



X-Series Science Camera

User's Manual



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1 Revision History

Version	Date	Initials	Changes
A	07/09/2019	AAR	Initial Release
B	01/06/2020	AAR	Correction to Aux cable pinout, 1308 gain states
C	12/17/2020	MGH	Updated with FRS Screenshots
D	09/13/2021	MGH	Added cables to camera system components list
E	11/10/2021	RIM	Added info regarding RS-232 interface. Updated export markings.
F	01/26/2022	RIM	Updated for X8580 & X6980
G	06/30/2023	RAW	Updated Pixel Operability Spec. Updated Record input description.
H	10/31/2023	RIM	Updated SSD section to clarify drive format is not directly viewable in Windows

2 Introduction

Thank you for choosing a FLIR X-series science camera! The X-series cameras are some of the fastest commercial infrared cameras in the world, and they were designed with the high-end infrared camera user in mind.

2.1 Camera System Components

The Cooled X-series infrared camera and its accessories are delivered in a box which typically contains the items below. There may also be additional items that you have ordered such as lenses, software, CDs, etc.

Description	FLIR Part Number
X6800sc Camera	29420-2xx (InSb)
X69xx/X6980 Camera	29267-2xx (InSb) or 29421-2xx (SLS)
X85xx/X8580 Camera	29422-2xx (InSb) or 29428-2xx (SLS)
Power supply, 24V, 4A	4227599
Gigabit Ethernet Cat-6 cable, 2m length	24277-000
AUX Breakout Cable	4212860
Bayonet mount plug	4142249
Micro USB Cable 6ft	4142225
BNC Cable 3M	26393-000
Laboratory calibration plate	261-0005-00
500GB SSD	4142223
SSD to USB cable	4142222
Filter wheel wrench	4239528
HDMI video cable, 6-ft	4142224
Water-resistant transit case	24043-005

2.2 Camera Models

The X-series is a camera family. There are several different models, ensuring a wide variety of customer needs can be met. The X6800-series cameras are a slower, less expensive version of the X69XX-series series. The X69XX-series cameras are 640x512 cameras built for very high frame rates. The X85XX-series cameras have an HD 1280x1024 focal plane array.

Model	Description	FLIR Part Number
X6800sc	<ul style="list-style-type: none"> f/2.5 Broadband (InSb: 1.5-5μm response) 	29420-200
X6801sc	<ul style="list-style-type: none"> f/2.5 InSb: 3-5μm response 	29420-201
X6802sc	<ul style="list-style-type: none"> f/4.1 Broadband (InSb: 1.5-5μm response) 	29420-202
X6803sc	<ul style="list-style-type: none"> f/4.1 InSb: 3-5μm response 	29420-203
X69xx	<ul style="list-style-type: none"> f/2.5 Broadband (InSb: 1.5-5μm response) Broadband (SLS: 3-12μm response)* 	29267-200 29421-200
X6901sc	<ul style="list-style-type: none"> f/2.5 InSb: 3-5μm response SLS: 7.5-12μm response* 	29267-201 29421-201
X6902sc	<ul style="list-style-type: none"> f/4.1 Broadband (InSb: 1.5-5μm response) Broadband (SLS: 3-12μm passband)* 	29267-202 29421-202
X6903sc	<ul style="list-style-type: none"> f/4.1 InSb: 3-5μm response SLS: 7.5-12μm response* 	29267-203 29421-203
X6980	<ul style="list-style-type: none"> f/2.5 Manual or Motorized lenses Broadband (InSb: 1.5-5μm response) Broadband (SLS: 3-12μm response)* 	29267-280 29421-280
X6981	<ul style="list-style-type: none"> f/2.5 Manual or Motorized lenses InSb: 3-5μm response SLS: 7.5-12μm response* 	29267-281 29421-281

Model	Description	FLIR Part Number
X6982	<ul style="list-style-type: none"> f/4.1 Manual or Motorized lenses Broadband (InSb: 1.5-5μm response) Broadband (SLS: 3-12μm passband)* 	29267-282 29421-282
X6983	<ul style="list-style-type: none"> f/4.1 Manual or Motorized lenses InSb: 3-5μm response SLS: 7.5-12μm response* 	29267-283 29421-283
X85xx	<ul style="list-style-type: none"> f/2.5 Broadband (InSb: 1.5-5μm response) Broadband (SLS: 3-12μm response)* 	29422-200 29428-200
X8501sc	<ul style="list-style-type: none"> f/2.5 InSb: 3-5μm response SLS: 7.5-12μm response* 	29422-201 29428-201
X8502sc	<ul style="list-style-type: none"> f/4 Broadband (InSb: 1.5-5μm response) Broadband (SLS: 3-12μm passband)* 	29422-202 29428-202
X8503sc	<ul style="list-style-type: none"> f/4 InSb: 3-5μm response SLS: 7.5-12μm response* 	29422-203 29428-203
X8580	<ul style="list-style-type: none"> f/2.5 Manual or Motorized lenses Broadband (InSb: 1.5-5μm response) Broadband (SLS: 3-12μm response)* 	29422-280 29428-280
X8581	<ul style="list-style-type: none"> f/2.5 Manual or Motorized lenses InSb: 3-5μm response SLS: 7.5-12μm response* 	29422-281 29428-281
X8582	<ul style="list-style-type: none"> f/4 Manual or Motorized lenses Broadband (InSb: 1.5-5μm response) Broadband (SLS: 3-12μm passband)* 	29422-282 29428-282
X8583	<ul style="list-style-type: none"> f/4 Manual or motorized lenses InSb: 3-5μm response SLS: 7.5-12μm response* 	29422-283 29428-283
*NOTE: SLS upper cutoff tolerance is +/- 0.5 μ m		

2.3 System Overview

The X-Series infrared camera systems have been developed by FLIR to meet the needs of the research, industrial and range phenomenology communities.

The X85xx camera makes use of FLIR's advanced ISC1308 readout integrated circuit (ROIC), mated to an Indium Antimonide (InSb) detector to cover the shortwave and midwave infrared bands and a Type II Strained-Layer Superlattice (SLS) for longwave IR operation. The X68xx and X69xx cameras use the ISC0804 ROIC.

The X85xx camera utilizes an HD format, 1280x1024 array with 12 μ m pixel pitch. The X68xx and X69xx cameras use a large format, 640x512 array with 25 μ m pixels. The architectures of the camera systems fully exploit a rich palette of features available in both the 0804 and 1308 ROICs to support the specialized needs of high-end research.

The X-Series is a stand-alone imaging camera that interfaces to host PCs using standard interfaces, including Gigabit Ethernet, Camera Link®, and CoaXpress (CXP). The X-Series cameras are all GenICam compliant. The FLIR Science Camera SDK is also available, which makes it possible for the system designer to write their own camera controller and acquire image data with their own custom application.

2.4 Key features of the X-Series science cameras

Improved Linearity to Zero Well-Fill

Typical direct injection ROIC designs exhibit a non-linear response when the signal drops below 10% of well-fill. Both the ISC0804 and ISC1308 ROICs provides linear response even at very low signal levels. This results in an increased linear dynamic range, much better NUC performance at low signal levels and it makes it easier to perform a user calibration of the camera.

Fast Frame Rates

The X69xx and X85xx cameras feature fast pixel clocks: 355 Megapixels per second, which enable the X69XX camera to output 1000 frames per second at 640x512, and the X85xx camera to output >180 frames per second at a frame size of 1280x1024 pixels. The X68xx series frame rate is limited to approximately half the X69xx frame rate, but it has the same 355 Megapixels per second pixel clock speed.

14-Bit Digital Image Data

The X-Series camera systems are all built around high-performance 14-bit A/D converters, preserving the full dynamic range of the FPA.

Windowing Capability

Higher frame rates are available by windowing down at the Focal Plane Array (FPA) level. Semi-arbitrary size and location of windows are available, limited only by the intrinsic characteristics of the readout.

Presets

Up to four presets and their associated parameters such as integration time, frame rate, window size and window location are available for instant selection with a single command. These presets can be used in either Superframing or Preset Sequencing modes.

Factory Calibrations

Most variants of the X-Series cameras can be purchased with radiometric calibrations that are performed in the calibration laboratory in Niceville, Florida using NIST-traceable calibration sources. The calibrations translate the raw digital data from the sensor into radiometric images that can be interpreted by software into radiance and temperature images. These factory radiometric calibrations are stored inside the camera electronics and are linked to high-quality stored factory NUCs. The radiometric calibrations have temperature drift correction built in that utilizes various temperature sensors inside the camera body and on the lens interface to compensate for changes in the optics self-radiation levels caused by changes in the camera and optics temperatures.

Independently Adjustable Frame Rates

Frame rate is user selectable from 0.0015 Hz (X68xx/X69xx) or 0.5Hz (X85xx) up to the maximum allowed for the selected window size.

Multiple Triggering Modes and Synchronizing Interfaces

The X-Series cameras provide different interfaces to support maximum flexibility for synchronizing the camera to external events, as well as synchronizing external events to the camera.

- Sync In (TTL)
- Built-in IRIG timing decoder (not in X68xx series)
- Tri-Level Sync (not in X68xx series)
- Sync Out

Adjustable Digital Gains and Offsets

The X-Series cameras allow the user to adjust digital gains and offsets per preset, making it possible to map only the linear portion of the FPA to the full range of digital count values.

Multiple Control Options

The X-Series cameras can be controlled with the supplied control module within Research Studio, using the optional Science Camera SDK or with a third-party toolkit that supports GenICam. The following ports can be used for controlling the X69xx and X85xx-series cameras:

- Gigabit Ethernet port (GenICam)
- Camera Link® serial port (GenCP)
- CoaXpress (GenICam)
- USB-2 port
- Traditional RS-232 asynchronous serial port (GenCP)

The X68xx camera supports:

- Gigabit Ethernet port (GenICam)
- Camera Link® serial port (GenCP)
- USB-2 port
- Traditional RS-232 asynchronous serial port (GenCP)

Multiple Video Outputs

The X69xx and X85xx cameras feature multiple independent and simultaneous video outputs:

- Digital Data – Camera Link® Full
- Digital Data – Gigabit Ethernet
- Digital Data – CoaXpress (v1.1)
- Digital Video – SDI (1080p, 720p, 576i, 480i)
- Digital Video – HDMI (1080p or 720p)
- Analog Video – Composite video (NTSC or PAL). (N/A X6980/X8580-series)

The X6800 cameras have the following video outputs:

- Digital Data – Camera Link® Full
- Digital Data – Gigabit Ethernet
- Digital Video – HDMI (1080p or 720p)

Support for Camera Link Full or CoaXpress interfaces

The X69XX and X85XX cameras are the first commercial IR cameras to offer both Camera Link Full and CoaXpress (CXP) interfaces on the same camera. Both interfaces are simultaneously active.

The X6800 series has the Camera Link interface, but not CoaXpress.

Video Color Palettes

The X-Series cameras support a selection of standard and user-defined color palettes for the analog video and SDI outputs.

X6800 only has HDMI output.

Video Overlay

X69XX and X85XX: A configurable video overlay provides the user with IRIG time and camera status symbology on the analog video without needing to use the GUI.

X6800: A configurable video overlay provides the user with camera status symbology on the HDMI video output without needing to use the GUI.

Ruggedized Construction

The X-Series cameras are packaged in semi-sealed enclosures with integral forced air heat exchangers.

Digital Detail Enhancement (DDE)

DDE is an analog video AGC mode that provides a significant improvement to scene detail and contrast.

On-Camera NUCs with Auto Update

NUCs can be stored in camera memory and can be applied independently to the various digital and video outputs. The camera can be configured to automatically update the NUC using the internal flag based on a change of an internal temperature sensor and/or a timer.

IRIG Time Stamp (TSPI Accurate)

The X69XX and X85XX cameras can automatically sync to a standard IRIG-B analog time signal. The time stamp jitter is less than 10 microseconds. The time is encoded in the digital image header and can also be displayed on the analog video overlay.

The X6800 camera does not support an IRIG-B input.

4-position filter wheel

The X-Series cameras have internal motorized filter wheels that can position a warm filter between the lens and detector. The filters can be installed by the user and the filter holders support automatic identification.

Motorized Lens Interface [X6980/X8580 series only]

The FLIR Precision Optics – Motorized (FPO-M) lens interface is compatible with all manual and motorized lenses in the FPO optics family.

On-board recording with Solid State Drive (SSD) storage

The X-Series cameras have on-board 16GB RAM buffers that can record at any supported frame rate with zero dropped frames. Data in the RAM buffer can be played back over any digital data or video interface or can be stored to the internal SSD drive.

The SSD system uses standard commercial SATA SSDs used in PCs and laptops. The SSD is easily removed from the camera. The SSD can then be connected to the PC using a standard USB/2.5" drive SATA cable (provided). The drive data can be accessed using the provided Research Studio software.

X69XX and X85XX cameras running the latest X-series firmware have these additional capabilities:

- **Data Download:** Data stored in the RAM or SSD can also be downloaded directly to the PC over GigE, CameraLink or CXP using Research Studio or the Science Camera SDK.
- **Direct-to-SSD Recording:** X85XX can support full frame rate recording at full resolution. X69XX can support up to 800Hz recording at full resolution.

3 Warnings and Cautions

For best results and user safety, the following warnings and precautions should be followed when handling and operating the camera.

Warnings and Cautions:

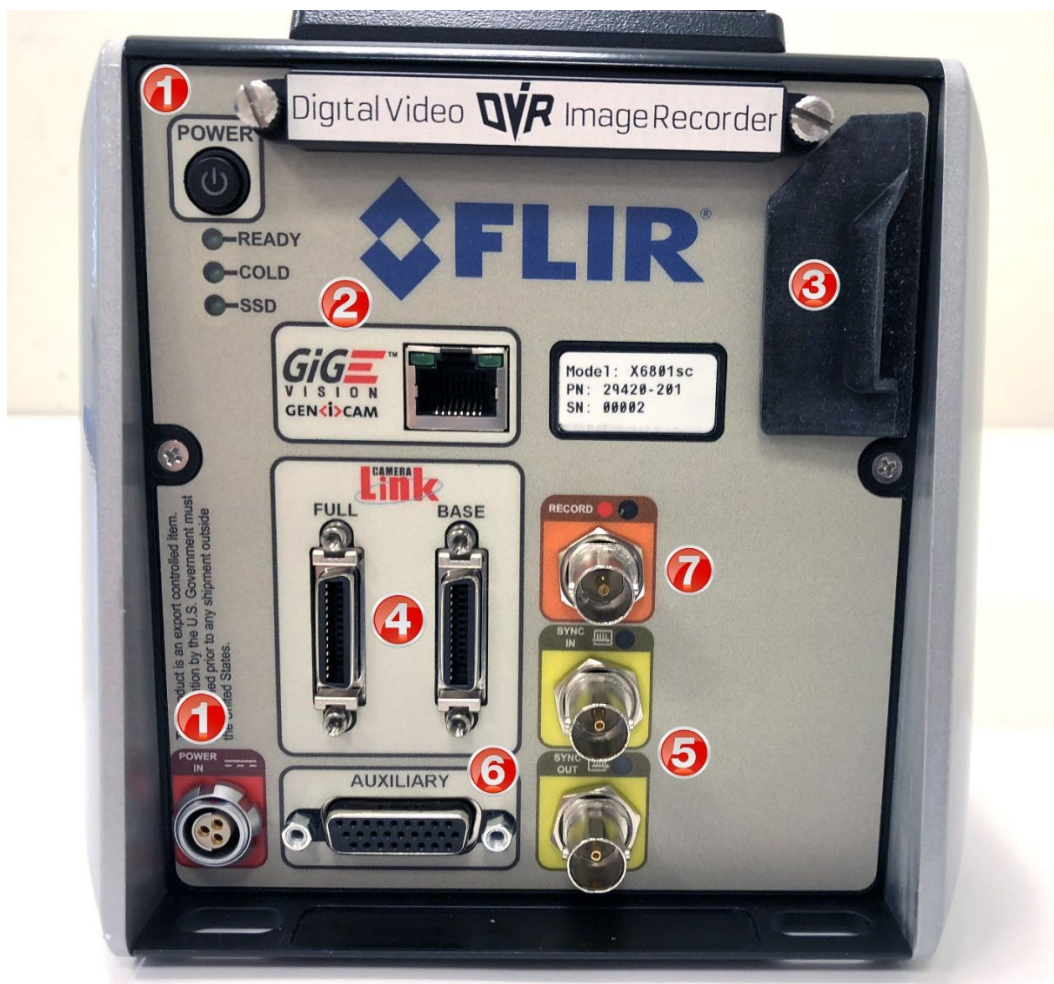
- **Do not open the camera body for any reason. Disassembly of the camera (including removal of the cover) can cause permanent damage and will void the warranty.**
- **Great care should be exercised with your camera optics. Refer to Chapter 9 for lens cleaning.**
- **Operating the camera outside of the specified input voltage range or the specified operating temperature range can cause permanent damage.**
- **The camera is not completely sealed. Avoid exposure to dust and moisture and replace the lens cap when not in use.**
- **Do not image extremely high intensity radiation sources, such as the sun, lasers, arc welders, etc.**
- **The camera contains static-sensitive electronics and should be handled appropriately. Refer to Section 8.8 for detailed environmental requirements.**

4 Installation

4.1 Basic Connections

All connections to the X-series cameras are located on the Back Panel. Although the X69XX and X85XX cameras have a large number of connections, only a small number are required for basic operation. The X6800 is a simplified version of the X69XX camera with fewer connections.

The X6800 series rear panel connections:



Item	Category	Description
1	Power	<p>Power button. DC power connector.</p> <p>Plug in the AC power supply to a standard outlet. The power supply is compatible with 120V/60Hz and 240V50Hz AC power. Plug adapters can be used for different regions. Connect the DC power cable between the power supply and the power connector located on the rear panel of the X6800sc camera. Turn on the camera by pressing the power button on the rear panel. The button will illuminate to indicate that the unit is ON.</p>
2	Digital Data	<p>Gigabit Ethernet</p> <p>The X6800sc has a Gigabit Ethernet interface that is GigE Vision compliant. Use a regular CAT5e or CAT6 Ethernet patch cable. If a crossover cable is used, the camera interface will automatically detect and configure itself to work with this kind of cable. The GigE interface is not capable of handling the full data rate of the camera. It can handle about 125Hz at full resolution.</p>
3	Video/USB	HDMI video output, USB-2 port and microSD card slot (not yet implemented)
4	Digital Data	<p>Camera Link Full</p> <p>The X6800sc has an industry standard Camera Link Full interface using MDR connectors. This interface can handle the full data rate of the camera.</p>
5	Sync	Sync input and output connectors
6	Auxiliary	This is the Auxiliary connector which is described in Section 6.2.10.
7	Record	This record input will trigger the recording to the internal RAM buffer in the camera. The input can be a contact closure or a rising-edge TTL pulse.

X69XX/X85XX Rear panel



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2	Digital Data	<p>Gigabit Ethernet</p> <p>The X-Series cameras have a Gigabit Ethernet interface that is GigE Vision compliant. Use a regular CAT5e, CAT6 or CAT7 Ethernet patch cable. If a crossover cable is used, the camera interface will automatically detect and configure itself to work with this kind of cable. The GigE interface is not capable of handling the full data rate of the camera. The interface can handle about 30Hz at the X85XX camera's full resolution and about 125Hz with the X69XX/X6800 cameras, but results may vary depending on the host computer.</p>
3	Video	HDMI, HD-SDI, Composite (NTSC/PAL)
4	Digital Data	<p>Camera Link Full</p> <p>The X-Series cameras have an industry standard Camera Link Full interface using MDR connectors. This interface can handle the full data rate of any of the cameras.</p>
5	Digital Data	<p>CoaXPress</p> <p>The X85xx and X69xx cameras use dual 5Gbps links with BNC connectors. This interface can handle the full data rate of the cameras.</p>
6	Auxiliary	This is the Auxiliary connector which is described in Section 6.2.10.

X6980/X8580 Rear Panel connections



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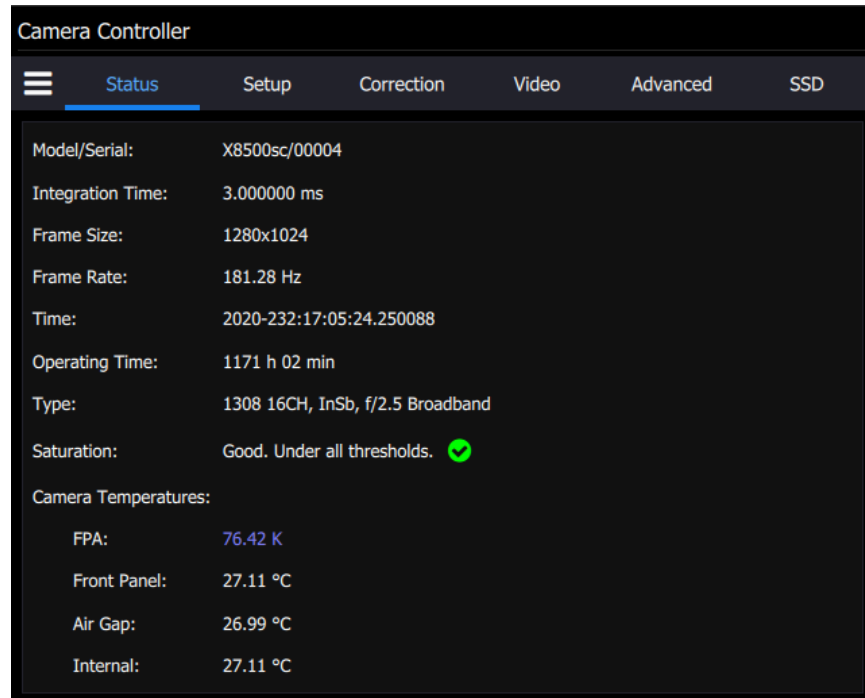
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1	Power	<p>Power button. DC power connector.</p> <p>Plug in the AC power supply to a standard outlet. The power supply is compatible with 120V/60Hz and 240V50Hz AC power. Plug adapters can be used for different regions. Connect the DC power cable between the power supply and the power connector located on the rear panel of the X-series camera. Turn on the camera by pressing the power button on the rear panel. The button will illuminate to indicate that the unit is ON.</p>
2	Digital Data	<p>Gigabit Ethernet</p> <p>The X-Series cameras have a Gigabit Ethernet interface that is GigE Vision compliant. Use a regular CAT5e, CAT6 or CAT7 Ethernet patch cable. If a crossover cable is used, the camera interface will automatically detect and configure itself to work with this kind of cable. The GigE interface is not capable of handling the full data rate of the camera. The interface can handle about 30Hz at the X85XX camera's full resolution and about 125Hz with the X69XX/X6800 cameras, but results may vary depending on the host computer.</p>
3	Video	HDMI, SDI
4	Digital Data	<p>Camera Link Full</p> <p>The X-Series cameras have an industry standard Camera Link Full interface using MDR connectors. This interface can handle the full data rate of any of the cameras.</p>
5	Digital Data	<p>CoaXPress</p> <p>The X85xx and X69xx cameras use dual 5Gbps links with BNC connectors. This interface can handle the full data rate of the cameras.</p>
6	Auxiliary	This is the Auxiliary connector which is described in Section 6.2.10.

5 X-Series Camera Controller

The camera controller in FLIR Research Studio software has a top ribbon composed of a “hamburger button” and six control group tabs:



When the camera is in Superframing mode, the total **range** of integration times are shown:

Camera Controller						
	Status	Setup	Correction	Video	Advanced	SSD
Model/Serial:	X8500sc/00004					
Integration Time:	0.500000 to 3.000000 ms					
Frame Size:	1280x1024					
Frame Rate:	1.78 Hz (Superframe)					
Time:	2020-232:17:11:19.512694					
Operating Time:	1171 h 07 min					
Type:	1308 16CH, InSb, f/2.5 Broadband					
Saturation:	Good. Under all thresholds. ✔					
Camera Temperatures:						
FPA:	76.43 K					
Front Panel:	29.31 °C					
Air Gap:	29.39 °C					
Internal:	29.31 °C					

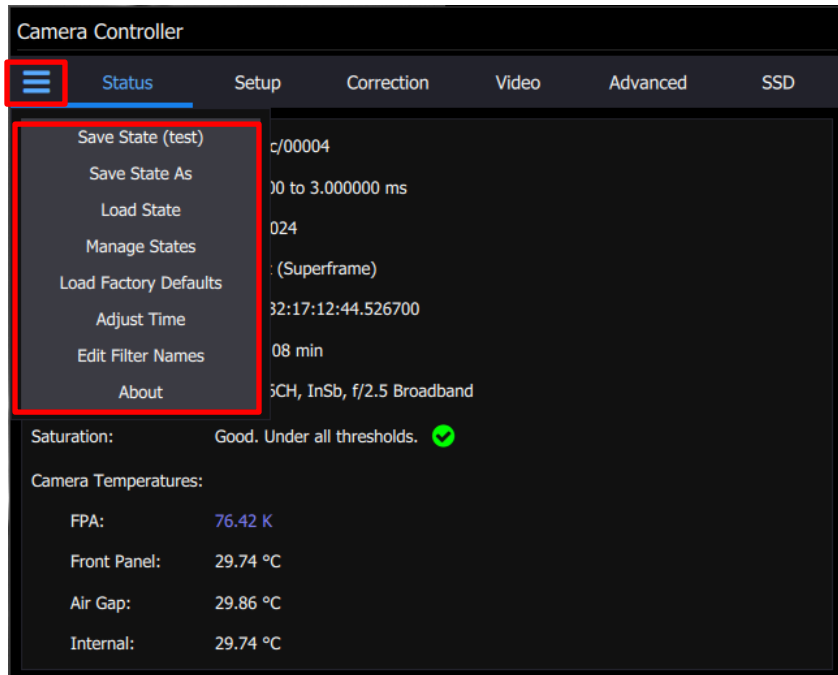
NOTE: The X6800sc uses the same camera controller software as the X69xx. The X6800sc is missing several features found in the X69xx but the controls for these functions may still be visible in the GUI. For example, the X6800sc has a precision image timestamp which may be referred to as a “IRIG” time. However, this time stamp cannot be synchronized to an external IRIG-B signal. It can only be set to reflect the PC or camera real-time clock (RTC) but will only free-wheel after being set. The IRIG timestamp will be set to the camera RTC automatically at power-up.

GUI controls for Genlock should not be used because this input is not available. The X6800sc only supports HDMI. Choosing options for SDI or composite video will result in no video to be displayed.

The X6800sc has a reduced maximum framerate compared to the X69xx. Various screenshots within this manual may show frame rates that are beyond what the X6800sc supports.

5.1 “Hamburger Button” Menu

The hamburger button is in the upper left corner of the Camera Controller window. It brings up a list of seven control options.



	Save State (Name)	Saves the camera state. This state will be reloaded at power up. Stored in flash memory.
	Save State As	Saves the current camera state to a name chosen by the user. State names other than (name) may be loaded manually. Stored in flash memory
	Load State	Load a state from flash memory.
	Manage States	Rename or delete states from camera memory.
	Load Factory Defaults	Loads factory defaults for all camera Settings and NUCs. The factory defaults cannot be modified by the user.
	Adjust Time	Allows the user to set the time in the camera

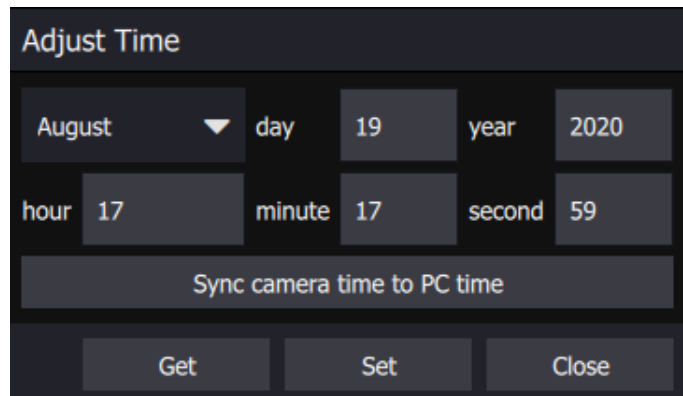
	Edit Filter Names	Edits the names of the filters in the filter wheel.
	About	The “About” menu item shows a dialog indicating the current controller version number. If the controller is connected to a camera a list will be displayed that shows all versions of software and firmware in the camera. The “Save” button allows the user to create a text file with this version information.

