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

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 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 X6900sc Camera X8500sc Camera	29420-2xx (InSb) 29267-2xx (InSb) or 29421-2xx (SLS) 29422-2xx (InSb) or 29428-2xx (SLS)
Power supply, 24V, 4A	24123-000
AC line cord	24124-000
Gigabit Ethernet Cat-6 cable, 2m length	24277-000
AUX Breakout Cable	4212860
Bayonet mount plug	4142249
Laboratory calibration plate	261-0005-00
500GB SSD	4142223
SSD to USB cable	4142222
Filter wheel wrench	C1004.M202
HDMI video cable, 6-ft	4142224
Water-resistant transit case	24043-005
Documentation CD	N/A

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 X6900-series series. The X6900-series cameras are 640x512 cameras built for very high frame rates. The X8500-series cameras have an HD focal plane array

Model	Description	FLIR Part Number
X6800sc	• f/2.5 • Broadband (InSb: 1.5-5µm response)	29420-200
X6801sc	• f/2.5 • InSb: 3-5µm response	29420-201
X6802sc	• f/4.1 • Broadband (InSb: 1.5-5um response)	29420-202
X6803sc	• f/4.1 • InSb: 3-5µm response	29420-203

Model	Description	FLIR Part Number
X6900sc	• f/2.5 • Broadband (InSb: 1.5-5µm response) • Broadband (SLS: 3-12µm response)*	29267-200 29421-200
X6901sc	• f/2.5 • InSb: 3-5µm response • SLS: 7.5-12µm response*	29267-201 29421-201
X6902sc	• f/4.1 • Broadband (InSb: 1.5-5um response) • Broadband (SLS: 3-12µm passband)*	29267-202 29421-202
X6903sc	• f/4.1 • InSb: 3-5µm response • SLS: 7.5-12µm response*	29267-203 29421-203
X8500sc	• f/2.5 • Broadband (InSb: 1.5-5µm response) • Broadband (SLS: 3-12µm response)*	29422-200 29428-200
X8501sc	• f/2.5 • InSb: 3-5µm response • SLS: 7.5-12µm response*	29422-201 29428-201
X8502sc	• f/4 • Broadband (InSb: 1.5-5um response) • Broadband (SLS: 3-12µm passband)*	29422-202 29428-202
X8503sc	• f/4 • InSb: 3-5µm response • SLS: 7.5-12µm response*	29422-203 29428-203
*NOTE: SLS upper cutoff tolerance is +/- 0.5um		

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 X8500sc 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 an SLS array for longwave infrared. The X6800 and X6900 cameras use the ISC0804 ROIC.

The X8500sc camera utilizes an HD format, 1280x1024 array with 12µm pixel pitch. The X6800 and X6900 cameras use a large format, 640x512 array with 25um 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. An 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 X6900 and X8500sc cameras feature fast pixel clocks: 355 Megapixels per second, which enable the X6900 camera to output 1000 frames per second at 640x512, and the X8500 camera to output >180 frames per second at a frame size of 1280x1024 pixels. The X6800 series frame rate is limited to approximately half the X6900 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 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 X6800 series)
- Genlock input (SD or HD) (not in X6800 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 ResearchIR, using the optional BHP SDK or with a third-party toolkit that support GenICam. The following ports can be used for controlling the X6900 and X8500-series cameras:

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

The X6800 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 X6900 and X8500 cameras feature multiple independent and simultaneous video outputs:

- Digital Data – Camera Link® Full
- Digital Data – Gigabit Ethernet
- Digital Data -- CoaXpress
- Digital Video – HD-SDI (1080p or 720p)
- Digital Video – HDMI (1080p or 720p)
- Analog Video – Composite video (NTSC or PAL)

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 X6900 and X8500 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 HD-SDI outputs.

X6800 only has HDMI output.

Video Overlay

X6900 and X8500: 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 X6900 and X8500 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.

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 SSDs used in PCs and laptops. The SSD is readily 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 ResearchIR software.

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 is a precision optical instrument and should not be exposed to excessive shock and/or vibration. Refer to Section 8.8 for detailed environmental requirements.**
- **The camera contains static-sensitive electronics and should be handled appropriately.**

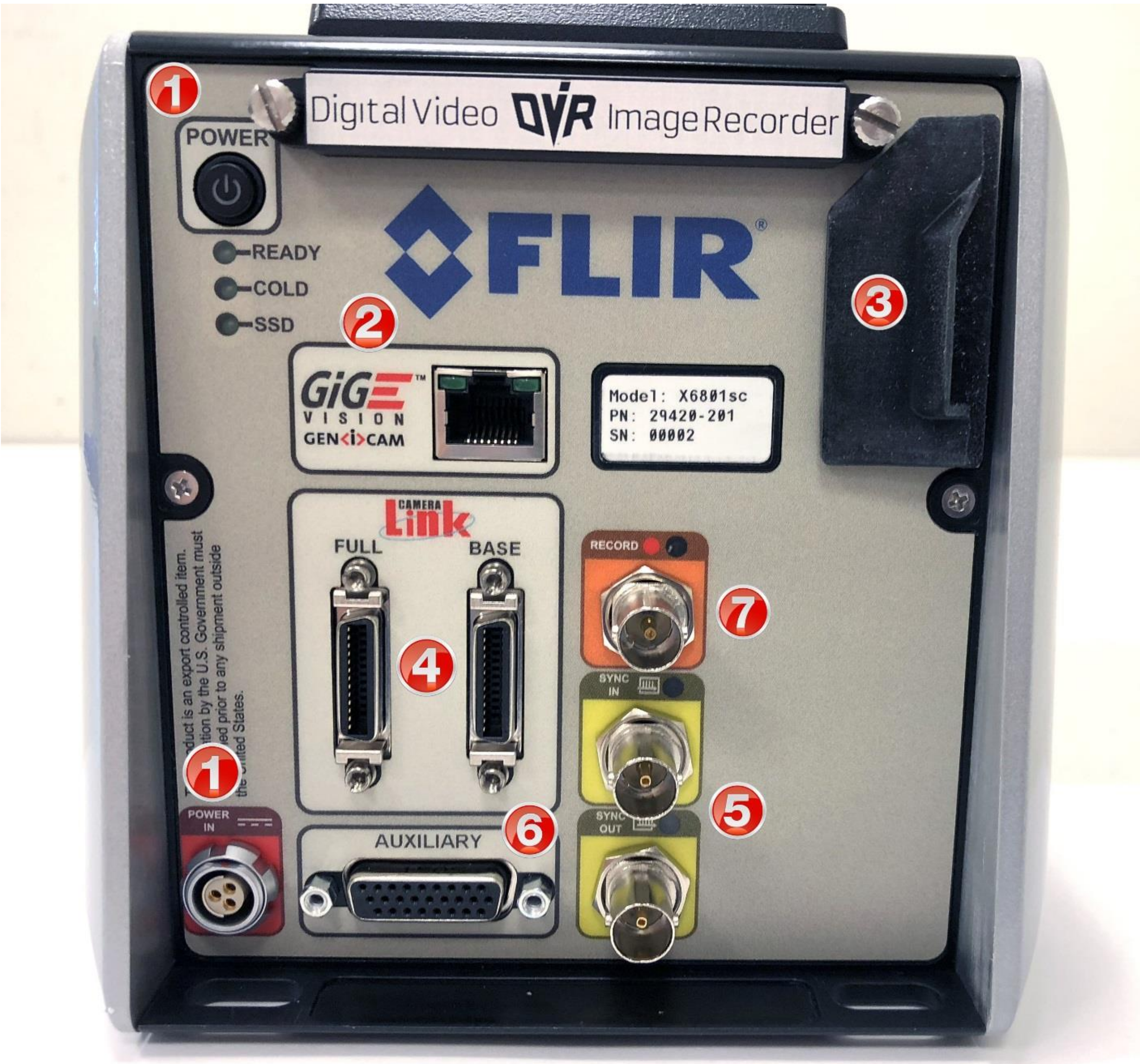
4 Installation

4.1 Basic Connections

All connections to the X-series cameras are located on the Back Panel. Although the X6900 and X8500 cameras have a large number of connections, only a small number are required for basic operation. The X6800 is a simplified version of the X6900 camera with fewer connections.

Item	Category	Description
1	Power	Power button. DC power connector. 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.
2	Digital Data	Gigabit Ethernet 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 X8500 camera's full resolution and about 125Hz with the X6900/X6800 cameras, but results may vary depending on the host computer.
3	Video	HDMI, HD-SDI, Composite (NTSC/PAL)
4	Digital Data	Camera Link Full 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.
5	Digital Data	CoaXPress The X8500sc and X6900sc cameras use dual 5Gbps links with BNC connectors. This interface can handle the full data rate of the cameras.
6	Auxiliary	This is the Auxiliary connector which is described in Section 6.2.10.

The X6800 series cameras have fewer connections:

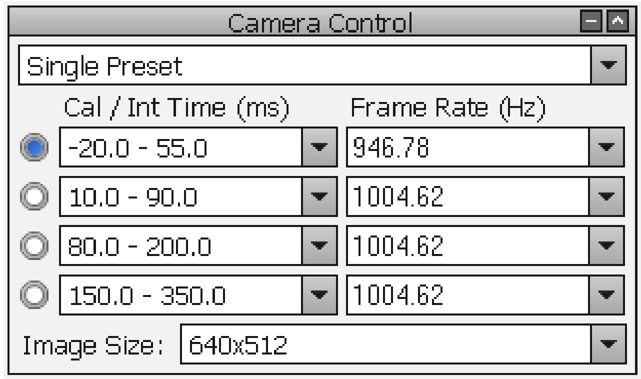


Item	Category	Description
1	Power	Power button. DC power connector. Plug in the AC power supply to a standard outlet. The power supply is compatible with 120V/60Hz and 240V50Hz AC power. Plug adapters can be used for different regions. Connect the DC power cable between the power supply and the power 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.
2	Digital Data	Gigabit Ethernet 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

Item	Category	Description
		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.
3	Video/USB	HDMI video output, USB-2 port and microSD card slot (not yet implemented)
4	Digital Data	Camera Link Full The X6800sc has an industry standard Camera Link Full interface using MDR connectors. This interface can handle the full data rate of the camera.
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 I the camera. The input can be a contact closure or a rising-edge TTL pulse.

5 X-Series Camera Controller

The X-Series Camera Controller (also called the Graphical User Interface or GUI) can be accessed from within the ResearchIR software. Once the user is connected to the camera, a mini controller will be visible in the left pane:



This controller will have basic controls for the most commonly used settings, like integration time, frame rate, preset selection, and window size. Clicking the “More” button will display the full camera controller. The rest of this chapter will describe the full camera controller features in detail.

The camera control pane shown above indicates that factory radiometric calibrations are loaded into the four presets of the camera. The values shown are temperature ranges. For example, the first preset is designed to measure object temperatures from -20C to 55C, the second from 10C to 90C. These factory calibrations are associated with NUC files which are stored in the camera. When the camera is connected to ResearchIR software, the software will detect the loaded calibration and interpret the raw image data into radiometrically calibrated images in radiance or temperature units. This is described more fully in the ResearchIR user manual.

The full camera controller can operate in two user modes, Basic or Advanced. The Basic mode gives the typical camera controls most users need. For advanced system requirements that exercise the full capabilities of the camera, the Advanced mode is used. The user mode can be selected from the Tools>>User Mode menu. In both modes, the menu bar is the same.

The Status pages looks similar in both modes, but the Advanced mode gives the user much more control of advanced camera features.

NOTE: The X6800sc uses the same camera controller software as the X6900sc. The X6800sc is missing several features found in the X6900sc 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.

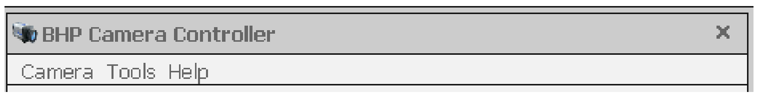
GUI controls for Genlock should not be used because this input is not available. The X6800sc only supports HDMI. Choosing options for SDI or composite video will result in no video to be displayed.

The X6800sc has a reduced maximum framerate compared to the X6900sc. Various screenshots within this manual may show frame rates that are beyond what the X6800sc supports.

5.1 Online Help

The X-Series Camera Controller provides two online help options. First there is this manual which can be accessed via the Help menu. Second, when placing the mouse cursor over a particular control, a Tooltip will be displayed giving a basic description of the control.

5.2 Menu Bar

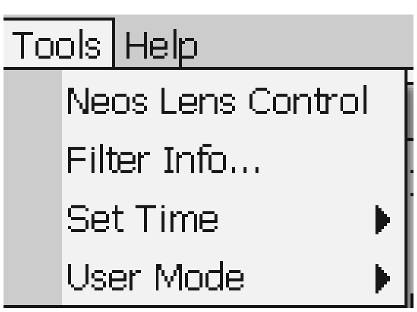


The menu bar is the same for both Basic and Advanced User Modes.

	Save State (name)	Saves the camera state to the current (name). 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.

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.

5.2.1 Tools Menu

	NEOS Lens Control	Activates control link to certain motorized lenses
	Filter Info	Shows ID info for filters in wheel
	Set Time	Options for setting time
	User Mode	Select Basic or Advanced mode
	Set PC Time to	Sets the PC clock to the time from the

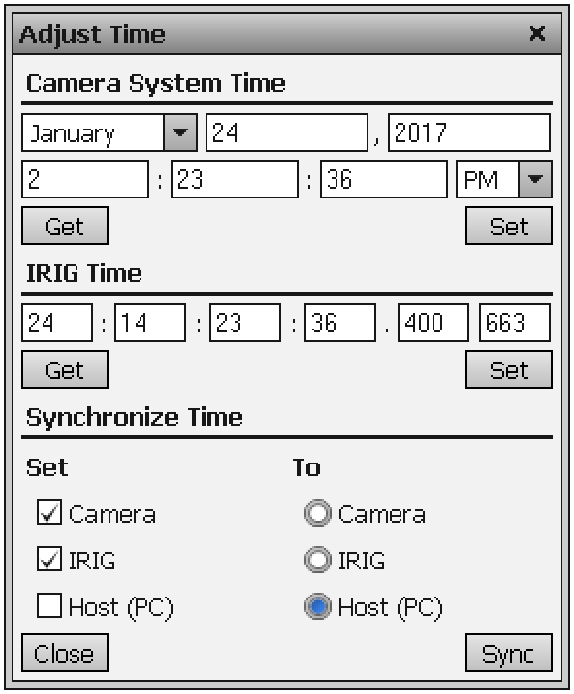
	Camera Time	camera IRIG clock. [Note: For the X6900 and X8500 cameras, at power up, the IRIG clock is automatically synchronized to the cameras Real Time Clock (RTC).] [Note: If the current PC user account does not have permission to access the system clock, this function will not work.]
	Set Camera Time to PC Time	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)
	Advanced…	Allows user to manually set the IRIG and RTC clocks in the camera. See Section 5.2.1.1
	User Mode >> Basic	Provides a limited subset of controls. All controls on a single page to minimize time needed to find a control.
	User Mode >> Advanced	Activates all controller features.

NOTE: The X-series cameras have two internal clocks: A Real Time Clock (RTC) and an IRIG 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 IRIG clock is a high resolution (microsecond) clock. This clock does not have a battery backup but at power up the IRIG clock is initialized to the current RTC time and will free-wheel until an IRIG signal is applied to the camera. The X6800 IRIG clock cannot be synchronized to an external IRIG time source.

5.2.1.1 Advanced Time Controls

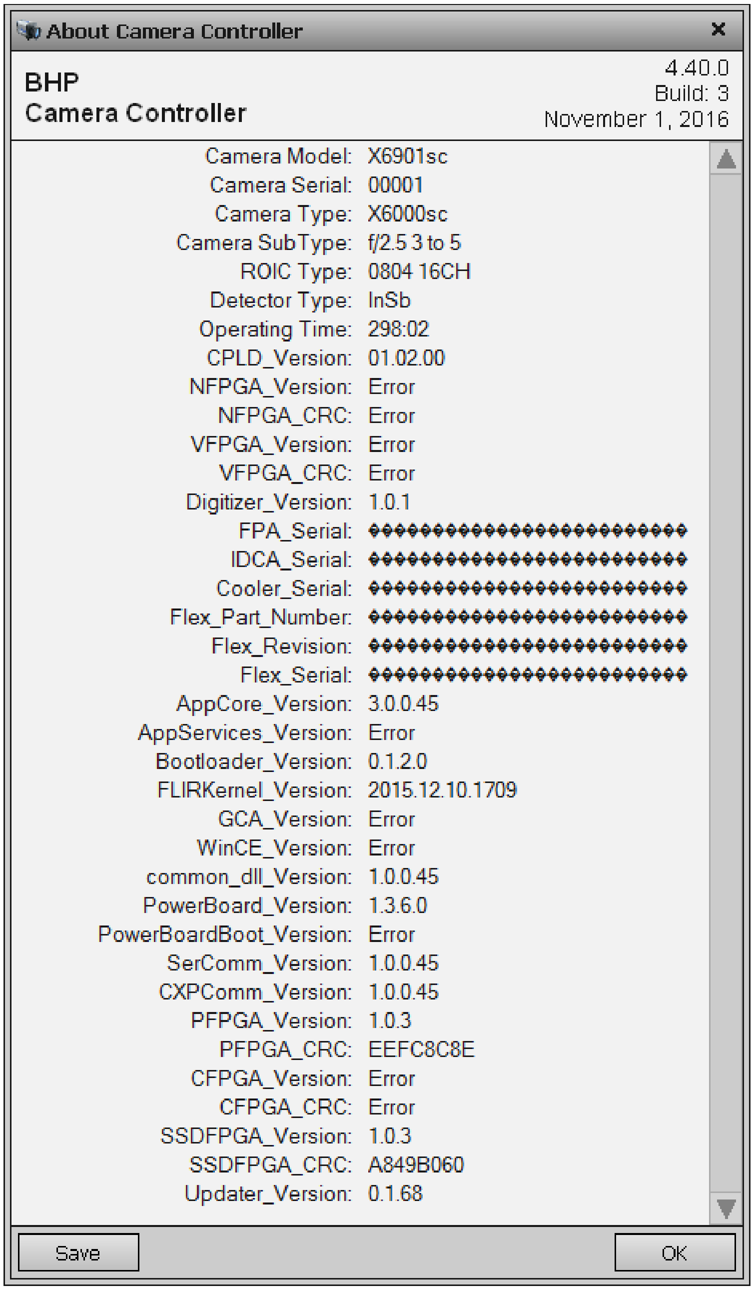
This dialog is accessed using the Tools>>Set Time>>Advanced menu options. This allows the user to directly set the cameras system time, and IRIG time. Under the Synchronize Time section the user can select various clocks on the left and synchronize them to a clock from the right. In the example below, the "Sync" button is pressed, the Camera System and IRIG clocks will be synchronized to PC time (including local time zone).

NOTE: Setting the PC time requires your PC user account to have certain permissions set. If you do not have sufficient permission, then this function will not work.



5.2.2 Help Menu

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.


About Camera Controller
BHP
Camera Controller
4.40.0
Build: 3
November 1, 2016
Camera Model: X6901sc
Camera Serial: 00001
Camera Type: X6000sc
Camera SubType: f/2.5 3 to 5
ROIC Type: 0804 16CH
Detector Type: InSb
Operating Time: 298:02
CPLD_Version: 01.02.00
NFPGA_Version: Error
NFPGA_CRC: Error
VFPGA_Version: Error
VFPGA_CRC: Error
Digitizer_Version: 1.0.1
FPA_Serial: ◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
IDCA_Serial: ◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
Cooler_Serial: ◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
Flex_Part_Number: ◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
Flex_Revision: ◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
Flex_Serial: ◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
AppCore_Version: 3.0.0.45
AppServices_Version: Error
Bootloader_Version: 0.1.2.0
FLIRKernel_Version: 2015.12.10.1709
GCA_Version: Error
WinCE_Version: Error
common_dll_Version: 1.0.0.45
PowerBoard_Version: 1.3.6.0
PowerBoardBoot_Version: Error
SerComm_Version: 1.0.0.45
CXPComm_Version: 1.0.0.45
PFPGA_Version: 1.0.3
PFPGA_CRC: EEFC8C8E
CFPGA_Version: Error
CFPGA_CRC: Error
SSDFPGA_Version: 1.0.3
SSDFPGA_CRC: A849B060
Updater_Version: 0.1.68
Save
OK

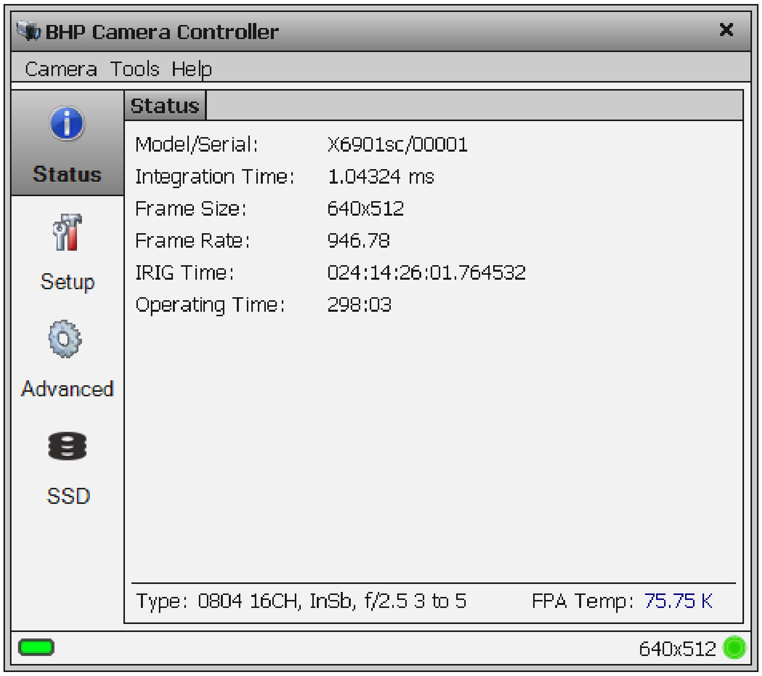
5.3 Basic User Mode

The Basic User mode enables a limited set of controls, thus greatly simplifying the controller interface. Most controls will be disabled until the user connects to the camera using the ***Camera>>Connect*** menu option.

