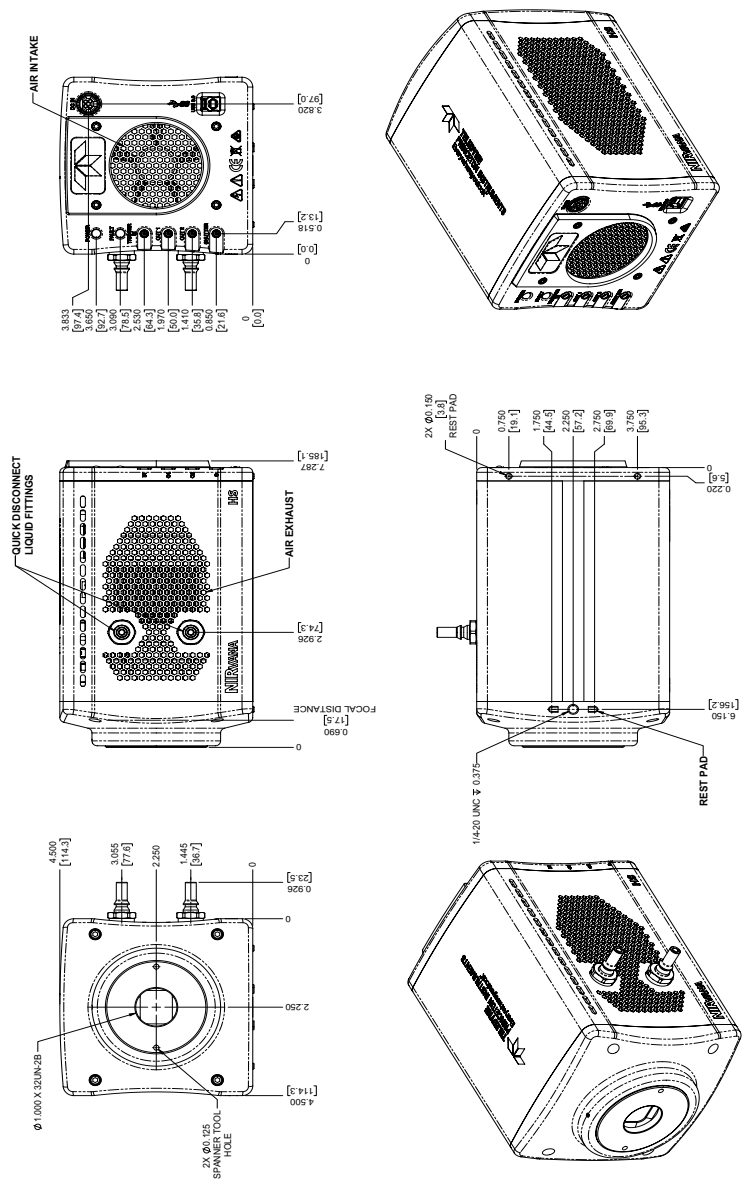
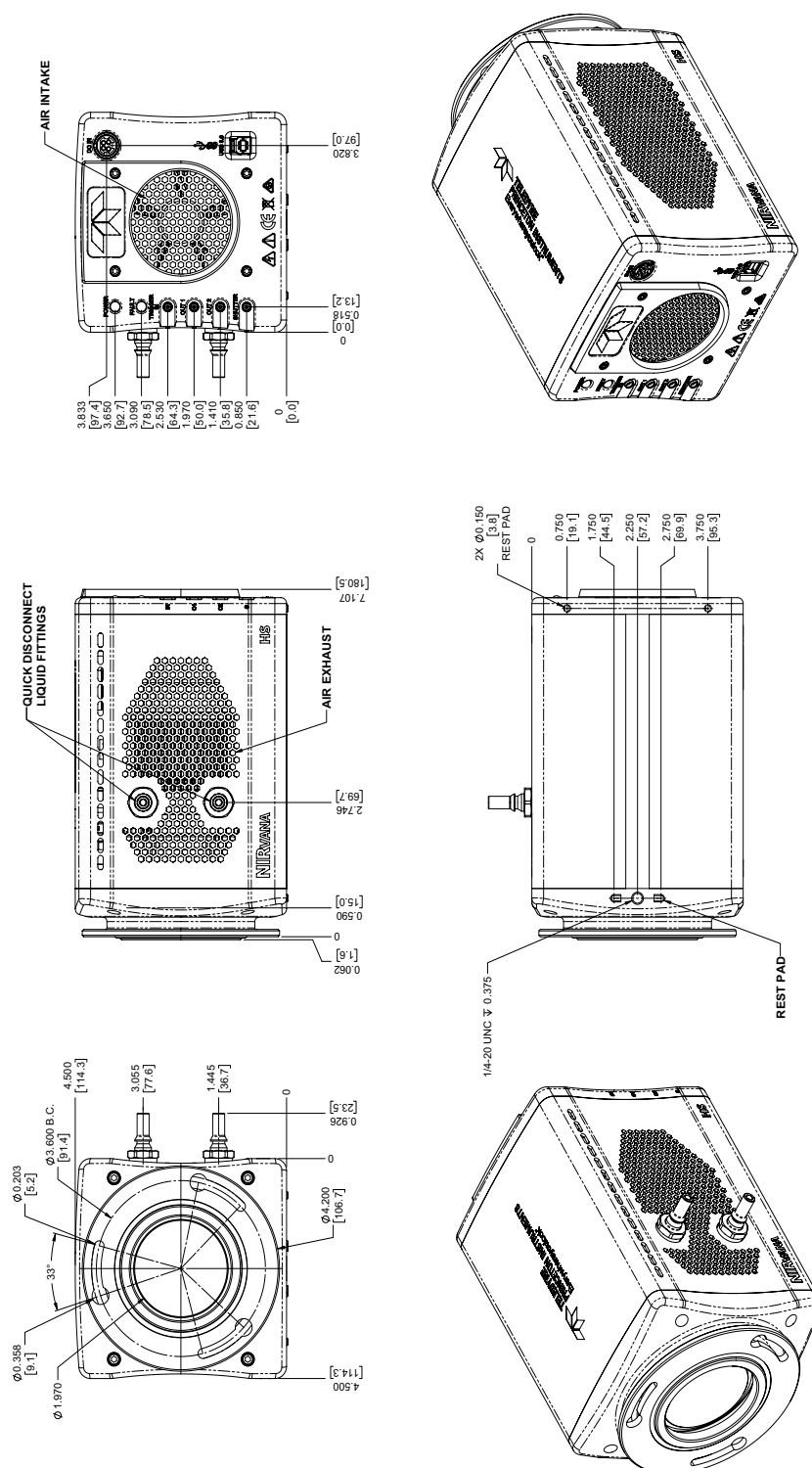
 **NOTE:** _____
All dimensions are listed in inches [mm].