NOTE: Camera states contain information about all configurable camera parameters. They do not contain the NUC data, but they do contain the filenames of the currently loaded NUCs. These NUCs will be reloaded with the state, however, if the NUCs are changed, deleted, or renamed, the state may not be able to load the NUCs.

NOTE: The Cooled X-Series Cameras have two internal clocks: A Real Time Clock (RTC) and a timestamp clock. The RTC is a low-resolution clock used to keep system time. The RTC has a battery backup and will retain time while the camera is off. The timestamp clock is a high-resolution clock (1us). This clock does not have a battery backup but at power up the timestamp clock is initialized to the current RTC time and will free-wheel until the camera is power cycled.

5.1.1 Adjust Time Controls

This dialog is accessed using the Adjust Time menu option under the “hamburger button”. This allows the user to directly set the camera system’s time. The Sync camera time to PC time button will pull a time value from the PC clock and set the RTC clock. The Get button displays the current time that the camera has in its RTC clock. The Set button will set the camera’s RTC clock using the manually-entered time.



The Sync camera time to PC time button sets the camera RTC/IRIG clocks to the time from the PC clock. If the camera IRIG clock is synchronized to an external source the time will momentarily blip if this function is selected and it will then resynchronize automatically with the IRIG source. (X6800 has RTC only)

5.2 Edit Filter Names

This dialog is accessed using the Edit Filter Names menu option under the “hamburger button”. This allows the user to manually edit the names of the filters associated with each Filter ID. The user can click “Reset to Default” to reset the Filter Name to the manufacturer default value.

ID	Name	Actions
0	0. Reserved	Reset to Default
1	1. ND 1.0	Reset to Default
2	2. ND 2.0	Reset to Default
3	3. ND 3.0	Reset to Default
4	4. ND 0.3	Reset to Default
5	5. ND 0.6	Reset to Default
6	6. ND 1.45	Reset to Default
7	7. MWIR 3000-5000nm	Reset to Default
8	8. ATM 3400-4170nm	Reset to Default
9	9. SRX 3500-5000nm	Reset to Default
10	10. THRU GLASS 2360nm, 80nm	Reset to Default
11	11. GLASS SURFACE 5000nm, 145nm	Reset to Default

5.3 Status Page


The Status Page gives general information about the camera state including camera model and serial number, integration time, frame size, frame rate, camera time, FPA type, and internal temperatures. The FPA temperature turns blue when the camera has reached its setpoint temperature, which is nominally 77 K. The Time is in Julian Day format, with the number of days since the beginning of the year, followed by the hour, minute, second and decimal second to 6 places. The Operating Time display is in HH:MM elapsed since the camera was manufactured, or the timer was reset at the factory.

The Type entry is the configuration of the integrated detector cooler assembly. In the example below, the sensor readout IC type is the 1308 which is used in the X850x camera family. “16CH” means 16 digitizer channels. “InSb” is indium antimonide, the detector type. “f/2.5” is the f/number of the cold shield. “Broadband” is the wavelength range of the cold filter. “Front Panel” and “Air Gap” are the temperatures of temperature sensors in the camera’s lens interface. These sensors are used for T-drift correction, a type of radiometric compensation for changes in the optics temperature that will affect radiometric measurements. The factory calibrations are done in an air-conditioned laboratory with a nominal temperature of 23 °C. If the camera is subsequently operated in a hot ambient environment, the total radiance reaching the sensor will be higher than it would be if the camera was


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still at 23 °C. This produces a radiance offset which leads to a temperature measurement error. The Tdrift compensation uses the measurements of the two temperature sensors to correct for the radiance offset in the digital image data.



The screenshot shows the 'Camera Controller' interface with the 'Status' tab selected. The interface displays the following information:

Parameter	Value
Model/Serial:	X8500sc/00004
Integration Time:	3.000000 ms
Frame Size:	1280x1024
Frame Rate:	181.28 Hz
Time:	2020-232:17:05:24.250088
Operating Time:	1171 h 02 min
Type:	1308 16CH, InSb, f/2.5 Broadband
Saturation:	Good. Under all thresholds. 
Camera Temperatures:	
FPA:	76.42 K
Front Panel:	27.11 °C
Air Gap:	26.99 °C
Internal:	27.11 °C

5.4 Setup

The Setup page allows the user to set up the camera for the desired operation. There are five sub-menus, including General Setup, Sync Settings, Video Output Settings, Filter Wheel Settings, and Flag settings. Depending on which submenus are open it may be necessary to scroll down to see everything.

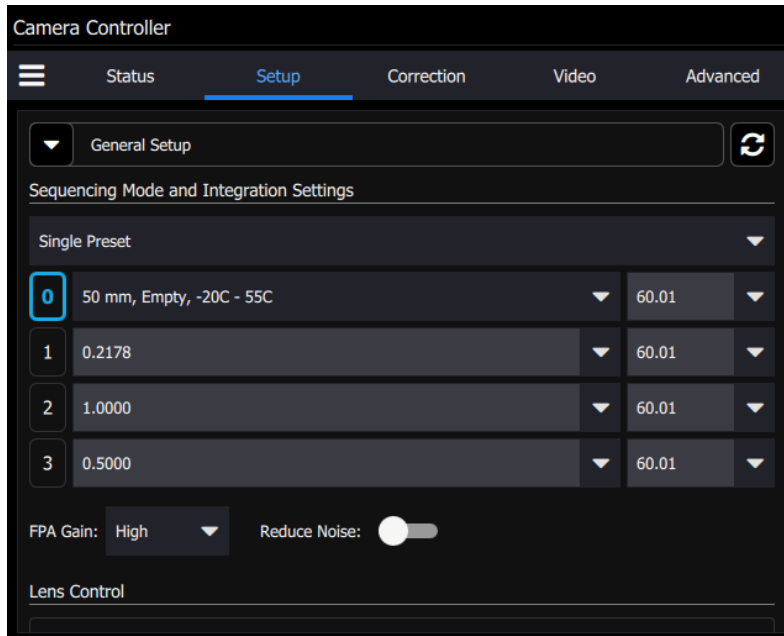


5.4.1 General Setup

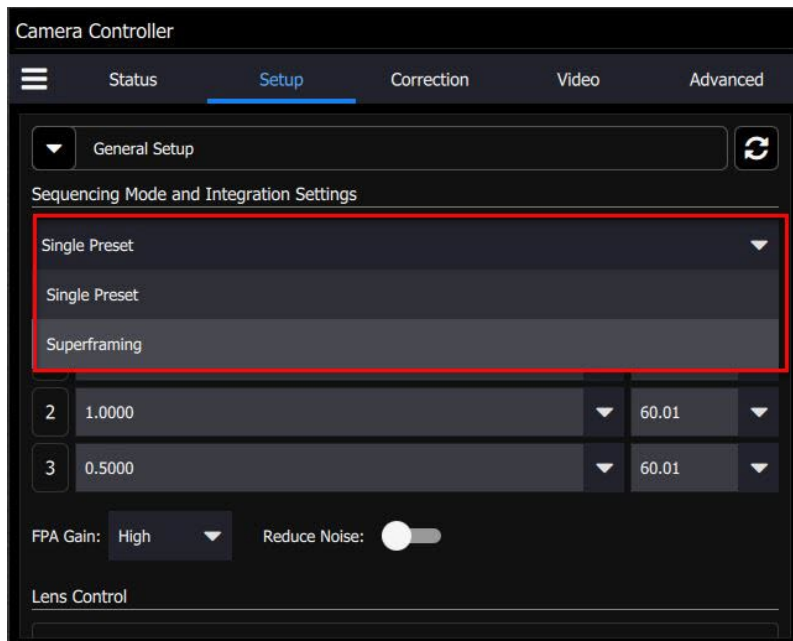
The settings under the General Setup menu include loading factory calibrations, changing integration time, selecting superframing, frame rate, and FPA gain.

Sequencing Mode

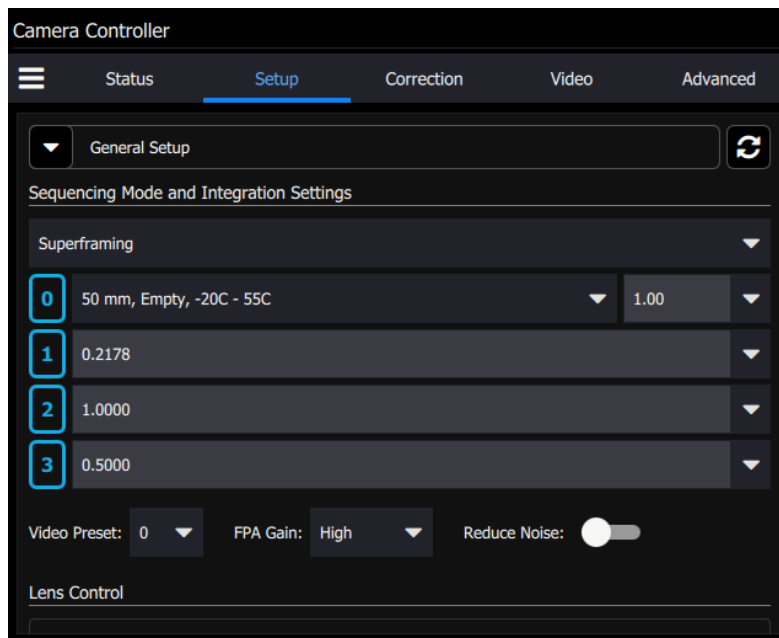
A Preset is a combination of four parameters: Integration Time, Frame Rate, Window Size, and Window Location. The X-series can store up to four presets in internal memory. The user can switch from one preset to another manually, using the GUI, or the camera can automatically switch using Preset Sequencing or Superframing. The time lag to switch from one preset to another using the GUI is on the order of 100 milliseconds. When using Preset Sequencing or Superframing, the X-series can switch between presets on a frame-to-frame basis. The camera is typically operated in Single Preset mode. This means that a single preset group of camera settings is used for every frame of image data. The other option is Superframing. This setting enables the camera to cycle through a set of presets to extend the dynamic range of the camera when measuring temperature or radiance. The active preset has its preset number box colored in blue. In the example below, Preset 0 is the active preset.



Superframing is selected by pulling down the Single Preset menu to Superframing:

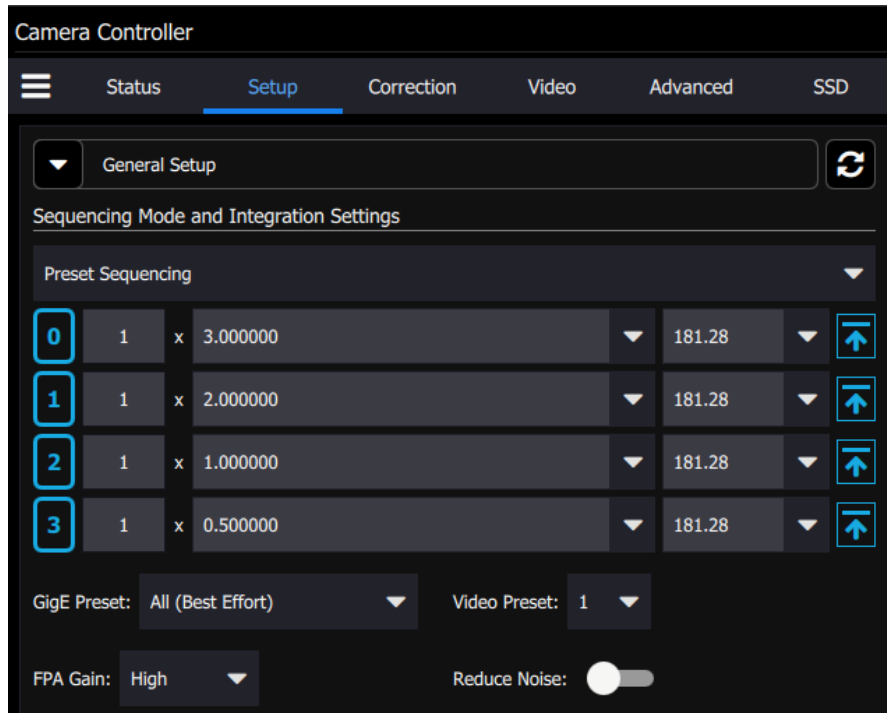


Presets are selected to be included in superframing by clicking on the preset numbers to make them change to a blue circled state. The figure below shows the camera set up with all four presets active. The Video Preset is the preset used to stream HD-SDI video out of the camera.

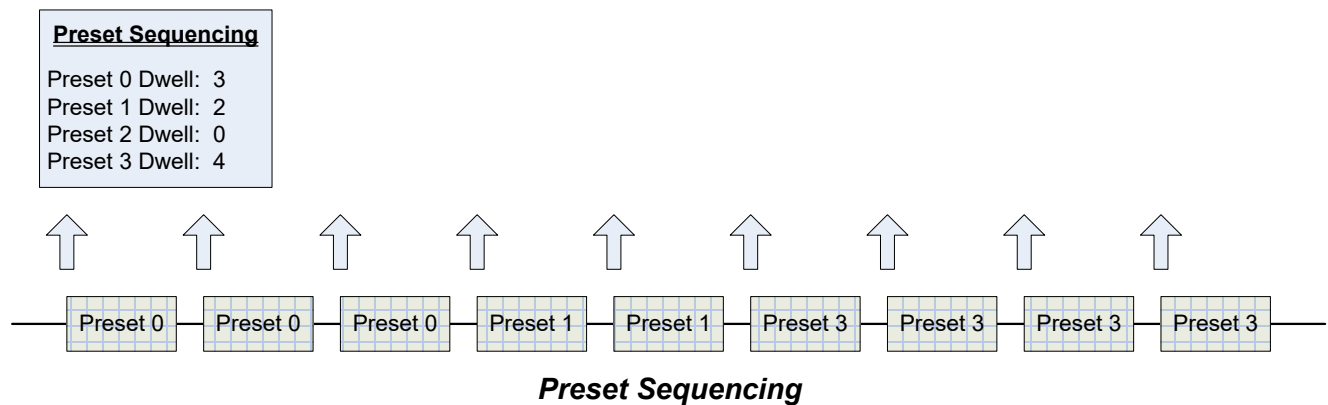


5.4.1.1.1 Preset Sequencing Mode

In preset sequencing mode, the camera will cycle through each preset on a frame-by-frame basis. Clicking the Preset Sequencing radio button changes the controller display and puts the camera in Preset Sequencing mode. The controller displays the current sequence configuration.



The camera will stay at each preset for a number of frames set in the Dwell column. This setting is the dwell time (in frames) for each preset. A dwell time of zero tells the camera to skip that preset and proceed to the next non-zero preset. For example:



The main purpose of preset sequencing is to capture a large dynamic range event with various integration times. Consider a rocket launch as an example. During the launch a short integration time

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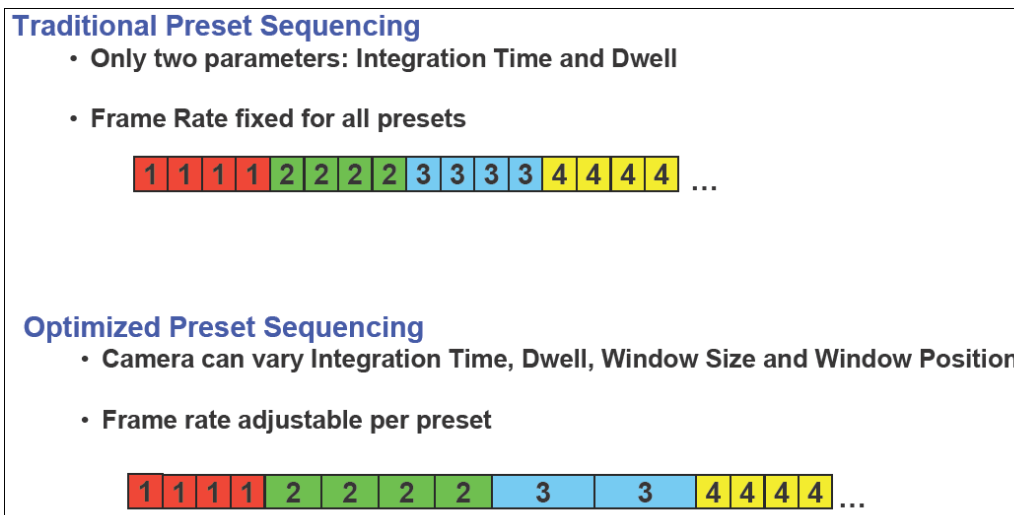
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would be needed to monitor the plume of the rocket. However, such a short integration time would not yield adequate images across the rest of the rocket body. If the integration time were increased to yield adequate images across the entire rocket, the rocket plume would saturate the detector. Preset sequencing cycles through up to four different integration periods.

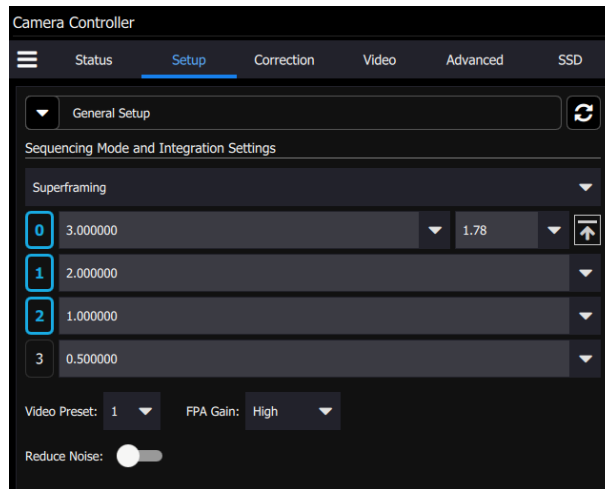
Optimized vs. Traditional Preset Sequencing

In traditional Preset Sequencing you can only adjust integration time and dwell for each preset. The X-series incorporates Optimized Preset Sequencing. This allows the user to set integration time, dwell, and frame rate for each preset. This is depicted in the diagram below.



NOTE: Optimized Preset Sequencing is only available when using internal frame sync. Traditional Preset Sequencing is used in external sync mode. To achieve the fastest possible frame rates, the camera must be in Frame Sync Starts Readout (FSSR) mode. If the camera is in Frame Sync Starts Integration (FSSI) mode, the camera will be limited to ITR frame rate timing.

5.4.1.1.2 Superframing Mode



Superframing is a subset of preset sequencing with dwell counts of 0 (selected) or 1 (unselected) and optimized frame rates for each preset. The user enables the checkbox for each preset they wish to include in the Superframing. The “superframe rate” is the rate at which the entire group of included presets is generated. The radio buttons to the left of the checkboxes select which preset will be displayed on the active video output.

Optimized vs. Traditional Superframing:

In traditional Superframing, the time between subframes is dictated by the longest integration time. In addition, the superframe rate cannot be set independently of the subframe rate. This typically forces a user to run the camera at the fastest frame rate in order to minimize the time between subframes. This may force the user to collect much more data than is actually necessary. With Optimized Superframing, the time between subframes is set by the minimum readout time. This allows the subframes to be packed together as closely as possible. The user sets the superframe rate. This sets the time between bursts of superframes. The end result is that with Optimized Superframing the user can achieve fast subframe rates to minimize registration error when “abating” the images while using a slower superframe rate to minimize data storage requirements. This is depicted in the diagram below.

Traditional Superframing

- Time between subframes set by longest integration time



- Superframe rate cannot be set independently from the subframe rate



Optimized Superframing

- Time between subframes set by minimum readout time



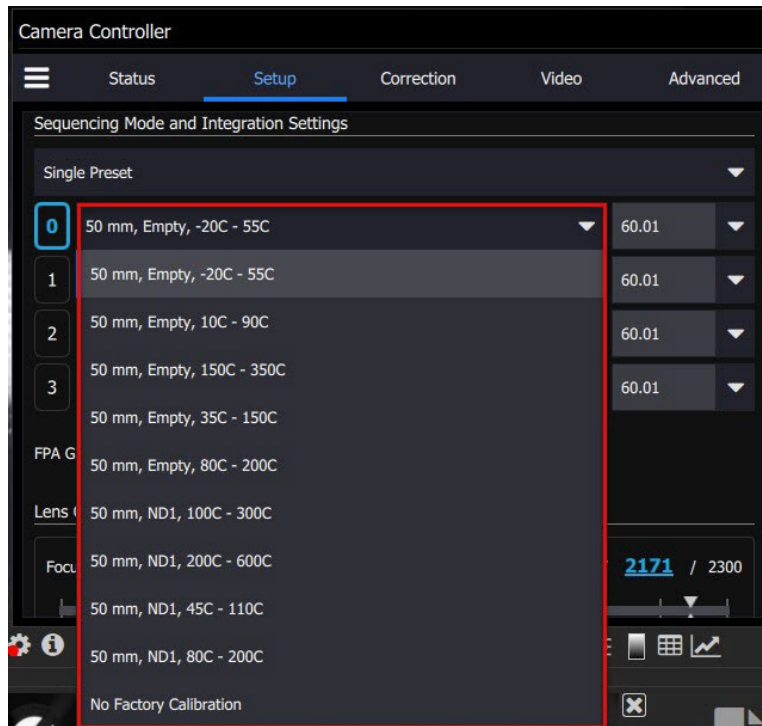
- Superframe rate independent of subframe rate



NOTE: Optimized Superframing is only available when using internal frame sync. Traditional Superframing is supported in external sync mode. To achieve the fastest possible frame rates, the camera must be in Frame Sync Starts Readout (FSSR) mode. If the camera is in Frame Sync Starts Integration (FSSI) mode, the camera will be limited to ITR frame rate timing.

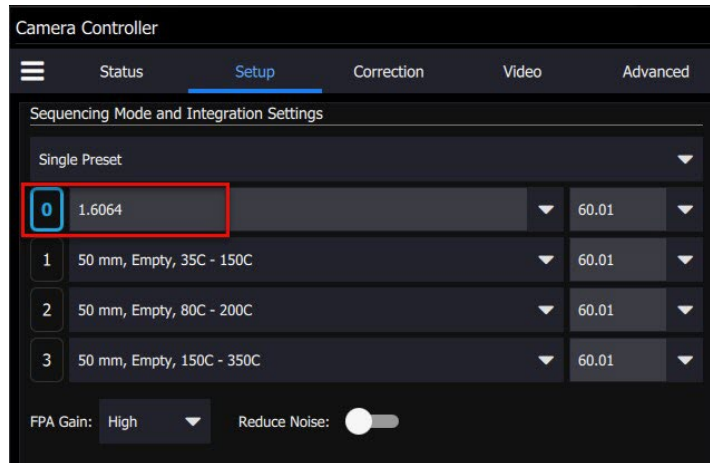
Loading Factory Calibrations:

Each preset has a pulldown menu that shows the factory calibrations that are present in the camera. If the camera does not have any factory calibrations, then the only option will be No Factory Calibration. In this example, the factory calibration that is loaded is called “50mm, Empty, -20-55C”. The notation indicates that the calibration applies to a 50mm lens calibration with no filter in the filter wheel and a temperature measurement range of -20 to 55C. The other options are shown in the pulldown menu. **Loading a factory calibration into a preset will automatically load the associated NUC.**



Changing Integration Time

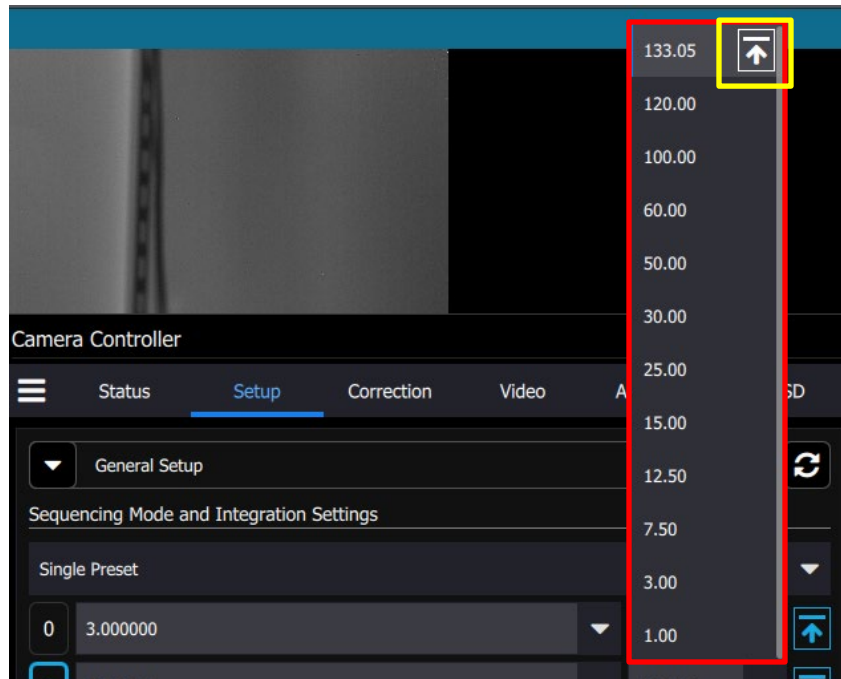
If No Factory Calibration is selected, the preset will display the integration time setting, which in this example is set to 1.6064 milliseconds. **The units of integration time are always milliseconds:**



The user can now change the integration time. Note that this may degrade the image quality if the NUC that is loaded was done for a different integration time setting.

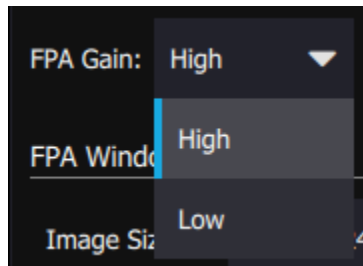
Changing Frame Rate

The pulldown menu to the right of the Factory Calibration pulldown enables the user to select from a set of frame rates. The user can also type in a custom frame rate. The arrow at the top of the dropdown sets the maximum frame rate possible for the selected integration time.



Changing FPA Gain

Some cameras have the option to change the FPA gain. This is preconfigured at the factory. For most applications we recommend not changing this setting without consultation with FLIR applications engineering.



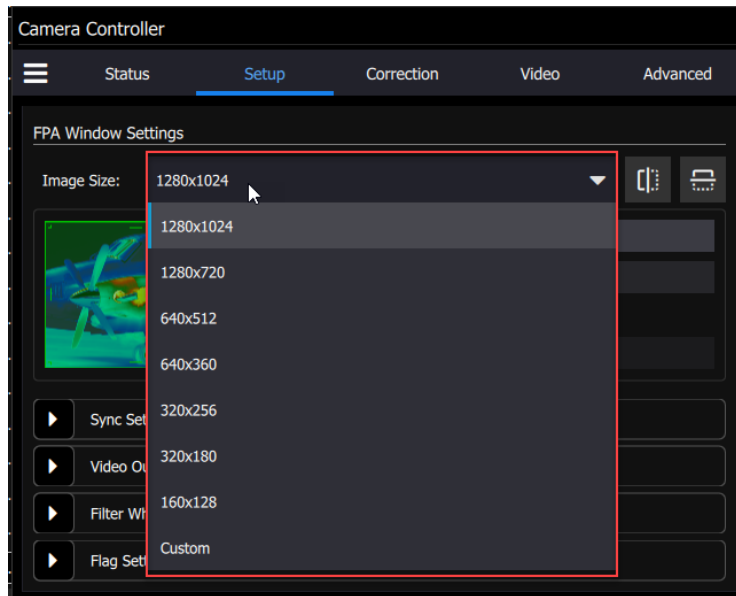
Reduce Noise

There is a Reduce Noise switch which improves image quality, but it will sometimes affect the frame rate.