Features supported in Basic Mode	
Manually Setting Integration Time	YES
Setting Window Size	Limited, Four window choices
Setting Frame Rate	YES
On-camera NUC	Must be enabled
NUC Management	None (Fixed NUC name)
NUC Controls	1-pt, 2-pt, Update Offset
External Sync	Only using SYNC IN BNC
Preset Sequencing/Superframing	NO
Independent Video and Data NUC	NO
Analog AGC	Manual Linear, PE, DDE, Brightness/Contrast, no ROI mode
AGC Filter	ON/OFF Only
Temporal Filter	ON/OFF Only
Invert/Revert	NO
Digital Zoom	YES
Color Palette	YES
Overlay Controls	NO

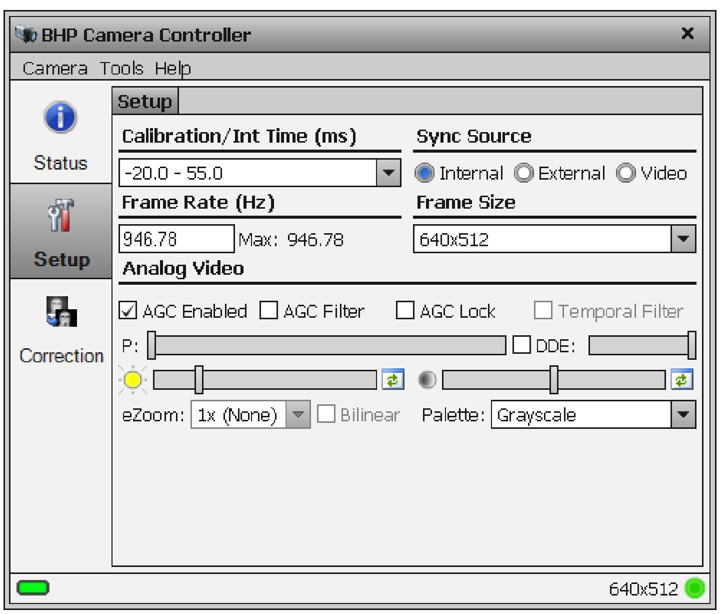
5.3.1 Status Page

The Status Page gives general information about the camera state including camera type, camera time, integration time, frame size, and frame rate. This page also shows the current IRIG time and the camera operating hours. At the bottom of the window the detailed camera type is displayed as well as the FPA operating temperature. The indicator at the bottom left will be green when a connection to a camera is established and will blink during communication.

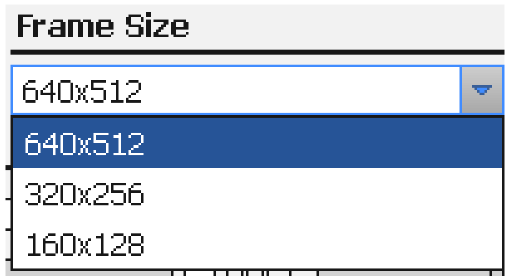


5.3.2 Setup Page

The Setup page allows the user to set integration time, frame rate, frame size, and Sync source. Frame size selection is limited to the drop list. The video output source cannot be chosen but AGC can be configured.



The frame size selections are here, 1280x720 is an option and is not shown:

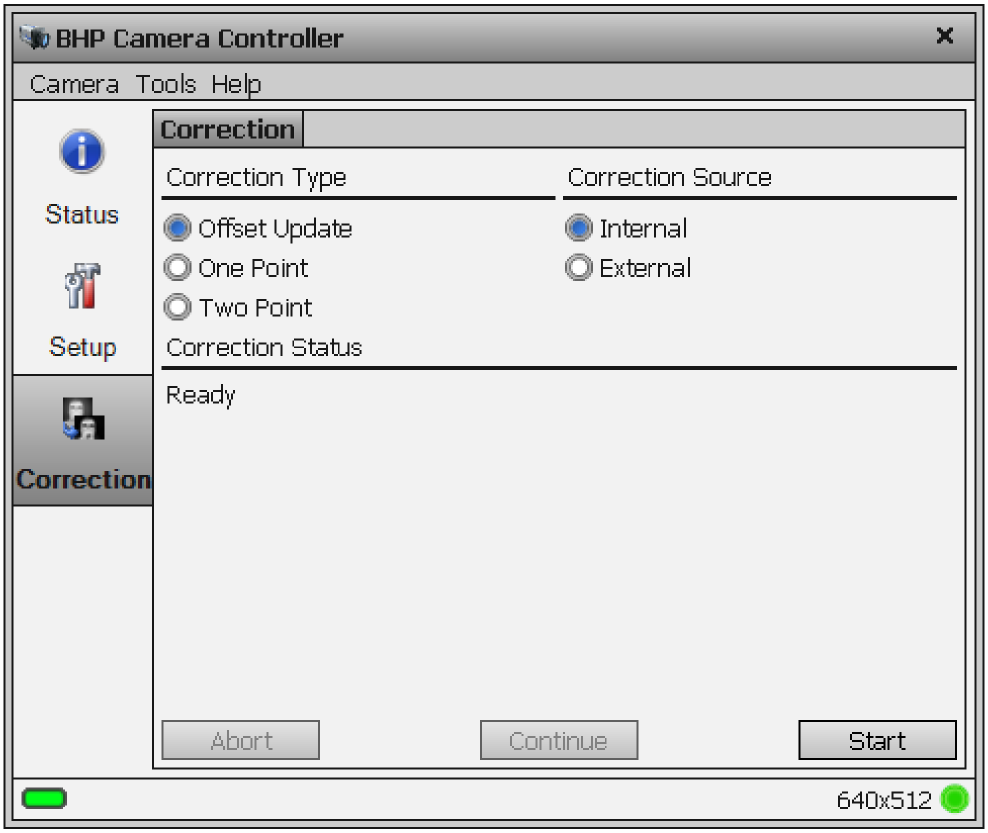


Basic Setup Page Controls	
Integration time	Enter integration (exposure) time in milliseconds. If factory calibration is active, then this will be a dropdown list of available calibration ranges.
Sync Source	Internal: internal clock used to generate FPA frame rate External: SYNC IN signal used to generate FPA frame rate Video: Internal video clock used to generate FPA frame rate
Frame Rate	Sets value of internal frame rate. Not used for External or video sync modes
Frame Size	In basic mode only 4 window sizes are available.
AGC Enabled	Turns video Automatic Gain Control (AGC) on and off. Several AGC algorithms are available in the Advanced mode.
AGC Filter	The AGC Filter controls how quickly the AGC will respond to scene changes. In basic mode can only be turned on/off. Uses settings from Advanced mode
AGC Lock	AGC normally computed for each image frame. AGC Lock freezes AGC setting to current values.
Temporal Filter	Not available on X-series
PE	If Plateau Equalization (PE) AGC is active in Advanced mode, “P” controls the strength of the AGC. Move slider to the right for more aggressive AGC.
DDE	If Digital Detail Enhancement (DDE) AGC is active in Advanced mode, “DDE” controls the strength of the AGC. Move slider to the right for more aggressive AGC. Checkbox enables/disables DDE
Brightness	Adjusts video encoder brightness level. No available for all video outputs
Contrast	Adjusts video encoder contrast level. No available for all video outputs
eZoom	Selects level of “digital” zoom
Bilinear	If disabled, eZoom uses pixel replication to create zoom. If enabled, zoom uses bilinear interpolation for eZoom.
Palette	Allows selection of false color palette for. Same palette used for all video outputs

5.3.3 Correction Page

The Correction Page provides functions related to performing an on-camera NUC. Three correction types are available and are described in the table below. The **Correction Status** area will show messages and prompt the user to complete certain tasks such as place a blackbody in the field of view.

To perform an on-camera NUC, select a Correction Type and Correction Source and press Start.



Correction (NUC) Types	
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.
One Point	Sets the gain terms to “1” and computes the offset terms. Uses a single NUC source. Does not compute a BP correction.
Two Point	Sets both the gain and offset terms. Uses two NUC sources. Computes a bad pixel correction.

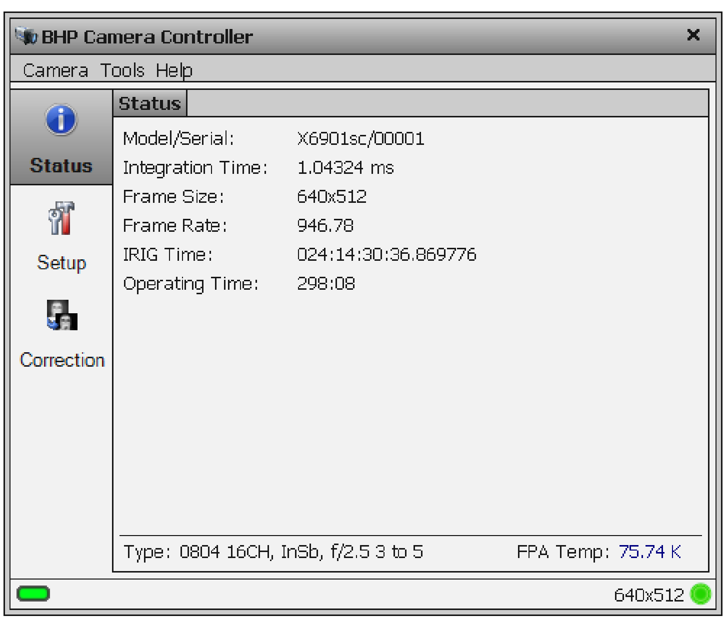
Correction Sources	
Internal	Use the internal flag as the NUC source. The flag is not temperature controlled and floats at camera internal
External	Use an external blackbody as the NUC source. Program will prompt the user to place each source in front of the camera. NUC source needs to fill the entire field of view.
Correction Process Controls (will be disabled if command not available)	
Abort	Stops the NUC process.
Continue	When prompted for an action, click “Continue” when action has been performed.
Start	Starts the selected NUC process.

5.4 Advanced User Mode

The Advanced User Mode exposes the full functionality of the camera controller. The controller looks similar to the basic mode, but additional tabs will appear on each page. This will be the preferred mode for most users.

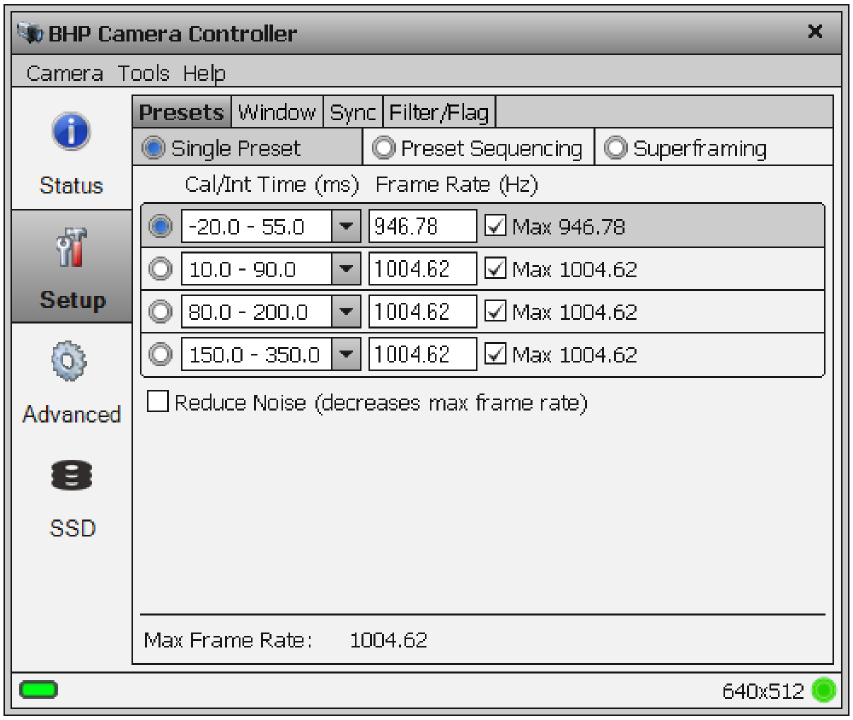
5.4.1 Status Page

The Status page is the same in both Basic and Advanced user modes. The Status Page gives general information about the camera state including camera type, camera time, integration time, frame size, and frame rate. This page also shows the current IRIG time and the camera operating hours. At the bottom of the window the detailed camera type is displayed as well as the FPA operating temperature. The indicator at the bottom left will be green when a connection to a camera is established and will blink during communication.



5.4.2 Setup Page

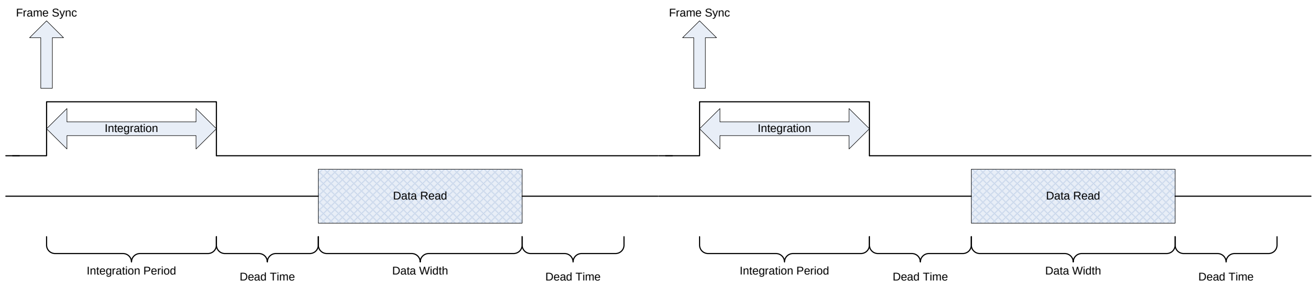
In Advanced mode, the Setup page allows the user to configure each camera preset, set integration time (or calibration range), frame rate, windowing, sync, and filter wheel options. The Setup Page has four tabs: Presets, Window, Sync, and Filter/Flag.



Before talking about the details of the Setup page, a brief discussion about frame rates and integration time will be helpful.

Frame rate is the number of images taken by the camera per second. The Integration time is the “exposure time”, the period of time the camera actually views the scene. Achievable frame rates are based on camera settings, camera overhead, and integration settings. A brief review of the processes that occur during a frame is needed to understand how to determine maximum achievable frame rates.

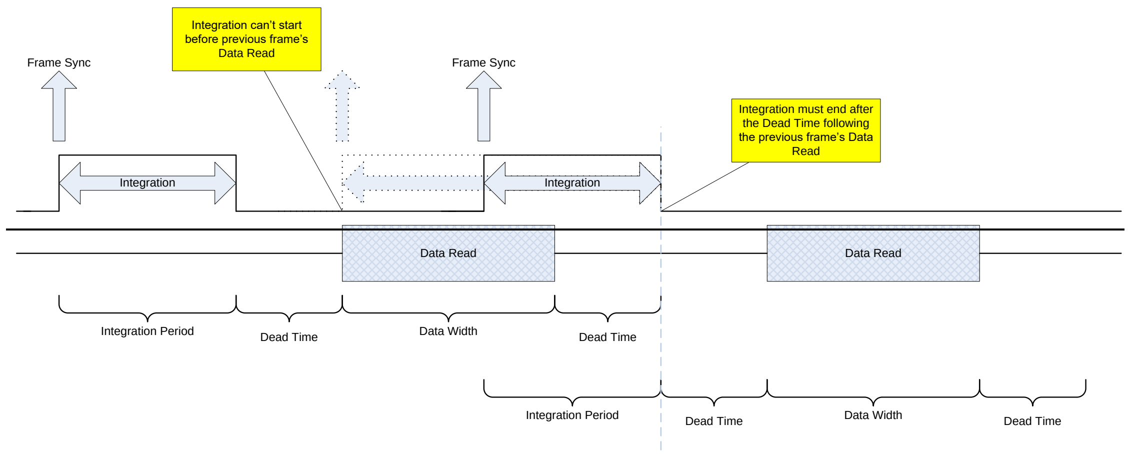
There are two basic integration modes, Integrate Then Read (ITR) and Integrate While Read (IWR). Integrate Then Read is the most basic behavior of the camera and shows the process most clearly. As seen in the ITR process diagram below, the frame generation process begins with a Frame Sync. The camera then integrates the set amount of time, goes through a fixed dead time, transmits data, goes through a second fixed dead time, and then is ready to start the process over again. Here you see the camera first completes the integration process and then reads the data out, hence the term Integrate Then Read.



ITR Frame Generation Process

The Integration and the Data Readout periods can be thought of as two separate processes; however, they are linked together by certain timing requirements. What this means is the camera can integrate for a period, start the data read out for that integration period, and during that readout start the integration period for the next frame. This process is called Integrate While Read (IWR) and can greatly speed up frame rates. The drawback to this process is it injects a fixed noise pattern into the data which can be removed by performing a Non Uniformity Correction (NUC) to the data.

> **NOTE:** A NUC update is recommended anytime an adjustment is made to either frame rate or integration time, regardless of the integration mode.



IWR Frame Generation Process

The integration period cannot end before the previous frame's data read and dead time period. The integration period cannot begin until after the previous frame's data read starts. Therefore, the calculation used to compute the maximum IWR frame rate depends on the integration and data read times.

5.4.2.1 Presets Tab

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.

5.4.2.1.1 Single Preset Mode

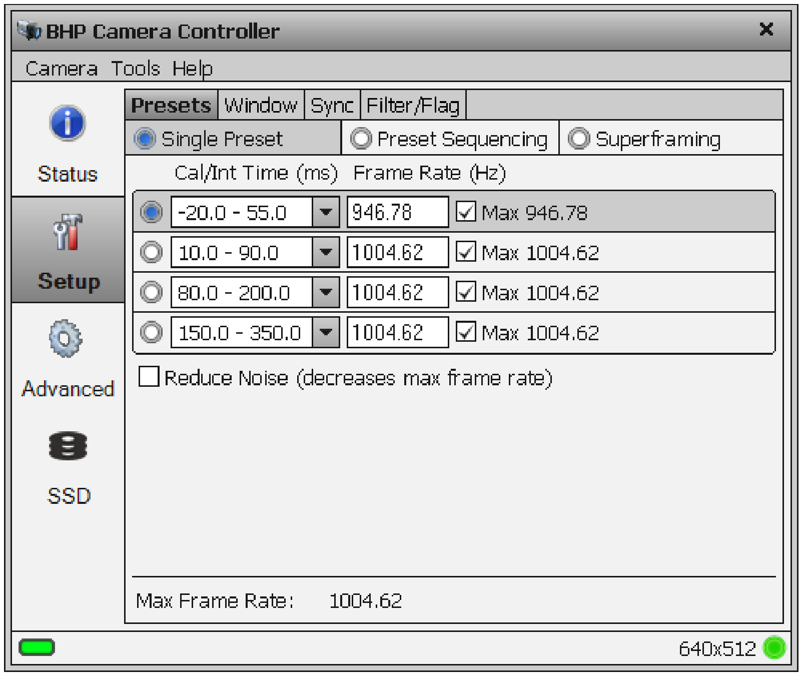
In Single Preset mode you can choose an existing factory calibration that is loaded into the camera, as well as a frame rate up to the maximum allowed frame rate for the integration time associated with that calibration. Or you can disable the factory calibration and instead choose an integration time value and a frame rate for each preset. Again, the frame rate you choose must be less than or equal to the maximum possible rate. That maximum rate is displayed to the right of the frame rate entry field, and can be selected by checking the checkbox next to the word Max.

