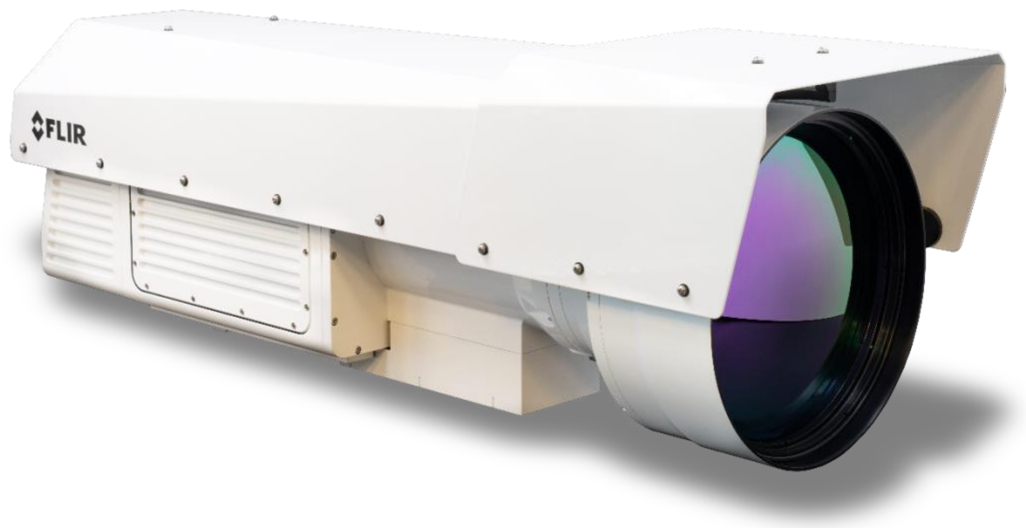
RS6780

User's Manual



Document Number: 4243686

Version: 3

Issue Date: November 22, 2023

WARNING - This document contains technology subject to the Export Administration Regulations (EAR) (15 C.F.R. Sections 730- 774). Export or diversion contrary to law is prohibited. (EAR99)

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.teledyneflir.com

Table of Contents

1 Revision History

Version	Date	Initials	Changes
1	22 APR 22	RIM	Initial Release
2	06/30/2023	RAW	Updated Pixel Operability specification
3	11/22/2023	MGH	Updated 3x afocal part #

2 Introduction

2.1 Camera System Components

The RS6780 infrared camera and its accessories are delivered in a box which typically contains the items below. There may also be additional items that you have ordered such as lenses, software, CDs, etc.

Description	FLIR Part Number
RS6780 Camera	29445-280
Power supply, 24V, 4A	4228270
AC line cord	24124-000
Gigabit Ethernet Cat-6 cable, 10m length	26395-000
BNC cable, 3m	26393-000
BNC cable, 10m	26393-001
Water-resistant transit case	P-CASE-066
CamTools Download Card	N/A

2.2 Camera Models

There is currently a single model in the RS6780 product family.

Model	Description	FLIR Part Number
RS6780	f/4 50-250mm Continuous zoom lens	29445-280
3X Teleconverter	Afocal, extends zoom range to 150-750mm	2412-370

2.3 System Overview

The RS6780 infrared camera systems have been developed by Teledyne FLIR to meet the needs of the commercial R&D and test range users.

The RS6780 has an InSb detector to cover the MWIR band, and it uses a 640 x 512 array with 15µm pixel pitch.

The The RS6780 is a stand-alone imaging camera that interfaces to a host Windows, Mac or Linux system running FLIR Research Studio software using Gigabit Ethernet. An SDK is available, which makes it possible for the system designer to write their own camera controller and acquire image data with their own custom application. This camera series is GenIcam compliant and can be controlled directly with third party GenIcam tools.

2.4 Key features of the RS6780 Series cameras

Fully GEV/GenICam compliant

The image stream protocol is GigE Vision 2.0 compliant, and the camera is controllable by GenICam.

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. FLIR ROICs 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.

14-Bit Digital Image Data

The camera systems are 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.

Presets

Up to four presets and their associated parameters such as integration time, frame rate, and window size are available for instant selection with a single command.

Superframing

Up to four presets can be cycled continuously. This can be used in conjunction with the Dynamic Range Extension (DRX) algorithm to provide a single movie with increased dynamic range.

Independently Adjustable Frame Rates

Frame rate is user selectable from 0.0015Hz up to the maximum allowed for the selected integration time and window size.

External Sync

The cameras provide a SYNC input that can be used to control the camera frame rate using an external LVCMOS or TTL input (can handle 5.5V Max).

External Trigger

An external trigger input can be used to signal ResearchIR or FLIR Research Studio to start recording or to precisely start the image stream relative to an external event.

Multiple Control Options

The RS6780 can be controlled with the supplied control module within ResearchIR, Research Studio, using the optional Science Camera SDK or with a third-party toolkit that support GenICam. The following ports can be used for controlling the camera:

- Gigabit Ethernet port (GenICam)
- CoaXpress (GenICam)
- Traditional RS-232 asynchronous serial port (GenCP)

Multiple Video Outputs

The RS-Series Cameras feature multiple independent and simultaneous video:

- Digital – Gigabit Ethernet
- Digital – CoaXpress (Single CXP-3 link)
- Digital – SDI

Standard Video Color Palettes

The cameras support a selection of standard and user-defined color palettes for the standard video output.

Ruggedized Construction

The RS6780 camera is packaged as a sealed enclosure that can maintain a dry nitrogen gas purge.

Digital Detail Enhancement (DDE)

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

On-Camera NUCs with Auto Update

NUCs can be stored in camera memory and can be applied independently to the 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.

Metric Zoom lens

The RS6780 camera offers an industry leading fully radiometric and spatially-metric IR zoom lens. The base 5X zoom lens goes from 50mm to 250mm. With the optional afocal 3x teleconverter, the zoom range is extended to 150mm-750mm. 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 RS6780 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.

3-Position Filter Wheel

The RS6780 has an internal motorized filter wheel that can position a warm filter between the lens and detector. Filters are an optional accessory. Up to three 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, or 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. Refer to Chapter 7 for detailed environmental requirements.**
- **The camera contains static-sensitive electronics and should be handled appropriately.**

4 Installation

4.1 Basic Connections

All connections to the RS6780 are located on the Back Panel.

Item	Name	Description
1	Status LEDs	READY LED will illuminate when camera is booted and ready to connect COLD LED will illuminate when detector has reach operating temperature (<80K)
2	Gigabit Ethernet (RJ45)	GigE Vision connection for digital IR image data
3	Power Switch and LED	LED will light when Camera is powered
4	Sync Input	External Frame Sync, TTL. Single frame for single pulse.
5	Sync Output	Provides a TTL pulse for each output frame

6	SDI Video Out	SDI (480i, 576i, 720p at 50/59.9Hz, 1080p at 25/29.9Hz according to SMPTE 296M).
7	CoaXpress output	V1.1 compliant, Single Link, CXP-3
8	Trigger In	External sequence trigger, TTL. One sequence per trigger pulse
9	Tri-level Sync	Uses standard analog video sync to clock FPA
10	IRIG	Analog IRIG-B input
11	Lock-in input	
12	Serial Port	RS-232 for camera control
13	Purge relief valve	
14	DC Power input	24V nominal
15	Purge Input port	For dry nitrogen purge

4.1.1 Power

Plug in the AC power supply to a standard outlet. Connect the DC power cable between the power supply and the power connector located on the rear panel of the camera. Turn on the camera by flipping the power toggle on the rear panel. The power LED will illuminate to indicate that the unit is ON. The camera will automatically boot up into the last saved state. The boot process takes about 60 seconds.

4.1.2 Video (HD-SDI)

To see the SDI video on a monitor, connect the provided BNC cable from the VIDEO port to your monitor (converter required for HDMI). If you are powering up the camera for the first time, the camera should produce the max resolution image of the particle model with a Non-Uniformity Correction (NUC) and bad pixel replacement enabled.

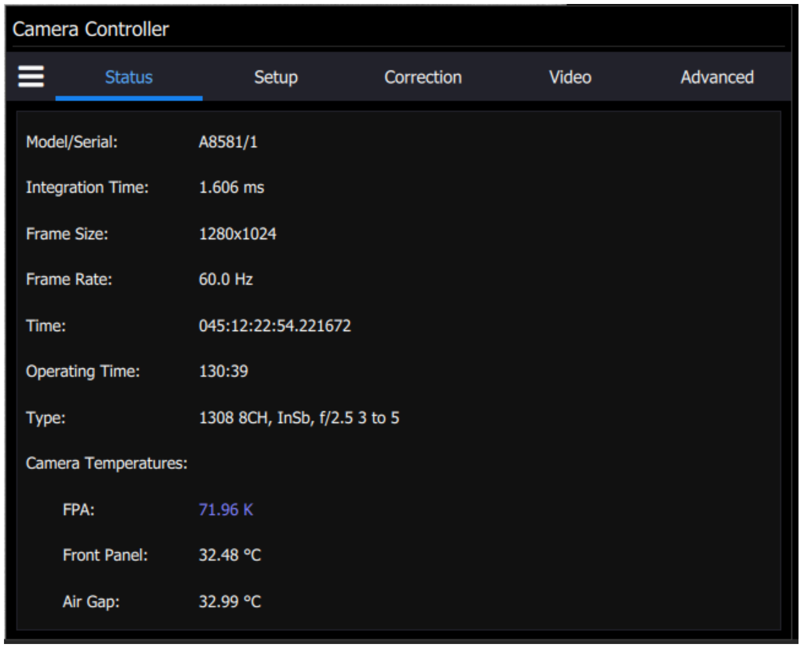
4.1.3 GigE Digital Video

If you have a PC data system running Research Studio, ResearchIR (or your own custom application based on the SDK or GenICam) you can view the 14-bit digital video over Gigabit Ethernet.

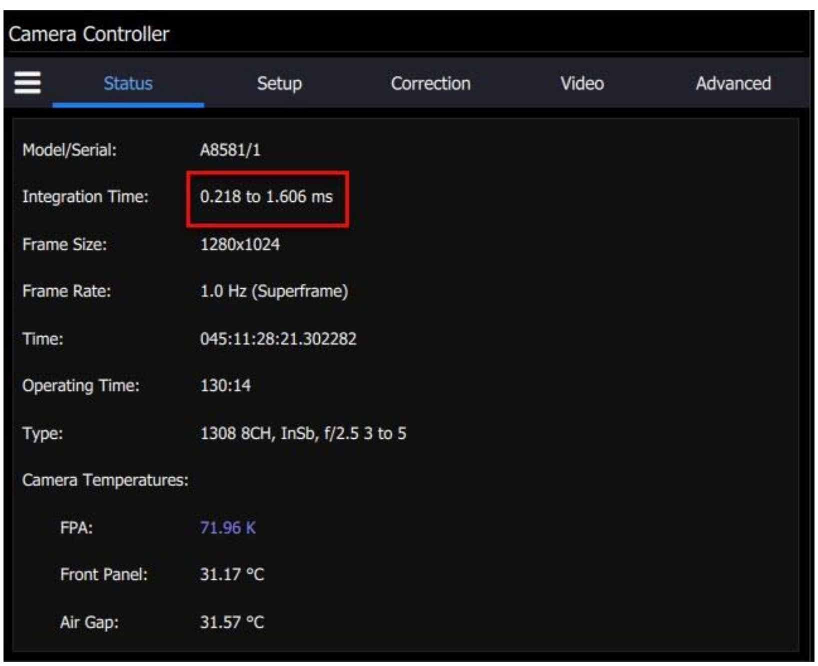
The cameras have a Gigabit Ethernet interface that is GigE Vision (GEV) and GenICam compliant. Use a regular CAT5e or CAT6 Ethernet patch cable. If a crossover cable is used, the camera interface will automatically detect and configure itself to work with this kind of cable.

5 Camera Controller

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

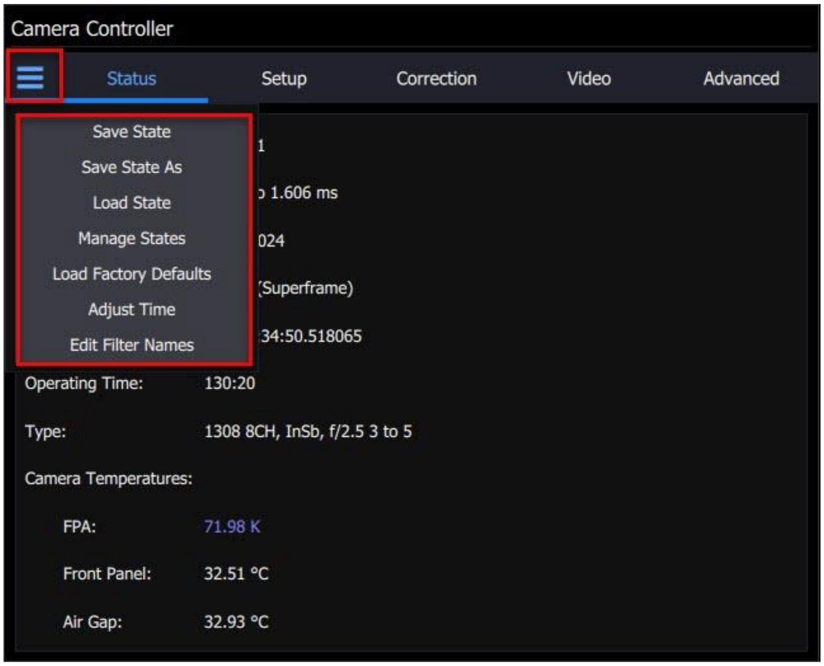


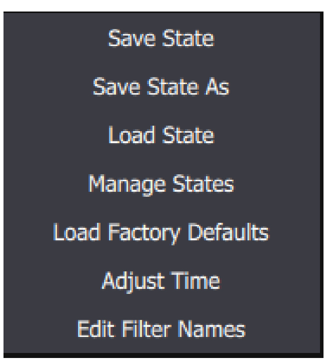
When the camera is in Superframing mode, the total **range** of integration times are shown:



5.1 *"Hamburger Button" Menu*

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



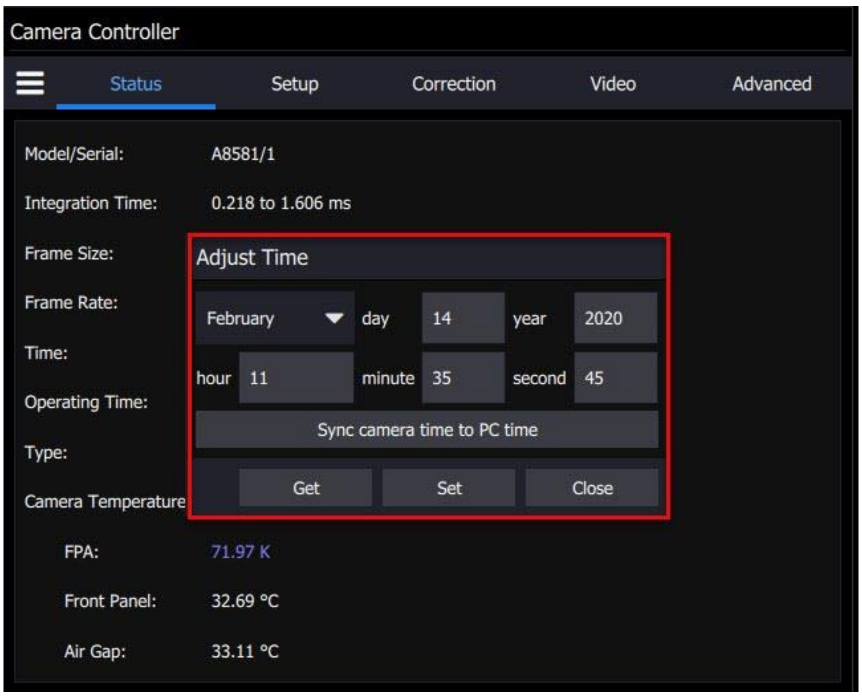
	Save State (Name)	Saves the camera state. This state will be reloaded at power up. Stored in flash memory.
	Save State As	Saves the current camera state to a name chosen by the user. State names other than (name) may be loaded manually. Stored in flash memory
	Load State	Load a state from flash memory.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

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

5.1.1 Adjust Time Controls

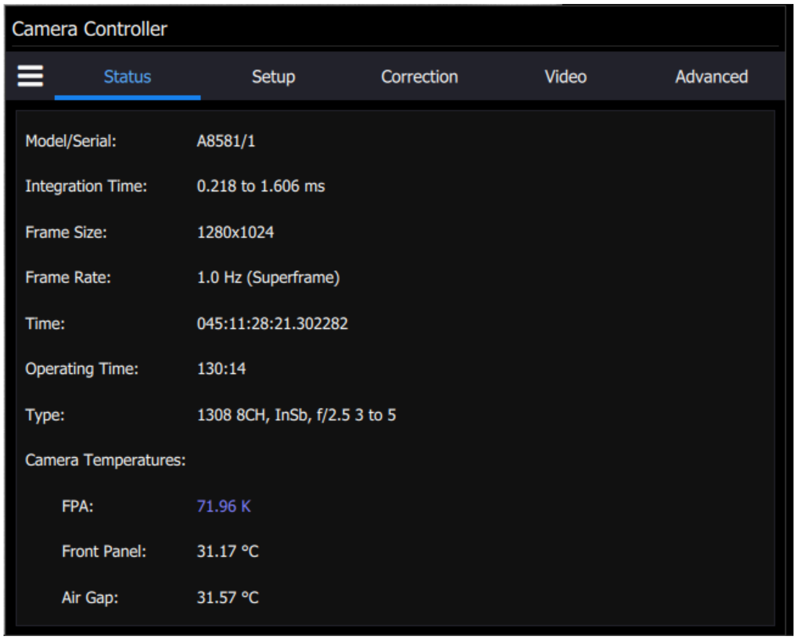
This dialog is accessed using the Adjust Time menu option under the "hamburger button". This allows the user to directly set the camera system's time. The Sync camera time to PC time button will pull a time value from the PC clock and set the RTC clock. The Get button displays the current time that the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



5.2 *Status Page*

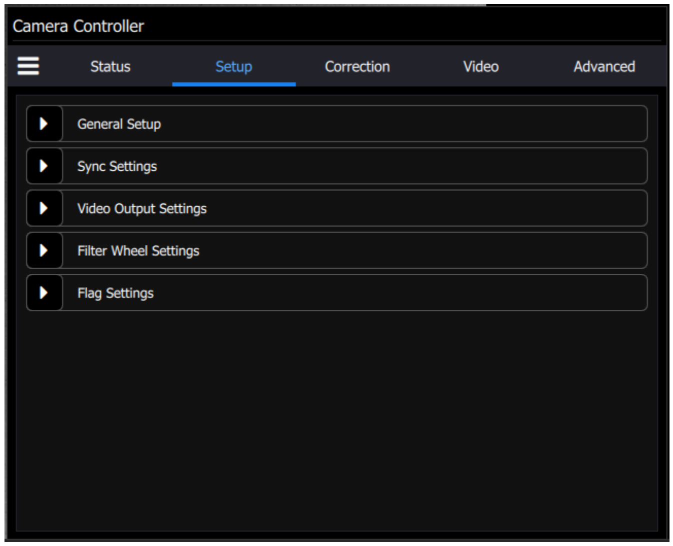
The Status Page gives general information about the camera state including camera model and serial number, integration time, frame size, frame rate, camera time, FPA type, and internal temperatures. The FPA temperature turns blue when the camera has reached its setpoint temperature, which is nominally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

The Type entry is the configuration of the integrated detector cooler assembly. In the example below, the sensor readout IC type is the 1308 which is used in the A858X camera family. "8CH" means 8 digitizer channels. "InSb" is indium antimonide, the detector type. "f/2.5" is the f/number of the coldshield. "3 to 5" is the wavelength range of the cold filter. "Front Panel" and "Air Gap" are the temperatures of temperature sensors in the camera's lens interface. These sensors are used for Tdrift correction, a type of radiometric compensation for changes in the optics temperature that will affect radiometric measurements. The factory calibrations are done in an air-conditioned laboratory with a nominal temperature of 23 °C. If the camera is subsequently operated in a hot ambient environment, the total radiance reaching the sensor will be higher than it would be if the camera was still at 23 °C. This produces a radiance offset which leads to a temperature measurement error. The Tdrift compensation uses the measurements of the two temperature sensors to correct for the radiance offset in the digital image data.



