FASTEC HS

FASTER THAN **VISION**

Fastec HS Series Cameras

Operator's Manual

Firmware / Software Version 3.3

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Fastec Imaging Corporation
17150 Via Del Campo
Ste. 301
San Diego, CA 92127
+1-858-592-2342

support@fastecimaging.com

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1 Product Overview

1-1 HS Product Differentiation

HS Camera

Fastec Imaging currently offers two HS high-speed CMOS digital camera models, with more models in development. These cameras are available in either monochrome or color and have a wide range of recording rates, sensor resolutions, and on-board memory options. All cameras are equipped with Micro Four Thirds (MFT) lens mounts, with electronic lens control and 1/4-20 tripod mounting holes. Additional lens mount adapters are available to fit most commercial and scientific optical systems.

Figure 1-1: HS Camera

The HS camera housing is made of 100% machined aluminum with a black anodized finish. It is both attractive and extremely durable. Side-mounted DIN connectors are used for Sync/Trigger connections. Trigger and power buttons are positioned adjacent to the I/O connectors. Power is supplied by an AC power adapter or any 12v DC source.

Table 1-1: HS Camera Models

Camera	Max Resolution / Frame Rate	Standard Memory	Sensor Size	Optional Memory	Optional Solid-State Drive
HS5	2560 x 2048 @ 253fps	8GB	16.4 mm	16GB, 32GB	/ 500GB (D)*/ 1TB (D)* / 2TB
HS7	1920 x 1080 @ 2500fps	8GB	22.0 mm	16GB, 32GB	/ 500GB (D)*/ 1TB (D)* / 2TB

* D Option includes Long Record functions that are not available with 2TB SSD

Table 1-2: Part Number Legend (Camera)

HS7-HC081TBD

Component	Options
Long Record	None / D (500GB or 1TB SSD enabled for LR modes)
SSD	None / 500GB / 1TB / 2TB
Memory	08 (8GB) / 16 (16GB) / 32 (32GB)
Color / Mono	C (Color) / M (Mono)
Resolution	Q = Quad HD (2560 x 2048) (HS5)/ H = Full HD / (1920 x 1080) (HS7)
Model	HS5 / HS7 / (more to come)

Figure 1-2: HS Controller

HS Controller

The HS camera system comprises a camera and a dedicated camera controller that provides for setup, network connectivity, mass storage, and display for recording and playback. (No additional computer is required.)

The controller also provides a Linux platform for communication, imaging, analysis and productivity applications.

The HSC-FN5 controller shown on this page is an Intel i5-based computer with an added high-performance fiber optic camera interface.

Table 1-3: Controller Models

Controller	Standard Memory	Standard SSD	Memory
HSC: Mini i5	16GB DDR-4	1TB SATA	16GB

Other standard models TBD, custom options may be available

Table 1-4: Controller Part Number Legend

HSC-FN5L161TB

Component	Options / Description
SSD	1TB SATA
Memory	16GB system memory
OS	"L" option= Linux
Model	i5 / i7
Series	FN / HN
Product	HS-Series Controller

Table 1-5: Controller Features and Software

Hardware Features (effective 4/22)

- SWFiber optic camera connection
- 2x HDMI 2.0b & 2x DP1.4a
- 3x USB 3.2 (10Gb) 2x USB4 (40G)
- 2x Thunderbolt 4 (40Gb)
- 2.5 Gigabit Ethernet (10Gigabit via TB4)
- WiFi 6 & Bluetooth 5.1

Pre-loaded Software (see Chapter 3: page 20)

- FASTEC FasMotion camera control software
- ImageJ open source imaging software
- VLC media player
- LibreOffice Suite
- Team Viewer
- Firefox
- GNU Image Manipulation Program (GIMP)

1-2 HS Controls, Indicators, and Connectors

Table 1-6: Camera Part Locations

Camera	Location(s)
MFT Lens-Mount (with electronic control)	Front
Lens Release Button	Front
1/4-20 Tripod Mounts	4 total: top, bottom, and each side
I/O Connectors (Micro BNC push-pull Male)	Right Side
Power Button with LED	Right side, below I/O ports
Trigger Button with Status LED	Right side, above I/O ports
Power Connector	Right side, below power button
High-Speed Interface (Type B Optic with MPO Connector)	Right side, above trigger button

Figure 1-3: HS Back View

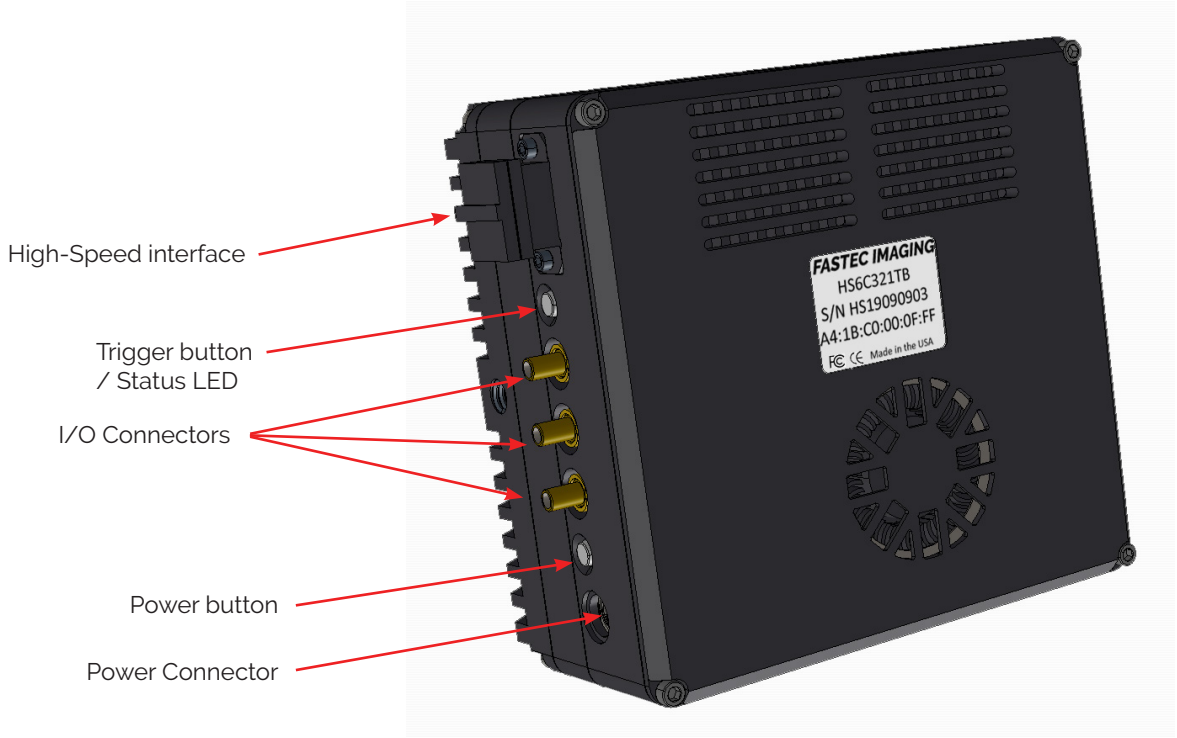


Figure 1-4: HS Front View

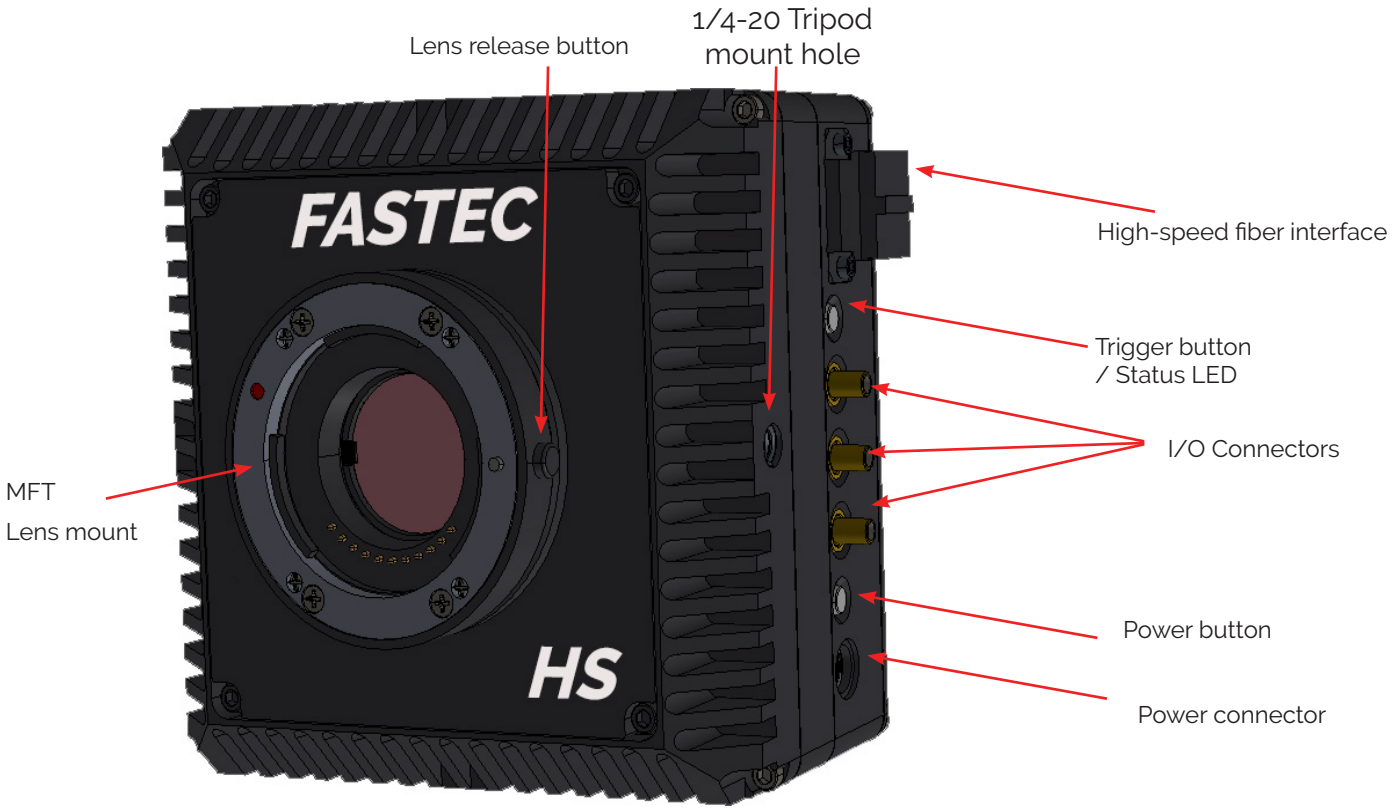


Figure 1-5: HS Top View

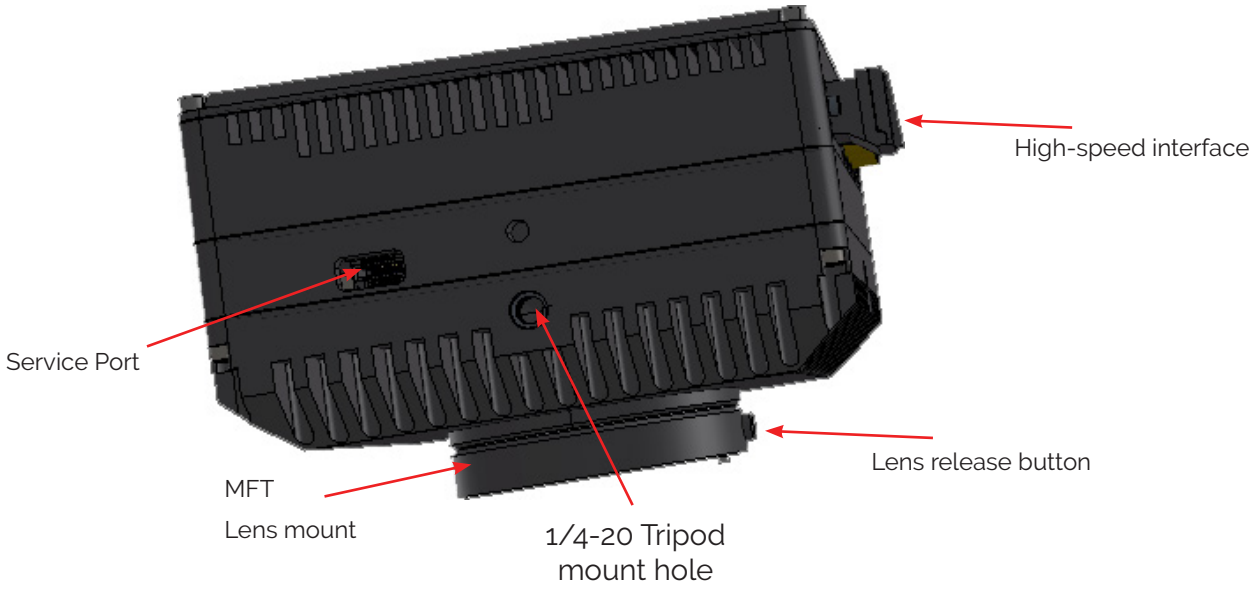


Table 1-7: Controller Part Locations

Controller	Location(s)
USB 3.2 (Type A Connectors)	Front; Back
Power Switch and with LED	Front
19V Power Inlet	Back
HDMI Connectors	Back
2.5 Gigabit Ethernet Connector	Back
Thunderbolt 4 via USB C	Back
High-Speed Interface (Type B Optic with MPO Connector)	Back

