RS8500

User's Manual

The information contained in this document pertains to a dual use product controlled for export by the Export Administration Regulations (EAR). Diversion contrary to US law is prohibited.This document contains no export-controlled information.

Document Number: 4225063

Version: A

Issue Date: March 24, 2020

FLIR Systems, Inc.

9 Townsend West,

Nashua, NH 03063

Support: 1-800-GO-INFRA (800-464-6372)

http://flir.custhelp.com

Service: 1-866-FLIR-911

www.flir.com

©2020 FLIR Systems, Inc.

Table of Contents

1 Revision History

Version	Date	Initials	Changes
A	03/26/20	RIM	Initial Release

2 Introduction

Thank you for choosing the RS8500 camera. The RS8500 camera is the most advanced commercial long-range infrared camera in the world.

2.1 Camera System Components

The RS8500 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 copper to fiber converters, etc.

Description	
RS8500 Camera	29442-2X3
Power supply, 24V, 4A	24123-002
AC line cord	24124-000
Gigabit Ethernet CAT6 cable	4141448
BNC video cable	26393-001

2.2 Camera Models

While often referred to as a camera, the RS8500 is in actuality a camera family. There are several different models ensuring the wide variety of customer needs can be met.

Model	Description	FLIR Part Number
RS8503	• Open Frame (no enclosure) • 1280x1024 12µm pixels (ISC1308) • 3-5µm band pass • Camera Link Full and CXP Dual Link	29442-203
RS8513	• 1280x1024 12µm pixels (ISC1308) • 3-5µm band pass • CXP Dual Link	29442-213
RS8523	• 1280x1024 12µm pixels (ISC1308) • 3-5µm band pass • Camera Link Full and CXP Dual Link	29442-223

2.3 System Overview

The RS8500 infrared camera system has been developed by FLIR to meet the needs of the research, industrial and range phenomenology communities. The camera makes use of FLIR's advanced ISC1308 readout integrated circuit (ROIC), mated to an Indium Antimonide (InSb) detector to cover the midwave infrared band. The RS8500 camera utilizes a large format HD FPA. The architecture of the camera system fully exploits a rich palette of features available in the ROIC to support the specialized needs of high-end research and target tracking.

The RS8500 is a stand-alone imaging camera that interfaces to host PCs using standard interfaces, including Gigabit Ethernet, CoaXpress (CXP), and Camera Link®. The RS8500-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 RS8500 camera

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. The ISC1308 ROIC provides a 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 makes it easier to perform a user calibration of the camera.

Fast Frame Rates

The RS8500 camera features a fast pixel clock – 355 Megapixels per second, which enables the camera to output >180 frames per second at a frame size of 1280x1024 pixels.

14-Bit Digital Image Data

The RS8500 camera system is 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.

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 RS8500 camera provides 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
- Sync Out

Adjustable Digital Gains and Offsets

The RS8500 allows the user to adjust digital gains and offsets per preset, making it possible to map the linear portion of the FPA to the full range of digital count values.

Multiple Control Options

The RS8500 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 camera:

- Gigabit Ethernet port (GenICam)
- Camera Link® serial port (GenCP) [RS8523 only]
- CoaXpress (GenICam)
- Traditional RS-232 asynchronous serial port (GenCP)

Multiple Video Outputs

The RS8500 camera features multiple independent and simultaneous video:

- Digital Data – Camera Link® Full [OM3 multi-mode fiber, RS8523 only]
- Digital Data – CoaXpress (CXP)
- Digital Data – Gigabit Ethernet
- Digital Video – HD-SDI (1080p or 720p)

Support for Camera Link Full or CoaXpress interfaces

The RS8500 offers the option of both Camera Link Full and CoaXpress (CXP) interfaces on the back panel. In that option, both interfaces are simultaneously active. The Camera Link Full option is implemented with fiber optic connectors. [The fiber connectors are installed on the rear panel of both the RS8513 and RS8523 but are only active on the RS8523].

SDI Video Color Palettes

The RS8500 camera supports a selection of standard color palettes for the SDI video output.

SDI Video Overlay

A configurable SDI video overlay provides the user with camera status symbology (including IRIG time) on the SDI video without needing to connect the GUI.

Ruggedized Construction

The RS8500 camera is packaged as a sealed enclosure that can maintain a dry nitrogen gas purge (expect for the open frame option).

Digital Detail Enhancement (DDE)

DDE is an SDI 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 digital and analog 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. There is an optional motorized lens cover that can also be used to do an external offset update to the NUC.

Metric Zoom lens

The RS8500 camera offers the industry’s first IR metric zoom lens. This 10X zoom lens goes from 120mm to 1200mm. This corresponds to a full-frame horizontal field of view ranging from 7.3 degrees to 0.73 degrees (at full zoom). The zoom and focus position are encoded in the image header on a frame-by-frame basis (with TSPI-accurate timestamp). There is also a focus to distance feature where the camera can be set to a preset focus distance.

IRIG Time Stamp (TSPI Accurate)

The RS8500 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 SDI video overlay.

4-Position Filter Wheel

The RS8500 has an internal motorized filter wheel that can position a warm filter between the lens and detector. Filters are an optional accessory. Up to four warm filters can be installed at the factory. The filter holders support automatic filter identification. The typical filter load will be an open position, and then ND1, ND2, and ND3 filters. This allows the user to image everything from cold targets to very hot targets (>1000C apparent temperature).

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 8 for lens cleaning.**
- **Operating the camera outside of the specified input voltage range or the specified operating temperature range can cause permanent damage.**
- **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. Section 7.8 has additional information on environmental specifications.**
- **The camera contains static-sensitive electronics and should be handled appropriately.**
- **If camera has the optional motorized lens cover installed, care must be taken to keep the area in front of the cover clear of any obstacles.**
  - **The motor drive is quite strong, and the mechanism can be damaged if the cover is blocked when it is moved by the operator. In addition, there is the possibility of injury if the cover is closed on a finger or hand, etc.**
  - **If the camera is resting on a bench, be sure the edge of the lens cover is free to move. This may require the camera to be propped up so that the edge of the cover does not touch the tabletop.**

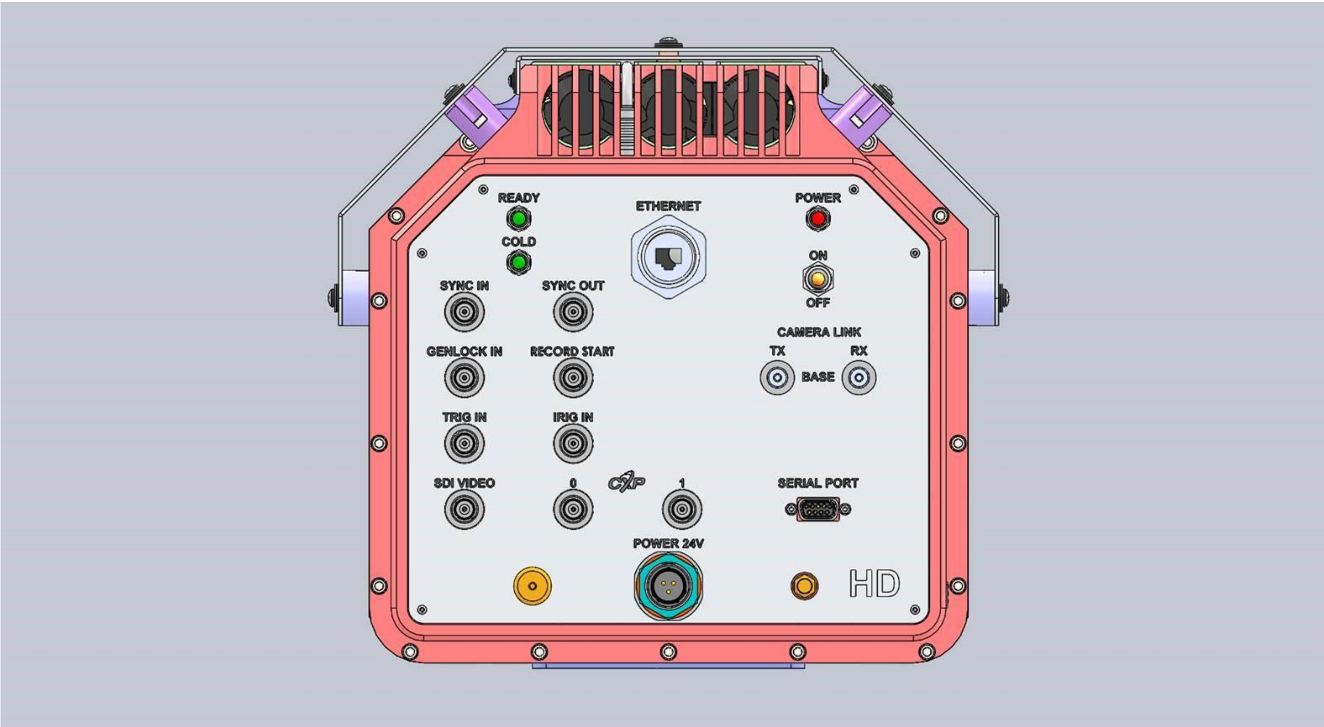
4 Installation

4.1 Basic Connections

All connections to the RS8500 are located on the Back Panel. Although the RS8500 has a large number of connections, only a small number are required for basic operation.

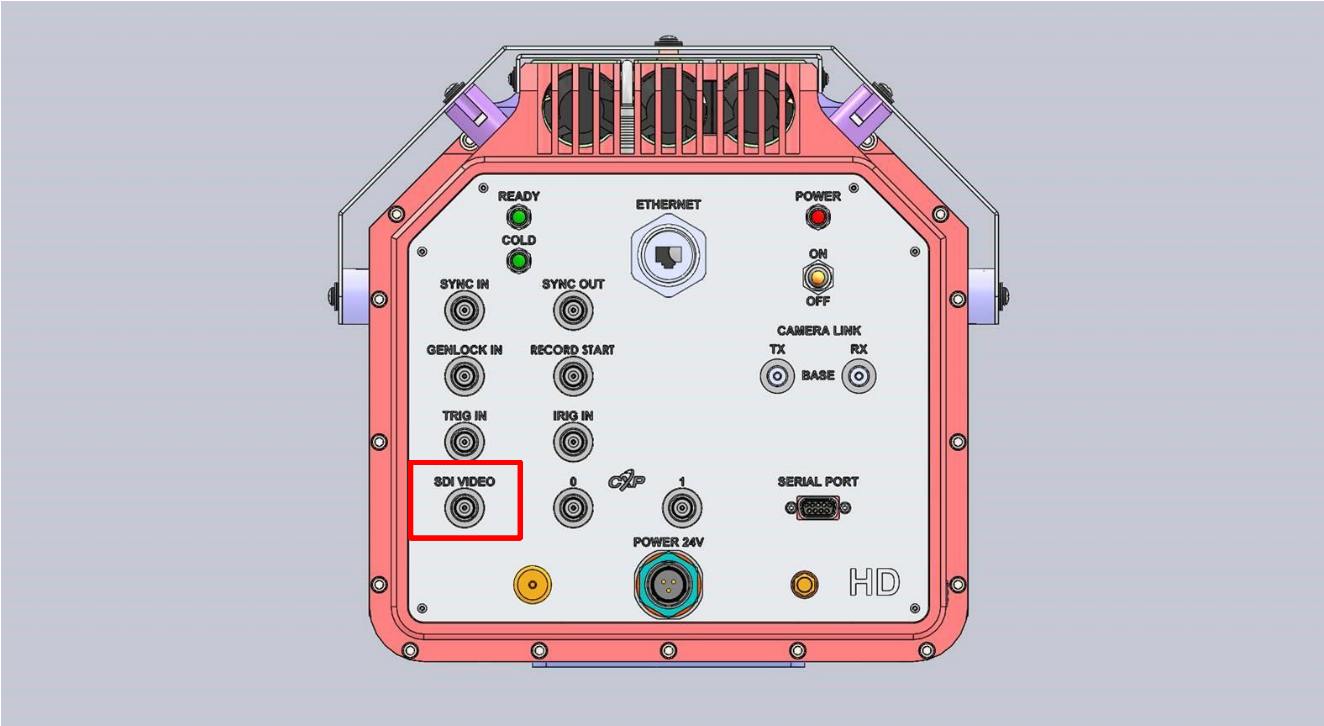
4.1.1 Power

Plug in the AC power supply to a standard 120V outlet. Connect the DC power cable between the power supply and the power connector located on the rear panel of the RS8500 camera. Turn on the camera by flipping the locking switch on the rear panel. The red power LED will illuminate to indicate that the unit is ON. When the camera is ready to connect to the host, the green READY LED will light. When the sensor has reached its operating temperature, the green COLD LED will light.



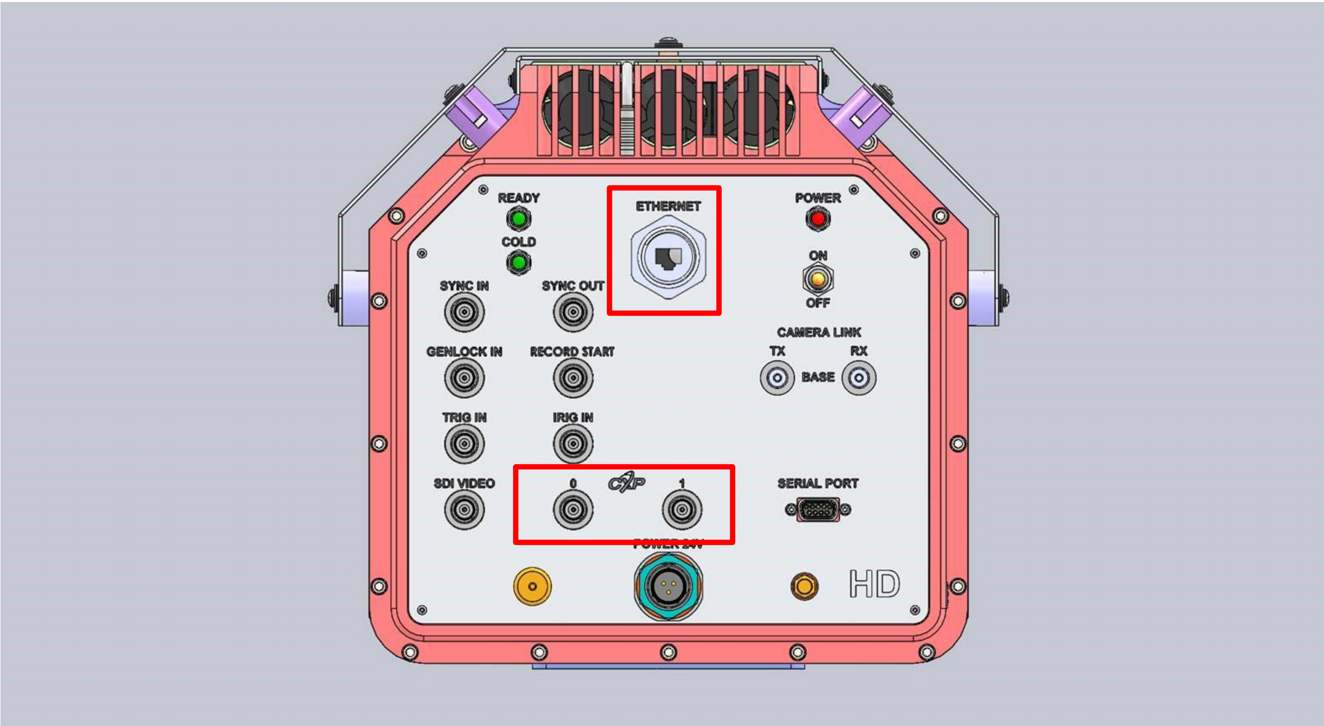
4.1.2 HD Video

The camera will automatically boot up into the last saved stated. The boot process takes about 60 seconds. To see HD video, connect the SDI port to a monitor. If you are powering up the camera for the first time, the camera should produce an image with Non-Uniformity Correction (NUC), and bad pixel replacement enabled.



4.1.3 Digital Video

If you have a PC data system running FLIR Research Studio or (or your own custom application based on the BHP SDK) you can view the 14-bit digital video. The RS8500 has two digital video interfaces: Gigabit Ethernet and CoaXpress (CXP). Both interfaces can be used simultaneously, and both can be used for video and camera control simultaneously. (A Camera Link Full fiber interface is available as an option).



Gigabit Ethernet Interface

The RS8500 has a Gigabit Ethernet interface that is GigE Vision compliant for video (but does not use GenICam for control). Use a regular CAT5e or CAT6 Ethernet patch cable. If a crossover cable is used, the camera interface will automatically detect and configure itself to work with this kind of cable.

CoaXpress (CXP) Interface

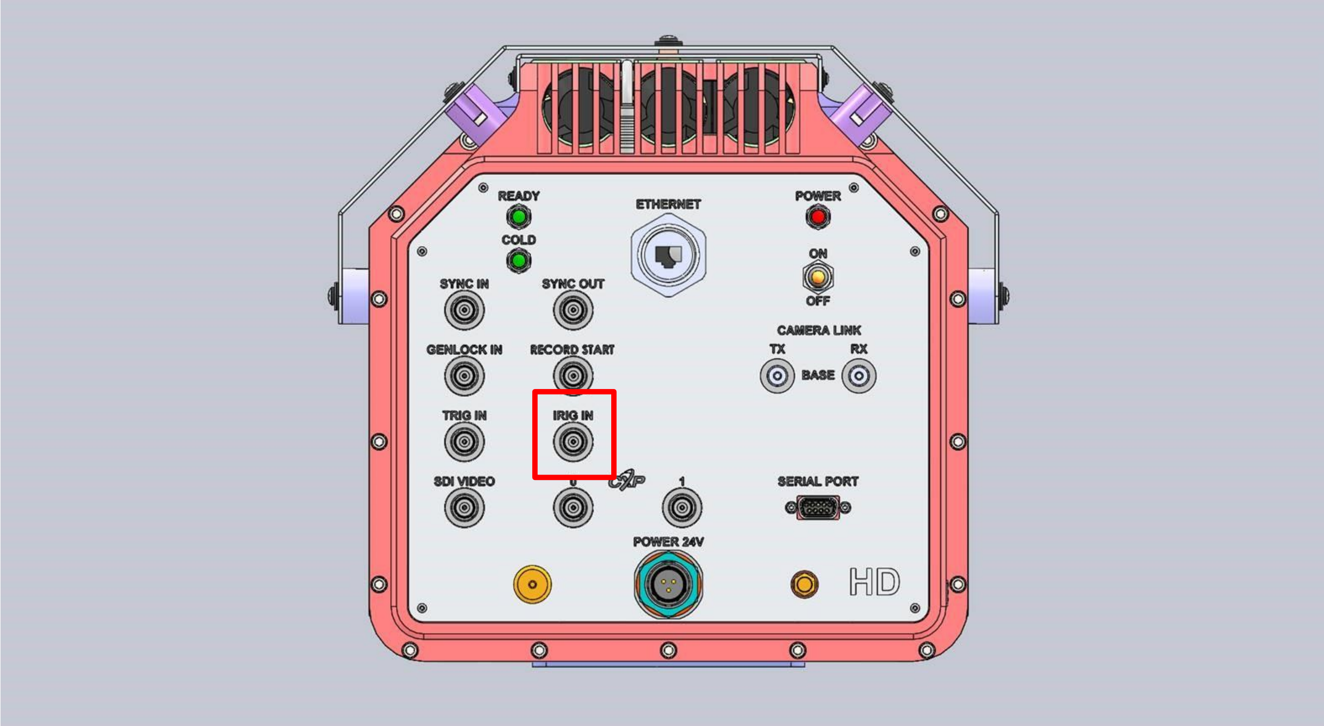
The RS8500 has an industry-standard CXP interface. The RS8500 uses a dual link running at 5 Gbps.

Camera Link Full Interface

The RS8503 and RS8523 includes a CL-Full interface. The RS8503 has standard copper MDR connectors on the rear panel of the camera. In order to preserve the sealed enclosure of the RS8523, the copper interface is internally converted to Multimode fiber. The camera has ST fiber connectors on the real panel and two duplex fibers are required. The fibers need to be 50/125μm (OM3) multimode with ST connectors for the camera side and LC connectors for the PC side. A set of fiber to copper converters for the PC side are provided with the camera.

4.1.4 IRIG-B Input

The RS8500 has an internal IRIG-B clock/decoder. The camera will use the IRIG clock to timestamp each frame in the image header. If no external IRIG-B sync signal is applied, the internal IRIG clock will synchronize to the internal Real Time Clock (RTC) on boot up and will free-wheel. If an IRIG signal is applied to the IRIG-B input, the camera will automatically synchronize the internal IRIG clock to the external source. If the sync signal is lost the internal clock will continue to free-wheel until the sync signal return. The IRIG lock status can be checked in on the Status page of the camera controller. If the camera is locked to an external IRIG source, an “L” will appear next to the IRIG time display.



5 RS8500 Camera Controller

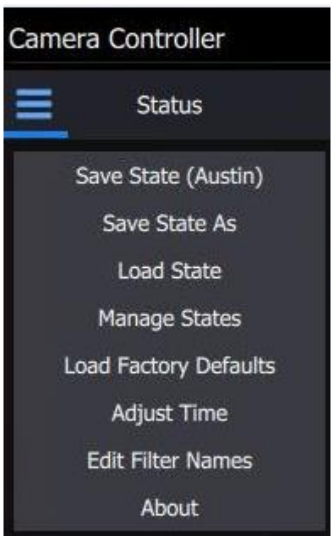
The RS8500 Camera Controller (also called the Graphical User Interface or GUI) can be accessed from within the FLIR Research Studio software.

5.1 Tooltips

If the user placed the mouse cursor over a particular control, a Tooltip will be displayed giving a basic description of the control.

5.2 Hamburger Menu

The “Hamburger Menu” looks like three horizontal bars stacked up. Here are the features that can be accessed via this menu:



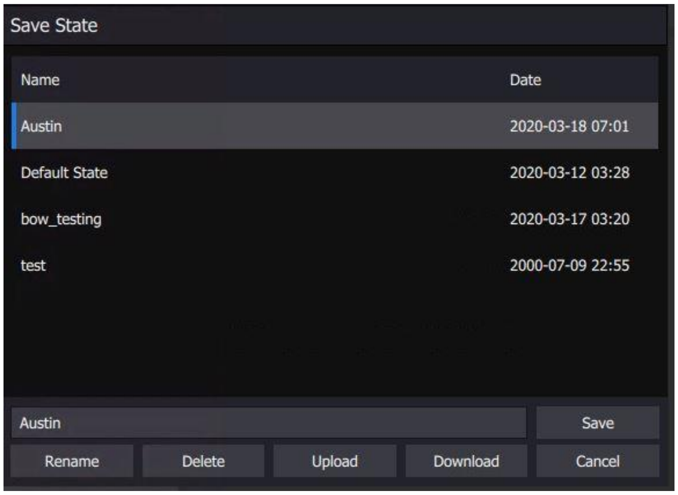
Save State (name)	Saves the camera state to the current (name). This state will be reloaded at power up. Stored in flash memory.
Save State As	Saves the current camera state to a name chosen by the user. State names other than (name) may be loaded manually. Stored in flash memory
Load State	Load a state 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.
Adjust Time	The user can adjust the internal clock in the camera.
Edit Filter Names	The user can change the displayed names for the filters that can be installed in the camera’s filter wheel.
About	This displays information about the camera hardware and software.

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

NOTE: The RS8500 has 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 clock that conforms to the IRIG-B standard. 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.

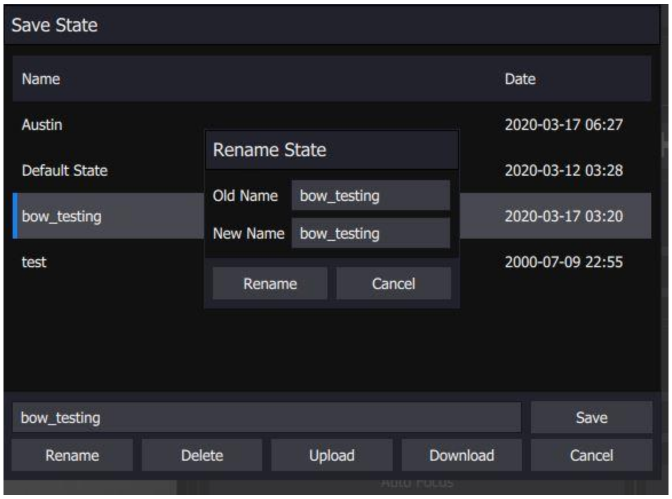
5.2.1 Save State As

The user can rename, delete, upload and download State files.