FPA Window Settings

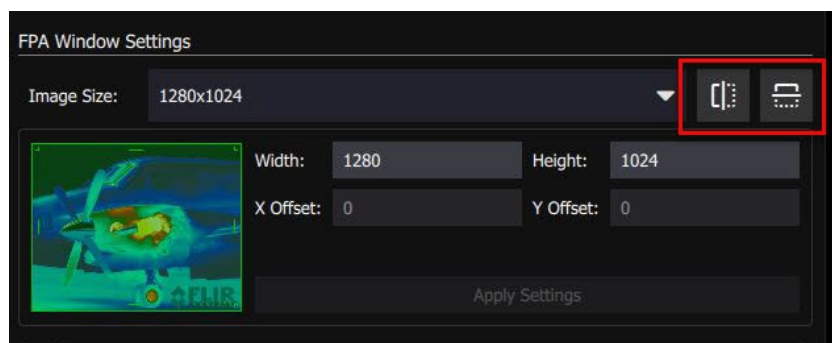
The FPA Window Setting menu allows the user to control the size of the FPA Window, as well as flip the image at the FPA level around both the horizontal and vertical axes. The window height, width, and offsets can be set to any desired value, within the limits of each ROIC type. The range of valid values for each field can be seen in a tooltip by moving the mouse over the field.

Common sizes can be chosen from the dropdown list or the user can enter the desired width and height directly. The box will turn red if an invalid number is entered. The user can also change the size by dragging the handles on the window indicator (green shaded box). Use the handles to set the window size and then drag the whole box to set the location.

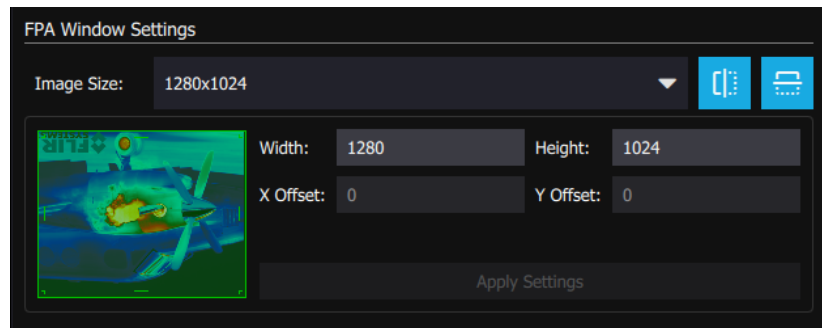


Invert and Revert

The user can flip the video vertically (invert) or horizontally (revert) using these controls highlighted in the red box:



When both controls are highlighted in blue, then the image is inverted and reverted, and the airplane image on the left side of the menu changes its orientation to indicate that:



Note: Using the invert and revert buttons change the way the image data is read out of the focal plane array, and the non-uniformity correction will be compromised. If the user needs to invert or revert the image, we recommend redoing the non-uniformity correction with the desired settings.

X6800/X69XX Frame Size Variables

	Minimum	Maximum	Step Size
Frame Width	32	640	32 pixels
Frame Height	4	512	4 pixels
Horizontal Offset	0	Depends on window size	4 pixels
Vertical Offset	0	Depends on window size	4 pixels

X85XX Frame Size Variables

	Minimum	Maximum	Step Size
Frame Width	64	1280	32 pixels
Frame Height	4	1024	4 pixels
Horizontal Offset	0	Depends on window size	4 pixels
Vertical Offset	0	Depends on window size	4 pixels

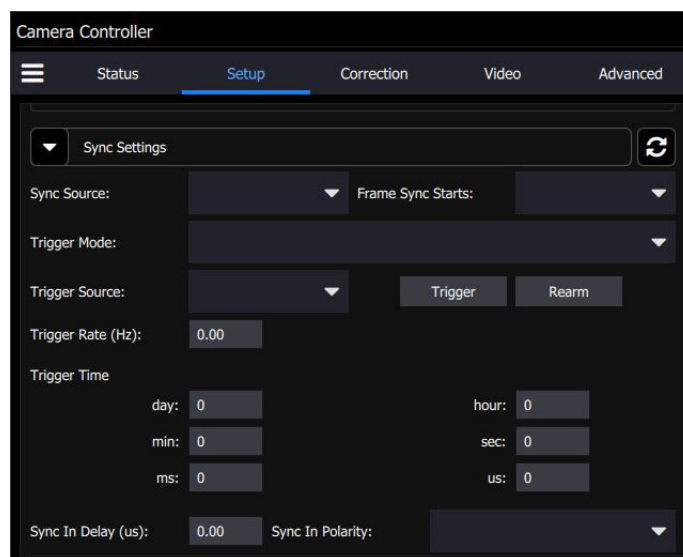
NOTE: Windowing in the horizontal direction will not affect frame rate.

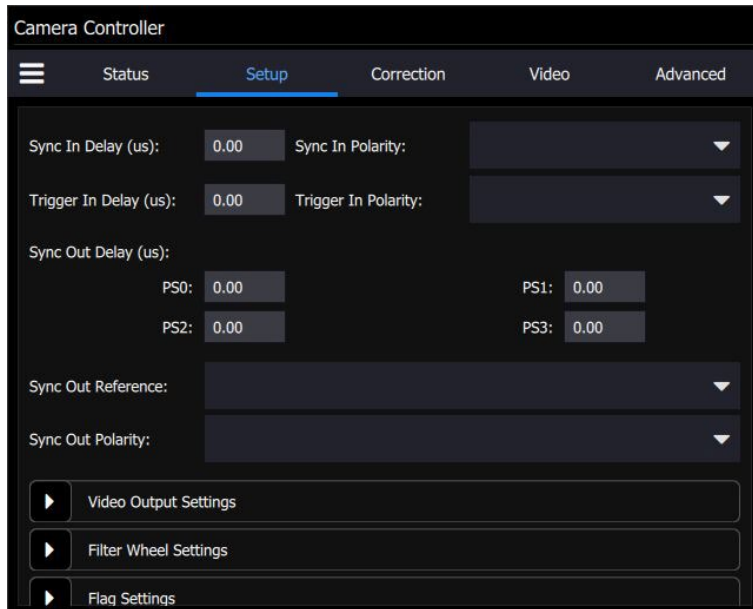
5.4.2 Sync Settings

The Sync Settings menu is a complex one. There are many options to consider if the intention is to synchronize the camera with another device, and it is well worth reading this entire section carefully.

Sync Source

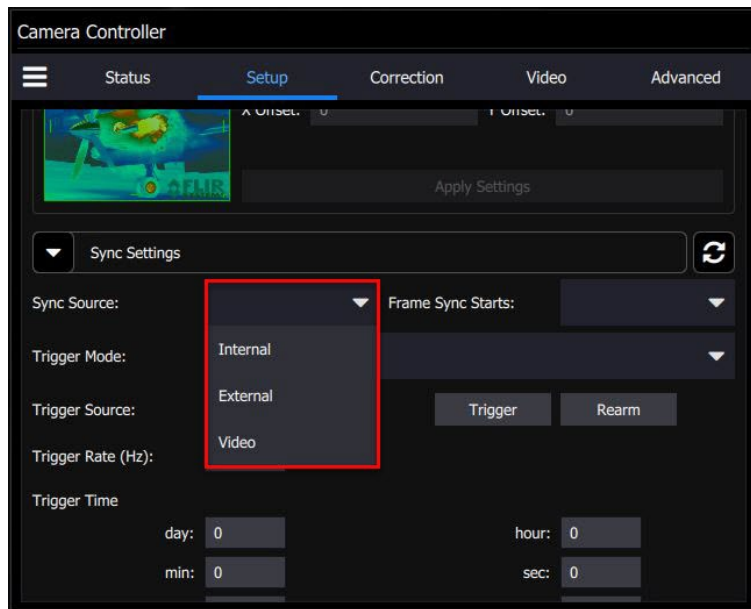
The Source options page allows the user to select the source for Syncs and Triggers. The Sync Tab allows the user to set the FPA sync mode, and sync/trigger options. At this point it is helpful to define some terms. A sync is a signal that synchronizes the timing of an individual frame. A trigger is a signal that synchronizes the start of a sequence of frames. The X-series has independent SYNC and TRIGGER inputs. The SYNC and TRIGGER IN input require a 3.3V TTL pulse (5V max).



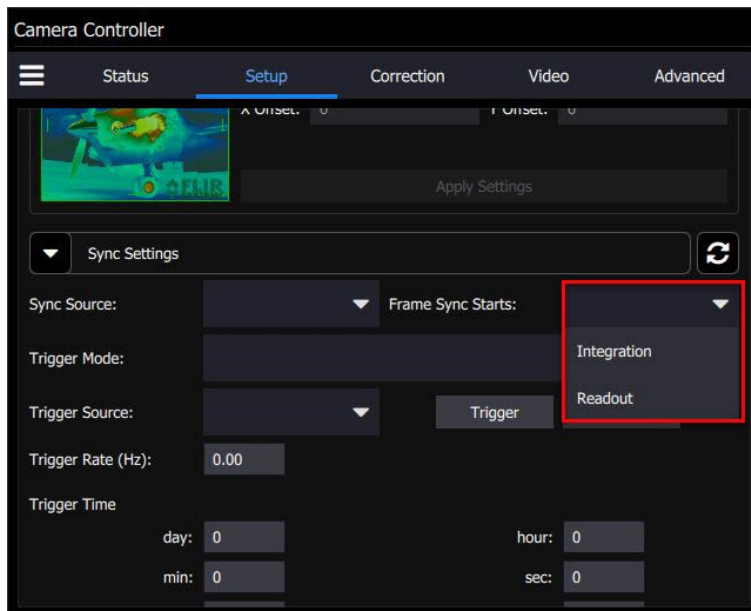


The pulldown menus show the following options: Sync Source can be Internal, External or Video.

Sync Sources	
Internal	The frame sync is generated internally to run at the frequency set by the user
External	The frame sync is generated externally through the Sync In connect on the camera rear chassis.
Video	The frame sync is generated from the internal video encoder, locking the HD-SDI and FPA clocks together.



The Frame Sync Starts pulldown shows the following options: Integration or Readout:



Frame Sync Starts

The camera makes use of frame syncs and triggers to control the generation of image data. Frame syncs control the start of individual frames, whereas triggers start sequences of frames.

The generation of a frame consists of two phases: *integration* and *data readout*. Depending on the timing between these two events, you can have two basic integration modes: Integrate Then Read (ITR) and Integrate While Read (IWR). In ITR, integration and data readout occur sequentially. The complete frame time is the combined total of the integration time plus readout time. In IWR, the

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integration phase of the current frame occurs during the readout phase of the *previous* frame. In other words, ITR and IWR terms refer to whether or not the camera will overlap the data readout and integration periods. In ITR, the data is not overlapped which means lower frame rates but provides a less noisy image. IWR can achieve much faster frame rates with a slight increase in noise. The camera does not require the user to explicitly choose whether to operate in ITR or IWR modes. The camera will automatically select the integration mode based on the integration time, frame rate, and frame sync mode.

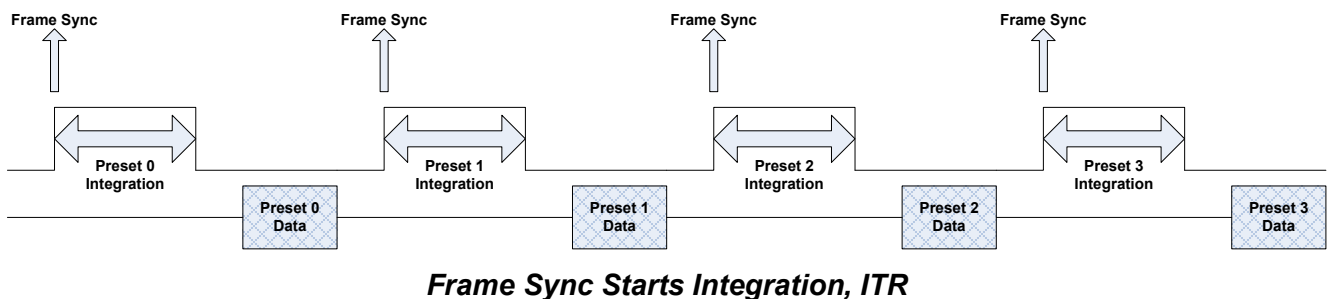
The camera supports two Frame Sync Modes: Frame Sync Starts Integration (FSSI), and Frame Sync Starts Readout (FSSR). FSSI and FSSR determine which phase of the frame generation process (integration or data readout) is synchronized to the frame sync. FSSI starts the integration period when a frame sync occurs (i.e. “take a picture now”). The camera automatically calculates when to start data readout. FSSR starts the data readout (for the previous frame) when a frame sync occurs (i.e. “give me data now”). The camera automatically calculates when to start integration for the current frame. In FSSI mode, the camera could be in either ITR or IWR mode. In FSSR mode, the camera is always in IWR mode.

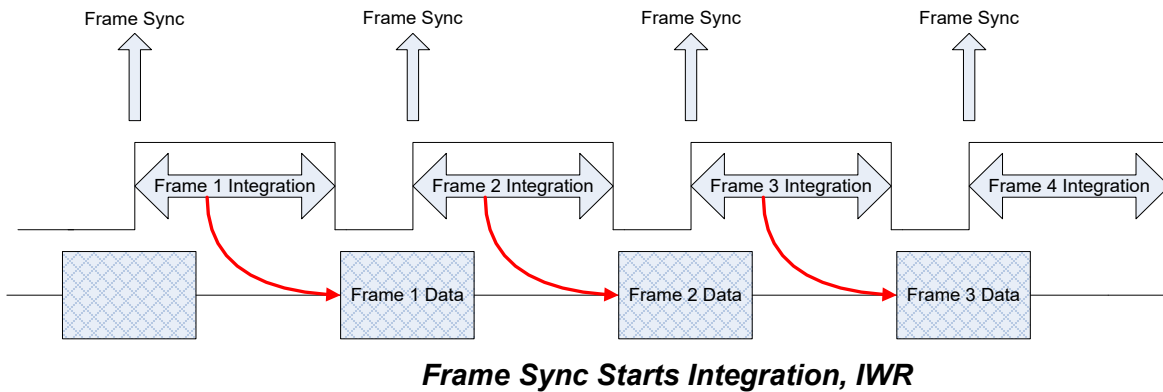
NOTE: When the camera is continuously imaging (i.e. internal sync mode), there is essentially no difference between FSSI and FSSR. In some cases FSSR may allow faster frame rates. However, FSSR may not be appropriate for external sync applications where the camera is stopped for extended periods because when syncs are restarted the first frame may be very old.

Frame Sync Starts Integration (FSSI)

Upon frame sync, the camera immediately integrates followed by data read out. Based on integration time, frame size, and frame rate, the camera will automatically choose ITR or IWR mode.

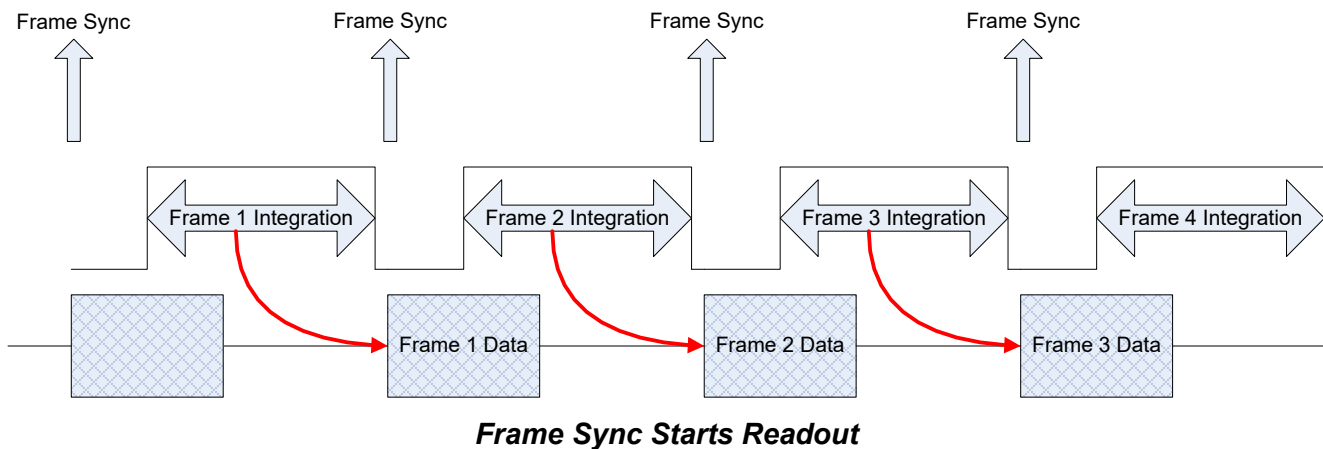
NOTE: When using an external frame sync and superframing, the external frame sync should be set to comply with ITR frame rate limits. If the external sync rate is too fast, the camera will ignore syncs that come before the camera is ready





Frame Sync Starts Readout (FSSR)

Upon frame sync, the camera immediately transmits the data from the previous frame. The integration period is then placed to meet ROIC requirements. This mode always operates in IWR mode. This mode can be used with either internal or external frame sync at full frame rates.

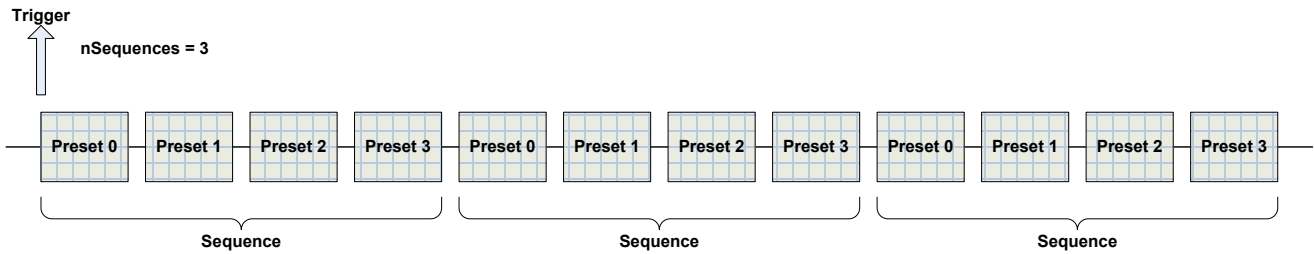


Trigger Mode

When the camera is placed in a triggered mode, the image stream will stop until the trigger is received.

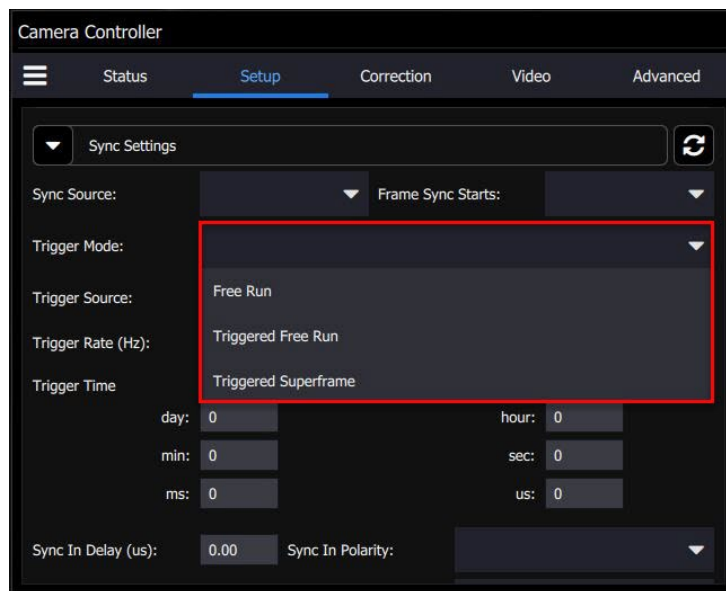
A sequence consists of a series of frames. In Preset Sequencing, that series of frames can be any number of any of the four presets. In Superframing, the series is one or zero frames from each preset. In Single Preset, the series is simply one frame of the selected preset.

When a trigger occurs, the camera will complete a sequence a set number of times. For example, if Preset Sequencing is used with a dwell of two frames set for all four presets, each trigger would generate 8 frames. If the user set the camera to complete 3 sequences upon triggering, the camera would generate 24 frames.

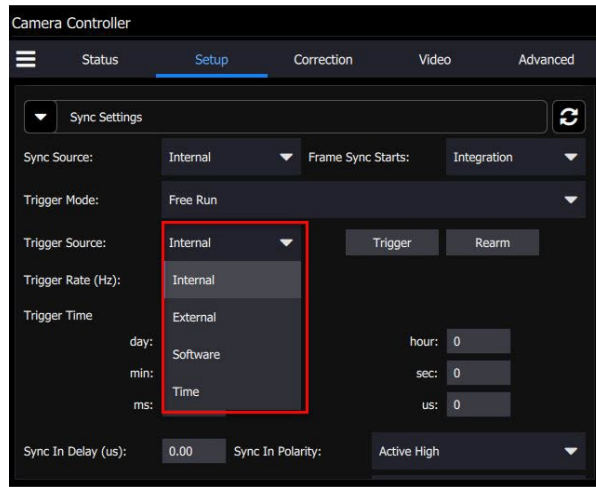


ITR Frame Process

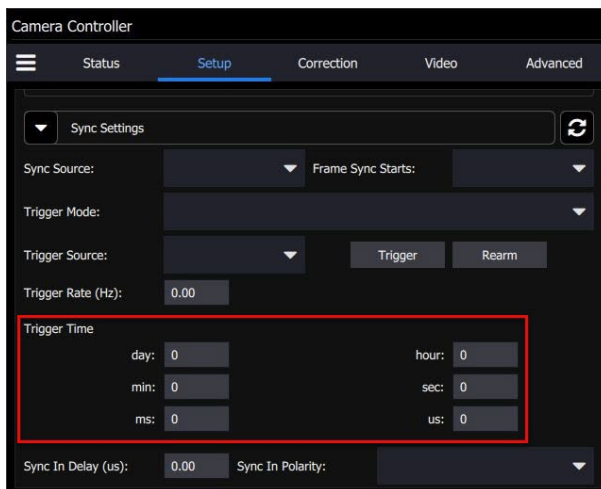
Trigger Modes	
Free Run	In free run the camera cycles through frames/sequences continuously.
Trigger, then do this many sequences	Upon receiving a trigger (external or software), the camera generates the number of sequences entered in the box (max limit: $>4 \times 10^9$).
Trigger then free run	Upon receiving a trigger (external or software) the camera will start to generate sequences continuously.
External Preset Advance	Upon receiving a trigger (external or software) the camera will advance to the next preset with a non-zero dwell setting.



The Trigger Source can be Internal, External, Software or Time:



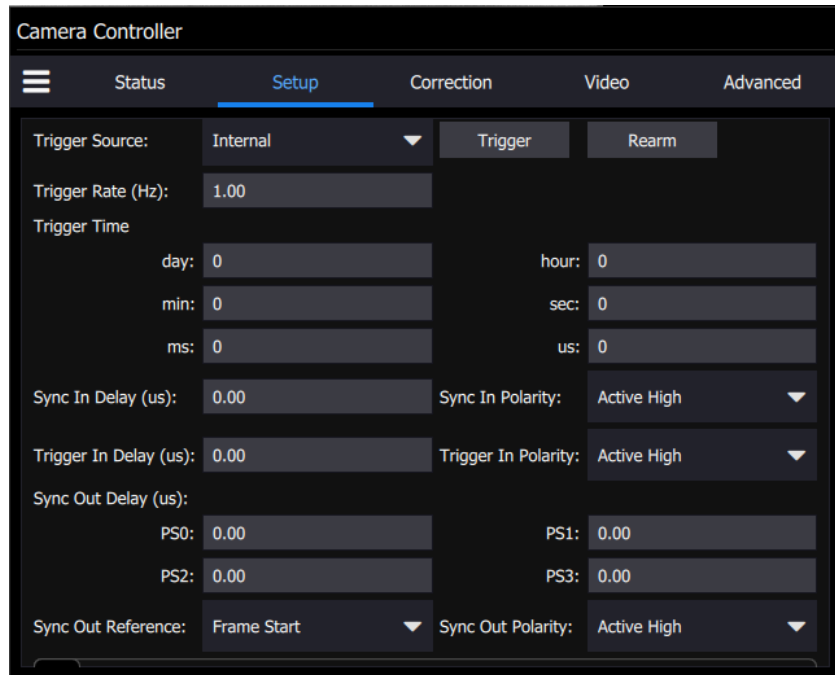
The Trigger Time can be set to activate on a very specific time as measured by the real time clock in the camera.



Trigger Sources	
Internal	The trigger is generated internally to run at the frequency set by the user (Hz).
External	The trigger is generated externally through the Trigger In connector on the camera rear chassis. (3.3V LVCMOS)
Software	The trigger is generated via a software button (Trigger button)
Time	Camera generates an internal trigger when the internal timestamp clock reaches a specified time.

Sync Options

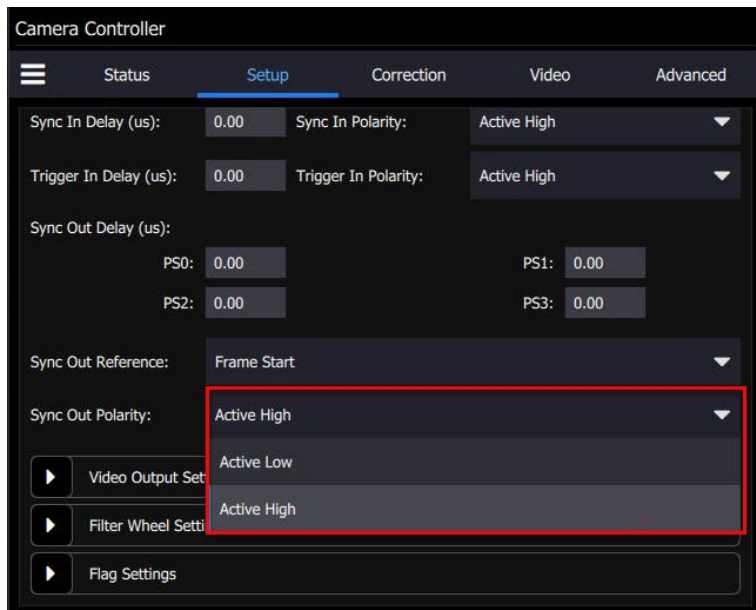
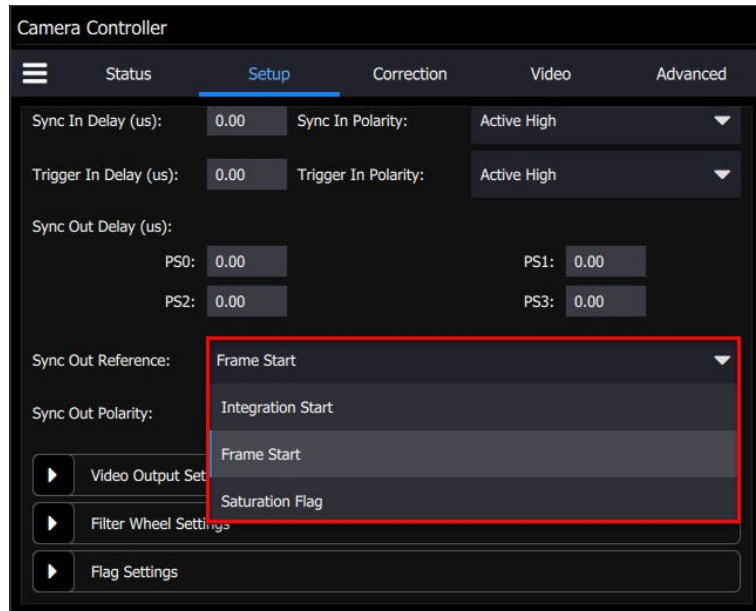
The Sync Options page allows the user to set delays, sync out reference, and polarities for the Sync and Trigger In. The delays can be set individually for each preset.