Figure B-1: Outline Drawing: NIRvana HS with C-Mount



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Figure B-2: Outline Drawing: NIRvana HS with Spectroscopy-Mount



Appendix C: Optical Mount Removal and Replacement

This appendix provides the procedures to remove and replace the optical mounts for a NIRvana HS.



NOTE:

The remove and replace procedures are identical for the C- and Spectroscopy optical mounts.

The following tools are required:

- 7/64-inch Hex Drive;
- 7/64-inch Torque Drive.

Perform the following procedure to remove the installed optical mount:



WARNING!

Before proceeding with this procedure, verify that the NIRvana HS has been disconnected from all power sources as well as the host computer.



CAUTION!

Removing the optical mount from the NIRvana HS exposes static-sensitive internal components. Always perform this procedure on a grounded workstation while wearing a personal grounding strap.

1. Carefully place the NIRvana HS on a grounded workstation with the optical mount facing up and the bottom of the camera facing you.



NOTE:

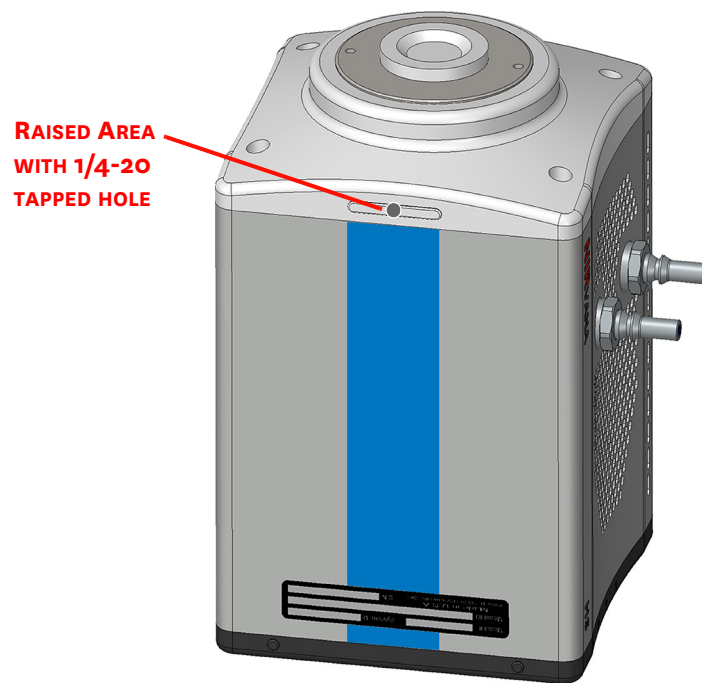
The bottom of the camera can be identified by a blue stripe running along its length, as well as the oblong raised area on the edge of the optical mount.

See [Figure C-1](#).

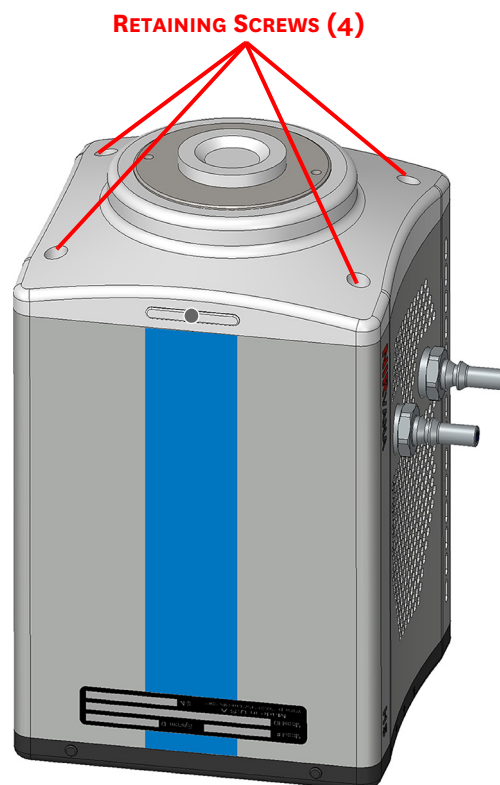


NOTE:

[Figure C-1](#) illustrates a C-Mount installed. The Spectroscopy Mount has the same raised area on it.

Figure C-1: NIRvana HS with Optical Mount Facing Up and Camera Bottom Identified

2. Use the 7/64" Hex Driver to loosen the four (4) screws securing the optical mount to the camera chassis. See [Figure C-2](#).

Figure C-2: Retaining Hardware Securing Optical Mount to Camera Chassis

3. Carefully lift the optical mount up and away from the camera chassis. Retain the four (4) sets of mounting hardware as they will be required for installing the alternate optical mount.
Each set of hardware comprises:
 - 6-32 x 0.5 hex-head screw;
 - Split Lock Washer;
 - Flat Washer.
4. Place the optical mount that has just been removed in a safe place for storage as it may need to be installed at a later time.
5. Carefully place the alternate optical mount on the camera chassis verifying that its edge with the oblong raised area faces the bottom of the camera. See [Figure C-1](#).
6. Carefully insert one set of mounting hardware into each of the four (4) mounting holes on the optical mount and use the 7/64-hex drive to hand tighten them.
7. Use the 7/64-inch Torque Driver to tighten each screw to 9 inch-pounds.