If you choose a factory calibration, the camera will automatically load the factory NUC associated with the radiometric calibration. This is a huge advantage to using factory calibrations over user calibrations: you do not need to keep track of what NUC is loaded.

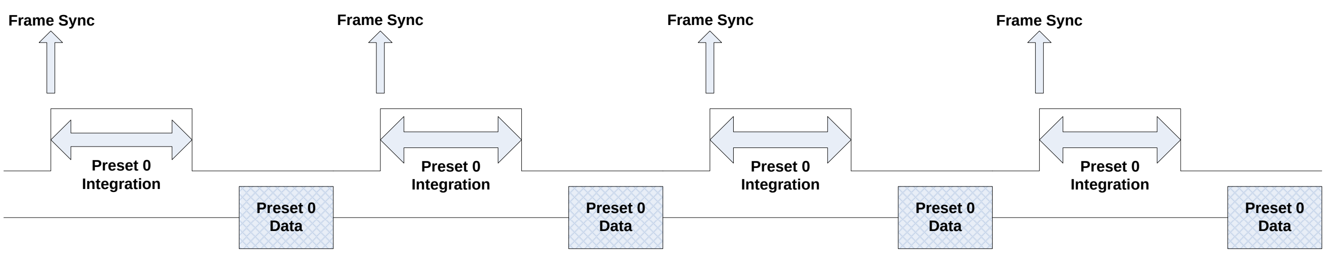
Use the radio buttons to choose the active preset. The camera will switch presets for both digital and video data.

Single Preset mode allows the user to treat each preset as a separate configuration and then simply select which configuration (preset) to use.

The “Reduce Noise” option forces the camera to use ITR timing (thus reducing max frame rate. The “noise” is some fixed pattern noise that can generally be removed by doing a NUC offset update.



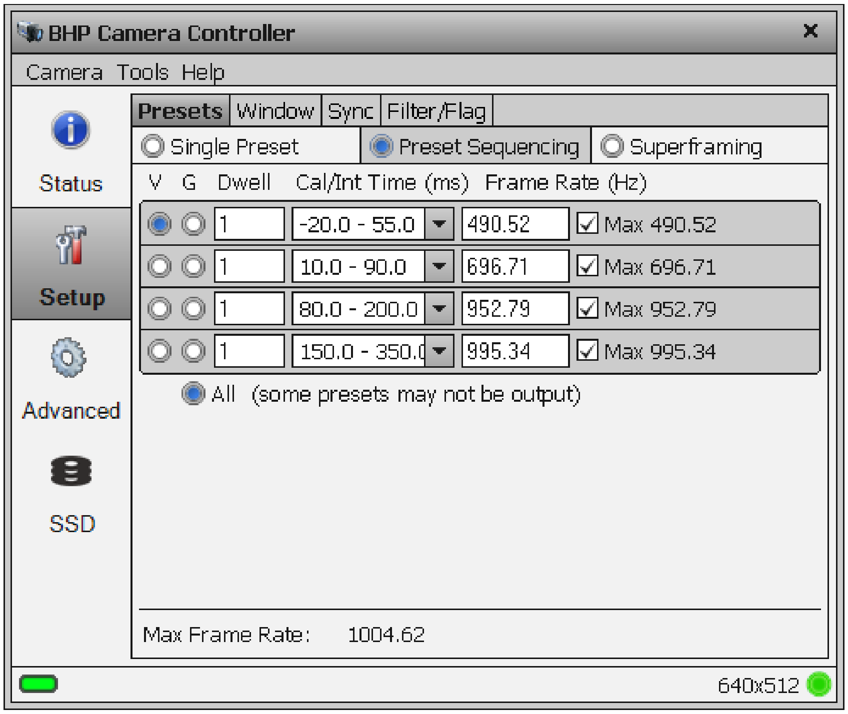
TIP: **The controller often provides additional information using tooltips. Mouse over just about any control or indicator to see information about the current setting or about the bounds of valid values for the control.**



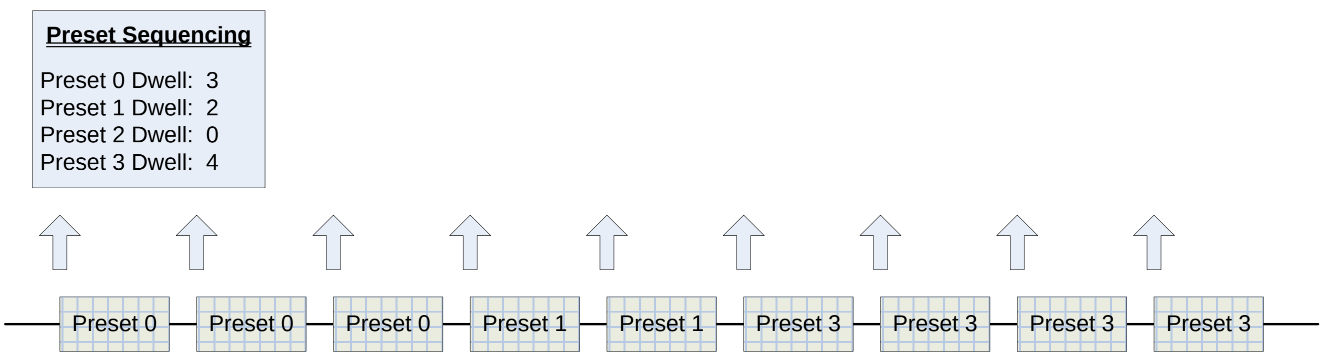
Single Preset Mode

5.4.2.1.2 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:



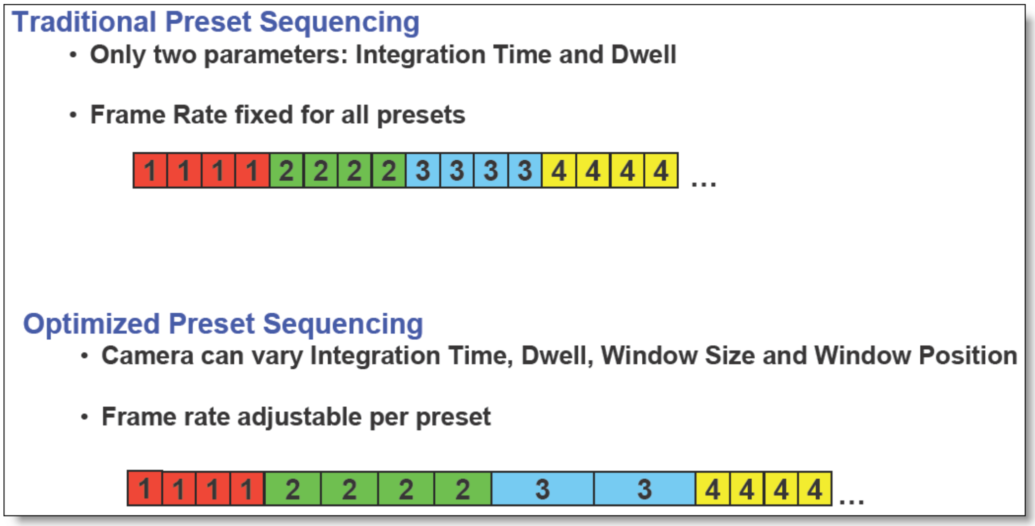
Preset Sequencing

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 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.

The radio button next to the Dwell field tells the camera which preset to send to the active video output.

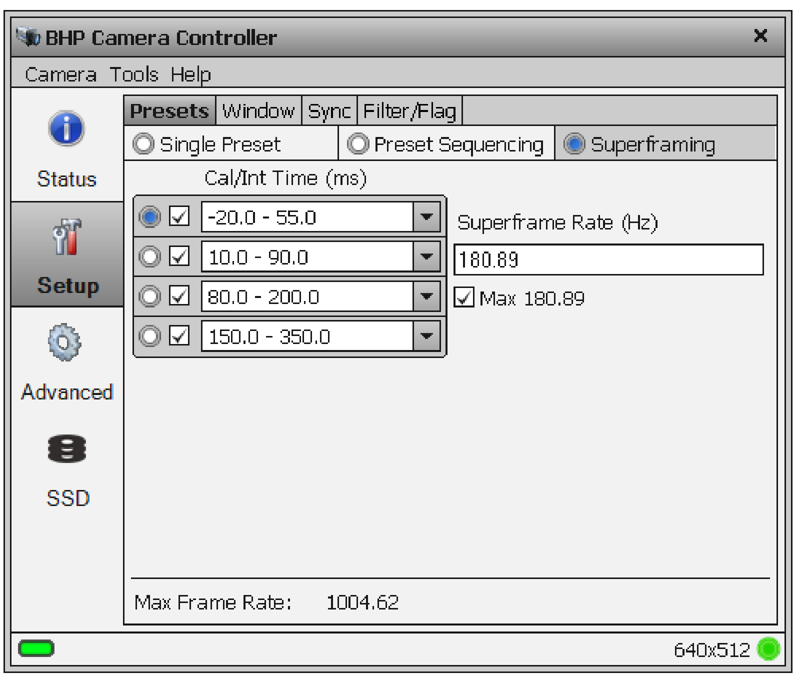
Optimized vs. Traditional Preset Sequencing

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. See Section 5.4.2 for more details.

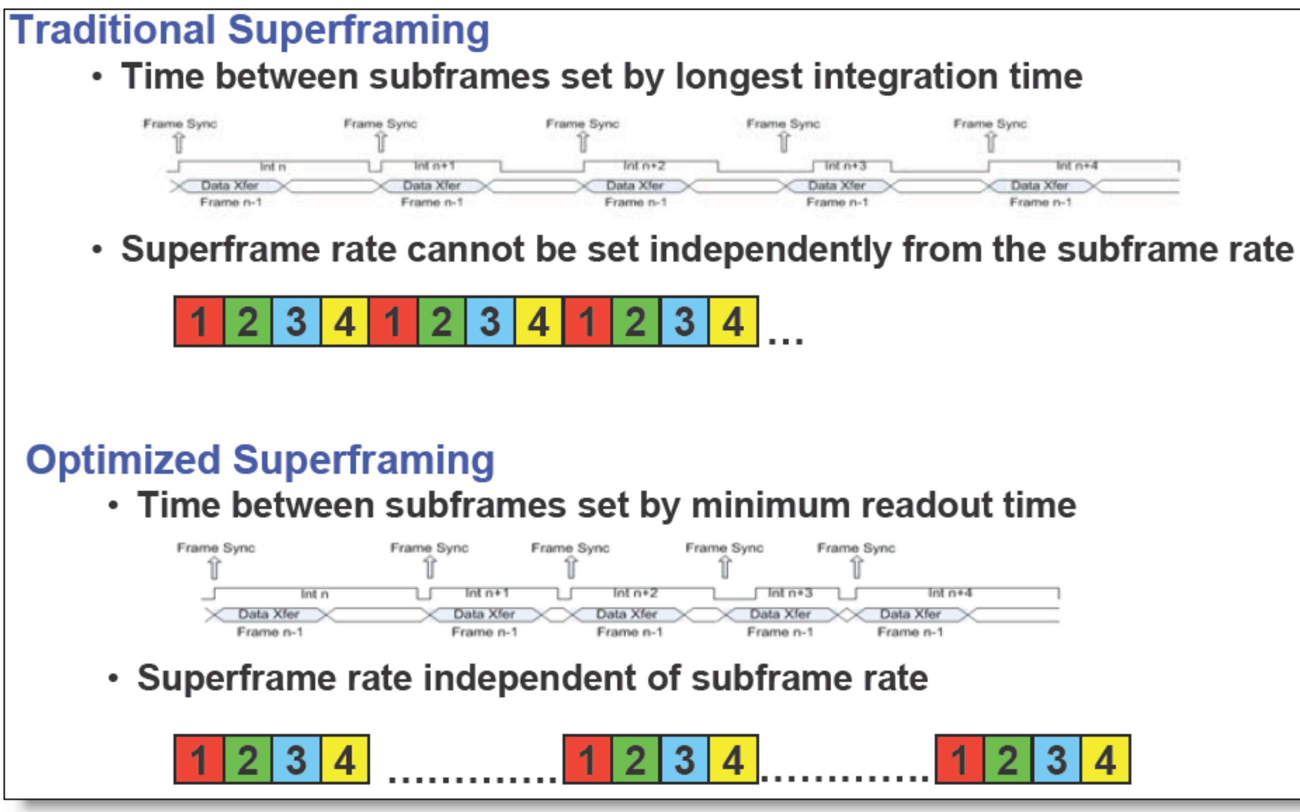
5.4.2.1.3 Superframing Mode



Superframing is a subset of preset sequencing with dwell counts of 0 (unchecked) or 1 (checked) 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.



> **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. See Section 5.4.2 for more details.

5.4.2.2 Window Tab

The Window tab allows the user to set the size of the active image window and the location of the window. The window size and offset for the image data must be the same for both the FPA and analog video. The Window Tab contains two sub-tabs: FPA and Analog Video.

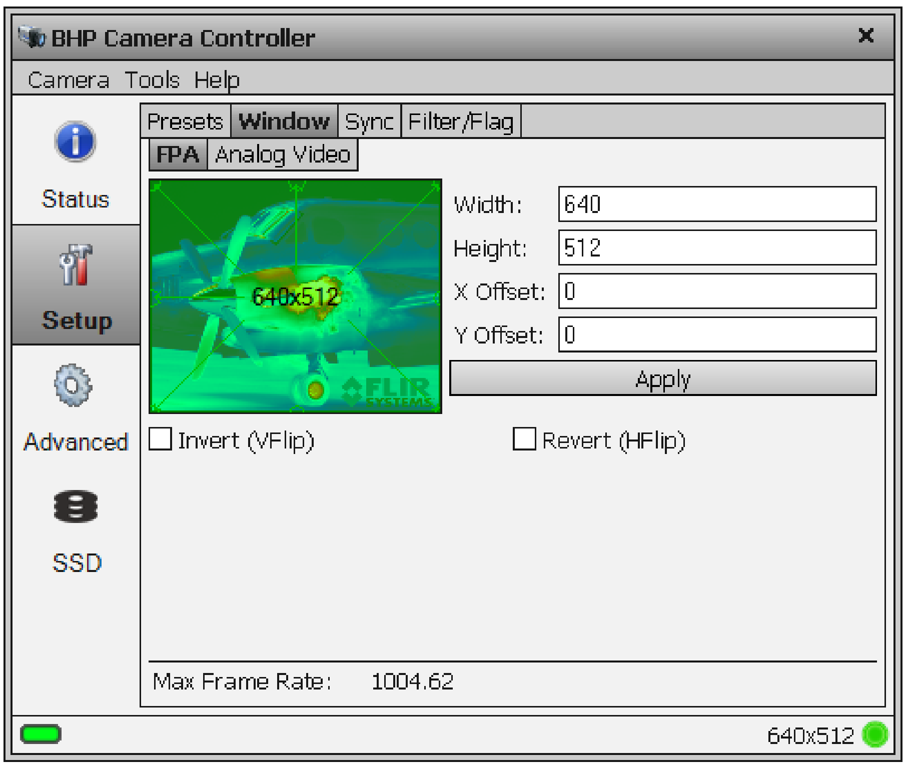
5.4.2.2.1 FPA Sub-tab

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.

The FPA Window settings can be changed by either entering values in the appropriate fields or 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. The window settings will turn red if a value has been changed but not applied. A yellow value indicates an invalid value has been chosen.

Click the Apply button to update the camera. The fields will turn gray when the changes have been accepted.

Use the Invert/Revert check boxes to flip the image vertically (Invert) or horizontally (Revert). This is useful if your optics cause the image to be flipped. This flipping is done on the FPA itself and a new NUC is typically required if these settings are changed.



X6800/X6900 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

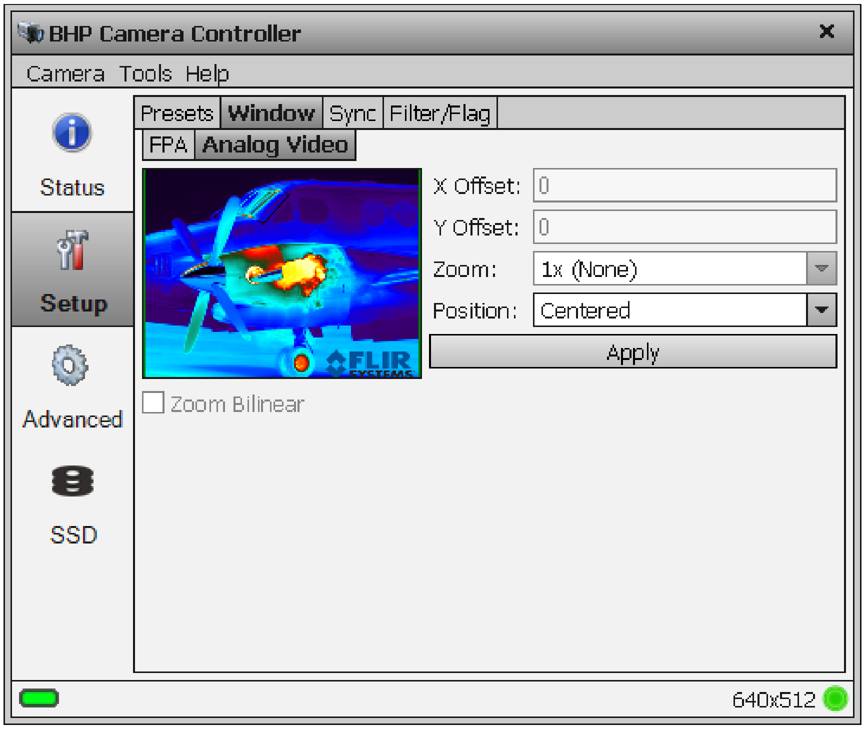
X8500 Frame Size Variables

	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.

5.4.2.2.2 Analog Video sub-tab

The analog video outputs always put out a standard size video frame. If the camera FPA image is windowed down in size, then there will be black areas in the Analog Video. The Analog Video sub tab allows the user to control how the FPA digital image data is positioned within the analog video frame.



Zoom Modes	
Zoom	Because video modes have a fixed frame size, adjusting the FPA window size can cause large empty areas around the image in the video. The video zoom feature can reduce this effect by applying a digital zoom factor to the image. The available zooms are: x½, x1, x2, x4/3, x4. (4/3 zoom is good for displaying a 640x512 image on a 720p display.
Analog Video Position Modes	
Centered	FPA data is placed in center of analog frame
Same as FPA	Uses Offsets from FPA sub-tab
Offset	Uses X & Y offsets on this page to locate upper left corner of image data in the video frame

5.4.2.3 Sync Tab

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).

5.4.2.3.1 *Sync Mode*

5.4.2.3.1.1 Frame Sync Starts

The X-series makes use of frame syncs and triggers to control the generation of image data. Again, frame syncs control the start of individual frames whereas triggers start sequences of frames.