Sync In	
Delay	Allows for the user to set a delay (μsec) for the external sync. See timing diagrams below.
Polarity	The sync is edge triggered. Allows for the camera to use the rising or falling edge.
Trigger In	
Delay	Allows for the user to set a delay (μsec) for the external trigger. See timing diagrams below.
Polarity	Trigger is edge triggered. Allows for the camera to use the rising or falling edge.

Sync Out

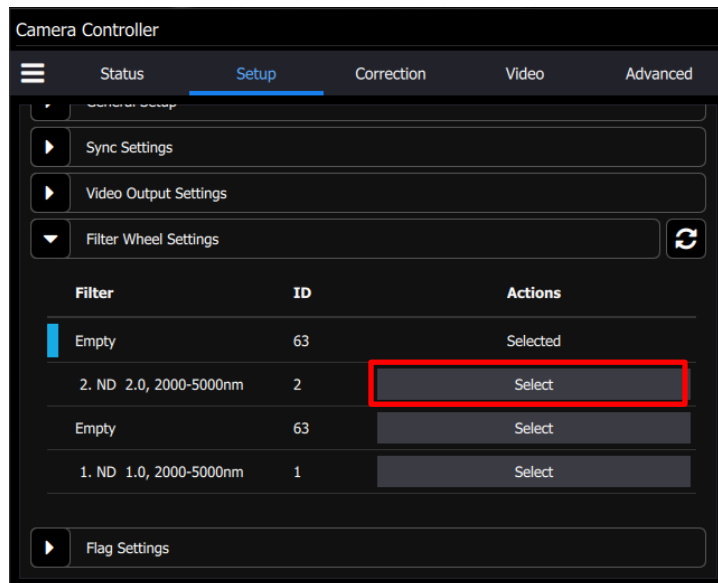
The Sync Out options allow the user to set a delay for the sync out pulse as well as the sync delay reference and polarity. The Sync Out signal always has a jitter of ± 1 clock (160nsec).



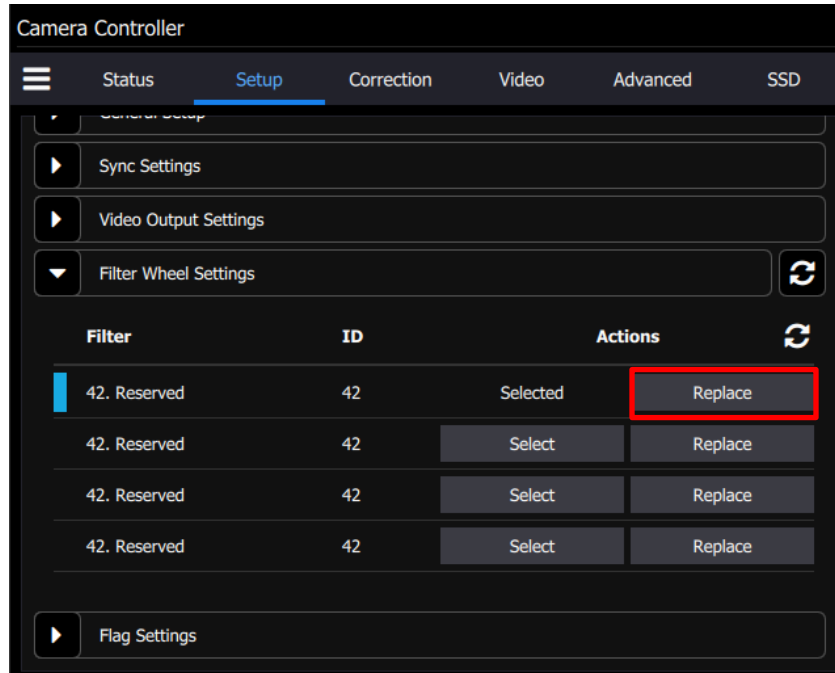
Sync Out Options	
Sync Out Delay	Allows for the user to set a delay for the sync out on a preset basis.
Sync Out Source	Allows for the sync out to be referenced to the start of frame or start of integration.
Sync Out Polarity	Allows for the sync out to be active high or low.

5.4.3 Filter Wheel Settings

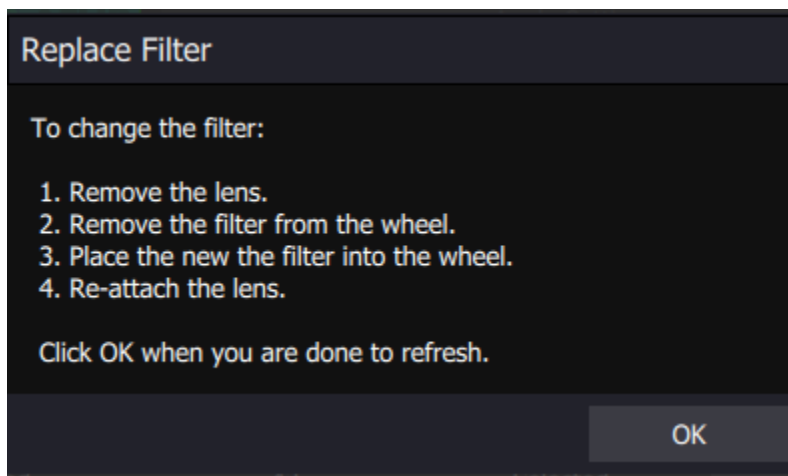
The X-series has a motorized 4-position filter wheel. Warm filters are held in the wheel by a removable filter holder. Each holder can hold up to two filters with a combined thickness of 2mm. The holders have an ID number that is encoded using a set of magnets. The camera can recognize the ID number. The camera can also store a text description for the filter ID. The current filter list shows the filters currently in the wheel. Selecting an item from the list will tell the camera to move that filter into the field of view.



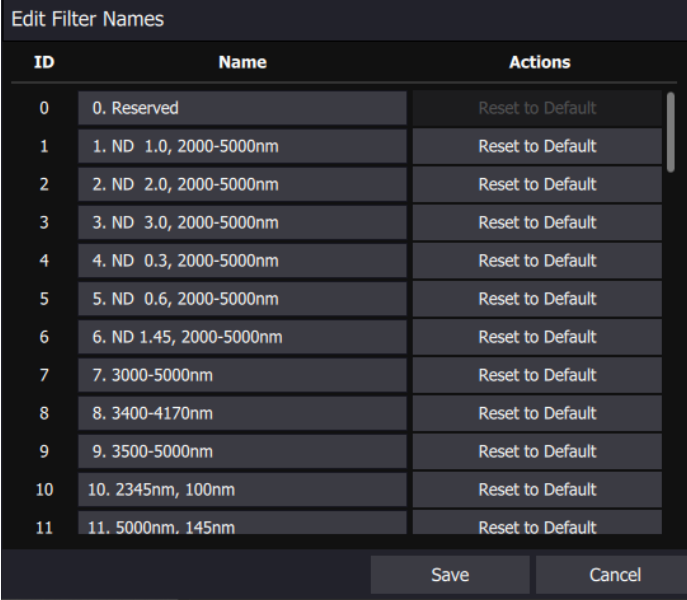
To load a new filter into the wheel click replace on the slot where you would like to load the filter.



At this point the user will see the dialog below directing them to physically exchange the filter. Once this is complete the camera will recognize the filter place in the wheel.



The filter names that are displayed in the GUI can be edited by the user using a menu accessed by the “hamburger” button:

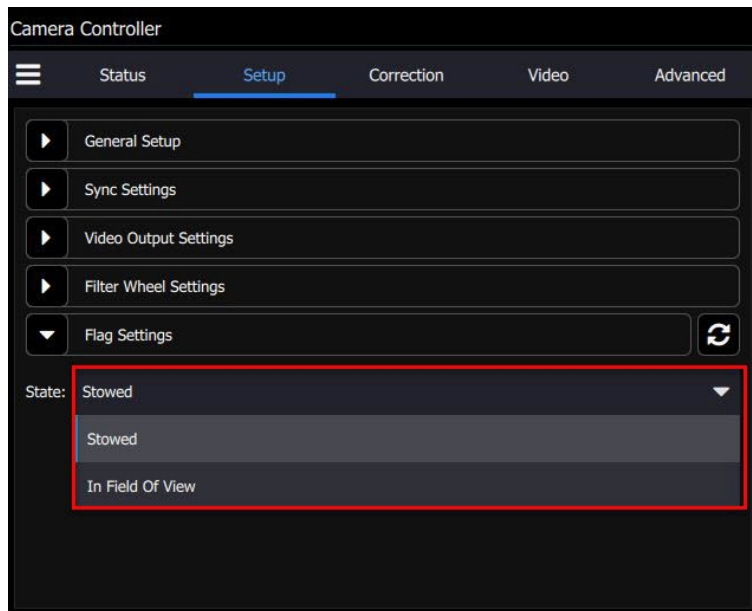


The screenshot shows a window titled "Edit Filter Names" with a table of filter settings. The table has three columns: ID, Name, and Actions. The rows are numbered 0 through 11. Each row has a "Reset to Default" button in the Actions column. At the bottom of the window, there are "Save" and "Cancel" buttons.

ID	Name	Actions
0	0. Reserved	Reset to Default
1	1. ND 1.0, 2000-5000nm	Reset to Default
2	2. ND 2.0, 2000-5000nm	Reset to Default
3	3. ND 3.0, 2000-5000nm	Reset to Default
4	4. ND 0.3, 2000-5000nm	Reset to Default
5	5. ND 0.6, 2000-5000nm	Reset to Default
6	6. ND 1.45, 2000-5000nm	Reset to Default
7	7. 3000-5000nm	Reset to Default
8	8. 3400-4170nm	Reset to Default
9	9. 3500-5000nm	Reset to Default
10	10. 2345nm, 100nm	Reset to Default
11	11. 5000nm, 145nm	Reset to Default

5.4.4 Flag Settings

The flag is at the ambient temperature inside the camera. It can be commanded to move into the field of view, and then be stowed. It is sometimes useful to move the flag into the field of view for test purposes, particularly when the camera is being operated remotely and there is no way to put a lens cap on the lens, for example.

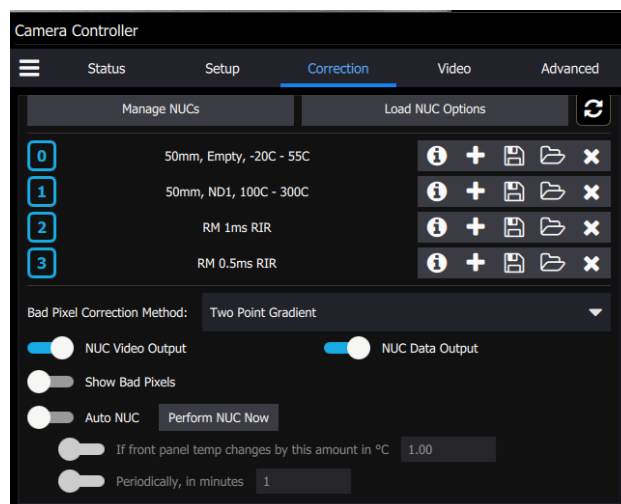







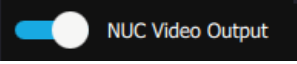
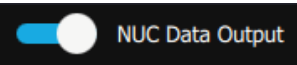
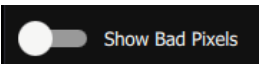
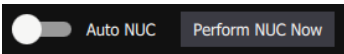
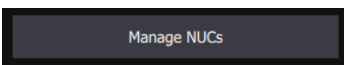
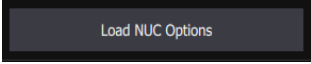
5.5 Correction Page

The Correction Tab contains all the controls needed to manage the on-camera NUCs. On-camera NUCs are stored in two types of memory:


RAM memory. This type of memory is used to store NUCs that will be applied to live image data. There is enough RAM memory for one NUC to be loaded for each Preset. This memory is volatile and is lost when the camera is turned off. If a NUC was loaded into RAM, the camera will reload that NUC from flash automatically when the camera is turned on if a Save State was performed.

Flash Memory. This type of memory is used as nonvolatile NUC storage. There is about 4GB of flash memory available for storing NUCs. This is enough space to store hundreds of full frame NUCs.



NUC Controls	
	NUC Info. Displays camera parameters and statistics related to the selected NUC
	Perform NUC. Starts the NUC Wizard.
	Updates the current NUC to flash memory
	Load a NUC from flash to RAM memory.
	Unload NUC from RAM memory. No on-camera NUC will be applied to the data.
	Apply NUC to SDI video data
	Apply NUC to Digital output (GigE, CoaXpress, CameraLink)
	Displays all pixels marked as “bad” as white dots on both the analog and digital outputs.
	When enabled, the camera will automatically drop the internal flag and perform a NUC Offset Update when selected criteria are met. The NUC update can be triggered on demand, by a change in the internal temperature sensor or by a timer
	Displays a list of NUCs stored in flash memory. User can delete NUCs from flash memory as well as upload/download NUCs (*.NPK files) from the host PC.
	Displays options for loading NUCs.

5.5.1 NUC Information

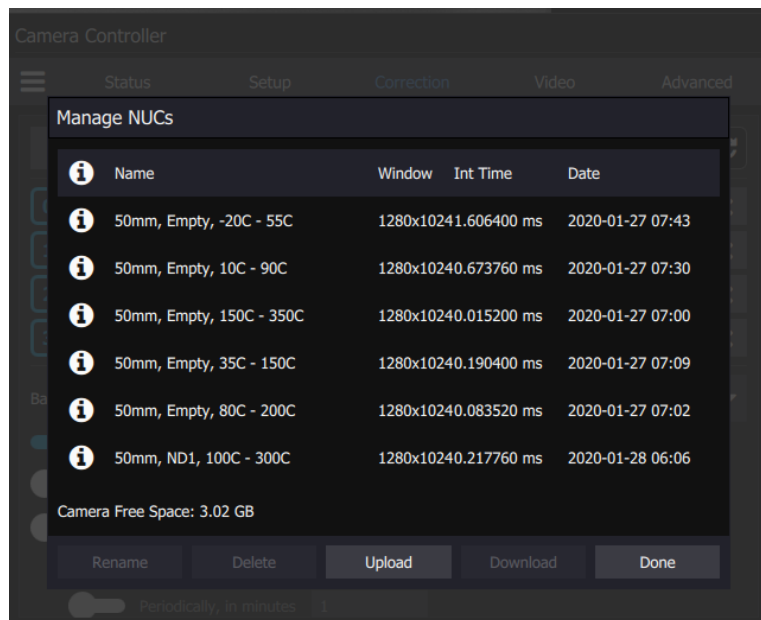
The  button brings up a list of camera parameters that are saved as part of the NUC as well as bad pixel statistics. Note that there is a scroll bar that can be used to see the whole list. The Save button allows the user to dump this list to a text file:

NUC Information	
Name	Value
Name	NUC_1.5mS
Size	5.00 MB
Date	Wed Nov 6 10:20:35 2019 GMT
Camera Model	X8501sc
Camera Serial	00004
Integration Time	1.500000 ms
Color	P on N
Frame Rate	1.50 Hz
Window	1280x1024 (0,0)
Invert	False
Revert	False
Readout Mode	Frame Sync Starts Integration
Filter ID	6
Detector Bias	-227.58
FPA Gain Level	0
Digital Gain	1.000
Digital Offset	0.0
Analog Offset	0.000
Skimming Enabled	True
Skimming Voltage	0.400
NUC Type	Two Point
NUC Source	External
Frames To Average	16
Detect Bad Pixels	True
A/D Min	100
A/D Max	16200
Gain Min	0.75
Gain Max	1.50
Detect Twinkling Pixels	True
Twinkler Frames To Collect	128
Twinkler Delta	100
Total Bad Pixels	449
Factory Bad Pixels	0

Save Done

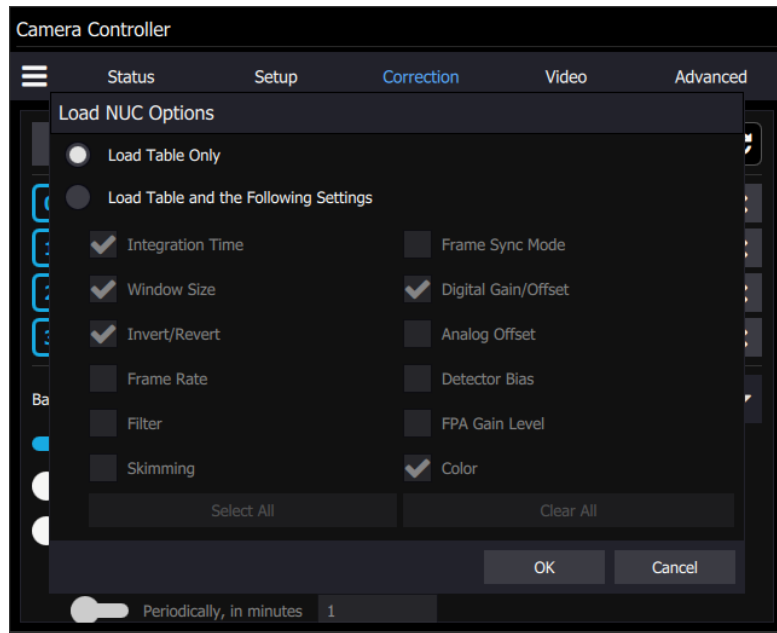
5.5.2 Manage NUCs

This dialog box allows the user to manage NUCs stored in non-volatile flash memory. Changes here will persist through a camera power cycle. For example, if you rename a NUC here and do not update the NUC loaded into RAM and the camera state, the camera will not be able to reload the NUC after a power cycle.



5.5.3 Load NUC Options

Typically, all the camera configuration parameters are derived from the current Camera State. When the camera is powered up, it loads the last saved camera state. The names of the NUCs are stored as part of the state. Normally the NUC is performed with the settings that are eventually going to be part of the state. If a NUC is loaded that has a setting that differs from the camera state, the state will override the NUC. If the user wants the NUC setting to override the state, then “Load NUC Options” can be set.

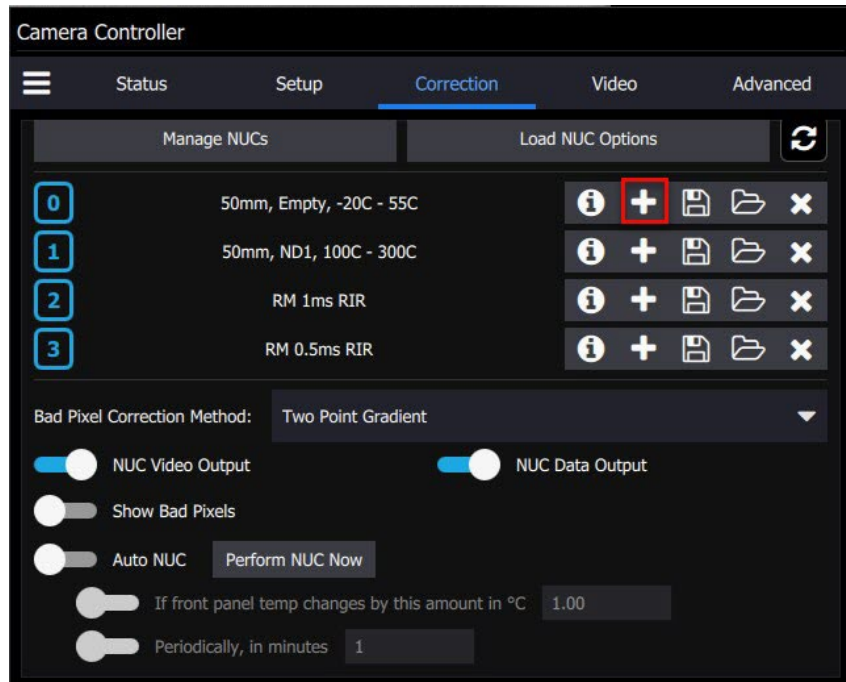


The default setting is to “Load Table Only”, in which case only the NUC coefficients are used from a NUC file. When the user selects “Load Table and the Following Settings”, the user can select which parameters from the NUC will override the current state. The option will not affect NUCs that are currently loaded into RAM, only those NUCs that are subsequently loaded from Flash memory. Unless a new state is saved, these override settings will not be remembered after a power cycle.

FLIR recommends that the user make use of the Load Table and the Following Settings option when operating the camera with user-created NUC tables, particularly when the window size has been modified from its full frame configuration.

5.5.4 Performing a NUC

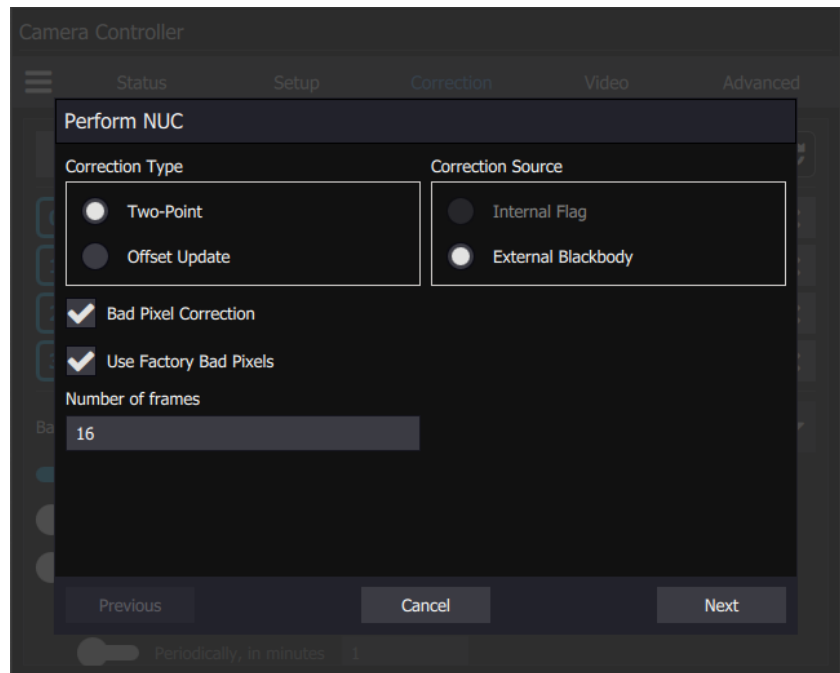
To build a NUC table using the camera electronics, select the *Perform Correction* icon to start the NUC Wizard for the desired preset.



NOTE: Due to differences in camera electronics and FPA timings it is important to perform the NUC with the camera operating modes configured as it will be used when imaging.

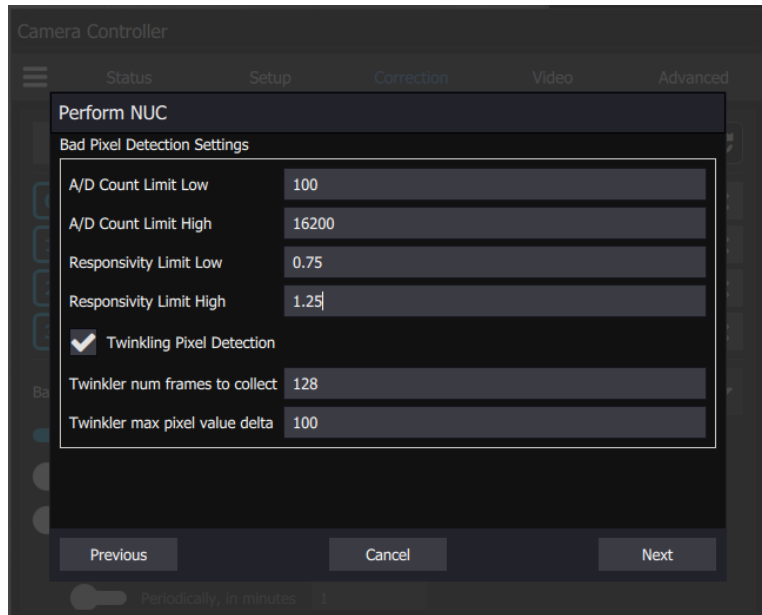
After selecting the *Perform Correction* a second window comes up to allow the user to select correction parameters. The user can choose between a Two-Point and an Offset Update. The Offset Update can be done with either the internal flag or an external blackbody. We recommend using an external blackbody for the Offset Update whenever possible to get the best uniformity because the correction will include any non-uniformities in the lens. It is also a good idea to set the focus of the lens to the desired setting before performing an Offset Update, otherwise subtle ring-shaped artifacts can appear in the image when viewing a very uniform scene.

When all selections have been made, click *Next>>* to continue.

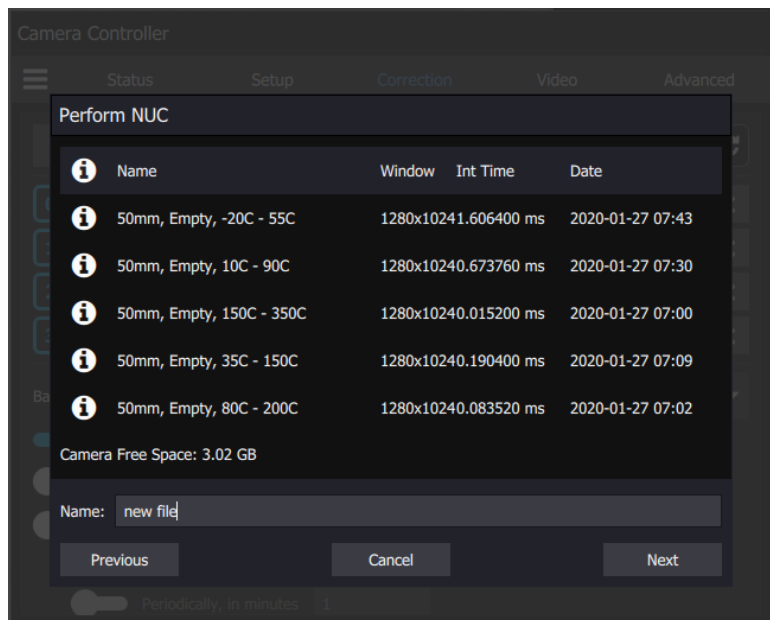


Correction (NUC) Types	
Two Point	Sets both the gain and offset terms. Uses two NUC sources. Computes a bad pixel correction.
Offset Update	Retains the current NUC gain terms and updates the offset terms. Uses a single NUC source. Retains the current bad pixel (BP) correction.
Correction Sources	
Internal Flag	Use the internal flag as the NUC source. Because the flag is not temperature controlled, it can only be used for 1-point and Offset Update NUC functions
External Blackbody	Use an external blackbody as the NUC source. Program will prompt the user to place each source in front of the camera. NUC source needs to fill the entire field of view.
Number of frames	Set the number of to average when computing NUC coefficients. "16 frames" is the default value, which works well for most scenarios. The value can be to be 2, 4, 8, 16, 32, 64, or 128.