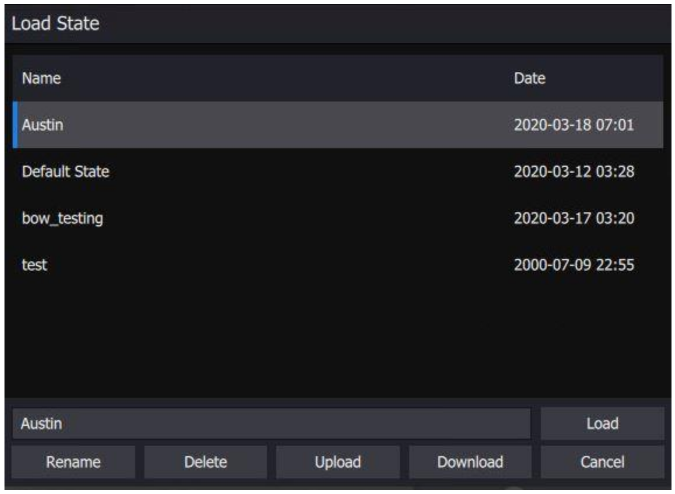
Rename State

The Rename button allows the user to rename a state file:



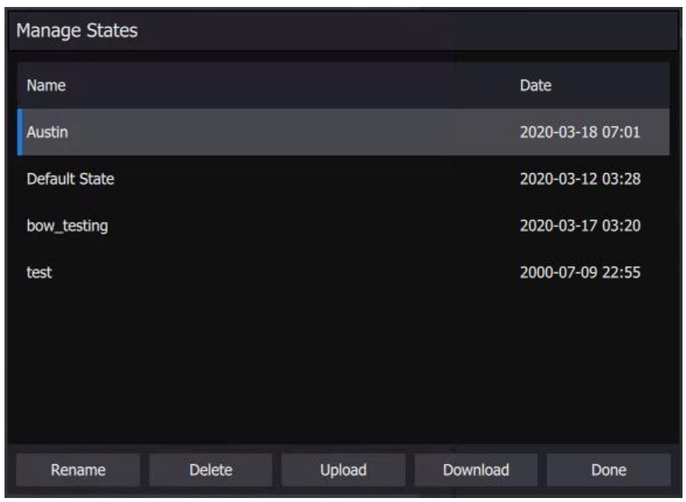
5.2.2 Load State

The user can load a state file that is already in the camera, or upload a state file from the Host and make it the active state file:



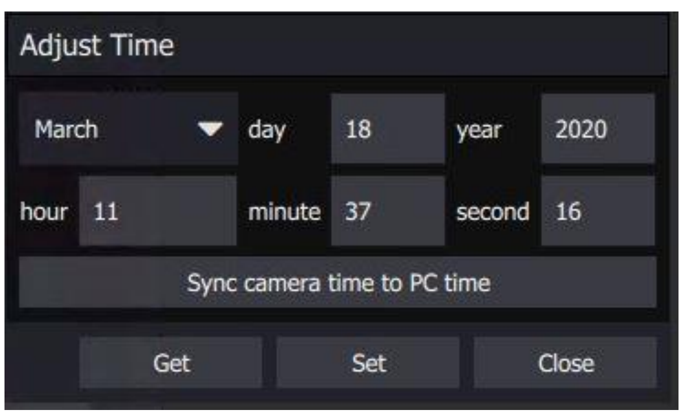
5.2.3 Manage States

The user can manage state files from this screen:

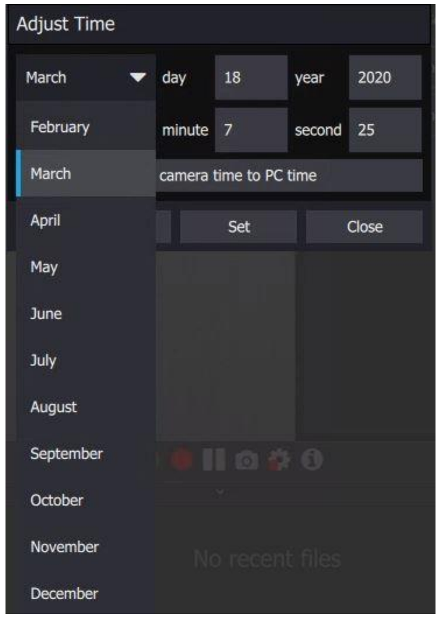


5.2.4 Adjust Time

The use can adjust the time on the Real-Time Clock inside the camera through this menu selection:

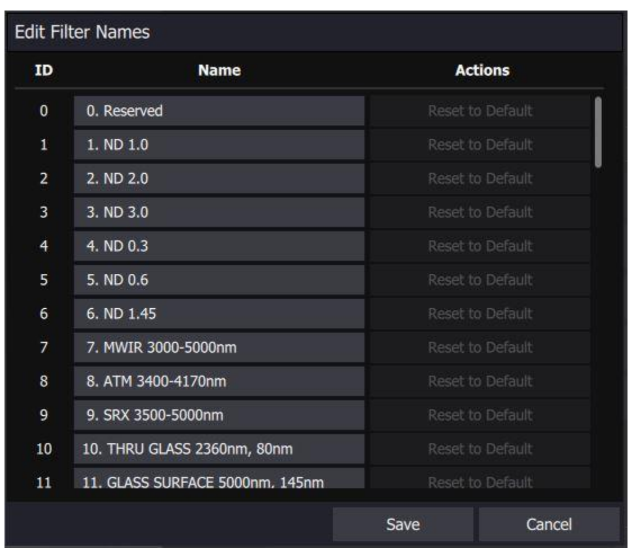


Get displays the current time on the RTC. Set sets the RTC to whatever the user types into the fields. Sync camera time to PC time will pull a time and date value from the PC and set the RTC to those values. The Month is set with a pull-down menu:



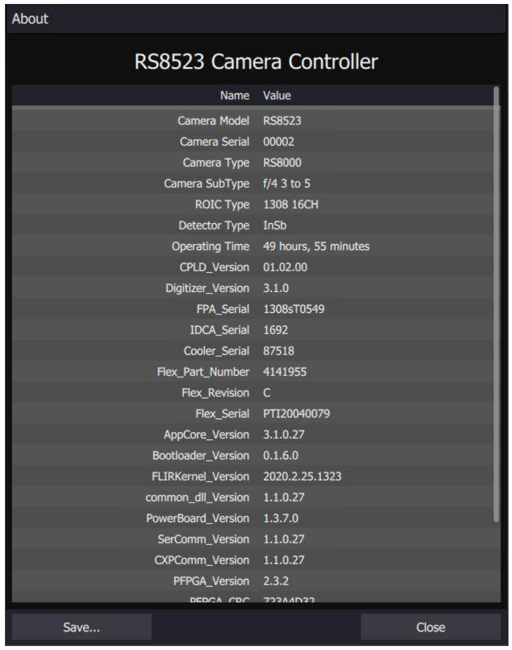
5.2.5 Edit Filter Names

This option allows the user to change the naming convention of the installed filters, if any. There are 64 filter ID numbers. Note: Since the filters must be installed at the factory and cannot be changed out by the user, we strongly recommend not changing any of these filter names.

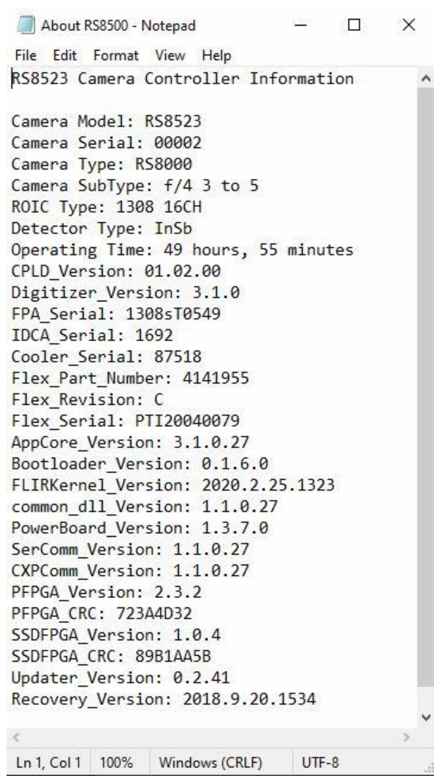


5.2.6 About

This displays information about the camera hardware and software. The file can be downloaded as a text file using the Save… button at the bottom:



This is what the downloaded About file looks like when opened in Notepad:

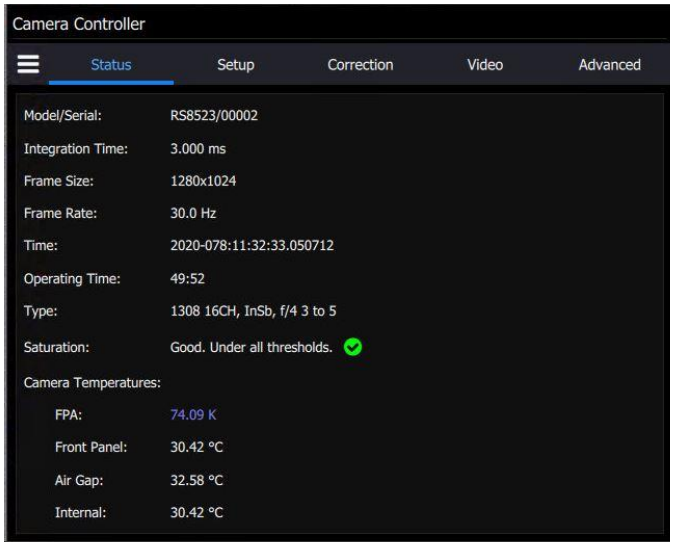


RS8523 Camera Controller Information

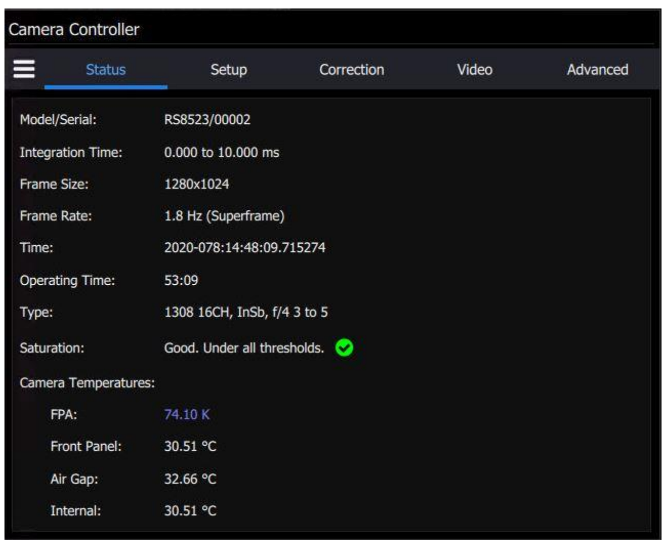
Camera Model: RS8523
Camera Serial: 00002
Camera Type: RS8000
Camera SubType: f/4 3 to 5
ROIC Type: 1308 16CH
Detector Type: InSb
Operating Time: 49 hours, 55 minutes
CPLD_Version: 01.02.00
Digitizer_Version: 3.1.0
FPA_Serial: 1308sT0549
IDCA_Serial: 1692
Cooler_Serial: 87518
Flex_Part_Number: 4141955
Flex_Revision: C
Flex_Serial: PTI20040079
AppCore_Version: 3.1.0.27
Bootloader_Version: 0.1.6.0
FLIRKernel_Version: 2020.2.25.1323
common_dll_Version: 1.1.0.27
PowerBoard_Version: 1.3.7.0
SerComm_Version: 1.1.0.27
CXPComm_Version: 1.1.0.27
PFPGA_Version: 2.3.2
PFPGA_CRC: 723A4D32
SSDFPGA_Version: 1.0.4
SSDFPGA_CRC: 89B1AA5B
Updater_Version: 0.2.41
Recovery_Version: 2018.9.20.1534

5.3 Status Page

The Status Page gives general information about the camera state including camera mode land serial number, the integration time for the active preset (or integration time range for superframing mode), the frame size, and frame rate. The current IRIG time and the camera operating hours are displayed as well. The Type is the readout IC part number, the number of FPA channels used (16), the detector type (InSb), the f/number (4), and the bandpass of the cold filter (3 to 5 microns). At the bottom of the window, the temperatures of the focal plane array and three camera housing temperatures are displayed.



There is a range of integration times shown for Superframing and Preset Sequencing mode:

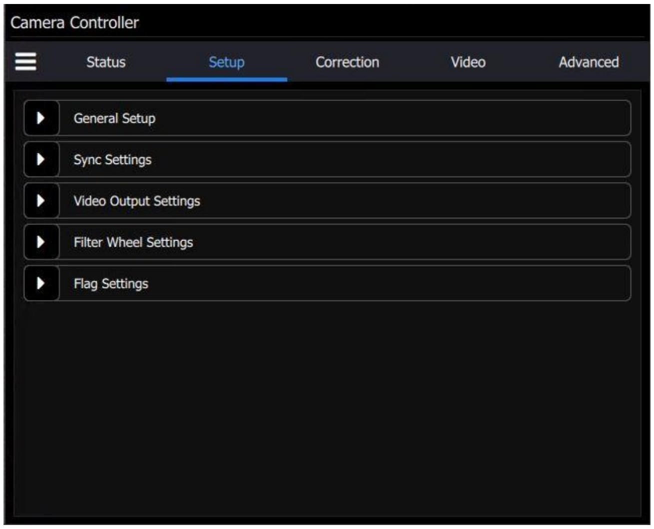


5.3.1.1.1 Camera Temperatures

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.

5.4 Setup Page

The Setup page has five dropdown menus that are used to control a number of camera functions:

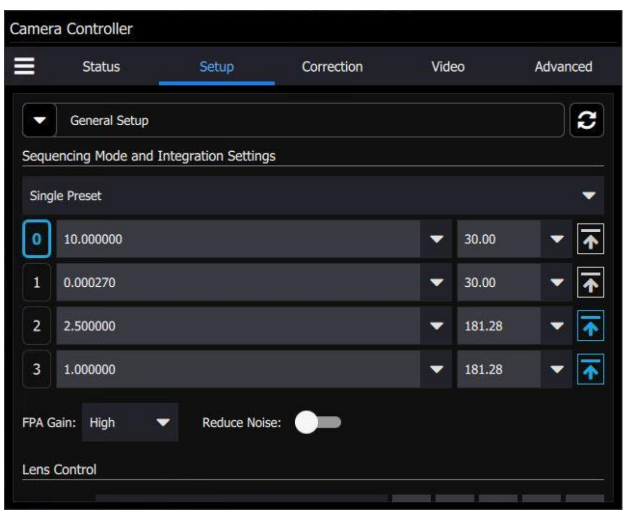


5.4.1 General Setup

The General Setup menu controls the Presets, Sequencing Mode and Integration Settings, Lens Control and FPA Window Settings.

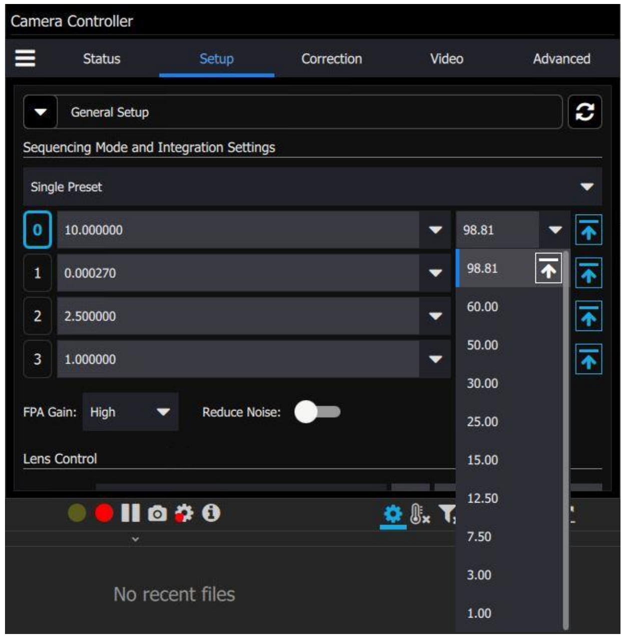
A Preset is a combination of four parameters: Integration Time, Frame Rate, Window Size, and Window Location. The RS8500 can store up to four presets in internal memory. The user can switch from one preset to another manually, using the GUI, or the camera can automatically switch using Preset Sequencing 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 RS8500 can switch between presets on a frame-to-frame basis.

The typical sequencing mode is Single Preset, as shown below. In this example, the integration time and frame rate of Preset 0 are set to 10msec and 30Hz respectively:



5.4.1.1.1 Frame Rate

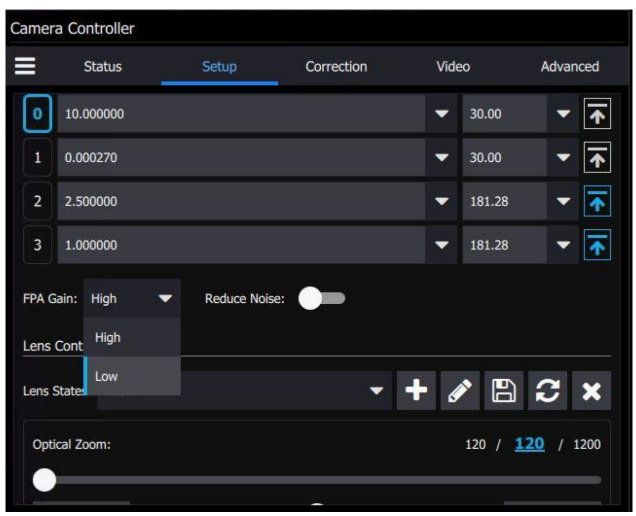
The frame rate for the active preset can be selected with a dropdown menu:



One can also type in the desired frame rate. The frame rate you choose must be less than or equal to the maximum possible frame rate. The maximum possible frame rate can be selected at the top of the dropdown, or by pushing the up-facing arrow button to the right of the dropdown.

5.4.1.1.2 FPA Gain

The user can select the FPA gain state with the pulldown menu. The sensor in the RS8500 is a midwave detector, and it should be operated in High Gain mode. FLIR recommends that the user not change from high gain mode.



5.4.1.1.3 Reduce Noise

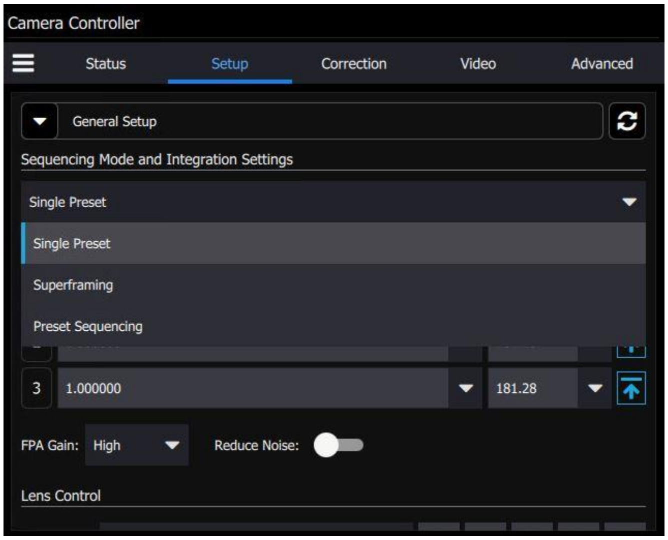
The "Reduce Noise" option forces the camera to use ITR timing (thus reducing max frame rate. The "noise" is some fixed pattern noise that can generally be removed by doing a NUC offset update.

Sequencing Mode

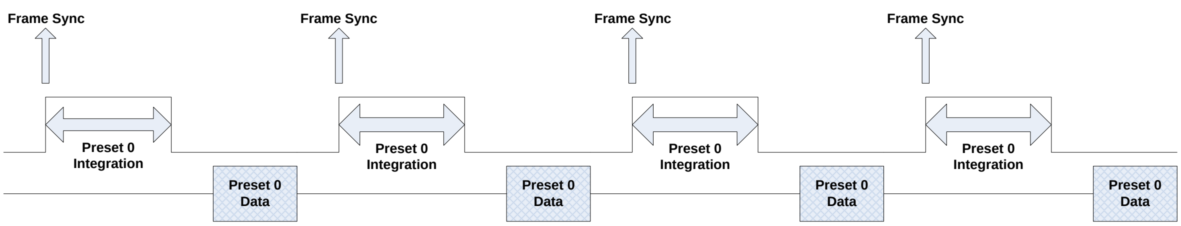
The user can select from three sequencing modes: Single Preset, Superframing and Preset Sequencing.

5.4.1.1.4 Single Preset

The standard selection is single preset. The camera will run at a single integration time.



Here is a schematic diagram of how Single Preset mode handles the data:

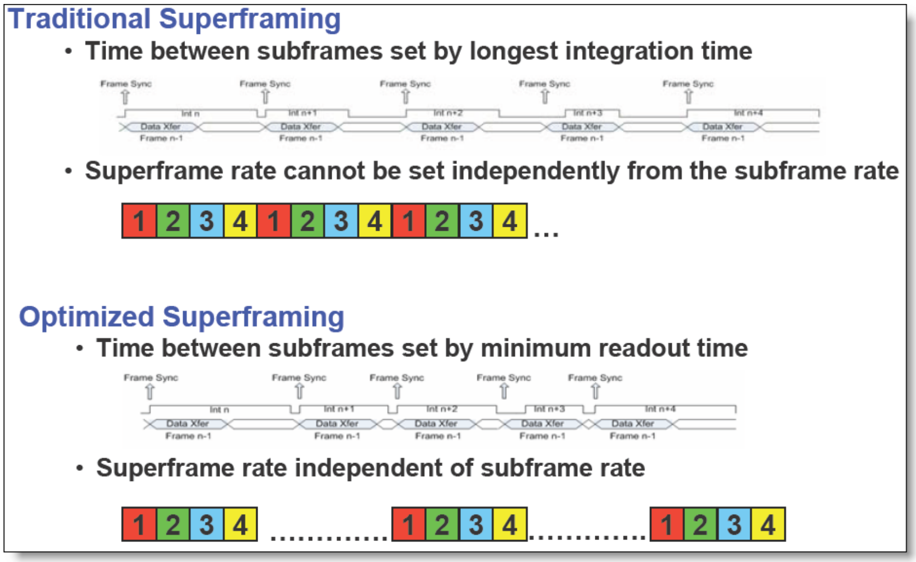


5.4.1.1.5 Superframing

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.

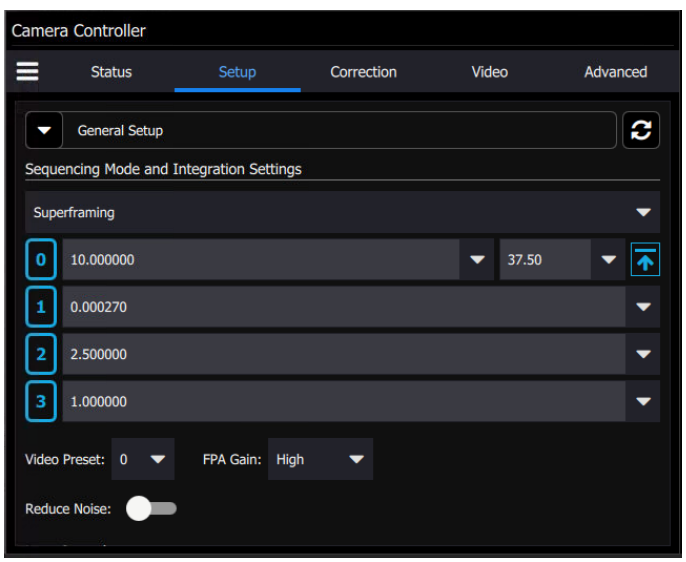
Optimized vs. Traditional Superframing:

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.

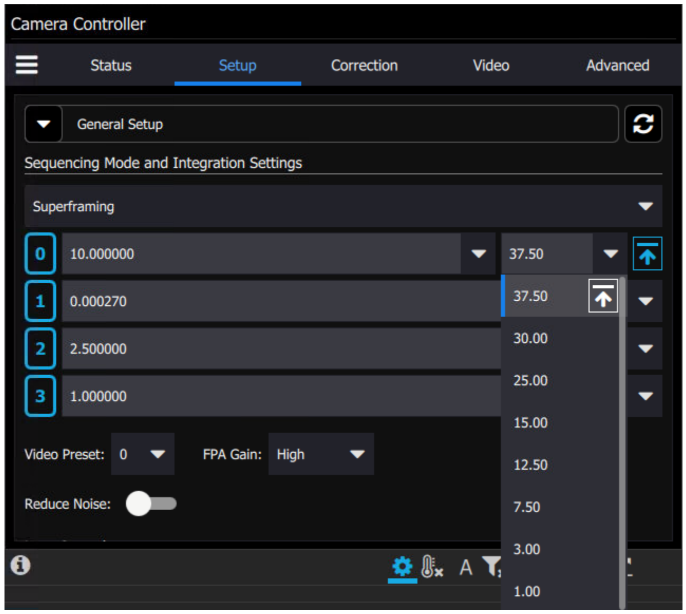


NOTE: Optimized Superframing is only available when using internal frame sync. Traditional Superframing is supported in external sync mode. To achieve the fastest possible frame rates, the camera must be in Frame Sync Starts Readout (FSSR) mode. If the camera is in Frame Sync Starts Integration (FSSI) mode, then the camera will be limited to ITR frame rate timing. See Section **Error! Reference source not found.** for more details.

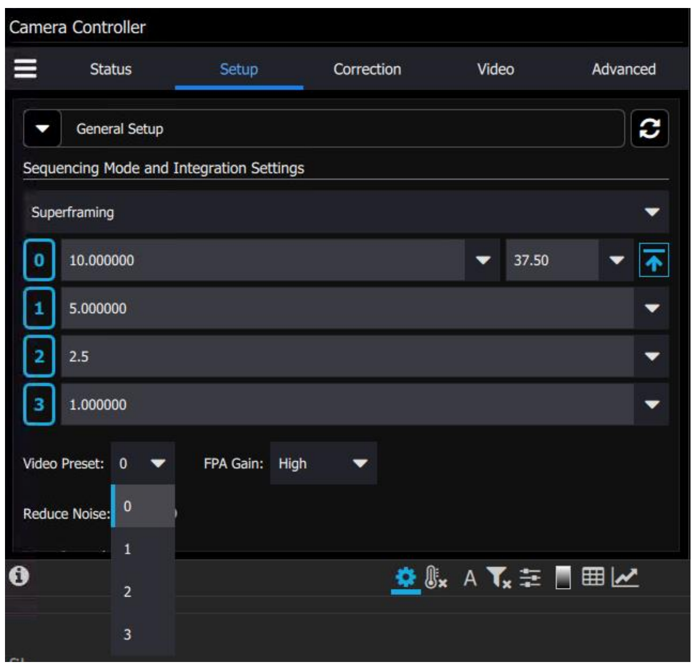
Superframing mode makes the camera cycle between 2,3, or 4 presets. This example shows all four presets active, denoted by the blue squares around the preset numbers:



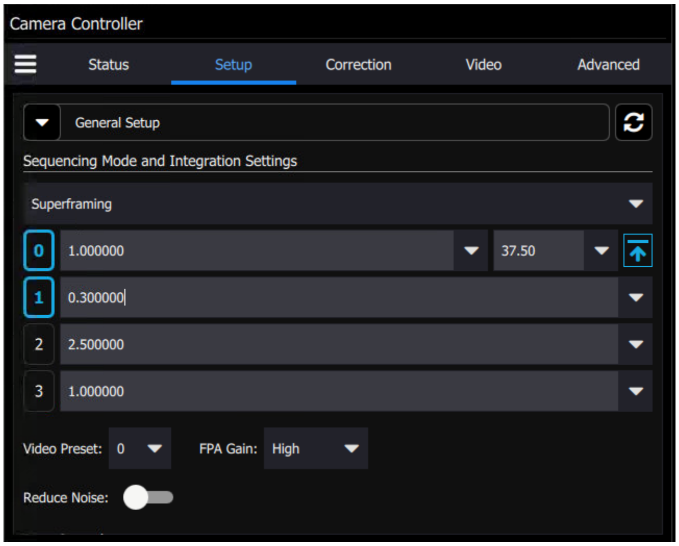
The blue up-facing arrow button makes the camera run at the maximum frame rate in superframing mode. There is a dropdown menu to select other frame rates as well:



The video preset dropdown allows the user to select which preset is used as the source for the SDI video. The system cannot generate SDI video from superframes – it can only be a single preset.