C.1 Optical Mount Reference Drawings

[Figure C-3](#) illustrates an exploded view of the Optical C-Mount.

Figure C-3: Optical C-Mount Reference Exploded View

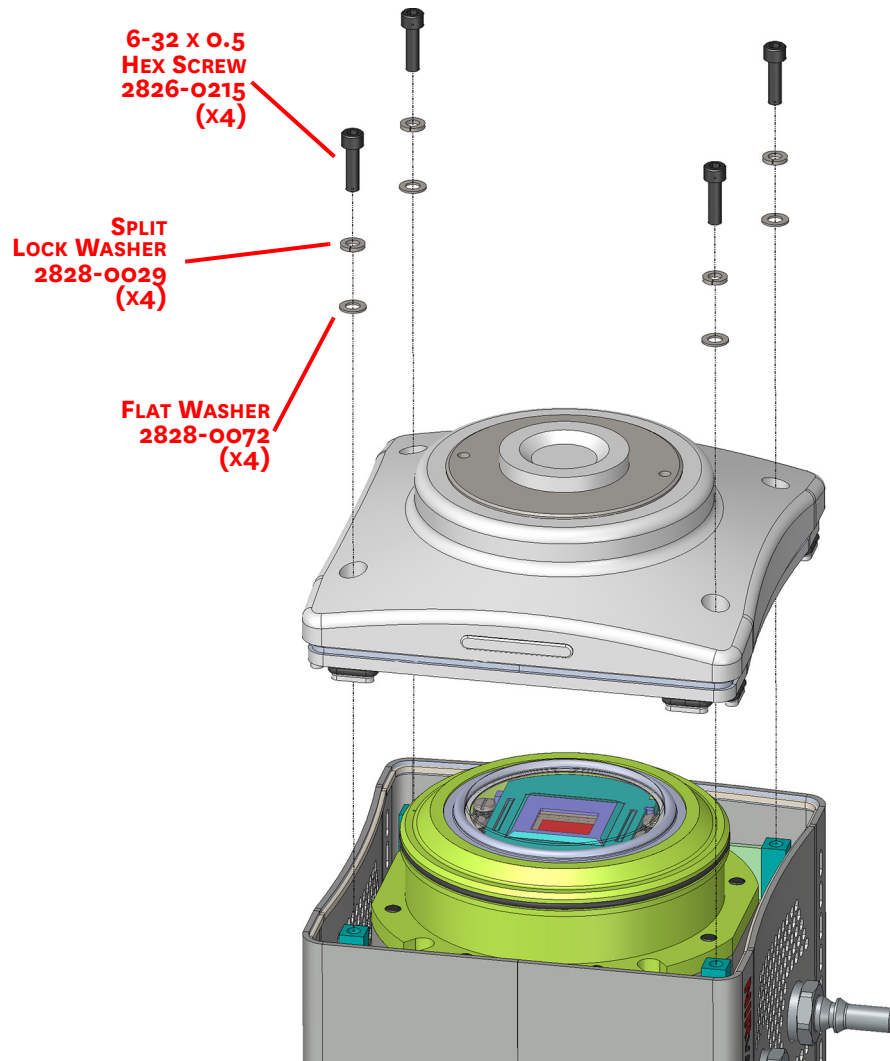
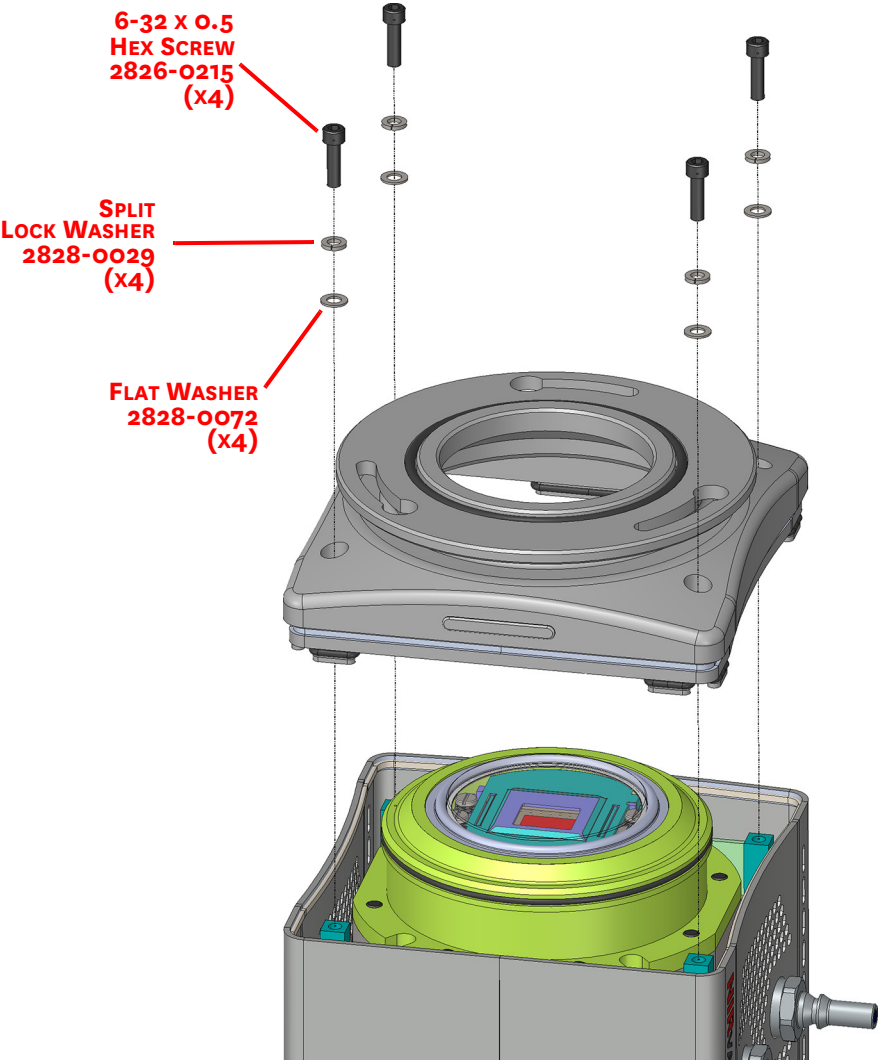


Figure C-4 illustrates an exploded view of the Optical Spectroscopy-Mount.