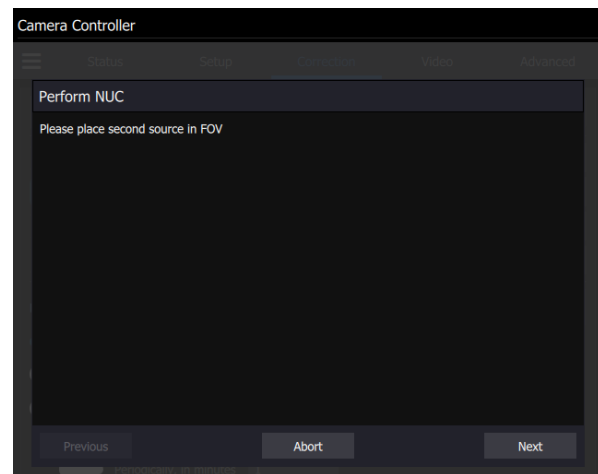
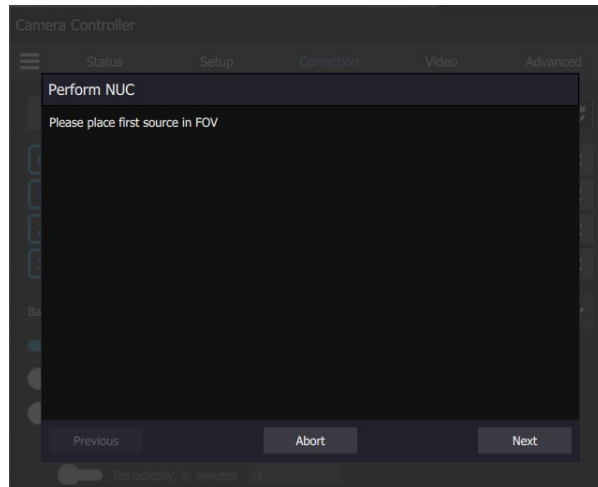
After configuring the correction parameters and selecting *Next>>* the next window allows the user to set up the parameters used for the Bad Pixel Detection. Once the parameters are set, select *Next>>* to continue.

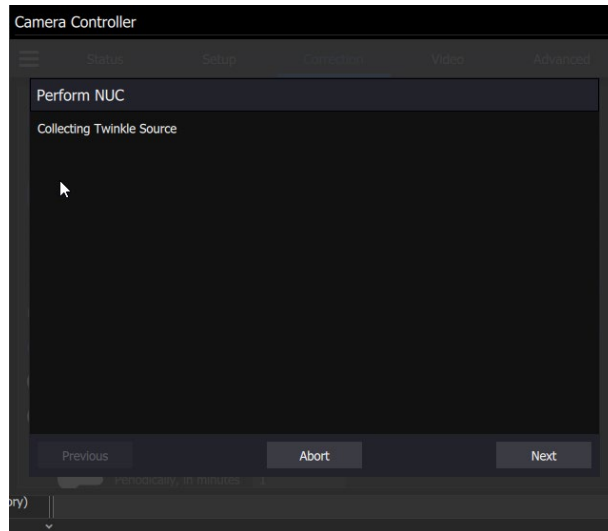


The next window allows the user to name the NUC. Simply type in the name for the table in the text box or select a previously saved file to replace it. Select *Next>>* to continue.

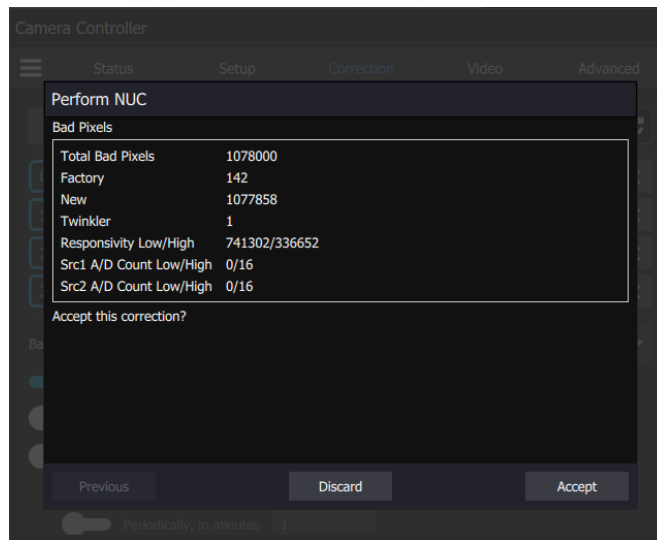


The next screens will collect data from the NUC sources. If using the internal flag, you will only see a few status messages. If using external blackbodies, you will be prompted. After each step, click *Next>>* to continue.





The last screen gives a report of the bad pixels found. The dialog shows how many pixels failed in each category. If the result is satisfactory, click **Accept** to save the NUC. The NUC table will be stored to flash memory and loaded into RAM memory for that preset. If the NUC gives a poor-quality image and you want to abort, click **[Discard]**.



NOTE: It is possible for a bad pixel to fail more than one category, so the total bad pixels may be less than the sum of each category. "Factory" bad pixels are those that were determined to be bad during camera production testing.

5.5.5 What is a Non-Uniformity Correction (NUC)?

Non-Uniformity Correction (NUC) refers to the process by which the camera electronics correct for the differences in the pixel-to-pixel response for each individual pixel in the detector array. The camera can create (or allow for the user to load) a Non-Uniformity Correction (NUC) table which consists of a unique gain and offset coefficient and a bad pixel indicator for each pixel. The table is then applied in the digital processing pipeline as shown in Figure 4-12. The result is corrected data where each pixel responds consistently across the detector input range creating a uniform image.

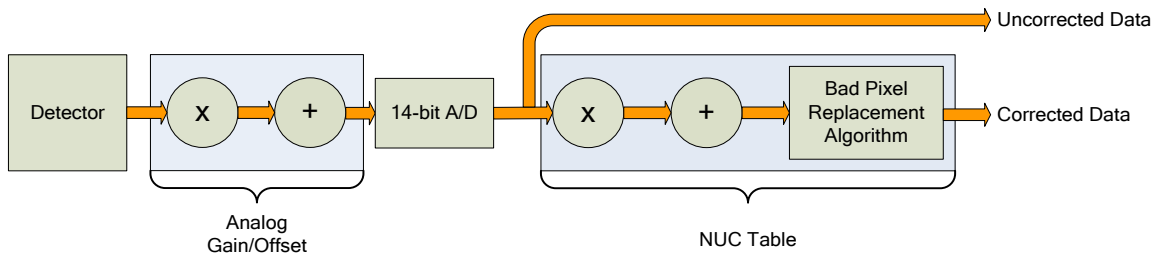


Figure 4-12: Digital Process Showing NUC Table Application

To create the NUC table, the camera images either one or two uniform temperature sources. The source can be an external source provided by the user or the camera's internal NUC flag which is basically a shutter the camera places in front of the detector. If the source is external it should be uniform and large enough to overfill the camera's field-of-view (FOV). By analyzing the pixel data from these constant sources, the non-uniformity of the pixels can be determined and corrected. There are two types of processes which are used to create the NUC table; Two-Point, and Offset Update.

5.5.5.1.1 Two-Point Correction Process

The Two-Point Correction Process builds a NUC table that contains an individually computed gain and offset coefficient for each pixel as seen in Figure 4-14. Two uniform sources are required for this correction. One source at the low end and a second source at the upper end of the usable detector input range. Because of the use of two images at either end of the input range, the Two-Point Correction yields better correction results. A two-point correct will also work better over a wider range of scene temperatures.

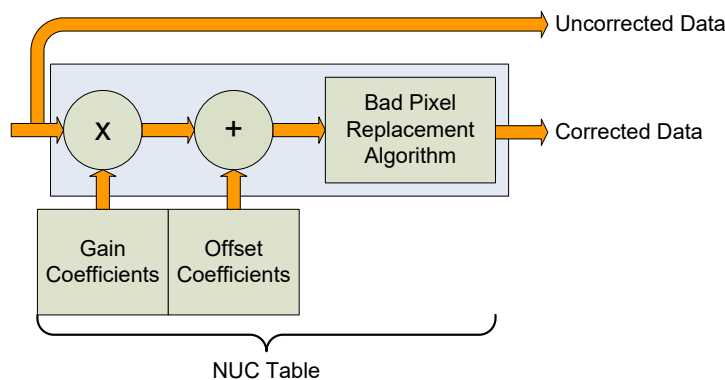


Figure 4-14: Two-Point Correction

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5.5.5.1.2 Offset Update

Often during the normal operation of a camera, the electronics and/or optics will heat up or cool down which changes the uniformity of the camera image. This change requires a new NUC. However, this change is mainly in the offset response of the image while the gain component stays constant. An Offset Update simply computes a new offset coefficient using the existing gain coefficient and corrects the image non-uniformity. Offset Updates are typically performed when a Two-Point NUC table is being used.

An Offset Update requires only one uniform source, usually set at a temperature on the lower edge of the operational range.

5.5.5.1.3 Bad Pixel Correction

Within the NUC table there is an indication if a particular pixel has been determined to be bad, as seen in Figure 4-15. There are two methods the camera uses to determine bad pixels.

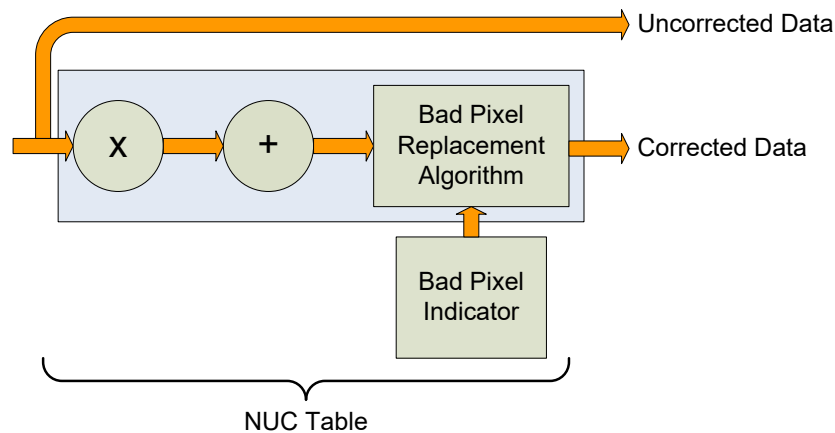


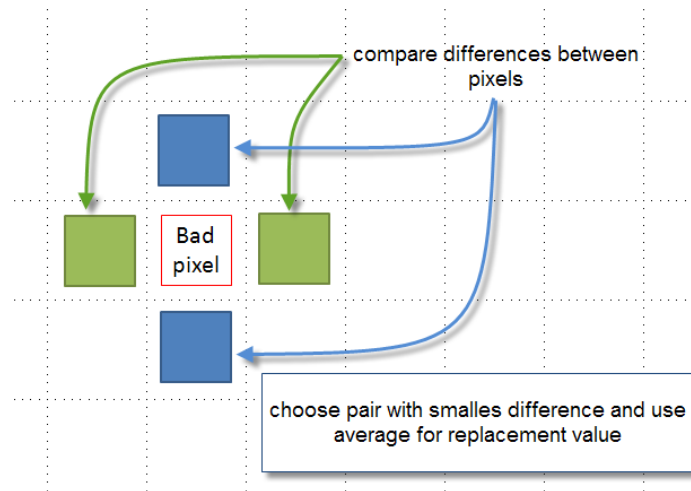
Figure 4-15: Bad Pixel Correction

First, the NUC table gain coefficients are compared to a user defined acceptance boundary, *Responsivity Limit Low/High (%)*. The responsivity of a pixel can be thought of as the gain of that pixel. The gain coefficient in the NUC Table is a computed value that attempts to correct the individual pixel gain, or responsivity, to a normalized value across the array. Since the responsivity value directly relates to the gain coefficient in the NUC table, the camera can scan the NUC table gain coefficients and use them to determine if a pixel's responsivity exceeds the limits as set by the user.

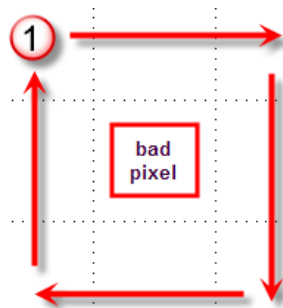
The second method of determining bad pixels is to search for twinklers. Twinklers are pixels that have responsivity values within normal tolerances, but still exhibit large swings for small input changes. These pixels are on the "verge" of being bad and often appear to be noisy. To find these types of pixels the camera collects N number of frames and records the maximum and minimum values across that sample set for each pixel. If the delta between max and min exceeds the *Twinkler max pixel value delta* then the pixel is determined to be bad.

The camera supports two algorithms for bad pixel replacement: 2-point Gradient, and Nearest Neighbor.

The 2-point gradient algorithm is the default bad pixel correction method. With this algorithm, the two pairs of pixels above and below and to the left and right of the bad pixel are evaluated. The algorithm compares the differences between the pixels and chooses the pair with smallest gradient (difference). It then averages the two adjacent pixels and uses that value for the replacement value. This algorithm is better at handling bad pixels near a high contrast edge and is the default method. If the algorithm encounters a situation it cannot solve (for example, an edge or corner) it will fall back on the nearest neighbor algorithm.

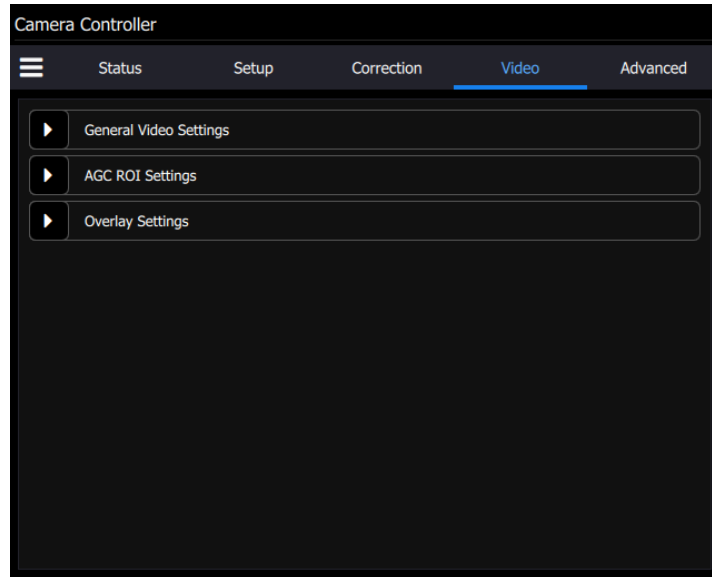


Nearest neighbor uses a simple replacement using an adjacent pixel. The adjacent pixel is picked using the pattern depicted below. When a bad pixel is near an edge, those search positions are skipped.

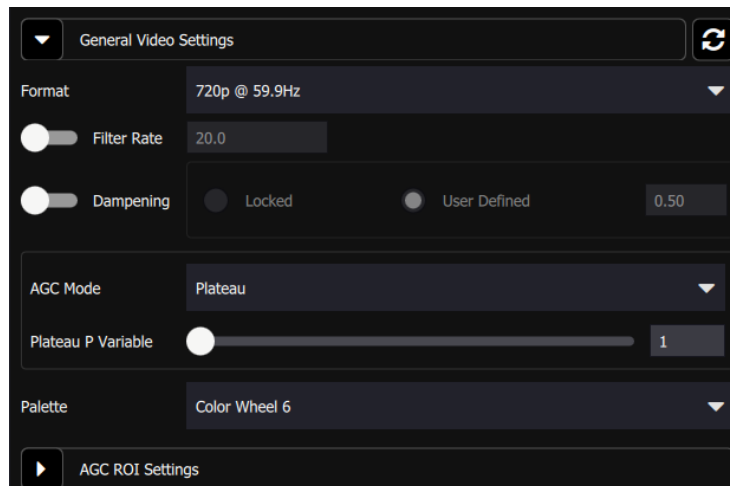


5.6 Video Page

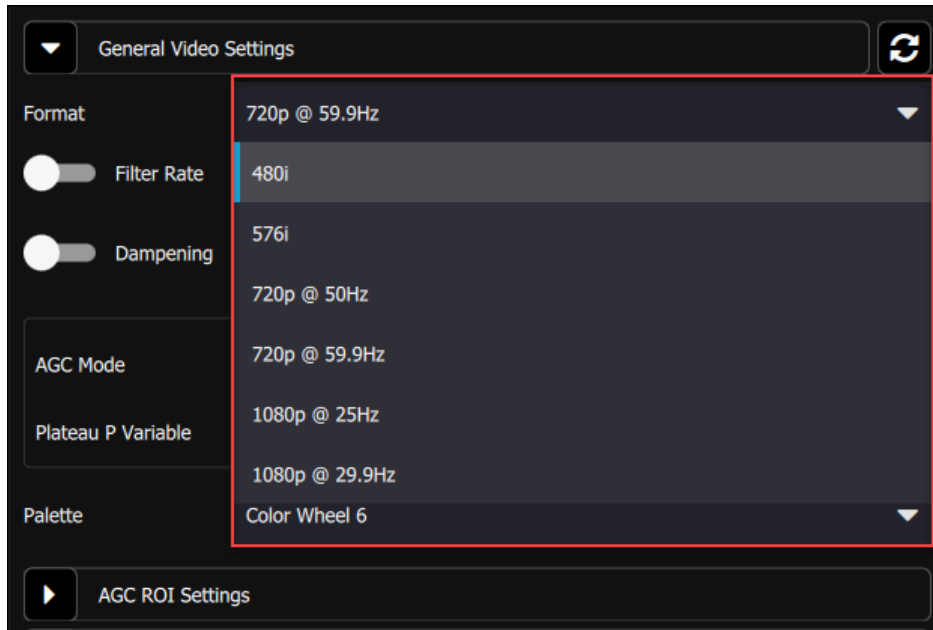
The camera has a 14-bit digital video output. However, the SDI output is only 8-bit. An Automatic Gain Control (AGC) algorithm is used to map the 14-bit digital to the 8-bit analog data. The Video Tab provides controls related to optimizing the Analog video output. **These controls affect only the HD-SDI video output.**



The general video settings include the image format, the filter rate and dampening.



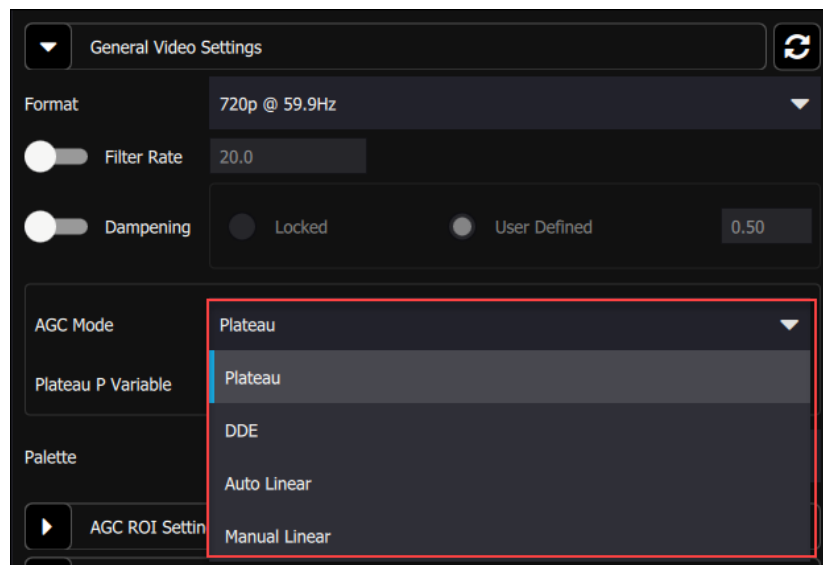
The formats for the video output are as follows: 480i, 576i, 720@50Hz, 720p@59.9Hz, 1080p@25Hz, 1080p@29.9Hz, NTSC (Square Pixel), and PAL (Square Pixel):



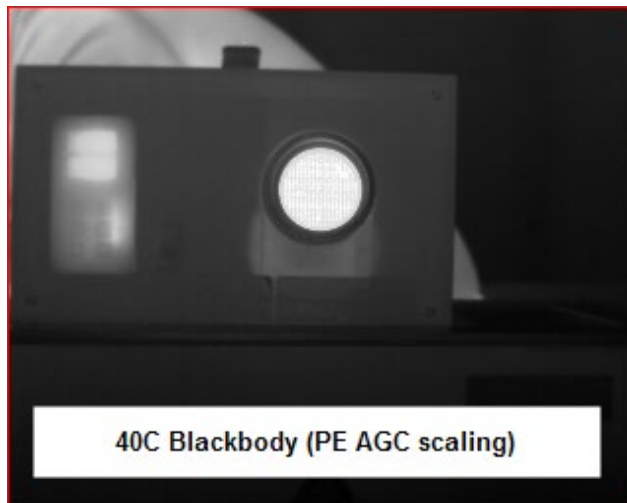
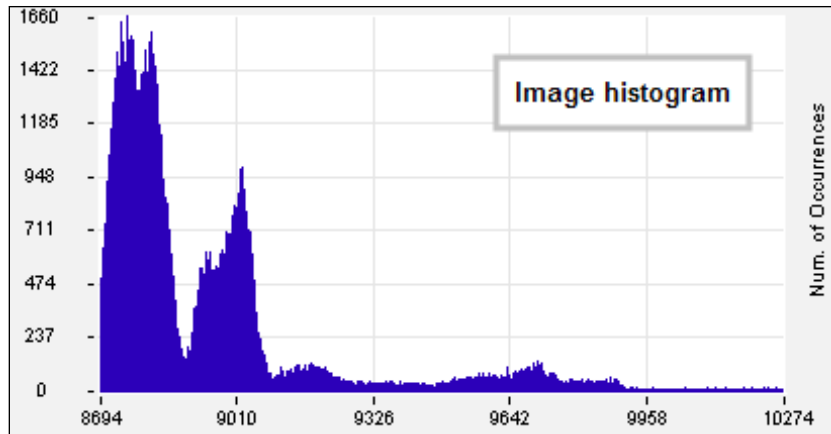
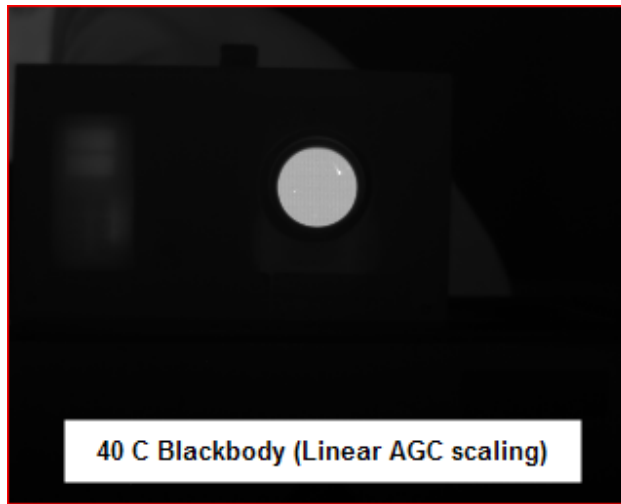
Analog Video Setup Options	
Format	HDMI/SDI: 1080p @ 29.9/25Hz, 720p @ 59.9/50Hz, NTSC, PAL
Overlay	Enables the video overlay.
Filter Rate	Rate at which AGC is computed (1 to 20 Hz). Enable with checkbox
Dampening	Rate at which AGC is allowed to change. This will keep the AGC from responding rapidly to fast tridents changes. Specified as a fraction from 0 to 1. This fraction is used as a weighting factor for the current AGC vs. the newly computed AGC. Setting this to 0 will “lock” the AGC to its current settings. Enable with checkbox.
AGC Mode	<p>Plateau: Uses a plateau equalization (PE) algorithm to scale the image data for video display</p> <p>DDE: Digital Detail Enhancement.</p> <p>Manual Linear: Scales the image data to a windowed section of data range as set by the user</p> <p>Auto Linear: Same as Manual Linear except camera analyzes image and sets limits at ~1% and 98% of the histogram.</p>
Plateau P	<p>Scaling factor for the Plateau Equalization function</p> <p>Note: Plateau P is only visible when AGC Mode>>Plateau is selected</p>

Analog Video Setup Options	
Bounds	Sets the lower and upper data range to be scaled to on the video data. Note: Bounds is only visible when AGC Mode>>Manual Linear is selected
DDE Sharpness	Only visible when AGC is set to DDE. Selects the amount of enhancement processing.
Palette	Allows user to select the color scheme to use on the analog video channel.

These are the different AGC Modes that are available in the Cooled A-Series Cameras:



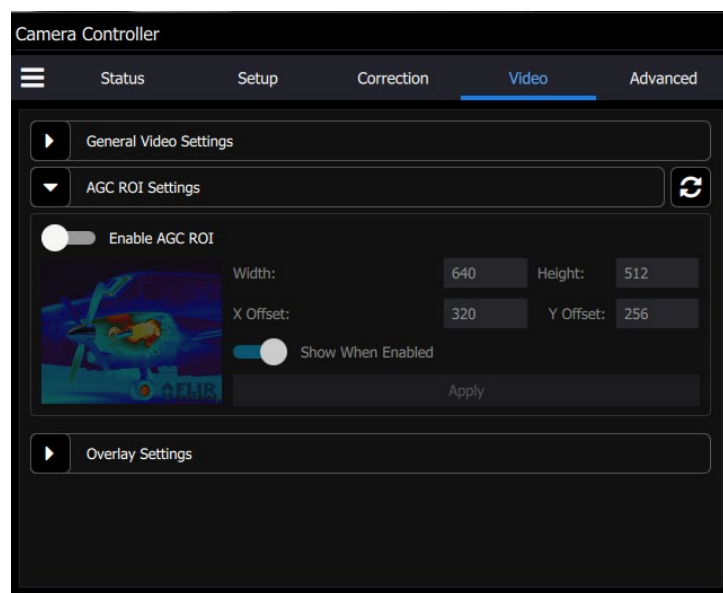
The Manual Linear algorithm evenly distributes the grayscale values over the digital values. This works fairly well if the image dynamic range is fairly evenly distributed but in general does not produce high contrast imagery, but it also does not saturate or clip the hot and cold regions either. The Plateau Equalization algorithm (also called PE) is a nonlinear AGC algorithm that uses the image histogram to optimally map the 256 gray scales. This algorithm works well for most scenes, but it works best when the scene has a “bi-modal” distribution (two clumps). It usually the most popular because algorithm because it produces high contrast (but more saturated) video. The following pictures illustrate the differences in AGC algorithms. (The data was captured from the digital output, but the effect is similar for the analog side.)



One final note about the PE algorithm: it is very aggressive. It can pull detail out of very low contrast imagery. It can also greatly enhance some very low-level NUC and FPA artifacts and noise if the contrast is low enough. This does not necessarily mean there is a problem with either the camera or the NUC.

5.6.1 AGC ROI Settings

The AGC ROI Settings panel allows the user to define a box region. Only the pixels within the box will be used to calculate the AGC coefficients. This is particularly useful if there is part of the scene that is much higher or lower in intensity than the target of interest. The ROI is defined by entering the size and position directly in the parameter fields or the user can use the mouse to drag the corners of the green box to create the desired rectangular region. The default is that the AGC ROI is not enabled, in which case the panel controls are grayed out:



When Enable AGC ROI is on, the panel controls can be accessed. The user can change the size and position of the box. At this point, the Apply button will not be grayed out. When the user hits the Apply button, the changes are made and the apply button grays out again. The Show When Enabled control makes the ROI visible on the SDI video as an overlaid rectangular frame.