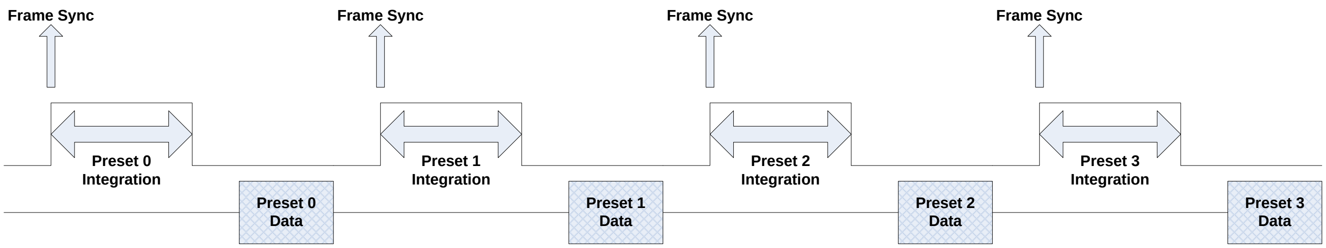
The generation of a frame consists of two phases: *integration* and *data readout*. Depending on the timing between these two events, you can have two basic integration modes: Integrate Then Read (ITR) and Integrate While Read (IWR). In ITR, integration and data readout occur sequentially. The complete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

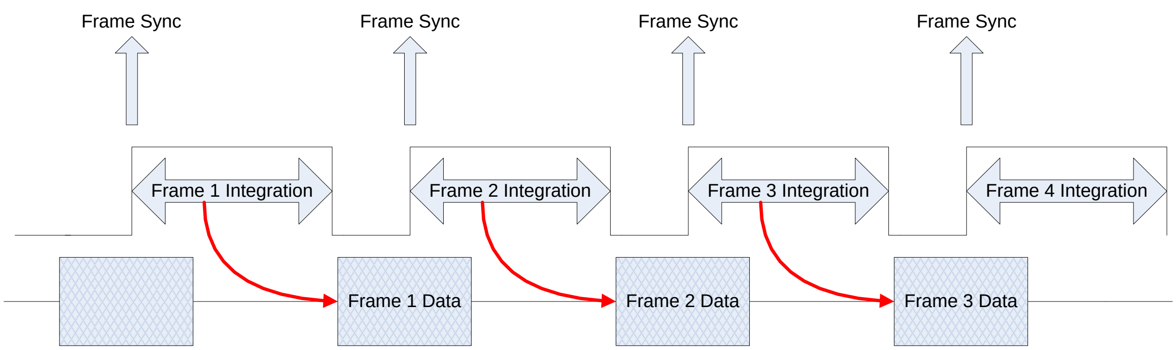
5.4.2.3.1.1.1 Frame Sync Starts Integration (FSSI)

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 preset sequencing or 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



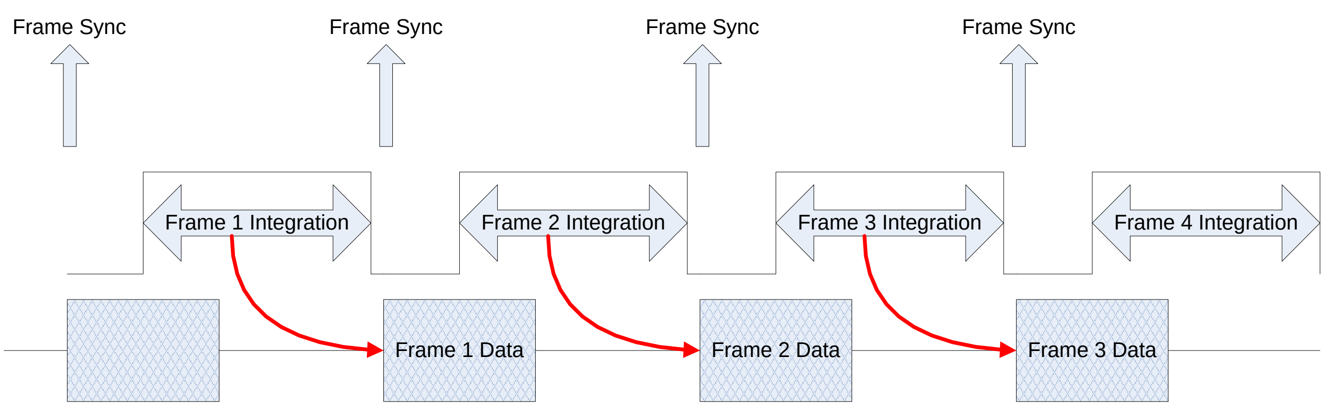
Frame Sync Starts Integration, ITR



Frame Sync Starts Integration, IWR

5.4.2.3.1.1.2 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.



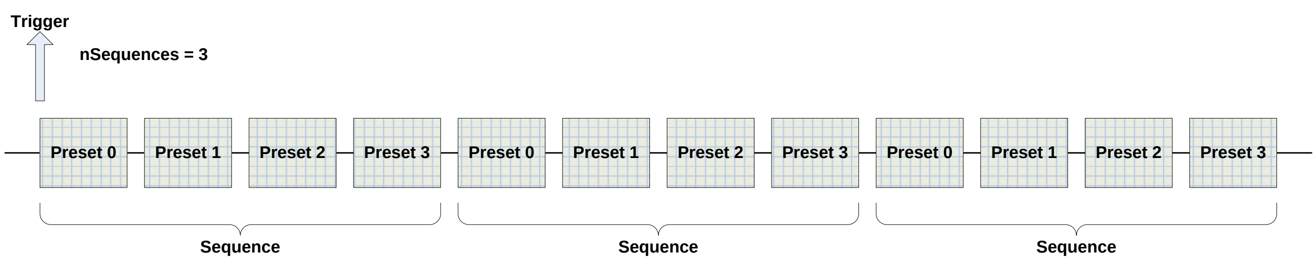
Frame Sync Starts Readout

5.4.2.3.1.2 Trigger Mode

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.

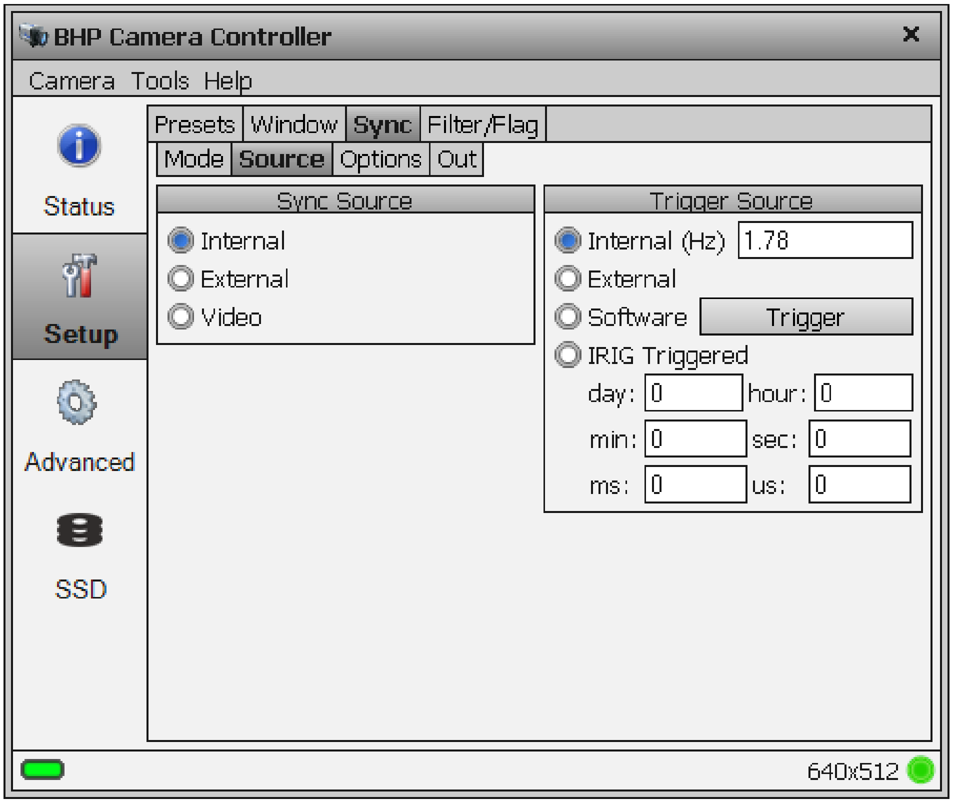
Trigger Modes	
Free Run	In free run the camera cycles through frames/sequences continuously.
Trigger, then do this many sequences	Upon receiving a trigger (external or software), the camera generates the number of sequences entered in the box (max limit: >$4x10^9$).
Trigger then free run	Upon receiving 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.



ITR Frame Process

5.4.2.3.2 Sync Source

The Source options page allows the user to select the source for Syncs and Triggers.

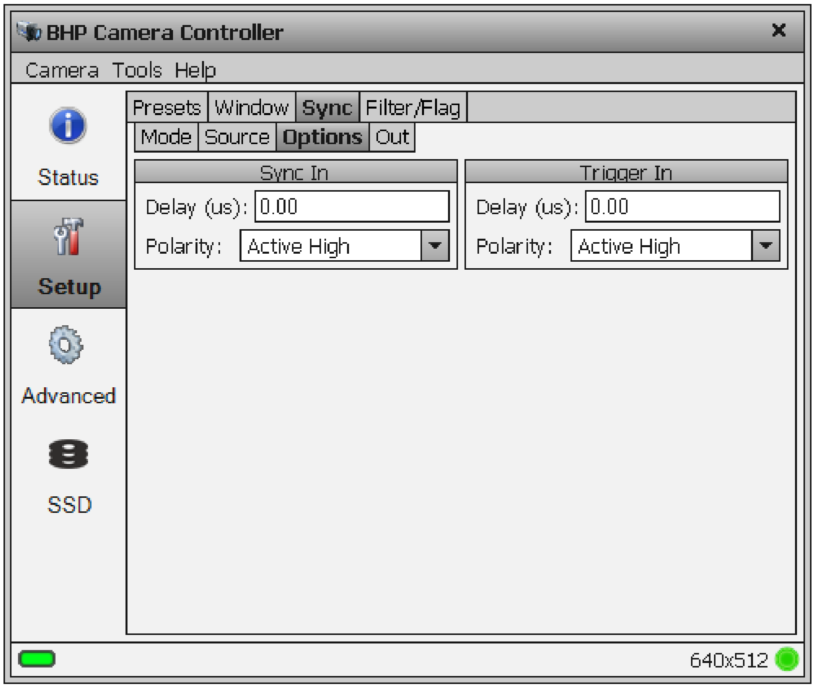


Sync Sources	
Internal	The frame sync is generated internally to run at the frequency set by the user
External	The frame sync is generated externally through the Sync In connect on the camera rear chassis.
Video	The frame sync is generated from an external video source connected to the Gen Lock In connector on the camera rear chassis.
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 TTL)
Software	The trigger is generated via a software button (Trigger button)
IRIG Triggered	Camera generates an internal trigger when the internal IRIG

	clock reaches a specified time.

5.4.2.3.3 Sync Options

The Sync Options page allows the user to set delays and polarities for the Sync and Trigger In.

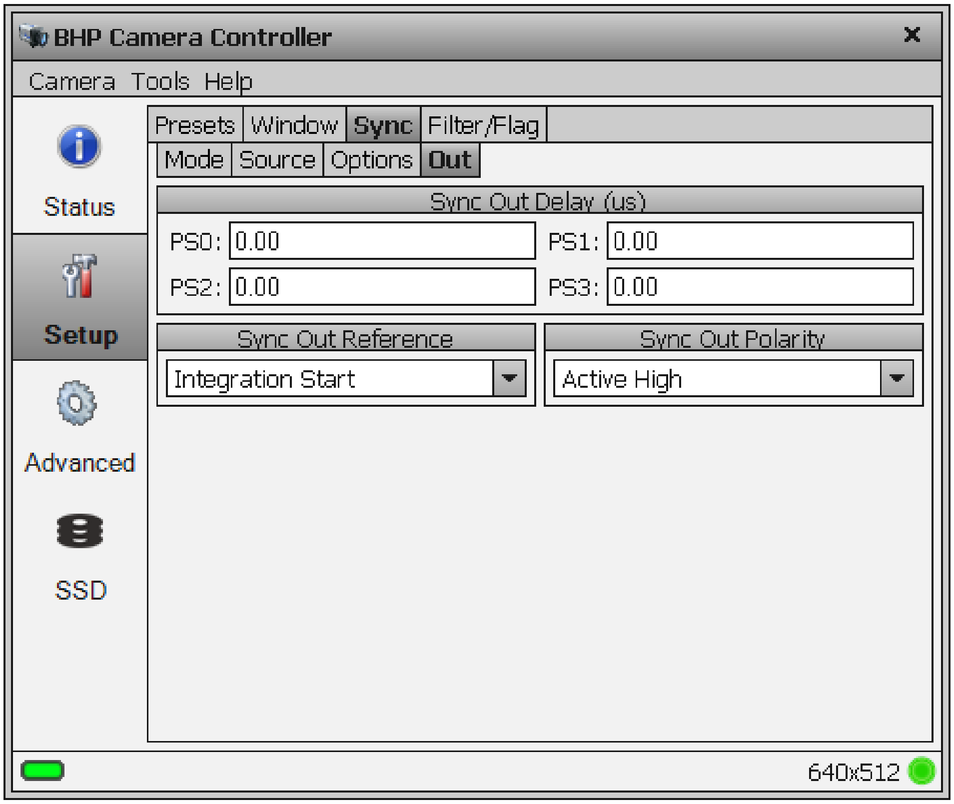


Sync In	
Delay	Allows for the user to set a delay (µsec) for the external sync. See timing diagrams below.
Polarity	The sync is edge triggered. This allows for the camera to use either the rising or falling edge.
Trigger In	
Delay	Allows for the user to set a delay (µsec) for the external trigger. See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

NOTE: The camera has a latency of approximately 1 microsecond when responding to a sync or trigger signal.

5.4.2.3.4 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).



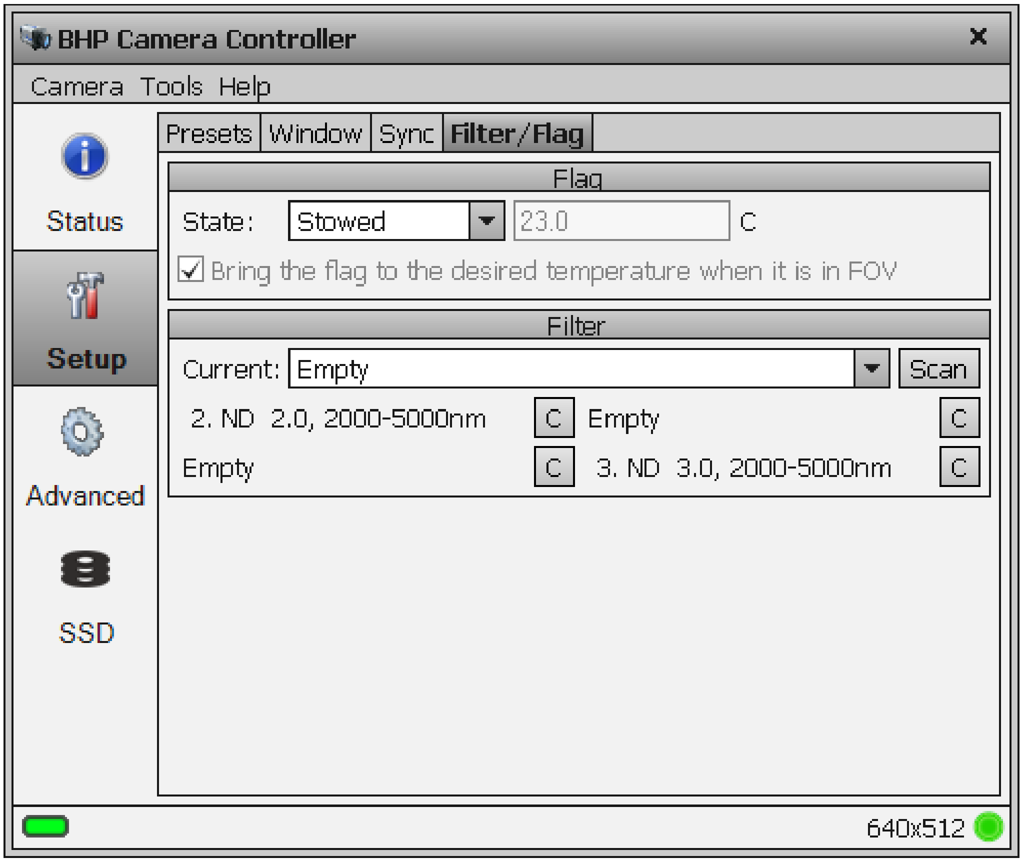
Sync Out Options	
Sync Out Delay	Allows for the user to set a delay (in microseconds) for the sync out on a preset basis.
Sync Out Source	Allows for the sync out to be referenced to the start of frame or start of integration.
Sync Out Polarity	Allows for the sync out to be active high or low.

5.4.2.4 Filter/Flag

The Filter/Flag page controls the internal NUC flag and warm filter wheel.

5.4.2.4.1 Flag controls

Normally the NUC flag is primarily used with the Auto NUC function. However, it can be manually controlled from this page.



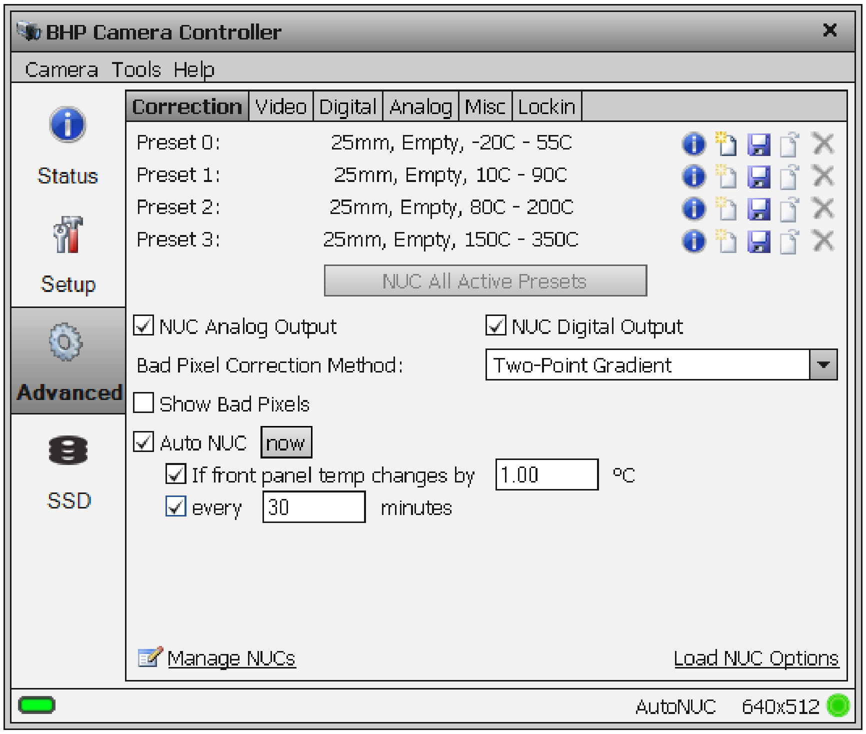
Flag Controls	
State	Stowed: Flag not in field of view Deployed: Flag in field of view
Temperature	The standard NUC flag does not have a temperature control, so this field and the checkbox will be grayed out. Cameras that do not have the filter wheel have a NUC flag with a TEC cooler. The temperature of the flag can be set from this page.

5.4.2.4.2 Filter Wheel Controls

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 drop down 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. Below the filter selector is a list of filters detected by the camera. If you wish to replace a filter, click the "C" button. This will move that filter into the field of view so that it can be accessed. See Section 7 for more information on how to install filters. After installing a filter, press the "Scan" button so that the camera can detect the new filter IDs.

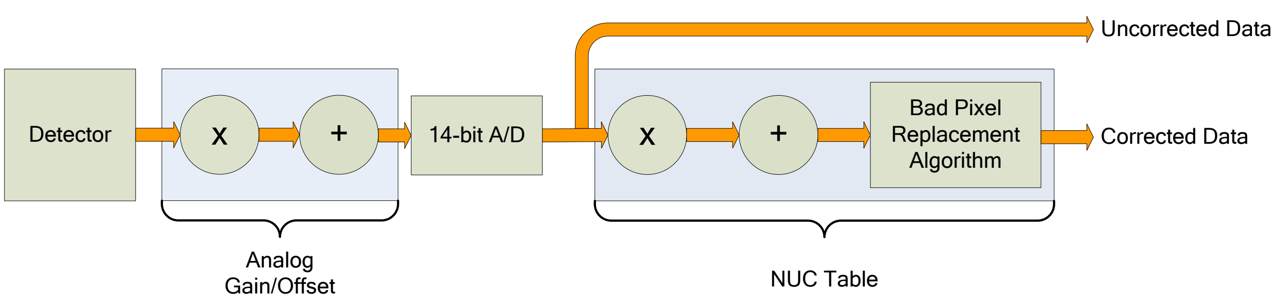
5.4.3 Advanced Page

The Advanced Page contains controls for performing and managing on-camera Non-Uniformity Corrections (NUCs), Analog video AGC, analog and digital offset, detector bias and a few advanced miscellaneous features.



5.4.3.1 Non-Uniformity Correction (NUC)

Non-Uniformity Correction (NUC) refers 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 below. The result is corrected data where each pixel responds consistently across the detector input range creating a uniform image.

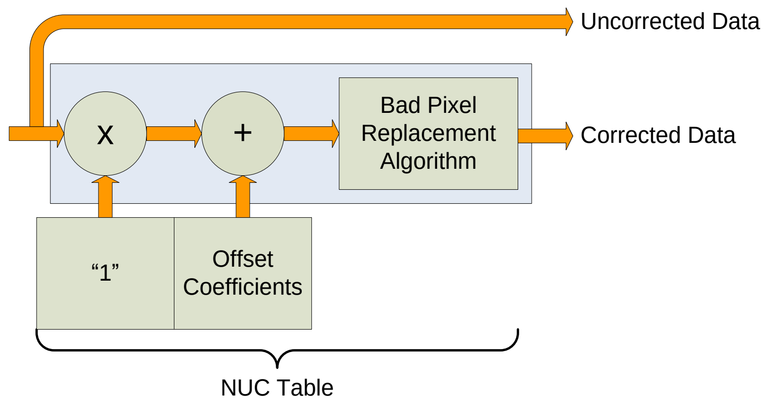


Digital Process Showing NUC Table Application

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 cameras 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 three types of processes which are used to create the NUC table; One-Point, Two-Point, and Offset Update.