5.3 Setup

The Setup page allows the user to set up the camera for the desired operation. There are five sub-menus, including General Setup, Sync Settings, Video Output Settings, Filter Wheel Settings and Flag settings.



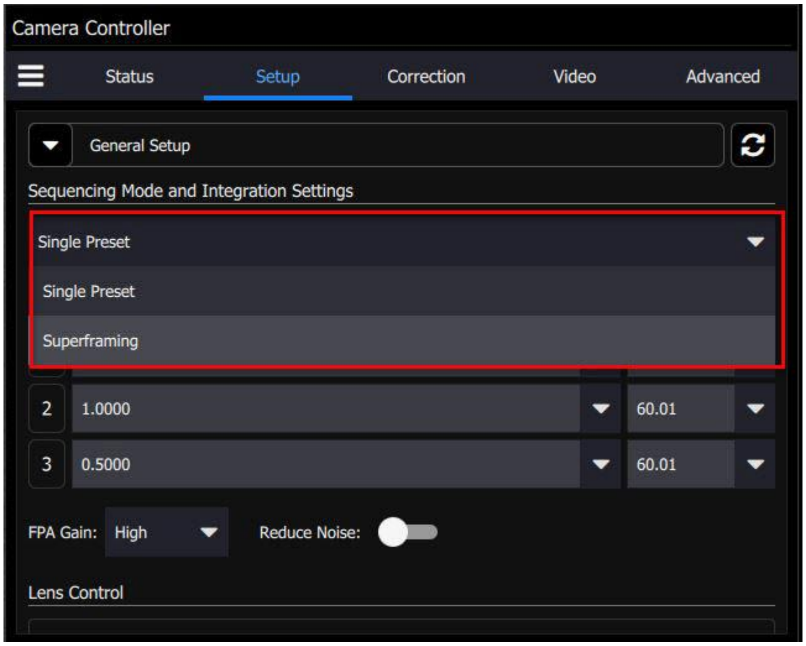
5.3.1 General Setup

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

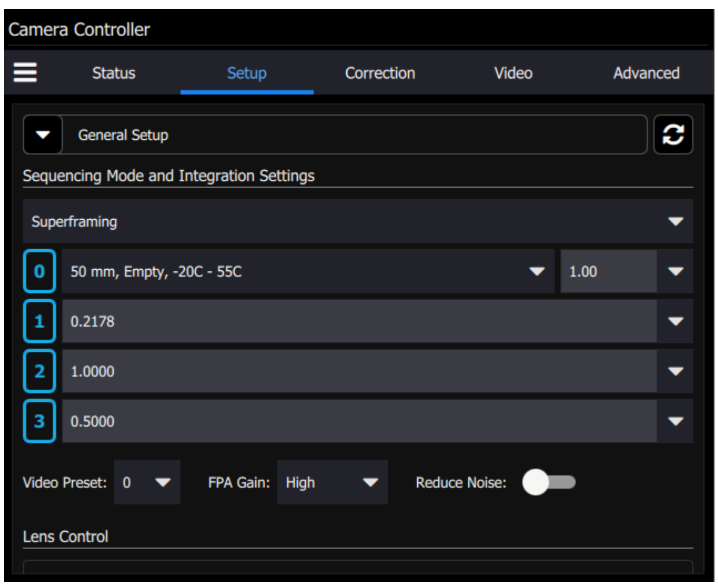
5.3.1.1 Sequencing Mode

The camera is typically operated in Single Preset mode. This means that a single preset group of camera settings is used for every frame of image data. The other option is Superframing. This setting enables the camera to cycle through a set of presets to extend the dynamic range of the camera when measuring temperature or radiance. The active preset has its preset number box colored in blue. In the example below, Preset 0 is the active preset.

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

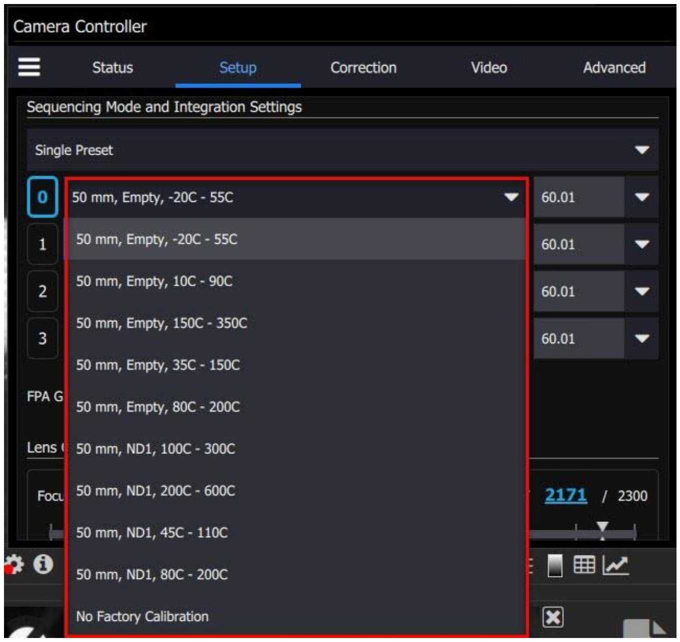


Presets are selected to be included in superframing by clicking on the preset numbers to make them change to a blue circled state. The figure below shows the camera set up with all four presets active. The Video Preset is the preset used to stream SDI video out of the camera.



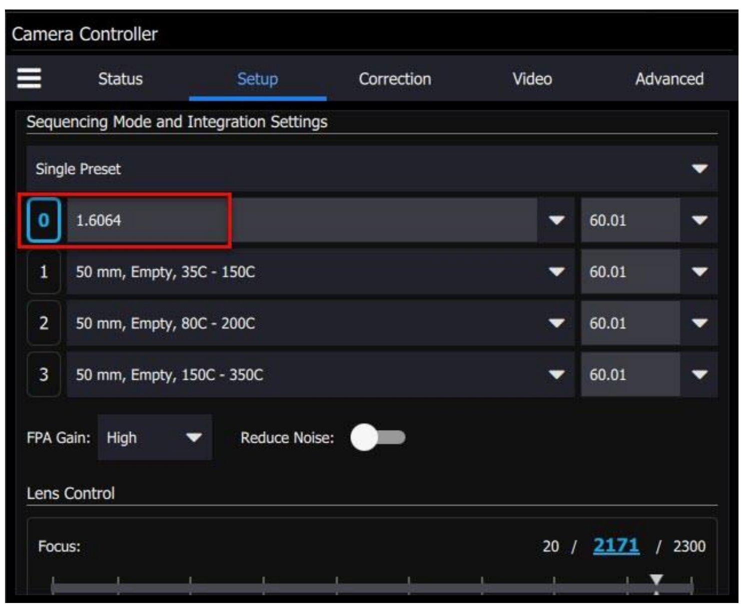
5.3.1.2 Loading Factory Calibrations:

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



5.3.1.3 Changing Integration Time

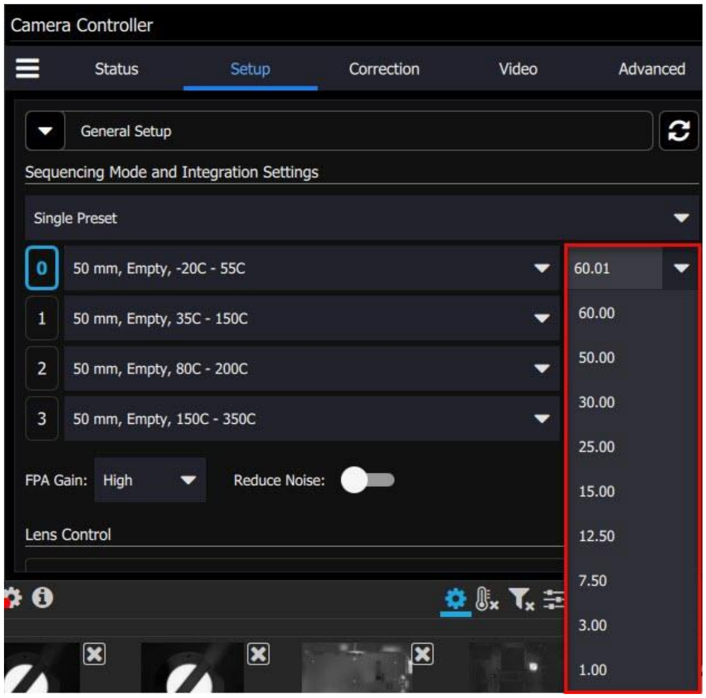
If no Factory Calibration is selected, the preset will display the integration time setting, which in this example is set to 1.6064 milliseconds. **The units of integration time are always milliseconds**:



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

5.3.1.4 Changing Frame Rate

The pulldown menu to the right of the Factory Calibration pulldown enables the user to select from a set of frame rates. The user can also type in a custom frame rate.

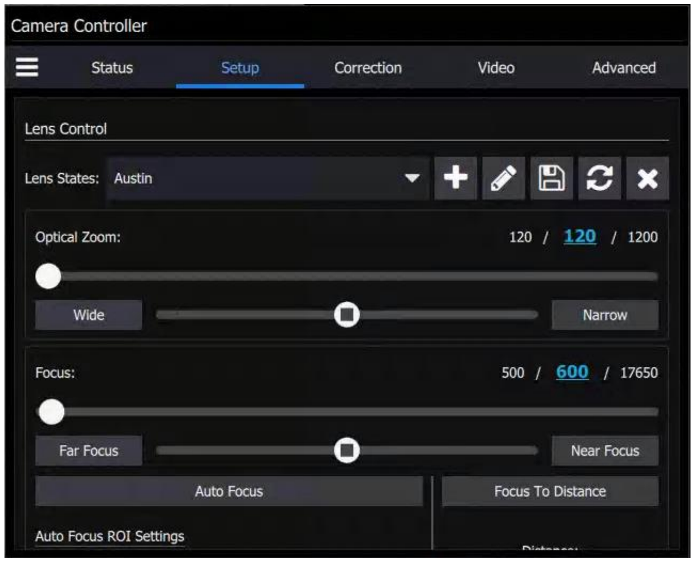


5.3.1.5 Reduce Noise

There is a Reduce Noise switch which may improve image quality, but it will restrict the camera to ITR (Integrate-then read) timing. This will result in lower max frame rates.

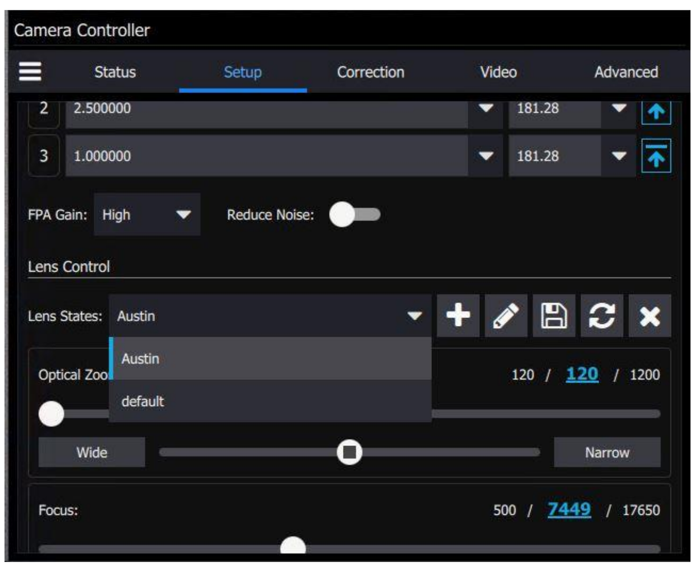
5.3.1.6 Lens Control

The lens control section allows the user to set the zoom lens focal length, as well as set the focus position of the lens.

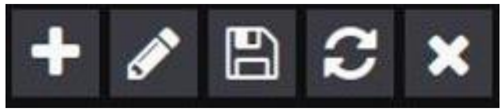


5.3.1.6.1 Lens States

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:

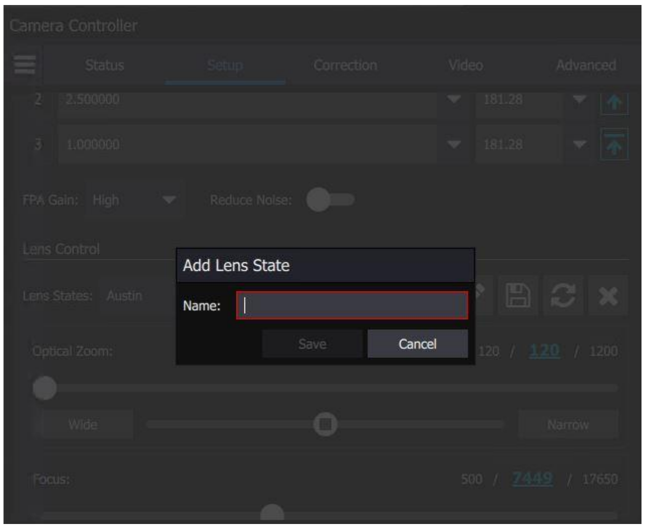


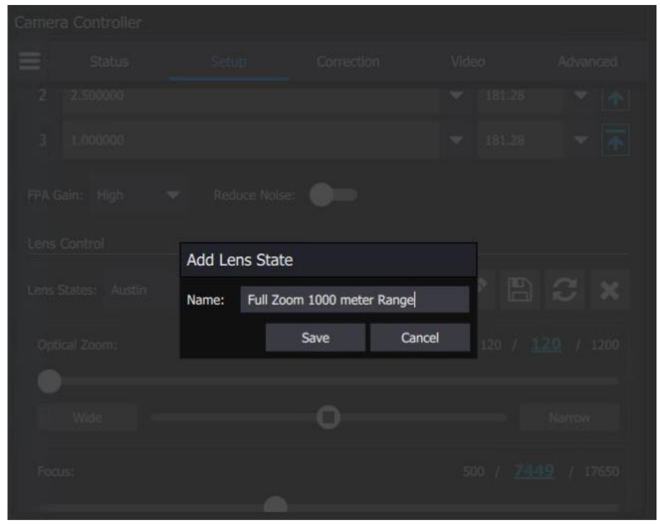
Lens state controls to the right of the dropdown are: Add Lens State, Rename Lens State, Save Lens State, Reload Lens State (Discard Changes), and Delete Lens State. These are the icons in order:



5.3.1.6.1.1 Add Lens State:

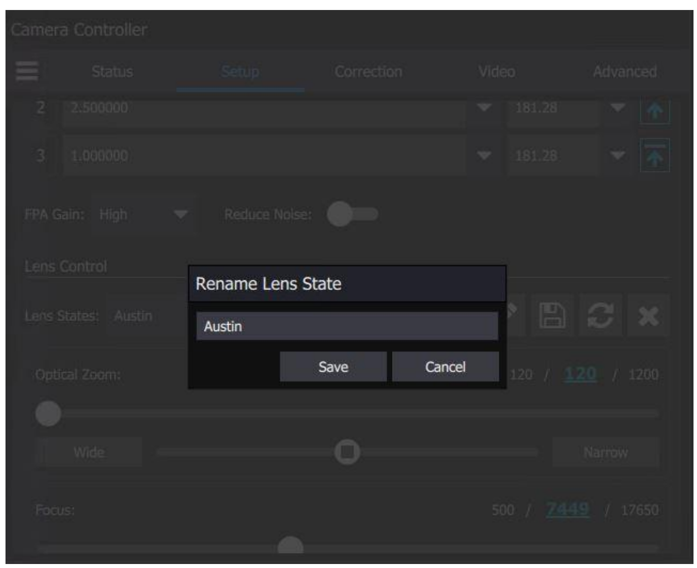
The control looks like a plus sign. The text field is surrounded by red until the user inputs a name for the Lens State:





5.3.1.6.1.2 Rename Lens State

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



5.3.1.6.1.3 Save Lens State

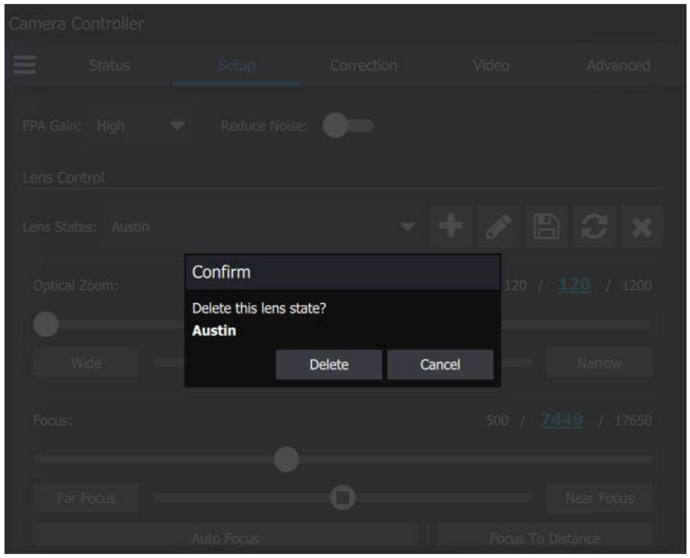
This control looks like a floppy disk. Changes can be made to the active lens state, and then it can be saved again.

5.3.1.6.1.4 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.

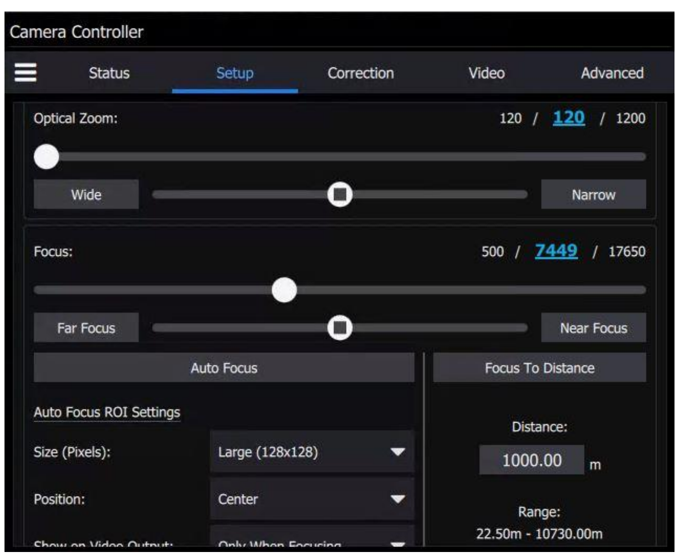
5.3.1.6.1.5 Delete Lens State

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

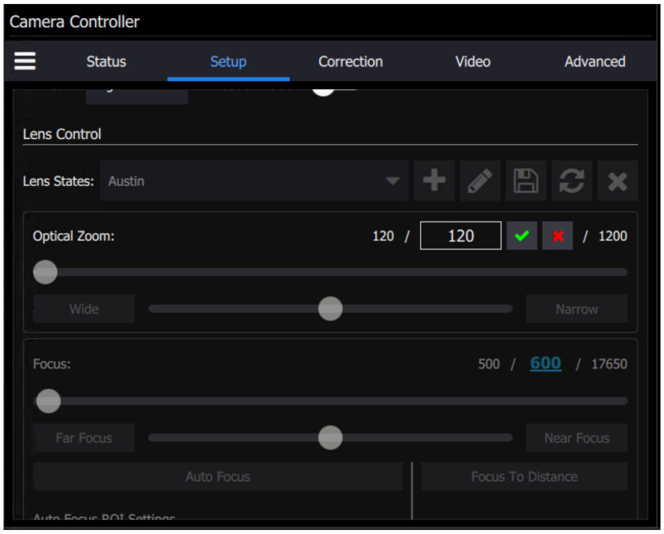


5.3.1.6.2 Optical Zoom

The zoom rate/direction slider below it has a white circle surrounding a grey square. Do not drag the control with the mouse. Rather, click on the bar and the slider control will lock to that position and the lens will slew smoothly, as you click further from the center, the rate of zoom travel increases The user can also command the lens to immediately travel to either extreme of zoom with the Wide and Narrow buttons.