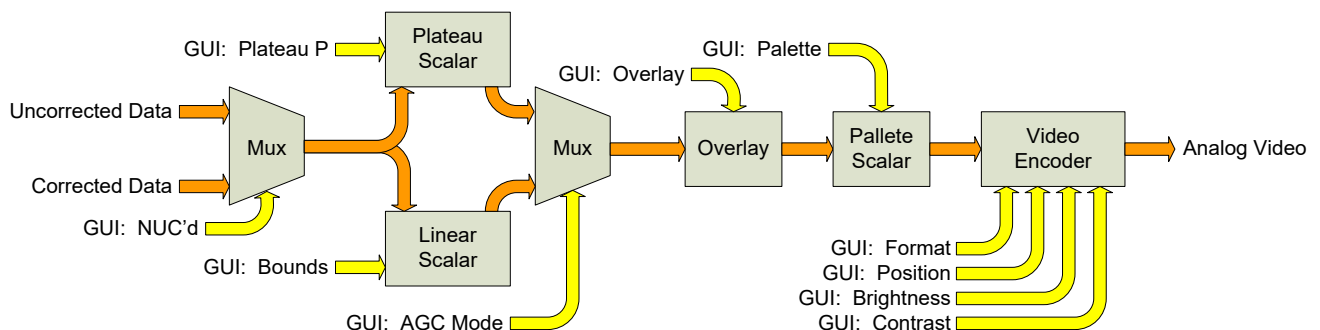
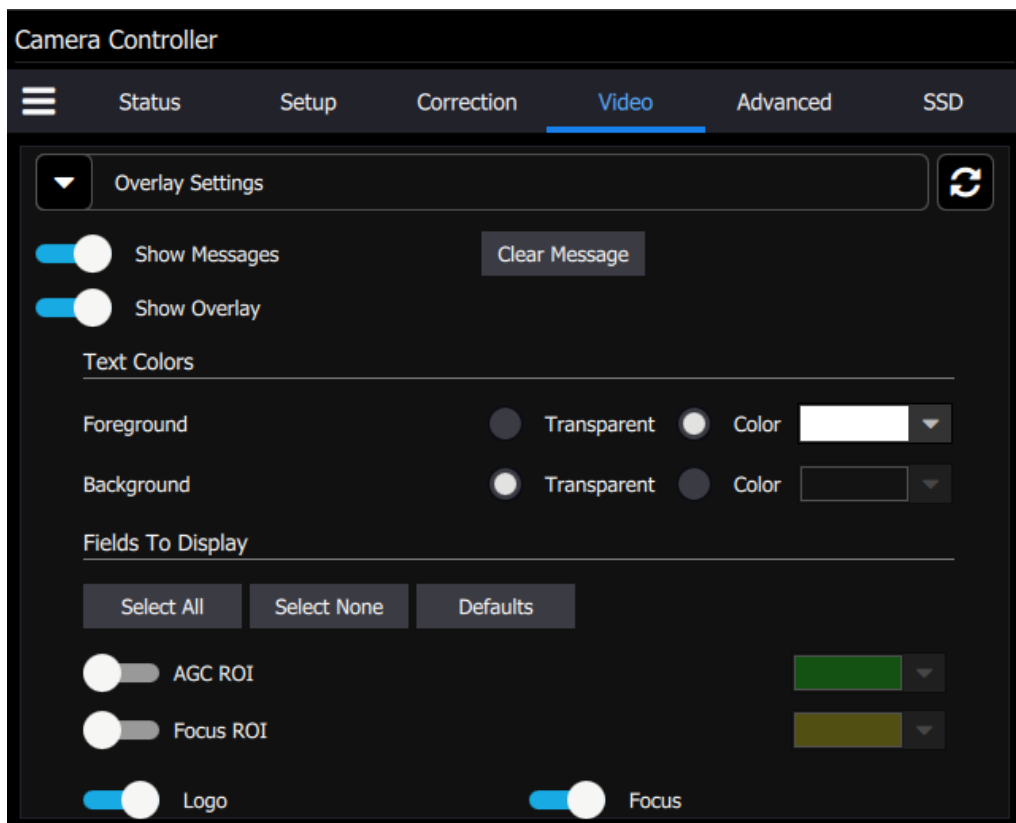
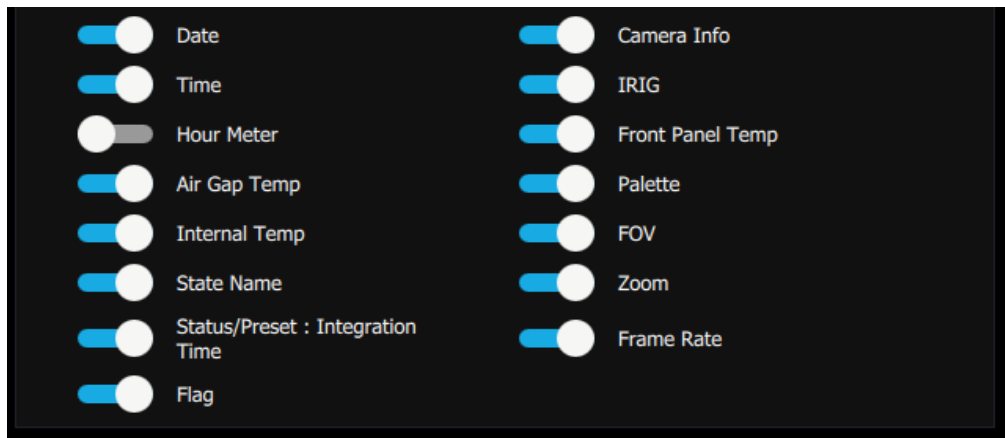


Figure 4-1: Analog Video Flow

5.6.2 Video Overlay Settings

The X-series cameras have a video overlay feature that can display a wide variety of camera status indicators on the analog video. This lets an operator see the camera status without needing to have a PC connected. The Video Overlay tab allows the user to control which parameters are displayed and what colors are used. The position of the checkbox in the dialog box give the approximate location the object will appear in the overlay. The position of the objects cannot be adjusted in the GUI, but the SDK allow the user to completely customize the look of the overlay. Options that are grayed out are either not supported by the camera or are not enabled in another part of the GUI.





Video Overlay Options	
Enable Overlay	Turns the overlay On or Off without changing the selected options
Logo	Displays the FLIR logo
Date	Displays the system date stamp
Time	Displays the system time stamp
Hour Meter	Displays the accumulated camera “on” time (H:M). (Cannot be reset by user)
Zoom	Display the level of Digital Zoom (x1, x2, x4), and position (C, F, O)
Front Panel Temp	Displays the temperature of front panel sensor in °C
Air Gap Temp	Displays the current temperature of air gap between front panel and internal chassis in °C
Internal Temp	Displays the current temperature of the internal chassis in °C
AGC ROI	Displays the ROI used to compute AGC values. Option is disabled if AGC ROI not enabled.
Flag	Displays the NUC flag status
Palette	Displays the current analog video palette name
Camera Info	Displays camera model and serial number
IRIG	Displays current IRIG time
Status/Presets	Displays sequencing mode and currently displayed preset
Frame Rate	Displays FPA frame rate (in single Preset mode). Displays effective rate when Preset Sequencing (PS) or Superframing (SF)
Select All	Selects all overlay options
Clear All	Deselects all overlay options
Defaults	Selects default overlay options (stored in current camera state)

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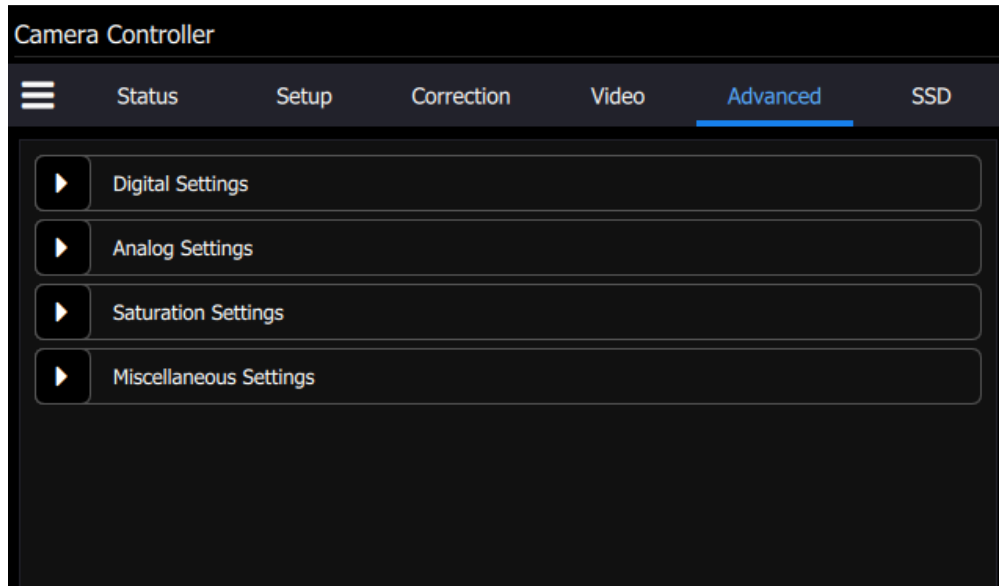
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Video Overlay Options	
Text Color	Selects overlay text color
Text Background	Selects overlay background color
AGC ROI Color	Selects AGC ROI Color
Show Messages	Displays special status messages
Clear Message	Clears current special status message display but new messages will be displayed

5.7 Advanced

The Advanced menu contains four submenus. They are Digital Settings, Analog Settings, Saturation Setting, and miscellaneous setting.

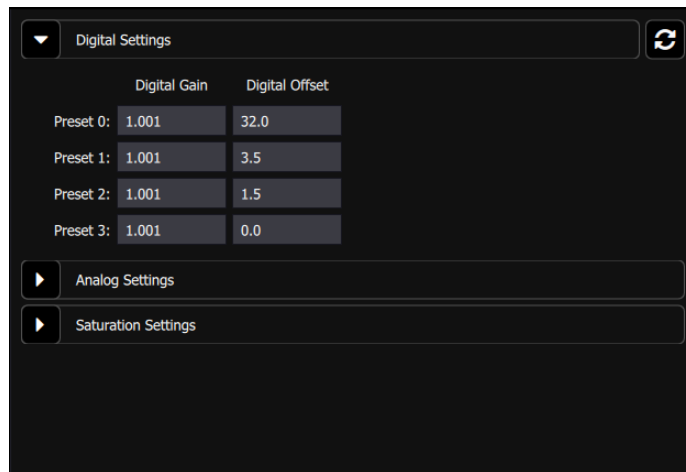


5.7.1 Digital Settings

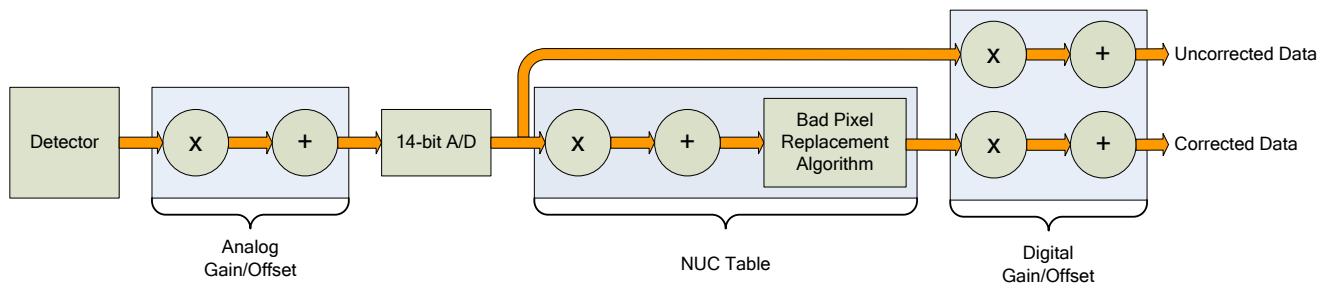
The digital settings menu contains digital gain and digital offset values for each of the four presets. If a Factory Calibration is loaded into a preset, then these boxes will be populated with values that are derived from the Tdrift compensation, and the user is NOT allowed to change the values. If the user attempts to change them, a red outline appears around the box.

	Digital Gain	Digital Offset
Preset 0:	1.000	0.0
Preset 1:	5	3.0
Preset 2:	1.001	1.5
Preset 3:	1.001	-0.5

If a preset does not have a factory calibration loaded, then it is possible to edit these values, as shown below:



The digital gain and offset stages are digital features of the camera that allow the corrected digital output of the camera to be mapped to different output ranges. The following diagram illustrates the position of these stages in the signal path:



X-Series Signal Processing Chain

The analog FPA data is passed through an analog gain and offset stage that are factory-set to ensure that the entire range of the FPA output is matched to the A/D input. This is shown in the figure below, which plots the digital output of a typical camera against background photon flux. The actual scale of the flux depends on integration time setting. The figure shows an example where the user desires to operate the camera between two flux points such that these two limits use the entire 14-bit range. With no global gain and offset adjustment these two points correspond to 3200 counts and 15800 counts for the low and high flux ranges respectively. Having obtained these numbers, we set the gain to use the full 14-bit range:

$$gain = \frac{16383}{15800 - 3200} = 1.30$$

Since the offset stage is *after* the gain stage, we calculate the offset value using the gain:

$$offset = -3200 \times gain = -4160$$

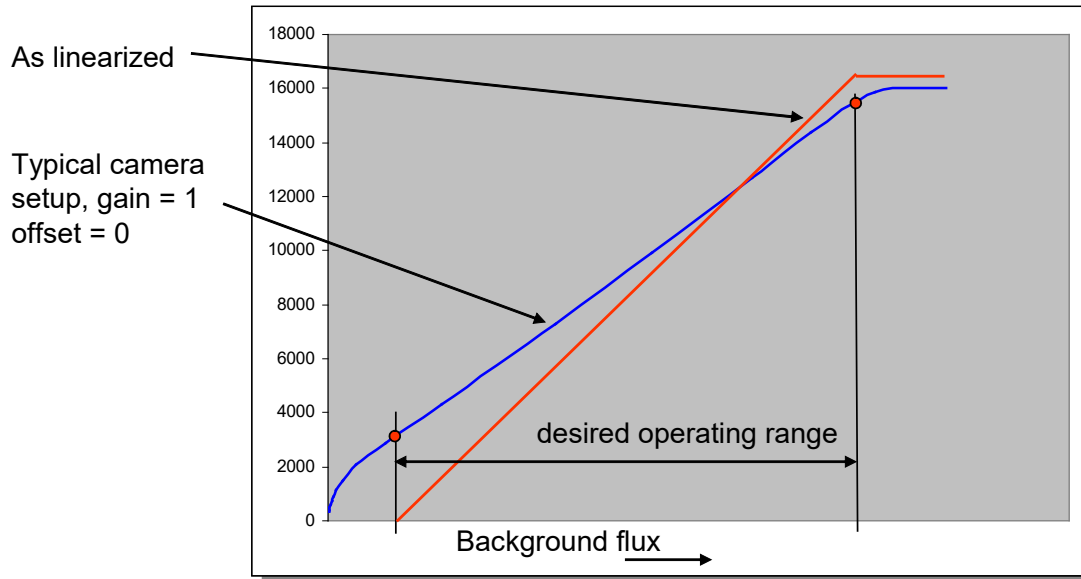
These values are then entered into the global gain and offset controls and the linearized (red curve) transfer function shown is the result.

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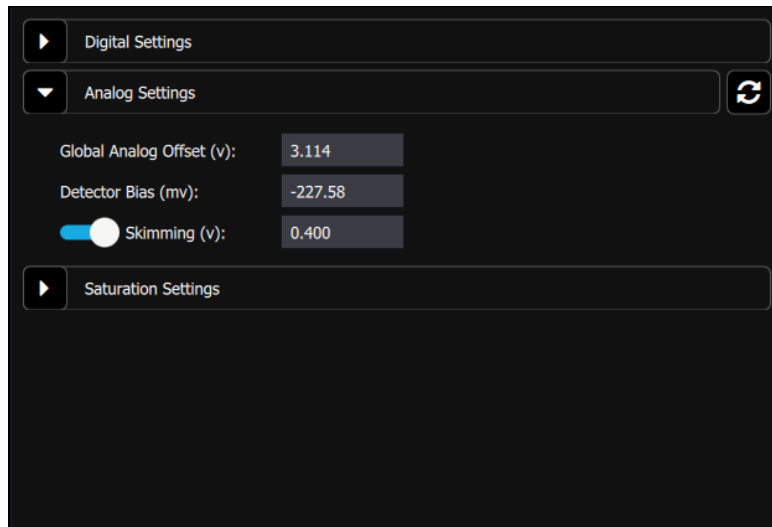
The available gain range is 1.999 to essentially zero; the available offset range is $\pm 32,767$. The default values are a gain of 1 and an offset of zero. Because the system sensitivity ($NE\Delta T$) is set prior to the A/D stages, there is no detrimental effect on performance from the use of the global gain and offset controls.



Use of global gain and offset to linearize the camera

5.7.2 Analog Settings

These controls are set at the factory for the focal plane array in the camera. The controls are intended only for the power user who should consult with FLIR application support before changing these values.



5.7.2.1.1 Integrate Active Polarity

Sets the polarity (active high or low) of the Integrate Active signal on the camera rear chassis AUX connector.

5.7.2.1.2 IRIG Latch

The X69XX and X85XX cameras place the IRIG time in the header for each frame of video. The X69XX and X85XX can latch the IRIG data at the start of a frame, *Frame Start*, or in relation to the integration time, *Integration Start* or *Integration End*. Depending on the frame process the Frame Start may indicate the time the integration starts or the time data is being passed out the camera. Latching the IRIG time on Integration Start or End marks the time the actual camera “exposure” occurred. The user should select the IRIG Latch value based on what action within the camera they need to know the exact time of.

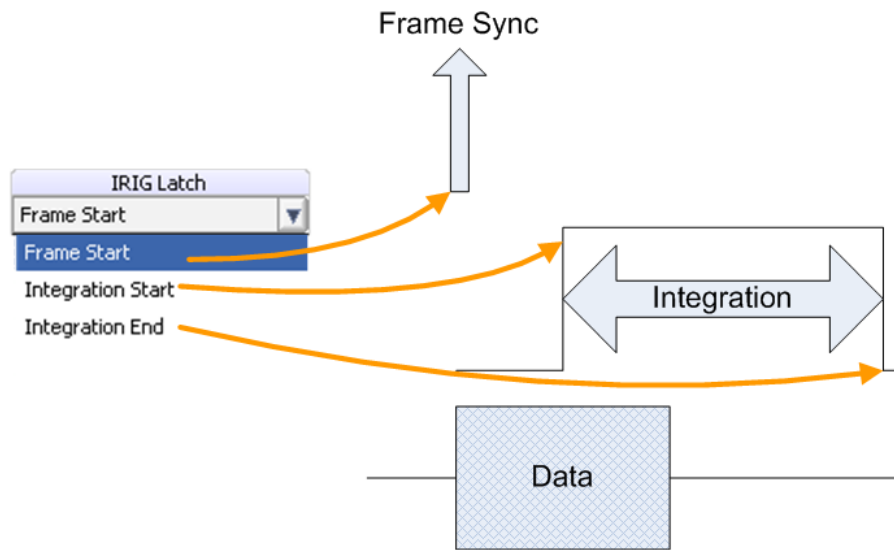
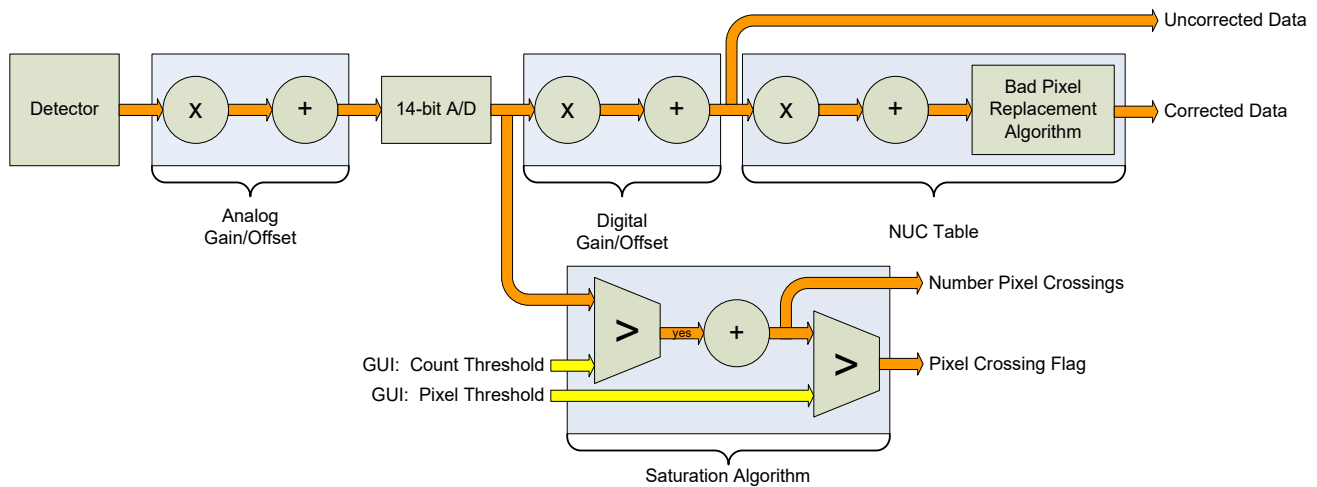


Figure 4-2: IRIG Latch Positions

5.7.3 Saturation Settings

These settings control the flag for saturated pixels. If the criteria for saturation is met, then a flag in the metadata switches to T from F. The Count Threshold value is the count value above which a pixel is considered to be saturated. Pixel Threshold is the number of pixels that need to meet the Count Threshold condition in order to trigger the Saturated Pixels flag.

	Count Threshold	Pixel Threshold	Saturated Pixels
Preset 0:	15000	500	19
Preset 1:	15000	500	0
Preset 2:	15000	500	0
Preset 3:	15000	500	0



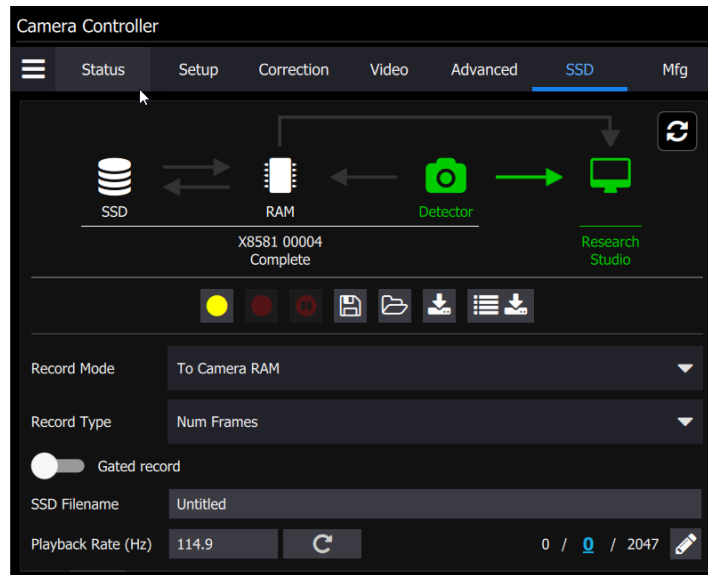
Saturation Detection

One example of this feature is to use the information to adjust the integration time. If the A/D count threshold is set to 75% of the full value (12,288) then the camera will count the number of pixels that are within 25% of saturation. If a set number of pixels fit that criterion, then the integration period should be lowered.

It is important to note the camera does not account for bad pixels when counting for saturation. When determining the threshold the user should account for the typical number of bad pixels.

5.7.4 SSD Page

The SSD (Solid State Drive) page allow the user to control the functions related to the on-board recording system. The X-Series cameras incorporate FLIR's Digital Video Image Recorder (DV-IR) system. The DV-IR system is a high-performance recording system that allow the camera to record the image stream at any frame rate supported by the camera with zero dropped frames.



The DV-IR system is comprised of two main components: (1) the RAM buffer and (2) the SSD drive storage. The RAM buffer consists of 16GB of DDR-3 RAM. The RAM buffer is not removable but is volatile. All data in the buffer is erased when the camera is powered off. Because the buffer is volatile it is important that the camera power not be interrupted until the buffer data has been stored to another non-volatile storage medium. The primary non-volatile storage mechanism is the integrated SSD drive. The data in the RAM buffer can also be played back within Research Studio over the “live” digital interface or can be downloaded to the PC as an ATS or SFMOV file using the camera controller within Research Studio (v2.1 or later). The file download can use any of the camera interfaces (GigE, Camera Link, CoaXpress) that is connected to Research Studio.

The camera uses standard form factor flash drives (2.5-inch SATA) used in PCs and laptops which can be obtained from a variety of retail outlets. FLIR recommends the use of high-performance SSD drives with a sequential write speed of 530MB/sec or faster.

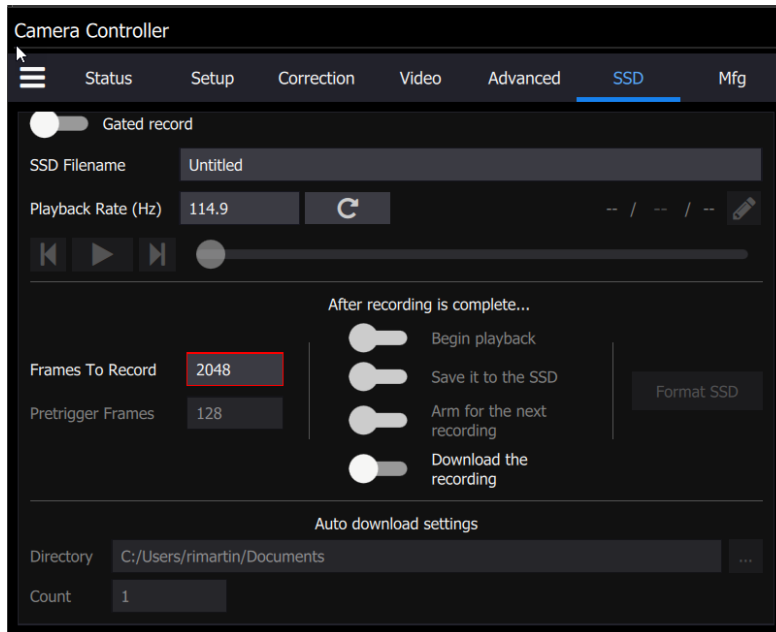
IMPORTANT NOTE REGARDING THE SSD FORMAT: The DV-IR SSD is not formatted as a normal Windows OS drive (such as NTFS). A proprietary drive format is used which is more efficient for high-speed recording. Because of this, the drive contents cannot be viewed directly in Windows Explorer. FLIR Research Studio (FRS) can be used to view/play the contents of the DV-IR RAM or SSD directly on the camera or the SSD contents can be accessed by using a commercially available SATA to USB adapter, such as the one provided with the camera. In order to store the recordings on a Windows accessible media, they must first be extracted and saved to an ATS or SAF file using FRS.

If the camera has Firmware Updater version 1.4.3 or higher (with the exception of 1.4.25), then the camera controller will have the ability to download data directly to a file on the PC.

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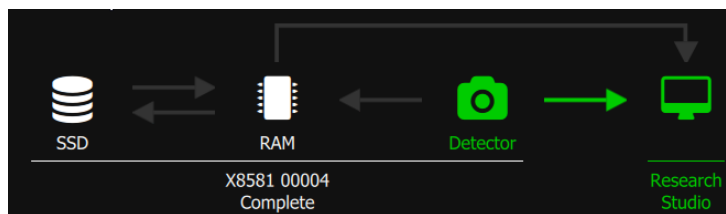
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5.7.4.1 Recording Controls






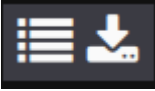
At the top of the SSD Page is a graphical diagram which depicts the data flow based on the currently selected options.