5.4.3.1.1 One-Point Correction Process

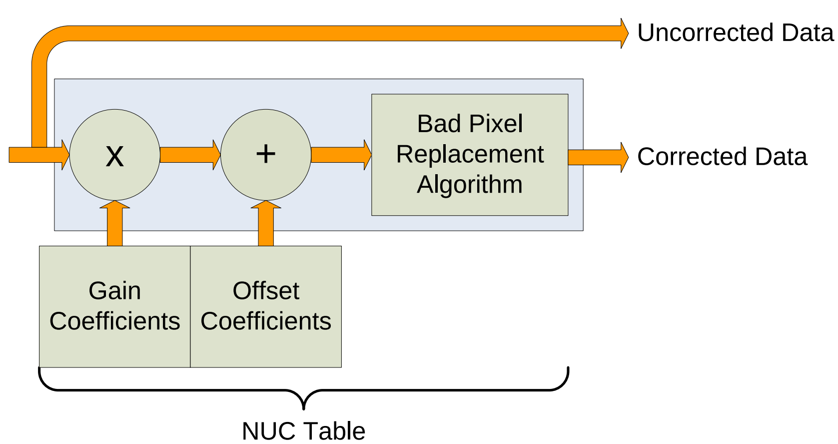
A One-Point Correction Process requires one uniform source, which is typically in the middle of the usable range. The One-Point Correction replaces all gain coefficients in the NUC table with a value of one ("1") as seen in the figure below. The offset coefficients are computed uniquely for each pixel.



One-Point Correction

5.4.3.1.2 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 the figure below. 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 verses the One-Point process. A 2-point correct will also work better over a wider range of scene temperatures than a 1-point correction.



Two-Point Correction

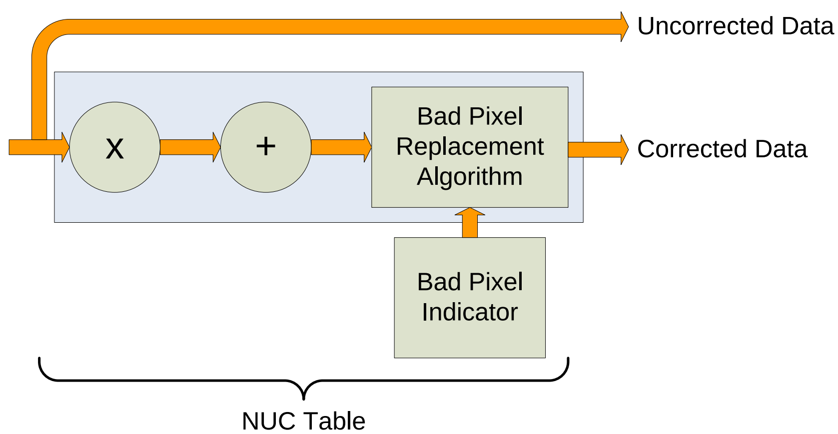
5.4.3.1.3 *Update Offset*

Often times 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 Update Offset simply computes a new offset coefficient using the existing gain coefficient and corrects the image non-uniformity. Update Offsets are typically performed when a Two-Point NUC table is being used.

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

5.4.3.1.4 *Bad Pixel Correction*

Within the NUC table there is an indication as to whether or not a pixel has been determined to be bad as shown below. There are two methods used to determine bad pixels.



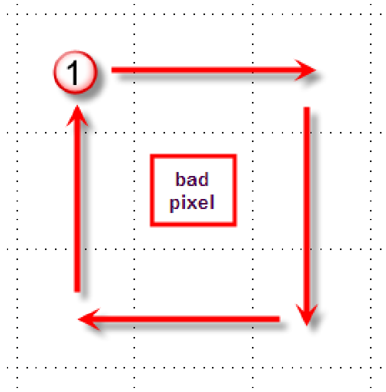
Bad Pixel Correction

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 a 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.

Since the responsivity test requires a gain coefficient, it is useless on NUC tables determine by the One-Point Correction because those tables have a value of one ("1") as the gain coefficients. The Twinkler test can be done on either correction process.

The X-series camera uses the Nearest Neighbor algorithm for bad pixel replacement, 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.

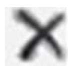


5.4.3.2 Correction Tab

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

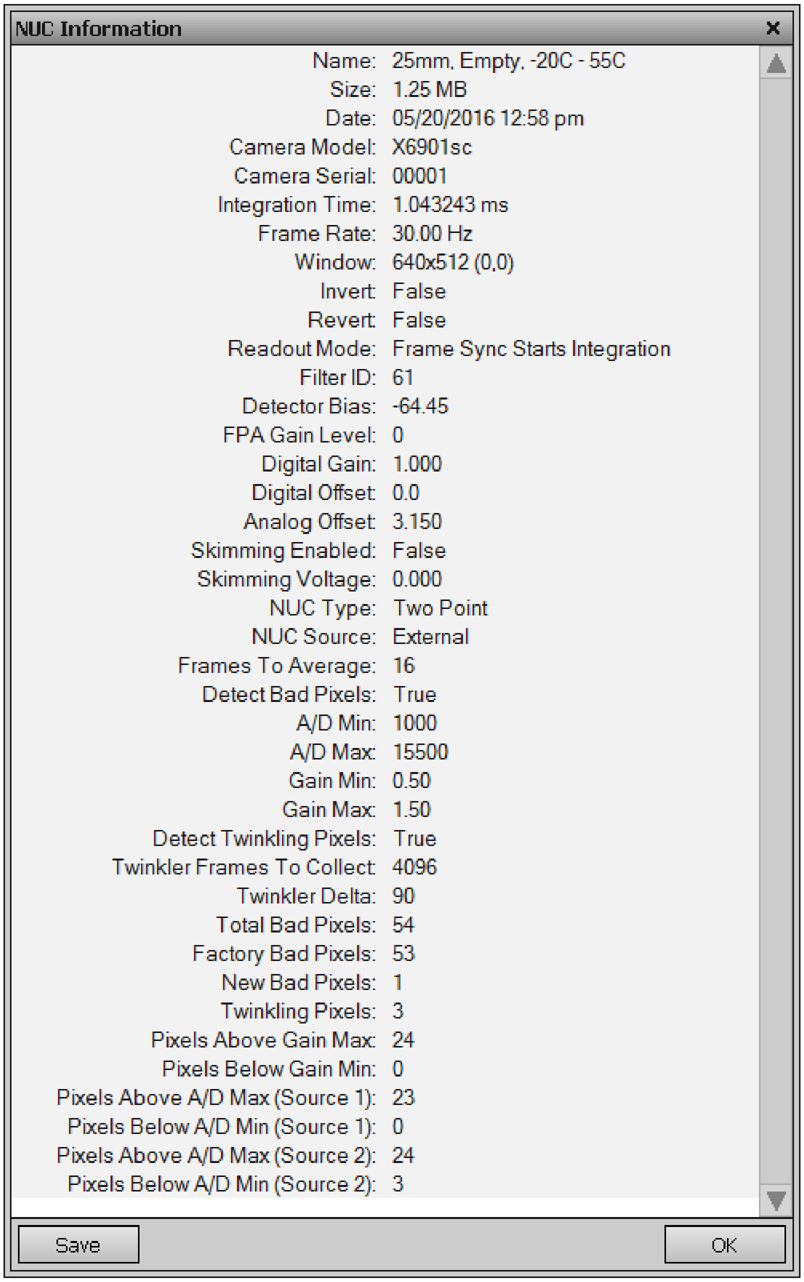
RAM memory. This type of memory is used to store NUCs that will be applied to live image data. There is enough RAM memory for one NUC to be loaded for each Preset. This memory is volatile and is lost when then camera is turned off. If a NUC was loaded into RAM, the camera will reload that NUC from flash 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 2GB of flash memory available for storing NUCs. This is enough space to store >400 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.
☑ NUC Analog Output	Apply NUC to video data. “Analog” is a legacy description. This checkbox applies to all video outputs.
☑ NUC Digital Output	Apply NUC to Digital output (GigE, Camera Link)
☐ Show Bad Pixels	Displays all pixels marked as “bad” as white dots on both the analog and digital outputs.
☐ Auto NUC	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
Manage NUCs	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.
Load NUC Options	Displays options for loading NUCs.

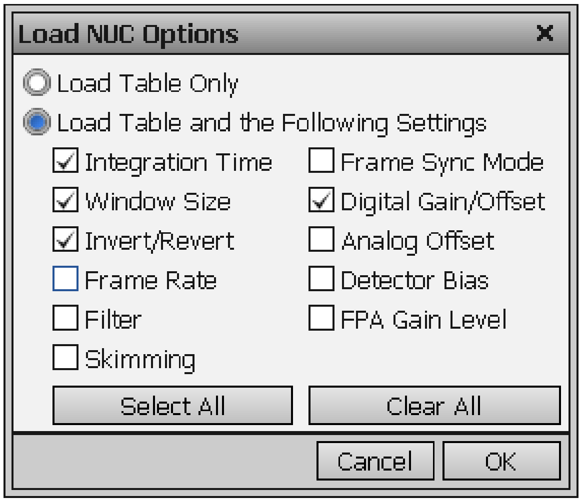
5.4.3.2.1 NUC Information

The button displays 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.



5.4.3.2.2 Load NUC Options

Typically, all of 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.



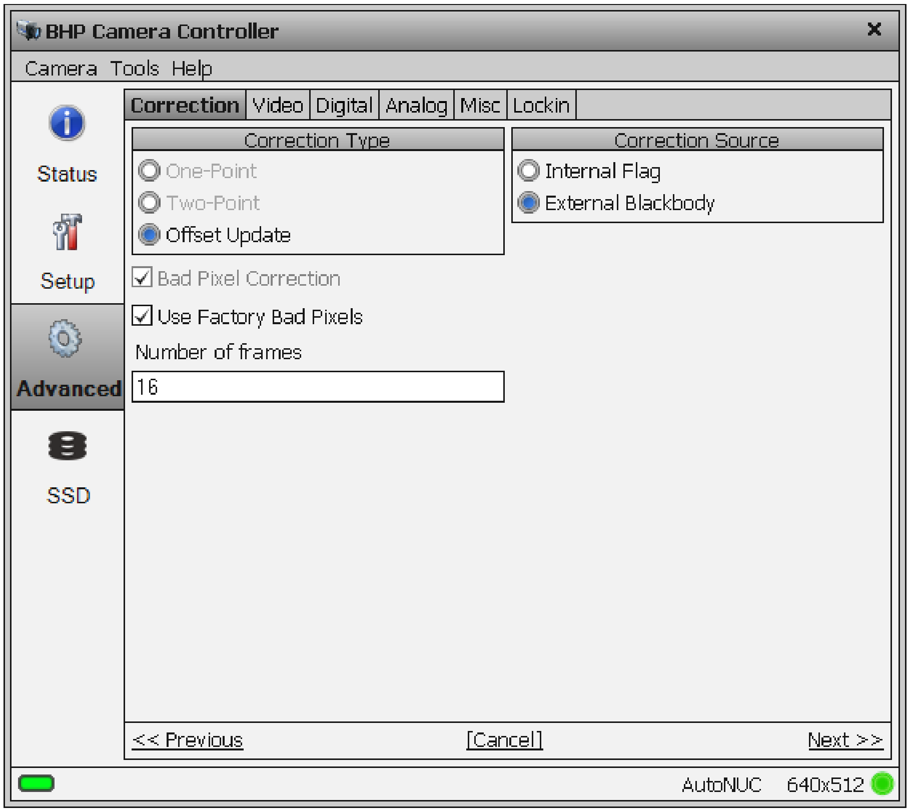
The default setting is to “Load Table Only”, in which case only the NUC coefficients are used from a NUC file. When the user selects “Load Table and the Following Settings”, the user can select which parameters from the NUC will override the current state. The option will not affect NUCs that are currently 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.

5.4.3.2.3 Performing a NUC

To create an on-camera NUC, select the *Perform Correction* icon  to start the NUC Wizard for the desired preset. If Preset Sequencing or Superframing is enabled, the camera will only perform the NUC on the preset you select while keeping camera in the desired sequencing mode. To perform a NUC operation on all active presets at the same time, press the *NUC All Active Presets* button. This is convenient, for example, if you want to do an offset update to all presets with a single source.

> **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.

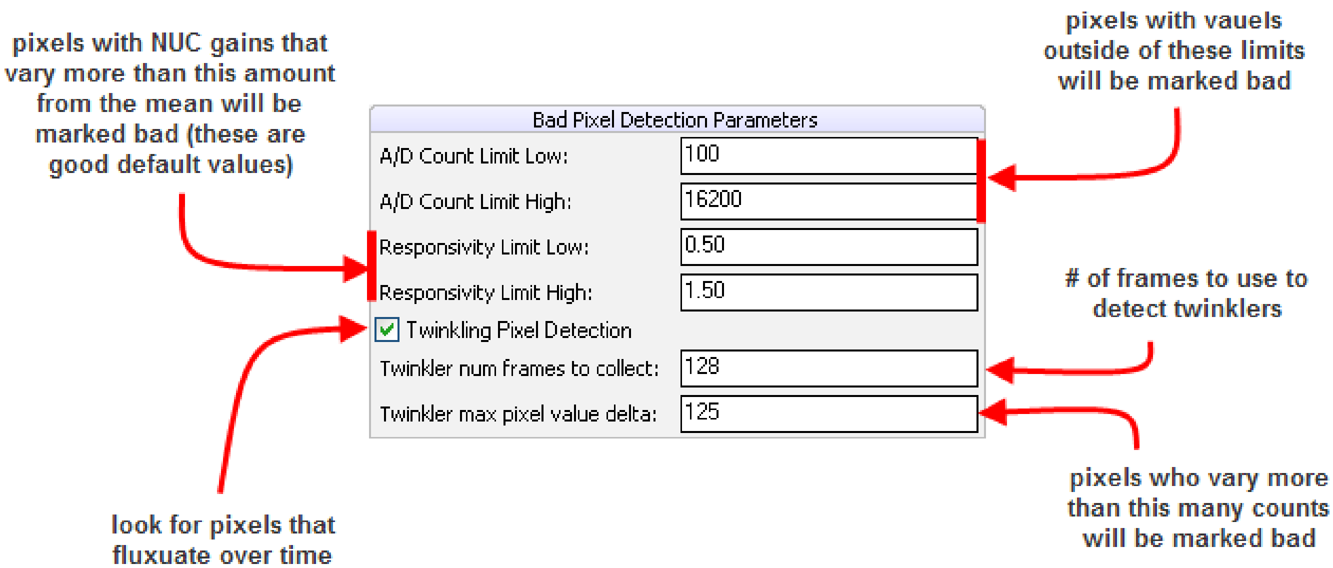
After selecting the *Perform Correction* a second window comes up to allow the user to select correction parameters. When all selections have been made, click *Next*>> to continue.



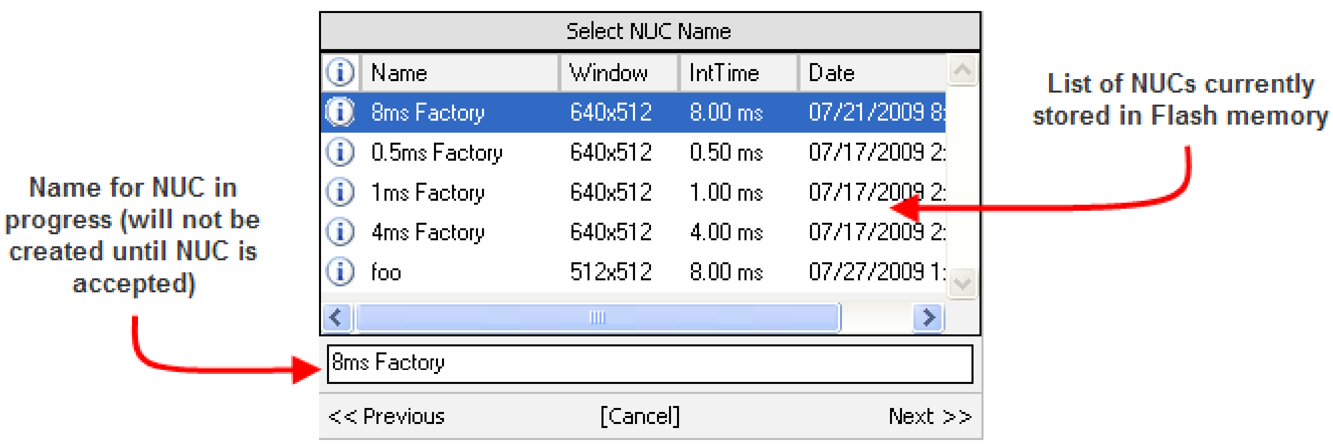
Correction (NUC) Types	
One Point	Sets the gain terms to “1” and computes the offset terms. Uses a single NUC source. Does not compute a BP correction.
Two Point	Sets both the gain and offset terms. Uses two NUC sources. Computes a bad pixel correction.
Offset Update	Retains the current NUC gain terms 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. This is disabled for 2-point NUC because the flag is not temperature controlled
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 frames to average when computing NUC coefficients. 16 is the default and 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. For most cases, the default values will produce a very good result. Once the parameters are set, select *Next*>> to continue.

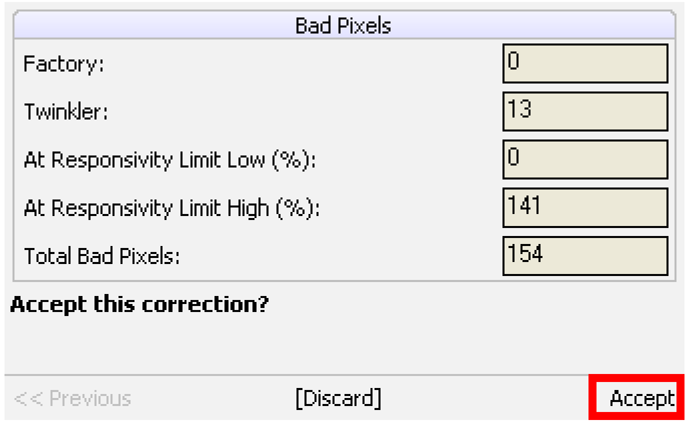


The next window allows the user to name the NUC. Simply type in the name for the table in the text box or select a previously saved file to replace it. Select *Next*>> to continue.



The next two 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.