Figure 1-6: Controller Front

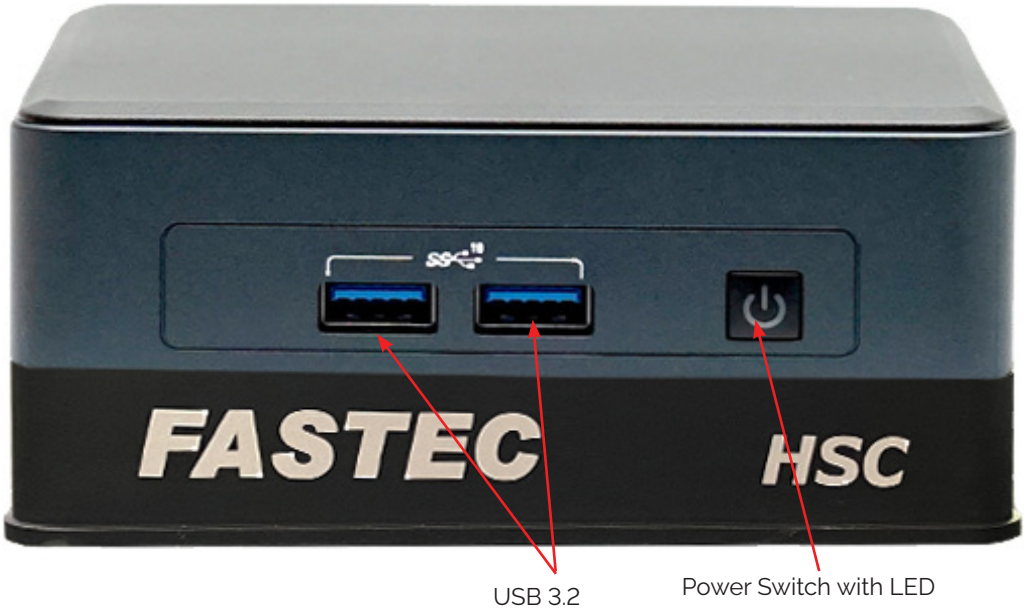
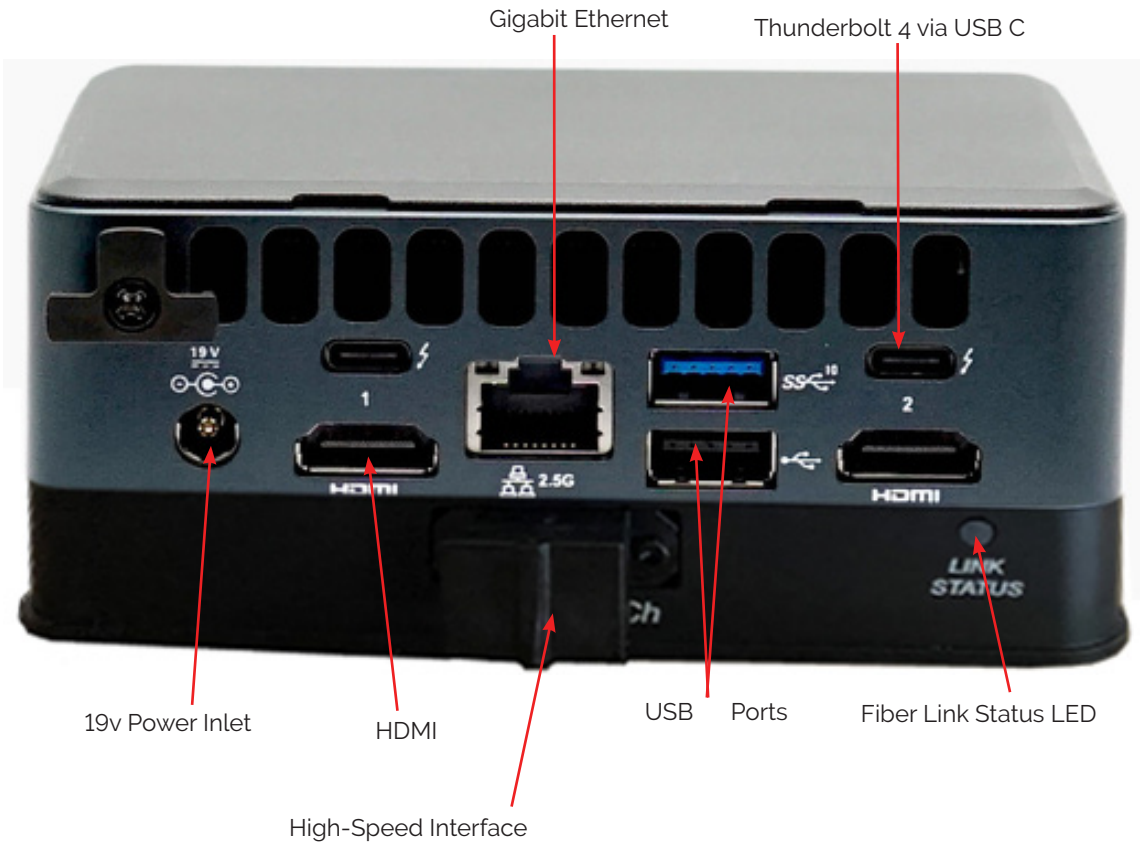


Figure 1-7: Controller Back



2 Getting Started

2-1 Unpacking the Camera

[Fastec Unboxing Video]

Table 2-1: Package Contents: Part	STD	OPT
HS Camera	X	
HS Controller	X	
MFT-Mount (factory installed and adjusted on the camera)	X	
C-Mount (factory installed option)		X
DC Power Supply-- 110/220VAC for Camera	X	
DC Power Supply-- 110/220VAC for Controller	X	
I/O Cable (three)	X	
Bluetooth keyboard with trackpad		X
PC Display		X
High-speed portable SSD		X
Software (Installed)	X	
Documentation (on Linux desktop)	X	

Fastec or its distributors can provide accessory items, including lenses, lighting, displays, etc. required for camera operation according to each customer's particular application needs.

2-2 Installing the Lens

The camera is shipped with a Micro Four Thirds (MFT) lens adaptor installed and adjusted at the factory. To install an MFT-mount lens, follow these steps:

1. Select a MFT-mount lens for use with the camera.

NOTE: There are many MFT-mount lenses available. Call Fastec or your distributor for help with lens selection. Both manual and electronic lenses may be used. Control of focus, iris, and zoom for electronic lenses is featured in the Fastec Fas*M*otion software.

2. Remove the lens mount cover from the camera'. This is a cover that is installed at the factory to protect the camera optics and sensor from dust contamination.
3. Align the registration marker on the lens with the marker on the camera adapter.
4. Rotate the lens 90 degrees counter-clockwise until you hear a clicking sound.

NOTE: Limit the time between removal of the cover and installation of the lens. Dust could settle on the face of the sensor cover glass, degrading image quality.

For instructions on using the MFT Lens Control features, please watch the **Lens Control Tutorial.** New lens feature on version 3.3: **Focus Control**

2-3 Power

Attaching the DC Power Supplies

HS Camera and controller have their own separate power supplies that are clearly marked "Camera" and "Controller."

Table 2-2: HS Power Supplies

	Input	Output	Power Inlet
Camera	100-240V, 50-60Hz	12v DC 5.0A	IEC 320 C14
Controller	100-240V, 50-60Hz	19v DC 6.32A	IEC 320 C6

The HS camera will power up as soon as the power cord is attached. When powered on, the camera's fan will spool up to its highest speed. It will normally run at a lower speed once it communicates with the Controller.

NOTE: Always power up the camera before the controller to ensure proper communication.

The HS controller powers up upon pressing the on/off button.

The power buttons on both the camera and controller use the same blue logo.

Figure 2-1: Camera Power button

Figure 2-2: Controller Power button

2-4 HS Memory and Mass Storage Options

The HS camera is equipped with 8GB, 16GB, or 32GB of internal high-speed internal memory that can be partitioned for one or more image sequences. Images stored in this memory may be reviewed on the Controller or PC, then saved to any mass storage device:

1. Internal Solid State Drive in the Controller (recommended only for limited testing)
2. Internal Solid State Drive in the Camera (if installed).
3. External drive connected via USB or Thunderbolt ports on the Controller (highly recommended)
4. Mass storage device on any network-connected PC

2-4 HS Controller Setup

HS Cameras may be run directly from their Controllers in what we will call a stand-alone system, or from a PC connected to the Controller via a network connection.

NOTE: the HS Controller runs on Linux. Confirm compatibility before purchasing peripherals.

Local Stand-Alone System Components:

- Fastec HS Camera + Power Supply
- Fastec HS Controller+ Power Supply
- Display
- Keyboard + pointing device

Networked System Components:

- Fastec HS Camera+ Power Supply
- Fastec HS Controller+ Power Supply
- Network infrastructure
- PC with FasMotion installed

HS Camera to Controller connection is accomplished with a 12 Channel Type B Fiber Optic patch cable with MPO connectors,

The cable comes with dust caps that should be kept on hand in case the camera is disconnected at any time. It is important that the cable ends are free of any contamination.

Cable ends are keyed and only fit in one orientation. The cable connectors and receptacles on both the Camera and Controller have white dots to help assure the orientation is correct.

The connectors should fit in very easily and click securely into place as shown in Figure 2-4.

Power Connections

Apply power to the camera before booting the Controller.

The Controller will automatically open Fas*M*otion in full screen mode, which will obscure the desktop. Exit full screen mode from the Fas*M*otion Window menu.

Figure 2-3: HS Camera Cable

Figure 2-4: Fiber Connection on HS Camera

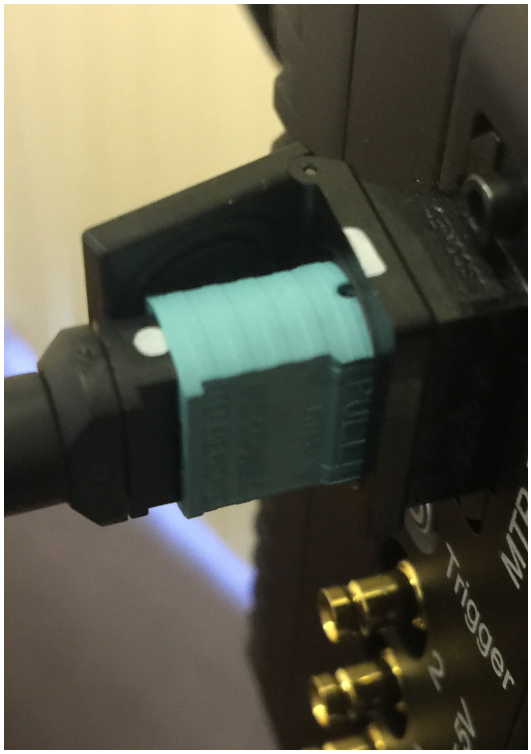


Figure 2-5: HS Stand-Alone System

HS Controller to Display connection may be HDMI or any interface adapter compatible with the USB Type C port. This could include VGA, DVI, HDMI, Display port, etc.

Touch enabled displays are supported on the Controller and can be a convenient way for setup and control of the system.

HS Controller to Keyboard and pointing device connection may be USB or Bluetooth. For initial setup it is easiest to use USB devices.

For Bluetooth devices, pairing is easily done through the Bluetooth dialog that opens when you click on the Bluetooth icon on the Task Bar.