Figure C-4: Optical Spectroscopy-Mount Reference Exploded View

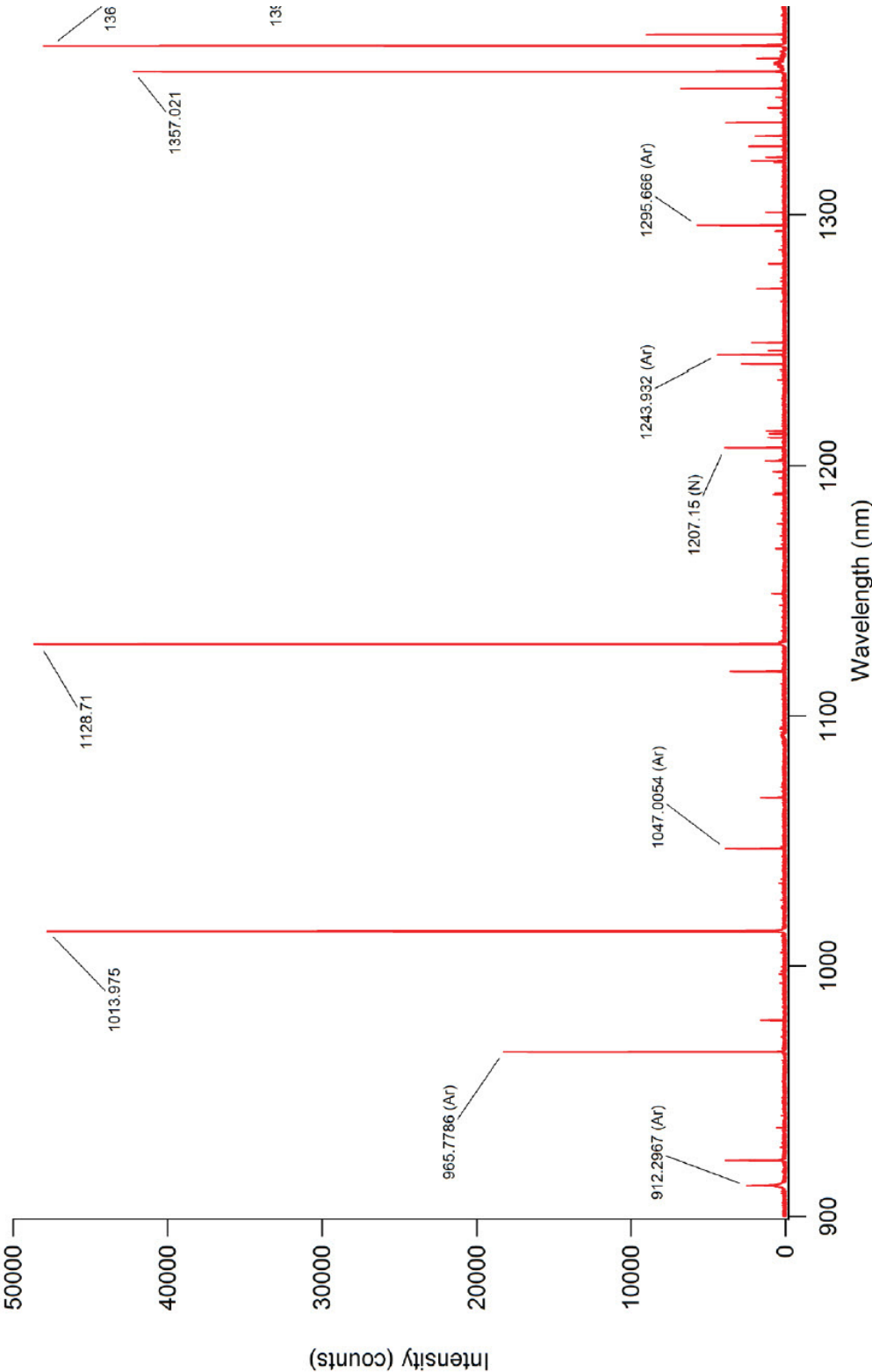


Appendix D: Calibration Charts

This appendix provides the following calibration charts for use with the NIRvana HS camera in spectroscopic applications:

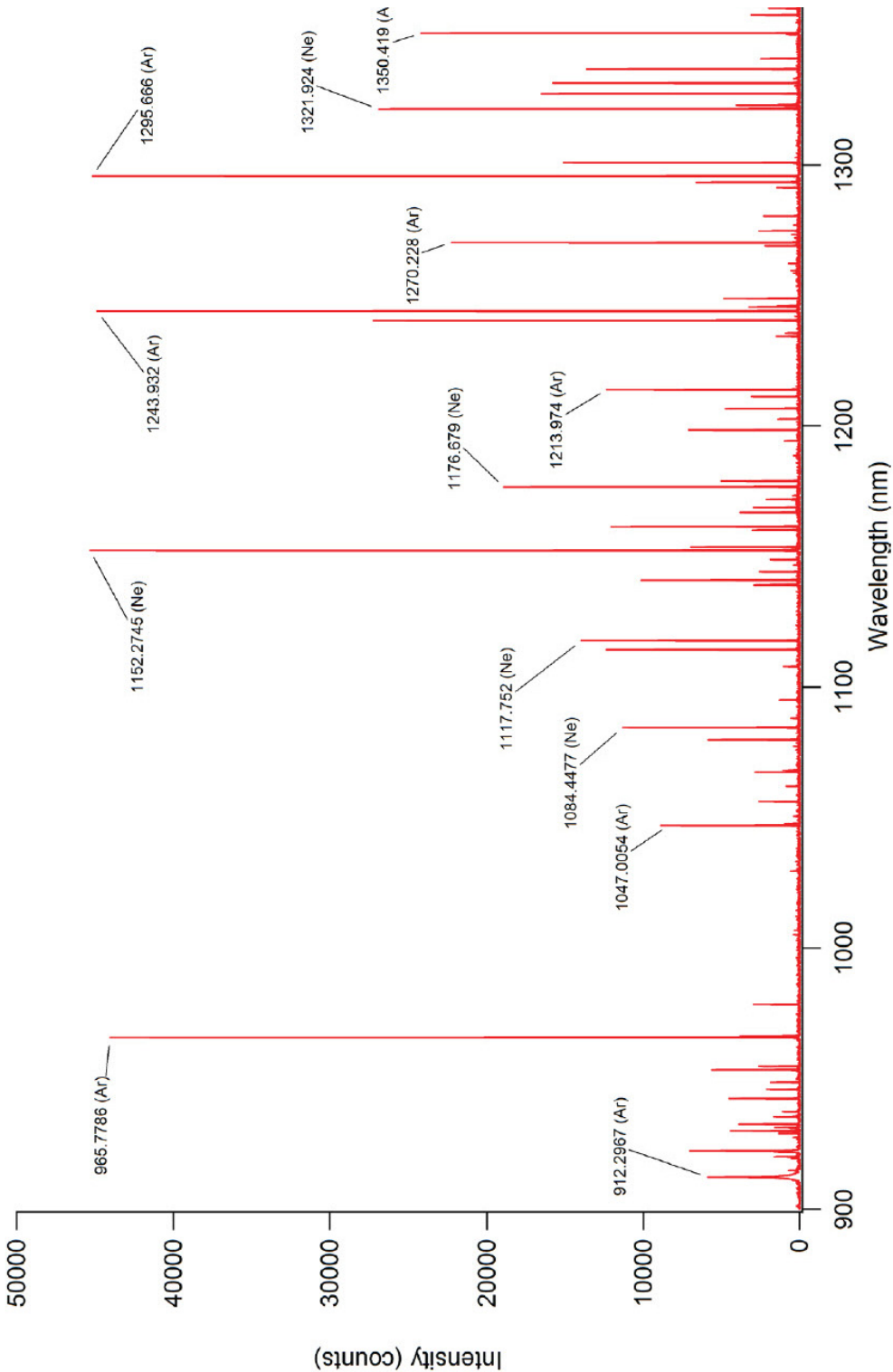
- HG Calibration Spectrum for NIRvana HS;
- Ne-Ar Calibration Spectrum for NIRvana HS.

Figure D-1: Hg Spectrum: NIRvana HS 1.7/SP-2500



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Figure D-2: Ne/Ar Spectrum: NIRvana HS 1.7/SP-2500



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Appendix E: Troubleshooting



WARNING!

Do not attach or remove any cables while the camera system is powered on.

Recommended troubleshooting guidelines are available for many issues that may occur while working with a NIRvana HS system. Refer to [Table E-1](#) for additional information.

Table E-1: Issues with Recommended Troubleshooting Guidelines

Issue	Refer to...
Baseline Signal Suddenly Changes	page 93
Camera Stops Working	page 93
External Coolant Circulator: Low Coolant (Air in the Hoses)	page 94
Temperature Lock Cannot be Achieved or Maintained	page 95
Gradual Deterioration of Cooling Capability	page 95
Device Is Not Found	page 96
TEC Fault LED Comes On	page 96

E.1 Baseline Signal Suddenly Changes

A change in the baseline signal is normal if the temperature, gain, or speed setting has been changed. If this occurs when none of these settings have been changed, there may be excessive humidity in the camera vacuum enclosure. Turn the camera off and contact Teledyne Princeton Instruments Customer Support. Refer to [Contact Information](#) on page 100 for complete contact information.

E.2 Camera Stops Working

Problems with the host computer system or software may have side effects that appear to be hardware problems. If you are sure the problem is in the camera system hardware, begin with the following simple checks:

- Turn off all AC power.
- Verify that all cables are securely fastened.
- Turn the system on.

If the system still does not respond, contact Teledyne Princeton Instruments Customer Support.

E.3 External Coolant Circulator: Low Coolant (Air in the Hoses)



WARNING!

If more than 2" [50.8 mm] of the coolant line is filled with air, the pump will stop working and may be damaged. If flow stops while the pump is on, turn off the coolant circulator and add coolant.

Perform the following procedure to troubleshoot a low coolant level:

1. Verify that the coolant circulator in question has been turned off, and its power cord removed from the AC wall receptacle.
2. Remove the reservoir cap and verify that the coolant reservoir contains coolant. If additional coolant is required, carefully add a 50:50 mixture of water and ethylene glycol until it is at the recommended level.
3. Replace the reservoir cap.
4. Verify the power switch is in the off position.
5. Plug the circulator into an appropriate 100-240 V_{AC}, 47-63 Hz power source.
6. Turn the circulator on.
7. Verify there are no leaks or air bubbles in the hoses.



NOTE:

Small air bubbles that are approximately the size of bubbles in soda are common, particularly at start up, and do not prevent proper operation.

- If there are no problems, proceed to step 8.
 - If leaks or large air bubbles/pockets are observed, turn the circulator off and attempt correct the problem(s) by securing the hoses or adding more coolant to the reservoir. Turn the circulator back on.
 - If there are no problems, proceed to step 8.
 - If the problem persists, turn off the system, and contact Teledyne Princeton Instruments Customer Support. Refer to [Contact Information](#) on page 100 for complete contact information.
8. Turn the camera on.
 9. Launch the application software.