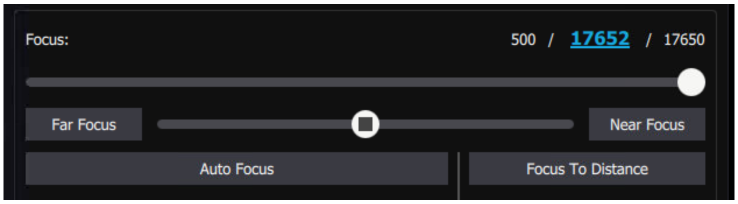


It is possible to manually enter an optical zoom lens focal length setting by clicking on the blue value and hitting the green checkmark:

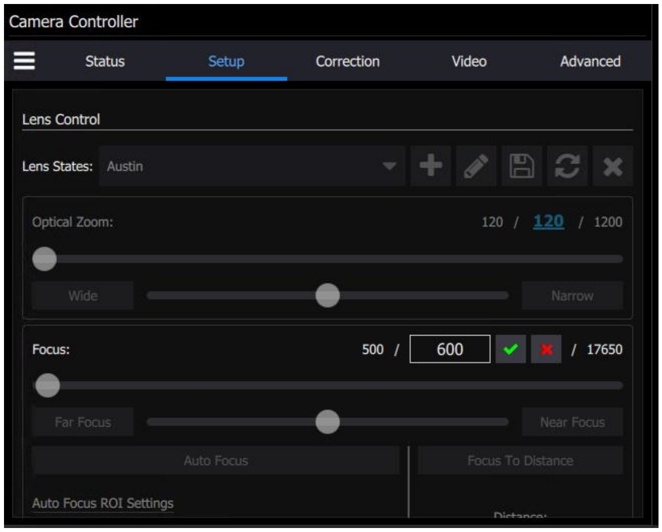


5.3.1.6.3 *Focus Controls*

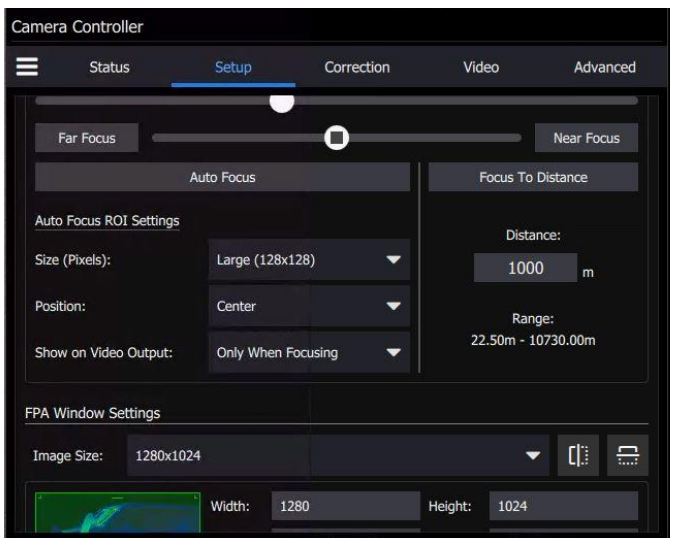
The focus controls include manual focus, auto focus and focus to distance. Manual focus is set with a slider denoted with a white circle. The focus rate/direction slider below it has a white circle surrounding a grey square. Do not drag the control with the mouse. Rather, click on the bar and the slider control will lock to that position and the lens will slew smoothly, as you click further from the center, 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.

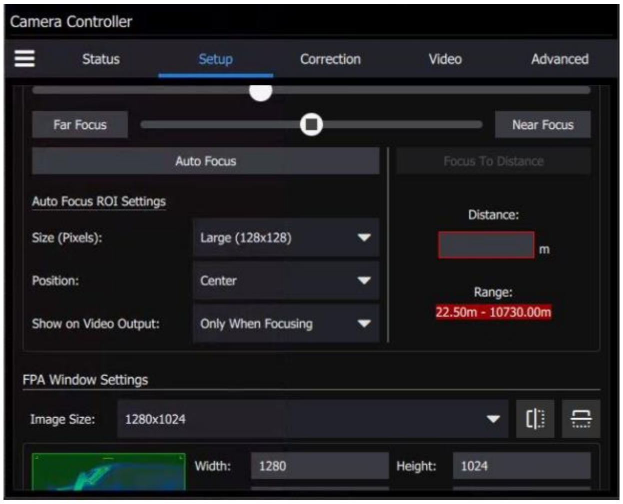


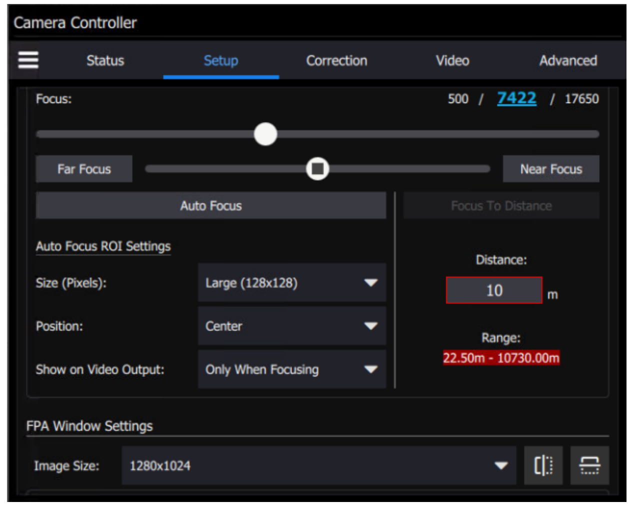
It is also possible to manually enter a focus position settings by clicking on the blue value and hitting the green checkmark. The focus position number is an encoder value which is not represented in engineering units.



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.

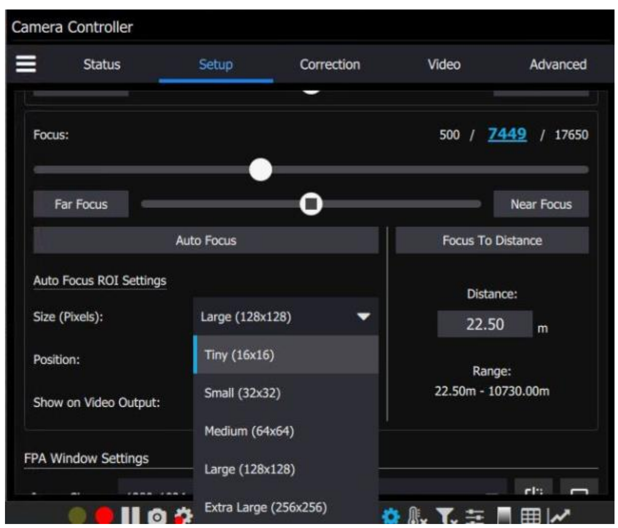


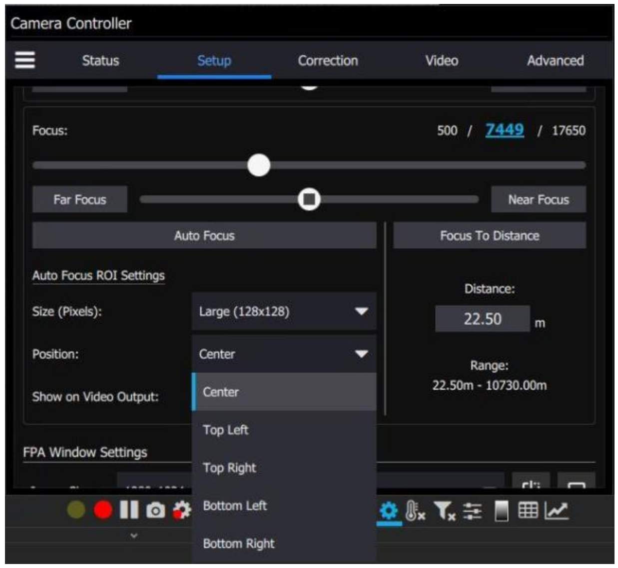


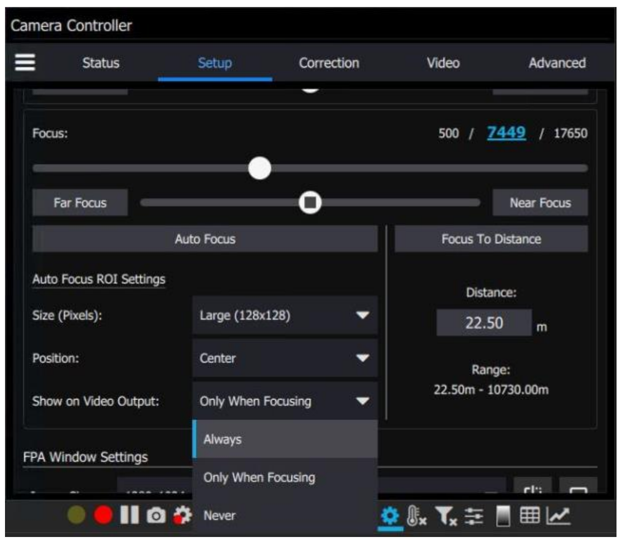


5.3.1.6.4 Auto Focus

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. In order for the algorithm to work, there needs to be some contrast, such as an edge within the ROI. The region of interest (ROI) is user controlled in terms of its size, position and whether it is shown on the SDI video output. If enable on SDI, the ROI is also visible on the GigE data in Research Studio.



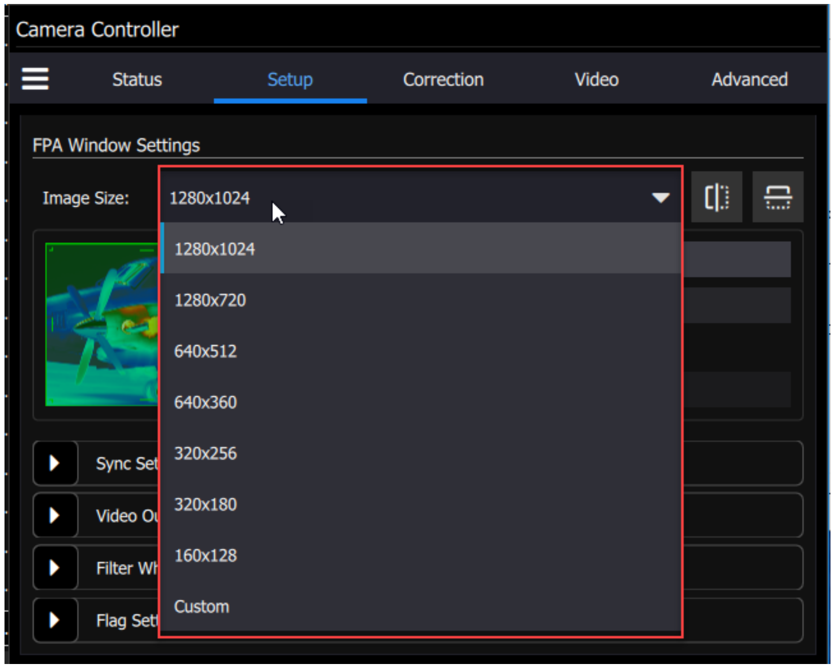

Camera Controller
Status
Setup
Correction
Video
Advanced
Focus:
500 / 7449 / 17650
Far Focus
Near Focus
Auto Focus
Focus To Distance
Auto Focus ROI Settings
Size (Pixels):
Large (128x128)
Position:
Center
Show on Video Output:
Center
Top Left
Top Right
Bottom Left
Bottom Right
Distance:
22.50
m
Range:
22.50m - 10730.00m
FPA Window Settings


Camera Controller
Status
Setup
Correction
Video
Advanced
Focus:
500 / 7449 / 17650
Far Focus
Near Focus
Auto Focus
Focus To Distance
Auto Focus ROI Settings
Size (Pixels):
Large (128x128)
Position:
Center
Show on Video Output:
Only When Focusing
Always
Only When Focusing
Never
Distance:
22.50
m
Range:
22.50m - 10730.00m
FPA Window Settings

5.3.1.7 FPA Window Settings

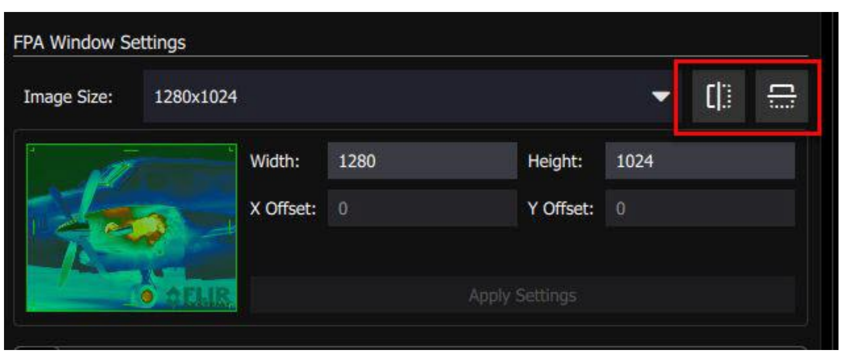
The FPA Window Setting menu allows the user to control the size of the FPA Window, as well as flip the image at the FPA level around both the horizontal and vertical axes.

Common sizes can be chosen from the dropdown list or the user can enter the desired width and height directly. The box will turn red if an invalid number is entered.

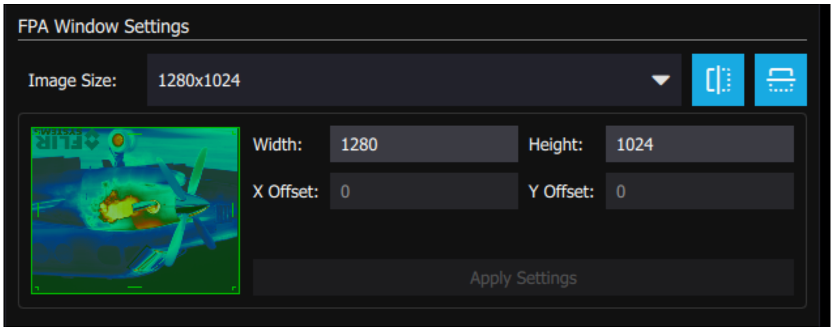


5.3.1.8 Invert and Revert

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



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



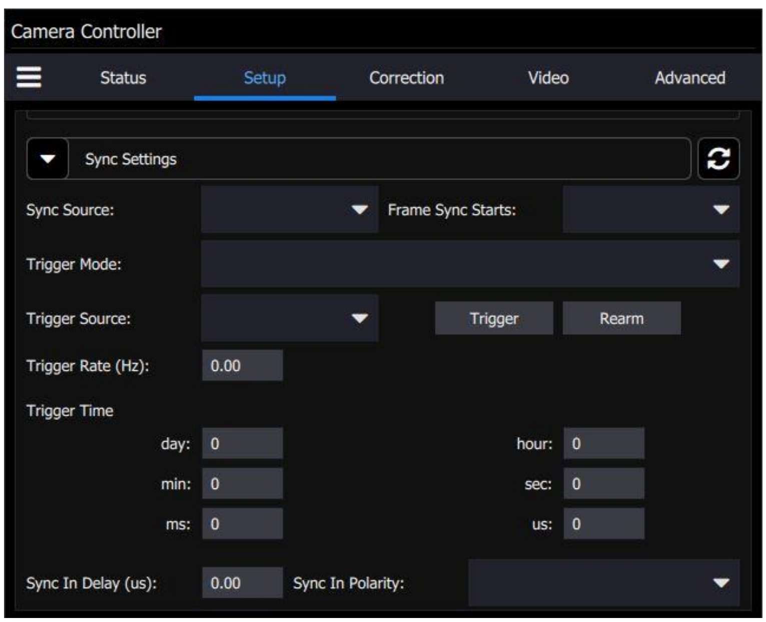
Note: Using the invert and revert buttons change the way the image data is read out of the focal plane array, and the non-uniformity correction will be compromised. While a NUC offset update will improve the image significantly, if the user needs to invert or revert the image, we recommend doing a non-uniformity correction with the desired settings to get the optimal results.

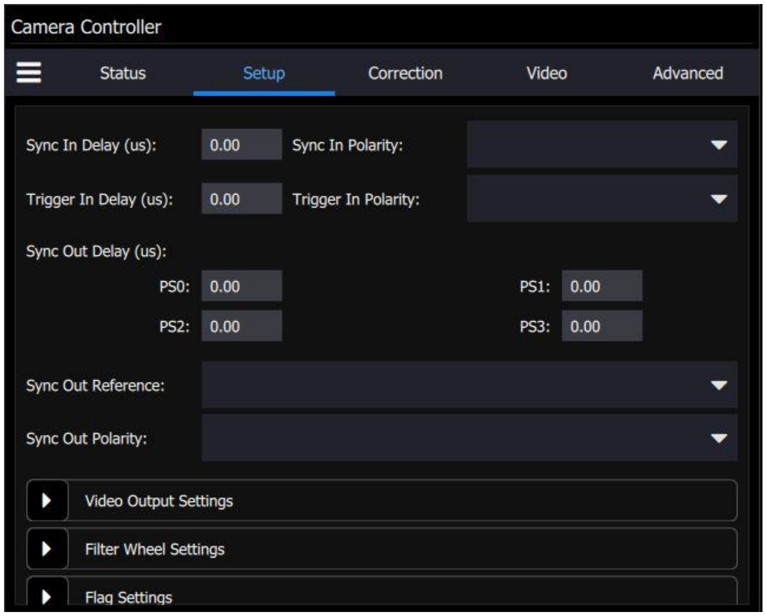
5.3.2 Sync Settings

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

5.3.2.1 Sync Source

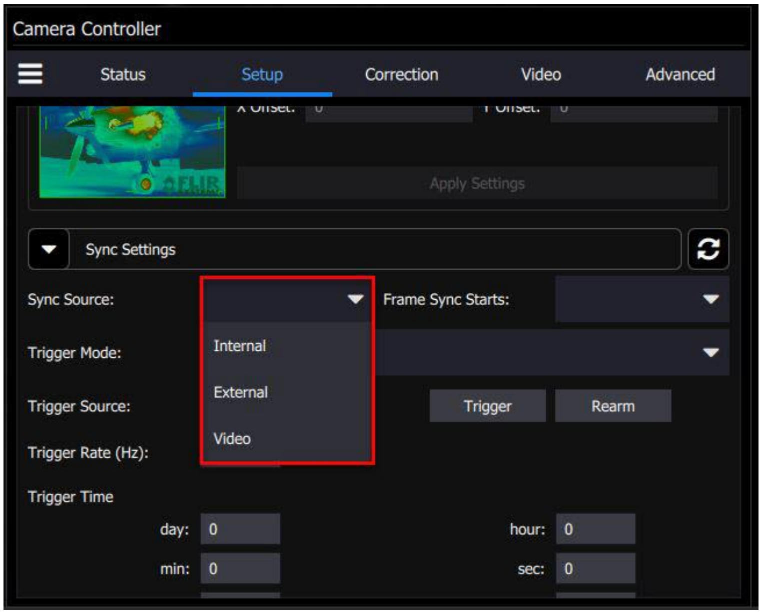
The Source options page allows the user to select the source for Syncs and Triggers.



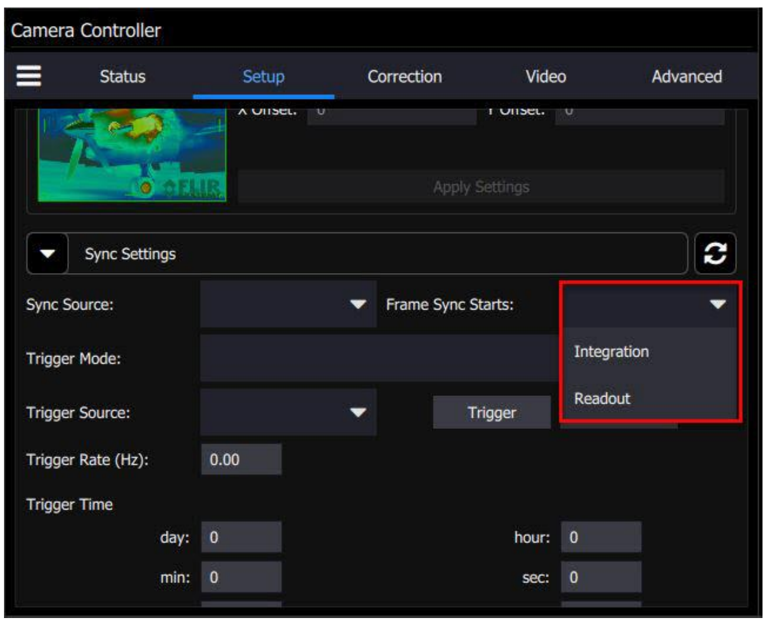


The pulldown menus show the following options: Sync Source can be Internal, External or Video.

