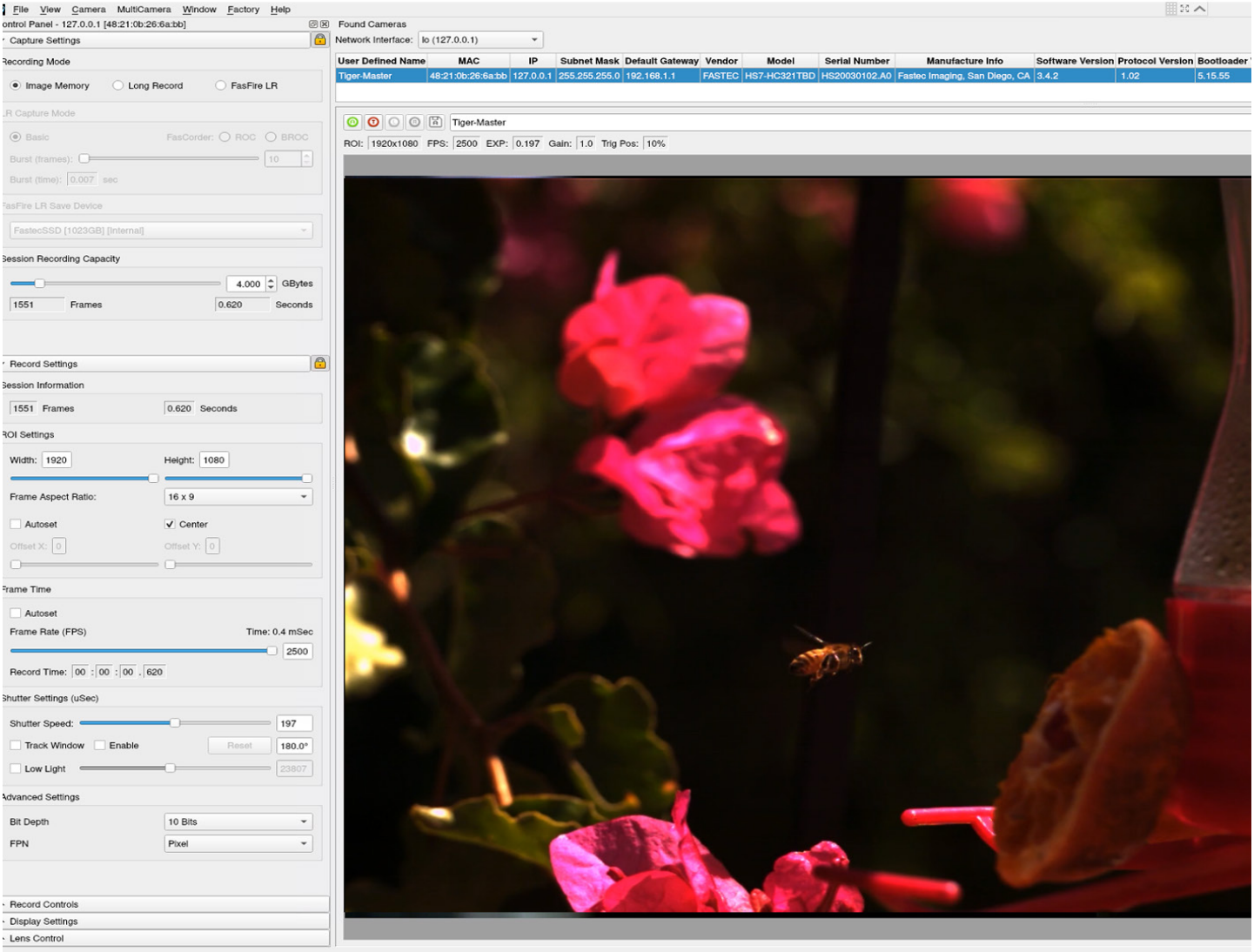
FASTEC Imaging

an RDI Technologies Company



FasMotion Manual

Software Version 3.5.x

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Reader Response

We at Fastec Imaging strive to produce quality documentation and welcome your feedback. Please contact us with technical questions, comments and suggestions.

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1 Fas*M*otion Setup

1-1 Install Fas*M*otion Camera Control Software

Availability:

Fas*M*otion Software is always available free of charge to all Fastec camera users with compatible cameras. It may be loaded on any number of computers and may be freely shared with clients.

You will find Fas*M*otion on the USB flash drive shipped with IL and TS cameras. The latest versions of Fas*M*otion (for Windows and Mac) and other Fastec software and documentation is available via website registration at https://www.fastecimaging.com/firmware-software/

Fas*M*otion and camera software updates may be downloaded directly from Fas*M*otion. See "1-2 Online Updates" on page 12.