E.4 Cooling Troubleshooting

This section provides recommended troubleshooting guidelines for cooling-related issues.

E.4.1 Temperature Lock Cannot be Achieved or Maintained

Possible causes for not being able to achieve or maintain lock include:

- Ambient temperature greater than +20°C. This condition affects TE-cooled cameras. If ambient is greater than +20°C, you will need to cool the camera environment or raise the set temperature.
- Airflow through the camera and/or circulator is obstructed. The camera needs to have approximately 2 inches (50 mm) clearance around the vented covers. If there is an enclosure involved, the enclosure needs to have unrestricted flow to an open environment. The camera vents its heat out the side vents near the nose. The air intake is at the rear of the camera.
- A hose may be kinked. Unkink the hose.
- Coolant level is low. Add coolant. Refer to [Section E.3, External Coolant Circulator: Low Coolant \(Air in the Hoses\)](#), on page 94, for additional information.
- There may be air in the hoses. Add coolant. Refer to [Section E.3, External Coolant Circulator: Low Coolant \(Air in the Hoses\)](#), on page 94, for additional information.
- The coolant circulator may not be working. If you do not hear the pump running when the circulator is powered on, turn off the circulator and contact the manufacturer's Customer Support.
- The coolant circulator is positioned higher than the camera.
Reposition the circulator so that it is a minimum of 6 inches (15 cm) below, but no more than 10 feet (3 m) below, the camera. Typically, the camera is placed at table height and the circulator is on the floor.
- The target sensor temperature is not appropriate for the particular camera and sensor.
- The camera's internal temperature may be too high, such as might occur if the operating environment is particularly warm, if you are attempting to operate at a temperature colder than the specified limit, or if you have turned off the fan and are not circulating coolant through the camera. TE cameras are equipped with a thermal-protection switch that shuts the cooler circuits down if the internal temperature exceeds a preset limit. Typically, camera operation is restored automatically in about ten minutes. Although the thermo-protection switch will protect the camera, it is nevertheless advised to power down and correct the operating conditions that caused the thermal-overload to occur.

E.4.2 Gradual Deterioration of Cooling Capability

Although unlikely with a NIRvana HS camera¹, if a gradual deterioration of the cooling capability is observed, it might be due to damaged camera vacuum. This can affect temperature performance such that it may be impossible to achieve temperature lock at the lowest temperatures. It is highly desirable to maintain the system's lowest temperature performance because lower temperatures result in lower thermal noise and better the signal-to-noise ratio. Contact the factory to make arrangements for returning the camera to the support facility.

¹. Teledyne Princeton Instruments guarantees a permanent vacuum for the life of a NIRvana HS camera.

E.5 Device Is Not Found

When LightField is launched, it looks for devices (e.g., cameras, spectrographs, and filters,) that are powered on and connected via a communications interface with the host computer. If it cannot find a device that had been used in the last experiment, it will continue to look for it.

Figure E-1 illustrates a typical error dialog displayed when LightField is unable to locate a device (e.g., a spectrograph.)

Figure E-1: Typical Load Experiment: Devices Missing Dialog



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When trying to determine the cause for the hardware's not being found,

- Verify the device is connected and powered on.
 - If LightField cannot find a spectrograph that is connected and powered on, turn the spectrograph off and back on. LightField should now find it.
- Cancel loading the experiment.

Canceling a load means that the last used experiment will not be loaded automatically when LightField opens. However, you can load the experiment after all the devices are available, you can start a new experiment design, or you can load a different experiment that matches the devices you are using.

E.6 TEC Fault LED Comes On

When cycling the power supply off and on, wait a minimum of 10 seconds before switching the supply back on. The TEC Fault LED may come on if the power supply's on/off state is switched too quickly.



NOTE:

The TEC Fault LED will also be illuminated if there is a problem with the cooling system.

Warranty and Service

Limited Warranty

Teledyne Princeton Instruments ("us," "we," "our,") makes the following limited warranties. These limited warranties extend to the original purchaser ("You," "you,") only and no other purchaser or transferee. We have complete control over all warranties and may alter or terminate any or all warranties at any time we deem necessary.

Basic Limited One (1) Year Warranty

Teledyne Princeton Instruments warrants this product against substantial defects in materials and/or workmanship for a period of up to one (1) year after shipment. During this period, Teledyne Princeton Instruments will repair the product or, at its sole option, repair or replace any defective part without charge to you. You must deliver the entire product to the Teledyne Princeton Instruments factory or, at our option, to a factory-authorized service center. You are responsible for the shipping costs to return the product. International customers should contact their local Teledyne Princeton Instruments authorized representative/distributor for repair information and assistance, or visit our technical support page at www.princetoninstruments.com.

Limited One (1) Year Warranty on Refurbished or Discontinued Products

Teledyne Princeton Instruments warrants, with the exception of the CCD imaging device (which carries NO WARRANTIES EXPRESS OR IMPLIED,) this product against defects in materials or workmanship for a period of up to one (1) year after shipment. During this period, Teledyne Princeton Instruments will repair or replace, at its sole option, any defective parts, without charge to you. You must deliver the entire product to the Teledyne Princeton Instruments factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Teledyne Princeton Instruments. International customers should contact their local Teledyne Princeton Instruments representative/distributor for repair information and assistance or visit our technical support page at www.princetoninstruments.com.