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



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



5.3.2.2 Frame Sync Starts

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

The generation of a frame consists of two phases: *integration* and *data readout*. Depending on the timing between these two events, you can have two basic integration modes: Integrate Then Read (ITR) and Integrate While Read (IWR). In ITR, integration and data readout occur sequentially. The complete frame time is the combined total of the integration time plus readout time. In IWR, the integration phase of the current frame occurs during the readout phase of the *previous* frame. In other words, ITR and IWR terms refer to whether or not the camera will overlap the data readout and integration periods. In ITR, the data is not overlapped which means lower frame rates but provides a less noisy image. IWR can achieve much faster frame rates with a slight increase in noise. The camera does not require the user to explicitly choose whether to operate in ITR or IWR modes. The camera will automatically select the integration mode based on the integration time, frame rate, and frame sync mode.

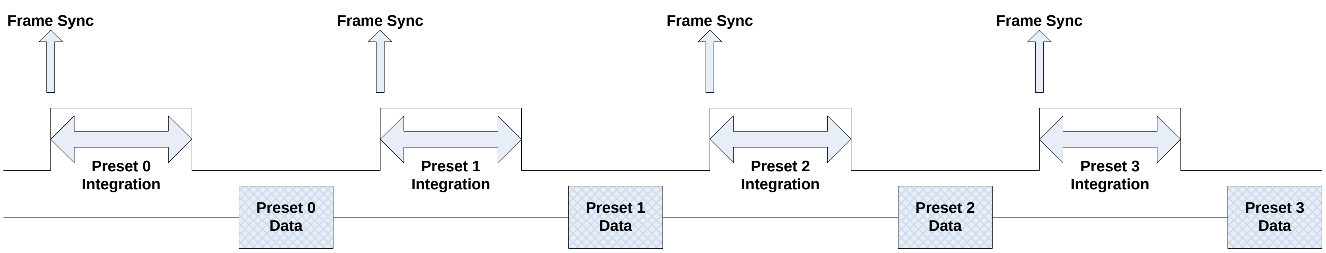
The camera supports two Frame Sync Modes: Frame Sync Starts Integration (FSSI), and Frame Sync Starts Readout (FSSR). FSSI and FSSR determine which phase of the frame generation process (integration or data readout) is synchronized to the frame sync. FSSI starts the integration period when a frame sync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

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

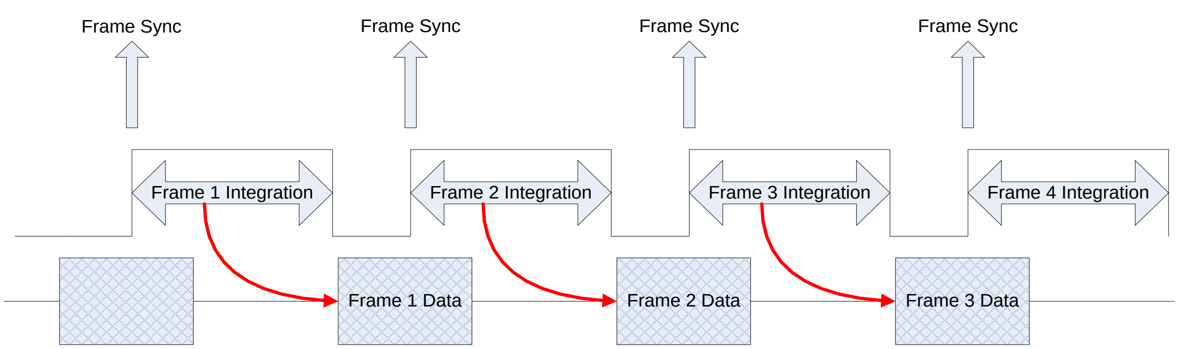
5.3.2.3 Frame Sync Starts Integration (FSSI)

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

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



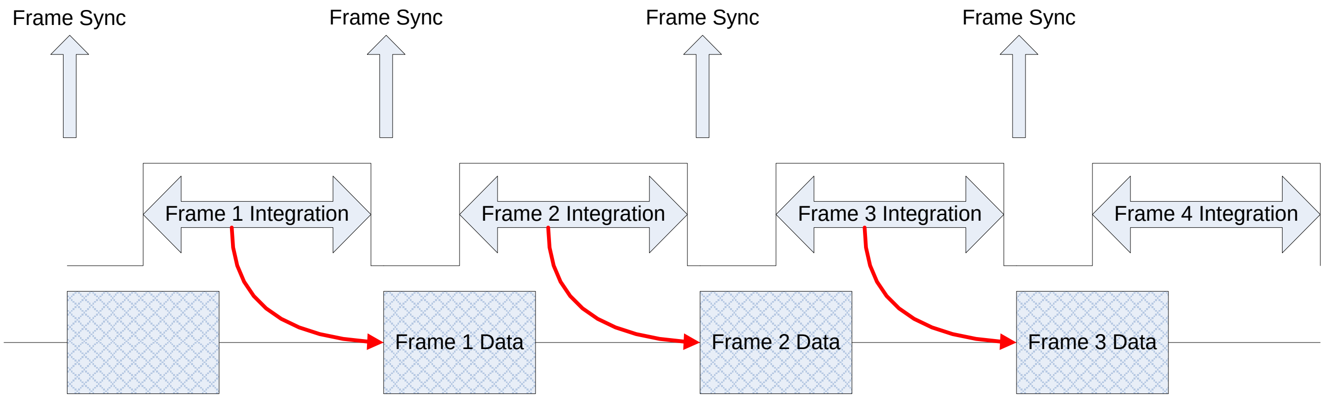
Frame Sync Starts Integration, ITR



Frame Sync Starts Integration, IWR

5.3.2.4 Frame Sync Starts Readout (FSSR)

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



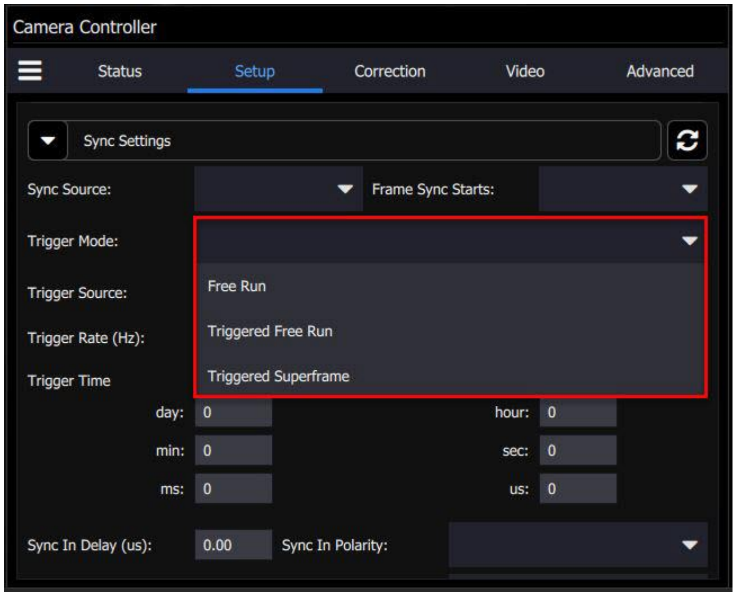
Frame Sync Starts Readout

5.3.2.5 Trigger Mode

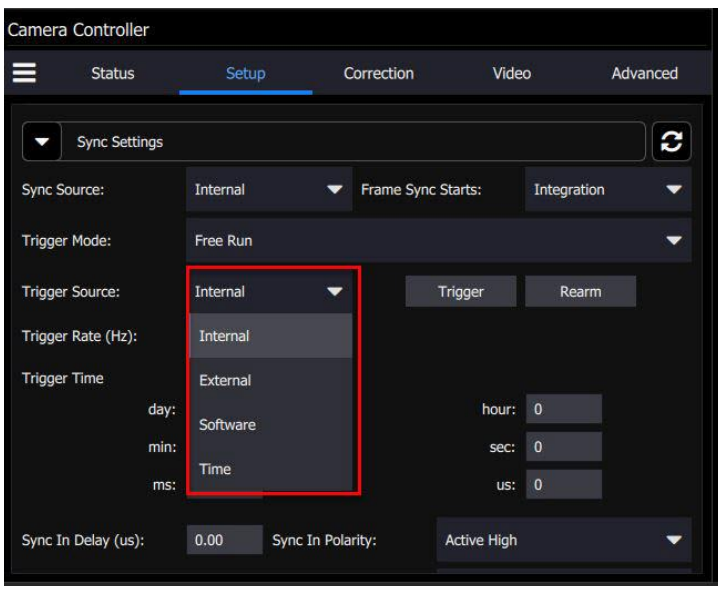
When the camera is placed in a triggered mode, the image stream will stop until the trigger is received.

Trigger Modes	
Free Run (No Trigger)	In free run the camera cycles through frames/sequences continuously.
Trigger then free run	Upon receiving a trigger (external or software) the camera will start to generate sequences continuously.

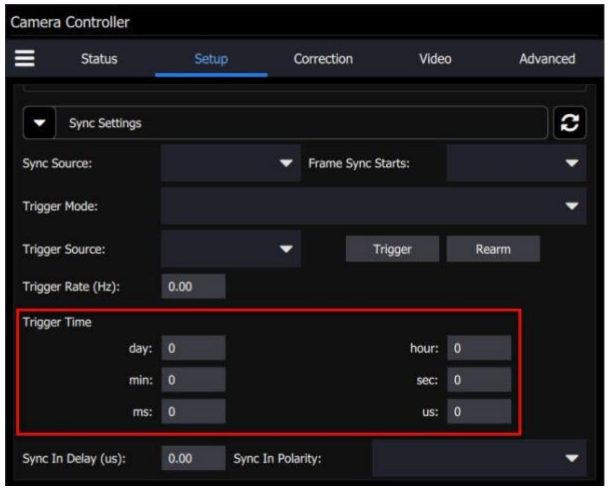
The Trigger Mode options are Free Run, Triggered Free Run, and Triggered Superframe:



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



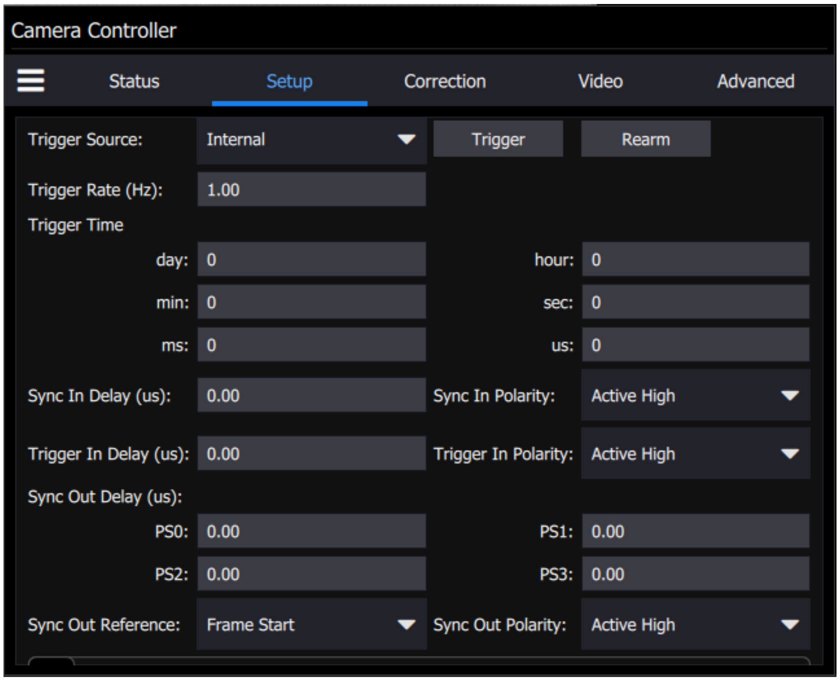
The Trigger Time can be set to activate on a very specific time as measured by the real time clock in the camera.



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

5.3.2.6 Sync Options

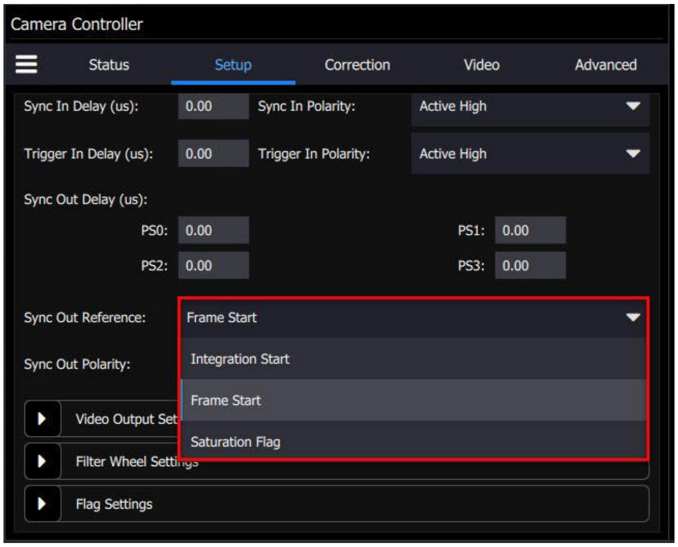
The Sync Options page allows the user to set delays, sync out reference, and polarities for the Sync and Trigger In. The delays can be set individually for each preset.

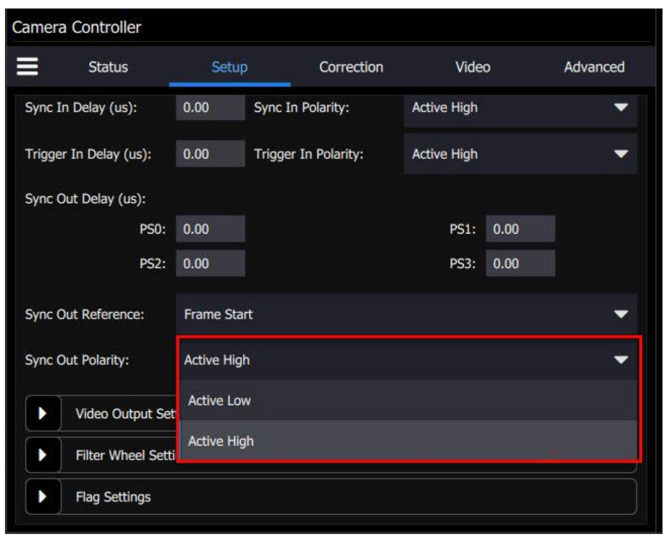


Sync In	
Delay	Allows for the user to set a delay (µsec) for the external sync. See timing diagrams below.
Polarity	The sync is edge triggered. Allows for the camera to use the rising or falling edge.
Trigger In	
Delay	Allows for the user to set a delay (µsec) for the external trigger. See timing diagrams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

5.3.2.7 Sync Out

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

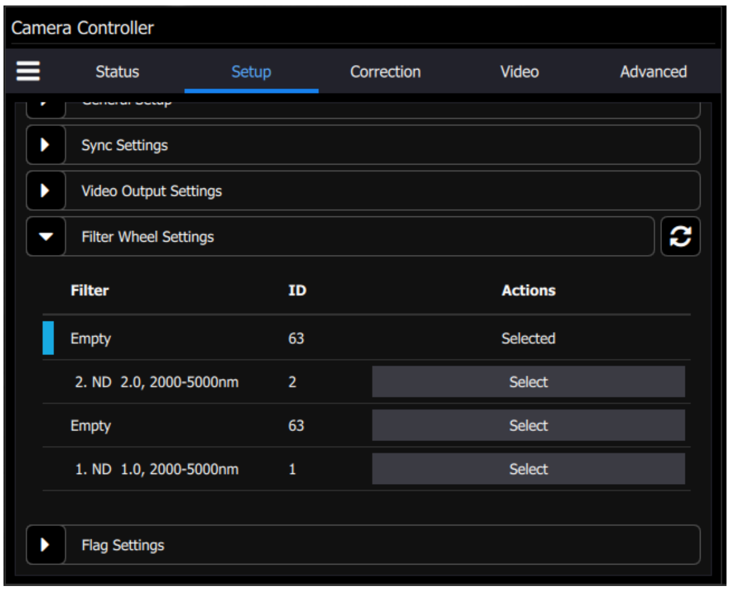




Sync Out Options	
Sync Out Delay	Allows for the user to set a delay for the sync out on a preset basis.
Sync Out Source	Allows for the sync out to be referenced to the start of frame or start of integration.
Sync Out Polarity	Allows for the sync out to be active high or low.

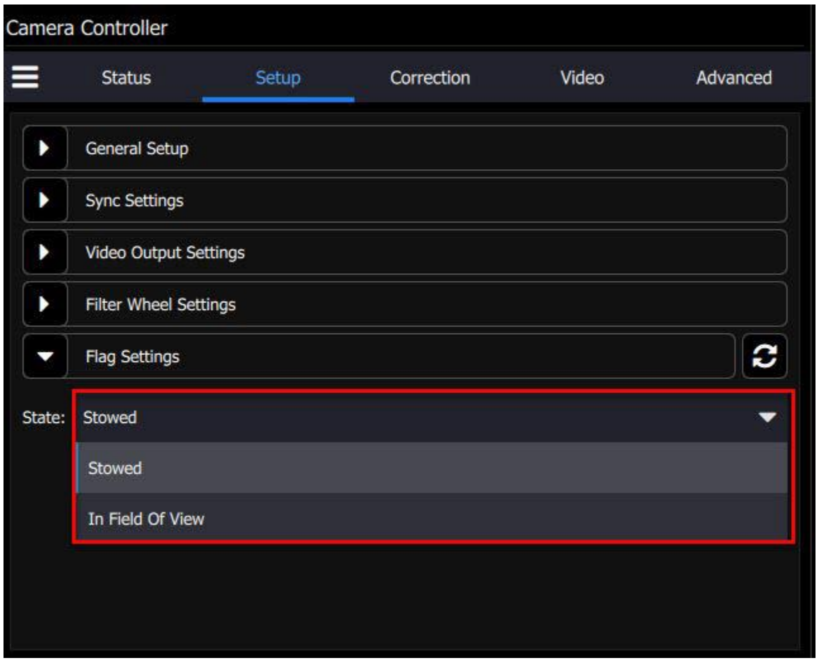
5.3.2.8 Filter Wheel Settings

The RS6780 has a motorized 3-position filter wheel which can be populated with warm filters at the time of manufacturing. The filter wheel can hold 1-inch diameter filters. Each holder can hold up to two filters with a combined thickness of 2mm. The camera can store a text description for the filter ID. 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. For example, a typical filter load could be Empty, ND1, ND2 or ND3. These choices make it possible to do radiometry up to 3000C.