FASTEC Camera Controllers, required for HS cameras, are shipped with Fas*M*otion already installed. While HS camera systems may be operated via their controllers (local mode), HS cameras may also be accessed and controlled via PCs on a common network (remote mode).

Use:

Fas*M*otion may be used to set up and control one or more Fastec IL, TS, and/or HS cameras.

With it you may configure all parameters including Record Mode, Session Length, Resolution, Frame Rate, Exposure, Color Balance, Autosave, Trigger point, and I/O Sync options.

Fas*M*otion is also used to save image sequences from cameras and for playback and transcoding stored image sequences and videos.

To install Fas*M*otion on a Windows PC:

(Please refer to "To install Fas*M*otion on a Mac:" on page 12 for instructions on installing Fas*M*otion on a Mac.)

1. Run the Fas*M*otion install file on your PC. The file will have the format: Fas*M*otion<version>.exe. For example, Fas*M*otion_3.1.18.exe would be the install file for version 3.1.18. It is recommended that you copy the install file to the hard drive of your PC for safekeeping.
2. The Windows Account Control will display a message asking if you want to allow the installer to make changes to your computer. Answer "Yes."
3. The Installer Setup window will appear as shown informing you that the install process has begun. Click on "Next."
4. The next window allows you to choose a location for the program. Select a location and click on "Next."