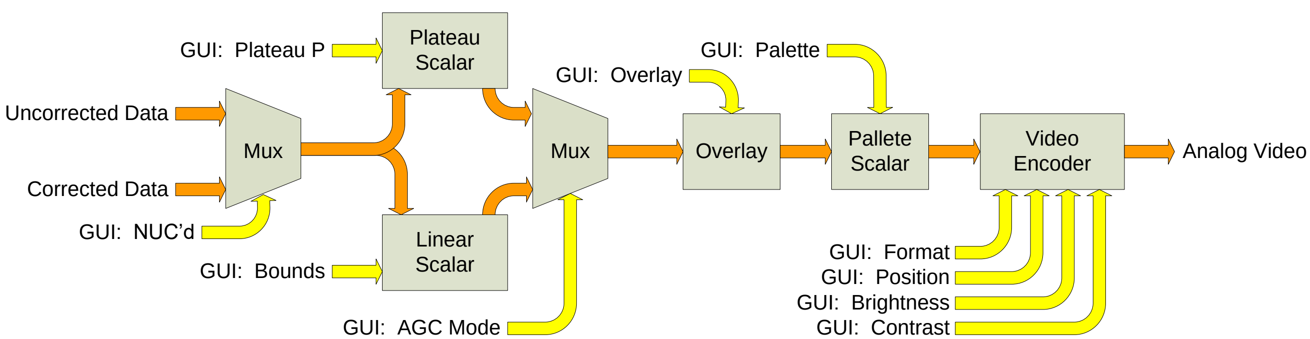
The last screen gives a report of the bad pixels found. The dialog shows how many pixels failed in each category. If the result is satisfactory, click Accept to save the NUC. The NUC table will be stored to flash memory and loaded into RAM memory for that preset. If the NUC is poor and you want to abort,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



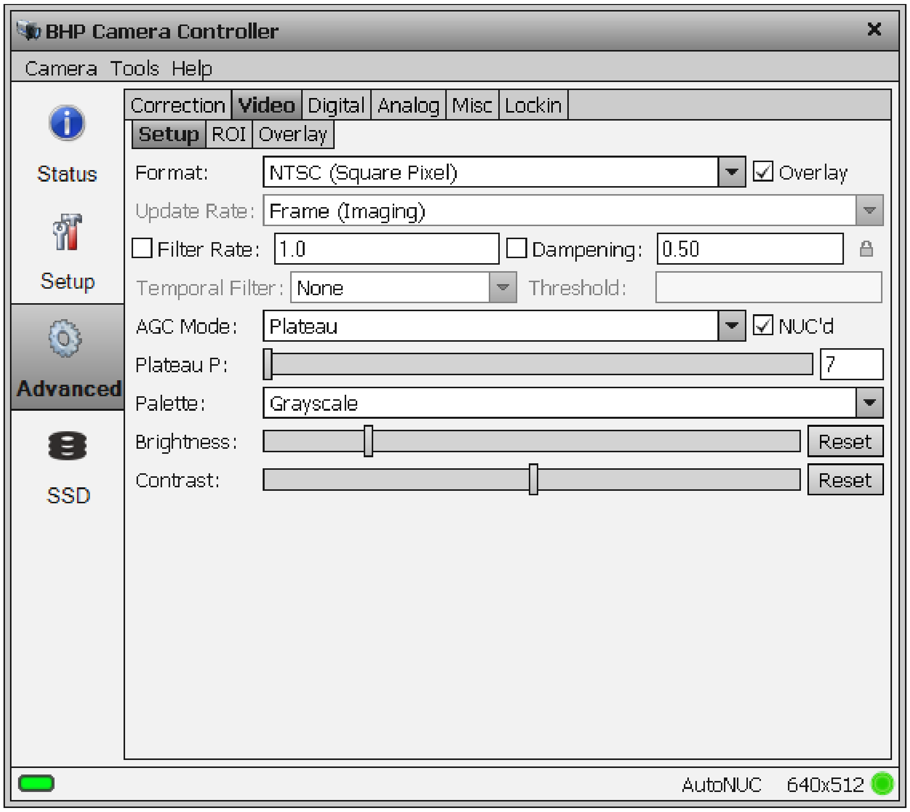
NOTE: It is possible for a bad pixel to fail more than one category, so the total bad pixels may be less than the sum of each category. "Factory" bad pixels are those that were determined to be bad during camera production testing.

5.4.3.3 Video Setup Tab

The X-series cameras have a 14-bit digital output. However, the video 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/SD video**. The diagram below shows a flow chart of the video process and how the parameters of this screen are used.



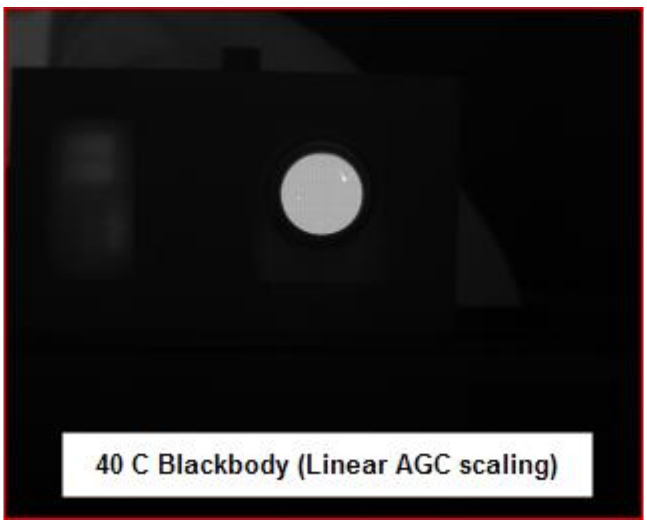
Video Flow

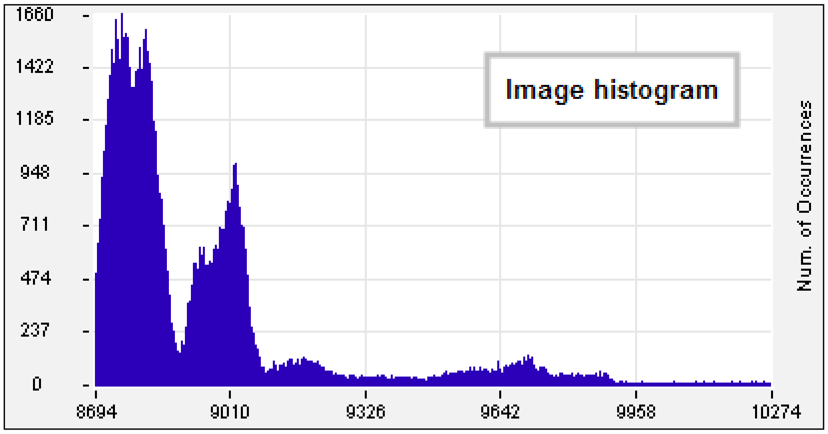


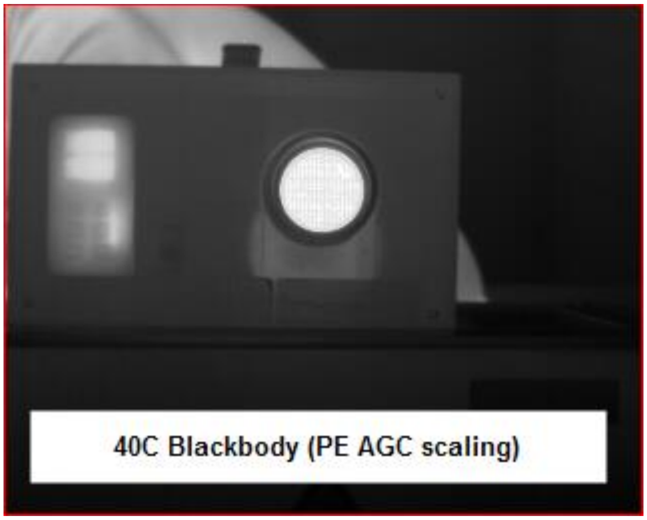
Analog Video Setup Options	
Format	HDMI/SDI: 1080p @ 29.9/25Hz, 720p @ 59.9/50Hz, NTSC, PAL,
Overlay	Enables the video overlay.
Filter Rate	Rate at which AGC is computed (1 to 20 Hz). Enable with checkbox
Dampening	Rate at which AGC is allowed to change. This will keep the AGC from responding rapidly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

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.
Brightness and Contrast	Allows user to set brightness and contrast on the video encoder. This occurs after the digital data has been scaled and converted to analog. These controls don't tend to have as much effect as the controls that are applied to the digital side (before the video encoder).

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.)



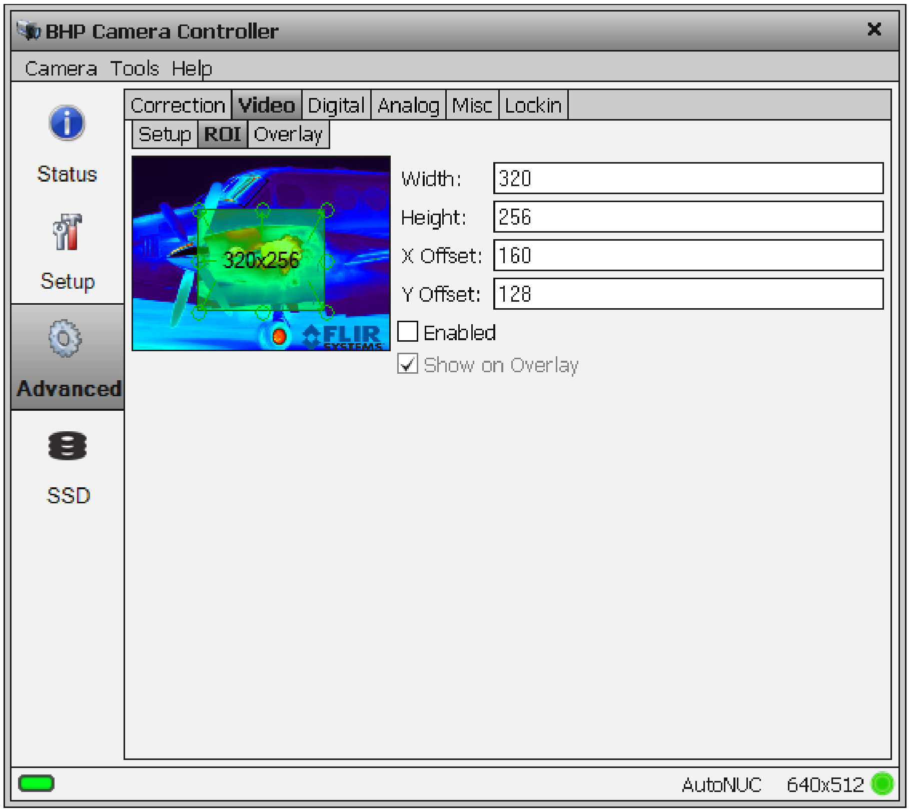




One final note about the PE algorithm: it is very aggressive. It can pull detail out of very low contrast imagery. It can also greatly enhance some very low-level NUC and FPA artifacts and noise if the contrast is low enough. This does not necessarily mean there is a problem with either the camera or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

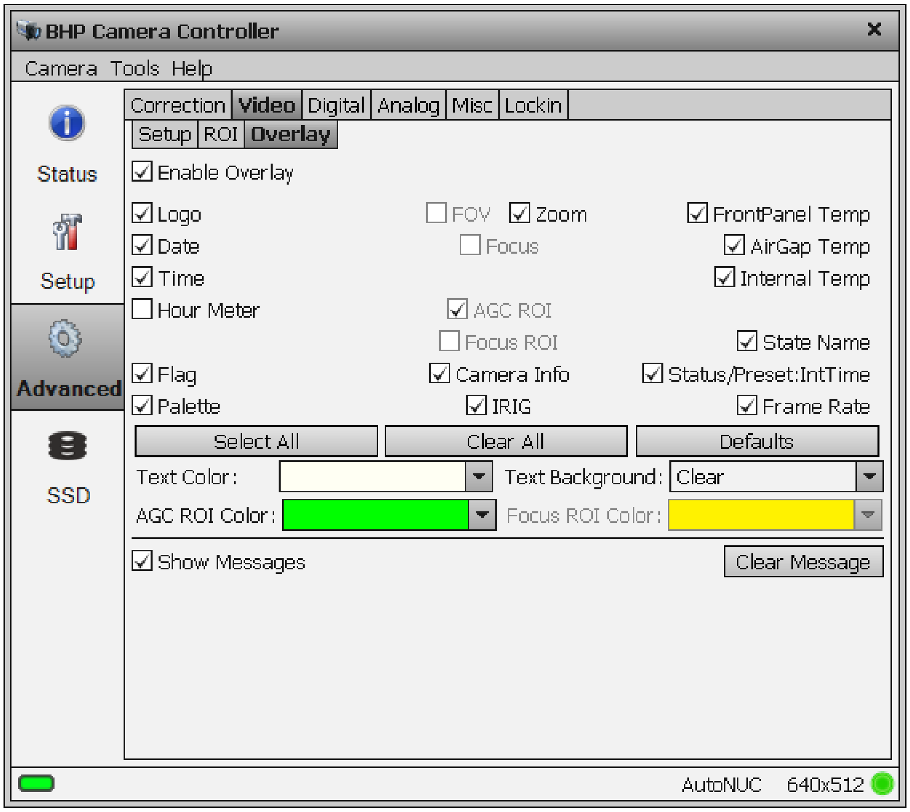
5.4.3.4 Video ROI

The Video ROI feature allows the user to define a box region and 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.



5.4.3.5 Video Overlay Tab

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. (For example, Focus will be grayed out on X-series but not on the RS6700).

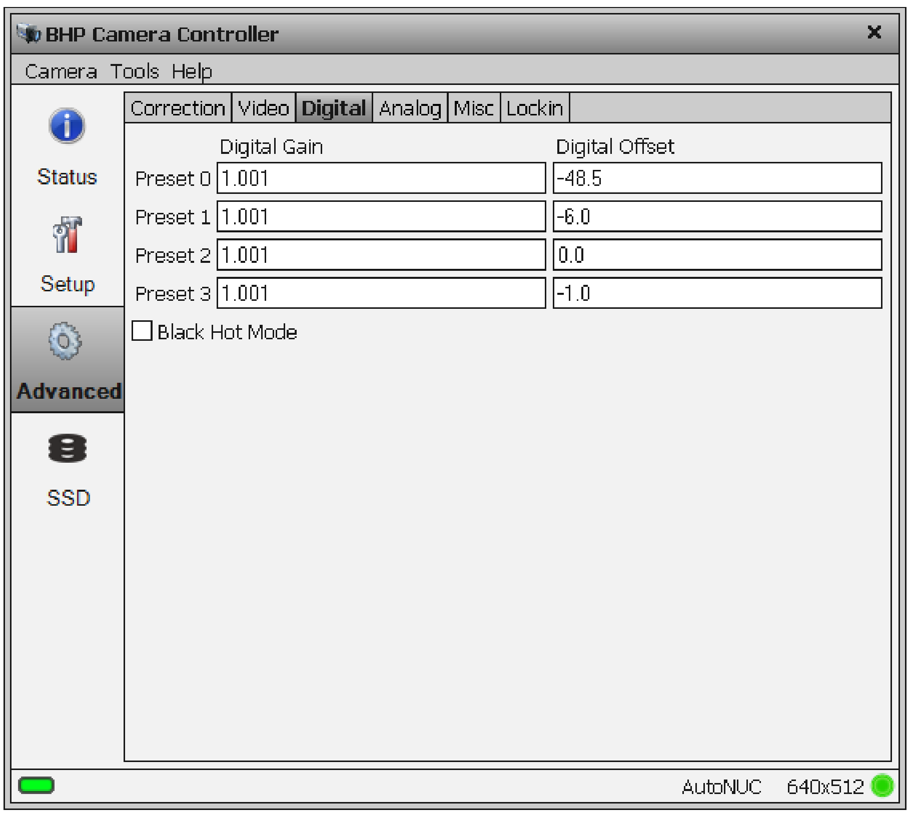


Video Overlay Options	
Enable Overlay	Turns the overlay On or Off without changing the selected options
Logo	Displays the FLIR logo
Date	Displays the system date stamp
Time	Displays the system time stamp
Hour Meter	Displays the accumulated camera “on” time (H:M). (Cannot be reset by user)
Zoom	Display 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

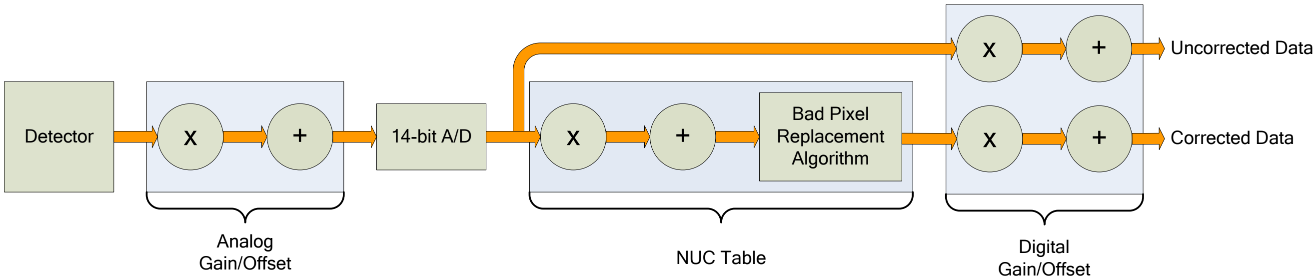
Video Overlay Options	
Status/Preset	Displays sequencing mode and currently displayed preset
Frame Rate	Displays FPA frame rate (in single Preset mode). Displays effective rate when Preset Sequencing (PS) or Superframing (SF)
Select All	Selects all overlay options
Clear All	Deselects all overlay options
Defaults	Selects default overlay options (stored in current camera state)
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

5.4.3.6 Digital Tab

The Digital Tab allows the user to apply an additional gain and offset to the digital data.



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:

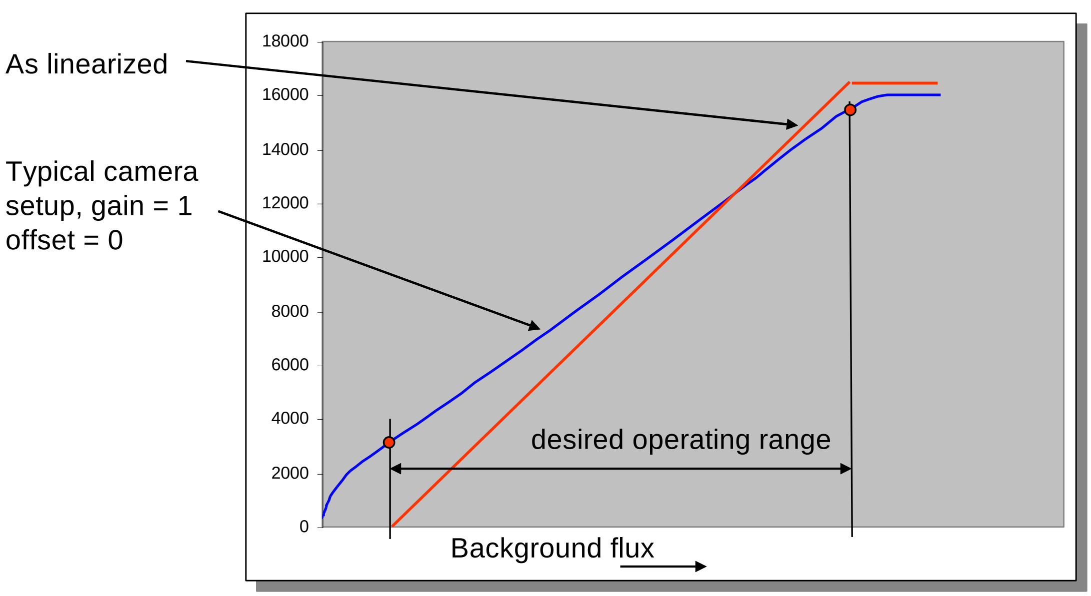
$$gain = \frac{16383}{15800 - 3200} = 1.30$$

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.

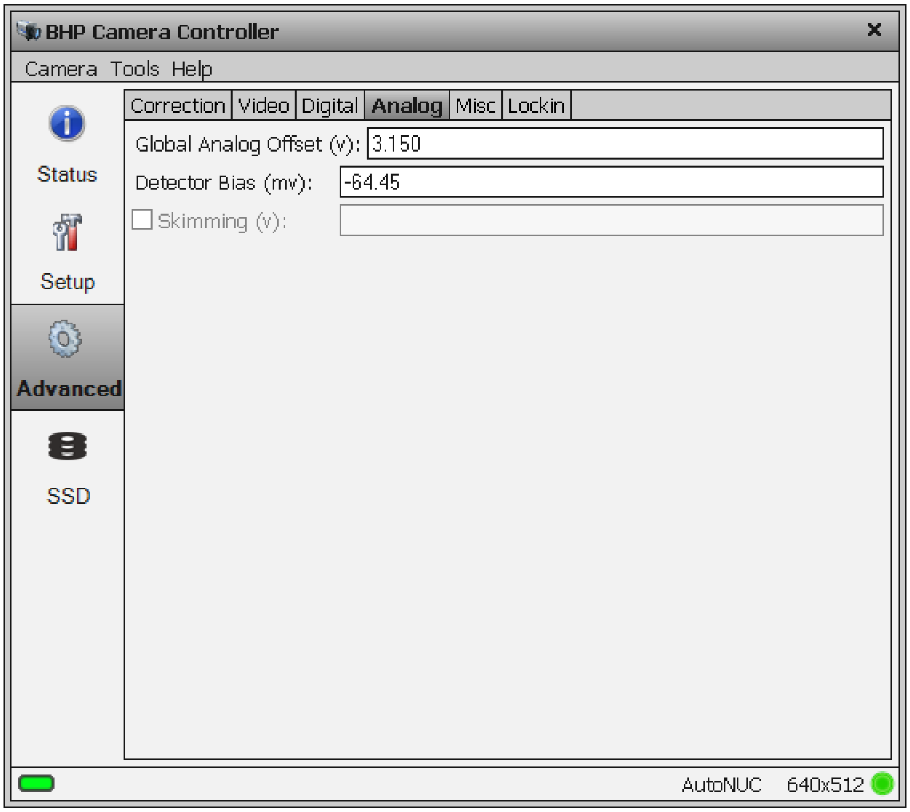
The available gain range is 1.999 to essentially zero; the available offset range is $\pm$ 32767. The default values are a gain of 1 and an offset of zero. Because the system sensitivity (NE∆T) is set prior to the A/D stages, there is no detrimental effect on performance from the use of the global gain and offset controls.