Figure 2-6: Controller Bluetooth Pairing

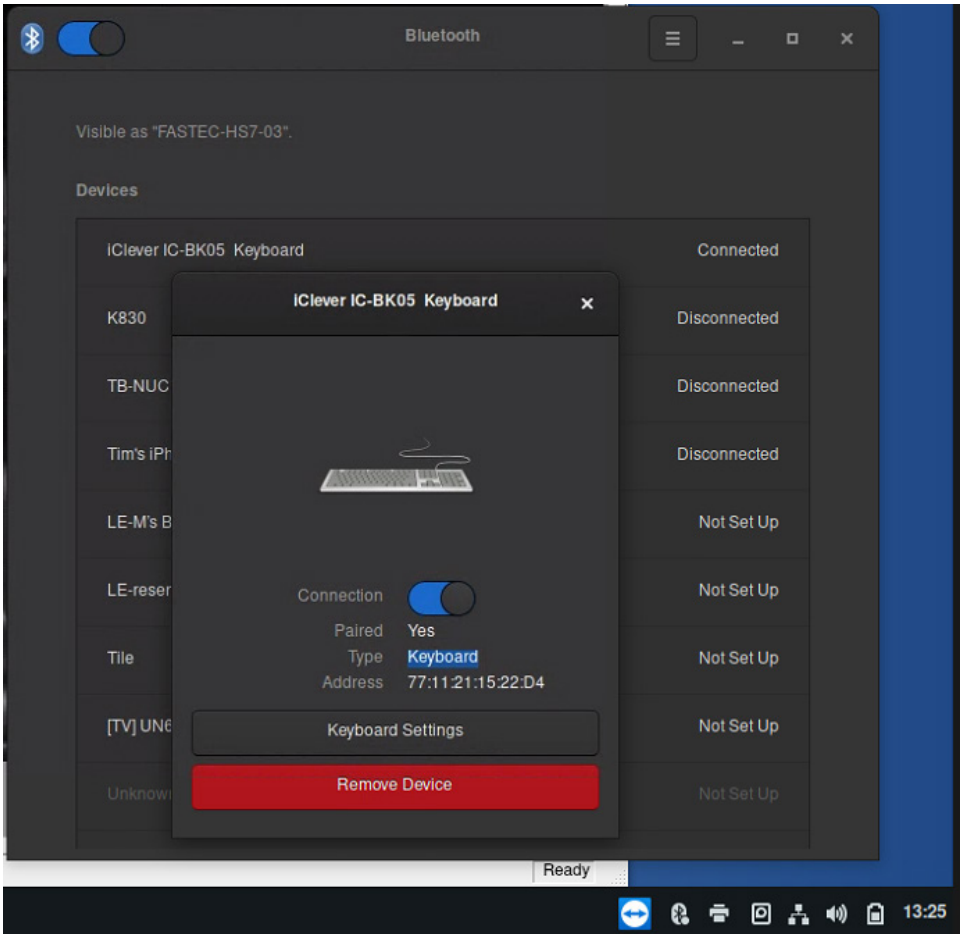
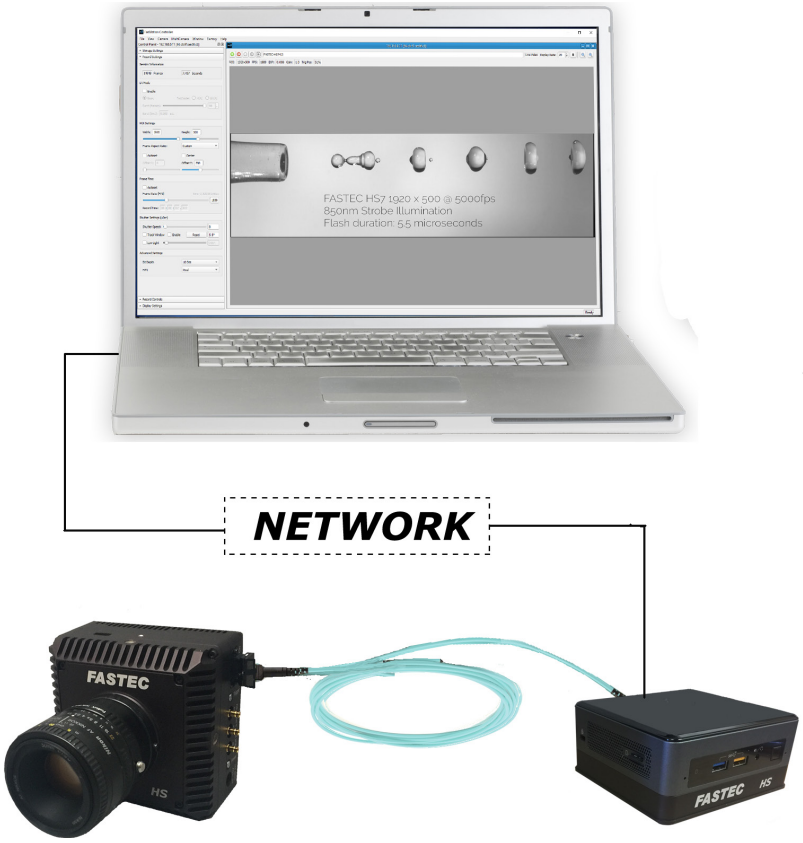


Figure 2-7: HS Networked System



The HS Controller Network Connection is highly flexible. The Controller has an onboard 2.5 Gig-E interface as well as a WiFi 6 interface.

Additionally, there are 3 USB 3.2ports and two Thunderbolt 4 ports, any of which may be used for the addition of network interfaces.

The Thunderbolt interface may be cabled directly to a Thunderbolt port on a PC or Mac for 10Gig Ethernet without any additional adaptors.

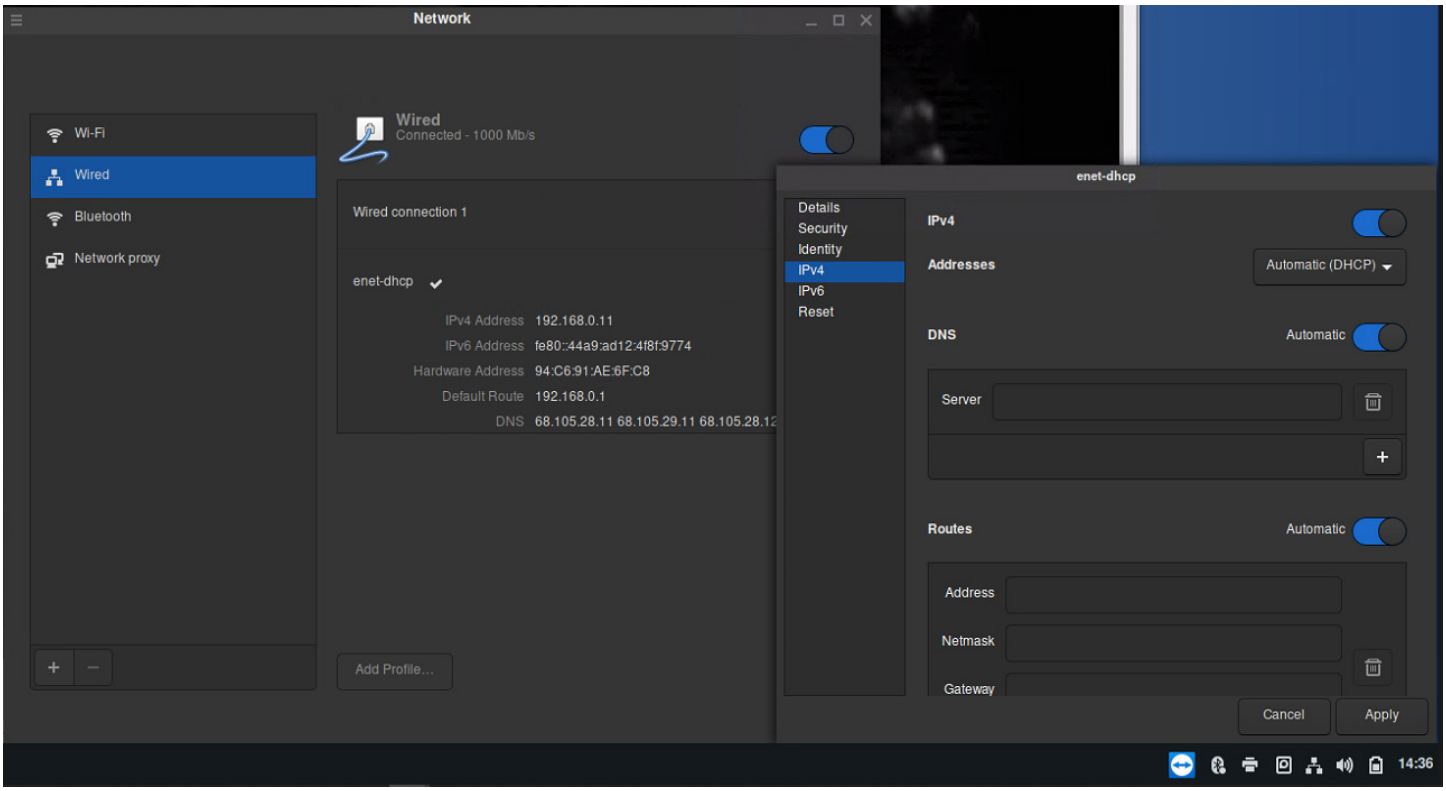
The default setting for the Controller is DHCP on the wired Ethernet interface. The WiFi is disabled.

These settings are easily changed. The network setup utility on the Controller opens upon clicking on the network icon on the Task Bar.

Once a network connection is established, any PC on the network running FasMotion.

Please refer to the FasMotion Manual for more details about running FasMotion from a networked PC.

Figure 2-8: Network Setup on the Controller



2-5 External I/O Connections

There are three External I/O connections on HS-series that may be configured for Arm, Sync, or Trigger for controlling or synchronizing the camera.

Instructions for setup and usage of these ports is covered in the Fas*M*otion manual.

Three 1-foot DIN to BNC (female) cables are supplied with each camera.

These cables were chosen for use with the HS-series cameras because of their superlative electrical properties and small size. They are very popular on high-end camera systems for those reasons.

These are push-pull cables and are very easy to connect and disconnect.

Before connecting, take a look at the connectors. On the cable end, you have the male connector. The pin is very small and may be difficult to see without magnification. It looks like a small dot in the image, below. The camera connector (female) has a small tube, which is also difficult to see.

Connecting:

- Hold the cable loosely by the heat-shrink tubing just below the connector.
- Gently align the cable with the connector by feel. (This should be very easy!)
- Gently push the cable into the connector until you hear a soft click.
- Pull gently on the cable using the same grip to confirm that it is coupled.

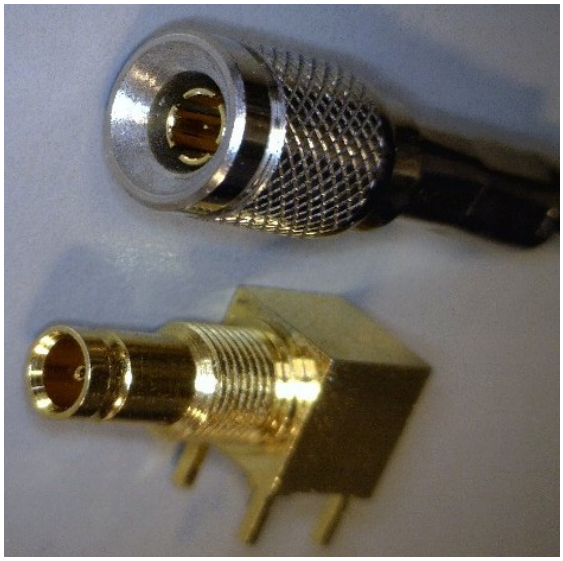
It takes very little pressure to make the connection when the connector is properly aligned. **Forcing the connectors may damage them!**

Disconnecting:

- Hold the cable by the knurled portion of the connector.
- Gently pull the cable away from the camera. The cable should disengage with very little effort.