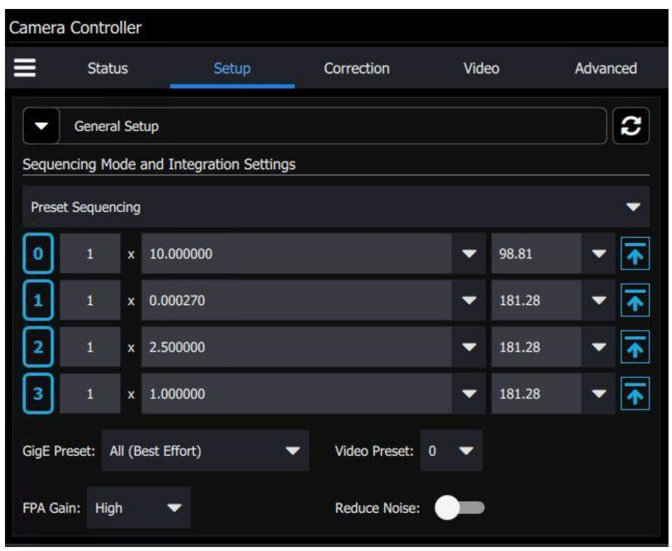


Here is an example of superframing where only two presets are selected. Clicking on the preset number toggles the blue coloring on and off. The blue color means the preset is active and will be used in the superframe cycle:

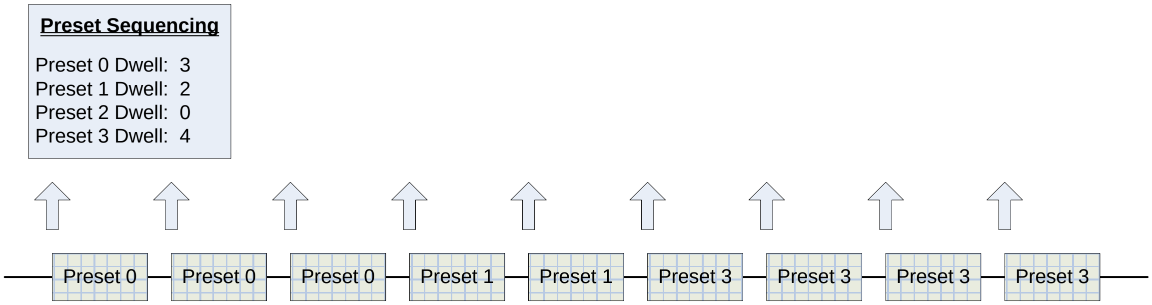


5.4.1.1.6 *Preset Sequencing*

Preset sequencing mode allows the user to output a chosen number of frames from each preset, then advance to the next preset. 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:



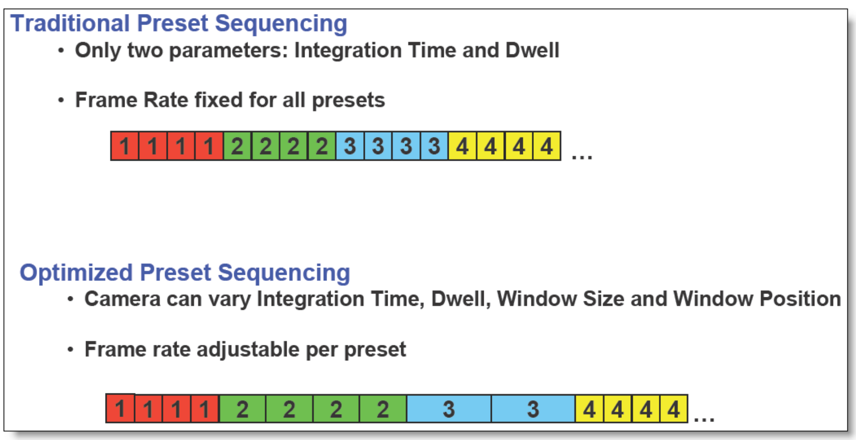
Preset Sequencing

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 Preset number next to the Dwell field tells the camera which preset to send to the active video output. The preset is activated when the button is clicked and the number and box outline turn blue.

Optimized vs. Traditional Preset Sequencing

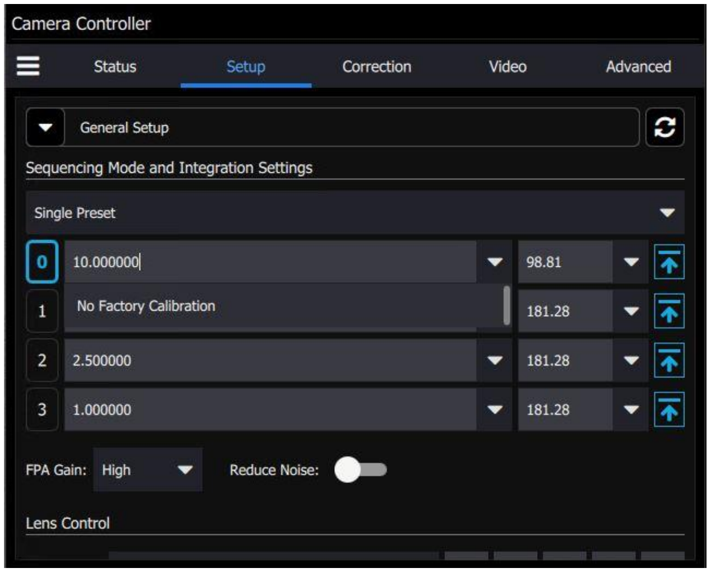
In traditional Preset Sequencing you can only adjust integration time and dwell for each preset. The RS8500 incorporates Optimized Preset Sequencing. This allows the user to set integration time, dwell, and frame rate for each preset. This is depicted in the diagram below.



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, then the camera will be limited to ITR frame rate timing. See Section **Error! Reference source not found.** for more details.

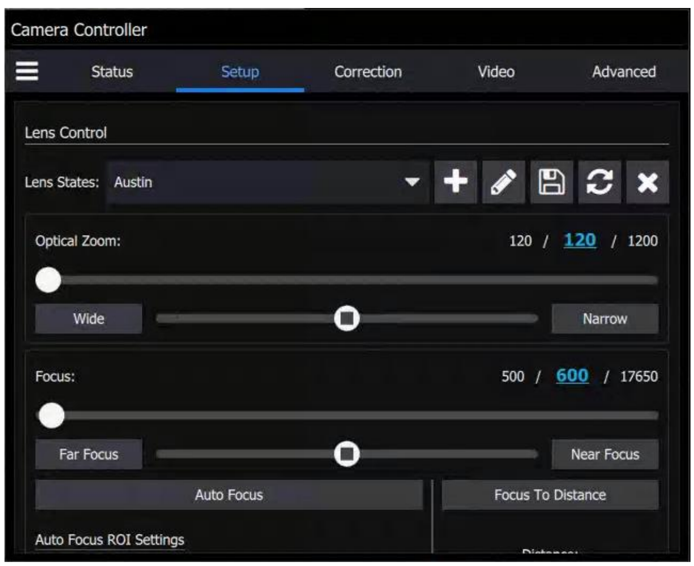
5.4.1.1.7 No Factory Calibration

There is a dropdown for the integration time which shows the option of No Factory Calibration. Selecting that will not affect the integration time. There are currently no plans to offer factory calibrations on the RS8500 cameras.



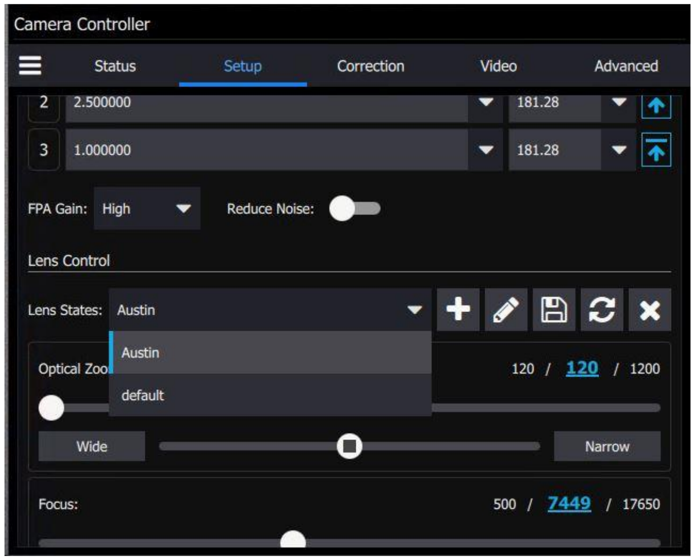
Lens Control

The lens control section allows the user to set the zoom lens focal length between its limits of120 and 1200mm, as well as set the focus position of the lens.

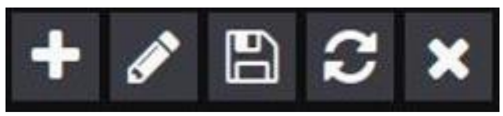


5.4.1.1.8 Lens State

The lens state is a zoom and focus preset that the user can program. The camera will hold an essentially unlimited number of lens states. The user can select the active lens state from a dropdown menu:

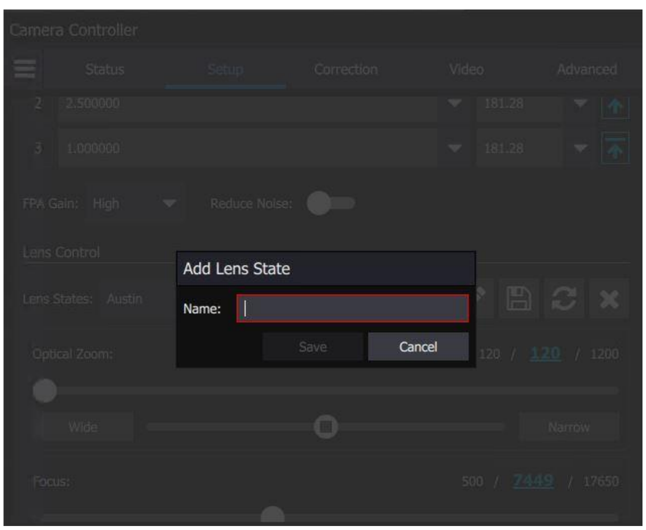


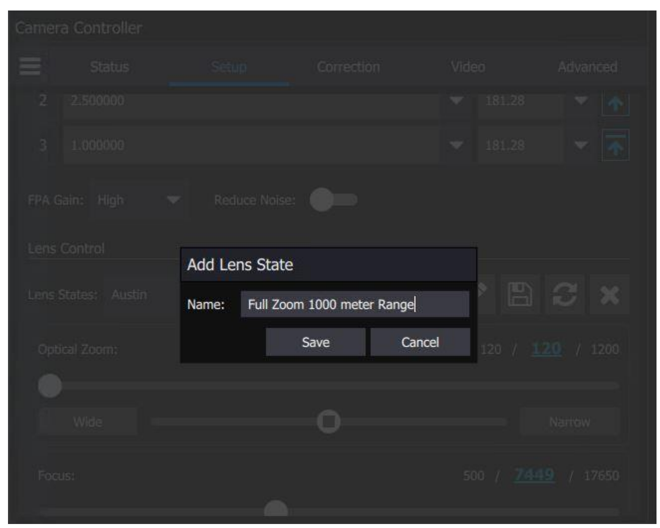
Lens state controls to the right of the dropdown are: Add Lens State, Rename Lens State, Save Lens State, Reload Lens State (Discard Changes), and Delete Lens State. These are the icons in order:



5.4.1.1.8.1 Add Lens State:

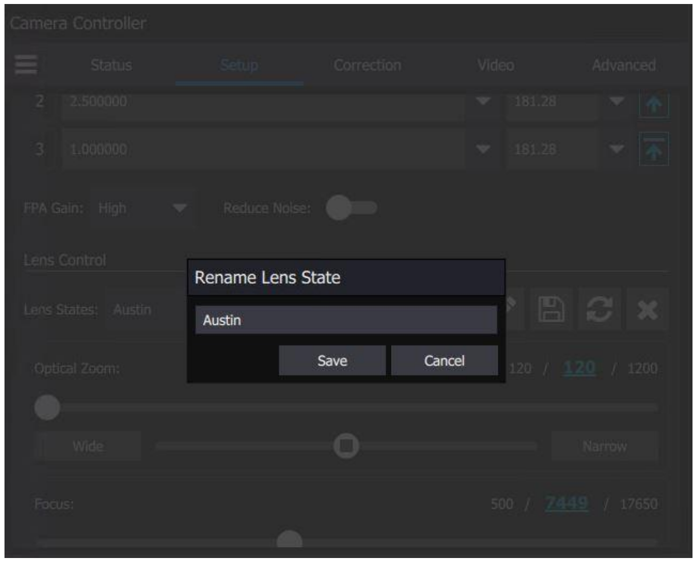
The control looks like a plus sign. The text field is surrounded by red until the user inputs a name for the Lens State:





5.4.1.1.8.2 Rename Lens State

The control looks like a pencil. The active lens state can be renamed:



5.4.1.1.8.3 Save Lens State

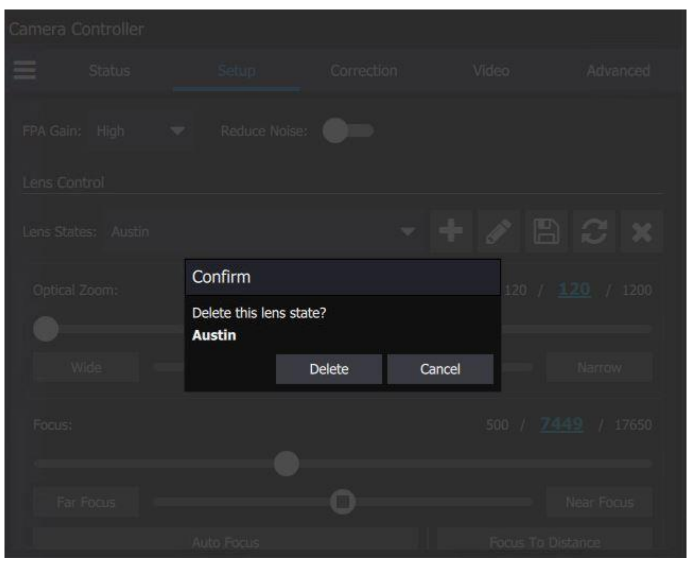
This control looks like a floppy disk. Changes can be made to the active lens state, and then it can be saved again.

5.4.1.1.8.4 Reload Lens State

The reload lens state will reload the last saved version of the active lens state, and discard any changes the user may have made since the lens state was loaded.

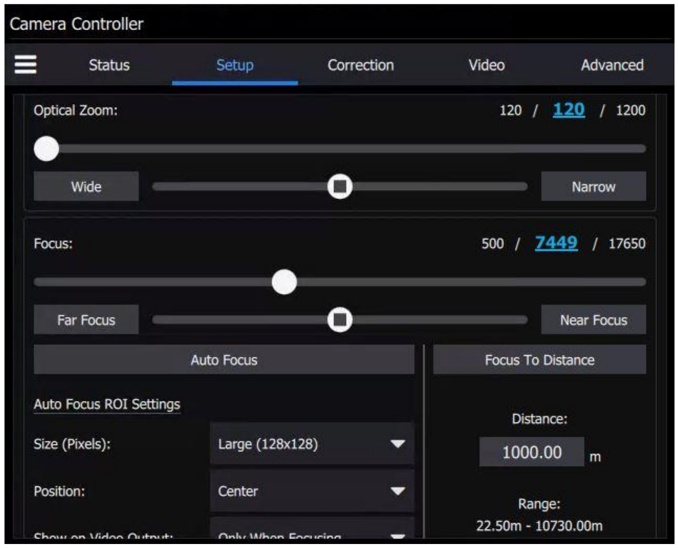
5.4.1.1.8.5 Delete Lens State

The control looks like an X. The active lens state can be deleted with this control:

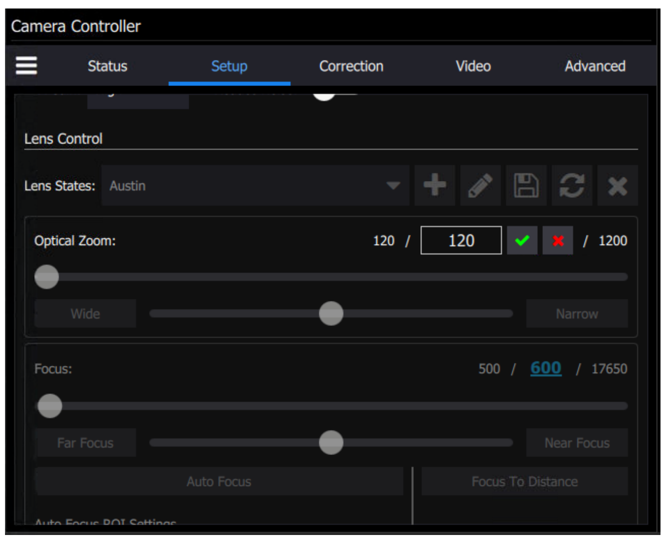


5.4.1.1.9 Optical Zoom

The user can use the sliders to select the optical zoom value which is in millimeters of focal length. The field of view of the RS8500 at the shortest focal length is 7.3 degrees by 5.9 degrees. At the maximum focal length of 1200mm, the FoV is 7.3 degrees by 5.9 degrees. The user can also command the lens to immediately travel to either extreme of zoom with the Wide and Narrow buttons.

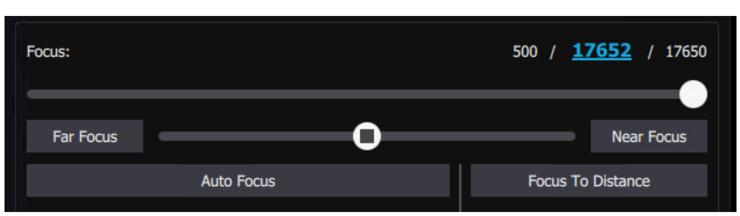


It is possible to manually enter an optical zoom lens focal length setting by clicking on the blue value and hitting the green checkmark:

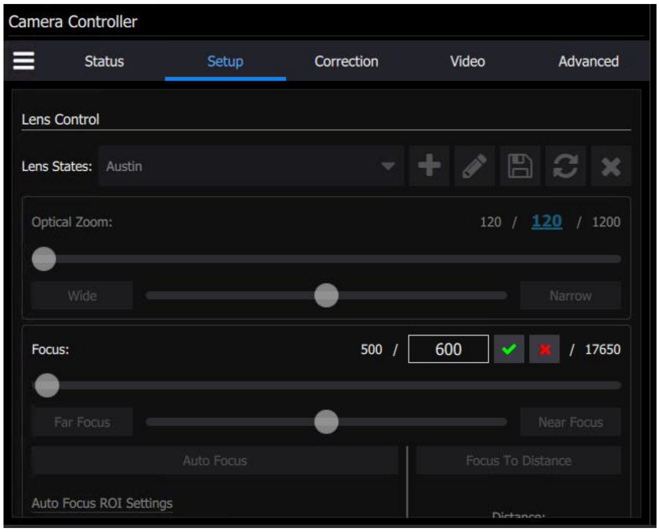


5.4.1.1.10 *Focus Controls*

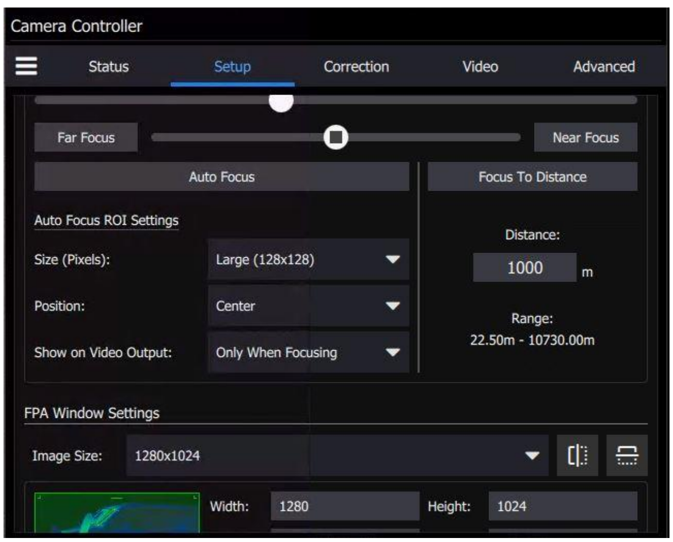
The focus controls include manual focus, auto focus and focus to distance. Manual focus is set with a slider denoted with a white circle. The focus rate/direction slider below it has a white circle surrounding a grey square. As the slider is moved away from the center position, the rate of focus travel increases. Here is an image of the controls when the lens is set to Near Focus. The encoder position goes to its maximum value at near focus.

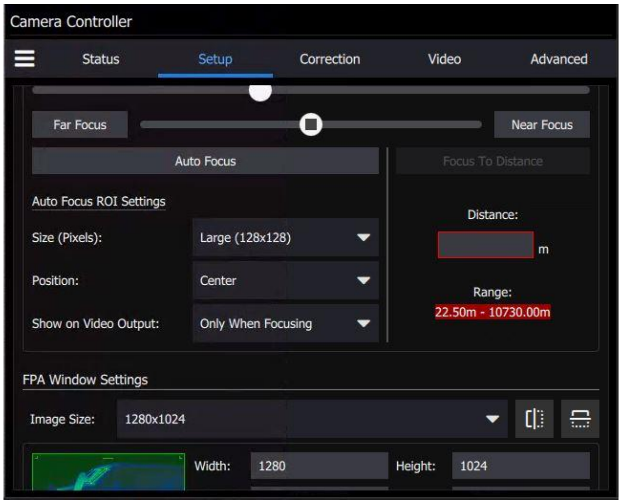


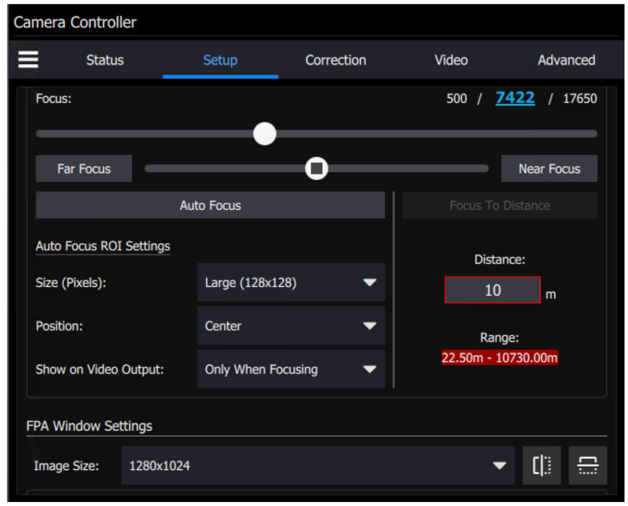
It is also possible to manually enter a focus position settings by clicking on the blue value and hitting the green checkmark. The focus position number is an encoder value which is not represented in engineering units.



The focus to distance control allows the use to input a distance to a target. The camera lens will go to a preset value for that distance by using an internal lens lookup table that is set up at the factory. The user inputs a value and hits return. If no value is entered or the value is out of range, a red outline appears around the box to warn the user. The acceptable range for this input is 22.5 meters to 10730 meters.