XP Vacuum Chamber Limited Lifetime Warranty

Teledyne Princeton Instruments warrants that the cooling performance of the system will meet our specifications over the lifetime of an XP style detector (has all metal seals) or Teledyne Princeton Instruments will, at its sole option, repair or replace any vacuum chamber components necessary to restore the cooling performance back to the original specifications at no cost to the original purchaser. *Any failure to "cool to spec" beyond our Basic (1) year limited warranty from date of shipment, due to a non-vacuum-related component failure (e.g., any components that are electrical/electronic) is NOT covered and carries NO WARRANTIES EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Sealed Chamber Integrity Limited 12 Month Warranty

Teledyne Princeton Instruments warrants the sealed chamber integrity of all our products for a period of twelve (12) months after shipment. If, at anytime within twelve (12) months from the date of delivery, the detector should experience a sealed chamber failure, all parts and labor needed to restore the chamber seal will be covered by us. *Open chamber products carry NO WARRANTY TO THE CCD IMAGING DEVICE, EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Vacuum Integrity Limited 12 Month Warranty

Teledyne Princeton Instruments warrants the vacuum integrity of “Non-XP” style detectors (do not have all metal seals) for a period of up to twelve (12) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twelve (12) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Image Intensifier Detector Limited One Year Warranty

All image intensifier products are inherently susceptible to Phosphor and/or Photocathode burn (physical damage) when exposed to high intensity light. Teledyne Princeton Instruments warrants, with the exception of image intensifier products that are found to have Phosphor and/or Photocathode burn damage (which carry NO WARRANTIES EXPRESSED OR IMPLIED,) all image intensifier products for a period of one (1) year after shipment. *Refer to additional Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

X-Ray Detector Limited One Year Warranty

Teledyne Princeton Instruments warrants, with the exception of CCD imaging device and fiber optic assembly damage due to X-rays (which carry NO WARRANTIES EXPRESSED OR IMPLIED,) all X-ray products for one (1) year after shipment. *Refer to additional Basic Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Software Limited Warranty

Teledyne Princeton Instruments warrants all of our manufactured software discs to be free from substantial defects in materials and/or workmanship under normal use for a period of one (1) year from shipment. Teledyne Princeton Instruments does not warrant that the function of the software will meet your requirements or that operation will be uninterrupted or error free. You assume responsibility for selecting the software to achieve your intended results and for the use and results obtained from the software. In addition, during the one (1) year limited warranty. The original purchaser is entitled to receive free version upgrades. Version upgrades supplied free of charge will be in the form of a download from the Internet. Those customers who do not have access to the Internet may obtain the version upgrades on a CDROM from our factory for an incidental shipping and handling charge. *Refer to Item 12 in [Your Responsibility](#) of this warranty for more information.*

Owner's Manual and Troubleshooting

You should read the owner's manual thoroughly before operating this product. In the unlikely event that you should encounter difficulty operating this product, the owner's manual should be consulted before contacting the Teledyne Princeton Instruments technical support staff or authorized service representative for assistance. If you have consulted the owner's manual and the problem still persists, please contact the Teledyne Princeton Instruments technical support staff or our authorized service representative. *Refer to Item 12 in [Your Responsibility](#) of this warranty for more information.*

Your Responsibility

The above Limited Warranties are subject to the following terms and conditions:

1. You must retain your bill of sale (invoice) and present it upon request for service and repairs or provide other proof of purchase satisfactory to Teledyne Princeton Instruments.
2. You must notify the Teledyne Princeton Instruments factory service center within (30) days after you have taken delivery of a product or part that you believe to be defective. With the exception of customers who claim a "technical issue" with the operation of the product or part, all invoices must be paid in full in accordance with the terms of sale. Failure to pay invoices when due may result in the interruption and/or cancellation of your one (1) year limited warranty and/or any other warranty, expressed or implied.
3. All warranty service must be made by the Teledyne Princeton Instruments factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Teledyne Princeton Instruments factory and receive a return authorization number (RMA.) Products or parts returned for service without a return authorization evidenced by an RMA will be sent back freight collect.
5. These warranties are effective only if purchased from the Teledyne Princeton Instruments factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Teledyne Princeton Instruments is not responsible for installation, setup, or disassembly at the customer's location.
7. Warranties extend only to defects in materials or workmanship as limited above and do not extend to any product or part which:
 - has been lost or discarded by you;
 - has been damaged as a result of misuse, improper installation, faulty or inadequate maintenance, or failure to follow instructions furnished by us;
 - has had serial numbers removed, altered, defaced, or rendered illegible;
 - has been subjected to improper or unauthorized repair;
 - has been damaged due to fire, flood, radiation, or other "acts of God," or other contingencies beyond the control of Teledyne Princeton Instruments; or
 - is a shutter which is a normal wear item and as such carries a onetime only replacement due to a failure within the original 1 year Manufacturer warranty.
8. After the warranty period has expired, you may contact the Teledyne Princeton Instruments factory or a Teledyne Princeton Instruments-authorized representative for repair information and/or extended warranty plans.
9. Physically damaged units or units that have been modified are not acceptable for repair in or out of warranty and will be returned as received.

10. All warranties implied by state law or non-U.S. laws, including the implied warranties of merchantability and fitness for a particular purpose, are expressly limited to the duration of the limited warranties set forth above. With the exception of any warranties implied by state law or non-U.S. laws, as hereby limited, the forgoing warranty is exclusive and in lieu of all other warranties, guarantees, agreements, and similar obligations of manufacturer or seller with respect to the repair or replacement of any parts. In no event shall Teledyne Princeton Instruments' liability exceed the cost of the repair or replacement of the defective product or part.
11. This limited warranty gives you specific legal rights and you may also have other rights that may vary from state to state and from country to country. Some states and countries do not allow limitations on how long an implied warranty lasts, when an action may be brought, or the exclusion or limitation of incidental or consequential damages, so the above provisions may not apply to you.
12. When contacting us for technical support or service assistance, please refer to the Teledyne Princeton Instruments factory of purchase, contact your authorized Teledyne Princeton Instruments representative or reseller, or visit our technical support page at www.princetoninstruments.com.