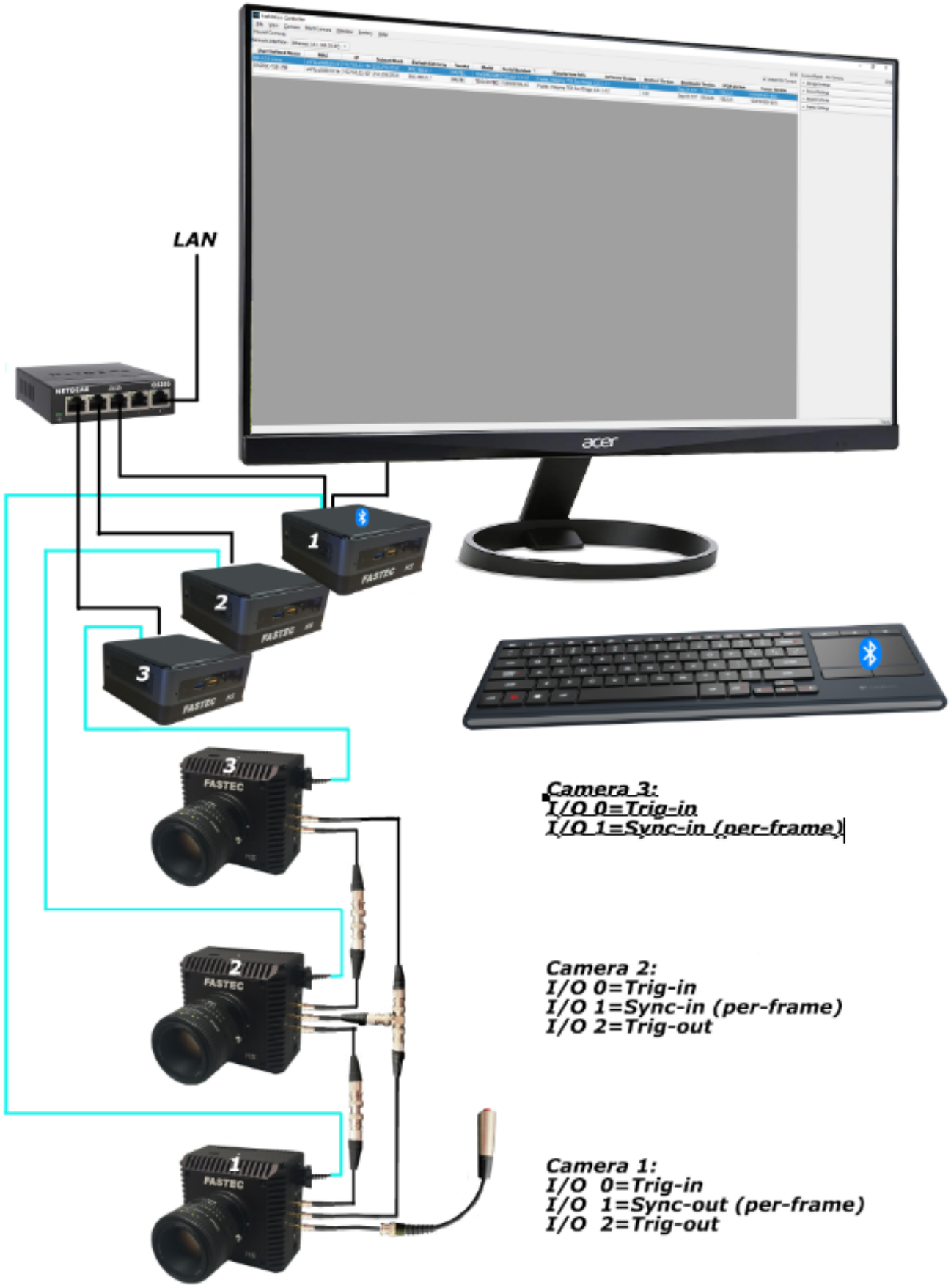
Figure 2-9: External I/O Connections

Figure 2-10: DIN 1.0/2.3 Connectors



2-6 Multiple Camera Setup

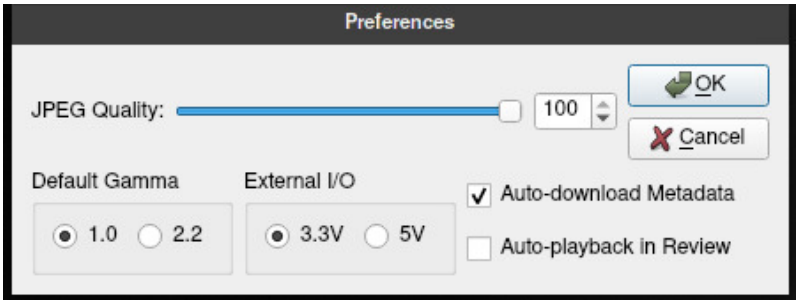
Figure 2-11: Synchronized Multi-Camera Example



"Figure 2-9: External I/O Connections" on page 12 depicts a typical 3-camera HS system with trigger and frame synchronization. In this example, camera 1 serves as the "master" and cameras 2 and three serve as "slaves."

- All three camera views will be available in one instance of Fas*M*otion.
- If the three cameras are the same model, camera parameters may be locked (see the Fas*M*otion manual for details).
- There is no imposed limit on the number of cameras that may be synchronized.

Figure 2-12: Camera Preferences



I/O considerations:

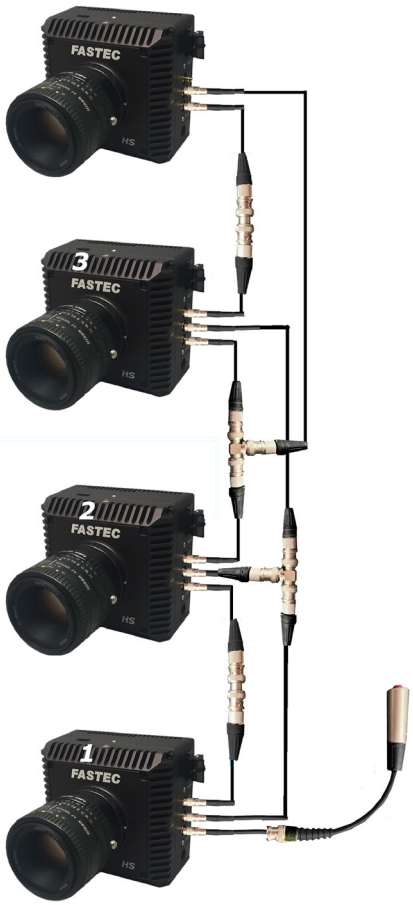
Camera I/O either 3.3v LVTTL or 5v TTL, selectable for each camera via FasMotion Camera Preferences.

Fan-out from the I/O transceivers would support 15 or more like devices, however it is not recommended to gang more than two inputs to one signal on larger camera networks for troubleshooting purposes. (It is much easier to find a shorted connection in a daisy chain (serial connection) than in a fanned (parallel) connection.

In the four-camera example, we have chosen to gang the syncs together for cameras 2 and 3, while we gang the triggers together for cameras 3 and 4.

We try to avoid ganging multiple cameras to trigger switches if there is any possibility of bounce. The trigger input of camera 1 will eliminate any such bounce and deliver a clean signal going forward.

Figure 2-13: Four Camera Sync Example



Camera 4:
I/O 0=Sync-in (per-frame)
I/O 1=Trig-in

Camera 3:
I/O 0=Trig-in
I/O 1=Sync-in (per-frame)
I/O 2=Sync-out (pass thru)

Camera 2:
I/O 0=Trig-in
I/O 1=Sync-in
I/O 2=Trig-out (pass thru)

Camera 1:
I/O 0=Trig-in
I/O 1=Sync-out (per-frame)
I/O 2=Trig-out

3 Installed Software

This is a high-level guide to the software applications found on the HS controller. It is not an exhaustive list, but will point you to a few things that will be useful when using the camera system..

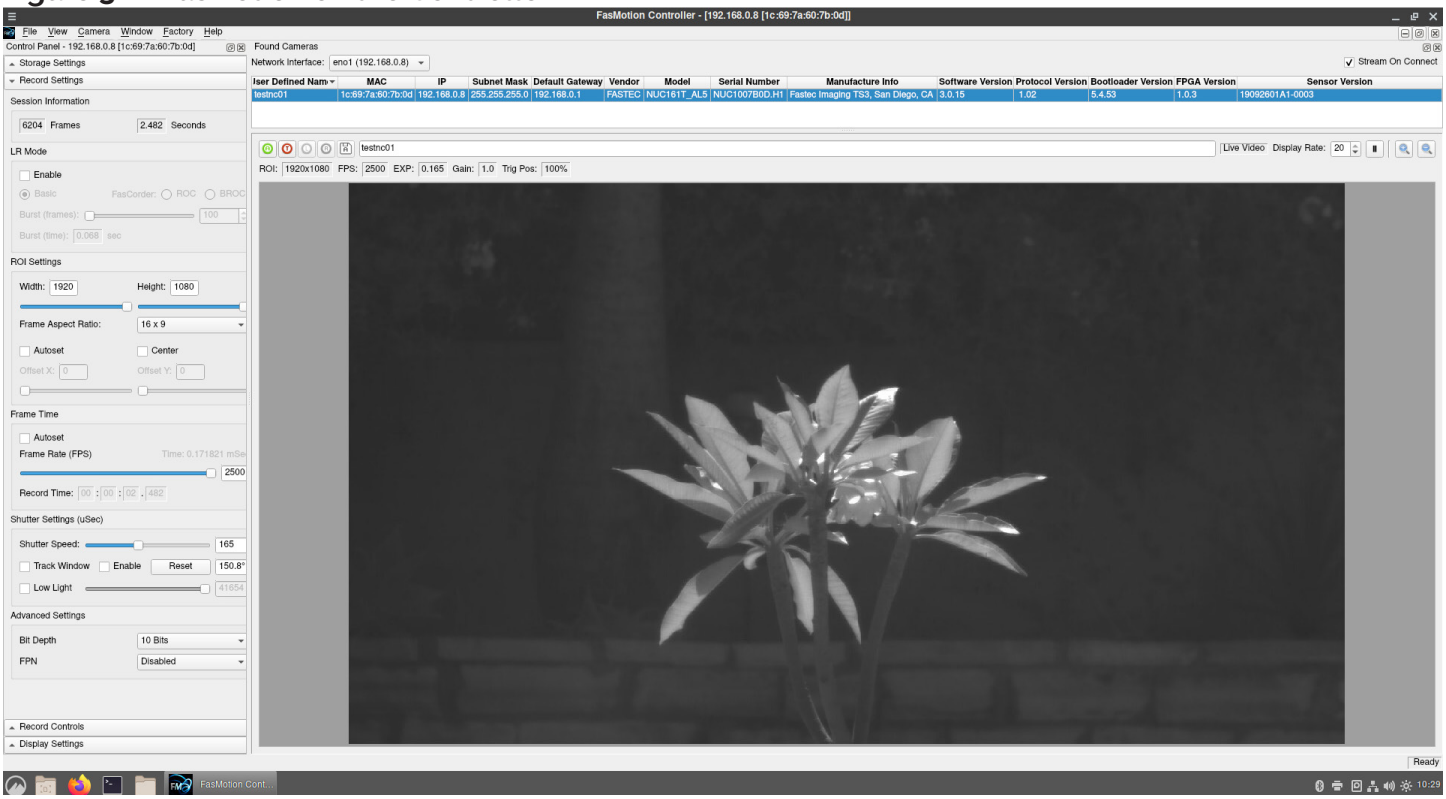
3-1 Fas*M*otion

Fas*M*otion software opens by default when the system is powered up. FasMotion is used for:

- Setting the camera recording mode and parameters such as record buffer size, resolution, frame rate, exposure, trigger mode and trigger position
- Setting up I/O parameters, including I/O voltage, trigger In/Out, Arm In/Out, frame Sync In/Out, polarities, etc.
- Playback of captured video from the camera and from stored image files
- Saving captured video in many formats to mass storage devices

Please refer to the Fas*M*otion Manual for details.

Figure 3-1: FasMotion on the Controller



3-2 Cinnamon Desktop

Upon closing or minimizing Fas*M*otion, the Controller desktop becomes visible.

The HS controller comprises a small, but powerful PC running Arch Linux with a Cinnamon desktop.

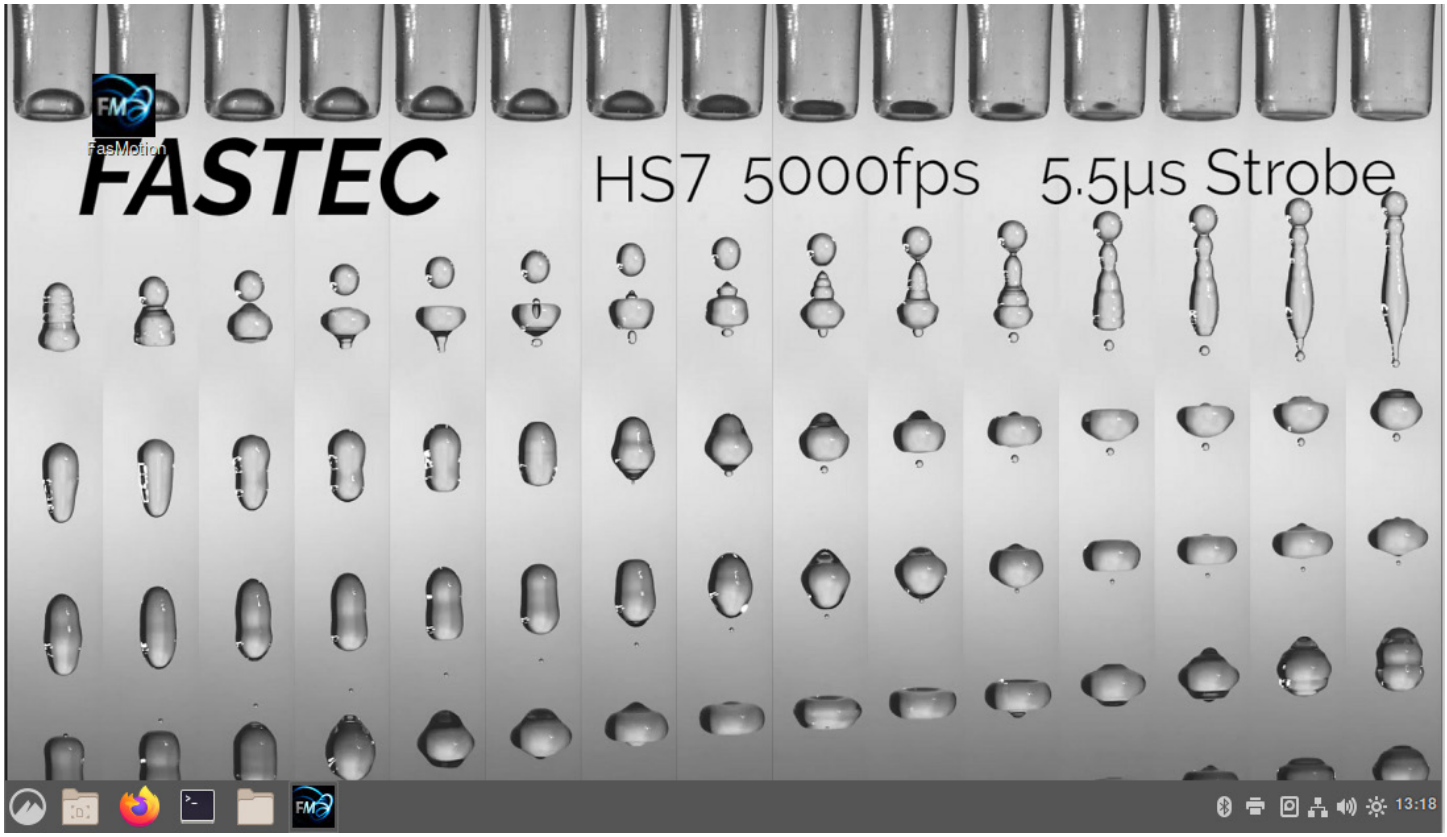
If you are familiar with the Windows environment, you will acclimate to the Cinnamon desktop very easily.