5.3.2.9 Flag Settings

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

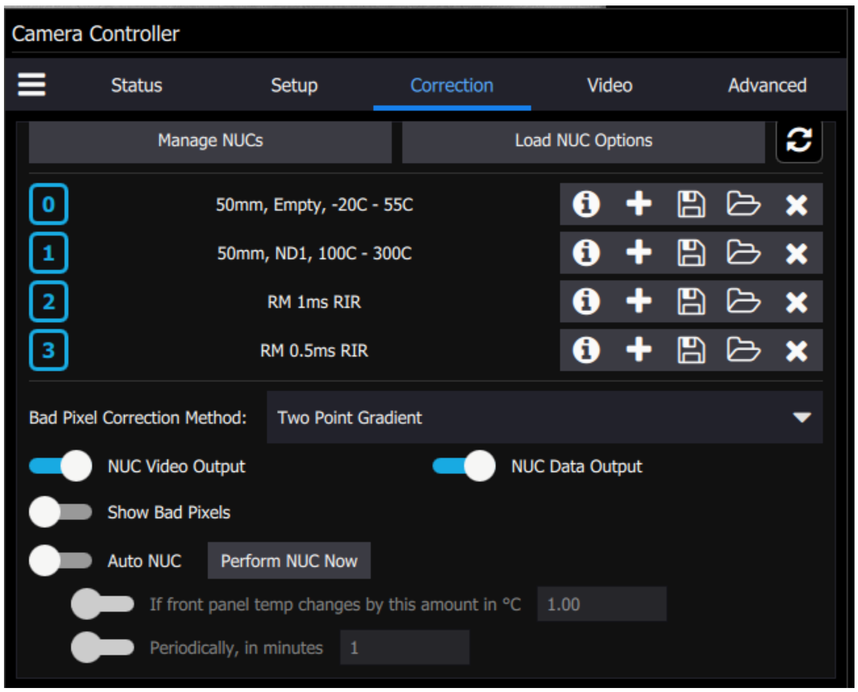


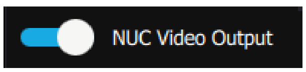
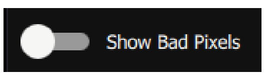
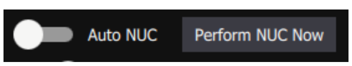
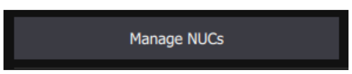
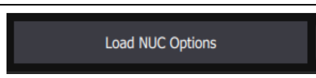
5.4 *Correction Page*

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

RAM memory. This type of memory is used to store NUCs that will be applied to live image data. There is enough RAM memory for one NUC to be loaded for each Preset. This memory is volatile and is lost when 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.

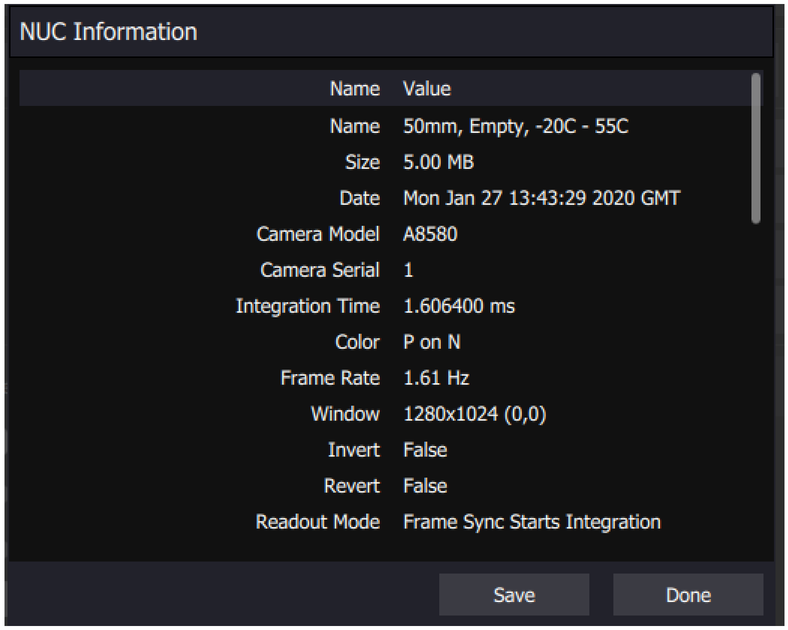
Flash Memory. This type of memory is used as nonvolatile NUC storage. There is about 4GB of flash memory available for storing NUCs. This is enough space to store hundreds of full frame NUCs.



NUC Controls	
	NUC Info. Displays camera parameters and statistics related to the selected NUC
	Perform NUC. Starts the NUC Wizard.
	Updates the current NUC to flash memory
	Load a NUC from flash to RAM memory.
	Unload NUC from RAM memory. No on-camera NUC will be applied to the data.
	Apply NUC to SDI video data
	Apply NUC to Digital output (GigE, CoaXpress)
	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.

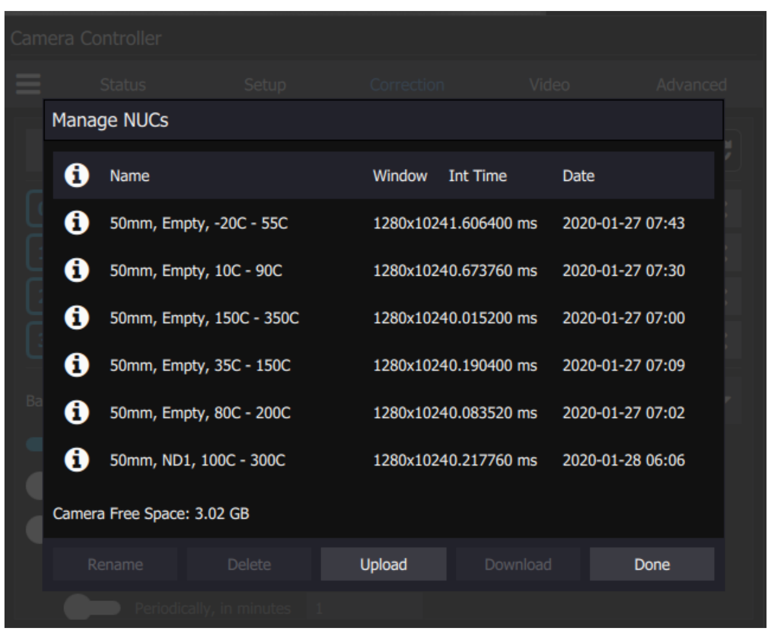
5.4.1 NUC Information

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



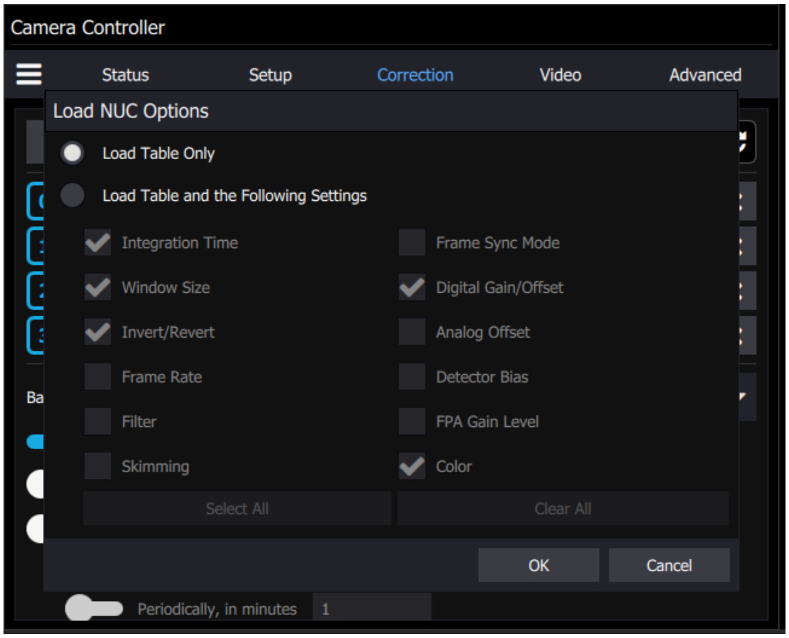
5.4.2 Manage NUCs

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



5.4.3 Load NUC Options

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

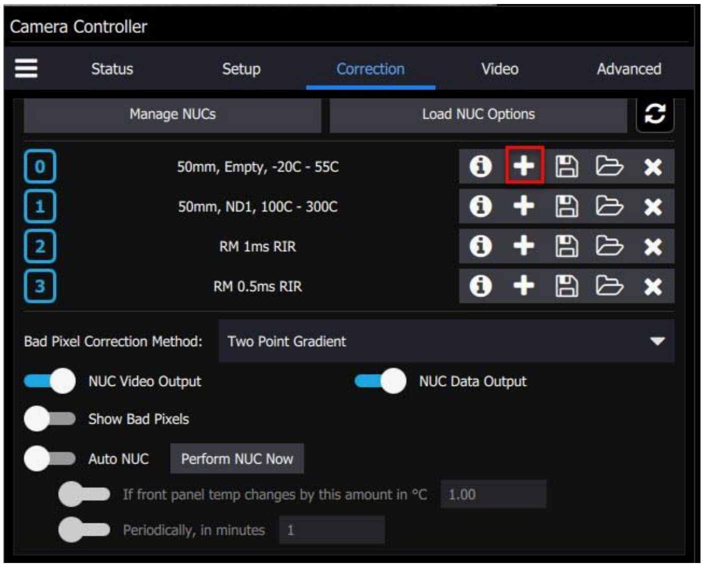


The default setting is to “Load Table Only”, in which case only the NUC coefficients are used from a NUC file. When the user selects “Load Table and the Following Settings”, the user can select which parameters from the NUC will override the current state. The option will not affect NUCs that are currently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

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

5.4.4 Performing a NUC

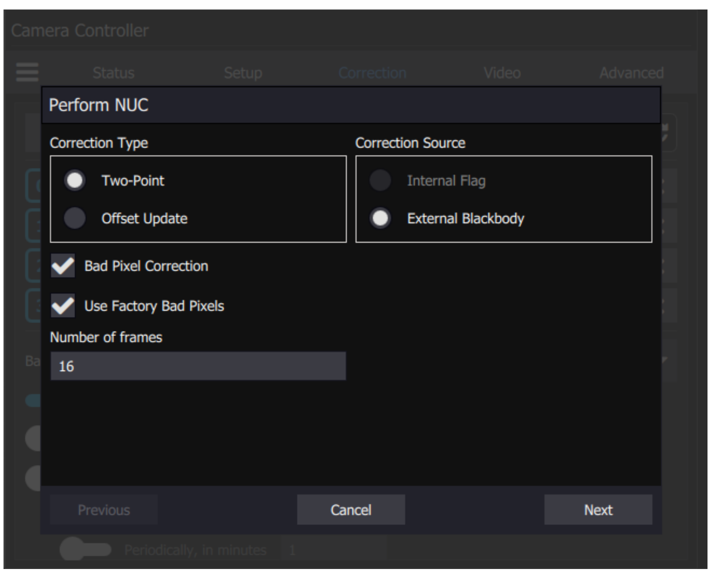
To build a NUC table using the camera electronics, select the *Perform Correction* icon to start the NUC Wizard for the desired preset.



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

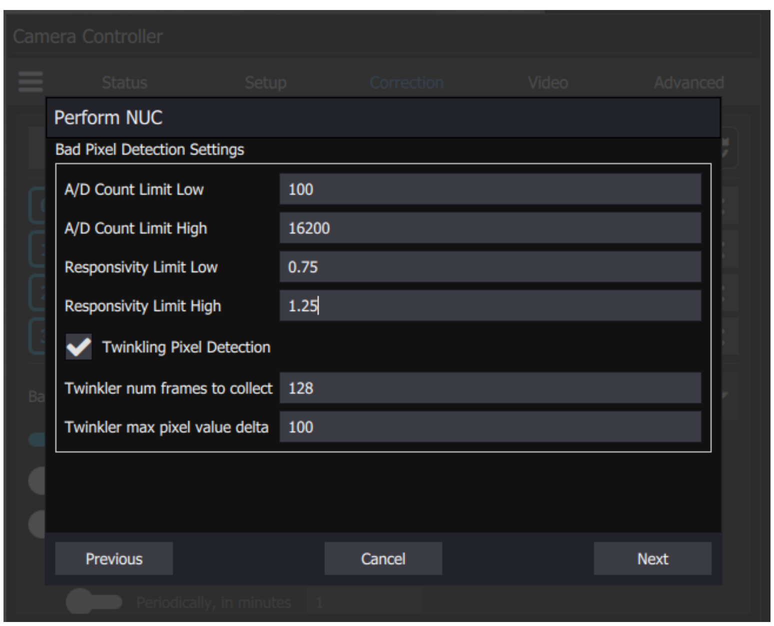
After selecting the *Perform Correction* a second window comes up to allow the user to select correction parameters. The user can choose between a Two-Point and an Offset Update. The Offset Update can be done with either the internal flag or an external blackbody. We recommend using an external blackbody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

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

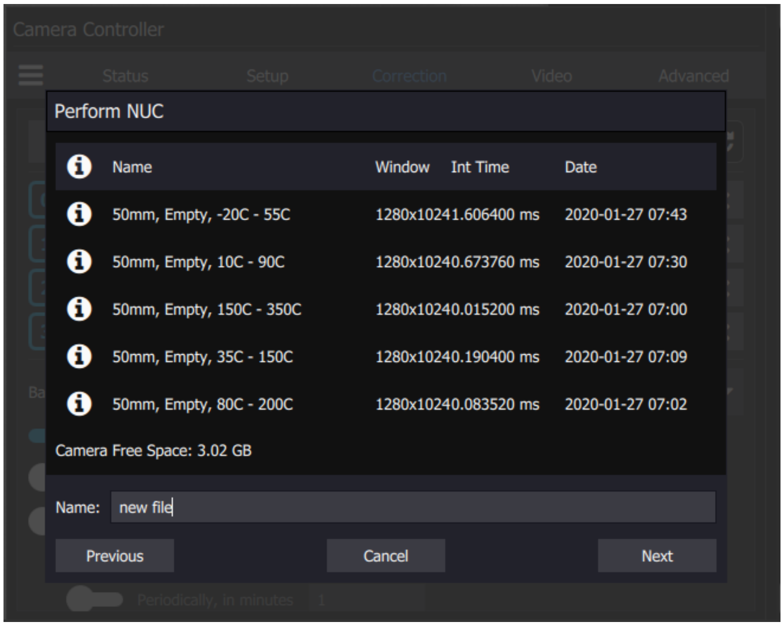


Correction (NUC) Types	
Two Point	Sets both the gain and offset terms. Uses two NUC sources. Computes a bad pixel correction.
Offset Update	Retains the current NUC gain terms and updates the offset terms. Uses a single NUC source. Retains the current bad pixel (BP) correction.
Correction Sources	
Internal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

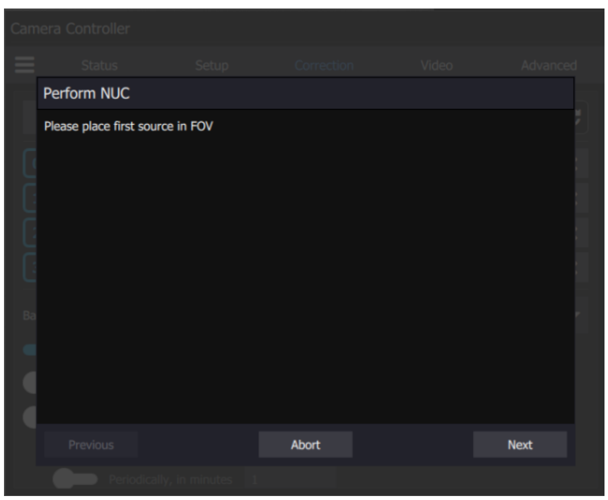
After configuring the correction parameters and selecting *Next>>* the next window allows the user to set up the parameters used for the Bad Pixel Detection. Once the parameters are set, select *Next>>* to continue.

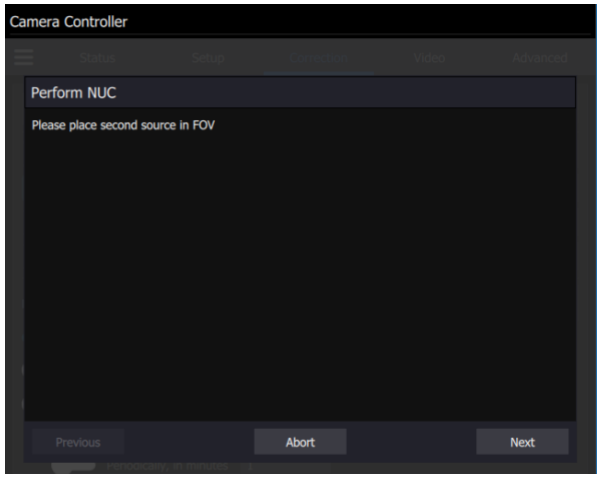


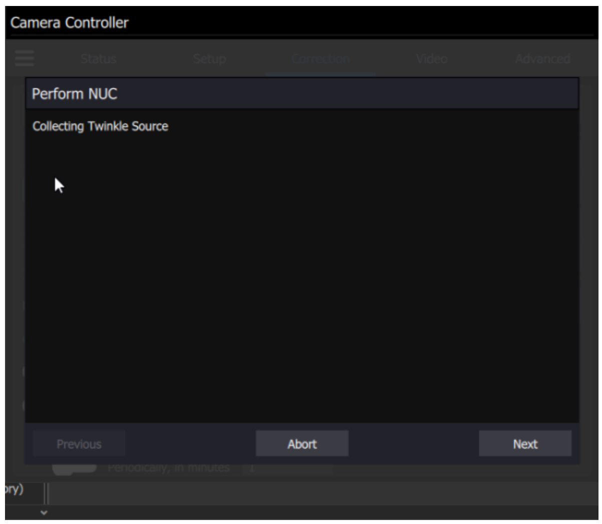
The next window allows the user to name the NUC. Simply type in the name for the table in the text box or select a previously saved file to replace it. Select *Next*>> to continue.



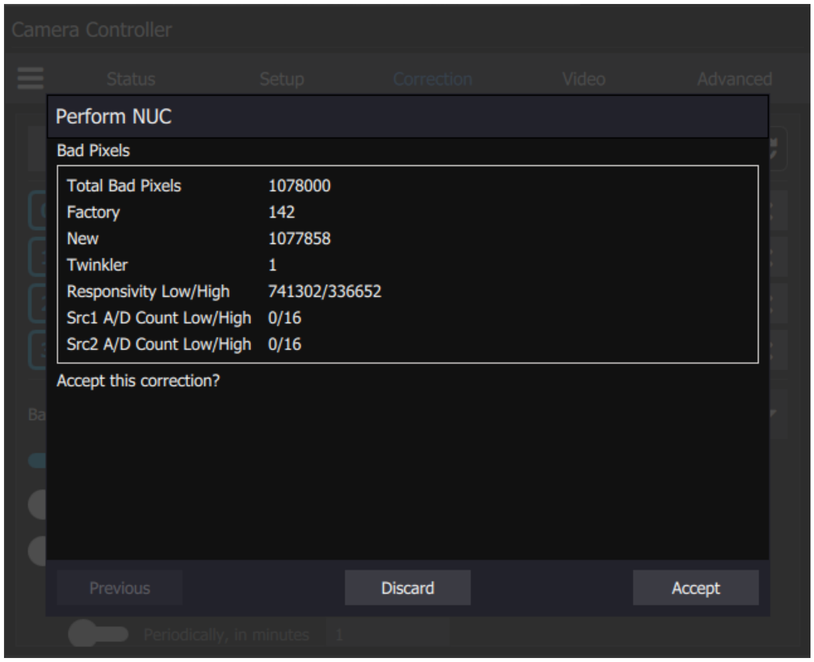
The next screens will collect data from the NUC sources. If using the internal flag, you will only see a few status messages. If using external blackbodies, you will be prompted. After each step, click *Next*>> to continue.