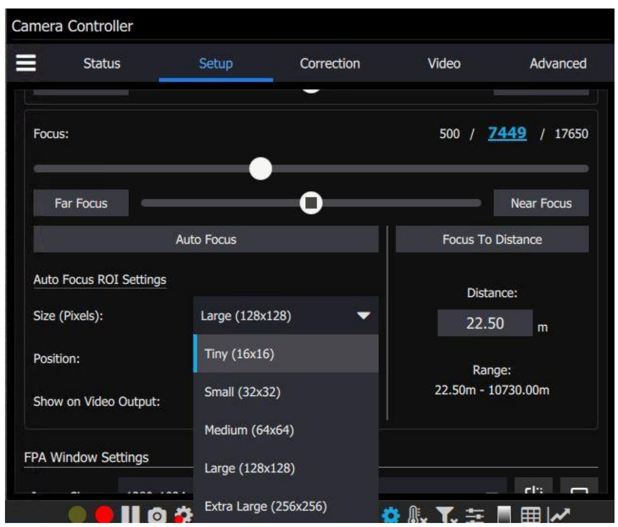


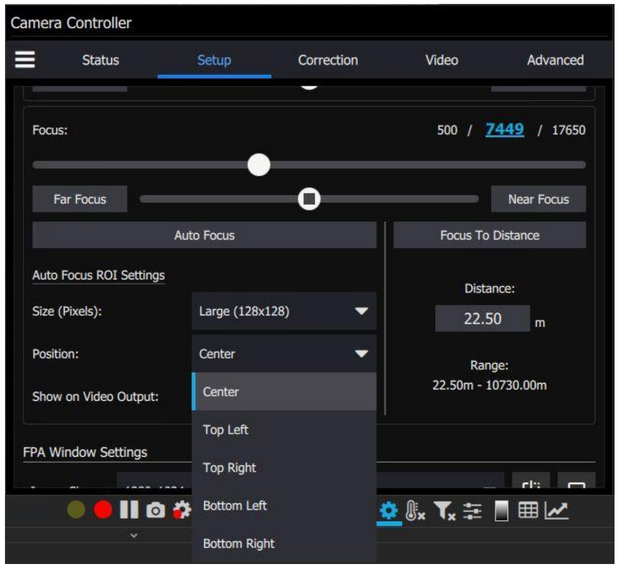


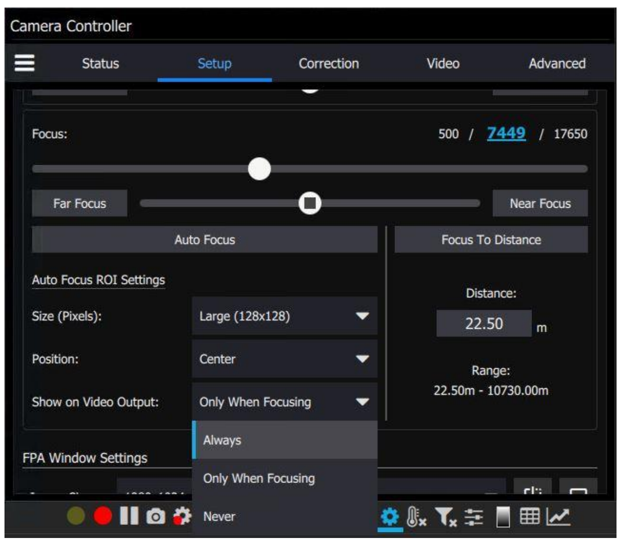


5.4.1.1.11 *Auto Focus*

The Auto Focus control uses image data to control the focus setting of the lens. The algorithm maximizes the high spatial frequency components of a region of interest. The region of interest (ROI) is user controlled in terms of its size, position and whether it is shown on the SDI video output.

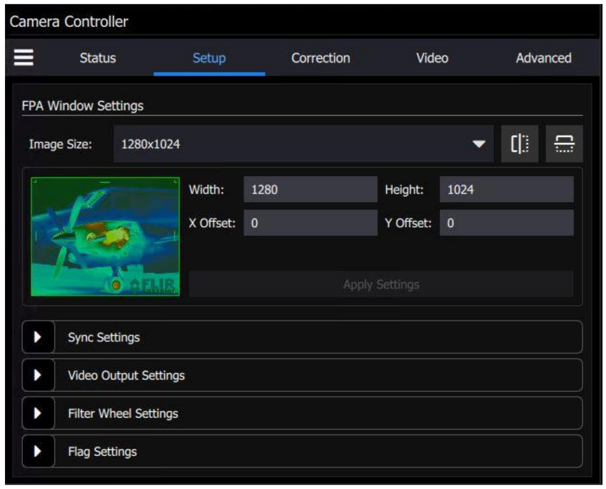






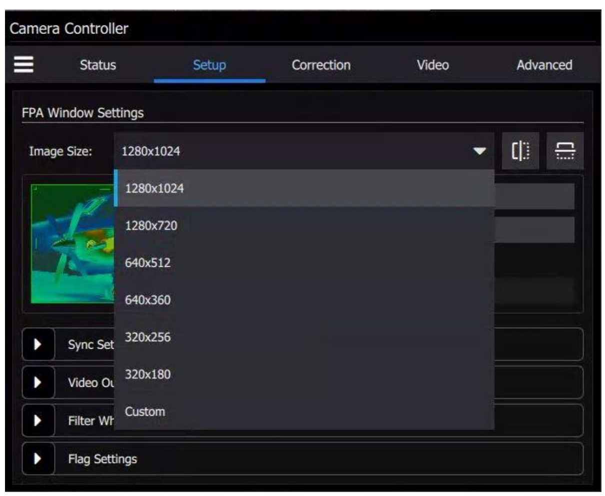
FPA Window Settings

This set of controls allows the user to window the focal plane array down, which will increase the frame rate of the camera.



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.

The user can select from presets of window sizes which will resize the window and center it in the FPA:

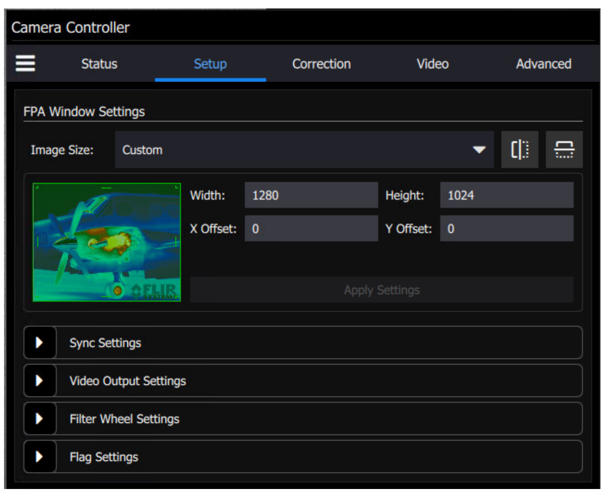


The user can also specify a custom window size, and X and Y offsets, subject to restrictions imposed by the ROIC architecture which are spelled out in the tool tips and in the table below.

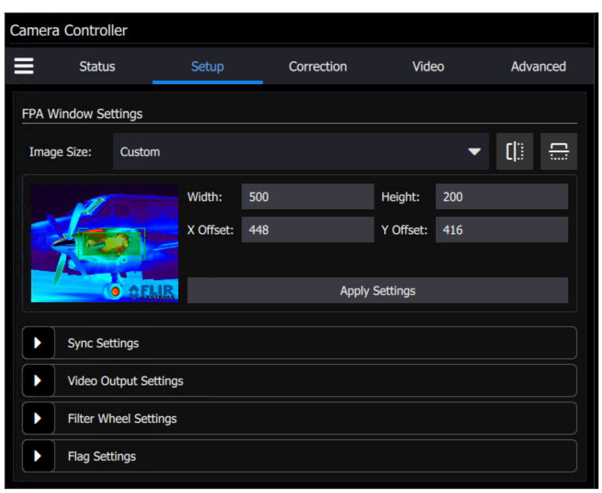
RS8500 Frame Size Variables

	Minimal	Maximum	Step Size
Frame Width	64	1280	64 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

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 yellow if a value has been changed but not applied. A red value indicates an invalid value has been chosen.



The changes are only applied when the Apply Settings button is pushed.



5.4.2 Sync Settings

The sync menu is used to synchronize the camera with an external frame clock source. The sync Settings menu also contains the controls for triggering the camera. The sync menu allows the user to set the FPA sync mode, and sync/trigger options.

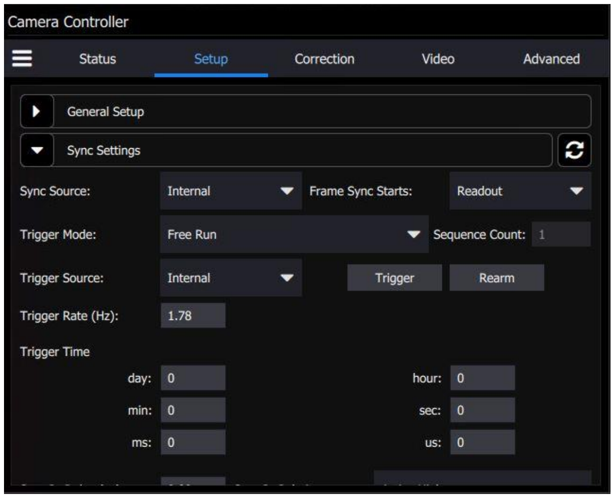
At this point it is helpful to define some terms. A ***sync*** is a signal that synchronizes the timing of an individual frame. A ***trigger*** is a signal that synchronizes the start of a sequence of frames. The RS8500 has independent SYNC and TRIGGER inputs. The SYNC and TRIGGER IN input require a 3.3V TTL pulse (5V max).

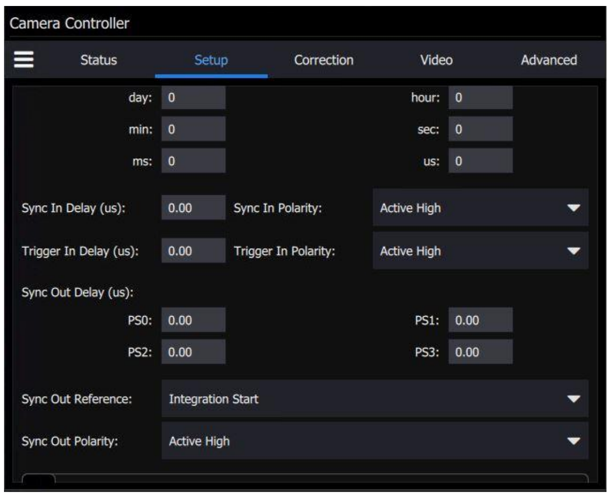
Summary: Syncing is used when there is a repetitive signal. Triggering is a one-shot event.

Sync Sources	
Internal	The frame sync is generated internally to run at the frequency set by the user
External	The frame sync is generated externally through the Sync In connect on the camera rear chassis.
Video	The frame sync is generated from the internal video clock.
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.

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

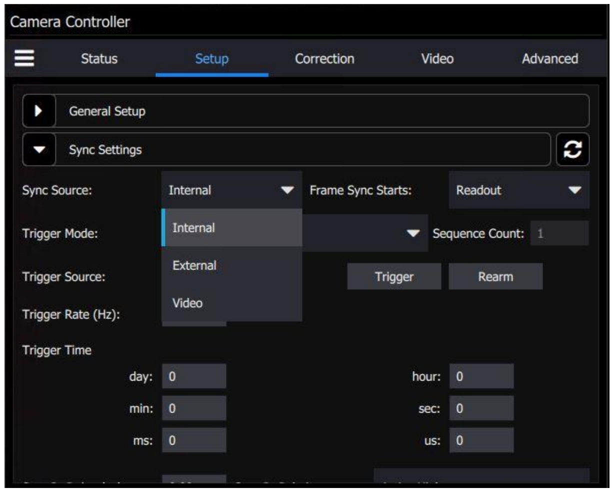
Here is the sync menu in two consecutive screen shots, since you have to scroll down to see all the items:





Sync Source

The sync sources can be Internal, External and Video, and are selected with the pulldown menu shown below. The camera is normally operated with the internal sync source. If the user commands the camera into external sync mode, the video will freeze unless there is an external sync source connected to the camera. The Video option makes the camera run at the video frame rate selected in the Video tab, see section 5.5.8 for more details.



Frame Sync Starts

The RS8500 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.

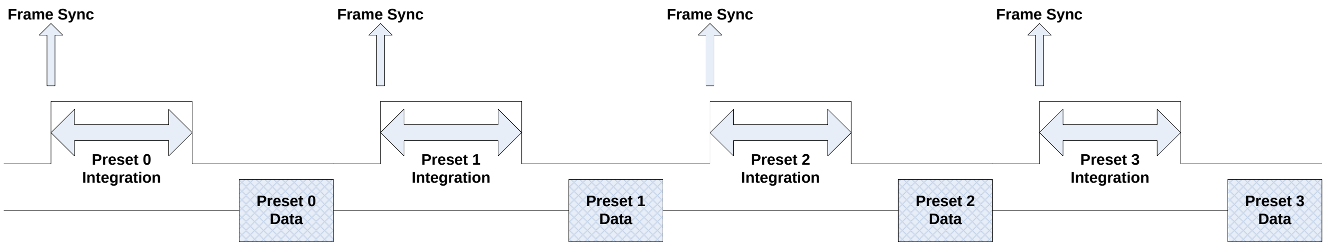
The generation of a frame consists of two phases: *integration* and *data readout*. Depending on the timing between these two events, you can have two basic integration modes: Integrate Then Read (ITR) and Integrate While Read (IWR). In ITR, integration and data readout occur sequentially. The complete 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 RS8500 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 RS8500 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.

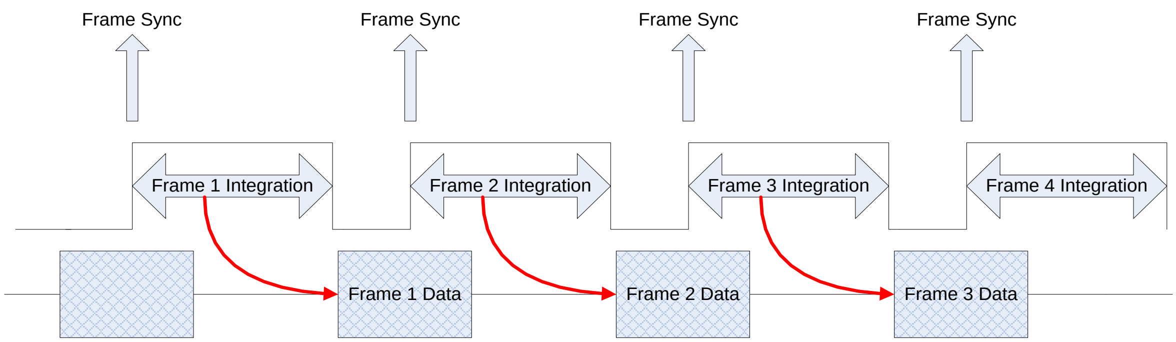
5.4.2.1.1 Frame Sync Starts Integration (FSSI)

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



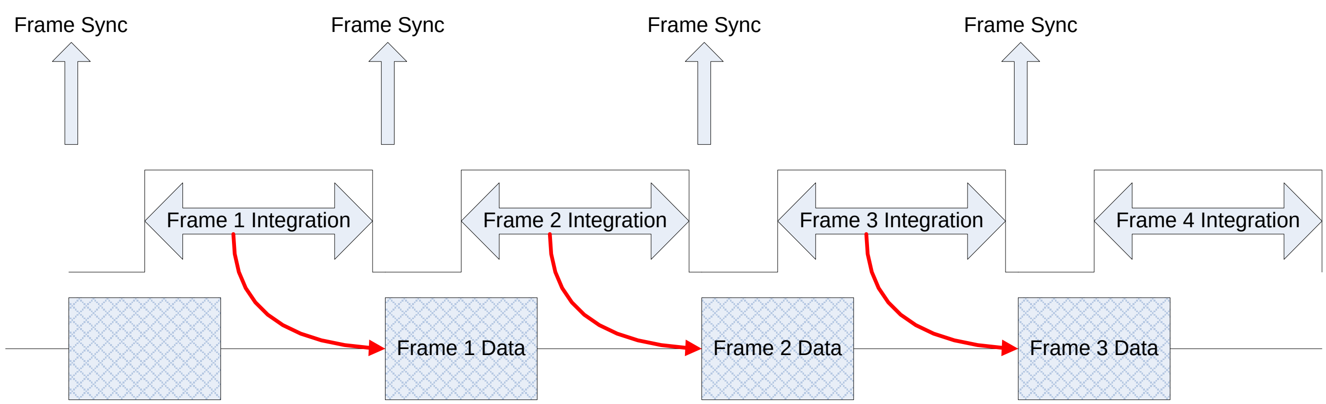
Frame Sync Starts Integration, ITR



Frame Sync Starts Integration, IWR

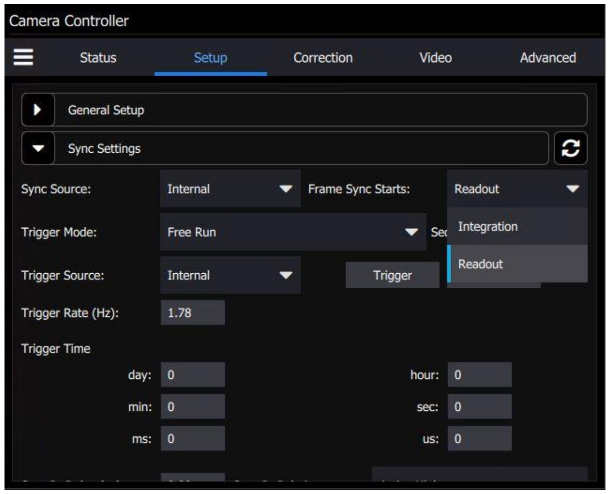
5.4.2.1.2 Frame Sync Starts Readout (FSSR)

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.



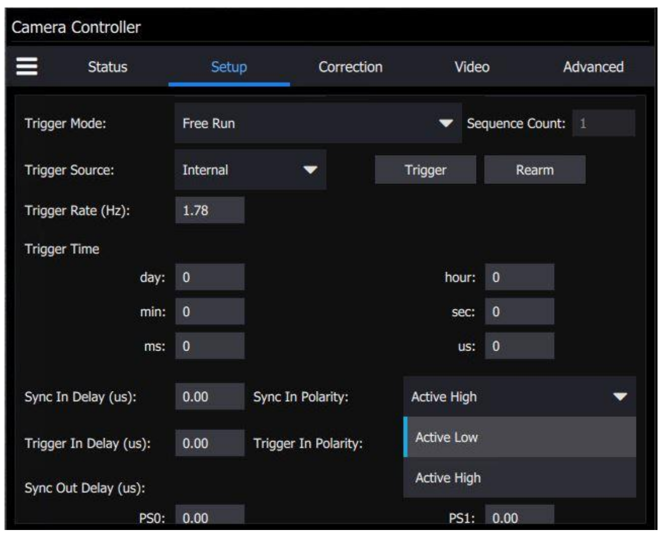
Frame Sync Starts Readout

Here is the pulldown menu where the user selects the Frame Sync Starts mode:



Sync Delay

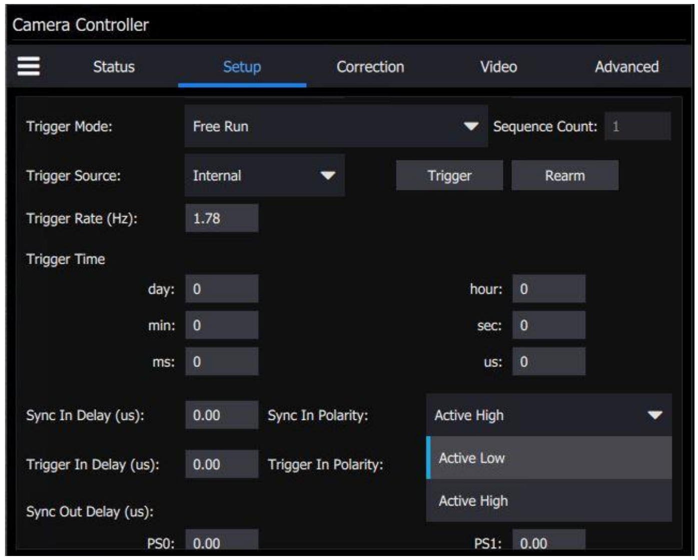
The sync delay can be adjusted by the user using the Sync Delay dialog box. When the sync pulse is received, the camera will delay the specified number of microseconds before either starting integration or readout, depending on what was selected previously.



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.

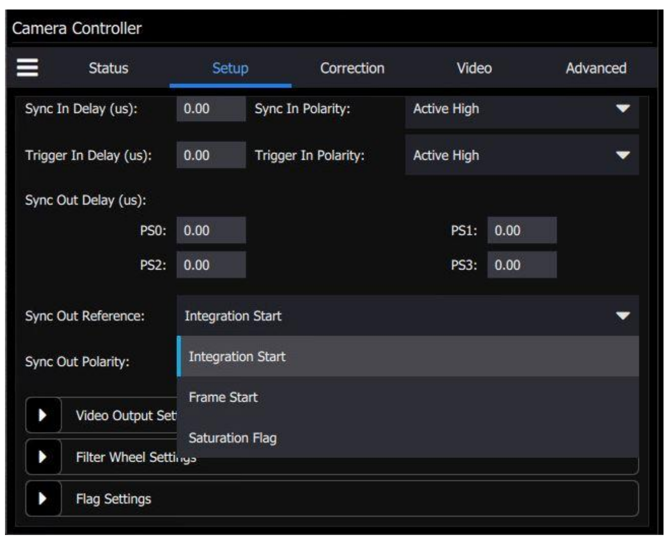
Sync In Polarity

The user selects the Sync In polarity with this pulldown menu. The default is Active High:

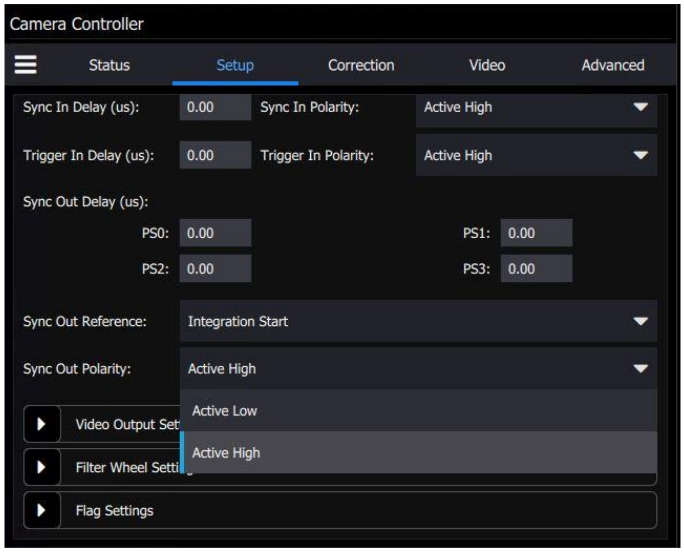


Sync Out Delay, Reference and Polarity

The sync out pulse can be delayed by a specified number of microseconds for each preset. The Sync reference can be Integration Start, Frame Start or Saturation Flag.



The sync out polarity can be set to Active High or Active Low. The Active High is the default setting.

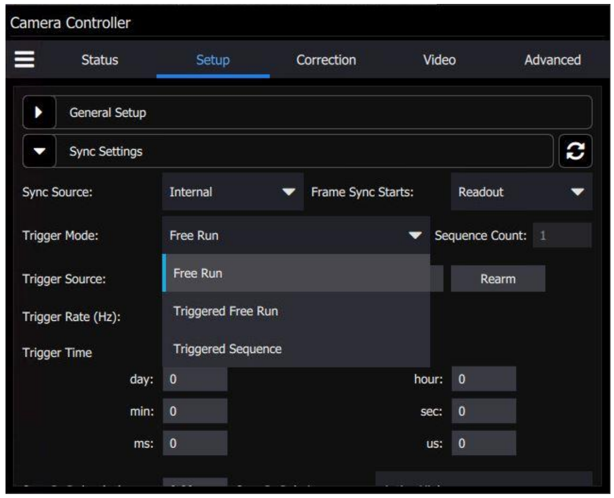


The Sync Out options allow the user to set a delay for the sync out pulse as well as the sync delay reference and polarity. The Sync Out signal always has a jitter of ±1 clock (160nsec).

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.

5.4.3 Trigger Mode

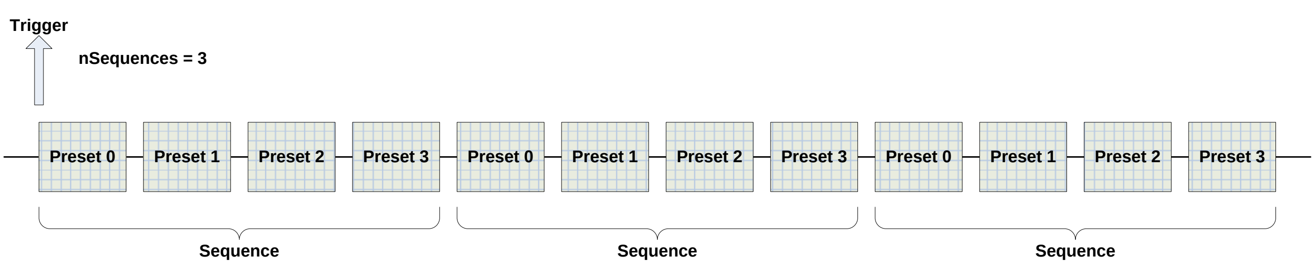
Trigger mode enables the user to trigger the camera to generate frames in response to an external signal. Unlike the Sync Input, which generates one frame per pulse, trigger input can be used to generate multiple frames per pulse. When the camera is "free-running", the trigger input or the record start input can be used to mark a bit in the image header that can be used to initiate recording in external software such as ResearchIR or Research Studio.



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.