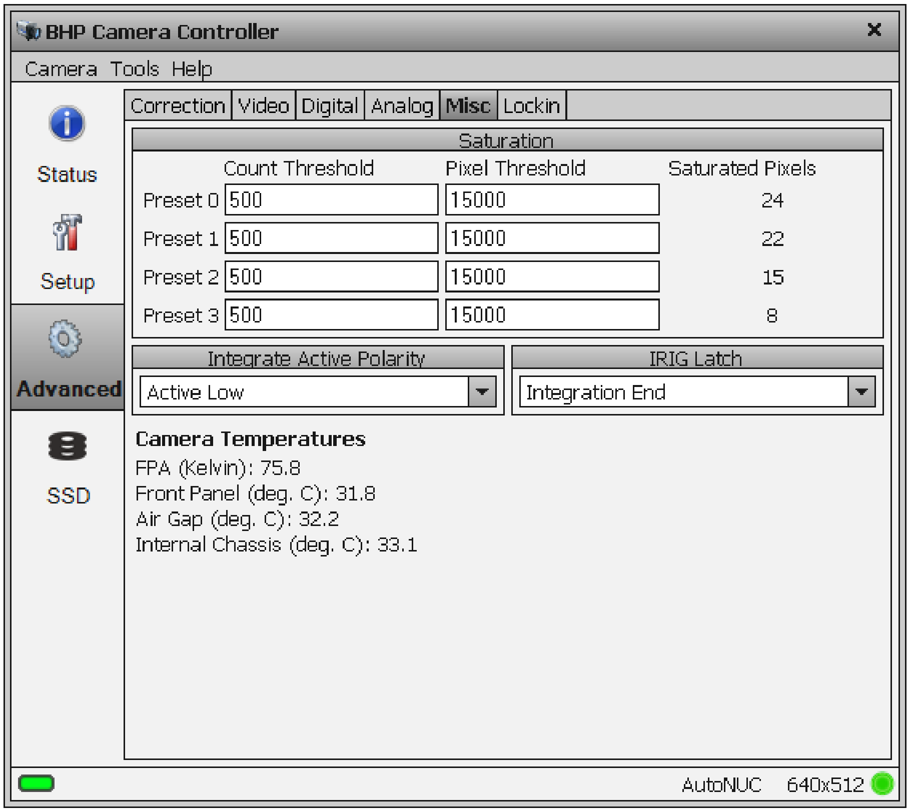
Use of global gain and offset to linearize the camera

5.4.3.7 Analog Tab

These parameters are set at the factory and are generally not adjusted by the user.



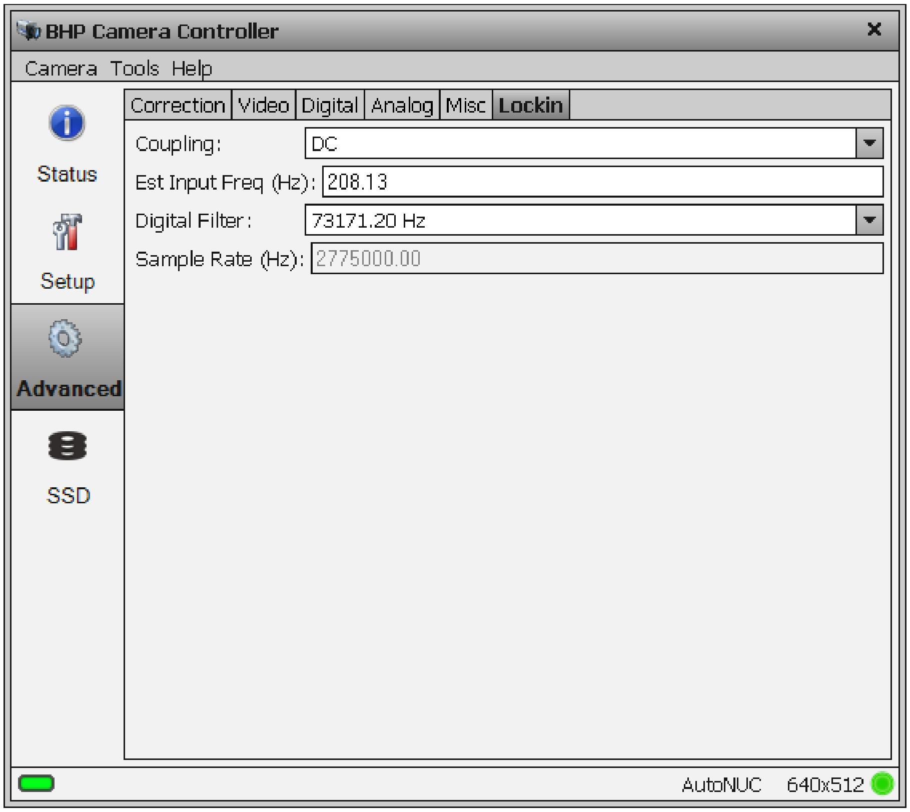
5.4.3.8 Misc Tab



5.4.3.9 Lockin Tab

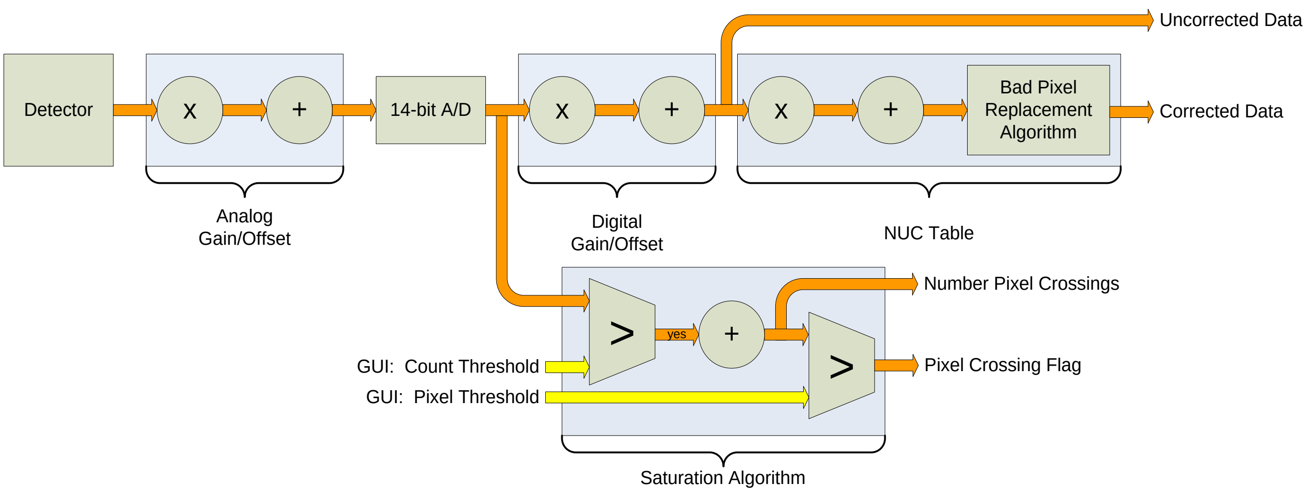
The lockin feature is designed for a non-destructive testing technique, where a periodic thermal excitation is applied to a part under test. An electrical signal that is synchronous with the excitation mechanism is also sent into the lockin input port on the camera's Auxiliary connector. This signal has its mean amplitude value and its period measured by the camera, and the results are stored in the image header metadata. An image sequence is acquired with this lockin metadata stored in the image header for each frame. This metadata is used for a post-acquisition analysis that can pull very weak signals out of the IR images and reveal defects in the part that are impossible to detect with conventional IR imaging techniques.

The signal period is determined by measuring the time interval between signal crossings of the digitizer midpoint value of 8192 counts, which is half of the 14-bit scale. The signal does not have to have any particular shape to get its period measured – it just has to be periodic. The lockin input has a 1.25 MHz sampling rate at 14 bits of depth, and selectable AC/DC coupling, with latency less than 1 microsecond. The input signal range is 0-5 volts. The frame period is the effective latency if it is used as a regular input, since it is only updated once per frame. When not used as a lockin input, this port still stores a value for each new image frame.



5.4.3.10 Saturation Detection

The camera can compare each pixel to a user defined threshold and count the number of pixels that exceed that threshold. Once that count has been determined for the entire frame, it is compared to threshold and sets a flag in the image header.



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.

5.4.3.10.1 Integrate Active Polarity

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

5.4.3.10.2 IRIG Latch

The X6900 and X8500 cameras place the IRIG time in the header for each frame of video. The X6900 and X8500 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 selected (see Section 5.4.2.3.1.1) 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.

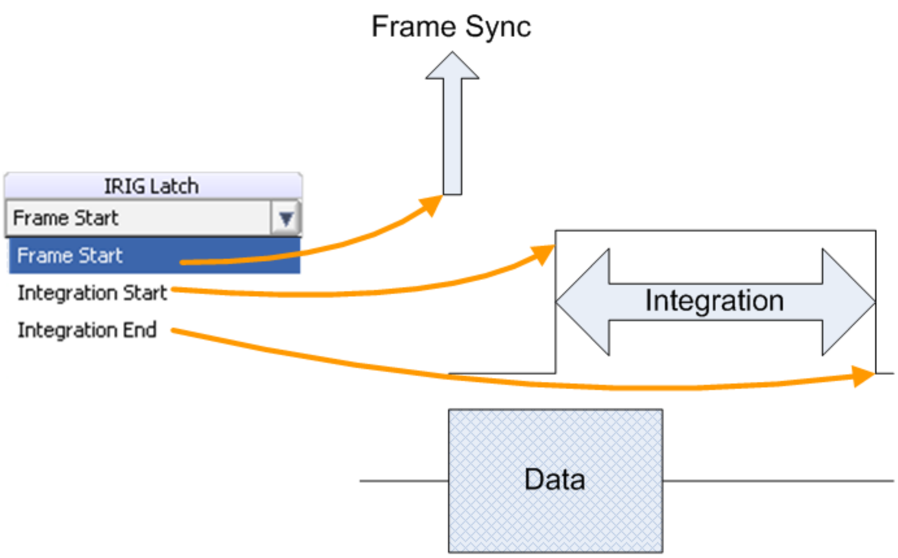
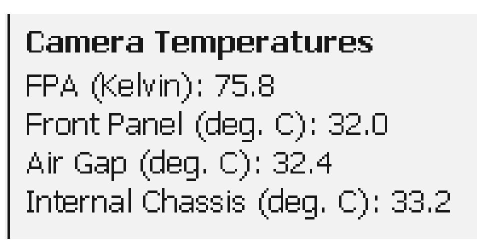


Figure 4-1: IRIG Latch Positions

5.4.3.10.3 Camera Temperatures

This part of the window displays the current temperature of the FPA, lens, and internal chassis temp sensors. These values are automatically updated every few seconds. If all the values are not visible, drag the corner of the controller window to make it larger.

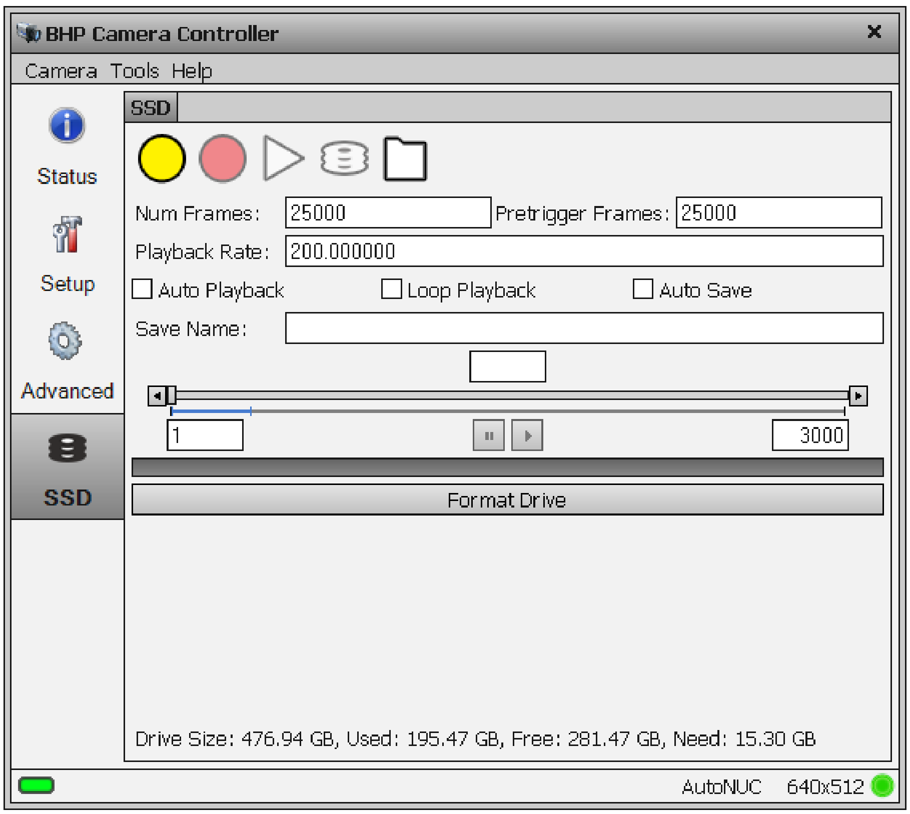


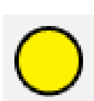
5.4.4 SSD Page

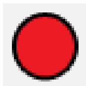
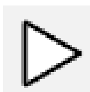
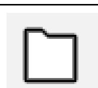
The SSD (Solid State Drive) page allow the user to control the functions related to the on-board recording functions. The X-Series cameras incorporate FLIR's Digital Video Image Recorder (DV-IR) system. The DV-IR system is a high-performance recording system that allow the user to record the image stream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

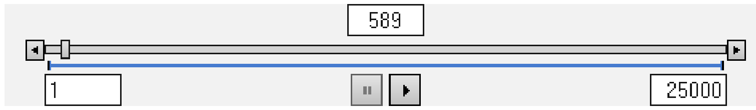
The DV-IR system is comprised of two main components, the RAM buffer and the SSD drive storage. The RAM buffer consists of 16GB of DDR-3 RAM. The RAM buffer is not removable but is volatile. All data in the buffer is erased when the camera is powered off. Because the buffer is volatile it is important 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 buffer can also be played back over the camera's other digital interfaces (GigE, Camera Link, CoaXpress, SDI) so that it can be captured by external software or an external recorder.

The camera uses standard form factor flash drives used in PCs and laptops which can be obtained from a variety of retail outlets. FLIR recommends the use of premium quality SSD drives as these will typically have much faster read/write times.



SSD Functions	
	**Arm Buffer**. Press this button to prepare the system for a new recording. Once "armed", the buffer will be configured according to the settings for Num Frames and Pretrigger 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

SSD Functions	
	the rear panel of the camera. NOTE: Any data currently in the RAM buffer from a previous recording WILL BE LOST once the system is re-armed.
	**Start Recording**. Pressing this button will initial the recording of live data to the RAM buffer. This button will be disabled until the system is armed.
	**Playback**. Playback the data currently stored in the RAM buffer. This button is disabled during data recording. 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.
	**Store data in RAM Buffer to SSD**. This is the fastest way to save the buffer. Speed will depend on SSD performance but with a high performance SSD it typically takes about 1.5x the record time to complete the save. The movie will be named according to the text in the “Save Name” field. The name is optional as all movies are also assigned a unique index number.
	**Display SSD Contents**. If an SSD is installed, pressing this button will display a list of movies it contains.
Num Frames	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.
Playback Rate	The rate, in Hz that data is played back from the RAM buffer.
Auto Playback	If enabled, RAM buffer playback will start immediately after the recording completes.
Loop Playback	If enabled, the playback will loop continuously until stopped by the user.
Auto Save	If enabled, the RAM buffer will be automatically saved to the SSD once the recording is completed.
Save Name	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.

SSD Functions	
Playback Controls	 These controls allow the user to precisely control the playback limits. The start and stop frame can be set directly by the text boxes. The handles at the end of the blue line can also dragged by the mouse to set the limits. The gray bar controls the current playback position. The box above displays the current frame and can be edited to set the current frame manually. The handle on the bar can be dragged using the mouse to set the current frame. The buttons at the ends of the playback slider can be used to advance/rewind a single frame at a time.
Format Drive	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.
Drive Size	Indicates total drive capacity
Used	Indicates space used by movies
Free	Indicates space available for new recordings
Need	Indicates space need to store data currently in RAM buffer

5.4.4.1 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).

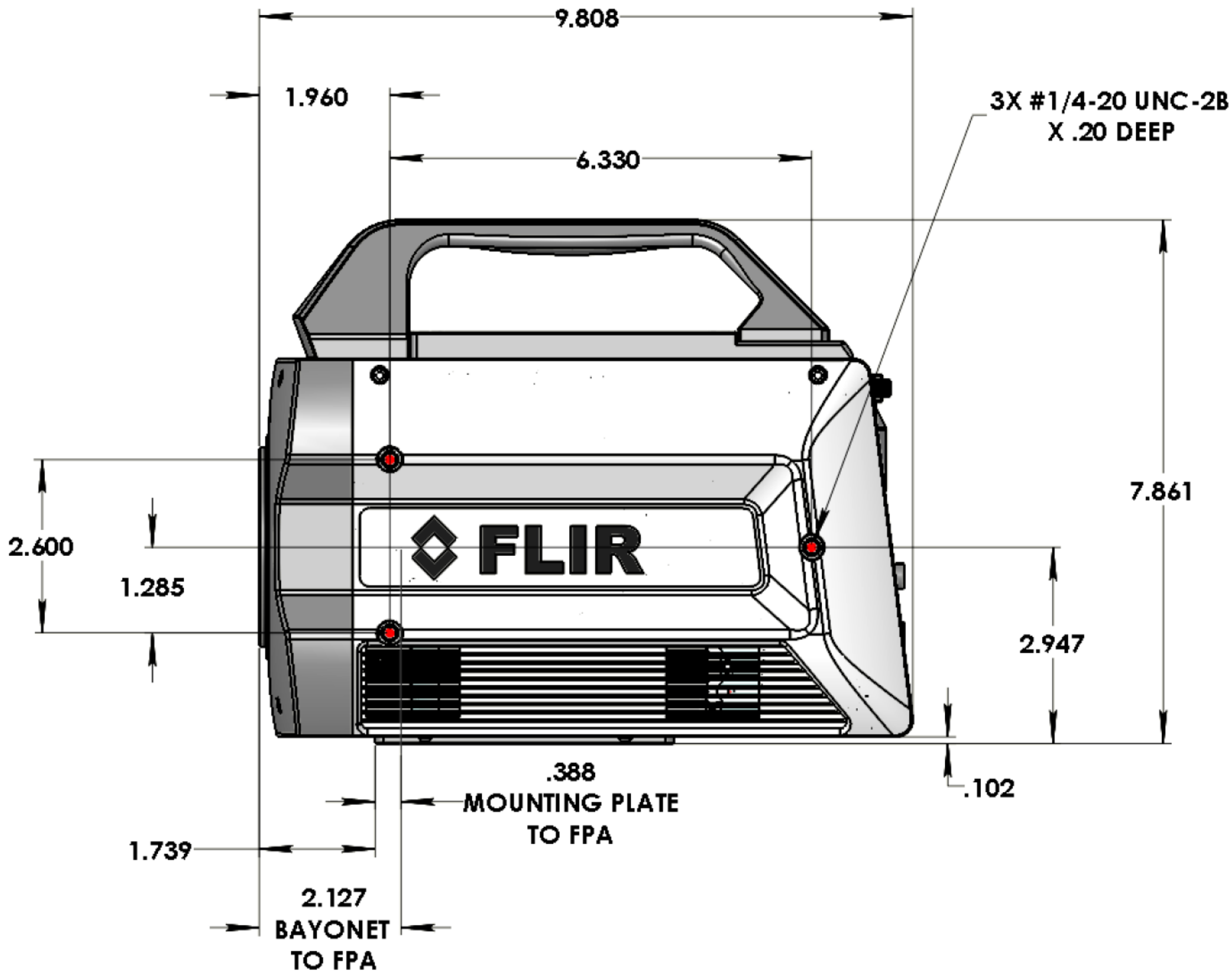
The drive is hot-swappable and can be inserted or removed with the camera powered on or off. If the camera is on the SSD light on the rear panel will illuminate when a drive is detected.