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



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

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

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

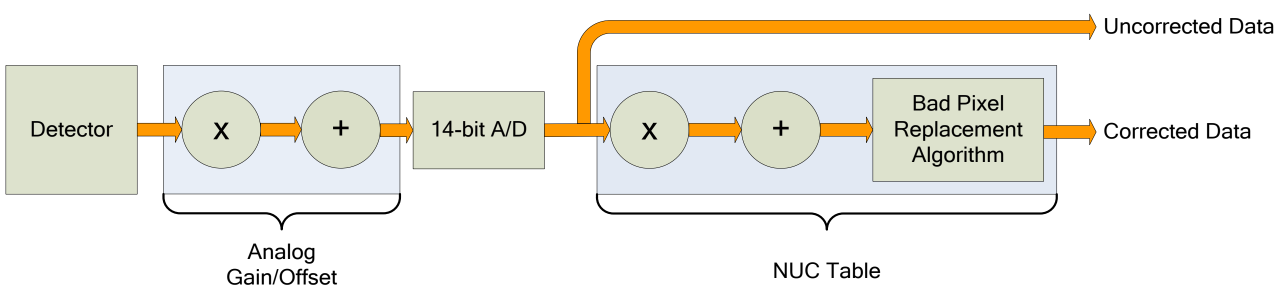


Figure 4-12: Digital Process Showing NUC Table Application

To create the NUC table, the camera images either one or two uniform temperature sources. The source can be an external source provided by the user or the camera's internal NUC flag which is basically a shutter the camera places in front of the detector. If the source is external it should be uniform and large enough to overfill the 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.

5.4.5.1.1 Two-Point Correction Process

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

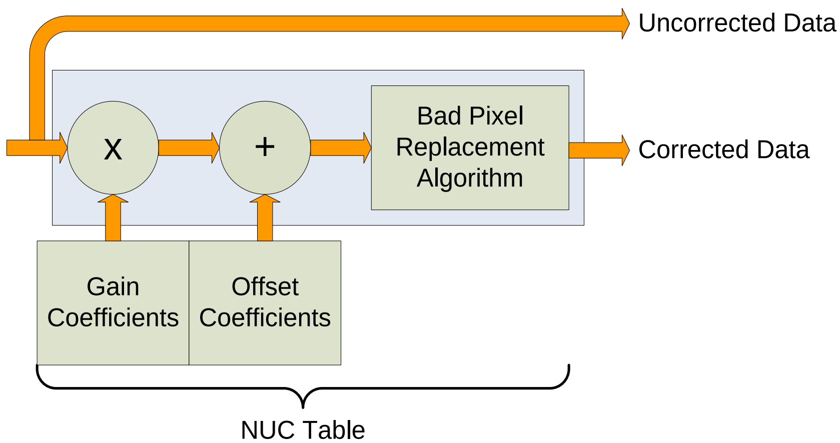


Figure 4-14: Two-Point Correction

5.4.5.1.2 Offset Update

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

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

5.4.5.1.3 Bad Pixel Correction

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

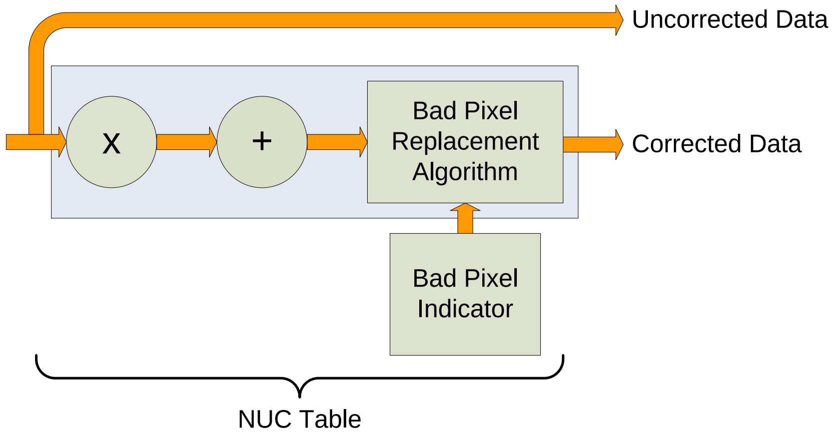


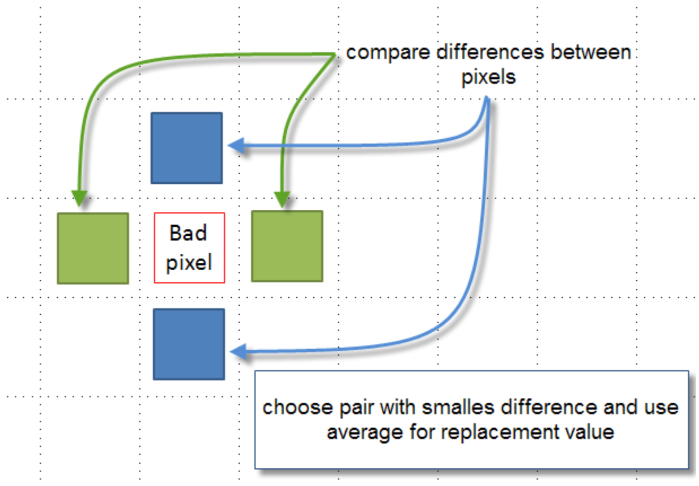
Figure 4-15: Bad Pixel Correction

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

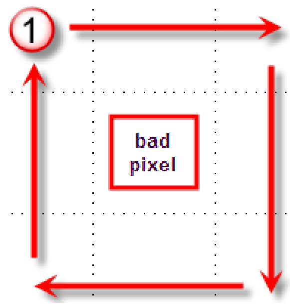
The second method of determining bad pixels is to search for twinklers. Twinklers are pixels that have responsivity values within normal tolerances, but still exhibit large swings for small input changes. These pixels are on the "verge" of being bad and often appear to be noisy. To find these types of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

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

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



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



5.5 Video Page

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

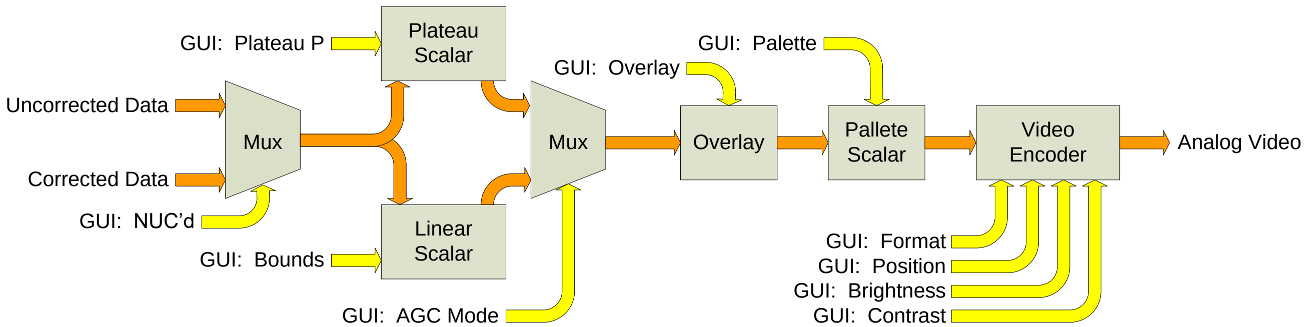
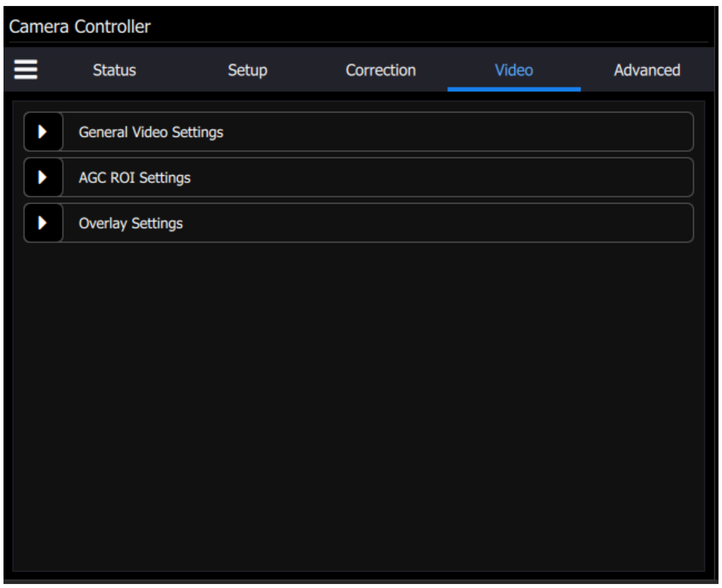
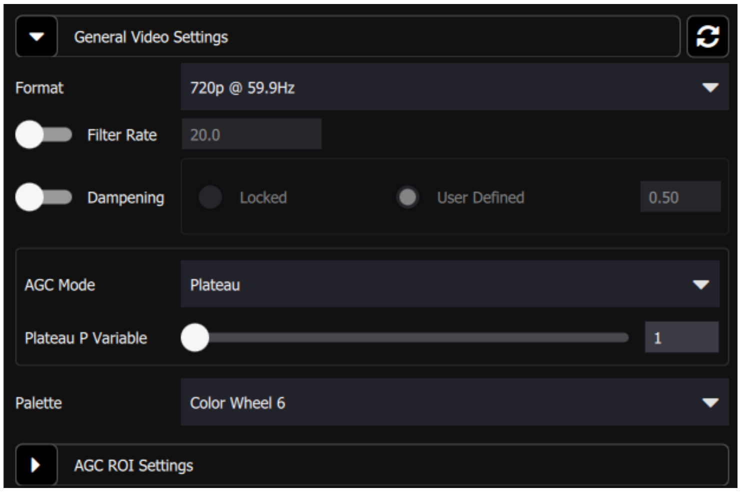


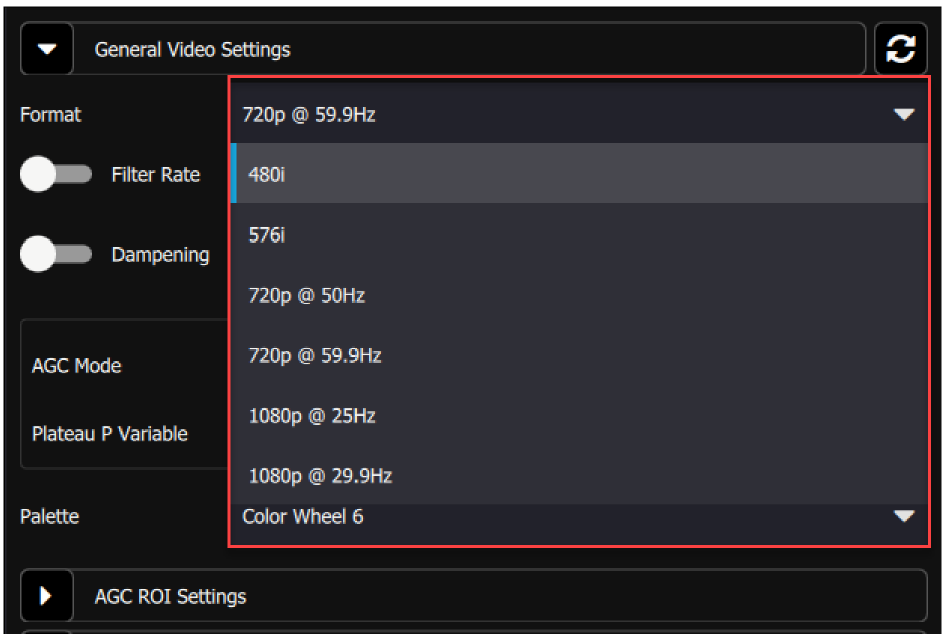
Figure 4-1: Standard Video Flow



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



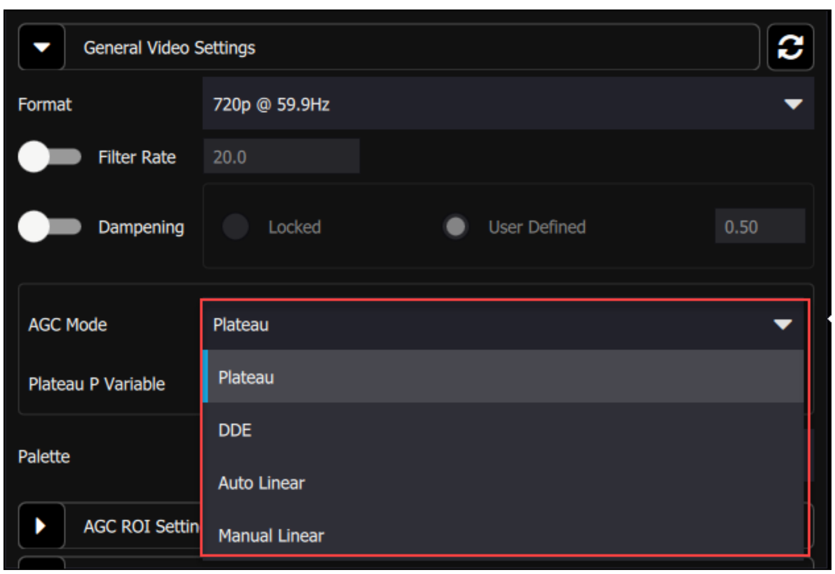
The formats for the video output are as follows: 480i, 576i, 720@50Hz, 720p@59.9Hz, 1080p@25Hz, and 1080p@29.9Hz:



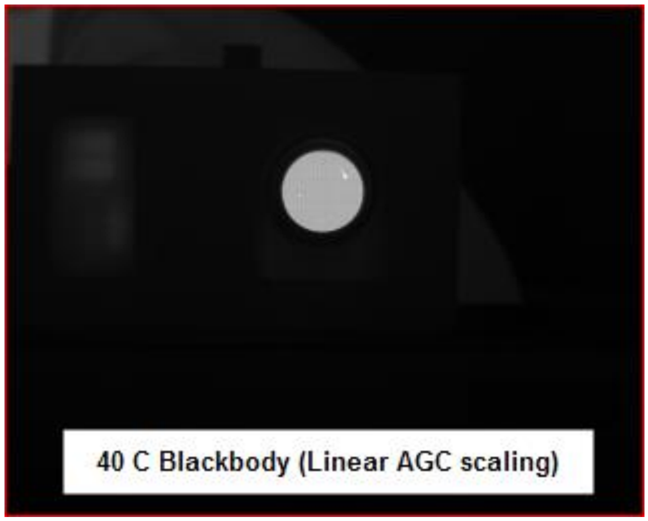
Standard Video Setup Options	
Format	SD-SDI: 480i, 576i, HD-SDI: 1080p @ 29.9/25Hz, 720p @ 59.9/50Hz
Overlay	Enables the video overlay.
Filter Rate	Rate at which AGC is computed (1 to 20 Hz). Enable with checkbox

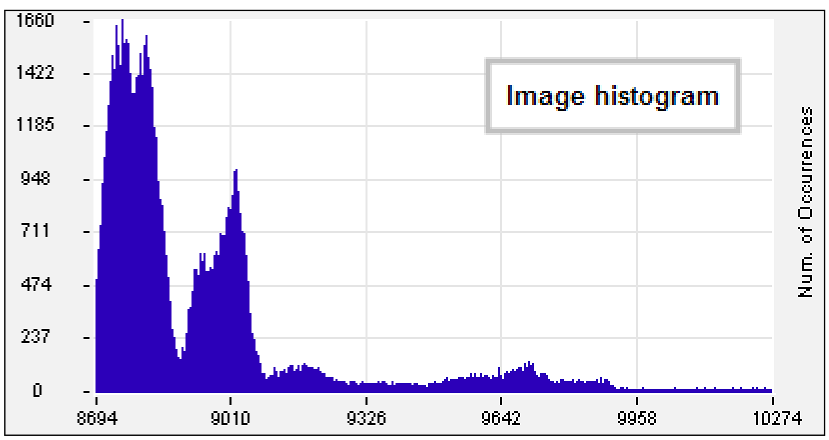
Standard Video Setup Options	
Dampening	Rate at which AGC is allowed to change. This will keep the AGC from responding rapidly to fast changes. Specified as a fraction from 0 to 1. This fraction is used as a weighting factor for the current AGC vs. the newly computed AGC. Setting this to 0 will "lock" the AGC to its current settings. Enable with checkbox.
AGC Mode	Plateau: Uses a plateau equalization (PE) algorithm to scale the image data for video display DDE: Digital Detail Enhancement. Manual Linear: Scales the image data to a windowed section of data range as set by the user Auto Linear: Same as Manual Linear except camera analyzes image and sets limits at ~1% and 98% of the histogram.
Plateau P	Scaling factor for the Plateau Equalization function Note: Plateau P is only visible when AGC Mode>>Plateau is selected
Bounds	Sets the lower and upper data range to be scaled to on the video data. Note: Bounds is only visible when AGC Mode>>Manual Linear is selected
DDE Sharpness	Only visible when AGC is set to DDE. Selects the amount of enhancement processing.
Palette	Allows user to select the color scheme to use on the analog video channel.

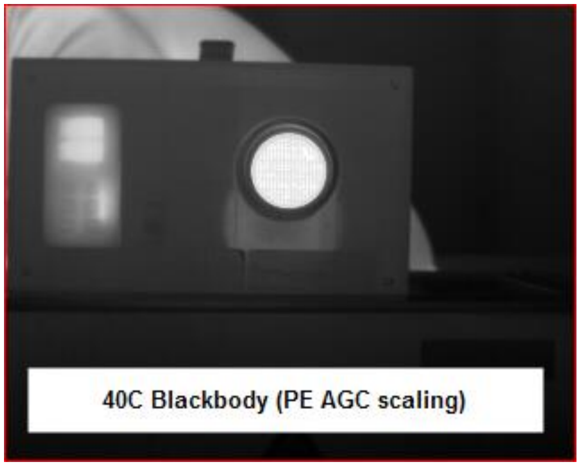
These are the different AGC Modes that are available in the RS6780 camera:



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.)



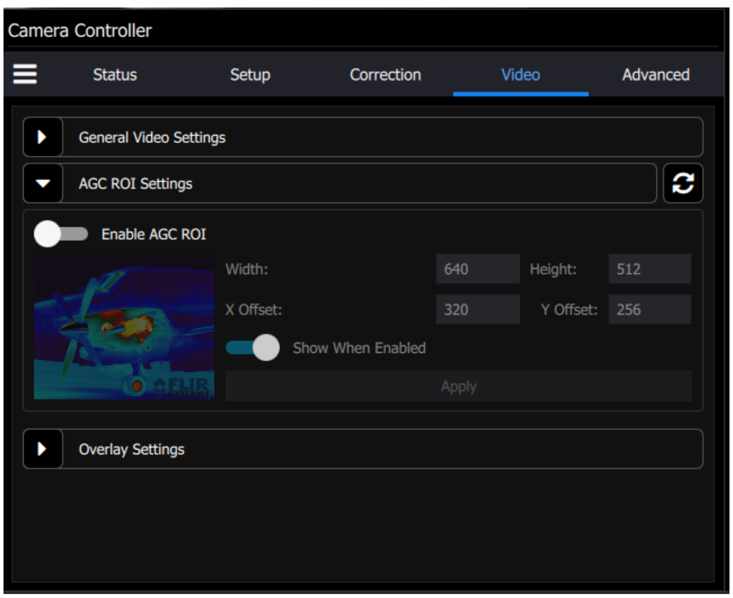




One final note about the PE algorithm: it is very aggressive. It can pull detail out of very low contrast imagery. It can also greatly enhance some very low-level NUC and FPA artifacts and noise if the contrast is low enough. This does not necessarily mean there is a problem with either the camera or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

5.5.1 AGC ROI Settings

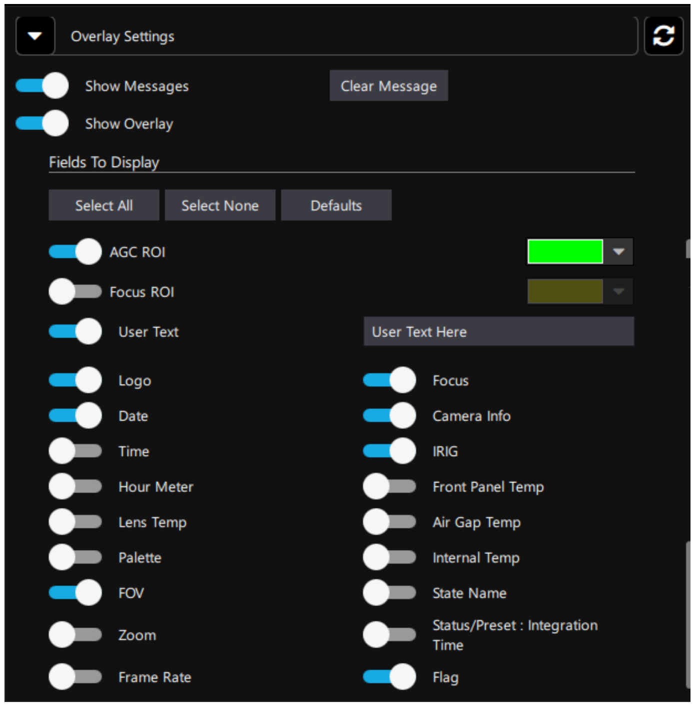
The AGC ROI Settings panel allows the user to define a box region. Only the pixels within the box will be used to calculate the AGC coefficients. This is particularly useful if there is part of the scene that is much higher or lower in intensity than the target of interest. The ROI is defined by entering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



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

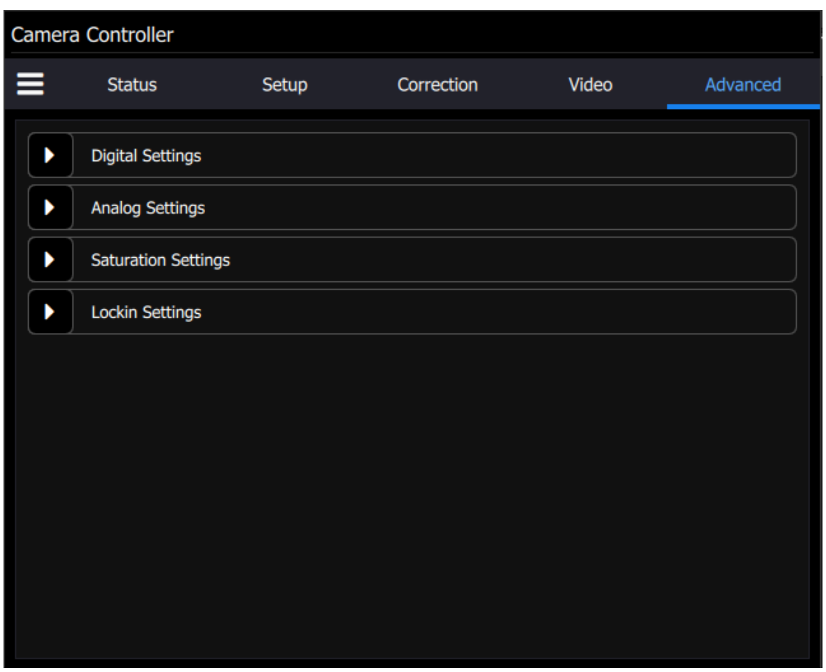
5.5.2 Overlay Settings

The Overlay Settings section allows the user to configure the SDI video overlay. Various elements can be turned on or off. To preserve changes through a power cycle, save the camera state.