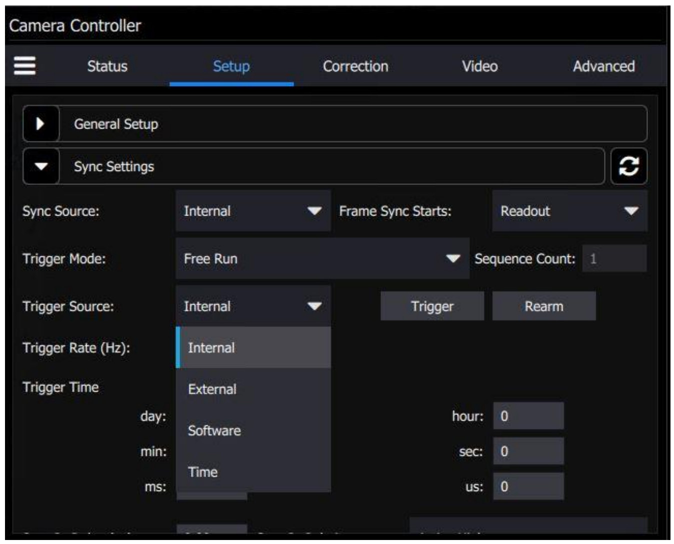


ITR Frame Process

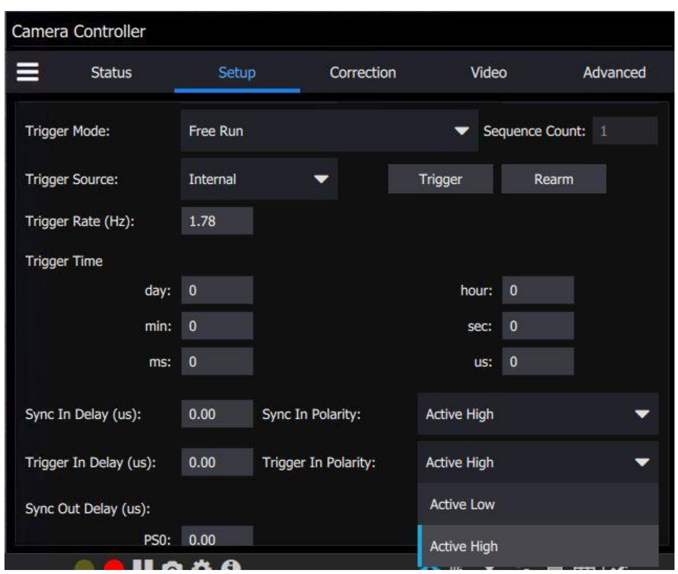
Trigger Source and Trigger In Polarity

The trigger source can be internal, external, software or time. External means that a trigger pulse is sent into the trigger input (TRIG IN) on the back panel of the camera. Software means that the user must press the Trigger button in the user interface. The time trigger is done in the following way: the user can set a time when the camera triggers, then the user arms the software with the Rearm button. When the RTC clock in the camera reaches that time, the camera is triggered.

Here are the Trigger Source pulldown menu options:



Here are the two Sync In Polarity options:

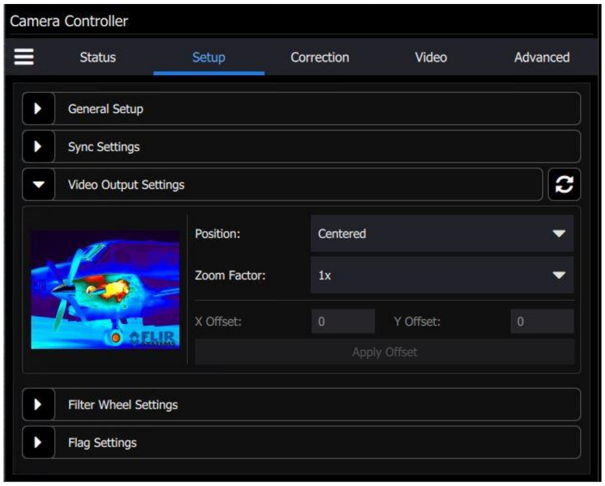


Trigger In	
Delay	Allows for the user to set a delay (µsec) for the external trigger.
Polarity	The trigger is edge triggered. This allows for the camera to use either the rising or falling edge.

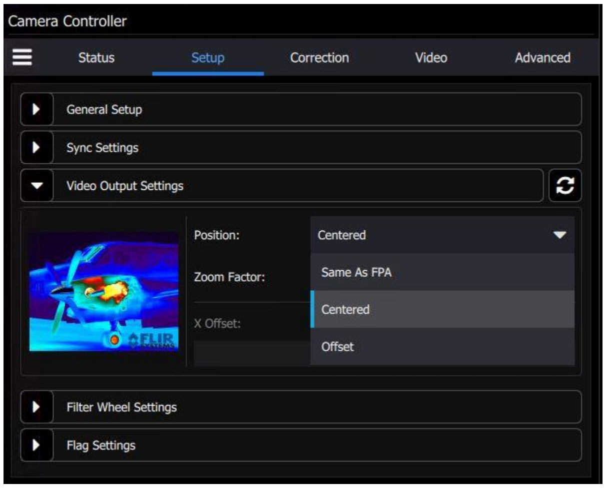
NOTE: The camera has a latency of approximately 1 microsecond when responding to a sync or trigger signal.

5.4.4 Video Output Settings

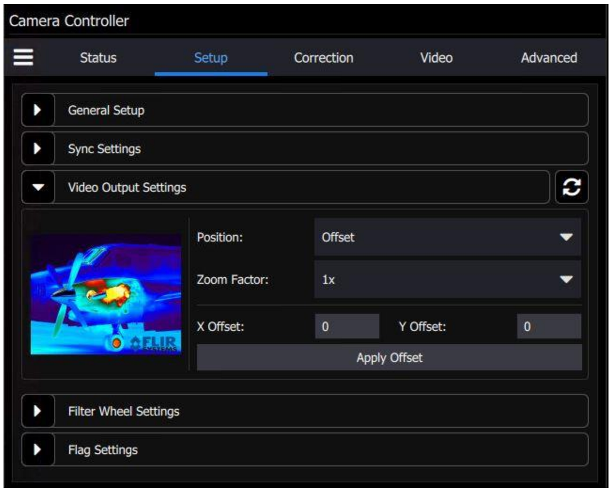
The video output refers to the SDI video that comes out of the camera.



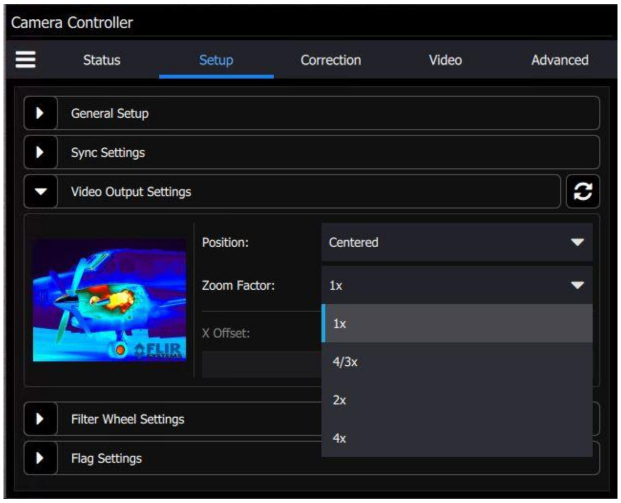
The default position is Centered:



If the user selects Offset, then the X and Y offsets inputs become active. The user enters values and the then hits Apply Offset to make them active.



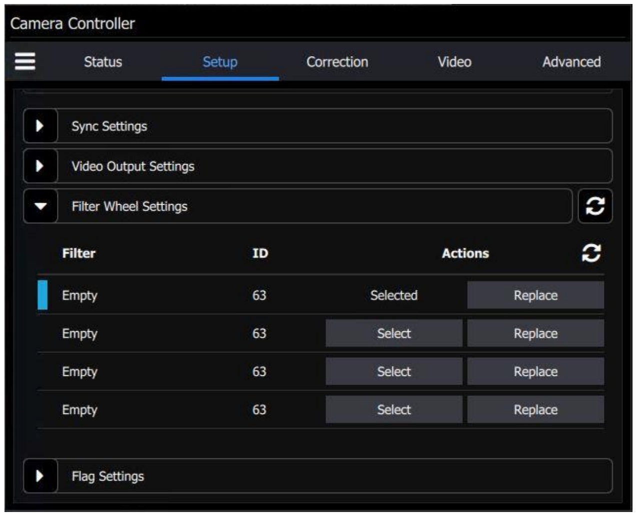
The zoom factor is useful when the user has windowed down the FPA. The zoom factor will grow the input signal to the SDI video signal chain to make the SDI video fill the monitor better:



5.4.5 Filter Wheel Settings

The RS8500 has a motorized 4-position filter wheel which can be populated with warm filters at the time of manufacturing. The filter wheel is a four-position wheel that can hold 1-inch diameter filters. 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.

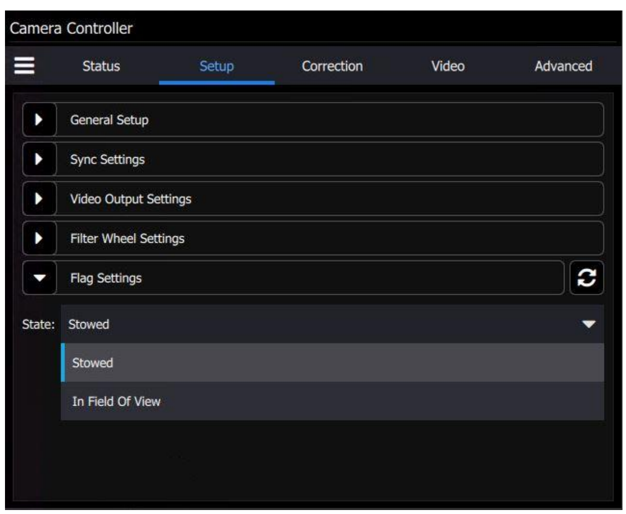
For the RS8500. these filters are typically neutral density filters which reduce the light signal reaching the sensor in order to facilitate the observation of very bright sources, such as rocket plumes, or decoy flares. In this example, the filter wheel is empty and shows the empty ID number of 63. The user can select the filter they want to use. The wheel will rotate around to locate the correct filter ID. The Replace filter button rotates the filter to a position where (in an X-series camera) it would be accessible from the front of the camera. However, since the filters are not accessible to the user, this button is only useful to the factory technicians.



Note: The camera user should not attempt to change warm filters in the filter wheel on the camera inside the RS8500 housing. This requires disassembly of the camera, which may void the warranty.

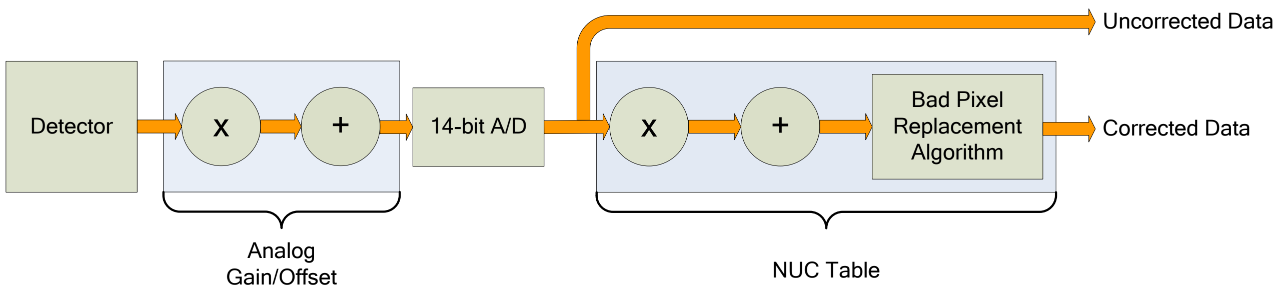
5.4.6 Flag Settings

The user can command the internal flag to move into the field of view, or to be stowed using the dropdown menu shown below. The flag is a piece of metal painted with a high emissivity paint. It moves in front of the warm window on the camera sensor housing to block incoming radiation.



5.5 Correction Tab

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

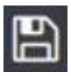
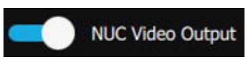
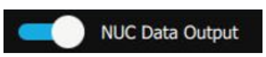
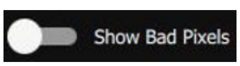
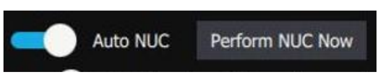
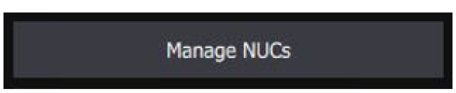
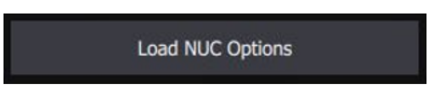
To create the NUC table, the camera images either one or two uniform temperature sources. The source can be an external source provided by the user or the camera's internal NUC flag which is basically a shutter the camera places in front of the detector. If the source is external it should be uniform 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 two types of processes which are used to create the NUC table; Two-Point, and Offset Update.

This section of the control GUI allows the user to load non-uniformity corrections (NUCs), create new NUCs, save NUCs and delete NUCs, as well as handle how the information in a NUC table is used to change camera settings.

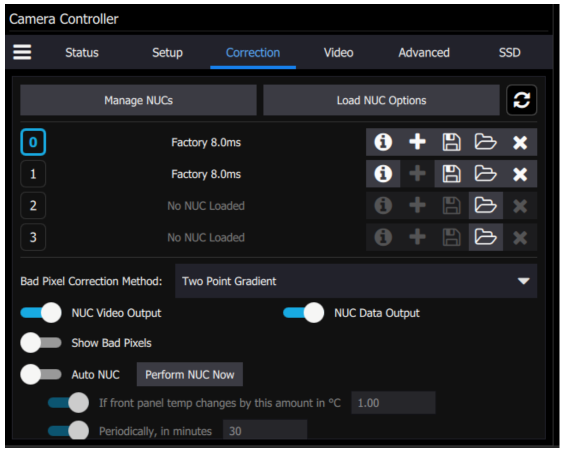
On-camera NUCs are stored in two types of memory:

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.
	Apply NUC to video data. “Analog” is a legacy description. This checkbox applies to all video outputs.
	Apply NUC to Digital output (GigE, CXP, Camera Link)
	Displays all pixels marked as “bad” as white dots on both the analog and digital outputs.
	When enabled, the camera will automatically drop the internal flag and perform a NUC Offset Update when selected criteria are met. The NUC update can be triggered on demand, by a change in the internal temperature sensor or by a timer
	Displays a list of NUCs stored in flash memory. User can delete NUCs from flash memory as well as upload/download NUCs (.NPK files) from the host PC.
	Displays options for loading NUCs.

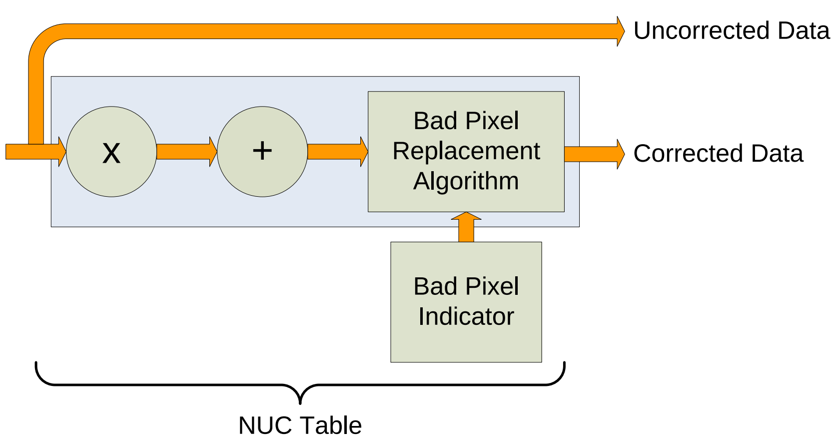
5.5.1 Auto NUC



5.5.2 Bad Pixel Correction Method

The user can select from three choices of how bad pixels are handled using the pulldown menu shown below.

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.



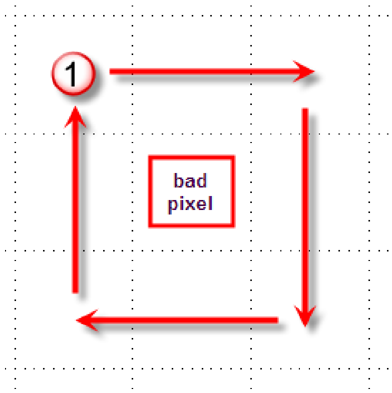
Bad Pixel Correction

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.

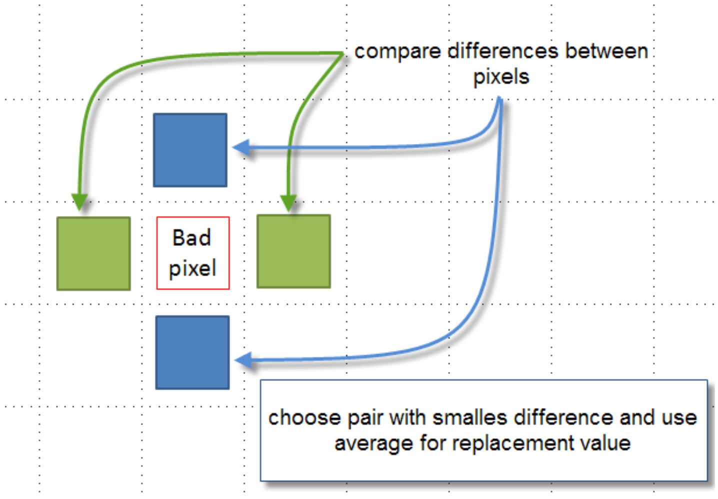
The second method of determining bad pixels is to search for twinklers. Twinklers are pixels that have responsivity values within normal tolerances, but still exhibit large swings for small input changes. These pixels are on the "verge" of being bad and often appear to be noisy. To find these types of 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 RS8500 offers two algorithms for bad pixel replacement: Nearest Neighbor, and 2-point Gradient. Nearest neighbor uses a simple replacement using an adjacent pixel. The adjacent pixel is picked using the pattern depicted below. When a bad pixel is near an edge, those search positions are skipped.

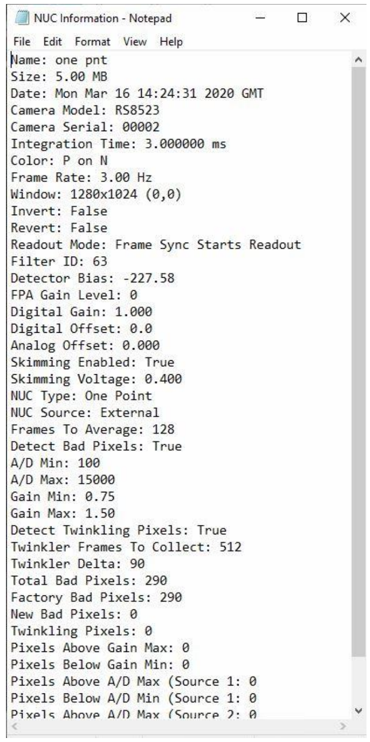


The 2-point gradient algorithm is more sophisticated. With this algorithm, the two pairs of pixels above and below and to the left and right of the bad pixel are evaluated. The algorithm compares the differences between the pixels and chooses the pair with smallest gradient (difference). It then averages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

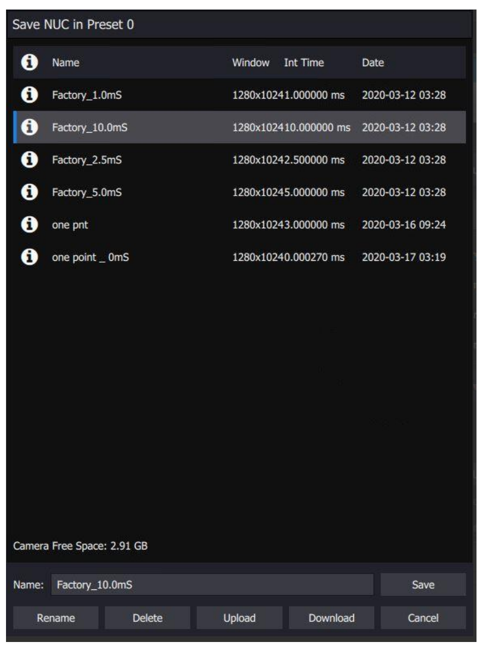


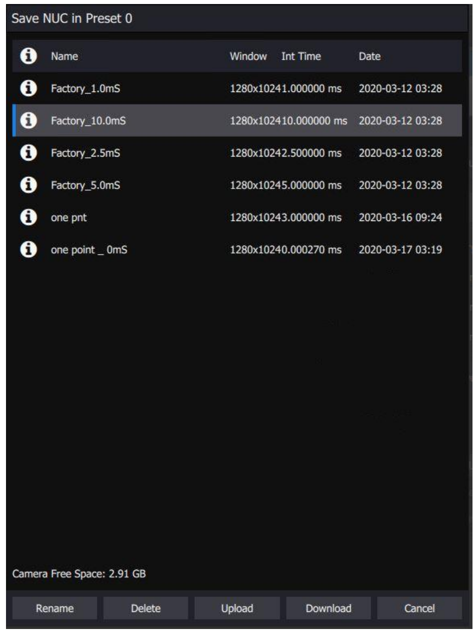
5.5.3 NUC Information

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.


NUC Information - Notepad
File Edit Format View Help
Name: one pnt
Size: 5.00 MB
Date: Mon Mar 16 14:24:31 2020 GMT
Camera Model: RS8523
Camera Serial: 00002
Integration Time: 3.000000 ms
Color: P on N
Frame Rate: 3.00 Hz
Window: 1280x1024 (0,0)
Invert: False
Revert: False
Readout Mode: Frame Sync Starts Readout
Filter ID: 63
Detector Bias: -227.58
FPA Gain Level: 0
Digital Gain: 1.000
Digital Offset: 0.0
Analog Offset: 0.000
Skimming Enabled: True
Skimming Voltage: 0.400
NUC Type: One Point
NUC Source: External
Frames To Average: 128
Detect Bad Pixels: True
A/D Min: 100
A/D Max: 15000
Gain Min: 0.75
Gain Max: 1.50
Detect Twinkling Pixels: True
Twinkler Frames To Collect: 512
Twinkler Delta: 90
Total Bad Pixels: 290
Factory Bad Pixels: 290
New Bad Pixels: 0
Twinkling Pixels: 0
Pixels Above Gain Max: 0
Pixels Below Gain Min: 0
Pixels Above A/D Max (Source 1: 0
Pixels Below A/D Min (Source 1: 0

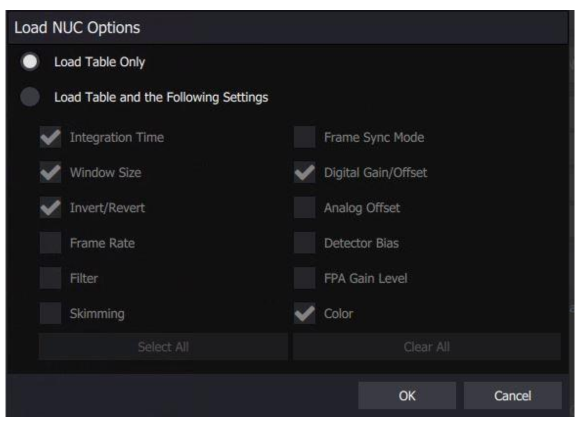
5.5.4 Load NUC


Save NUC in Preset 0
Name
Window
Int Time
Date
Factory_1.0mS 1280x10241.000000 ms 2020-03-12 03:28
Factory_10.0mS 1280x102410.000000 ms 2020-03-12 03:28
Factory_2.5mS 1280x10242.500000 ms 2020-03-12 03:28
Factory_5.0mS 1280x10245.000000 ms 2020-03-12 03:28
one pnt 1280x10243.000000 ms 2020-03-16 09:24
one point _ 0mS 1280x10240.000270 ms 2020-03-17 03:19
Camera Free Space: 2.91 GB
Name: Factory_10.0mS
Save
Rename
Delete
Upload
Download
Cancel



5.5.5 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.

5.5.6 Perform Correction

To create an on-camera NUC, select the *Perform Correction* 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.

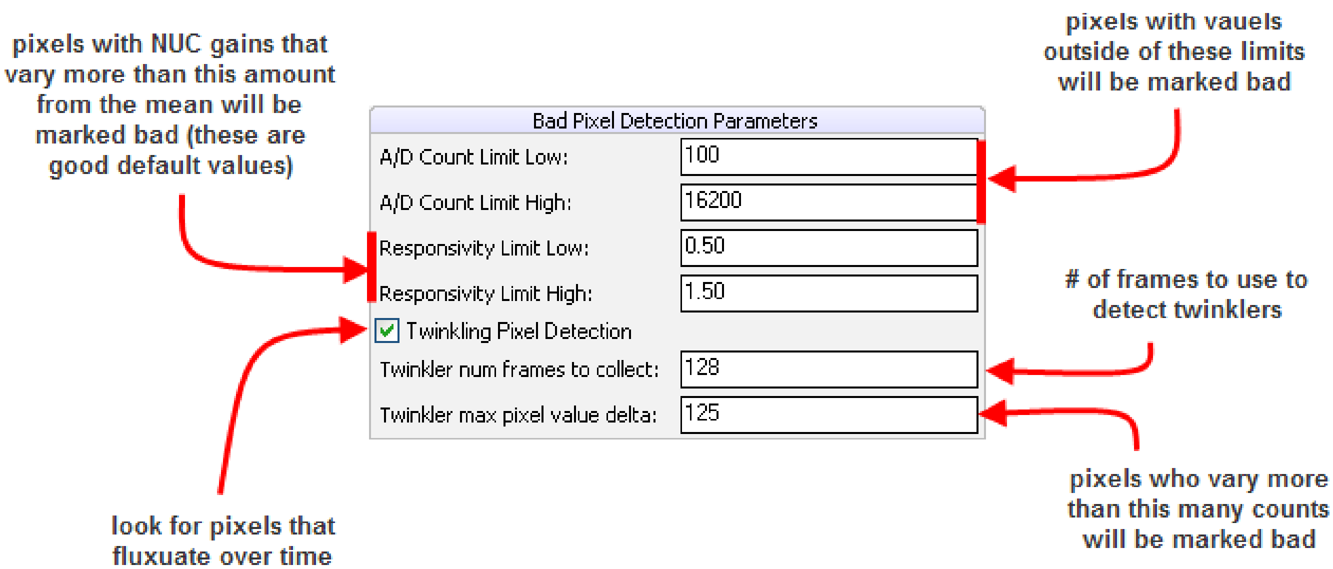
> **NOTE**: Due to differences in camera electronics and FPA timings it is important to perform the NUC with the camera operating modes configured as it will be used when imaging.

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.