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

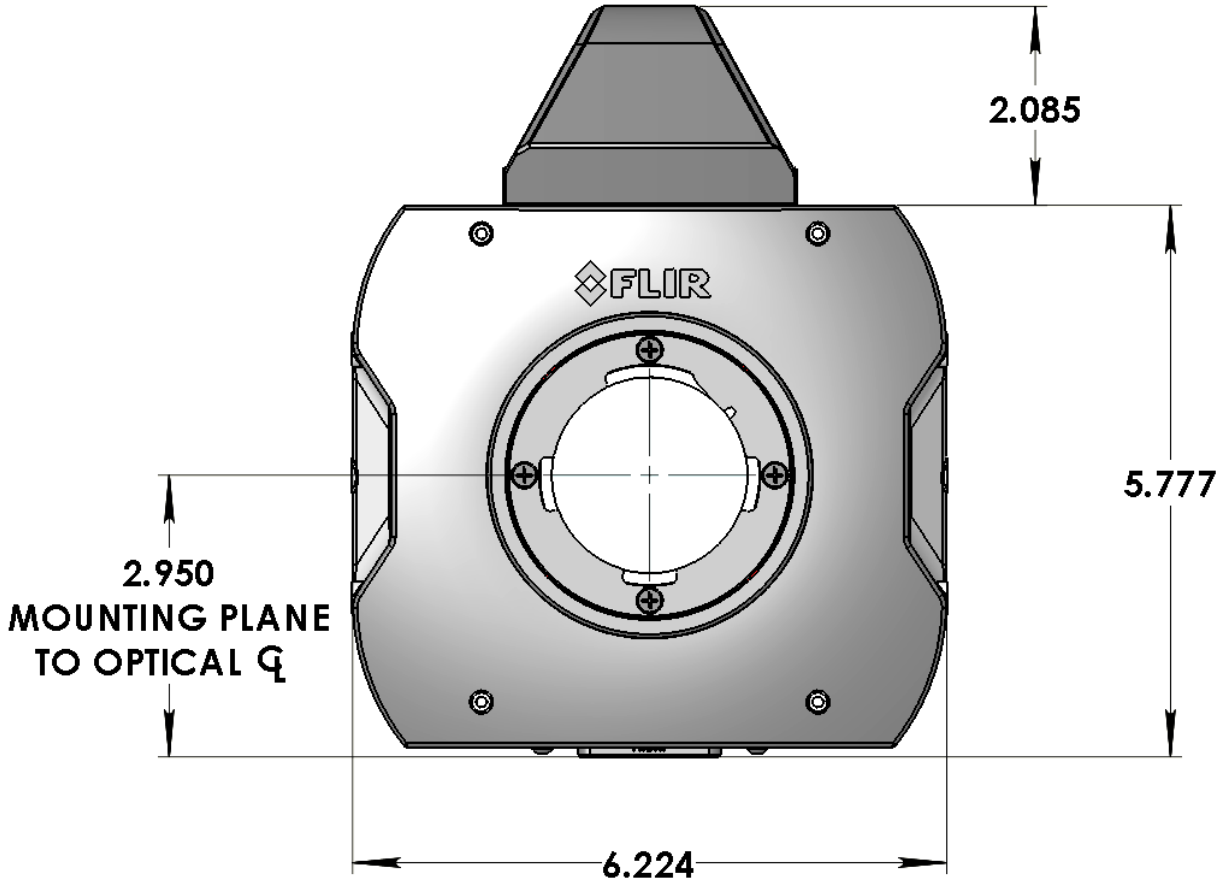
Here is a typical commercially-available 2.5 inch SATA solid-state drive one can easily buy online for the X-series. These 2.5 inch drives can be had up to 4TB:

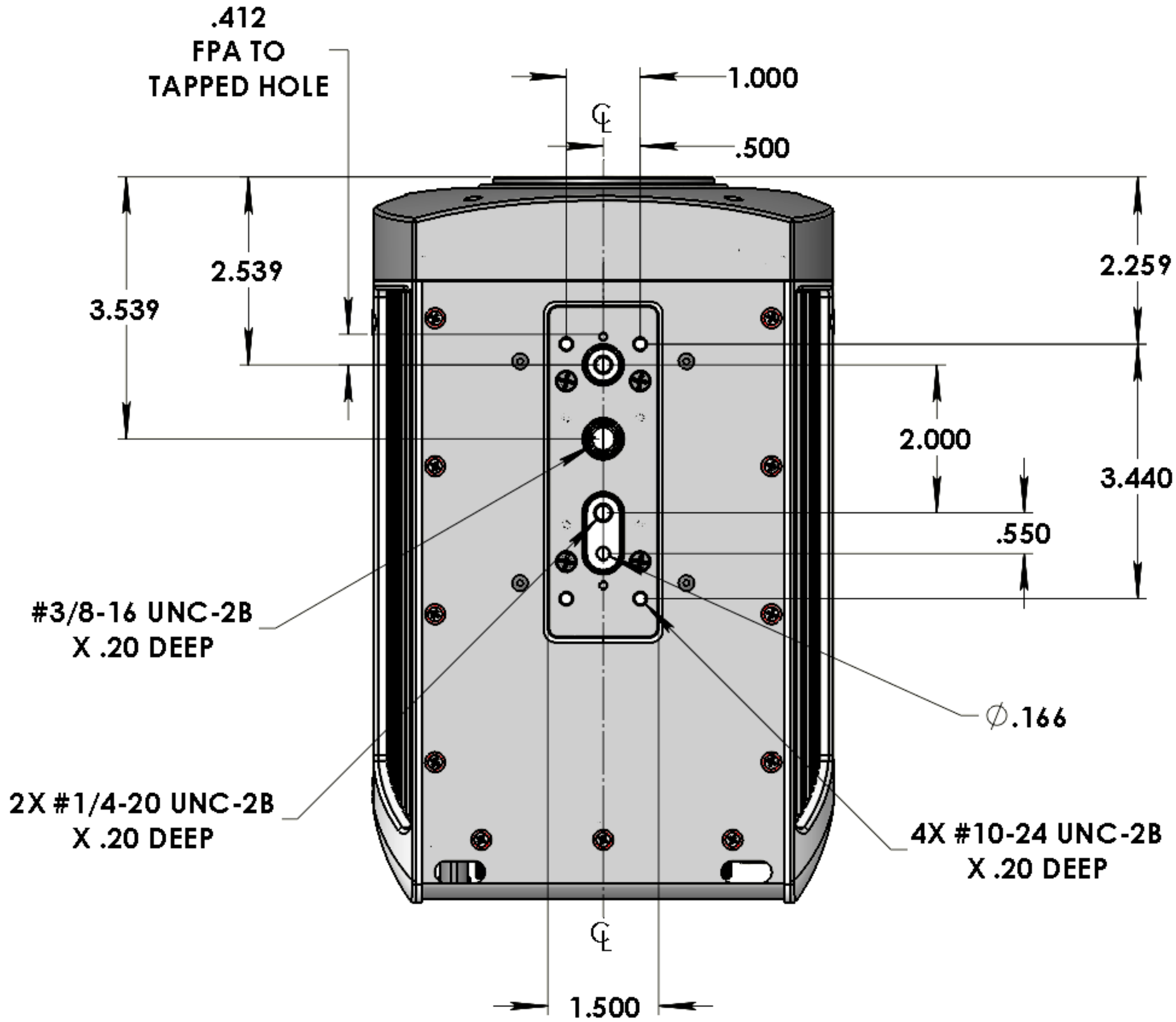
6 Interfaces

6.1 Mechanical Dimensions



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


2.085
5.777
2.950
MOUNTING PLANE
TO OPTICAL ℄
6.224
FLIR



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

6.2 Electrical – X8500 and X6900 Series

The X8500 and X6900-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 statues 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 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 X8500 and X6900-Series cameras provide a set of status indicators on the back panel to give the user some visual feedback on the camera operating state.

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

6.2.4 Gigabit Ethernet

	Gigabit Ethernet (GigE) is a common interface found in most PC's. The GigE interface can be used for image acquisition and/or camera control. The GigE interface is GEV/GenICam compliant. The GigE interface is the only digital data interface that cannot support the full data rate of the camera. This is because the camera maximum frame rate exceeds the bandwidth of GigE. It can support up to 30Hz frame rates at full resolution in the X8500-series cameras, and 125 fps in the X6900-series and X6800-series cameras at full resolution.

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.

 	Behind the rubber flap on the back of the X-Series cameras there is a slot and two connectors as described below (from top to bottom): MicroSD Card: This is not currently implemented and is reserved for future use. USB Client: The USB Client is a Command and Control port for the user interface. This connector also can be used for firmware upgrades provided by FLIR. This port is USB2 compatible. 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

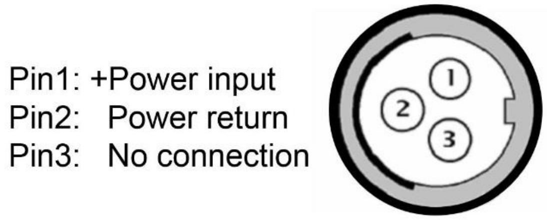
A 24VDC external AC-DC power converter is provided with the X-Series camera systems as a standard accessory. Power supply specifications are:

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.



X-Series Camera Power Input Pinouts

When using your own DC power supply, you should take note of the following information:

Input voltage range: 24 volts DC nominal, 20-28V range

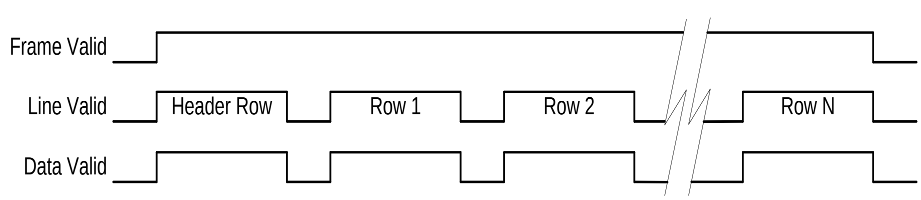
Current draw: 1.4 amps nominal steady state, 2.6 amps peak (during cool down)

X-Series camera power dissipation is <50 Watts steady state at nominal ambient temperature.

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)

6.2.9 Camera Link® Video Output

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".



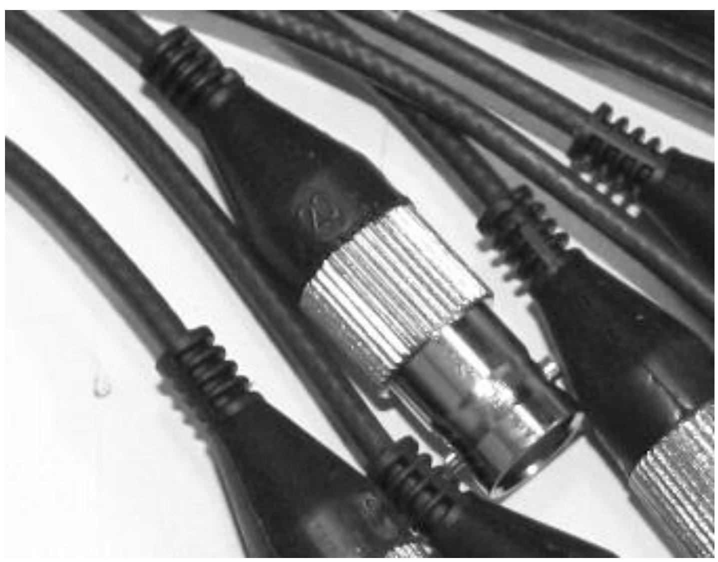
6.2.10 Auxiliary Connector/Breakout Cable

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			

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:


SERIAL



6.2.11 Record Trigger

	This input allows the user to use an external signal to start a recording to the internal RAM buffer. The input looks for a 3.3V CMOS "high" edge 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 [X6900/X8500 only]

	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 X8500 and X6900-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. Vih=2V, Vil=0.8V. Vih is the minimum voltage at which the camera will interpret the signal as a "high" and Vil is the maximum voltage at which the camera will interpret the signal as a "low".

6.2.14 HD-SDI [X6900/X8500 only]

	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 [X6900/X8500 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 [X6900/X8500 only]

The purpose of the Genlock input is to allow the X-Series cameras to synchronize the active standard video output to an external video signal. The X-Series cameras can Genlock to both SD and HD video signals.

SD: If the current video output mode is for NTSC or PAL then the video fed to the Genlock input must match.

HD: If the current video mode is 720p/59.9/50 or 1080p/29.9/25 then the Genlock input signal needs to match. The input video can be HD-SDI or the Green channel of a component video (Tri-Sync). The camera will detect which type of signal is being used.

The Genlock LED will illuminate if there is a valid signal on the input and it matches the current camera video output type.

Because the camera itself can run at frame rates that can exceed standard video, it is important to note that by itself, Genlock is only synchronizing the standard video output to the Genlock input. If you wish to lock the FPA clock to the Genlock input signal you must also change the Sync Source from Internal to Video [Sec. 5.4.2.3.2]

6.2.18 IRIG Input [X6900/X8500 only]

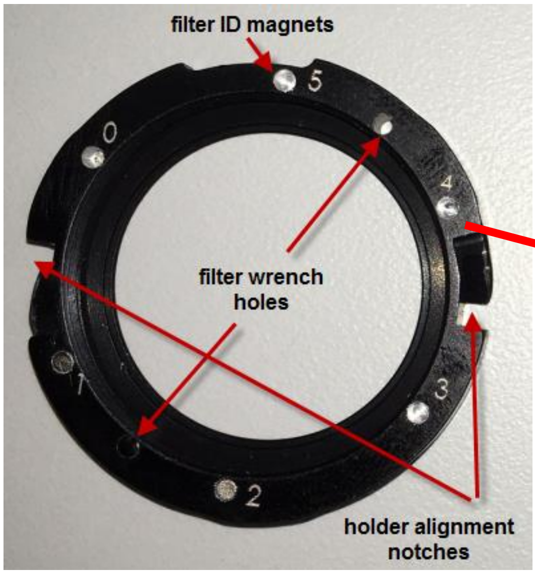
An IRIG-B decoder is built into the camera to allow for time stamping of each frame as well as support triggered data acquisition at user programmed times. The IRIG clock can decode IRIG-B-AM. Optimal format is B122 but other B12x formats should work, however, extra data (such as the year) will not be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

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

7 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 [Sec. 5.4.2.4.2]. 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.

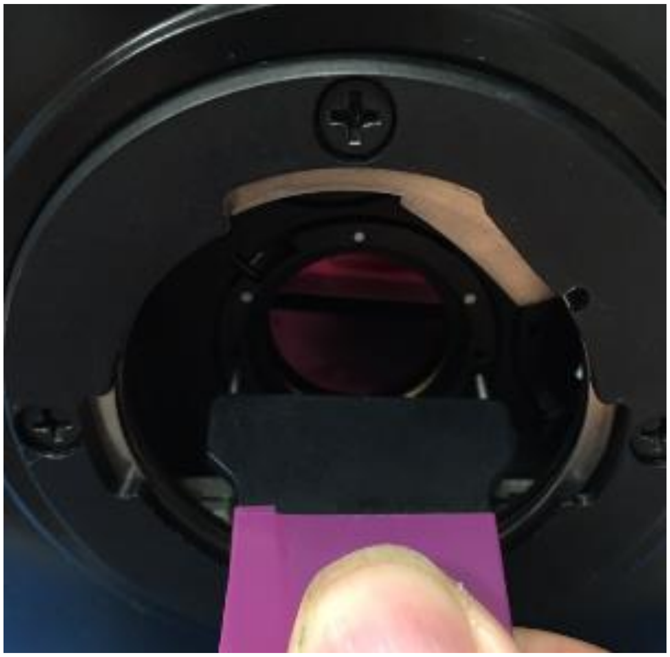


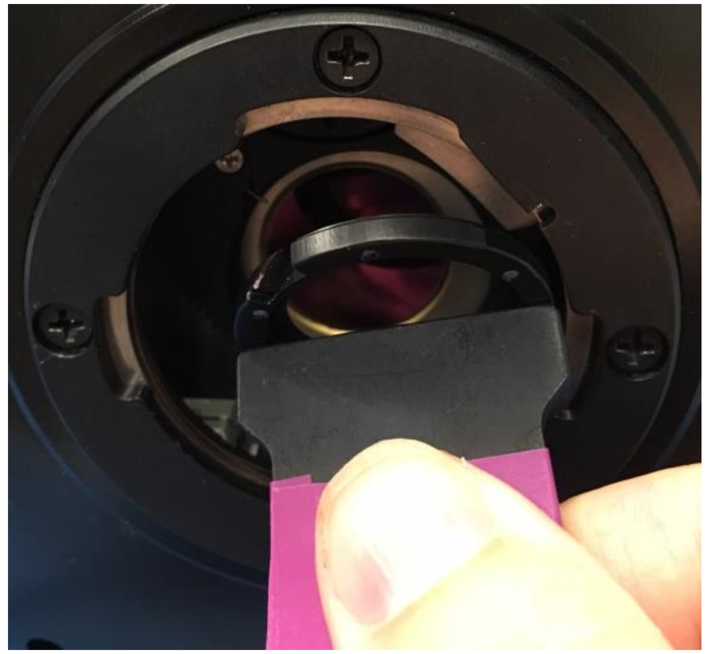
The camera keeps track of what filters are in the wheel by sensing a set of magnets installed in the holder. The camera scans the wheel on boot up (or on demand). The filter page in the camera controller displays the detected filter IDs. If a factory calibration range is selected that requires a filter, 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'oclock 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)	• NTSC/PAL selectable, BNC, 75Ω, 1V pk-pk • HDMI (720p 50/59.94, 1080p 25/29.97) • HD-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
Genlock In	SD: Composite sync input, field and lines sync of video output HD: HD-SDI or Tri-level Sync
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 HDC 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/X6900: 32 columns x 4 rows X8500: 64 columns x 4 rows
Windowing Step Size	X6800/X6900: 32 columns x 4 rows X8500: 64 columns x 4 rows
Maximum Window Size	X6800/X6900: 640 columns x 512 rows X8500: 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 (X6900):	
Max at Full Window	1004 Hz (< 0.996mS Integration Width)
Max at Minimum Window	29113 Hz (< 34.3uS Integration Width)
Minimum	1.45mHz
Resolution	90nS
Frame Rate (X8500):	
Max at Full Window	181 Hz (< 5.52mS Integration Width)
Max at Minimum Window	6026 Hz (< 166uS Integration Width)
Minimum	1.45mHz
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	• Genlock: synchronizes composite video to external composite video source or HDMI/SDI to external SDI or “Y” signal from component signal **(Not available in X6800)** • Frame Sync Starts Integration: synchronizes FPA integration to external sync source • Frame Sync Starts Readout: synchronizes FPA data readout to external sync source
Preset Sequencing	• 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:

	• 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 • Global Gain: 0→3.9; 2^{-14} resolution • Global Offset: ± full A/D resolution

8.4 Analog Video

Video Output	Selectable • HD-SDI (Not available in X6800) • HDMI • NTSC/PAL composite (Not available in X6800)
Data Output	Selectable • Raw, uncorrected • Corrected
MGC	Linear scaled with user controlled gain and offset
AGC	Selectable • 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 • Grayscale • Various color palettes
Zoom	Selectable • x1/2 • x1 • 4:3 (SD to HD) • x2 • x4
Temporal Filter	• N/A
Brightness and Contrast (analog video)	User controlled to increase or decrease
Video Boresight	+/- 16 rows

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	≈7 minutes to reach operating temperature
Sensitivity (w/o optics) **NEΔT[1]**	InSb: <20mK (18 mK typ.) SLS: <45mK (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 Accuracy[2]	± 1°C or ± 1% of reading 0°C to +3000°C (17mm, 25mm, 50mm, 100mm, 200mm Lenses) ± 2°C or ± 2% of reading -20°C to 0°C (17mm, 25mm, 50mm, 100mm, 200mm lenses) -10°C to +500°C (1X & 4X Closeup lenses)

1) NEΔT is at 50% nominal bucket fill, 298K background, ± 5ºC 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	One Point (offset value with unity gain) 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/X6900: ISC0804 X8500: ISC1308
Integration Mode	Snapshot
Format (HxV)	X6800/X6900: 640x512 X8500: 1280x1024
Operability	>99.5%, 99.9% typical
Charge Handling Capacity	X6800/X6900: 11.0 x 10^6 carriers X8500 (InSb) : Gain 0: 3.0 x 10^6 carriers X8500 (SLS) : Gain 1: 11.5 x 10^6 carrier
Detector Pitch	X6800/X6900: 25 microns X8500: 12 microns
Detector Cooling	Linear Sterling Cooler

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
Shock	40 g's, 11msec half sine pulse
Vibration	4.3 g's RMS random vibration, all three axes
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

<u>The Drag Wipe Method</u>:

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 Bromoiodide	Nitrogen		

1] Water free Acetone

2] Ethanol

3] Methanol

4] Isopropanol