While it is highly customizable, it is also very well organized and intuitive.

Figure 3-2 shows the initial configuration of the HS Controller Cinnamon desktop. The desktop image is easily changed via a context menu. The task bar may be moved to top, bottom, left, or right side and may be set to auto-hide. Note the familiar icons on the task bar.

The Cinnamon icon in the lower left of Figure 3-2 is used to open the Start menu.

Figure 3-2: Cinnamon Desktops



The default organization of the Start menu is in three columns.

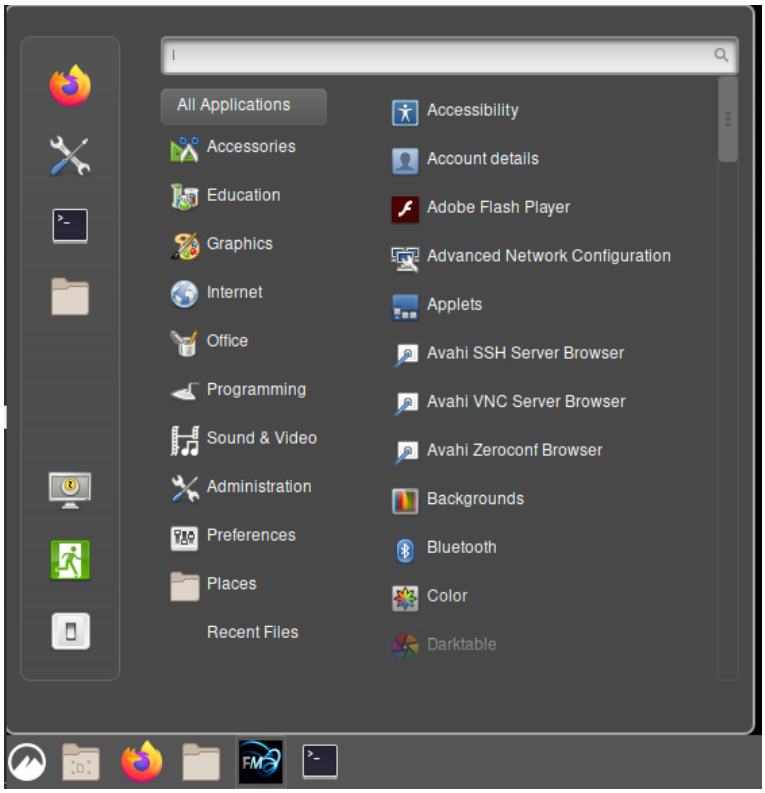
The first column are icons for frequently used items.

The middle column is a set of application categories. On the bottom of this column, you will also find "Places," which helps you navigate to common folders, an Recent Files.

The third column is the list of applications in the chosen category.

All of this is configurable via a context menu. Right-click on the Start button and select "Configure..." You may decide which columns to view and what is included in them.

Figure 3-3: Start Menu



3-3 Featured Application Groups

You will find many useful applications on the Fastec HS Controller. Some of these are Linux versions of applications you are familiar with such as the Mozilla Firefox Web browser, TeamViewer, and ImageJ. Others May be new to you, but enough like familiar applications for you to be productive with them with very little effort.

Accessories

There are a few applications here that may come in handy, some of which are pretty obvious.

Disks is a disk utility for formatting, partitioning, editing, repairing, etc. and should be used with great caution!

Galculator is a calculator...scientific or basic

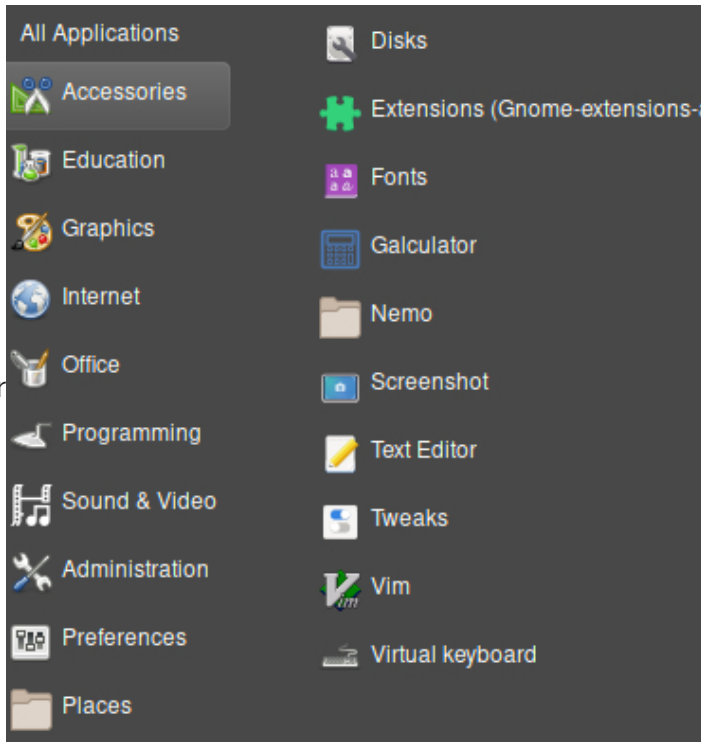
Nemo is a file explorer... a little different but easy to learn.

Tweaks is where you will find a lot of settings for appearance and behavior, including mouse and keyboard, startup applications, fonts, window behavior, etc.

Vim is an updated version of the Vi command-line editor.

Virtual Keyboard is just that, which is very handy if you find yourself needing to run the system without a keyboard.

Figure 3-4: Accessories



Graphics

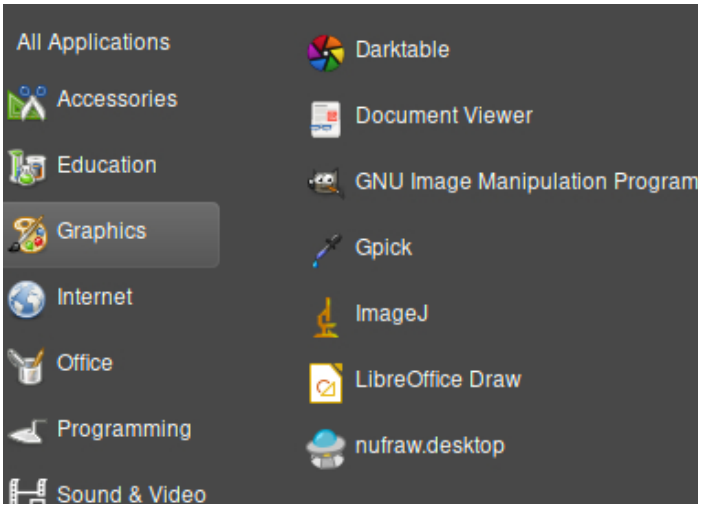
Darktable is an alternative for applications such as RawTherepee and Lightroom.

GNU Image Manipulation Program (GIMP) is an excellent image editor. It is open-source software that has been around for more than twenty years, so there is an active and healthy community supporting it.

Gpick is a color very good picker application.

ImageJ is another open-source application that has been around for a couple of decades. It is Java-based and was originally developed by the National Institutes of Health. There are a lot of image processing an analysis tools in ImageJ and a lot of plug-ins for doing all manner of image manipulations.

Figure 3-5: Graphics



LibreOffice Draw, part of the LibreOffice suite, is a diagramming application, excellent for producing technical drawings.

nUFRaw is an application for decoding and manipulating raw images.

Internet

Firefox is the default familiar Internet browser on the system.

TeamViewer is a popular application for remote desktop operation via the Internet. Fastec prefers using TeamViewer for support activities as it allows file transfers, text messaging, as well as desktop sharing and control.

TeamViewer is run on the Controller just as it is from a Windows machine. If you need help on your controller, the Fastec team will walk you through any setup and can give you a system demonstration in situ.

TigerVNC is another popular and very powerful application often used to open remote desktops on a network.

To use TigerVNC with the controller:

On your PC: Download and install the Tiger VNC server application on your PC. Information found at https://tigervnc.org/

On the Controller: Open a Terminal window on the controller and enter the command: vncserver <enter>

Run Tiger VNC on your PC. The application will ask for the IP address for the connection, which you can get from the Network Interface pull down in the Found Cameras pane of Fas*M*otion.

When you click on "Connect" VNC authentication will ask for a password. Use "fascam".

VNC opens a new and unique desktop for the controller, it does not mirror the controller desktop the way TeamViewer does. If Fas*M*otion is running on the Controller desktop, it must be closed before running Fas*M*otion on the VNC desktop.

Figure 3-6: Internet

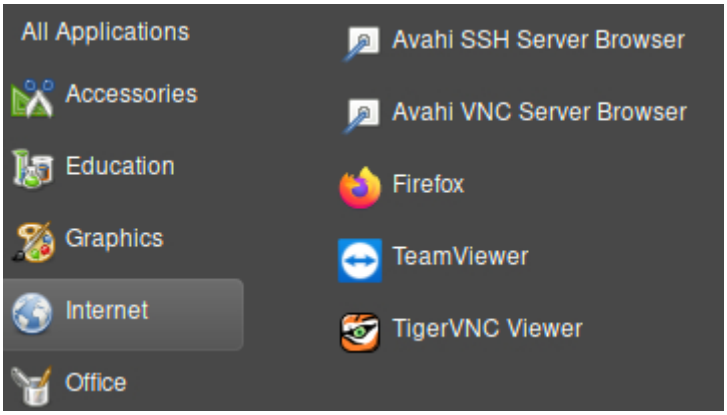


Figure 3-7: Controller eno1 IP Address

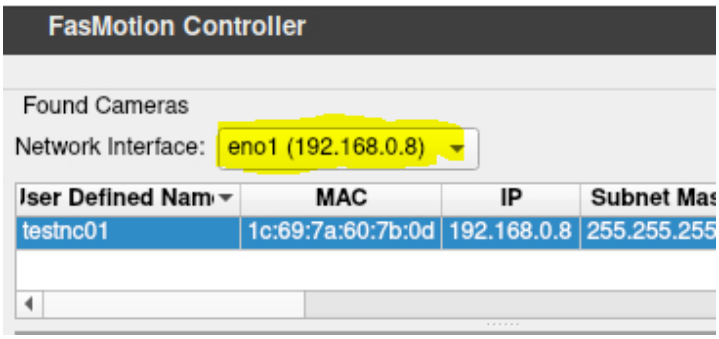


Figure 3-8: VNC Connection

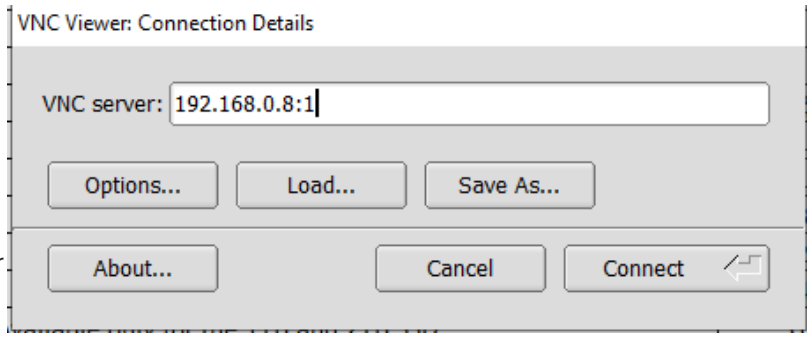
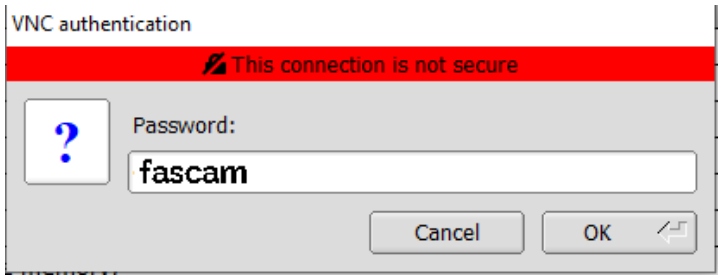