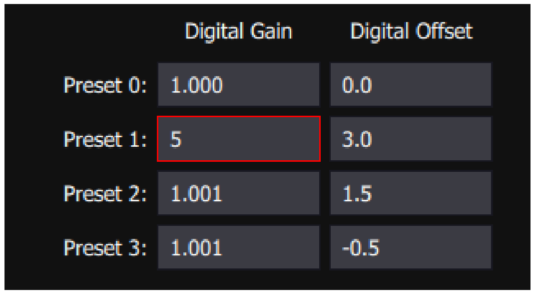
5.6 Advanced

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

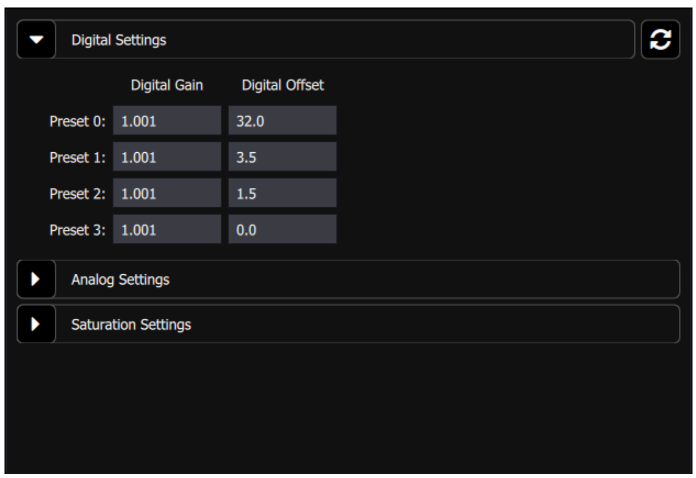


5.6.1 Digital Settings

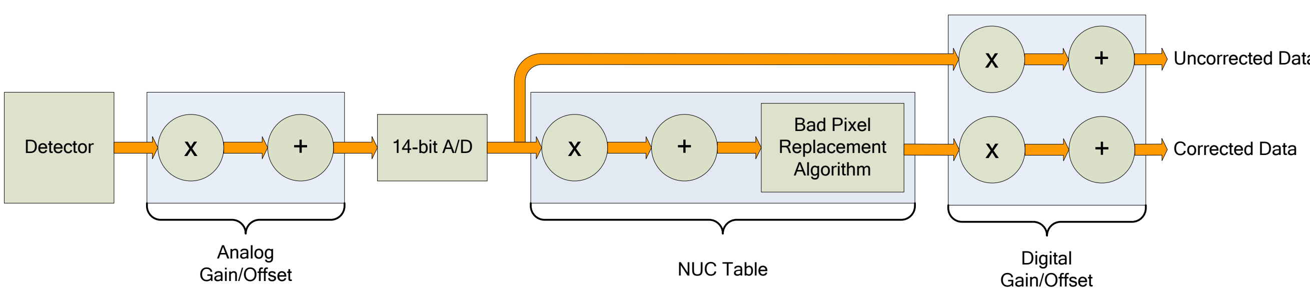
The digital settings menu contains digital gain and digital offset values for each of the four presets. If a Factory Calibration is loaded into a preset, then these boxes will be populated with values that are derived from the Tdrift compensation, and the user is NOT allowed to change the values. If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



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



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



RS6780 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:

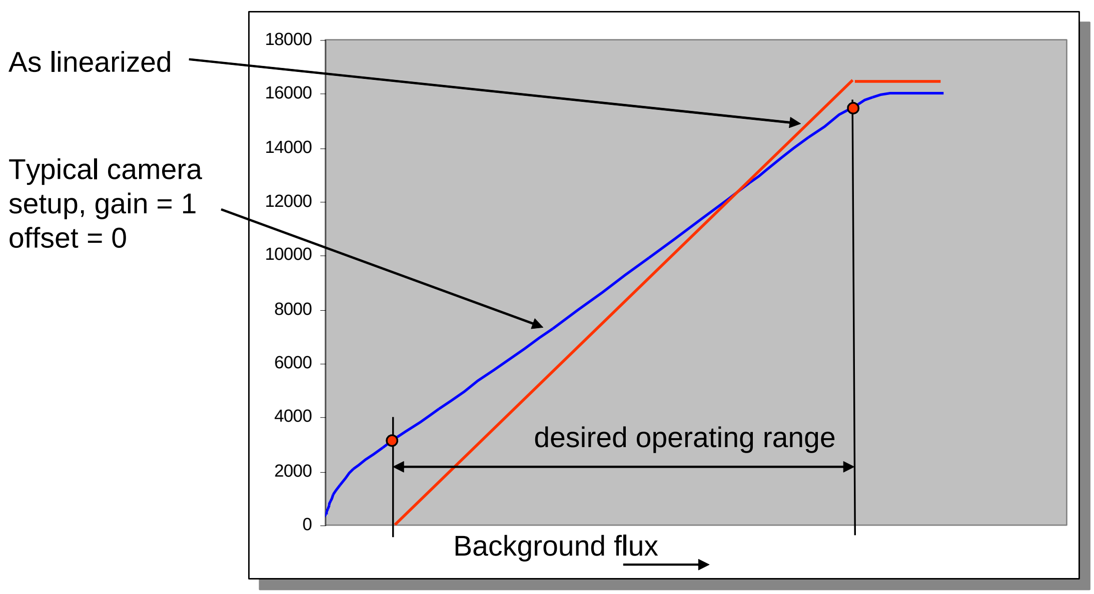
$$gain = \frac{16383}{15800 - 3200} = 1.30$$

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.

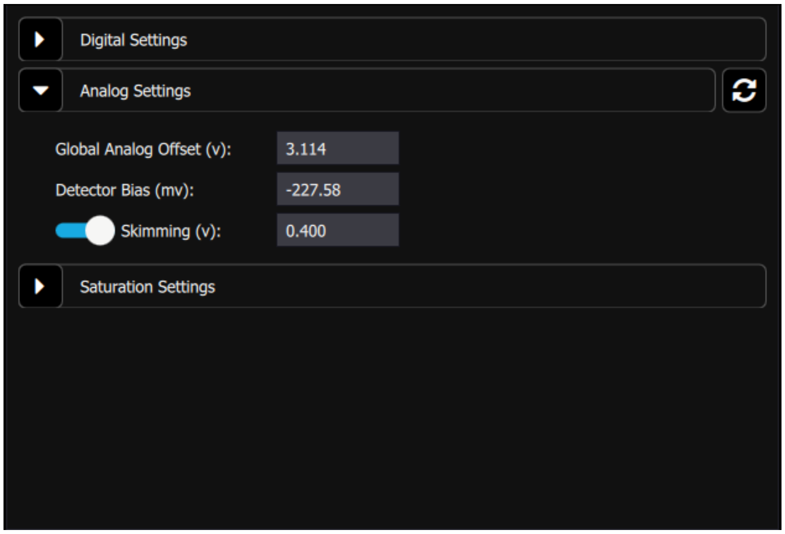
The available gain range is 1.999 to essentially zero; the available offset range is ± 32,767. The default values are a gain of 1 and an offset of zero. Because the system sensitivity (NE∆T) is set prior to the A/D stages, there is no detrimental effect on performance from the use of the global gain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



Use of global gain and offset to linearize the camera

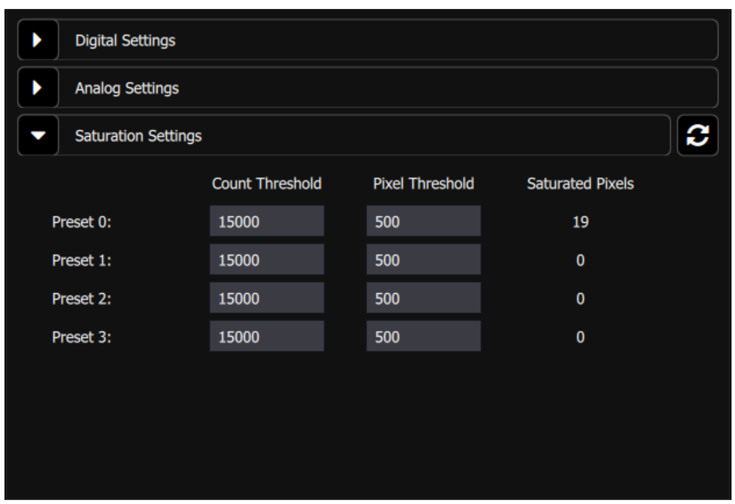
5.6.2 Analog Settings

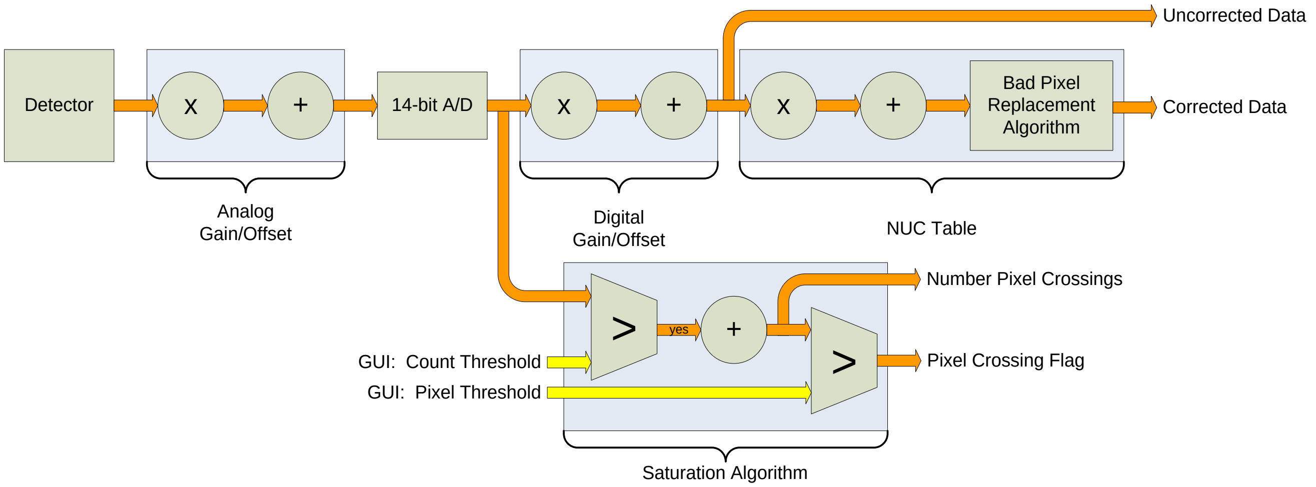
These controls are set at the factory for the focal plane array in the camera. The controls are intended only for the power user who should consult with FLIR application support before changing these values.



5.6.3 Saturation Settings

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





Saturation Detection

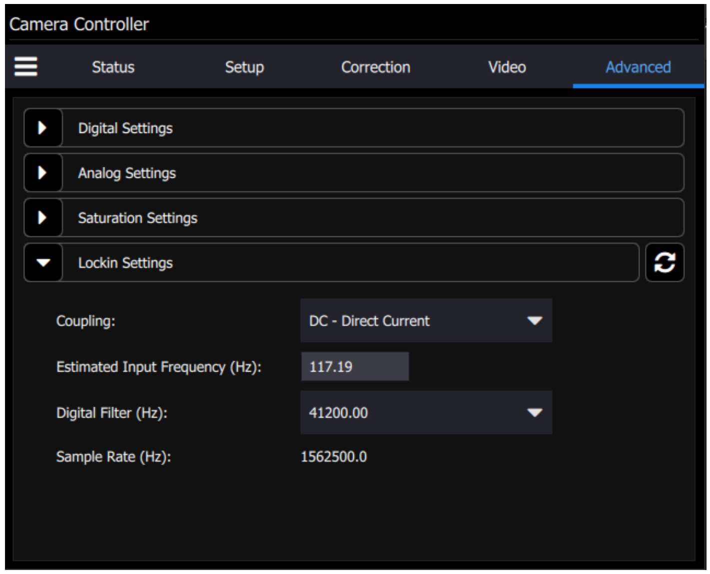
One example of this feature is to use the information to adjust the integration time. If the A/D count threshold is set to 75% of the full value (12,288) then the camera will count the number of pixels that are within 25% of saturation. If a set number of pixels fit that criterion, then the integration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

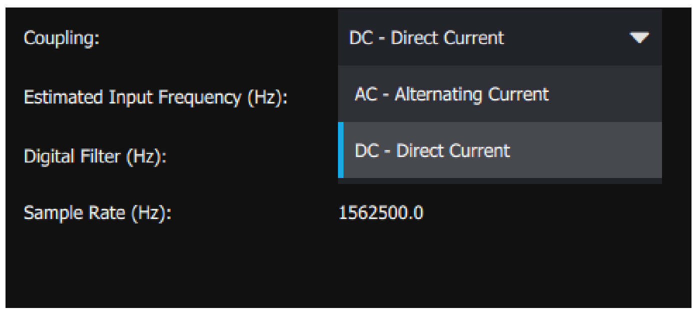
It is important to note the camera does not account for bad pixels when counting for saturation. When determining the threshold the user should account for the typical number of bad pixels.

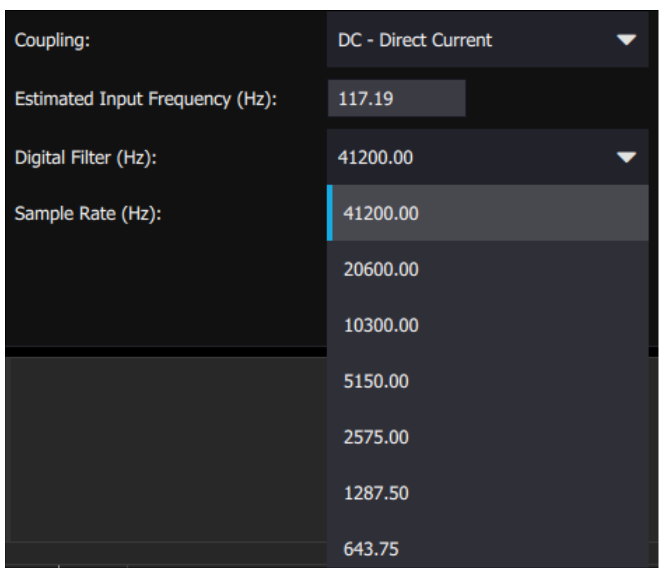
5.6.4 Lockin Settings

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

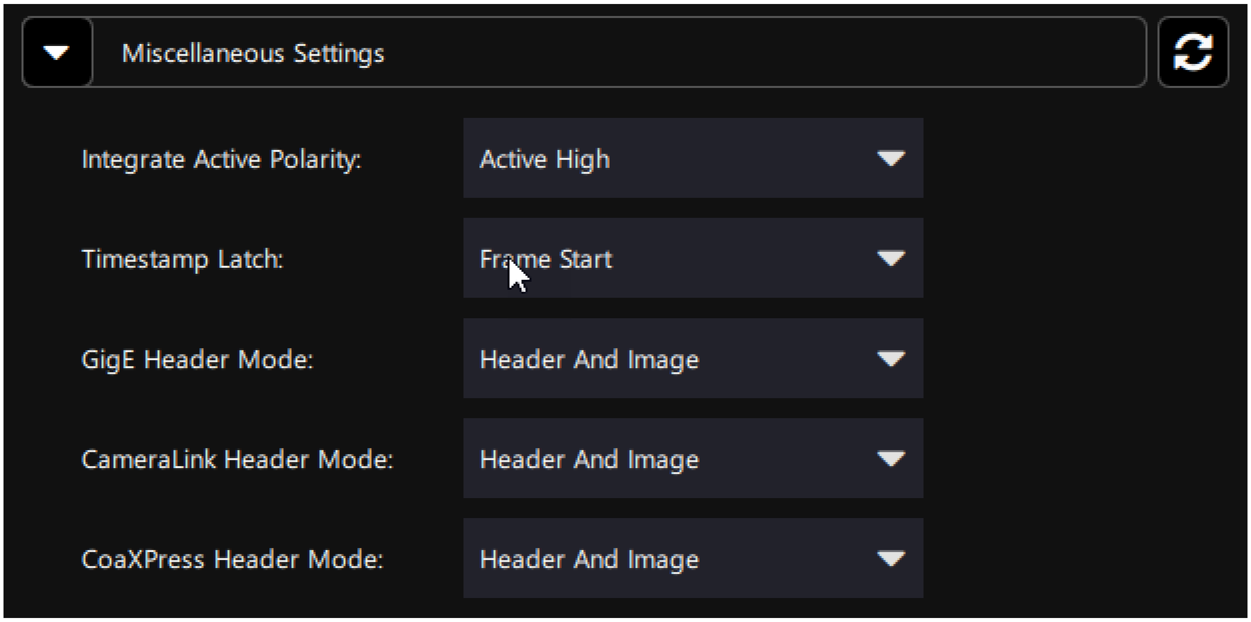
The signal period is determined by measuring the time interval between signal crossings of the digitizer midpoint value of 8192 counts, which is half of the 14-bit scale. The signal does not have to have any particular shape to get its period measured – it just has to be periodic. The lockin input has a 1.56 MHz sampling rate at 14 bits of depth, and selectable AC/DC coupling, with latency less than 1 microsecond. The input signal range is 0-5 volts. The frame period is the effective latency if it is used as a regular input, since it is only updated once per frame. When not used as a lockin input, this port still stores a value for each new image frame.