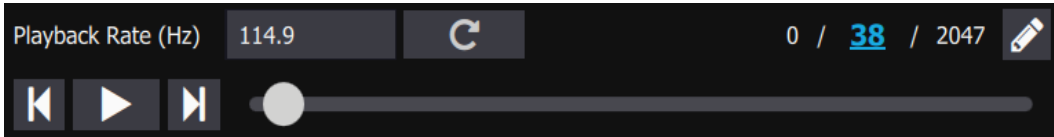
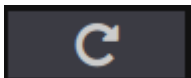


Recording Controls	
<p>Arm for Recording</p> 	<p>Prepare the system for a new recording. Once “armed”, the buffer will be configured according to the settings for record mode, type and pre-trigger frames. The system will start recording if the Record button on this page is pressed or if an external signal is applied to the RECORD input on the rear panel of the camera.</p> <p>NOTE: Any data currently in the RAM buffer from a previous recording WILL BE LOST once the system is armed.</p>
<p>Start Recording</p>	<p>Pressing this button will start the recording of live data to RAM or SSD. This</p>

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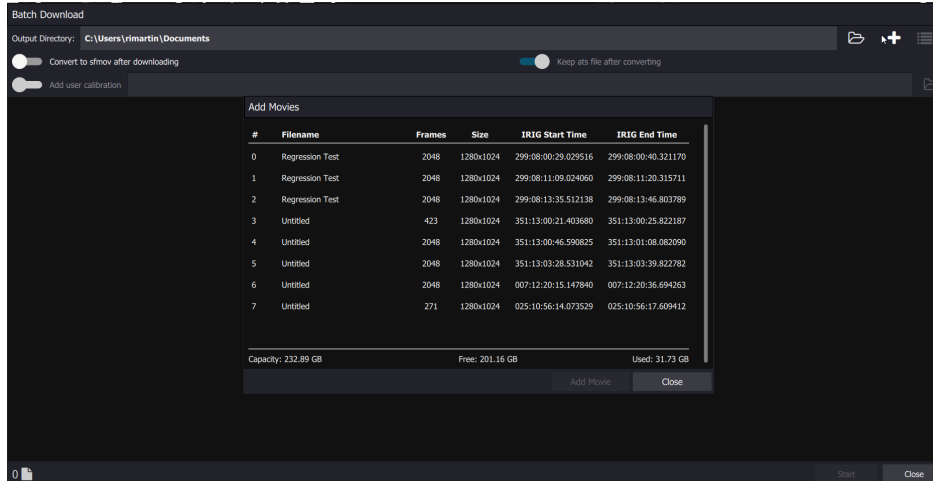
Recording Controls	
	button will be disabled until the system is armed.
Record Pause 	When a recording is active, pressing this button will pause the recording. This allows the user to avoid long gaps in a recording.
Save to SSD 	Store a RAM recording to the SSD
Load movie 	Allow the user to browse the SSD and choose a file to load back into RAM for playback.
Download Movie 	Download the movie currently in RAM to the PC. The entire movie or a portion can be downloaded. Will use the camera interface being used for “live” data.
Batch Movie Download 	User can select multiple movies stored on the SSD for download to the PC. Names can be chosen, and files can be stored in ATS or SFMOV.
Record Mode	User can select to record “To Camera RAM” or “to SSD”. These options are only available to X6980/X8580 series cameras or X69XX/X85XX series cameras with “X-refresh” firmware.
Record Type	There are three types of recording available 1. Num frames: The user specifies recording length as a specific number of frames. If mode is “To RAM”, Pre-trigger frames can also be specified 2. Duration: The user specifies recording length in time units. 3. Start-Stop: The recording is started and stopped manually by the user using the record controls in the camera controller or the record start input on the back of the camera. The recording will continue until the user stops it or until the available RAM/SSD storage is full.
Gated Record	This options controls the mode of the Record Start input on the rear panel. Off: Recording start is edge triggered. Record Type defines duration On: Recording start is level triggered. Recording active until when level drops or recording limits are reached.

Recording Controls	
SSD Filename	The text name given to the movie. This will be displayed in the SSD movie listing. Movies are organized on the SSD based on a unique index number assigned by the camera. The name is optional and if the name is not changed the same name will be given to multiple movies. The unique index will prevent that data would be overwritten.
Playback mode 	 <p>When the play icon is clicked the camera enters Playback Mode. All controller tabs are replaced with a playback indicator banner and playback controls become active. Playback can be paused.</p> <p>Click “Back to Live” to return the camera to “Live Imaging Mode”</p>
Playback Controls	 <p>Data will be played at the rate indicated in the “Playback Rate” control. Setting a rate slower than the acquisition frame rate will result in a “slow-motion” playback effect. The data playback will occur over all interfaces simultaneously (GigE, Camera Link, CXP, video). Only Camera Link and CXP can handle the full frame rate of the camera. GigE will drop frames if the data playback is too fast. User can choose the playback limits. The start and stop frame can be set using the edit tool. The gray bar controls the current playback position. The current frame and can be set by clicking the blue text. The handle on the bar can be dragged using the mouse to set the current frame or by using the scroll wheel. The adjacent to the play icon can advance/rewind a single buffer frame at a time.</p>
Playback Rate	The rate, in Hz that data is played back from the RAM buffer.
Frames To Record	Sets the total number of images frames to be collected in the RAM buffer. This includes pre-trigger frames.
Pretrigger Frames	Set the number of frames to record prior to the trigger event. Once the recording system is armed, the camera will continuously write images to the RAM buffer. When the recording is triggered (either by the REC button in the controller or using an external trigger signal), the trigger frame is marked in the buffer.
Begin Playback	If enabled, RAM buffer playback will start immediately after recording ends.
Loop Playback 	If enabled, the playback will loop continuously until stopped by the user.
Save it to the SSD	If enabled, the RAM buffer will be automatically saved to the SSD once the

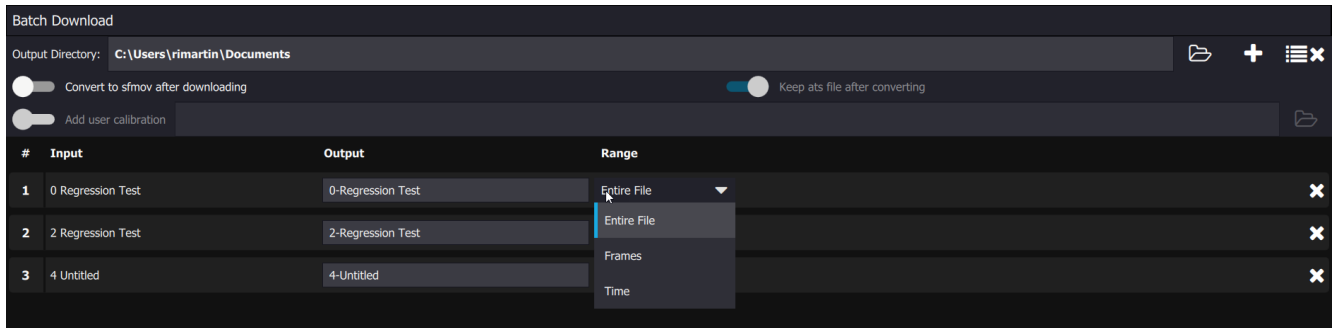
Recording Controls	
	recording is completed.
Arm for next recording	If enabled, Camera will re-arm after data is saved to SSD. Requires “Save it to the SSD” to also be enabled
Download the recording	If enabled, data will be automatically downloaded to the PC.
Format SSD	This button can be used to clear the SSD drive. It is NOT a secure wipe. It only clears the Movie Allocation Table (MAT). NOTE: Although movies can be individually deleted using the folder icon, this does not necessarily make more space available for recording. In order to achieve consistent performance, the recording system must start new recordings at the end of the last recording.
Auto Download Settings	These designate the destination directory and allow for an automatic counter to be put in the filename, which will be appended to the SSD Filename field to create a unique name.

5.7.4.2 Batch Download to PC

The batch download to PC feature allow the user to select multiple files at once. Click the “+” button to launch the file browser. Use the Ctrl and Shift key to select the desired files.



Once all the files are in the list, you can change the destination directory, edit the names give on the PC side, and set the range of date saved for each file



5.7.4.3 Installing the SSD

The SSD storage is removable. It is a commonly available 2.5 inch SATA solid-state drive. The drive slot is located at the top of the camera’s rear panel, as shown below. The drive slot is normally covered by a removable cap. To remove the cap, loosen the captive thumbscrews. The cap is mainly needed to secure the SSD when transporting the camera, or if there is a possibility of vibration that could unseat the drive. If the cap is not desired, it can be stored on the top of the camera, using the screw holes located on the right side of the upper heatsink, below the handle. With the cap removed, and no drive installed, the slot is still covered by a spring-loaded door.

To install an SSD, insert the drive, connector end first, into the slot. Simply push the drive through the spring loaded door until it seats in the connector. The back of the drive will protrude slightly. This allows the drive to be gripped for removal. To remove the drive, simply pull the drive out. (There is no eject or release mechanism).

The drive is hot-swappable and can be inserted or removed with the camera powered on or off. If the camera is on the SSD light on the rear panel will illuminate when a drive is detected.



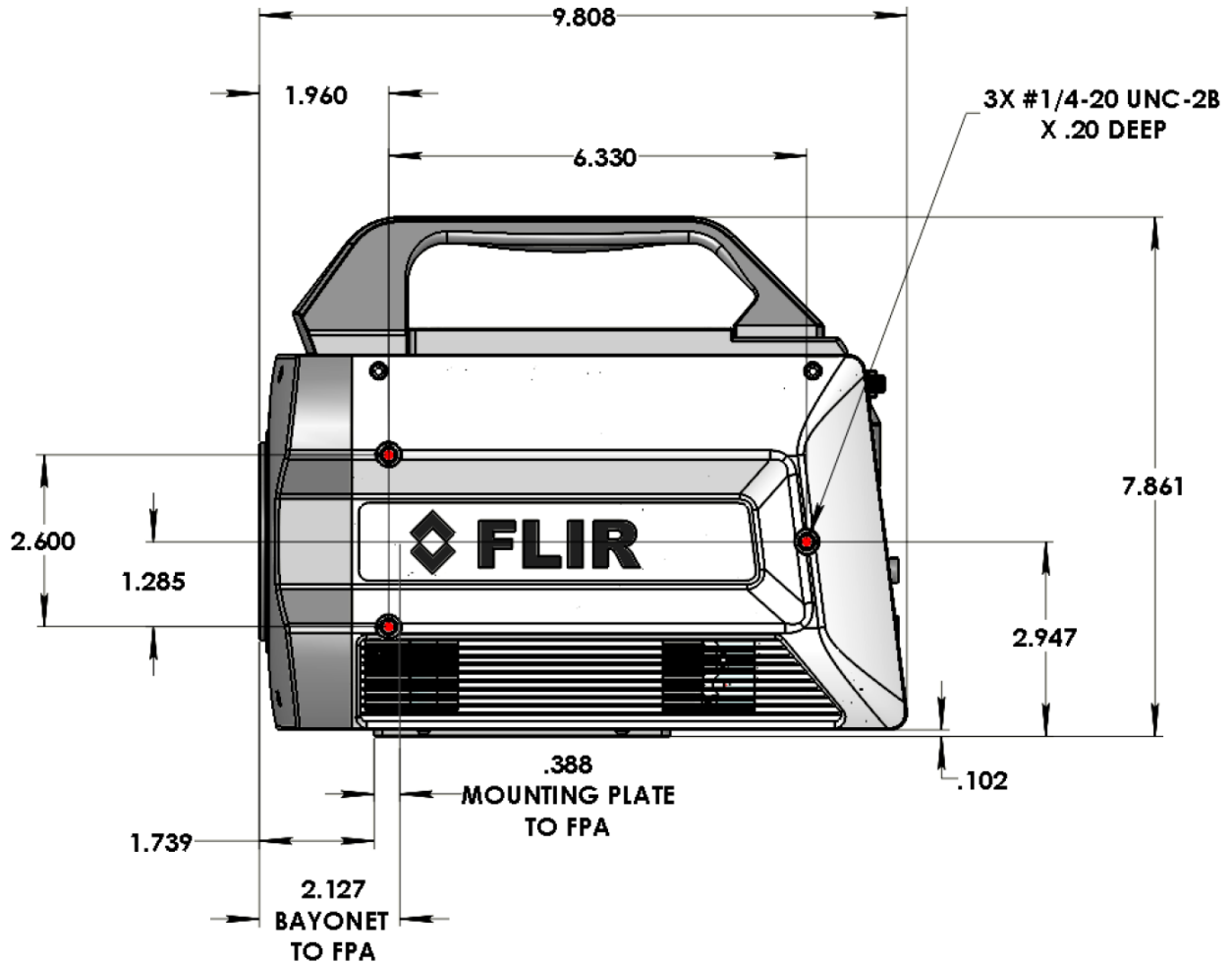
The only time the drive should not be removed is when data from the RAM buffer is being written to the SSD.

Here is a typical commercially-available 2.5 inch SATA solid-state drive one can easily buy online for the X-series. These 2.5 inch drives can be had up to 4TB: FLIR recommends drives with a sequential write speed of 530MB/sec or greater.

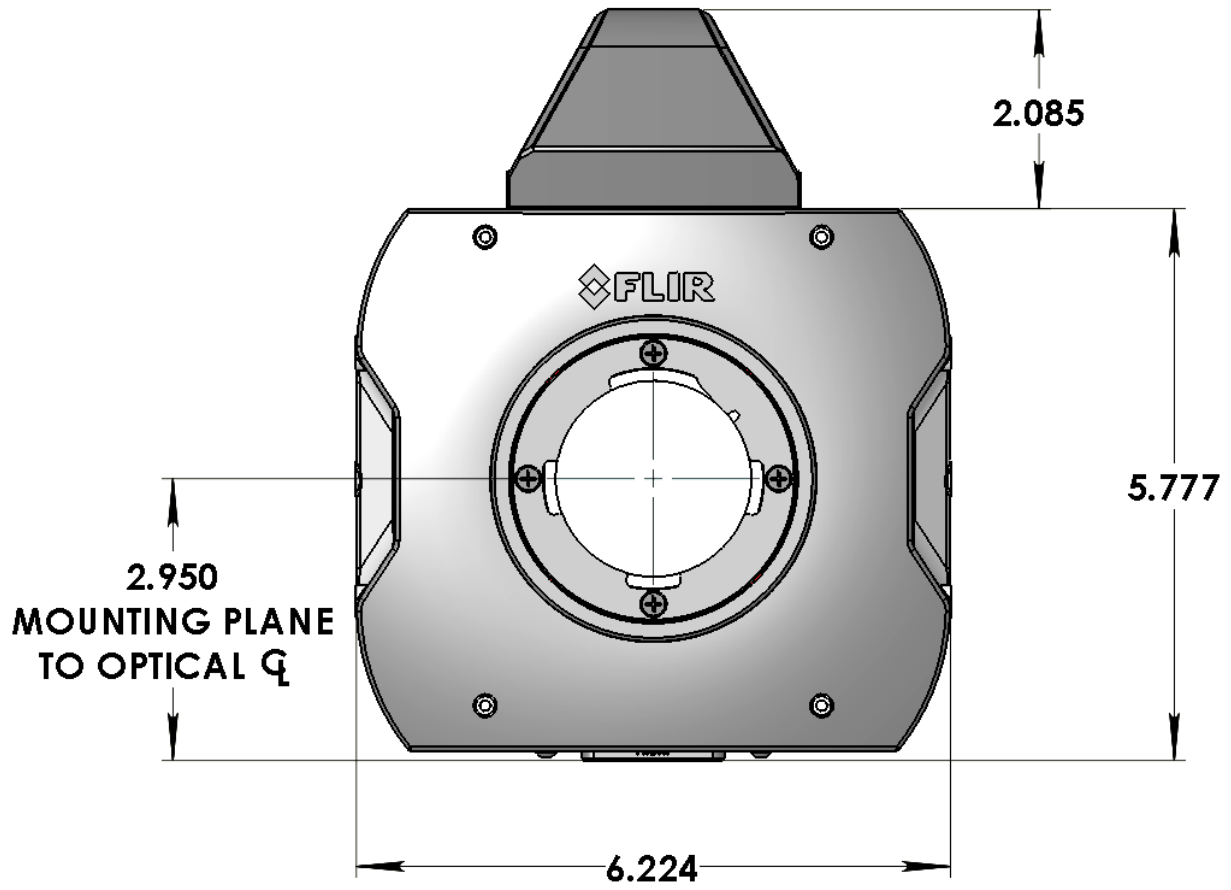


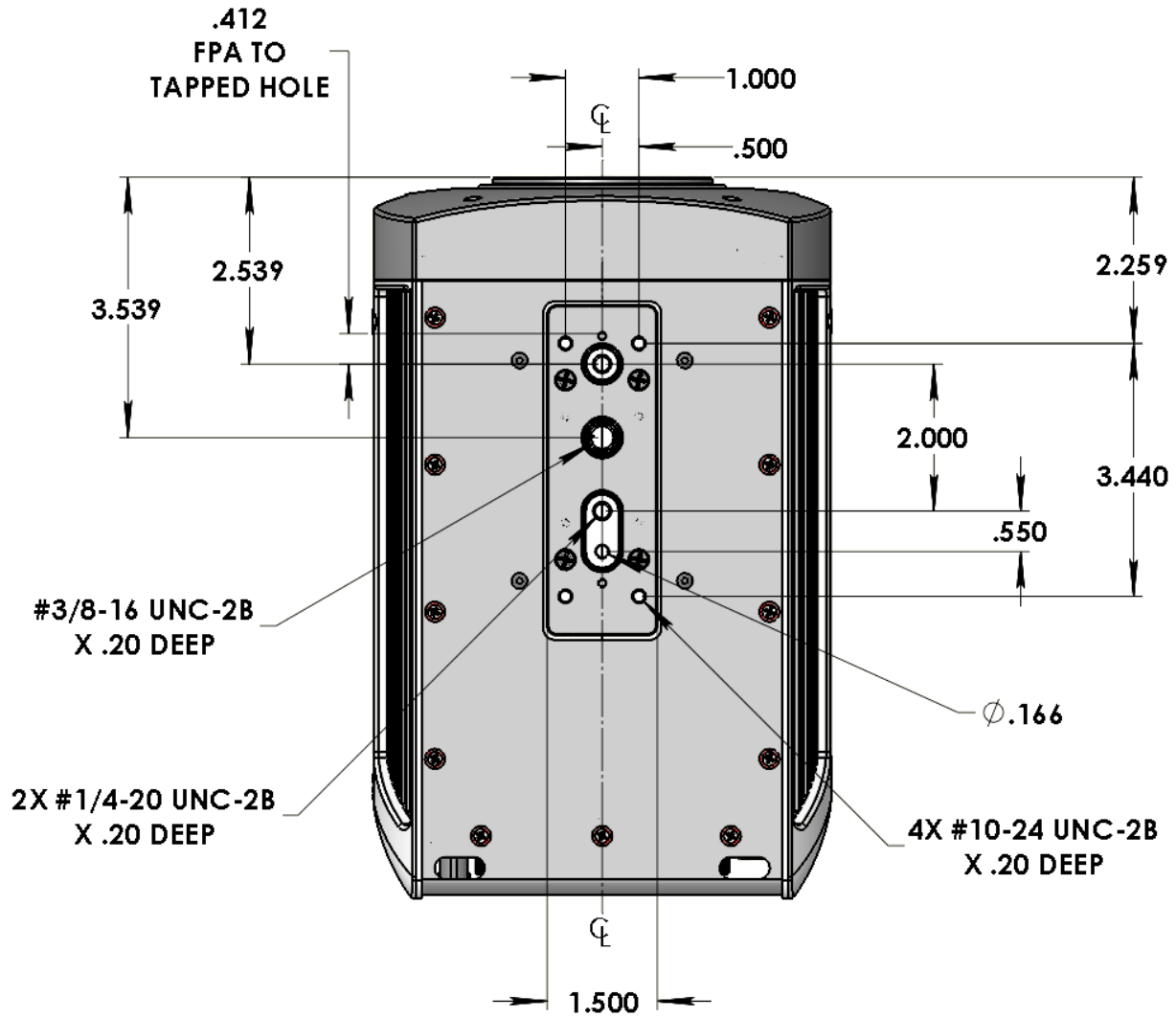
6 Interfaces

6.1 Mechanical Dimensions



Side view of X-Series cameras with 4-tab bayonet lens interface and filter wheel





Front and bottom view of X-Series cameras with filter wheel

6.2 Rear Panel– X85XX and X69XX Series

The X85XX and X69XX-Series cameras interface to the host computer through a variety of industry standards and camera specific signals. All pinouts and connectors are commercial standard types. All connections are on the back panel of the camera, as shown below. The last digit of the following section numbers corresponds to the callout numbers on the picture below.



6.2.1 Power Switch



Illuminates when camera power is ON. Switch is mechanical and retains its ON/OFF status through a power cycle. Camera power cannot be controlled remotely.

6.2.2 Solid State Drive

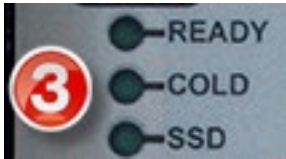
The X-series cameras use a standard form factor 2.5 inch SSD that is used in PCs and laptops and can be obtained from many retail outlets. A 512GB high performance SSD is provided with the cameras, and SSD drives with capacities up to 4TB are available. Using a high performance SSD (sequential write speed of 530 MB/sec or greater) will result in faster data transfers from RAM to the SSD.

The SSD is hot-swappable and can be removed at any time, EXCEPT when data from the RAM buffer is being written to the SSD. To remove the drive, remove the SSD cover. The cover is held in place by two thumb screws. The cover is optional but provides additional mechanical stability and provides accidental drive removal. Cover can be stored using screw holes located on side of the top handle. Then simply pull the drive from the slot. To insert the drive, insert the drive label up, connector end first into the drive slot until you feel the connector seat.



6.2.3 Status Lights

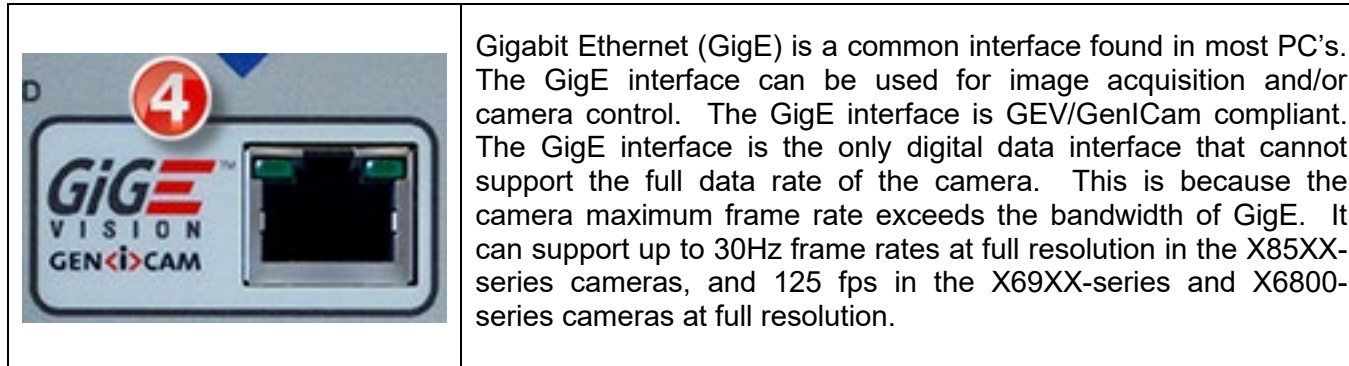
The X85XX and X69XX-Series cameras provide a set of status indicators on the back panel to give the user some visual feedback on the camera operating state.

	<p>READY: When on, Camera electronics have completed boot up. Camera is ready to accept commands.</p>
	<p>COLD: When on, this indicates that the FPA has reached operating temperature (<80K).</p>
	<p>SSD: When on, this indicates that camera detects a Solid State Drive (SSD) is inserted.</p>

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6.2.4 Gigabit Ethernet



6.2.5 MicroSD

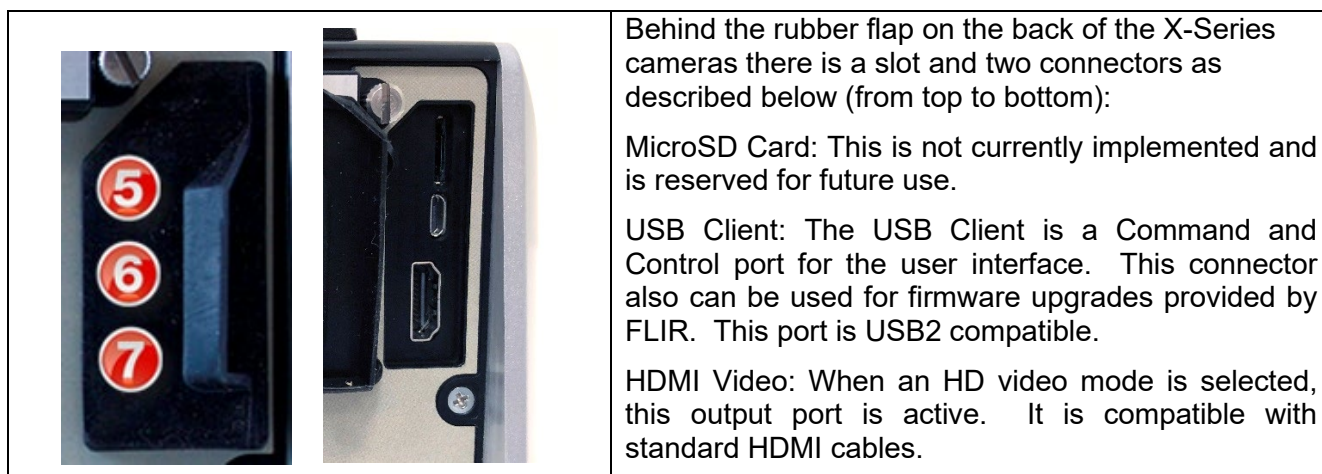
Not currently implemented. Reserved for future use.

6.2.6 USB Client


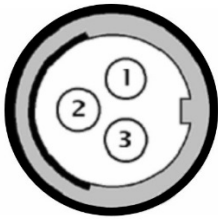
The USB Client is a Command and Control port for user interface, and it can also be used for firmware upgrades provided by FLIR. This port is USB2 compatible.

6.2.7 HDMI Video


When an HD video mode is selected, this output port is active. It is compatible with standard HDMI cables.

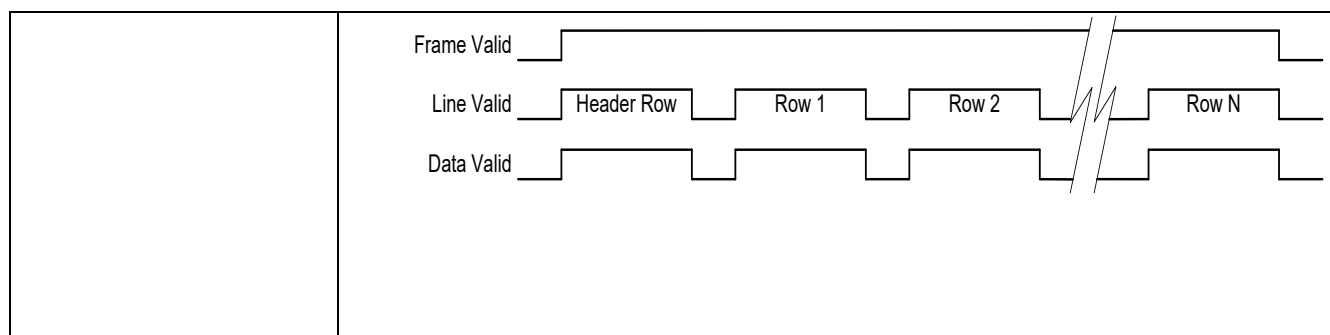


6.2.8 Power Interface

	<p>A 24VDC external AC-DC power converter is provided with the X-Series camera systems as a standard accessory. Power supply specifications are:</p> <p>AC Input voltage range: 100-250VAC 50/60Hz Current draw: 24 VDC at up to 4.0 amps input to the camera Converter dimensions: 6.25 inches x 3.5 inches x 2.75 inch (L x W x H) Converter weight: approximately 1 lb.</p> <div style="display: flex; align-items: center; justify-content: center;"> <div style="margin-right: 20px;"> <p>Pin1: +Power input Pin2: Power return Pin3: No connection</p> </div> <div style="text-align: center;">  </div> </div> <p style="text-align: center;"><i>X-Series Camera Power Input Pinouts</i></p> <p>When using your own DC power supply, you should take note of the following information:</p> <p>Input voltage range: 24 volts DC nominal, 20-28V range Current draw: 1.4 amps nominal steady state, 2.6 amps peak (during cool down) X-Series camera power dissipation is <50 Watts steady state at nominal ambient temperature.</p> <p>Mating Connector: Fisher Connectors, S103A052-130+E31 103.1/5.7 +B. (FLIR PN 26399-000). The power cable should be 20AWG (stranded 10/30), 3 conductors, no shield, max diameter of 0.223 inches. (Example: Alphawire PN 882003)</p>
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6.2.9 Camera Link® Video Output

	<p>Camera Link® is a standard data interface for high end visible and IR cameras. The X-Series cameras use a Camera Link® Full interface in a 4-tap, 16-bit configuration, at 85Mhz. In terms of ports, the A and B ports are used with bit A0 being the LSB and bit B7 being the MSB of the data transferred. The header row uses the entire 16-bit value while the pixel data has a 14-bit range with the upper MSB's masked to "0".</p>
---	--



6.2.10 Auxiliary Connector/Breakout Cable

This connector provides access to a number of less commonly used input and output signals. The inputs and outputs are easily accessed using the Aux Breakout Cable (P/N 4212860) supplied with the camera. The camera auxiliary connector is a standard DB-26 (mating connector: Digikey PN A31505-ND).