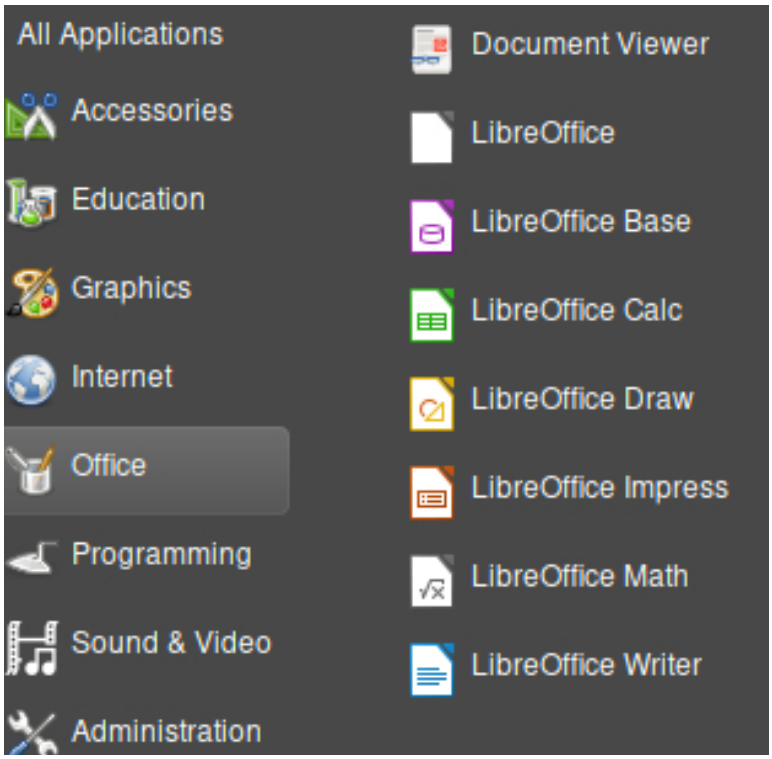
Figure 3-9: VNC Authorization



LibreOffiice Applications

The LibreOffice suite, much like the Microsoft Office suite, includes a group of very powerful productivity applications designed to provide day to day computing functionality we all rely on.

Figure 3-10: LibreOffice Applications



Document Viewer (Evince) is a basic viewer that opens XPS, TIFF, PostScirpt, PDF, DVI DjVu, and Comic Book documents.

Base is a desktop database front end, providing support for a wide of database engines, including MySQL/MariaDB, Adabas D, MS Access and PostgreSQL. In addition, the built-in support for JDBC- and ODBC-standard drivers allows you to connect to virtually any other existing database engine as well.

Calc is a spreadsheet application much like Microsoft Excel. It is compatible with many file formats and runs on many platforms. A detailed feature comparison is found here: https://wiki.documentfoundation.org/Feature_Comparison:_LibreOffice_-_Microsoft_Office

Draw is a diagraming application that can do most of the work you may be doing with Visio.

Impress is a substitute for PowerPoint. While fully capable of creating high-quality presentations, it does lack some of the animation and collaboration functions of PowerPoint.

Math is a formula editor that allows you to create mathematical and scientific formulas to be inserted into your documents.

Writer is the word processor application of LibreOffice. It is preferred by many over Microsoft Word because of its greater compatibility with popular formats. For example, you can directly edit pdf documents.

Sound and Video

Fas*M*otion is Fastec's control software for HS, TS, and IL-series cameras. It is also a stand-alone application for viewing and transcoding image stacks and videos recorded by these cameras.

mpv Media Player based on MPlayer and mplayer2, supports many video file formats as well as input URL types. The displayed controls are minimal, yielding little space away from the video display, but there are a host of keyboard controls as well as command line control available.

For much more information on this very powerful player: https://mpv.io/manual/master/

OBS Studio is an extremely handy application, designed for streaming and recording video directly from the display. This can be used for creating video demos with voice-overs for sharing with clients and colleagues.

VLC media player is a familiar and flexible player, capable of recording clips during playback.

Open Shot Video Editor is a simple video editor, good for editing and combining video clips and transcoding them to any one of many video formats. Audio tracks may be added and edited, but not created in this application.

Figure 3-11: Sound & Video

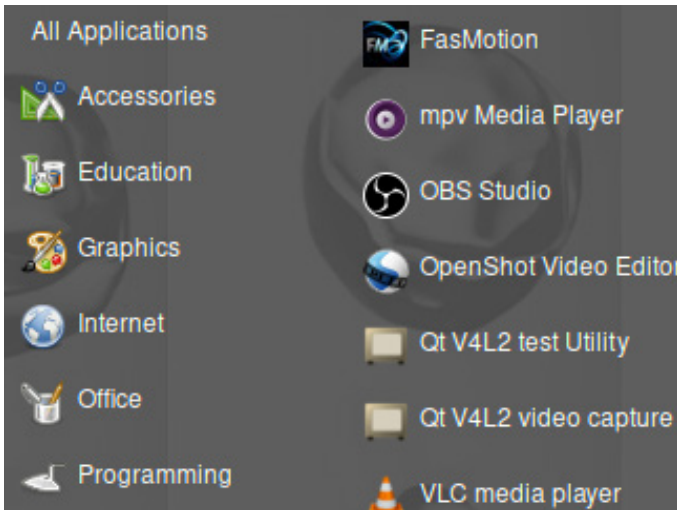


Figure 3-12: OBS Studio Application

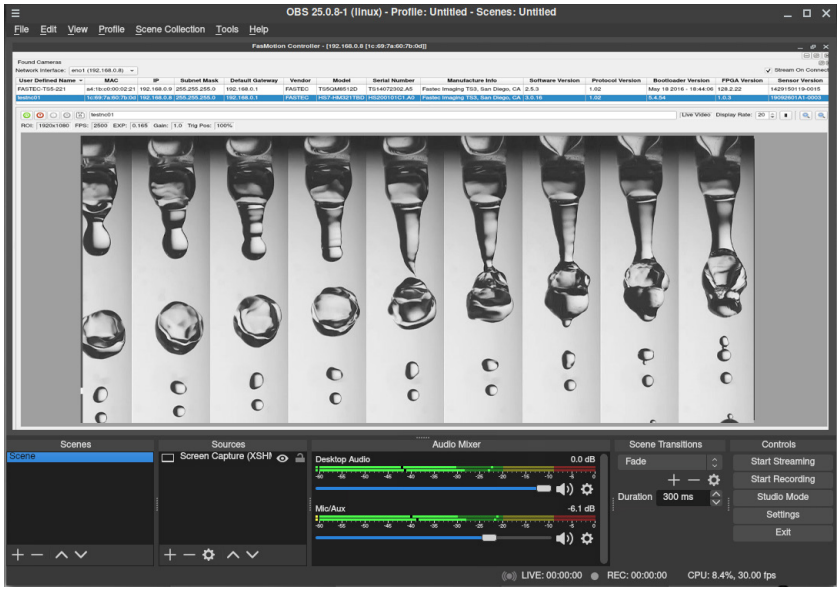
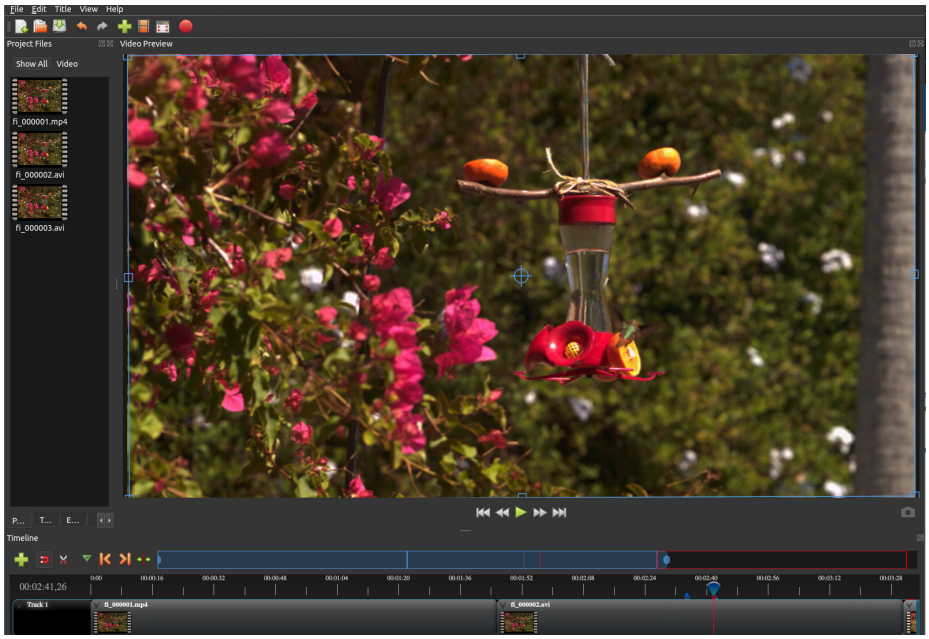


Figure 3-13: Open Shot Video Editor



Appendices

Appendix A: Definition of terms

Table 4-1: Definitions

Arm	Arming the camera begins recording: When armed, the camera will capture and write images into a partition of camera memory, and then overwrite it continually until it receives a trigger.
Arm/Record Bug	The Arm/Record Bug is the small graphic marker used in conjunction with the Record Bar to indicate the progress of the camera while acquiring pre- and post-trigger images.
AVI	Audio Video Interleave (AVI) is a popular multimedia container. (One file = many images.) Fastec AVI files may comprise JPEG or BMP images.
Backlight	The Backlight is the illumination used to light the LCD display on the camera.
Binning	Combining the outputs of multiple pixels on the sensor to produce one image pixel. 2 x 2 binning, for example combines two adjacent pixels on a row with the two pixels on the row beneath to produce one image pixel. In the IL5/TS5/HS5 the pixel values are averaged together, thereby decreasing noise.
Bit Depth	Images captured by the camera sensor are saved in binary form. Each pixel is given a binary 8-bit value from 0 to 255, 10-bit value from 0 to 1023, or 12-bit value from 0 to 4095. All numbers represent shades of gray from very dark to very bright. The operator has the option of saving a minimum of 8 bits per pixel for every image, or may save 10 or 12 bits, depending on the camera.
BMP Stack	BitMaP (BMP) files contain non-compressed image data. Each BMP file contains one image. The BMP Stack is a collection of frames, written as BMP files representing a captured video sequence.
Brightness	Linear image control that increases or decreases all pixel values without disturbing the slope of the response curve.
CinemaDNG	CinemaDNG is an open digital cinema format that uses the Adobe Digital Negative Specification (DNG), widely used as an archival format for Raw images. The specification is an attempt to standardize digital commercial video format thereby simplifying collaboration and workflow across the entertainment industry and all other industries dependent on digital video recording, i.e. automobile crash testing, military testing, etc.
Color Temperature	The Color Temperature of a light source is an assigned value that approximates a color match between it and the color radiated by an "ideal black body" at a specific temperature in degrees Kelvin (K). High color temperatures (above 6000K) are seen bluish, while lower color temperatures (below 3000K) are seen reddish.
Config.	Camera Configuration that can be saved and reloaded. Includes settings for Frame Rate, Resolution, Shutter Speed, Trigger, bit depth, and Auto Save.
Contrast	Linear image control that enhances the difference between pixel values by changing the slope of the curve, while maintaining the mean value.
Cursor	The cursor may be any graphic indication of where the current focus is within the user interface. This may be anything from a blinking vertical line as used within a dialog box when the user is entering text, or it may be a change in the color of a button as when navigating through menus.
DHCP	DHCP is a utility by which a server dynamically assigns IP addresses to clients on a network. When DHCP is selected in the Network Menu, the camera will allow a server on a connected network to assign it an IP address. In the absence of a DHCP server, cameras and PCs will assign themselves a "Local Link Address" in the format 169.254.xxx.xxx.
Download	Electronically transferring image data from a camera to a "remote" device, i.e. a PC or other mass storage.