Camera Controller
Status
Setup
Correction
Video
Advanced
Digital Settings
Analog Settings
Saturation Settings
Lockin Settings
Coupling:
DC - Direct Current
Estimated Input Frequency (Hz):
117.19
Digital Filter (Hz):
41200.00
Sample Rate (Hz):
1562500.0


Coupling:
DC - Direct Current
Estimated Input Frequency (Hz):
AC - Alternating Current
Digital Filter (Hz):
DC - Direct Current
Sample Rate (Hz):
1562500.0


Coupling:
DC - Direct Current
Estimated Input Frequency (Hz):
117.19
Digital Filter (Hz):
41200.00
Sample Rate (Hz):
41200.00
20600.00
10300.00
5150.00
2575.00
1287.50
643.75

5.6.5 Miscellaneous Settings



Setting	Options
Integrate Active Polarity	• Active High • Active Low
Timestamp Latch	• Frame Start • Integration Start • Integration End
GigE Header Mode	• Header and Image • Header Only • Image Only
Camera Link Header Mode	IGNORE. NOT SUPPORTED.
CoaXPress Header Mode	• Header and Image • Image Only

6 Interfaces

6.1 Mechanical (dimensions in inches)

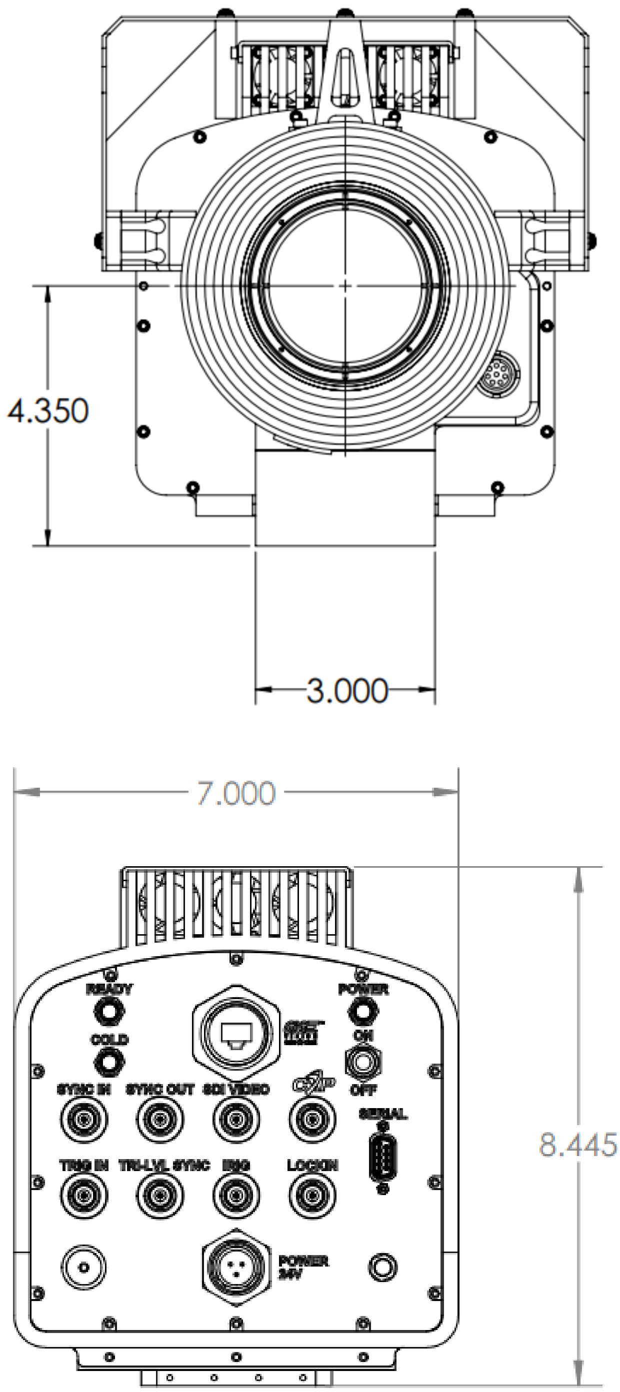


Figure 6-1: Front and rear view of RS6780 (base zoom)

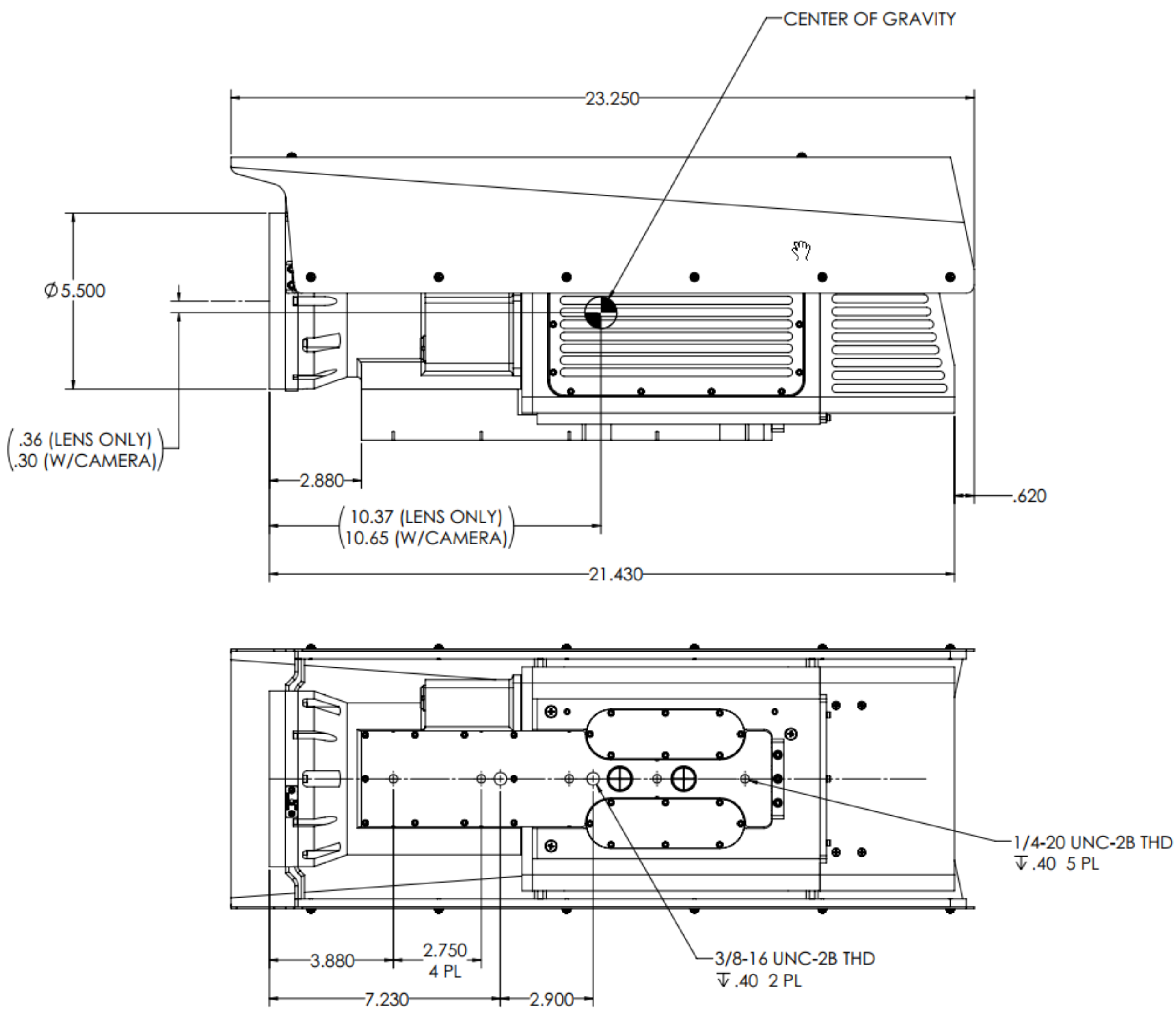
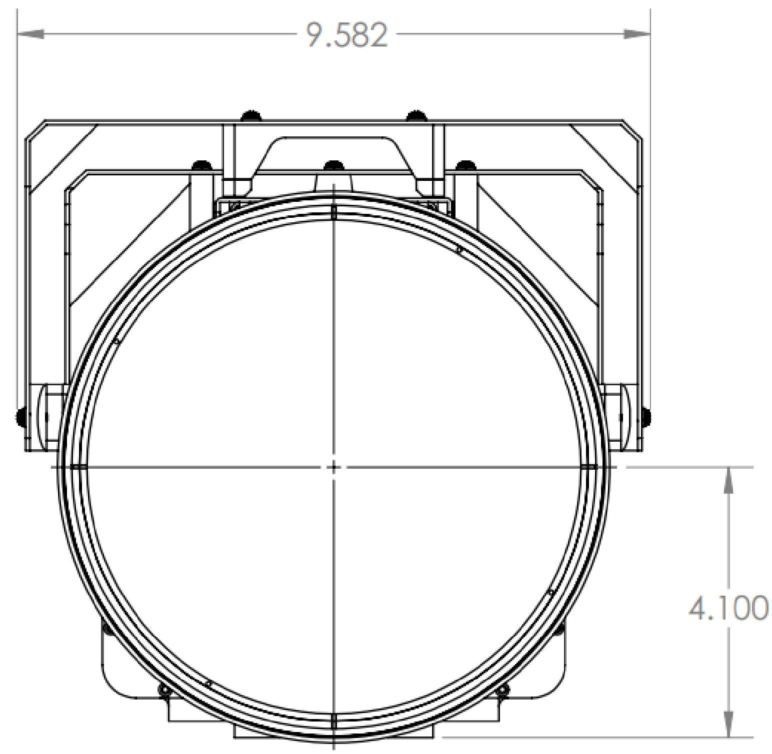


Figure 6-2: Side and bottom view of RS6780 (base zoom)



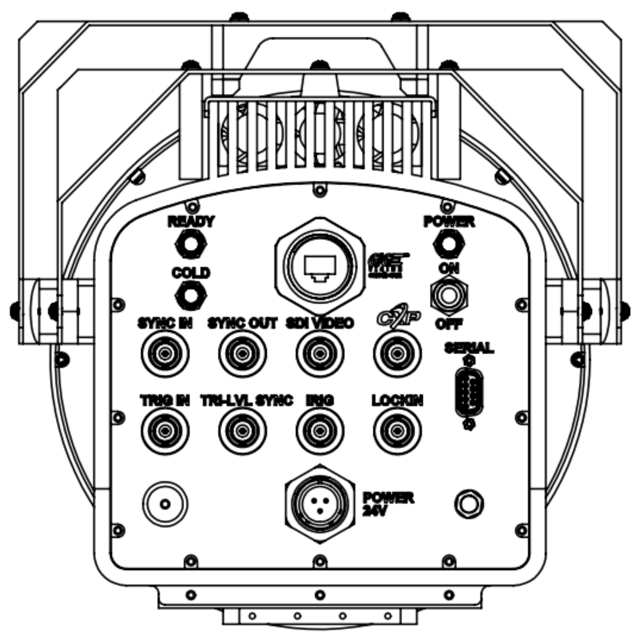


Figure 6-3: From and rear view of RS6780 with 3x and sunshield.

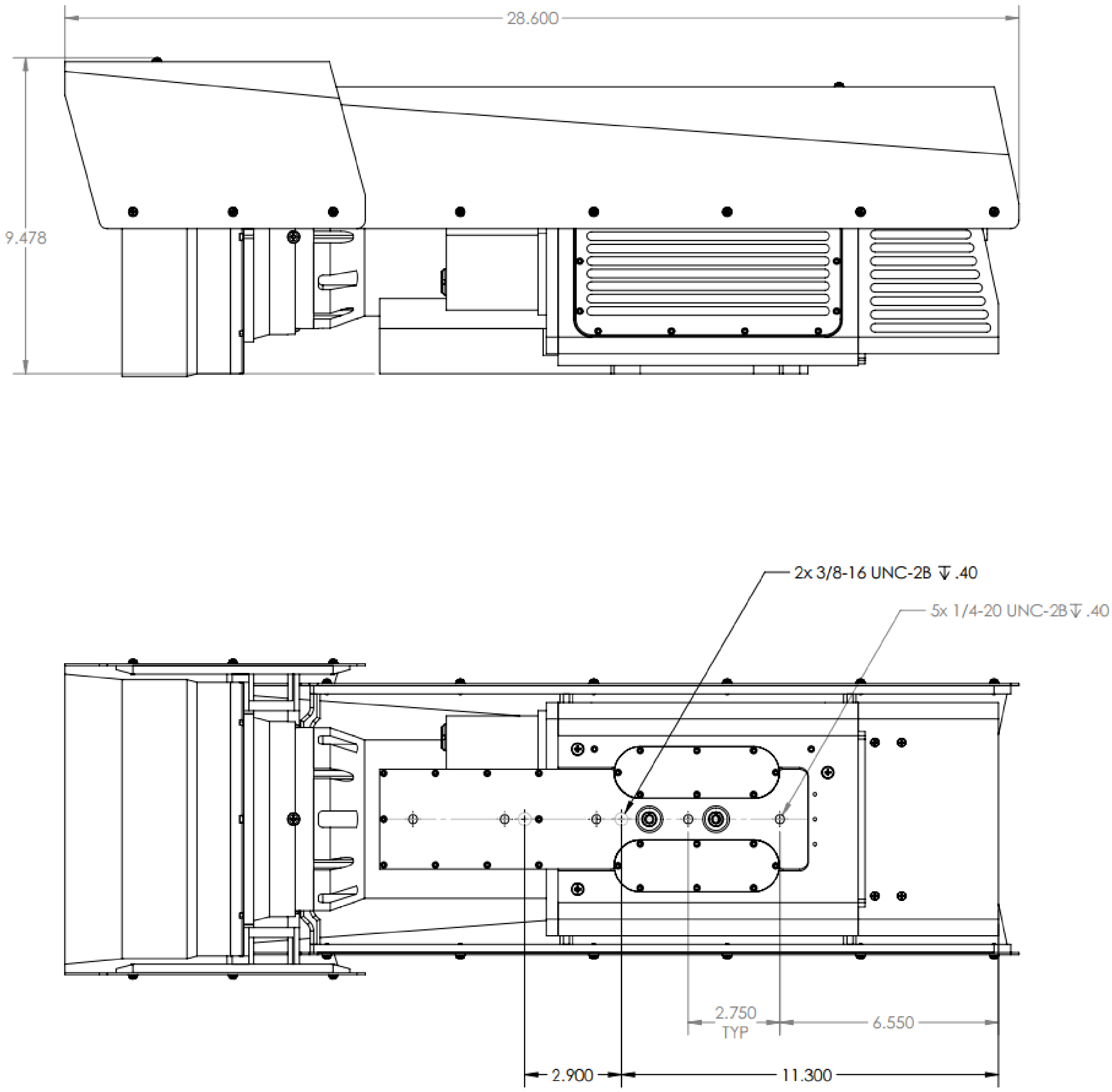


Figure 6-4: Side and bottom view of RS6780 with 3x and sunshield

6.2 Status Lights

The RS6780 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).

6.3 Power Interface

A 24V external AC-DC power converter is provided with the RS6780 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.

<table>
<tr><td rowspan="3">
</td><td>A</td><td>+24V IN</td></tr>
<tr><td>B</td><td>+24V RTN</td></tr>
<tr><td>C</td><td>GND</td></tr>
</table>

Figure 6-1: RS6780 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!
- RS6780 power dissipation is <100 Watts steady state at nominal ambient temperature
- Mating Connector: FLIR P/N 26431-000, AMPHENOL PN PT06J-12-3S

6.4 Digital Interfaces

6.4.1 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 is GigE Vision compliant.

6.4.2 CoaXpress (CXP)

The RS6780 supports a 3.0 Gbps single-link CXP 1.1 interface.

6.4.3 SDI

SDI is a standard 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.

6.4.4 RS-232 Camera Control

The RS6780 can be controlled using an RS-232 port on the Serial Port connector. A standard, off-the-shelf (straight-through) serial cable can be used.

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

6.4.5 Synchronization Interfaces

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

6.4.5.1 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.

6.4.5.2 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.

6.4.5.3 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.

6.4.5.4 Tri-Level Sync

Allows the FPA frame sync to be driven by an external analog video sync signal

6.4.5.5 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 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.

7 Specifications

7.1 Interfaces

Specifications	
AC Power	90-230V_{AC}, 50-60 Hz (using FLIR 4228270 power supply)
Control	GenICam over Gigabit Ethernet (10/100/1000)
Video Out	BNC
Frame Sync In	TTL, BNC, selectable polarity, >160ns pulse width, 5.5V max
Digital Video Out	14-bit Gigabit Ethernet (GigE Vision 2.0)
Mechanical Interface	2 (two) ¼-20 tripod screws; 1 (one) $^3/_8$-16 professional tripod screw; 4 (four) 10-24 mount holes

7.2 Windowing Capacity

Specifications	
Window Sizes	Flexible
Windowing Step Size	Row: 16, Column: 4
Window Offset Step Size	No offset, FPA centered

7.3 Acquisition Modes and Features

Specifications	
Frame Rate:	
Max at Full Window	125Hz
Max w/ Windowing	½: 406Hz ¼: 1063Hz
Max @ Min Window	4,130Hz @ 16x4
Minimum	<1Hz

Resolution	480nS
Pixel Rate	50 MHz
Integration Width:	
Maximum	~full frame period (1/frame rate)
Minimum	480nS
Resolution	160nS
Digital Video Output:	Selectable: • Raw digital video (14-bits) • Gain and offset (NUC) corrected (14-bits) • NUC with bad pixel replaced (14-bits)

7.4 SDI Video

Video Output	SD-SDI 480i, 576i HD-SDI 720p @ 50/59.9Hz or 1080p @ 25/29.9
Data Output	Selectable • Raw, uncorrected • Corrected
AGC	Selectable • DDE • Plateau based equalization • Linear equalization
AGC Filter	User controlled damping factor User controlled update rate
Overlay	Available on HD-SDI output
Palettes	Selectable • Grayscale • Various color palettes
Zoom (HD-SDI video)	• Automatic, best fit

7.5 Performance Characteristics

Power Consumption FLIR PWR Supply @ 110V$_{AC}$	Continuous Cool Down: Continuous Normal:	<57.2 Watts <53.9 Watts
Power Consumption Camera DC Power @ 24V$_{DC}$	Continuous Cool Down: Continuous Normal:	<34.08 Watts <32.4 Watts
Cool-down Time	≈5-7 minutes to reach operating temperature	
Sensitivity NEΔT[1]	≤ 27 mk typical	

1) NEΔT is at 50% nominal bucket fill, 298K background, ± 5°C signal

7.6 Non-Uniformity Correction

NUC Types	Two Point (offset and gain values) non-volatile Two Point w/Bad Pixel Detection/Replacement Update Offset (recalculates offset using current gain)
NUC Source	Internal: Ambient flag (for 1-pt and offset update only) External: Any user supplied source which covers entire FOV
Bad Pixel Replacement	Two-Point Gradient and nearest neighbor (auto selected)
Number of NUC's	4 active NUC's in preset selectable form >100 NUCs in on-board flash
NUC Time	< 15 seconds
NUC Performance	0.1%

7.7 Detector/FPA

Spectral Response	3-5um
Detector Types	InSb
f/#	f/4
Integration Mode	Snapshot

Format (HxV)	640x512
Operability	≥ 99.5% (≥99.95% typical)
Charge Handling Capacity[1]	7.2M electrons
Detector Pitch	15 microns
Detector Cooling	Rotary Cryocooler, 77K nominal setpoint

7.8 General Characteristics

Size	Base zoom w/sunshield	w/ 3x and sunshield
Length	23.3 inches / 59.2 cm	28.6 inches / 72.6 cm
Width	7 inches / 17.8 cm	9.6 inches / 24.4 cm
Height	8.4 inches / 21.3 cm	9.5 inches / 24.1 cm
Weight	33.7 lbs.	
Operating Temperature Range	-20C to +50C (-4°F to 122°F)	
Humidity	<95% relative humidity, non-condensing	
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.

8.2 Lenses

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

1] Water free Acetone

2] Ethanol

3] Methanol

4] Isopropanol