Contact Information

Teledyne Princeton Instruments' manufacturing facility for this product is located at the following address:

Teledyne Princeton Instruments
3660 Quakerbridge Road
Trenton, NJ 08619 (USA)

Tel: 1-800-899-1144 / 1-609-587-9797

Customer Support E-mail: techsupport@princetoninstruments.com

Refer to <http://www.princetoninstruments.com/support> for complete support and contact information, including:

- Up-to-date addresses and telephone numbers;
- Software downloads;
- Product manuals;
- Support topics for Teledyne Princeton Instruments' product lines.

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www.princetoninstruments.com



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Figure 2-1:	NIRvana HS Camera System: Standard Items	15
Figure 2-2:	Typical NIRvana HS Camera.	16
Figure 2-3:	NIRvana HS Rear-Panel Connectors	19
Figure 2-4:	Available Optical Adapters	22
Figure 4-1:	Typical Imaging Experiment Layout: Air-cooled Camera.	27
Figure 4-2:	Typical Spectroscopy Experiment Layout: Air-cooled Camera	27
Figure 4-3:	Typical Imaging Experiment Layout: Air/Liquid-cooled Camera	28
Figure 4-4:	Typical Spectroscopy Experiment Layout: Air/Liquid-cooled Camera	28
Figure 5-1:	Adjustable C-Mount Adapter	30
Figure 5-2:	Coolant Input/Output Port Identification	32
Figure 6-1:	Block Diagram: NIRvana HS Light Path	35
Figure 6-2:	Typical Devices Tab: Imaging Application.	37
Figure 6-3:	Typical Experiment Devices Area: Adding NIRvana HS Camera	38
Figure 6-4:	Typical Workspace: NIRvana HS Camera	38
Figure 6-5:	Typical Imaging Application Workspace: View Tab.	39
Figure 6-6:	Typical Imaging Application View Tab: Image Display	39
Figure 6-7:	Typical Devices Tab: Spectroscopy Application.	42
Figure 6-8:	Typical Experiment Devices Area: Adding NIRvana HS and Spectrograph	42
Figure 6-9:	Typical Workspace: NIRvana HS Camera with Spectrograph	43
Figure 6-10:	Typical Spectroscopy Application Workspace: View Tab	45
Figure 6-11:	Experiment Options ► Align Spectrometer Selection.	46
Figure 6-12:	Align Spectrometer: Pre-Rotational Alignment	46
Figure 6-13:	Align Spectrometer: Post-Rotational Alignment	47
Figure 8-1:	Typical Readout Expander	53
Figure 8-2:	Typical Analog to Digital Conversion Expander	54
Figure 8-3:	Timing Diagram: Full Frame Readout, $t_{exp} > t_{ro}$	55
Figure 8-4:	Timing Diagram: Expose During Readout, $t_{exp} \geq t_{ro}$	56
Figure 8-5:	Timing Diagram: Frame Transfer Readout, $t_{exp} < t_{ro}$	57
Figure 8-6:	Vertically Stacked ROIs with Small Vertical Gap	61
Figure 8-7:	Vertically Stacked ROIs with Large Vertical Gap	61
Figure 8-8:	Horizontally Aligned ROIs with Large Horizontal Gap	62
Figure 8-9:	Vertically Aligned ROIs with Small Horizontal Gap	62
Figure 8-10:	Vertically Aligned Mid-Sensor ROIs with Large Horizontal Gap	63
Figure 8-11:	Vertically Offset ROIs with Large Horizontal Gap, Overlapping Rows.	63
Figure 8-12:	Vertically Offset ROIs with Large Horizontal Gap, No Vertical Gap or Row Overlap	64
Figure 8-13:	Vertically Offset ROIs with Large Horizontal Gap, 4 Row Vertical Gap	64
Figure 8-14:	Three ROIs with Horizontal Gaps and Overlapping Rows	65
Figure 8-15:	Excessive Number of Small Regions of Interest	65
Figure 8-16:	Typical Analog to Digital Conversion Expander	67
Figure 9-1:	Typical Online Corrections Expander: Background Subtraction	70
Figure 9-2:	Typical Online Corrections Expander: Flatfield Correction	70
Figure 9-3:	Typical Star Defect (Not to Scale)	71
Figure 10-1:	NIRvana HS Camera: Rear Panel	74
Figure 10-2:	Timing Diagram: No Response Mode.	75
Figure 10-3:	Timing Diagram: Readout Per Trigger	75
Figure 10-4:	Timing Diagram: Expose During Trigger Pulse.	76
Figure 10-5:	Timing Diagram: OUT 1/OUT 2 Control	77
Figure B-1:	Outline Drawing: NIRvana HS with C-Mount.	83
Figure B-2:	Outline Drawing: NIRvana HS with Spectroscopy-Mount	84

Figure C-1:	NIRvana HS with Optical Mount Facing Up and Camera Bottom Identified 86	
Figure C-2:	Retaining Hardware Securing Optical Mount to Camera Chassis . . .	86
Figure C-3:	Optical C-Mount Reference Exploded View	87
Figure C-4:	Optical Spectroscopy-Mount Reference Exploded View	88
Figure D-1:	Hg Spectrum: NIRvana HS 1.7/SP-2500	90
Figure D-2:	Ne/Ar Spectrum: NIRvana HS 1.7/SP-2500	91
Figure E-1:	Typical Load Experiment: Devices Missing Dialog	96

Table 1-1:	Related Documentation	11
Table 2-1:	NIRvana HS Rear-Panel Connectors	19
Table 2-2:	Standard NIRvana HS Camera System Cables	21
Table 8-1:	Full Frame Readout vs. Expose During Readout Frame Rate Comparison	
	58	
Table A-1:	General System Specifications	79
Table A-2:	NIRvana HS FPA Specifications	79
Table A-3:	Operating Temperatures	80
Table A-4:	Power Specifications	81
Table A-5:	NIRvana HS Environmental Specifications	81
Table A-6:	External Coolant Circulator Specifications	81
Table E-1:	Issues with Recommended Troubleshooting Guidelines	93

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