Enable Raw	A raw image is one where image processing including colorization, white balance, brightness, contrast, and gamma, are all bypassed. Pixel correction may still be applied.
File Type	Digital files are commonly identified by their extensions. Familiar types include PDF, TXT, JPEG,TIFF, DOC, MP3, etc. Each of these files has a specified format that usually includes information in the file header and specially formatted data that applications on PCs, Cameras, Printers, Smartphones, and other electronic devices can read, write, and decipher for human viewing, editing, listening, etc.
Gain	In imaging the term Gain is most often used as a multiplier applied to a pixel value.
Gamma	Power curve often used to encode image data so that a picture viewed on a given display appears true to the human perception of the original scene. Nominally, a particular display may have decode Gamma of 1.0, common among laptops, or 2.2, common among larger LCD and LED displays.
HDMI	HDMI, High-Definition Multimedia Interface, is used to transmit digitized video (and audio) data from the camera to a remote display. This is a popular method for connecting consumer products such as televisions, cable TV boxes, DVD players, etc.
Image Memory	Image memory is the internal memory in the camera reserved for raw image data. This is "volatile" memory that is erased when the camera is powered down.
JPEG Stack	Joint Photographic Expert Group (JPEG) format is a compressed file format, capable of reducing image files to a fraction of the size of a BMP or lossless TIFF. The image quality of JPEGs may be excellent, depending on the level of compression used.
MP4 Video	MP4 is a multimedia container, popular for streaming characteristics. It may be highly compressed without loosing image quality.
Network	The camera may be connected to one or more computers via its RJ45 GigE (Gigabit Ethernet) connection.
NTP Time	Network Time Protocol: Network Protocol for synchronizing time clocks of devices attached to a given network or internet, within a few hundredths of a second.
Play/Review Bug	In Review there is a progress bar that graphically indicates the position of the currently viewed frame within the image sequence. The small vertical line that is used as the indicator is referred to as the Review Bug.
Record	The camera is acquiring images and storing them in internal memory. This begins when the camera is armed, and ends after a trigger is received.
Refresh Rate	Rate at which image data is re-painted on the display. For CRTs this is analogous to the vertical frequency.
Review	Review is a camera utility for viewing image data while it resides in camera memory. It includes options for playing the imagery as a movie, forward or backward, or stepping through the frames one at a time. It also allows the user to adjust starting and ending points for an image sequence for viewing or saving. The user may adjust image properties such as brightness, contrast, gamma, color balance when reviewing the images. It is important to note that image adjustments made while using Review do not alter the image data in camera memory although they do alter the viewed and saved images.
Save	Moving image data from a camera's internal memory to some other mass storage device. This mass storage may be local, such as the SSD drive within the camera, or remote, such as a PC.
SD	This is Secure Digital memory, such as the SD-card used as a plug-in mass storage device for the camera.

SSD	Solid State Drive. This is a non-volatile mass storage device retains its data when powered down. SSDs may be installed in cameras or computers, or may be external.
Static IP	In order for one networked device to "talk" to each other, they need to have compatible IP addresses. One way to assure this is for the user to assign unchanging (static) IP addresses to each device.
Status Menu Bar	The Status Bar is a line of text at the bottom of the display that appears when the camera menus are turned on.
Sub Menu	Within each Menu, there may be additional Sub Menus from which to select.
TIFF Stack	Tagged Image File Format (TIFF) is a more flexible format than the BMP, in that it may be used for 8-bit, 10-bit, or 12-bit image stacks. 8-bit image data is saved 1 byte per pixel for mono images and 3 bytes per pixel for color images. 10- and 12-bit image data is always saved using 2 bytes per pixel (raw enabled), without any contrast, gamma, brightness or color interpolation applied.
USB	A thumb drive or some other mass memory device may be attached via the USB port of the camera.
USB OTG	When a PC is connected to the USB OTG (USB On The Go) port of the camera, FAT-32 formatted camera mass storage devices become accessible to the PC. This can be an effective way to transfer a limited number of images or video files from camera media to PC.
Web Application	Camera control software that runs via web browser such as Windows Internet Explorer, Safari, Firefox, etc.
White Balance	Many different kinds of illumination may be used with high speed cameras. Typical color temperatures for common types of illumination are used to compute RGB gains, which, when applied to captured imagery, should approximate what a human would perceive as accurate color. The term White Balance refers to the idea that, presented with a white card under a given light source, the camera should produce a white image.

Appendix B: HS Camera Specifications

Table 4-2: HS5 Specifications

Sensor	12-bit 5MP CMOS sensor with 5µm square pixels, color or mono
Sensor Modes	Standard; binning 2x2, 4x4; sub-sampling 2x2, 4x4; combination 2x bin + 2x sub
Minimum Frame Rate	24fps
Maximum frame Rate at Maximum Resolution	QSVGA 2560 x 2048 @ 253fps
Maximum Frame Rate at Minimum Resolution	64 x 32 @ 29,090fps
Light Sensitivity	1600 to 12,800* ISO monochrome; 800 to 6400* ISO color (depending on gain and bit selection)
Electronic Shutter	Global electronic shutter from 3µsec to 41.654ms

Table 4-3: HS7 Specifications

Sensor	10-bit 2MP CMOS sensor with 10µm square pixels, monochrome
Minimum Frame Rate	24fps
Maximum frame Rate at Maximum Resolution	Full HD 1920 x 1080 @ 2500fps
Maximum Frame Rate at Minimum Resolution	64 x 64 @ 35,168fps
Light Sensitivity	6400 (Monochrome)
Electronic Shutter	Global electronic shutter from 3µsec to 41.654ms

Table 4-4: General Camera Specifications

Mechanical Shutter	Automatic mechanical shutter used for sensor calibration
Image Memory	8GB (std.); 16GB / 32GB (optional)
File Formats	Stacks – BMP, DNG, JPEG, TIFF, Tiff(raw); Video – AVI, MP4, CAP(raw); Still – JPEG
Lens Mounts	Micro Four Thirds (most other mounts supported with adapters)
External I/O Ports (DIN 1.0/23)	3 configurable: Trigger in/out, Sync in/out, Arm in / out; or data in. 3.3v LVTTL or 5vTTL.
Construction	Anodized machined aluminum housing
Power	10-26v @ 22W (max). Universal power supply included
Operating Environment	+5°C to +50°C
Size and Weight	4.5" W x 4.5" H x 3" D. 1Kg (2.2 lbs.).
Optional Features	
SSD Storage	Solid State Drive (SSD): 250GB, 500GB, 1TB, 2TB
Long Record	Streams uncompressed video to SSD

Appendix C: HS Controller Specifications

Table 4-5: Controller Specifications

Compatibility	All Fastec TS, IL, and HS cameras
Processor	10th Gen Intel® Core i5-10210U
Operating System	Arch Linux
HS Camera Interface	12 Channel Type B Fiber Optic patch cable with MPO connectors
Memory	16GB DDR 4
Disk Drive	1TB NVMe SSD
SD card slot	SDXC (UHS-II)
USB Type-A	3x USB 3.1 Gen2 (10Gb/s)
USB Type-C	2x USB 3.1 Gen2 (10Gb/s) - one charging
Thunderbolt	Thunderbolt 3 (Alt-DP) on USB Type-C port
Video	HDMI 2.0a (4K), USB Type-C Display port (up to 3x 4K @ 60Hz)
Wireless	Intel® Wi-Fi 6 AX200, 2x2, Intel® Bluetooth 5
Gibabit Ethernet	Intel® Gigabit LAN i219-V
Size and Weight	4.5" W x 4.5" H x 2.125" D. 1Kg (2.2 lbs.).
Optional Features	
Memory Upgrade	32GB, 64GB
SSD Upgrade	2TB NVMe SSD
High-speed Portable SSD	500GB, 1TB, 2TB
External	BMP, TIFF, JPG, AVI, TIFF (RAW), DNG, CAP
Lens Mount	Micro Four Thirds (most other mounts supported with adapters)
Display	Portable Monitor with touch
Keyboard	Foldable Bluetooth Keyboard with Trackpad

Appendix D: HS7 Record / Resolution Tables

This table presents a sample of frame rates, resolutions, and record times available on HS7 cameras. Resolutions may be set in 4-pixel increments between the minimum resolution, 64 x 64, to the maximum, 1920 x 1080.

In Standard Mode, maximum frame rate is dependent on vertical resolution only. Maximum frame rate at a vertical resolution of 64 is 35168fps (regardless of horizontal resolution). Maximum frame rate at the maximum vertical resolution of 1080 is 2500fps.

Table 4-6: HS7 Std Mode Resolutions and Frame Rates

Sample Resolutions	Maximum Frame Rate	8-bit Recording	10-bit Recording
		Time	Time
1920 x 1080	2500 fps	2.48	1.86
1920 x 512	5200 fps	1.68	1.26
1280 x 1024	2634 fps	2.49	1.86
1280 x 720	3726 fps	3.54	2.65
1280 x 384	6874 fps	2.54	1.90
800 x 600	4455 fps	4.01	3.01
768 x 512	5200 fps	4.2	3.15
768 x 256	10136 fps	4.31	3.23
640 x 480	5537 fps	5.05	3.77
512 x 384	6874 fps	6.35	4.75
512 x 256	10136 fps	6.46	4.84
256 x 124	19158 fps	13.6	10.12
124 x 64	35168 fps	30.52	22.58

In Long Record Mode, maximum frame rate for the higher resolutions is dependent on the capabilities of the camera's built-in SSD, while the maximum at lower resolutions is held to 5000fps.

Table 4-7: HS7 LR Mode Resolutions and Frame Rates

Sample Resolutions	8-bit Recording/ 512 GB Session		10-bit Recording/ 512 GB Session	
	Maximum Frame Rate	Time	Maximum Frame Rate	Time
1920 x 1080	723 fps	5:41	542 fps	5:42
1920 x 512	1525 fps	5:41	1144 fps	5:41
1280 x 1024	1144 fps	5:41	857 fps	5:42
1280 x 720	1627 fps	5:41	1219 fps	5:41
1280 x 384	3051 fps	5:41	2286 fps	5:41
800 x 600	3124 fps	5:41	2340 fps	5:41
768 x 512	3814 fps	5:41	2860 fps	5:41
768 x 256	5000 fps	8:41	5000 fps	6:31
640 x 480	4881 fps	5:41	3650 fps	5:41
512 x 384	5000 fps	8:41	5000 fps	6:30
512 x 256	5000 fps	13:01	5000 fps	9:45
320 x 256	5000 fps	20:49	5000 fps	15:34
320 x 64	5000 fps	1:23:05	5000 fps	1:02:10

Appendix E: HS5 Record / Resolution Tables

Resolutions are available in increments of 2 x 2 pixels from 64 x 32 (maximum 29090 fps) to 2560 x 2048 (maximum 253 fps) Minimum resolution in for the IL4 in Long Recording mode is 320 x 240. All are available via Advanced Settings on the camera GUI, the Web-App or Fas*M*otion software. Frame rates are available in 1fps increments from 24 fps to the maximum rate for any resolution and mode.

Table 4-8: HS5 Std Mode Resolutions and Frame Rates

Sample Resolutions	Bin*	Maximum Frame Rate	8-bit Recording	10-bit Recording	12-bit Recording
			Time	Time	Time
2560 x 2048		253 fps	6.47	4.85	4.04
2560 x 1440		359 fps	6.48	4.86	4.05
1920 x 1080		634 fps	6.53	4.90	4.08
1280 x 1024		991 fps	6.61	4.95	4.13
1280 x 720		1403 fps	6.64	4.97	4.15
800 x 600		1677 fps	10.66	7,.99	6.66
768 x 576		1746 fps	11.11	8.33	6.29
768 x 576	✓	2764 fps	7.02	5.26	4.38
768 x 256		3823 fps	11.42	8.56	7.12
768 x 256	✓	5910 fps	7.39	5.54	4.6
512 x 384		2590 fps	16.85	12.62	10.47
512 x 384	✓	4061 fps	10.75	8.05	6.68
512 x 256		3823 fps	17.12	12.82	10.64
512 x 256	✓	5910 fps	11.08	8.29	6.88
256 x 124		7507 fps	35.95	26.75	22.14
256 x 124	✓	11142 fps	24.22	18.02	14.92

Frame rates in LR mode for the HS5 are dependent on a combination of sensor capabilities and SSD bandwidth. For some high resolutions, where bandwidth is the limiting factor, the maximum frame rates vary with bit depth. At lower resolutions, sensor capabilities come into play and frame rates are consistent at all bit depths.