Pin	Signal	Level	Cable Molded-In Label	Connector Type
2	TX	RS-232	Serial	DB9 Female connector
4	RX	RS-232		
5	GND			
10	INTEG ACTIVE	TTL	10	BNC Male
11	GND			
14	Reserved		14	BNC Male
15	DIG_IN0	3V/5V CMOS	15	BNC Male
16	Reserved		16	BNC Male
17	DIG_IN1	3V/5V CMOS	17	BNC Male
18	Reserved		18	BNC Male
19	DIG_IN2	3V/5V CMOS	19	BNC Male
20	Reserved		20	BNC Male
21	TRIG_IN	3V/5V CMOS	21	BNC Male
22	GND			
23	ANALOG_IN0	0-5V	23	BNC Male
24	ANALOG_IN1	0-5V	24	BNC Male
25	LOCKIN	0-5V	25	BNC Male
26	GND			

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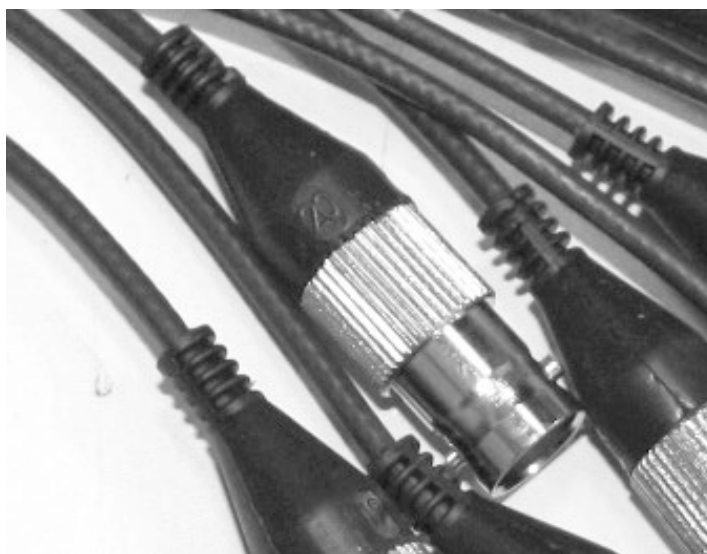
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Note: Regarding RS-232, a standard, off-the-shelf (straight-through) serial cable can be used.

The camera uses Genicam as the control protocol for all interfaces, including RS-232. There is no ASCII based command set. Because Genicam is not a formal standard for RS-232, the RS-232 interface complies with the GenCP 1.1 standard. Device discovery and baud rate selection is handled automatically.

Here is an image of the breakout cable, and a closeup of the molded-in number on Cable 20, which is reserved for future capabilities:





6.2.11 Record Trigger



This input allows the user to start or gate a recording to the internal RAM buffer. The input status is also placed in the image metadata allowing the input to be read by the host for recording control as well.

The input has a pull-up resistor so it is compatible with a simple switch closure. It can also be driven with a 3.3V CMOS signal and is buffered to handle up to 5V.

The LED indicator will flash when the recorder is armed (from the camera controller) and will be steady on during recording.

6.2.12 CoaXPress (CXP) Video Output [all except X6800]



CXP is a standard interface for high speed digital video data. Unlike SDI, it can support flexible image sizes and frame rates. It uses common 75-ohm coax cables. The better the cable, the longer the transmission distance. The X85XX and X69XX-Series cameras support dual CXP links at 5Gbps.

6.2.13 Sync In



The Sync In can be selected, by the user, to operate as an external Frame Sync to clock frames. It is a rising edge TTL signal with selectable polarity. The minimum width is 160nS. The LED will illuminate when a valid signal is present. (If the external sync rate is <1 Hz, the LED may blink). Nominal operating voltage is 0 to 5.5V. The absolute maximum range is -0.5V to 6.5V. $V_{ih}=2V$, $V_{il}=0.8V$. V_{ih} is the minimum voltage at which the camera will interpret the signal as a “high” and V_{il} is the maximum voltage at which the camera will interpret the signal as a “low”.

6.2.14 SDI Video [all except X6800]



HD-SDI is a standard HD video interface. This interface can transmit either 1080p or 720p video over distances up to 300ft using standard RG-59 coax. Although monitors with direct SDI inputs are typically found in the broadcast industry, off-the-shelf converters are available to convert SDI to HDMI for use with standard TV monitors.

6.2.15 Composite Video Output [X69XX/X85XX only]



Composite video out (BNC connector). User selectable to be NTSC standard (640x480, 29.97Hz interlaced) or PAL standard (640x512, 25Hz interlaced). Video supports user selectable color palettes

6.2.16 Sync Out



This TTL single ended signal is normally synchronous with the camera Sync In and can be used to synchronize other events to the camera when the camera is in a free run mode. It is also used in conjunction with the clock out signal to synchronize two X-Series cameras in master-slave fashion. When used in this way, the camera acting as the master makes appropriate adjustments to the camera sync out signal to assure that the data output of the two cameras is synchronized at the pixel level. This output is available in both ITR and IWR mode. The polarity is selectable.

6.2.17 Genlock Input [X69XX/X85XX], Tri-LVL Sync [X6980/X8580]



This connector is not implemented on X69XX.X85XX



The Tri-LVL sync input allows the camera FPA frame sync to be driven by the sync of an analog video signal. This can be a sync only signal or a composite or component video.

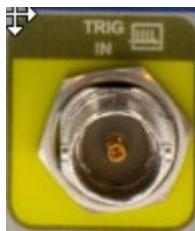
6.2.18 IRIG Input [X69XX/X85XX only]



An IRIG-B decoder is built into the camera to allow for time stamping of each frame as well as support triggered data acquisition at user programmed times. The IRIG clock can decode IRIG-B-AM. Optimal format is B122 but other B12x formats should work, however, extra data (such as the year) will not be decoded.

The LED will illuminate when camera is locked to an external IRIG signal.

6.2.19 Trigger Input [X6980/X8580 only]



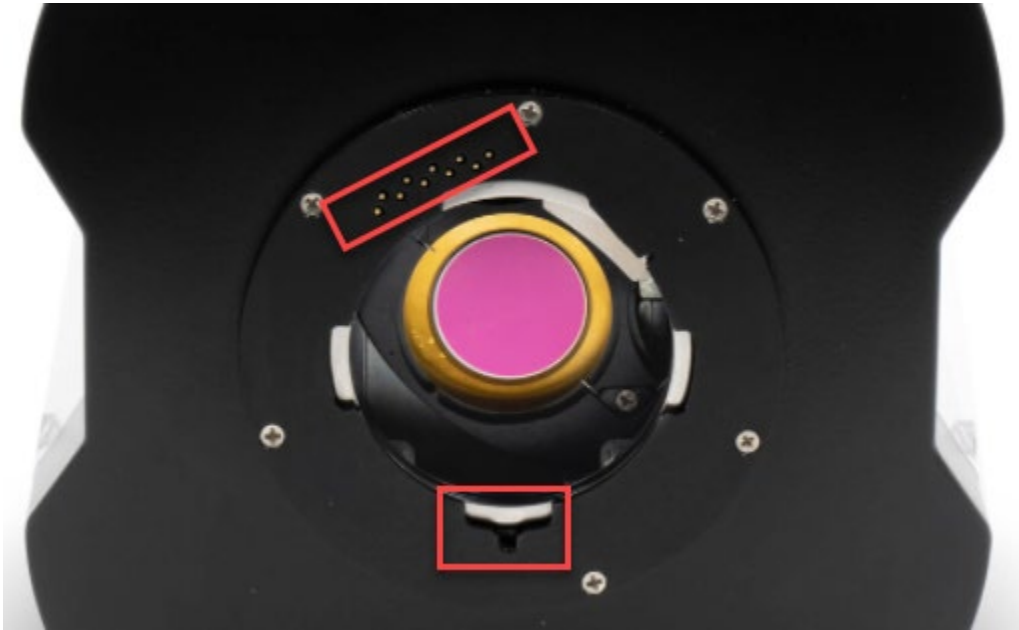
This is the same input found on the AUX connector of the original X69XX/X85XX. Many users requested that it be direct connection on the rear panel. With the removal of composite video, there was room for this again.

7 Motorized Lens Interface

The X6980 and X8580 series cameras bring the FLIR Precision Optics-Motorized (FPO-M) interface to the X-series.

The FPO-M interface is compatible with all lenses in the FPO lens family – both manual and motor focus. The electrical interface pins for the motorized lenses are normally retracted when no lens or a manual focus lens is installed. The motorized lenses have an extra tab at the bottom that engages the mechanism to extend the pins.

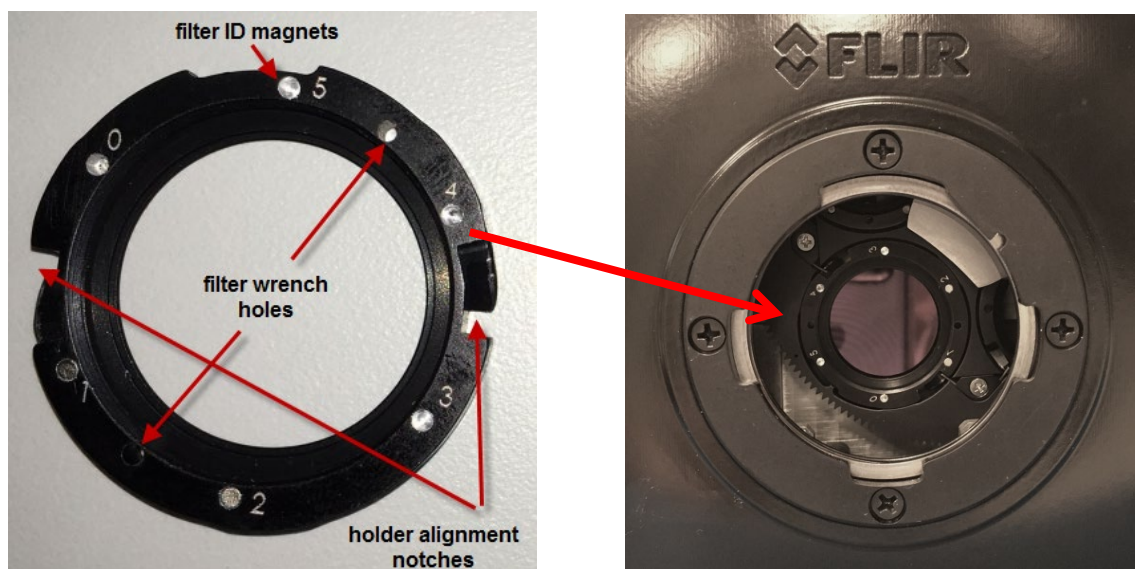
The electrical interface provides for both power and lens control. There is a lens detect feature which prevents the power pins from being energized unless a compatible lens is fully engaged.



8 Filter Wheel

The X-Series cameras have a 4-position, motorized, warm filter wheel. The wheel sits between the lens and the detector warm window. The filter wheel can be seen by removing the lens as shown in the picture below.

The filter wheel can be controlled from the camera controller. The filters are held in a removable holder (shown below). Each holder can hold one filter up to 2mm thick, or two filters with a combined thickness of 2mm.



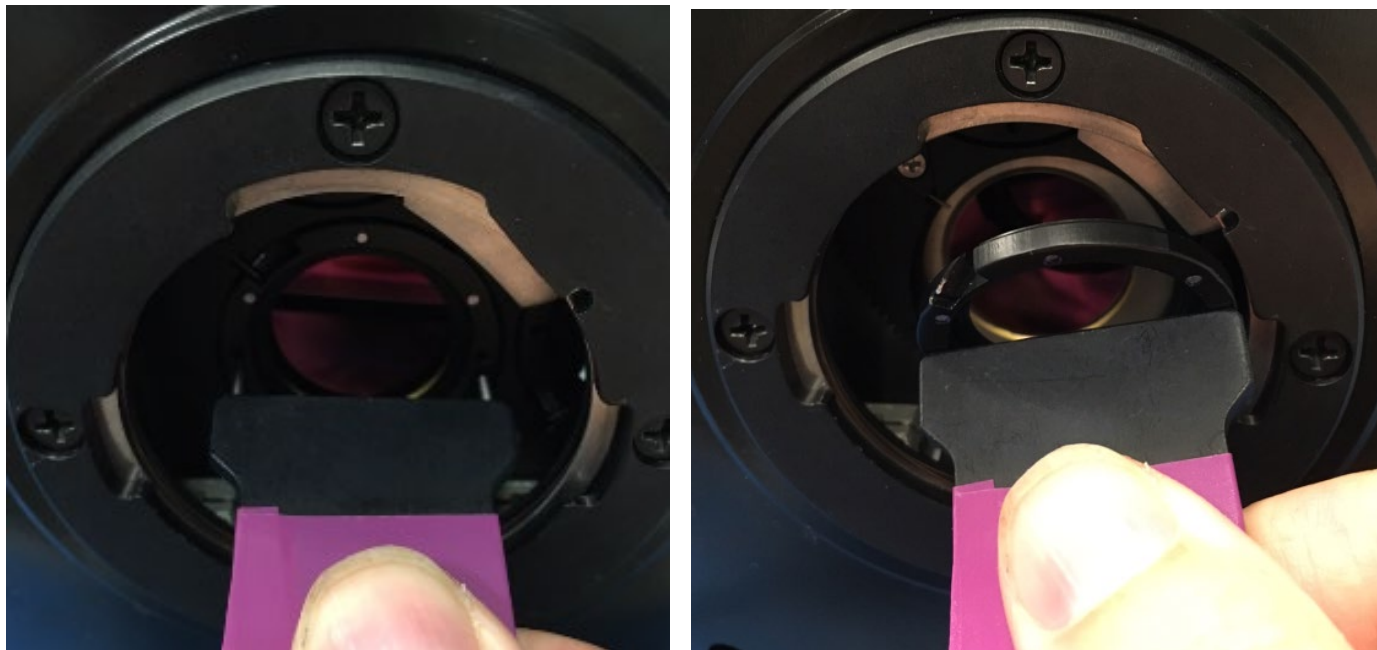
The camera keeps track of what filters are in the wheel by sensing a set of magnets installed in the holder. The camera scans the wheel on boot up (or on demand). The filter page in the camera controller displays the detected filter IDs. If a factory calibration range is selected that requires a filter, the camera will automatically search the wheel for that filter and put it in the field of view.

In most cases the filter wheel will be populated at the factory. If a user has more filters than can fit in the wheel at one time, it is easy to swap a filter. To do this you will need the filter wrench that is included in the shipping case with each camera. It looks like the picture to the right.



To remove a filter, first remove the camera lens, so you can see the filter wheel. Then, go to the Setup>>Filter/Flag page in the controller and press the “C” button next to the filter you wish to change. The camera will put this filter in front of the detector, where it can be seen. Each filter holder has two holes (located between filter ID slots 1&2 and 4&5, at the 3 o’clock and 9 o’clock positions when installed). Insert the two pins on the wrench into these holes. Twist gently a few degrees counter-clockwise and you will feel the holder click free of the retention springs.

Gently pull the wrench from the camera and the filter holder should stay with the wrench.



To install the new filter, put the holder on the wrench, with the ID numbers facing you. Align the notches (between ID positions 0&1 and 4&3) with the retention springs and seat the holder in the wheel so that the front of the holder is flush with the wheel. Turn gently (but firmly) a few degrees clockwise until you feel the holder click into position. On the Setup>>Filter/Flag page of the controller, press the scan button to refresh the filter list in the camera.



8 Specifications

8.1 Interface

AC Power	90-230V _{AC} , 50-60 Hz (using FLIR 24123-000 power supply)
Control	Gigabit Ethernet, USB, Camera Link Serial, CXP or RS-232
Standard Video Outputs (where applicable)	<ul style="list-style-type: none"> • NTSC/PAL selectable, BNC, 75Ω, 1V pk-pk • HDMI (720p 50/59.94, 1080p 25/29.97) • SDI (720p 50/59.94, 1080p 25/29.97)
Frame Sync In	TTL singled ended, BNC, selectable polarity, >160ns pulse width
Frame Sync Out	TTL singled ended, BNC, selectable polarity, 160ns pulse width
Trigger In	TTL singled ended, AUX, selectable polarity, >160ns pulse width
Integration Out	TTL singled ended, AUX, selectable polarity
Tri-Level Sync	Any standard analog video signal
IRIG-B in	IRIG-B-AM, B122 format, BNC
Digital Video Out	14-bit Camera Link Full, and Gigabit Ethernet, Dual-link CXP @ 5Gbps
Optical Interface	FLIR FPO or FPO-M bayonet
Thermal Interface	Sealed enclosure with integral forced air heat exchanger; bottom mounting surface provides direct heat path for low atmospheric pressure environments
Mechanical Interface	2 (two) ¼-20 tripod screws; 1 (one) 3/8-16 professional tripod screw; 4 (four) 10-24 mount holes. 3x ¼-20 screws each side

8.2 Windowing Capacity

Minimum Window Size	X6800/X69XX: 32 columns x 4 rows X85XX: 64 columns x 4 rows
Windowing Step Size	X6800/X69XX: 32 columns x 4 rows X85XX: 64 columns x 4 rows
Maximum Window Size	X6800/X69XX: 640 columns x 512 rows

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	X85XX: 1280 columns x 1024 rows
Window Offset Step Size	32 columns; 4 rows

8.3 Acquisition Modes and Features

Frame Rate (X6800):	
Max at Full Window	520.91 Hz (< 1.906mS Integration Width)
Max at Minimum Window	23076.92 Hz (<30uS Integration Width)
Minimum	1.45mHz
Resolution	90nS
Frame Rate (X69XX):	
Max at Full Window	1004 Hz (< 0.996mS Integration Width)
Max at Minimum Window	29133 Hz (< 34.3uS Integration Width)
Minimum	1.45mHz
Resolution	90nS
Frame Rate (X85XX):	
Max at Full Window	181 Hz (< 5.52mS Integration Width)
Max at Minimum Window	6026 Hz (< 166uS Integration Width)
Minimum	0.5Hz
Resolution	90nS
Pixel Rate (burst)	355 MHz
Integration Width	
Maximum	>98% selected frame time (1/frame rate)
Minimum	270 nanoseconds
Resolution	90 nanoseconds
Synchronization Modes	<ul style="list-style-type: none"> • Genlock: Not implemented • Tri-Level Sync: (X8580/X6980 only) • Frame Sync Starts Integration: synchronizes FPA integration to external sync source • Frame Sync Starts Readout: synchronizes FPA data readout to external sync source

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Preset Sequencing	<ul style="list-style-type: none"> • 4 presets programmable for 1 to 4,294,967,295 frames each • Preset sequence programmable for up to 4,294,967,295 sequences per triggered event
Digital Video Output	Selectable: <ul style="list-style-type: none"> • Raw digital video (14-bits) • Gain and offset (NUC) corrected (14-bits) • NUC with bad pixel replaced (14-bits)
Digital Gain and Offset	Variable, per preset <ul style="list-style-type: none"> • Global Gain: 0→3.9; 2⁻¹⁴ resolution • Global Offset: ± full A/D resolution

8.4 Standard Video

Video Output	Selectable <ul style="list-style-type: none"> • SDI (Not available in X6800) • HDMI 	
Data Output	Selectable <ul style="list-style-type: none"> • Raw, uncorrected • Corrected 	
MGC	Linear scaled with user controlled gain and offset	
AGC	Selectable <ul style="list-style-type: none"> • DDE • Plateau based equalization • Linear equalization 	
AGC Filter	User controlled damping factor User controlled update rate	
Display ROI	ROI of camera image can be selected and displayed	
Overlay	Available on all standard video outputs	
Palettes	Selectable <ul style="list-style-type: none"> • Grayscale • Various color palettes 	
Zoom	Original X-series <ul style="list-style-type: none"> • x1/2 • x1 • 4:3 (SD to HD) • x2 • x4 	X-refresh/X6980/X8580 <ul style="list-style-type: none"> • 1x • Auto (best fit)

8.5 Performance Characteristics

Power Consumption FLIR PWR Supply @ 120V_{AC}	Continuous Cool Down: 50 VA Continuous Normal: 41 VA Continuous Normal w/NUC Flag: 75 VA
Power Consumption Camera DC Power @ 24V_{DC}	Continuous Cool Down: 24 Watts Continuous Normal: 21.25 Watts Continuous Normal w/NUC Flag: 36 Watts
Cool-Down Time	\approx 7 minutes to reach operating temperature
Sensitivity (w/o optics) NEΔT¹	X69xx InSb: 20mK typ. InSb: 30 mK typ. SLS: 40 mK typ.
Factory Calibration Temperature Measurement Ranges	InSb: -20°C to 350°C (-4°F to 662°F) 45°C to 600°C (113°F to 1,112°F) 250°C to 2000°C (482°F to 3,632°F) 500°C to 3,000°C (932°F to 5,432°F) SLS: -20°C to 650°C (-4°F to 1,202°F) 250°C to 1,500°C (482°F to 3,632°F) 500°C to 3000°C (932°F to 5,432°F)
Factory Calibration Temperature Measurement Accuracy²	\pm 1°C or \pm 1% of reading 0°C to +3000°C (17mm, 25mm, 50mm, 100mm, 200mm Lenses) \pm 2°C or \pm 2% of reading -20°C to 0°C (17mm, 25mm, 50mm, 100mm, 200mm lenses) -10°C to +500°C (1X & 4X Closeup lenses)

1) NE Δ T is at 50% nominal bucket fill, 298K background, \pm 5°C signal

2) Assuming ideal laboratory conditions (close range, known high emissivity targets, stabilized camera and lens temperatures) and only if the lens and camera are matched, i.e. not a 3-5 micron lens on a broadband camera.

8.6 Non Uniformity Correction

NUC Types	Two Point (offset and gain values, non-volatile) Two Point w/Bad Pixel Detection/Replacement Update Offset (recalculates offset using current gain, volatile)
NUC Source	Internal: TE controlled flag External: Any user supplied source which covers entire window
Bad Pixel Replacement	Two-Point Gradient, or nearest neighbor
Number of NUC's	4 active NUC's in preset selectable form Greater than 24 full frame NUC's saved in camera memory
NUC Time	< 5 seconds
NUC Performance	Residual Non-Uniformity: 0.1%

8.7 Detector/FPA

Spectral Response	Xxx00sc/xx02: 1.5-5um; Xxx01/xx03: 3-5um
Detector Type	InSb or Type 2 SLS
Detector f/#	f/2.5 or f/4
Supported ROIC	X6800/X69XX: ISC0804 X85XX: ISC1308
Integration Mode	Snapshot
Format (HxV)	X6800/X69XX: 640x512 X85XX: 1280x1024
Operability	X6800/X69XX (InSb) >99.5%, 99.95% typical X69XX (SLS) >98%, 99% typical X85XX (InSb) >99.5%, 99.9% typical X85XX (SLS) >98%, 99% typical
Charge Handling Capacity	X6800/X69XX: 11.0×10^6 carriers X85XX (InSb) : Gain 0: 3.0×10^6 carriers X85XX (SLS) : Gain 1: 11.5×10^6 carrier
Detector Pitch	X6800/X69XX: 25 microns X85XX: 12 microns

Detector Cooling	X68xx: Rotary cryocooler, X85xx: Linear cryocooler
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8.8 General Characteristics

Size	
Length	249 mm (9.8 inches), not including lens or lens cover
Width	156 mm (6.2 inches)
Height	201 mm (7.9 inches) w/ handle, 147 mm (5.8 inches) w/o handle
Weight	6.4 kg (14 lbs.), not including lens or lens cover
Temperature	
Operating	-20C to +50C
Storage	-55C to +80C
Humidity	<95% relative humidity, non-condensing
Altitude	0 to 40,000 feet operational, 0 to 70,000 feet non-operational
Operating Orientation	No restriction in orientation

9 Maintenance

9.1 Camera and Lens Cleaning

9.1.1 Camera Body, Cables and Accessories

The camera body, cables and accessories may be cleaned by wiping with a soft cloth. To remove stains, wipe with a soft cloth moistened with a mild detergent solution and wrung dry, then wipe with a dry soft cloth.

Do not use benzene, thinner, or any other chemical product on the camera, the cables or the accessories, as this may cause deterioration.

9.1.2 Lenses

It is recommended that all optics be handled with care and the need for cleaning is eliminated or at least reduced. If, however, cleaning is deemed necessary, the methods herein are accepted industry standards and should yield good results.

Before you BEGIN:

Identify the type of optic to be cleaned.

- Is it hard or soft material?
- Is it coated & with what?

How is it contaminated?

- Particulate or film or both.

Set a standard of cleanliness.

- What is clean enough?
- Establish & document a standard.

Know your solvent.

- Read the MSDS
- See recommended solvents

Assemble your supplies:

- Latex gloves
- Clean, well-lit work area
- Inspection light
- Lens tissue or cloth
- Dust bulb or filtered air
- Proper solvent
- Solvent dispenser

The Drag Wipe Method:

Set-up a clean area to work from with an anti-roll barrier around the edge to prevent anything from leaving the table.

Use a clean, lint free cloth or lens tissue.

Wear latex gloves - clean them with alcohol or detergent before handling optic.

NEVER touch the face of the optic with your fingers.

Cover the optic and store in a dry - dust free area immediately after cleaning.

1. Blow or brush loose particles from surface. Don't let them contaminate your work area. Use air from a can or a filtered source.
2. Apply solvent directly to your cloth. Use slow, even, light pressure working from edge to edge across the optic.

Recommended Solvents

Material	Solvent		
Fused Silica	1,2,3,4	Zinc Selenide	1,2,4
BK-7	1,2,3,4	Zinc Sulfide	1,2,4
Optical Crown Glass	1,2,3,4	Sapphire	1,2,3,4
Zerodur	1,2,3,4		
Calcium Fluoride	1,2,4	Coated Optics	
Magnesium Fluoride	1,2,4	Dielectric coating	1,2,3,4
Sodium Chloride	Nitrogen	Interference filters	3
Potassium Chloride	Nitrogen	Soft metallic coating	Air only
Potassium Bromide	Nitrogen	Hard/Protected metallic	1,2,3,4
Thallium Bromiodide	Nitrogen		

1] Water free Acetone

2] Ethanol

3] Methanol

4] Isopropanol