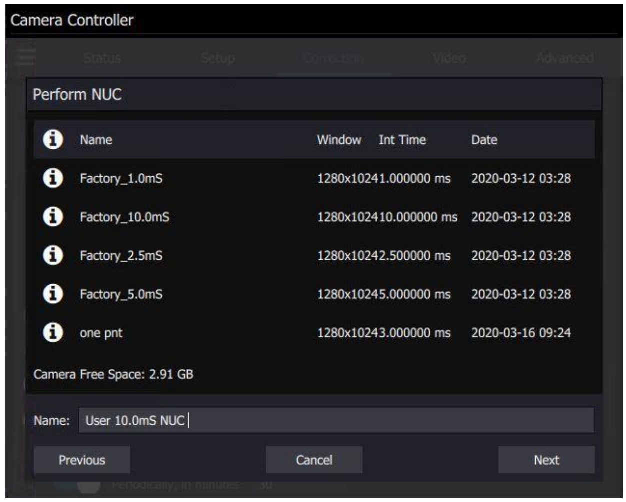
Two correction types are available and are described below. The **Correction Status** area will show messages and prompt the user to complete certain tasks such as place a blackbody in the field of view.

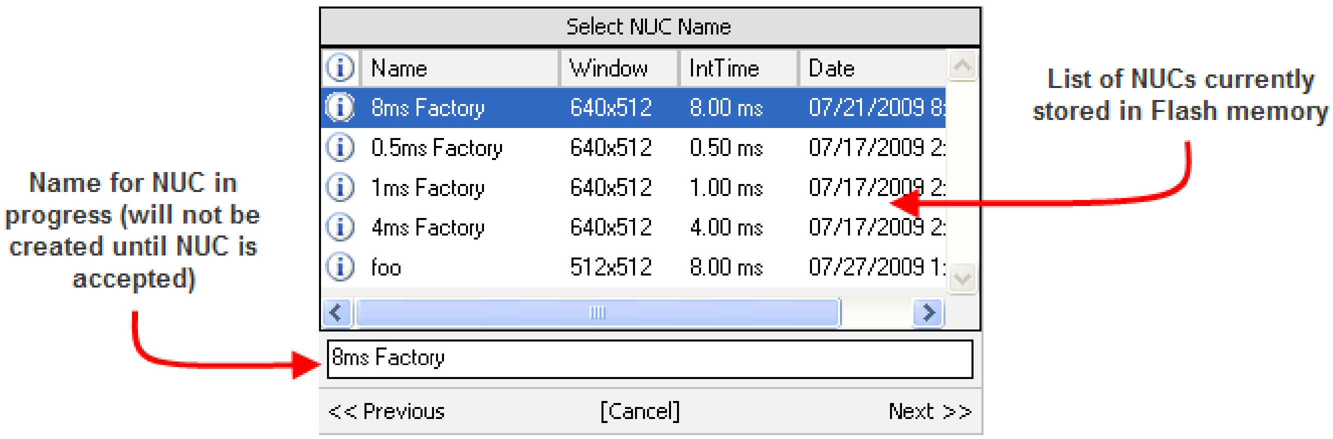
Correction (NUC) Types	
Offset Update	Retains the current NUC gain terms and updates the offset terms. Uses a single NUC source. Retains the current bad pixel (BP) correction.
Two Point	Sets both the gain and offset terms. Uses two NUC sources. Computes a bad pixel correction.
Correction Sources	
Internal	Use the internal flag as the NUC source. The flag is not temperature controlled and floats at the camera's internal temperature.
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.
Number of frames	Set the number of frames to average when computing NUC coefficients. 16 is the default value for the number of frames, and it works well for most scenarios. The value can be set to 2, 4, 8, 16, 32, 64, or 128.
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.

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.



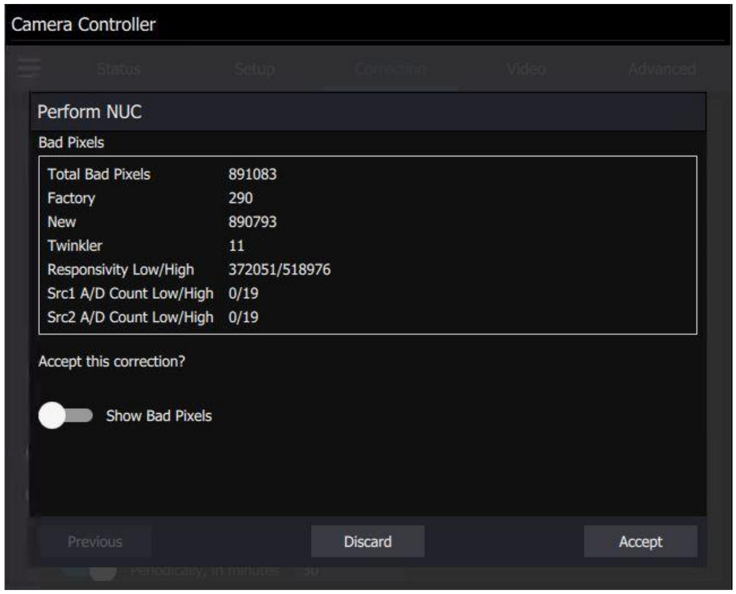
The next window allows the user to name the NUC. Simply type in the name for the table in the text box or select a previously saved file to replace it. Select *Next*>> to continue.





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.

5.5.6.1 Offset Update

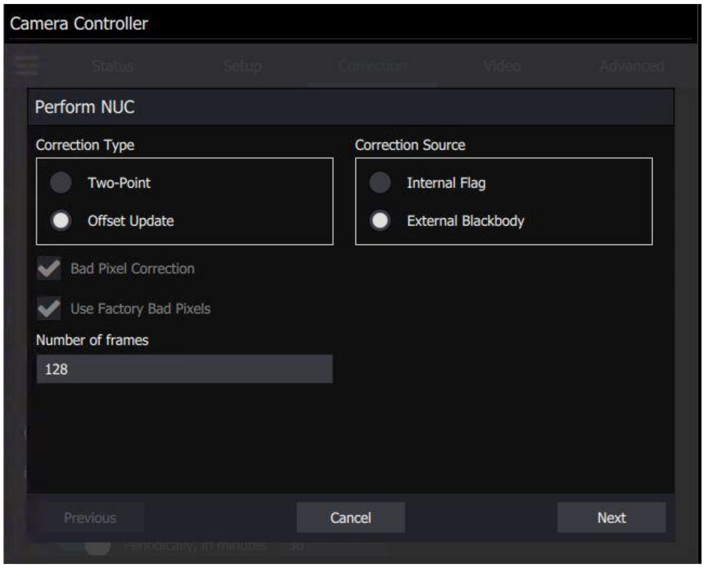
To perform an on-camera NUC, select a Correction Type and Correction Source and then press Start. We will start with the example of an Offset Update. Oftentimes during the normal operation of a camera, the electronics and/or optics will heat up or cool down which changes the uniformity of the camera 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 Offset Update requires only one uniform source, usually set at a temperature on the lower edge of the operational range.

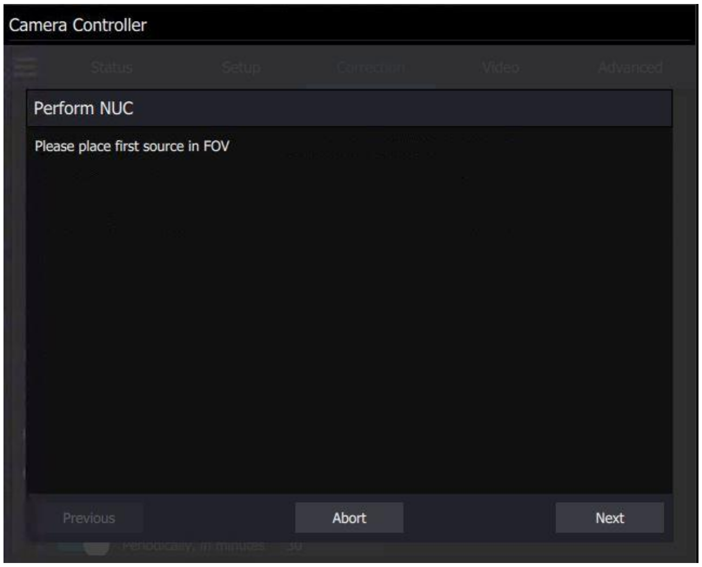
This NUC will touch up the offsets in the currently loaded NUC table. The offset update is not saved to the loaded NUC table, and if the camera is power cycled, it will be lost.

Choose the Offset Update option in Correction Type. The Correction Source internal flag is an option, but the external blackbody is a better choice if the camera front can be accessed. The optional motorized lens cover for the RS8500 is a great option for an external blackbody source if the camera is being used with a long integration time (>1 msec). A 16-inch square of foam rubber can be used as an external blackbody source, or the user can use a 12-inch heated blackbody, which is especially useful for shorter integration time operation. We recommend having the camera already zoomed and focused to the correct settings before performing the offset update, if possible. The internal flag can be used for an offset update, but since the flag is located behind the lens, the resulting correction may still have rings in it caused by non-uniform temperatures and reflections of stray light inside the lens assembly itself.

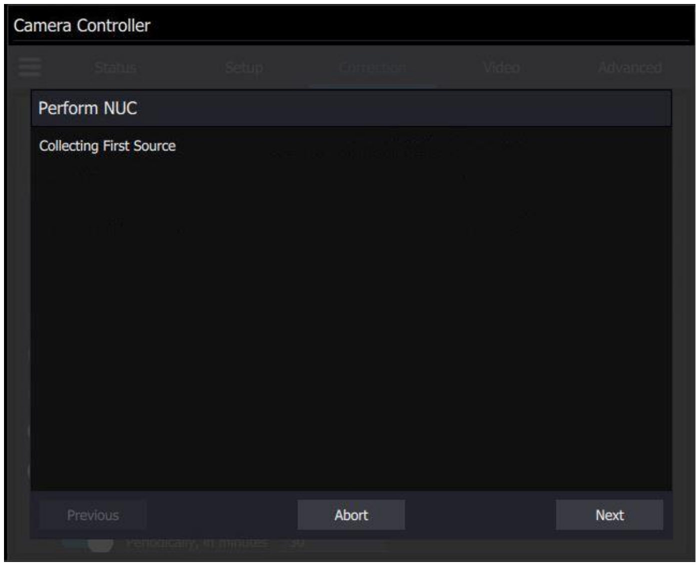
Select the Offset Update and External Blackbody options and click the Next button:



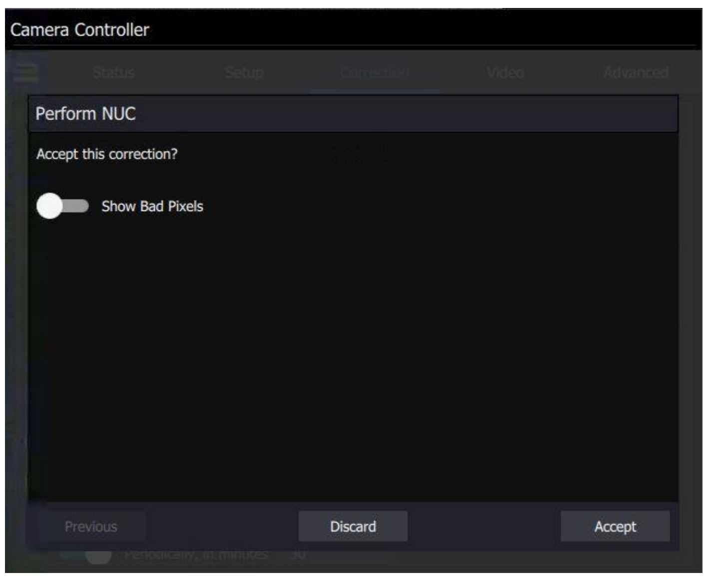
Place the blackbody in front of the lens. The blackbody source should be large enough to completely cover the lens opening with extra room to spare, and it should be uniform in temperature and have a high emissivity. Foam rubber works very well as an ambient temperature blackbody source. Once the blackbody is in position, hit Next:



The GUI will indicate that the camera is collecting frames from the source:

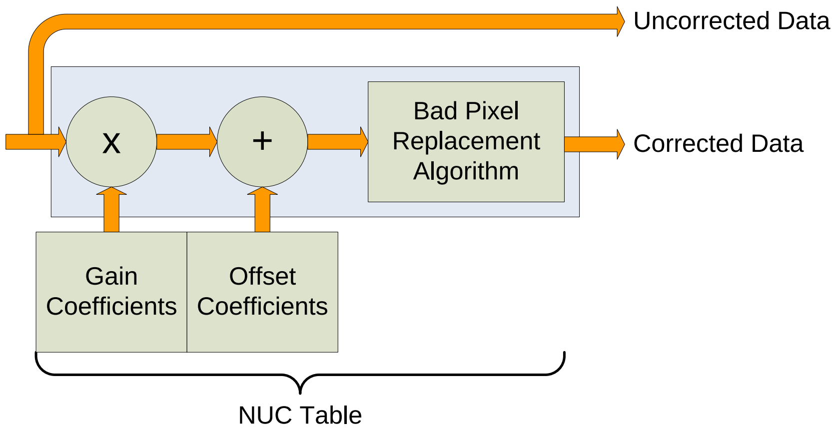


Once the NUC acquisition is complete, the user can evaluate the image quality by viewing the live video on the screen while the camera is still looking at the NUC source. The user is then given the option to accept the NUC, or discard it:

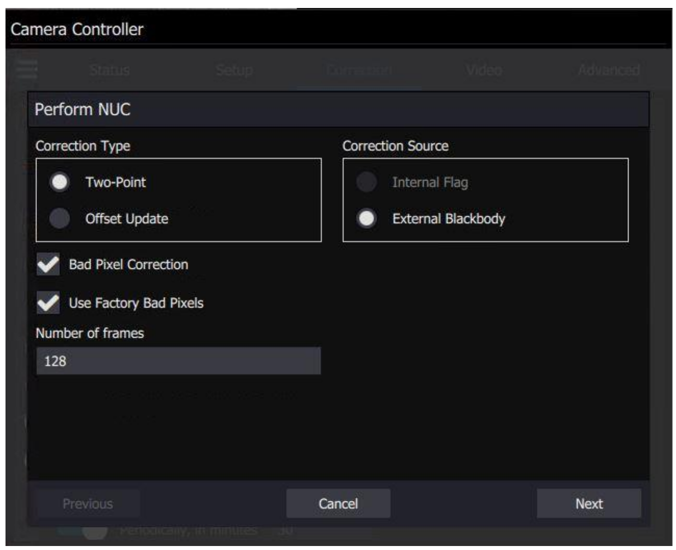


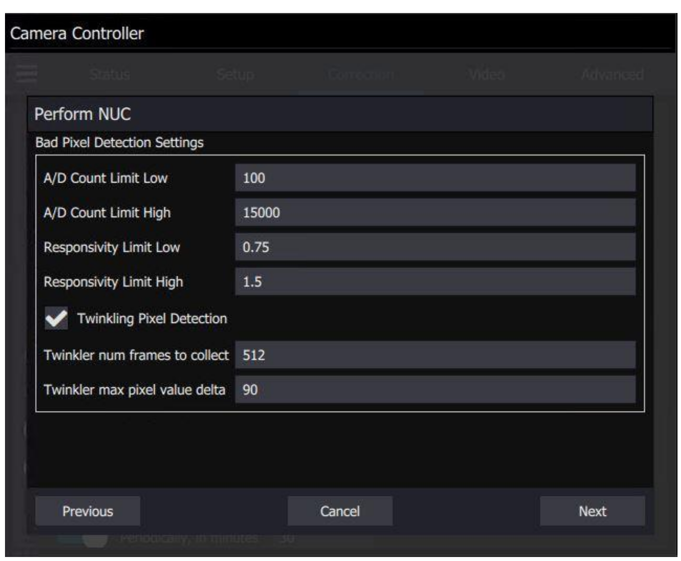
5.5.7 Two Point Correction

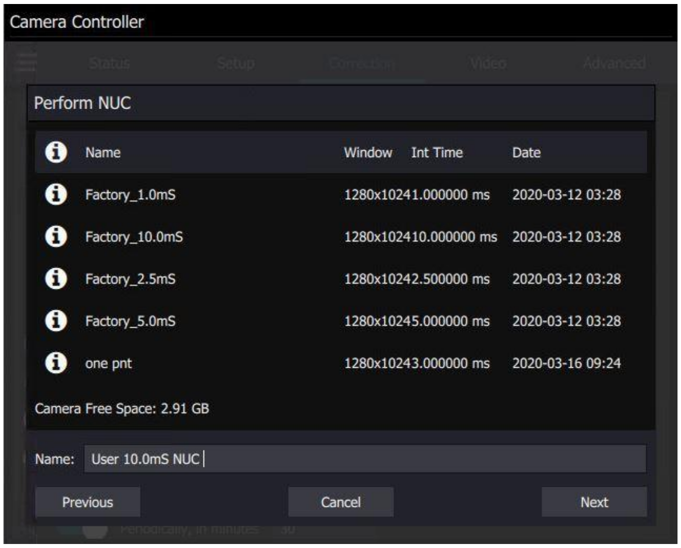
The Two-Point Correction Process builds a NUC table that contains an individually computed gain and offset coefficient for each pixel as seen in the figure below. Two uniform sources are required for this correction. One source at the low end and a second source at the upper end of the usable detector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

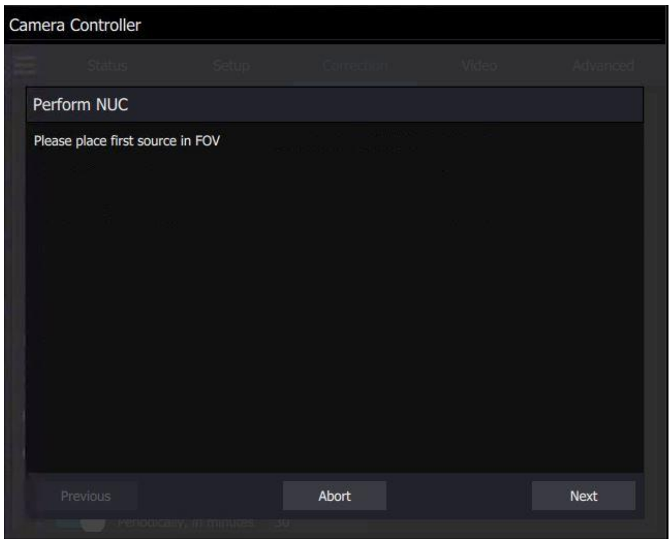


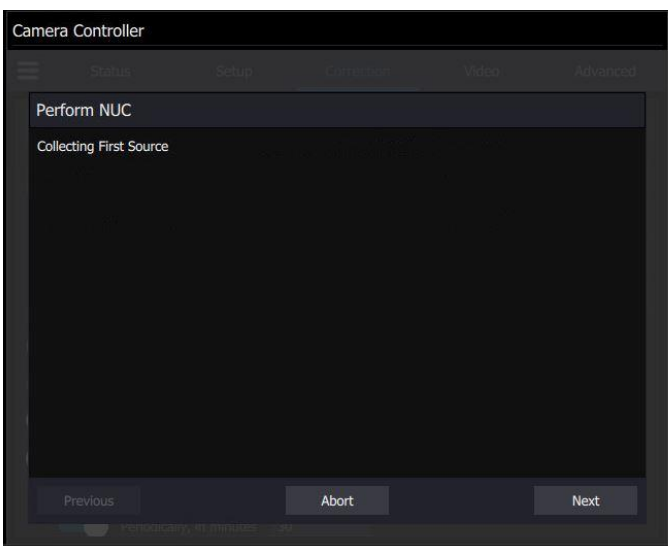
Two-Point Correction

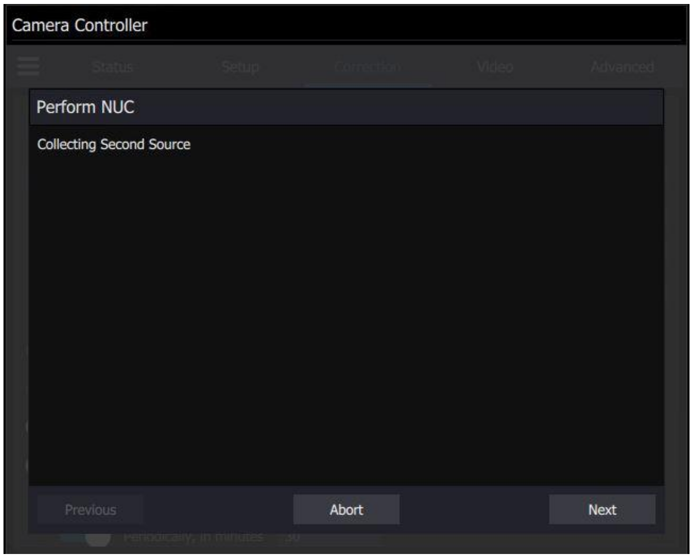


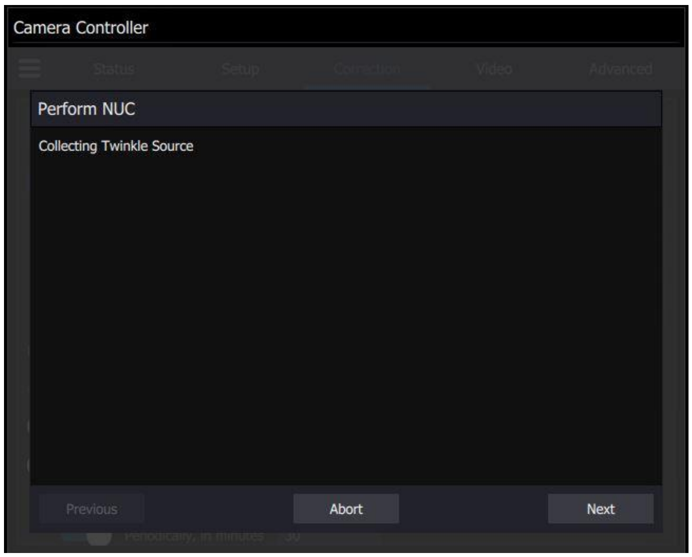


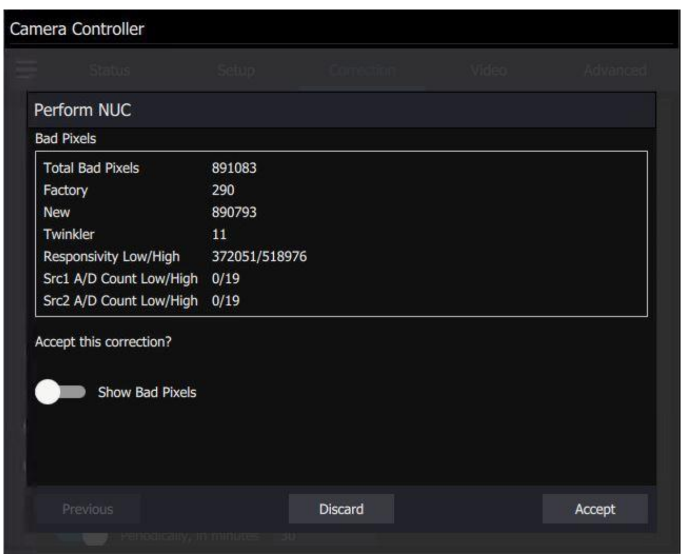

Camera Controller
Perform NUC
Name
Window
Int Time
Date
Factory_1.0mS
1280x10241.000000 ms
2020-03-12 03:28
Factory_10.0mS
1280x102410.000000 ms
2020-03-12 03:28
Factory_2.5mS
1280x10242.500000 ms
2020-03-12 03:28
Factory_5.0mS
1280x10245.000000 ms
2020-03-12 03:28
one pnt
1280x10243.000000 ms
2020-03-16 09:24
Camera Free Space: 2.91 GB
Name:
User 10.0mS NUC
Previous
Cancel
Next


Camera Controller
Perform NUC
Please place first source in FOV
Previous
Abort
Next


Camera Controller
Perform NUC
Collecting First Source
Previous
Abort
Next


Camera Controller
Perform NUC
Collecting Second Source
Previous
Abort
Next

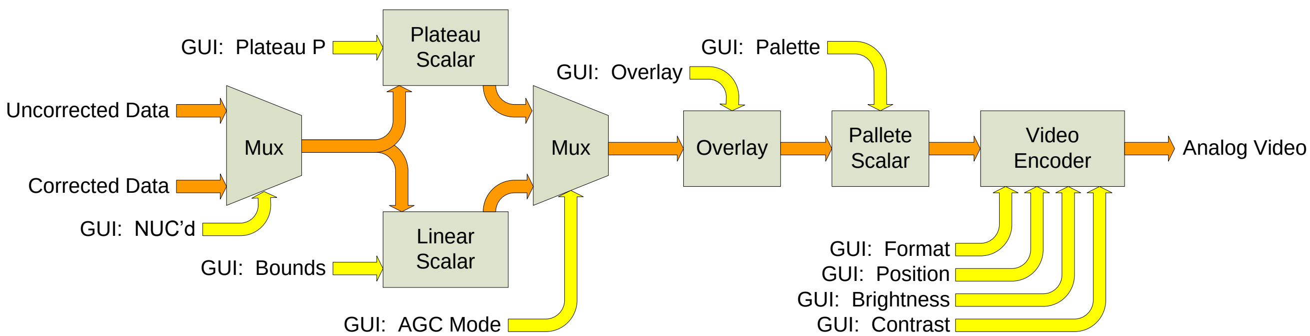

Camera Controller
Perform NUC
Collecting Twinkle Source
Previous
Abort
Next


Camera Controller
Perform NUC
Bad Pixels
Total Bad Pixels 891083
Factory 290
New 890793
Twinkler 11
Responsivity Low/High 372051/518976
Src1 A/D Count Low/High 0/19
Src2 A/D Count Low/High 0/19
Accept this correction?
Show Bad Pixels
Previous
Discard
Accept

5.5.8 Video

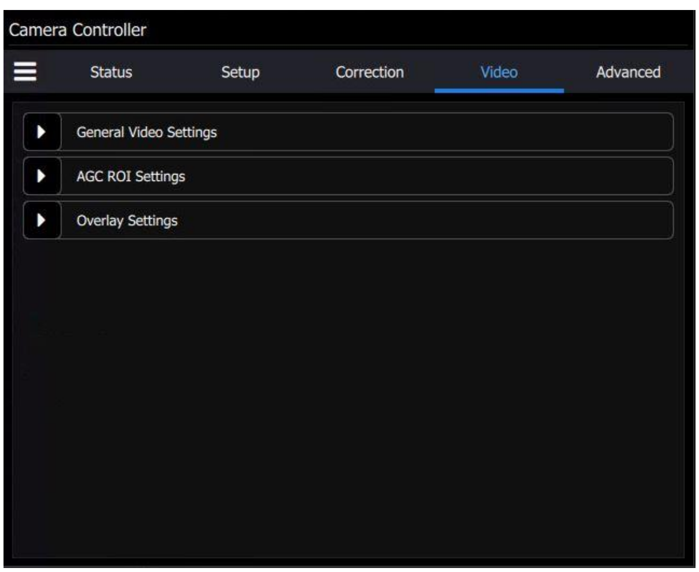
The SDI video outputs always puts out a standard size video frame. If the camera FPA image is windowed down to a smaller size, then there will be black areas in the SDI Video. The Video sub-tab allows the user to control how the FPA digital image data is positioned within the SDI video frame.