Table 4-9: HS5 LR Mode Resolutions and Frame Rates

Sample Resolutions	Bin*	8-bit Recording/ 512 GB Session		10-bit Recording/ 512 GB Session		12-bit Recording/ 512 GB Session	
		Maximum Frame Rate	Time	Maximum Frame Rate	Time	Maximum Frame Rate	Time
2560 x 2048		253	6:26	214	5:42	178	5:43
2560 x 1440		359	6:27	304	5:42	254	5:42
1920 x 1080		634	6:29	542	5:42	452	5:41
1280 x 1024		991	6:34	857	5:42	715	5:42
1280 x 720		1403	6:36	1219	5:41	1017	5:41
800 x 600		1677	10:36	1677	7:56	1677	6:37
768 x 576		1746	11:03	1746	8:17	1746	6:53
768 x 576	✓	2764	6:59	2542	5:41	2113	5:41
768 x 256		3823	11:21	3823	8:28	3823	7:05
768 x 256	✓	5000	8:41	5000	6:30	4755	5:41
512 x 384		2590	16:45	2590	12:32	2590	10:25
512 x 384	✓	4061	10:41	4061	8:00	4061	6:38
512 x 256		3823	17:01	3823	12:45	3823	10:35
512 x 256	✓	5000	13:01	5000	9:45	4755	8:30
320 x 124		5000	42;57	5000	32:05	5000	26:51

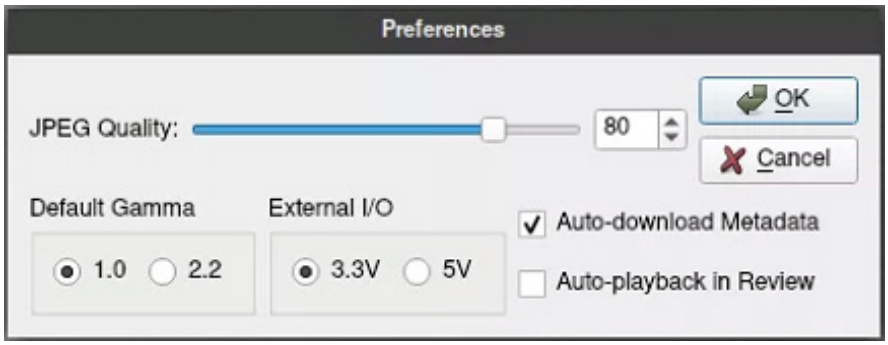
Appendix F: I/O Connections

HS cameras have 3 I/O ports, labeled 0, 1, 2 (see "Figure 4-2: I/O Dialog from FasMotion Record Controls" on page 30).

The Interface Schematic (Figure 4-3) shows the three identical ports. (All of the text in the schematic applies to each of the ports.)

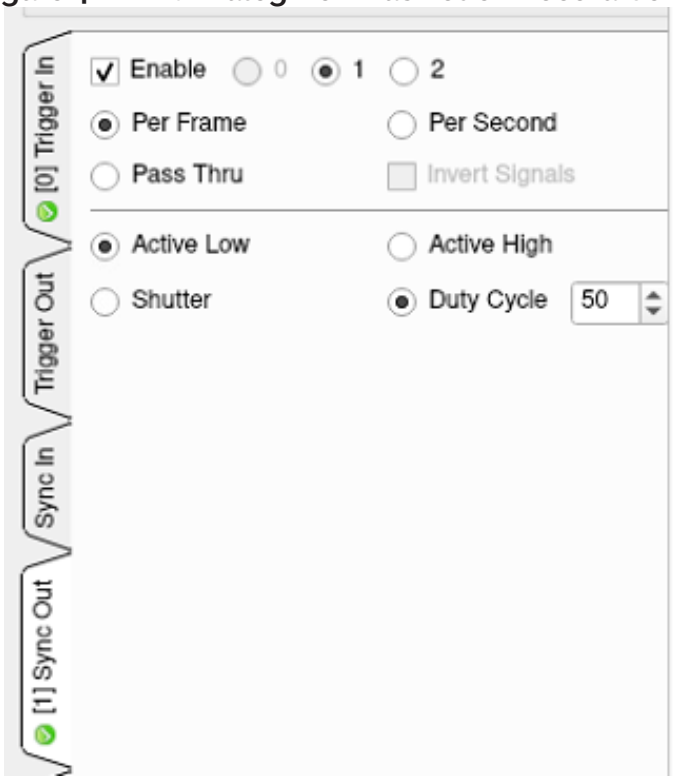
Note that the ports may be configured for either 5V or 3.3V. This is done via radio buttons in the Camera Preferences dialog in FasMotion from the Camera menu.

Figure 4-1: Camera Preferences Dialog



Any of these ports may be used as inputs for creating markers aligned and saved with per frame image data.

Figure 4-2: I/O Dialog from FasMotion Record Controls

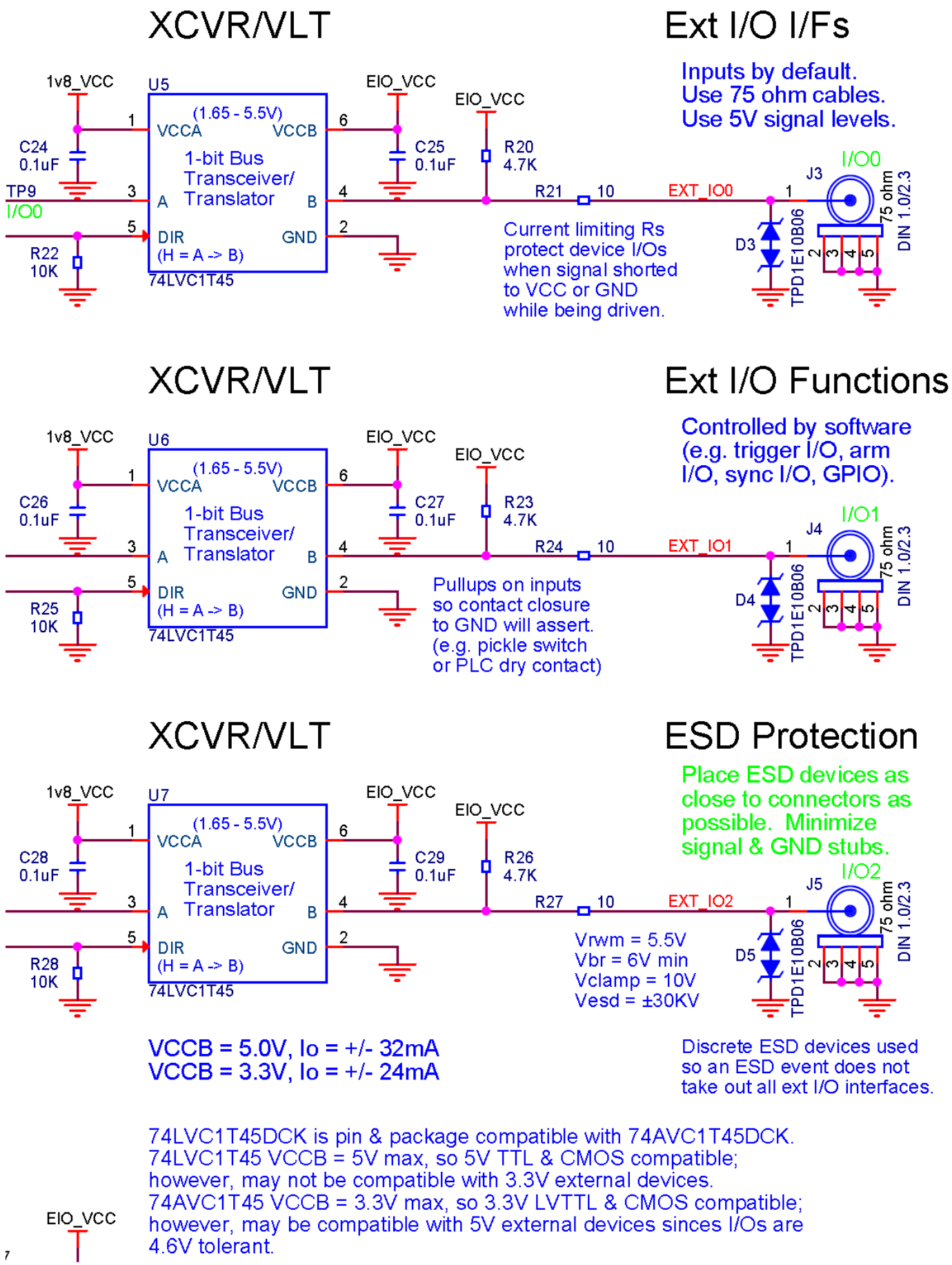


Ports not being used for marker data input may be configured for control I/O: Trigger-in, Trigger-out, Sync-in, Sync-out, Arm-in, or Arm-out. This is done via the bottom portion of the Record Controls tab of the FasMotion Control Panel:

1. Select the I/O function from the tabs
2. Enable the function using the check box.
3. Select the I/O port from the radio buttons at the top
4. Select the I/O parameters from the tab

See the FasMotion user manual for more details.

Figure 4-3: Sync I/O Camera Interface Schematic



For inputs greater than 5v:

PLCs and other devices that operate on higher voltage levels than the HS may be used for triggering and other I/O inputs with the proper conditioning circuit.

The output of the triggering device may be connected to the conditioning circuit in one of two ways, depending on whether the output is capable of sourcing or sinking ≥ 5mA.

The conditioning circuit also provides opto-isolation between the driving circuit and the camera. The opto-isolator adds about 2msec (0.002 seconds) of delay to the input.

The PLC Adapter is available directly through Fastec:

support@fastecimaging.com

(858) 592-2342

Figure 4-4: PLC to 3.3V Adapter Schematic

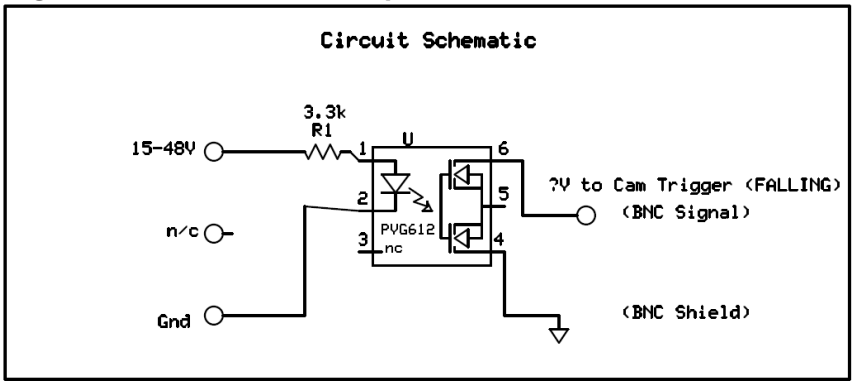


Figure 4-5: PLC 24V as Camera Trigger

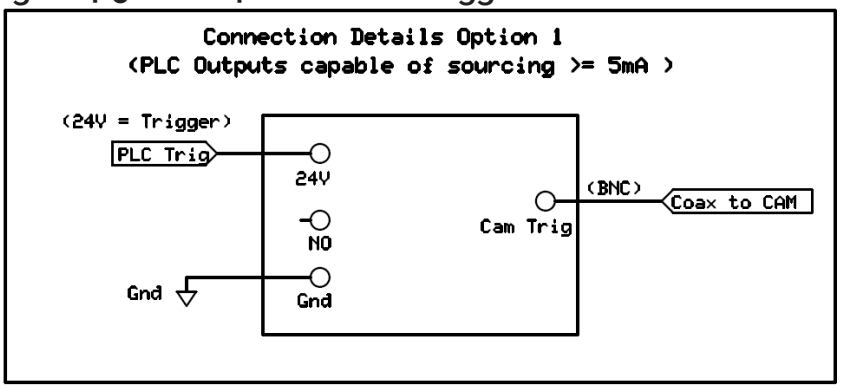
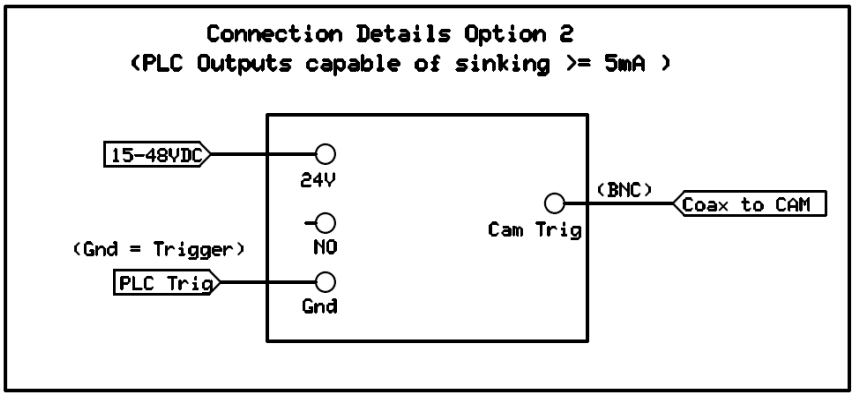


Figure 4-6: PLC Low as Camera Trigger



Appendix G: Camera Status LEDs

There are two buttons on the HS camera that have embedded LEDs.

The Trigger button has a red Status LED and the Power button has a Blue Power LED.

The Power LED is lit whenever the HS camera is powered on.

The Status LED will be off or blinking depending on the camera state.

Figure 4-7: HS I/O Ports and Buttons

Table 4-10: LED Blink Codes for Normal Operation

Camera Connected in Live or Review (not recording): Status LED remains off

Recording -- Armed: Slow blink on / off (500ms intervals)

Recording -- Armed and Triggered: Fast blink (200ms intervals)

Table 4-11: LED Blink Codes for Error Conditions

No communication with Controller -- blink on/off/on (300ms interval), then off for 1sec

Temperature Alert -- blink on/off 3x (300ms interval), then off for 1sec

Call Fastec!! -- blink on/off 4x (300ms interval), then off for 1sec