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 SDI video**. The diagram below shows a flow chart of the video process and how the parameters of this screen are used.



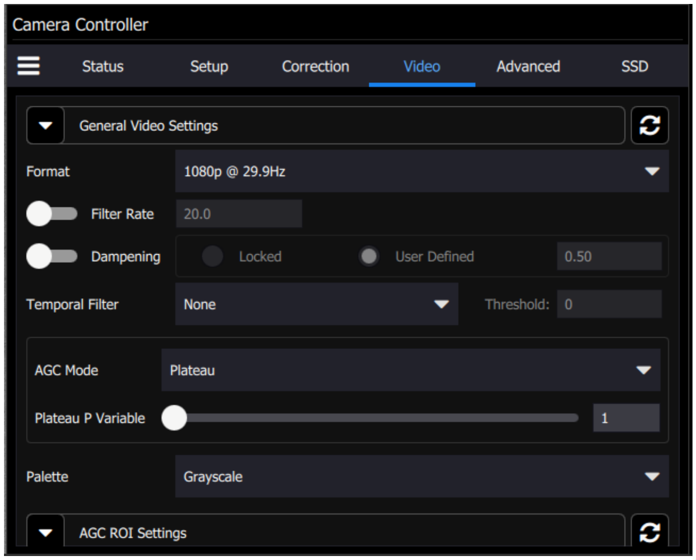
Video Flow

The Video tab has three sub-menus: General Video Settings, AGC ROI Settings and Overlay Settings:

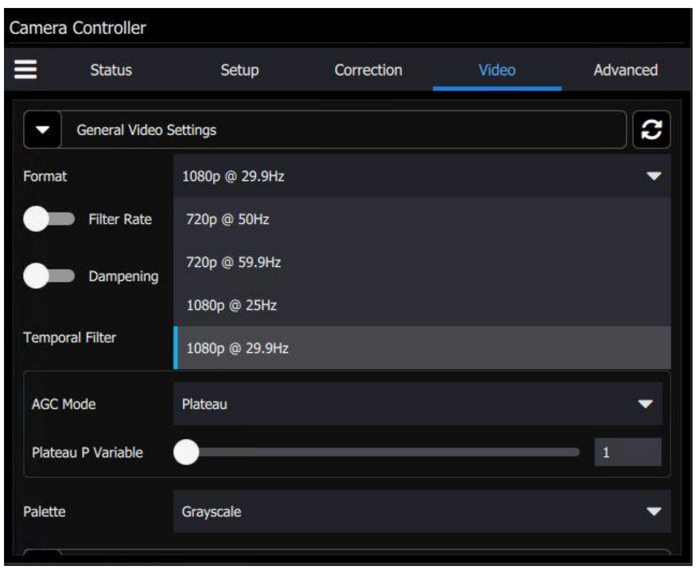


General Video Settings

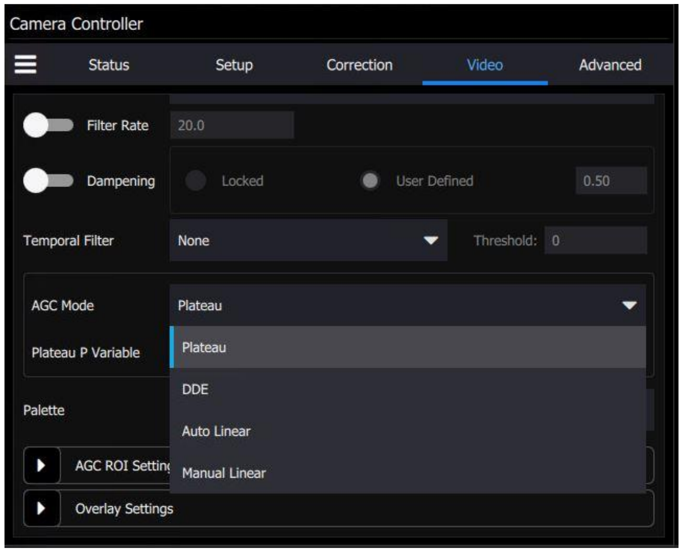
This is the factory default view of this sub-menu.



The format pulldown menu enables the choice of different video formats.

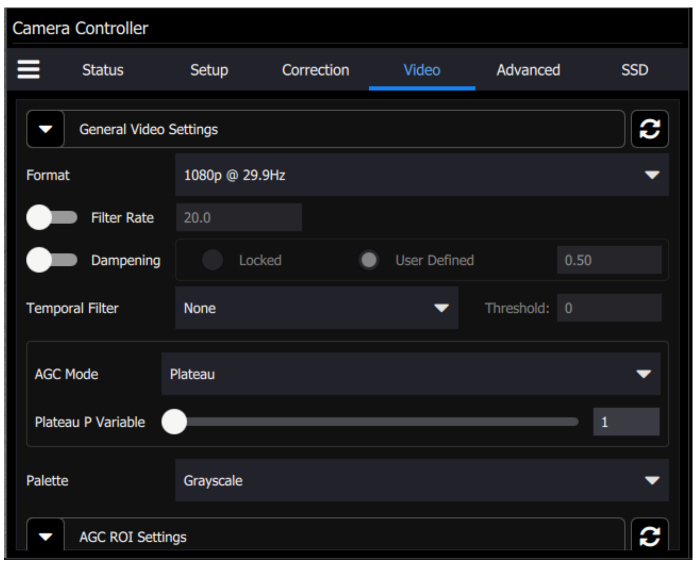


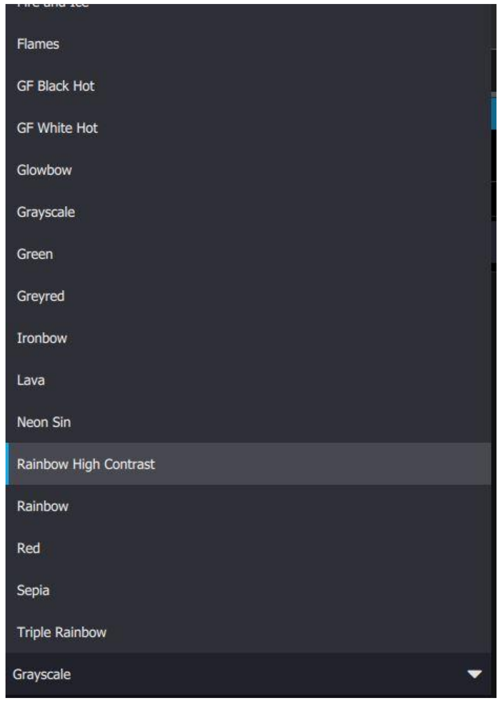
5.5.8.1.1 AGC Mode



5.5.8.1.2 Palette

A color palette can be applied to the SDI video. There are a number of palette choices. A subset of them are shown below.

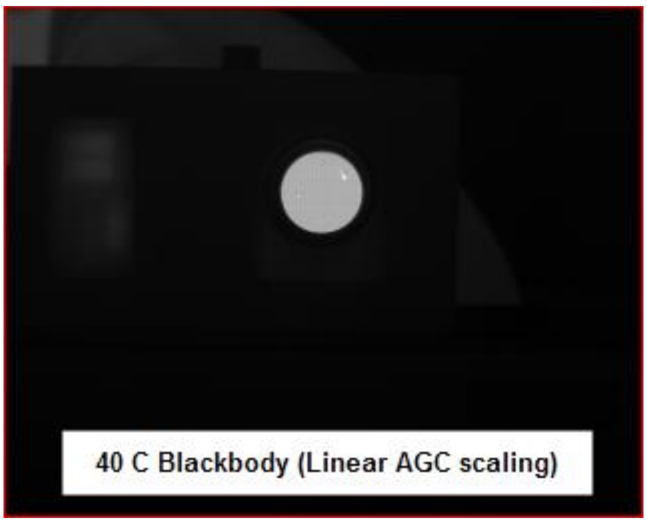


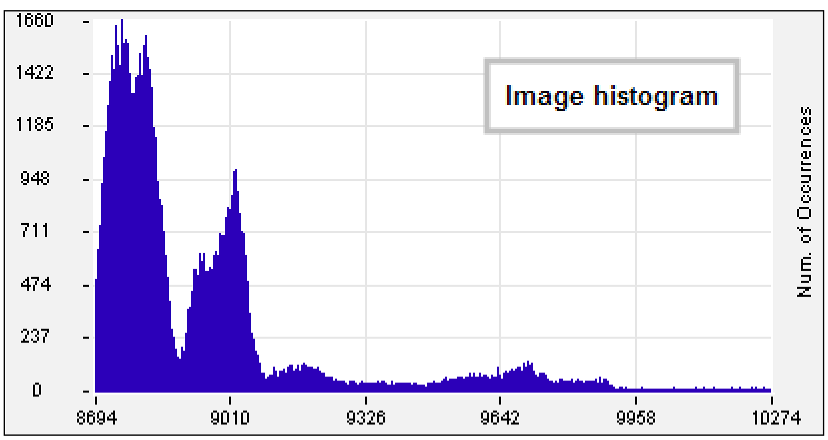


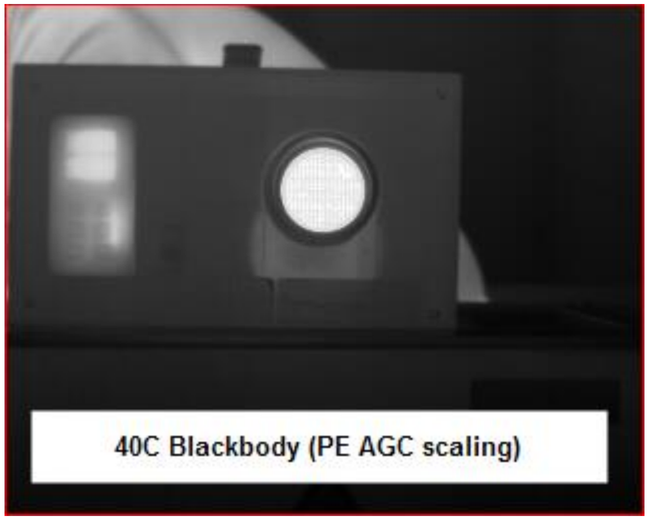
SDI Video Setup Options	
Format	HDMI/SDI: 1080p@29.9/25Hz, 720p@59.9/50Hz
Overlay	Enables the video overlay.
Filter Rate	Rate at which AGC is computed (1 to 20 Hz). Enable with checkbox
Dampening	Rate at which AGC is allowed to change. This will keep the AGC from responding rapidly to fast changes. Specified 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. Enabled with radio button.
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
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.

SDI Video Setup Options	
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.)



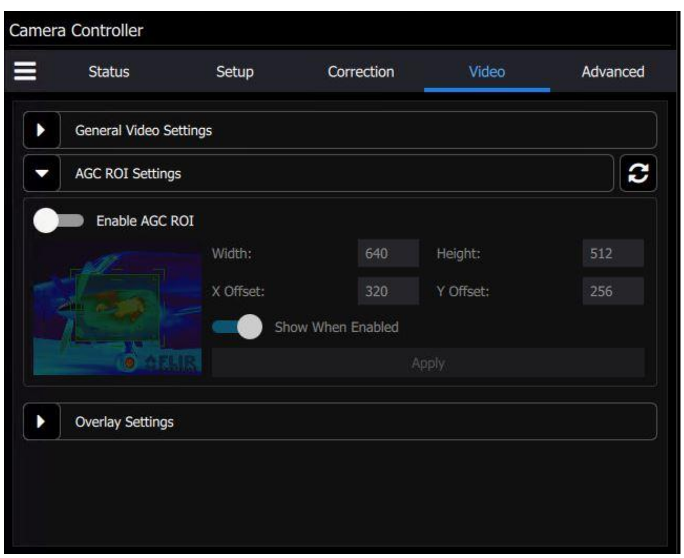




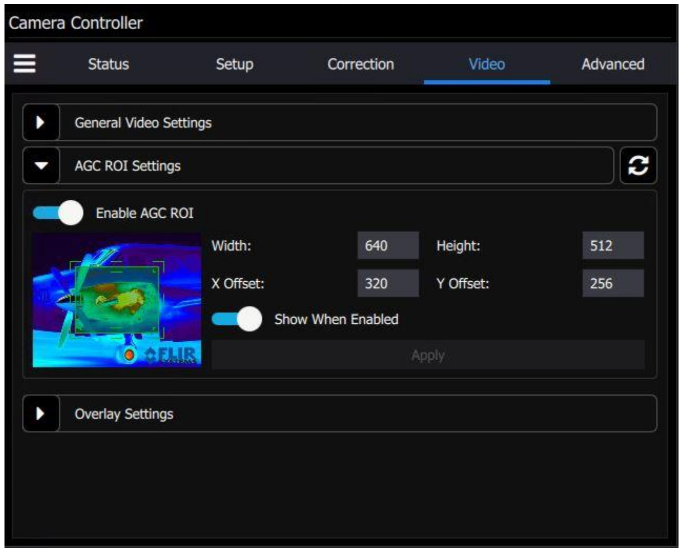
One final note about the PE algorithm: it is very aggressive. It can pull detail out of very low contrast imagery. It can also greatly enhance some very low-level NUC and FPA artifacts and noise if the contrast is low enough. This does not necessarily mean there is a problem with either the camera or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

5.5.8.1.3 AGC ROI Settings

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

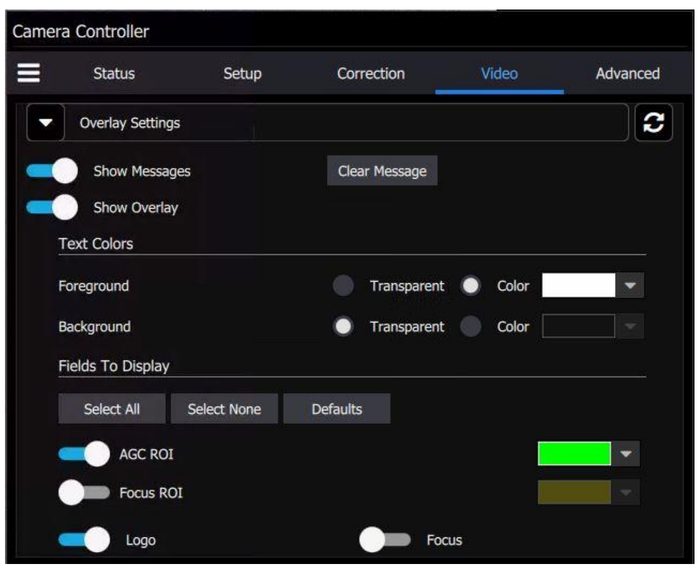


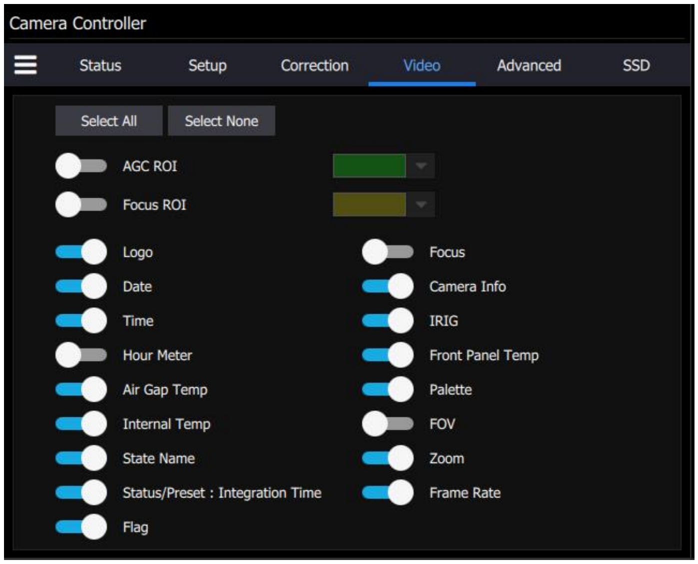
When Enable AGC ROI is on, the panel controls can be accessed. The user can change the size and position of the box. At this point, the Apply button will not be grayed out. When the user hits the Apply button, the changes are made and the apply button grays out again. The Show When Enabled control makes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



Overlay Settings

The RS8500 has an overlay feature that can display a wide variety of camera status indicators on the HD-SDI video. This lets an operator see the camera status without needing to have a PC connected. The Overlay Settings menu allows the user to control which parameters are displayed and what colors are used. Options that are grayed out are either not supported by the camera or are not enabled in another part of the GUI.





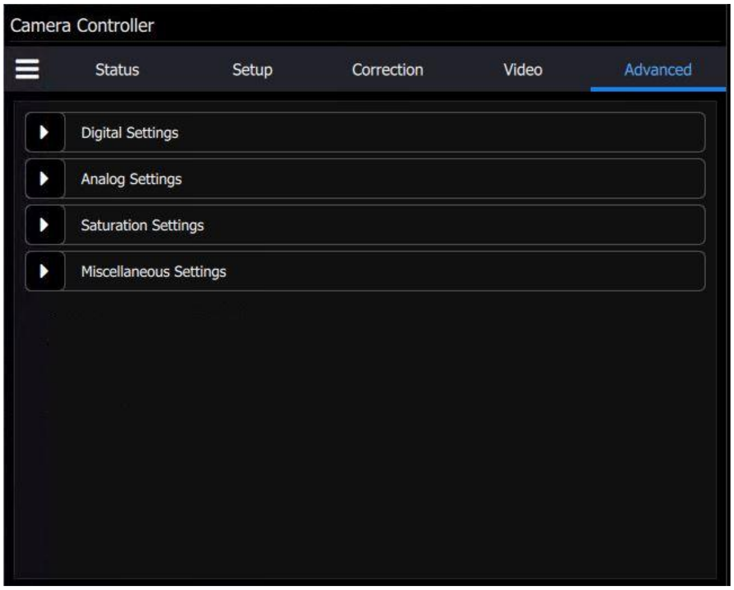
Video Overlay Options	
Enable Overlay	Turns the overlay On or Off without changing the selected options
Logo	Displays the FLIR logo
Date	Displays the system date stamp
Time	Displays the system time stamp
Hour Meter	Displays the accumulated camera “on” time (H:M). (Cannot be reset by user)
Zoom	Display the level of Digital Zoom (x1, x2, x4), and position (C, F, O)
Front Panel Temp	Displays the temperature of front panel sensor in °C
Air Gap Temp	Displays the current temperature of air gap between front panel and internal chassis in °C
Internal Temp	Displays the current temperature of the internal chassis in °C
AGC ROI	Displays the ROI used to compute AGC values. Option is disabled if AGC ROI not enabled.
Flag	Displays the NUC flag status
Palette	Displays the current analog video palette name
Camera Info	Displays camera model and serial number
IRIG	Displays current IRIG time
Status/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

Video 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

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 as follows: x1, x2, x4.
Zoom Bilinear	The digital zoom is done by adding additional pixels to the video output image. This is traditionally done by replicating pixels. The bilinear option uses an interpolation algorithm which improves the image quality.
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

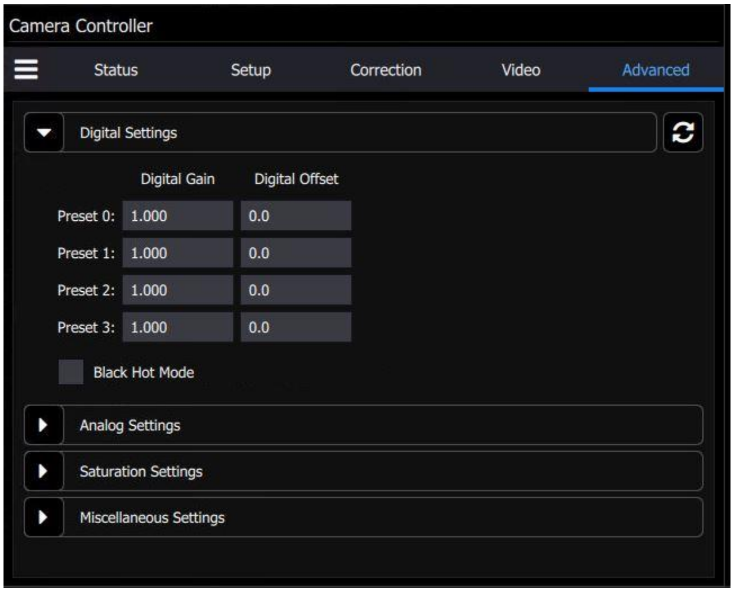
5.5.9 Advanced

The Advanced tab has four sub-menus: Digital Settings, Analog Settings, Saturation Settings, and Miscellaneous Settings.

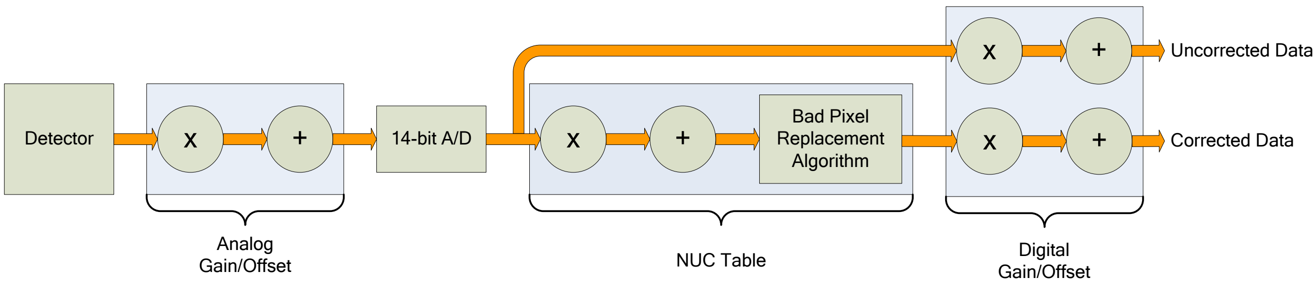


Digital Settings

The Digital Settings menu 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:



RS8500 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:

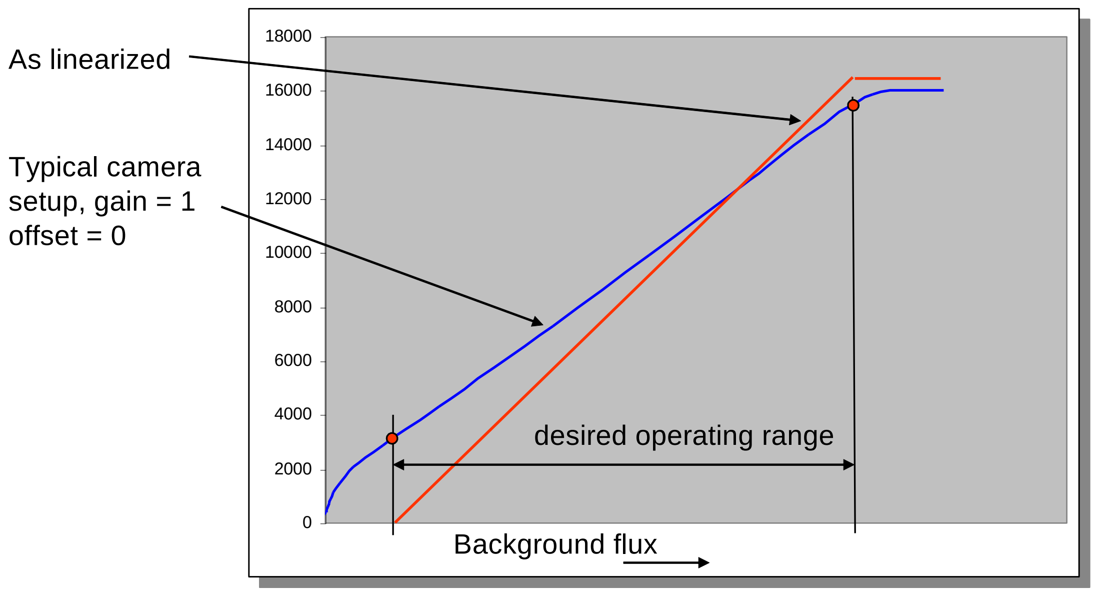
$$gain = \frac{16383}{15800 - 3200} = 1.30$$

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.

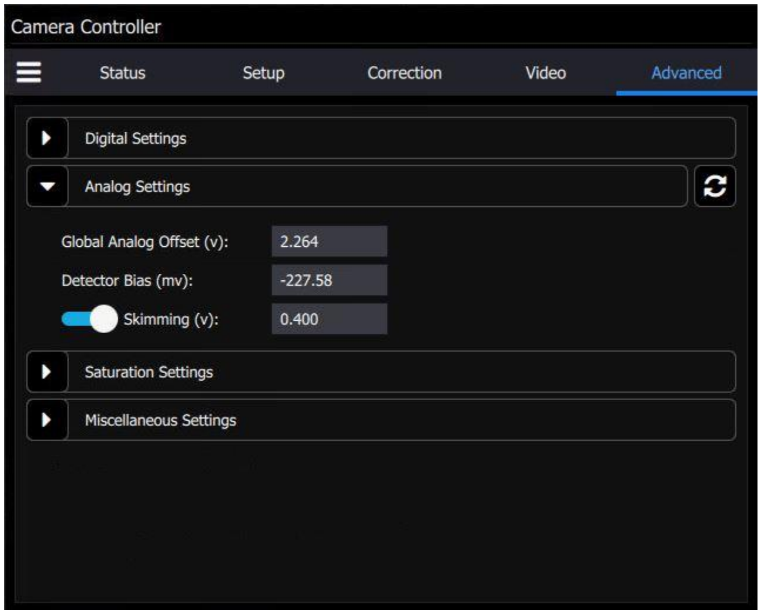
The available gain range is 1.999 to essentially zero; the available offset range is ± 32,767. The default values are a gain of 1 and an offset of zero. Because the system sensitivity (NEΔT) is set prior to the A/D stages, there is no detrimental effect on performance from the use of the global gain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



Use of global gain and offset to linearize the camera

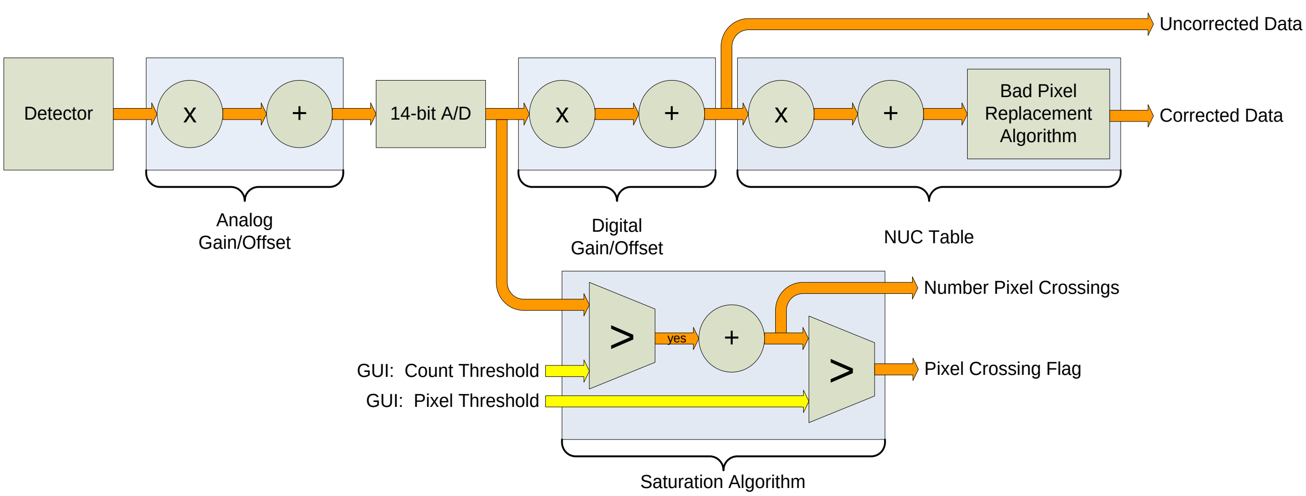
Analog Settings

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



Saturation Settings

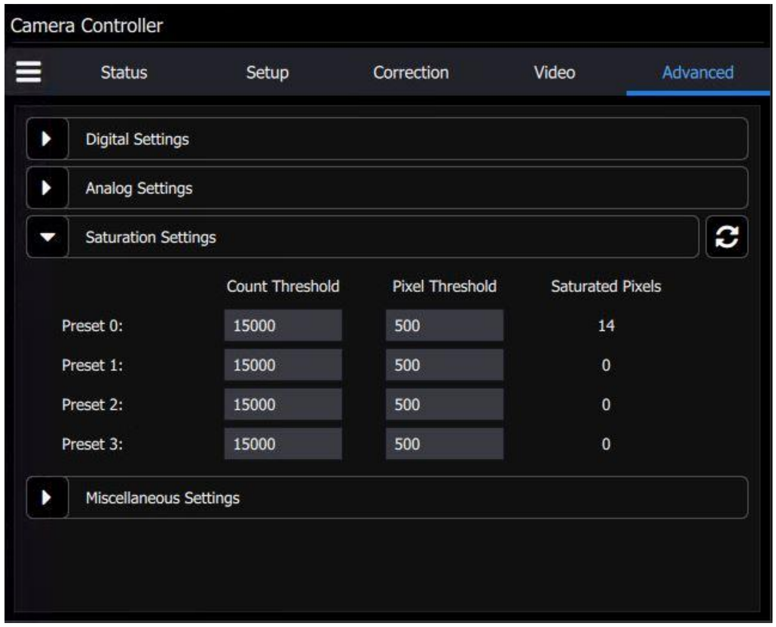
The camera can compare each pixel to a user defined threshold and count the number of pixels that exceed that threshold. Once that count has been determined for the entire frame, it is compared to threshold and sets a flag in the image header.



Saturation Detection

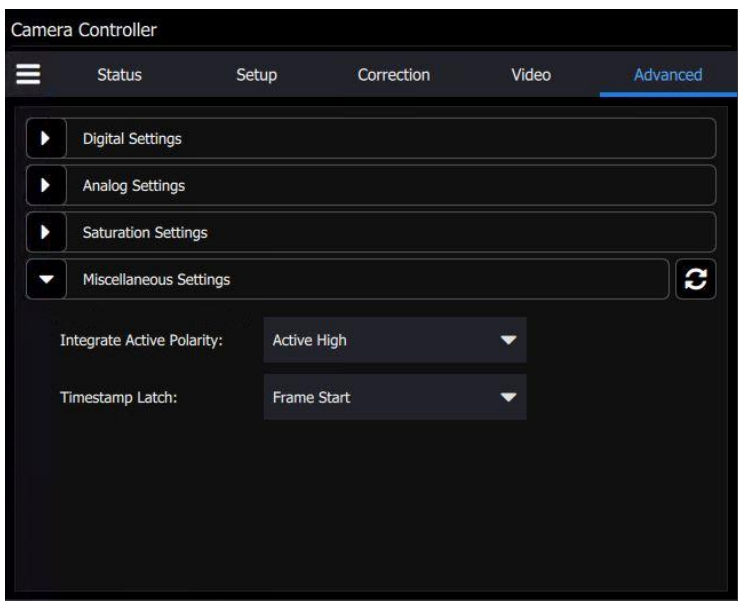
One example of this feature is to use the information to adjust the integration time. If the A/D count threshold is set to 75% of the full value (12,288) then the camera will count the number of pixels that are within 25% of saturation. If a set number of pixels fit that criterion, then the integration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



Miscellaneous Settings

The Miscellaneous Settings controls include the Integration Active Polarity and Timestamp Latch:



5.5.9.1.1 Integrate Active Polarity

Sets the polarity (active high or low) of the Integrate Active signal on the camera rear chassis AUX connector. [RS8503 only]

5.5.9.1.2 Timestamp Latch

The RS8500 places the IRIG time in the header for each frame. The RS8500 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 **Error! Reference source not found.**) t he 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.

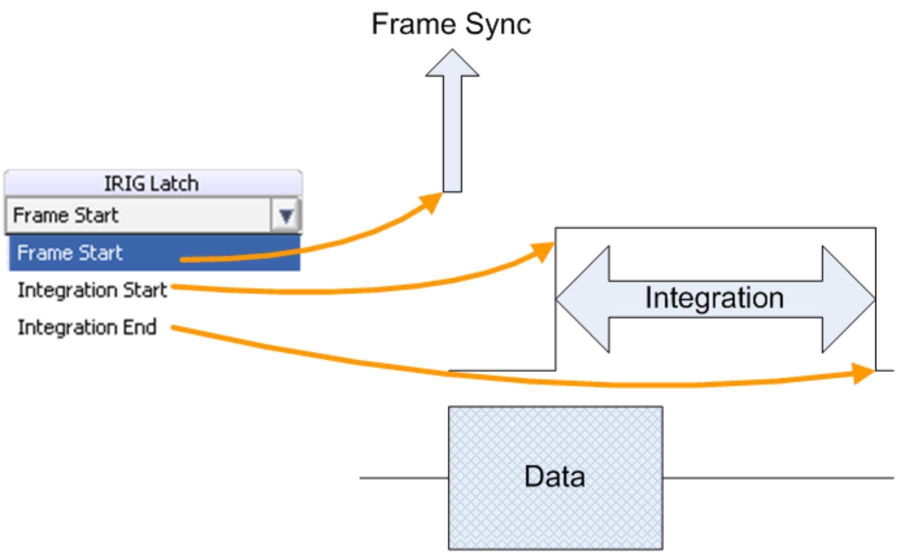


Figure 4-1: IRIG Latch Positions

6 Interfaces

6.1 Mechanical and Optical

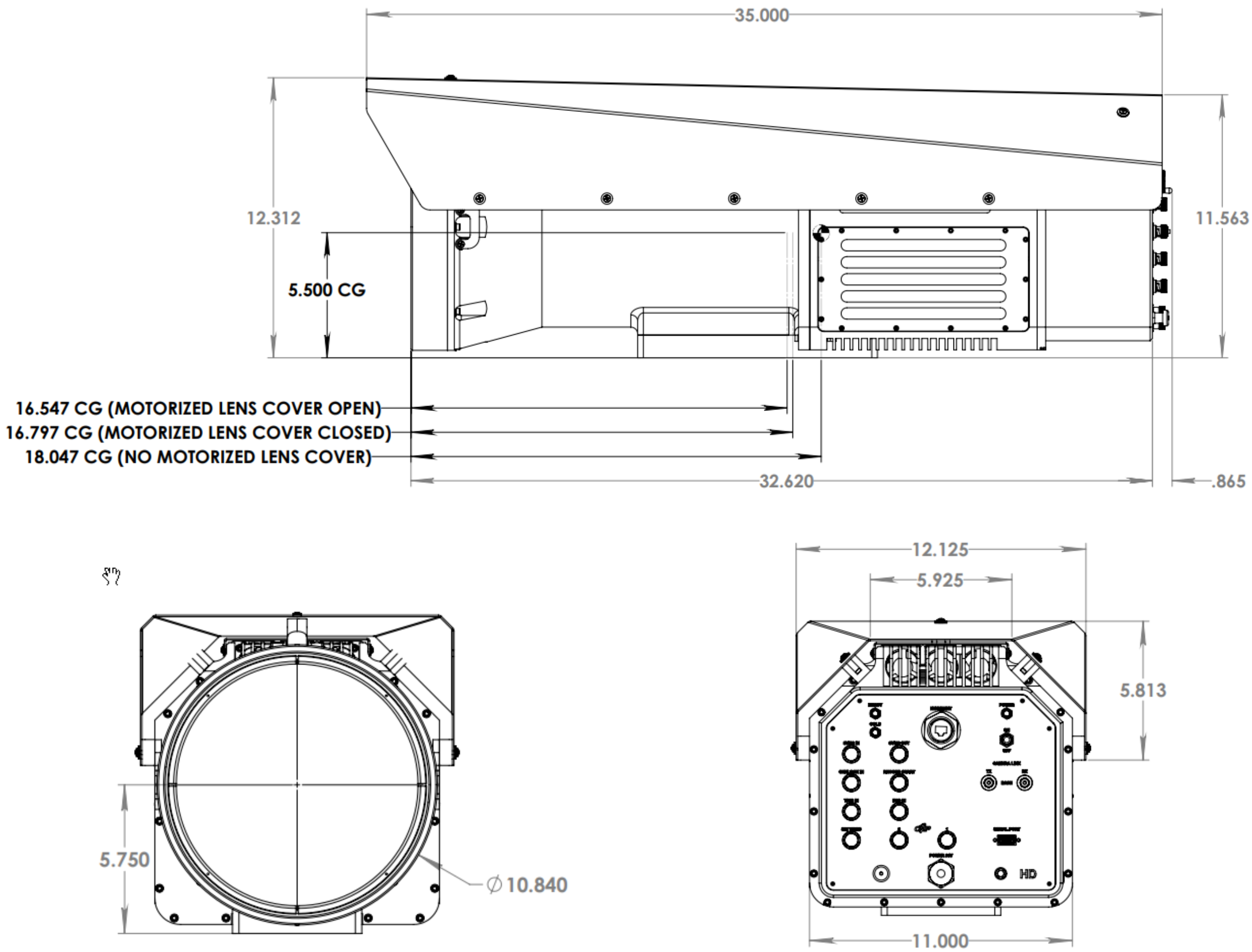


Figure 6-1: Front and Side view of RS8500

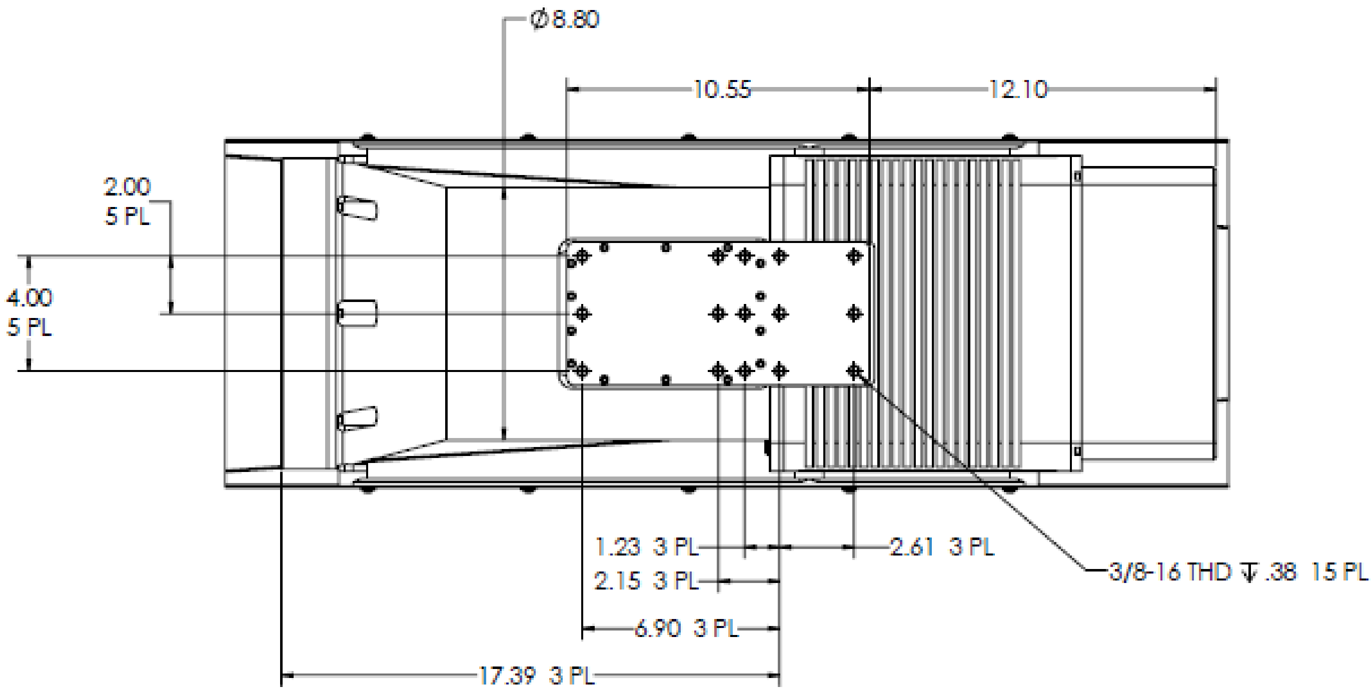
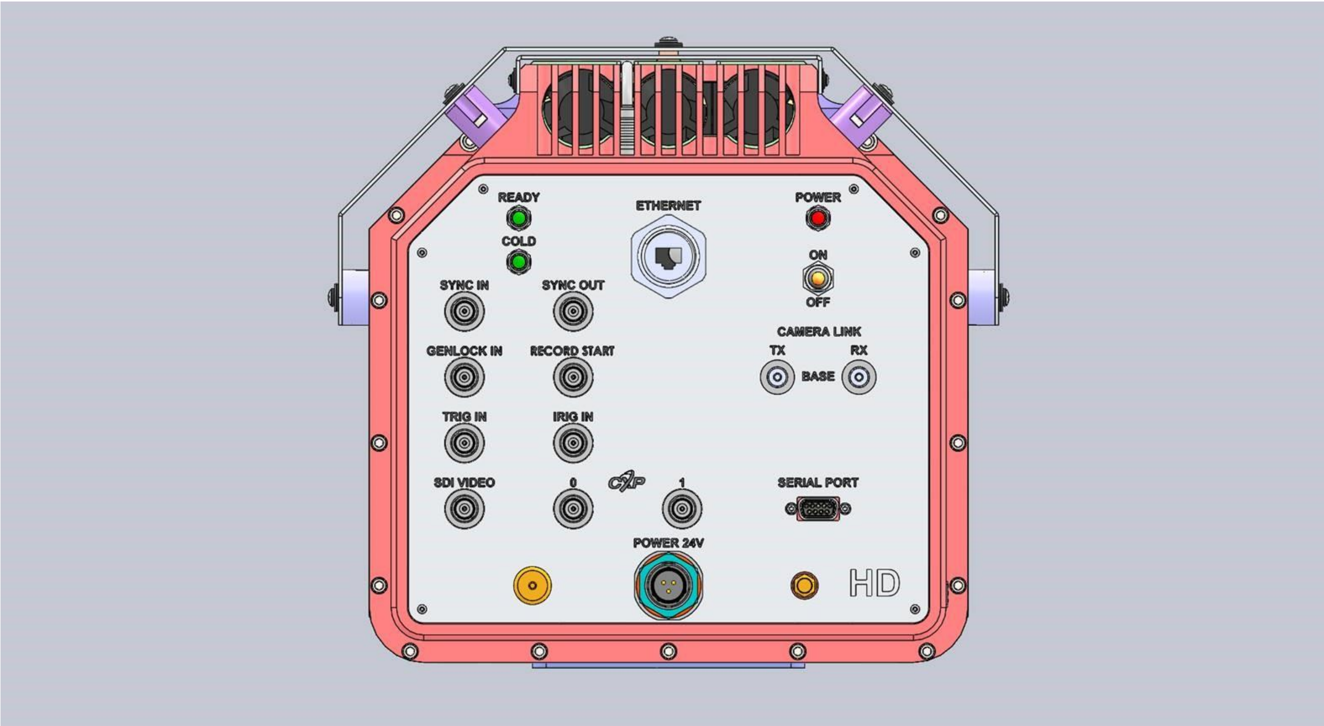


Figure 6-2: Bottom view of RS8500

6.2 Electrical

RS8500 camera interfaces to external devices through a variety of industry standard and camera specific signals. All connector types are commercial standard types. All connections are on the back panel of the camera, as shown below.



6.2.1 Status Lights

The RS8500 provides a set of status indicators on the back panel to give the user some visual feedback on the camera operating state.

POWER: Indicates that the camera is ON.
READY: Camera electronics have completed boot up. Camera is ready to accept commands.
COLD: Indicates that the FPA has reached operating temperature (<80K).

6.2.2 Power Interface

A 24V external AC-DC power converter is provided with the RS8500 camera system as a standard accessory. Power supply specifications are:

DC Input voltage range: +24V Power Input recommended Operating Range = 20V to 28V

Camera Current Draw: 4.2A@24 Volts DC

The power input pinouts are shown in Figure 6-2.

A	+24V IN
B	+24V RTN
C	GND

Figure 6-1: RS8500 Power Input Pinouts

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

- Input voltage: 24 VDC nominal @ 4.2 amps. Input voltage range is 20-28VDC. Do not exceed 28 Volts DC!
- RS8500 power dissipation is <100 Watts steady state at nominal ambient temperature
- Mating Connector: FLIR P/N 26431-000, AMPHENOL PN PT06J-12-3S

6.2.3 Digital Interfaces

6.2.3.1.1 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 uses a Pleora iPORT interface. The GigE interface is not GigE Vision compliant.

6.2.3.1.2 CoaXpress (CXP)

The RS8500 supports a 3.25Gbps single-link CXP interface.

6.2.3.1.3 Camera Link® (RS8503/RS8523 only)

Camera Link® is a standard data interface for high end visible and IR cameras. The RS8500 uses a Camera Link® Full interface in a 4- tap, 16-bit configuration. 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".

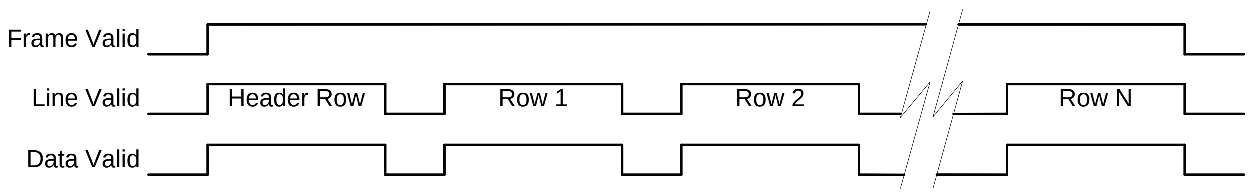


Figure 5-2: RS8500 Camera Link Output Signals

6.2.3.1.4 HD-SDI

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.

6.2.4 Synchronization Interfaces

A variety of interfaces are available for synchronizing the camera to external events as well as synchronizing external events to the camera.

6.2.4.1.1 Trigger In

The Trigger In can be selected, by the user, to operate as an external trigger to start a sequence (preset sequencing). It is a rising edge TTL signal with selectable polarity. The minimum width is 160nS.

6.2.4.1.2 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.

6.2.4.1.3 IRIG In

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.

6.2.4.1.4 Genlock Input

Currently, this input is not implemented. In a future firmware release this input will implement support for using a tri-level video sync signal to drive the camera frame sync.

6.2.4.1.5 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 RS8500 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.

6.2.4.1.6 RS-232 Camera Control

The RS8500 can be controlled using an RS-232 port on the Serial Port connector. Refer to the table below when making up a suitable cable.

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

Serial Port Connector	DB9 to Computer
Pin 8 (SER_RX)	Pin 3 (TX from computer)
Pin 9 (SER_TX)	Pin 2 (RX from computer)
Pin 5 (GND)	Pin 5 (GND)

7 Specifications

7.1 Interface

AC Power	100-240V_{AC}, 50-60 Hz (using FLIR 24123-002 power supply)
Control	Gigabit Ethernet, USB, Camera Link Serial, CXP or RS-232
Standard Video Outputs	HD-SDI (720p 50/59.94, 1080p 25/29.97)
Frame Sync In	TTL single-ended, BNC, selectable polarity, >160ns pulse width
Frame Sync Out	TTL single-ended, BNC, selectable polarity, 160ns pulse width
Trigger In	TTL single-ended, BNC, selectable polarity, >160ns pulse width
Integration Out	TTL single-ended, AUX, selectable polarity [RS8503 only]
Genlock In	Not implemented. (In a future firmware update this input will support using an external tri-level sync as the frame start signal)
IRIG-B in	IRIG-B-AM, B122 format, BNC
Digital Video Out	14-bit Camera Link Full, and Gigabit Ethernet, Dual-link CXP @ 5Gbps
Mechanical Interface	Array of 9 (nine) ¼-20 tripod screws

7.2 Windowing Capacity

Maximum Window Size	1280 columns x 1024 rows
Minimum Window Size	64 columns x 4 rows
Windowing Step Size	64 columns; 4 rows
Window Offset Step Size	64 columns; 4 rows

7.3 *Acquisition Modes and Features*

Frame Rate :	
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 µsec
Resolution	90 nsec
Synchronization Modes	• 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

7.4 SDI Video

Video Output	Selectable • HD-SDI
Data Output	Selectable • Raw, uncorrected • Corrected
Manual Gain Control	Linear scaled with user-controlled gain and offset
Automatic Gain Control	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 HD-SDI
Palettes	Selectable • Grayscale • Various color palettes
Zoom	Selectable • 1X • 2X • 4X

7.5 Performance Characteristics

Power Consumption **FLIR PWR Supply @ $120V_{AC}$**	Continuous Cool Down: <100 Watts Continuous Normal: <100 Watts Continuous Normal w/NUC Flag: <100 Watts
Power Consumption **Camera DC Power @ $24V_{DC}$**	Continuous Cool Down: <100 Watts Continuous Normal: <100 Watts Continuous Normal w/NUC Flag: <100 Watts

Cool-down Time	≈7 minutes to reach operating temperature
Sensitivity **NEΔT**[1]	<25 mK typ.

1) NE∆T is at 50% nominal bucket fill, 298K background, $\pm$ 5ºC signal

7.6 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)
NUC Source	Internal: ambient temp flag External: Any user supplied source which covers entire window
Bad Pixel Replacement	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	0.1%

7.7 Detector/FPA

Spectral Response	3-5µm
Detector Type	Indium Antimonide
Detector f/#	f/5
Supported ROIC	ISC1308
Integration Mode	Snapshot
Format (HxV)	1280x1024
Operability	>99.5%, 99.9% typical
Charge Handling Capacity	3.0 x 10^6 carriers (1308 operated in Gain 0 state for InSb)
Detector Pitch	12µm
Detector Cooling	Linear Sterling Cooler

7.8 General Characteristics

Size **Length** **Width** **Height**	 36 inches 12.125 inches 12.3 inches
Weight	~95 lbs lbs. (w/ chassis, no motorized lens cover)
Operating Temperature	-20C to +50C
Shock	40 g’s, 11 msec half sine pulse
Vibration	4.3 g's RMS random vibration, all three axes
Humidity	<95% relative humidity, non-condensing
IP Rating	IP65
Operating Orientation	No restriction in orientation

8 Maintenance

8.1 Camera and Lens Cleaning

8.1.1 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.

8.1.2 Lenses

It is recommended that all optics be handled with care and the need for cleaning is eliminated or at least reduced. If 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.

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