Figure 1-1: Fas*M*otion Installation

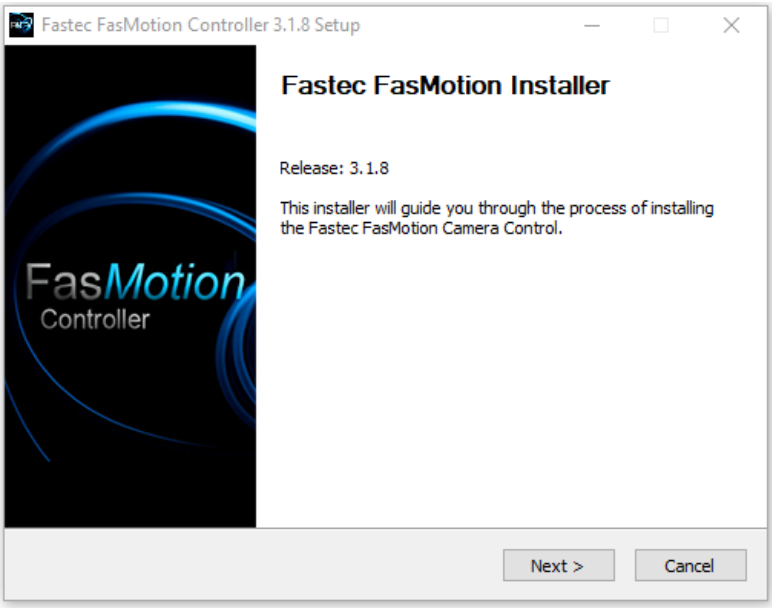


Figure 1-2: Fas*M*otion Install Location

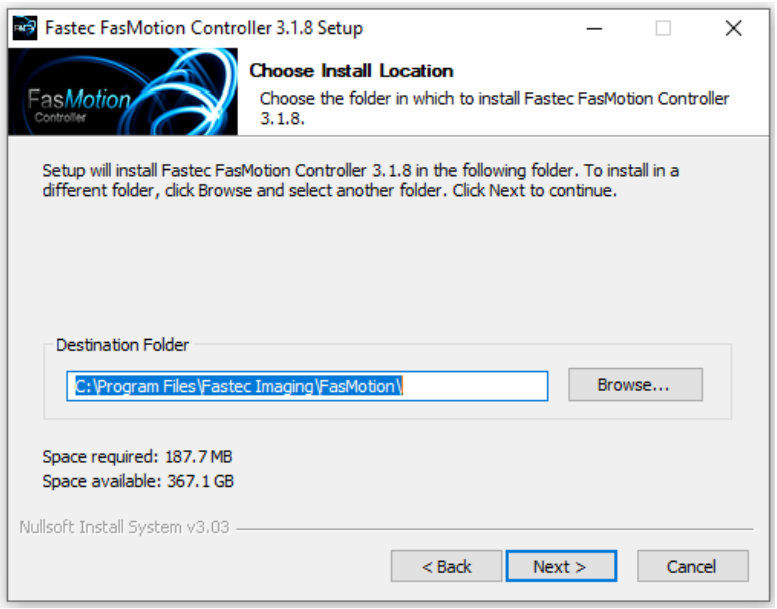
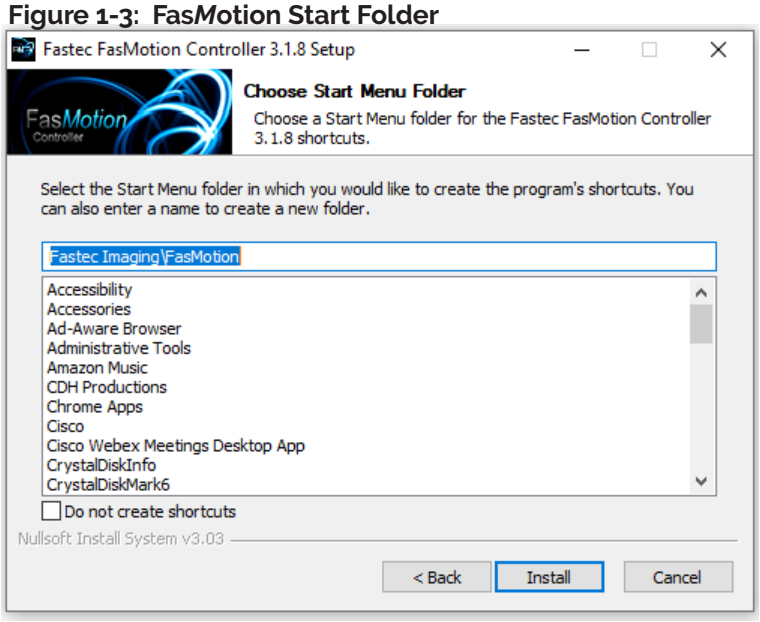
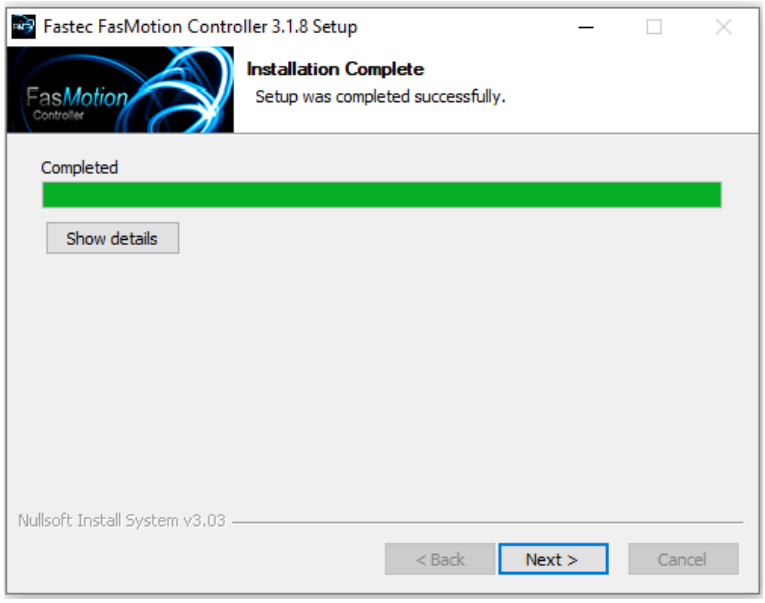


Figure 1-3: Fas*M*otion Start Folder



5. The next window gives you the option to create a shortcut for Fas*M*otion in the directory of your choice. Select a directory for a shortcut or click the "Do not create shortcuts" check box. Click on "Install" to continue.

Figure 1-4: Fas*M*otion Install Progress



6. Fas*M*otion will now be installed on the PC. A window with a progress bar will appear.

Figure 1-5: Fas*M*otion Installation Complete

7. The final install window gives you the option to run Fas*M*otion software and a link to the Fastec web page. Click on "Finish" when done to exit the install program.

Note: Fas*M*otion may need to be added to the list of programs allowed to communicate through Windows Firewall before you will be able to get an image from the camera.

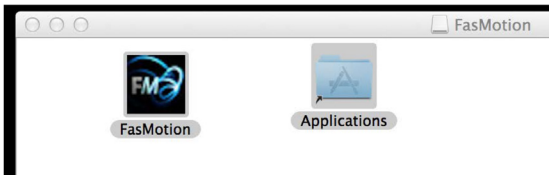
These settings are located at:

Control Panel\System and Security\ Windows Defender Firewall\Allowed apps

Make sure that all instances of Fas*M*otion have permission!

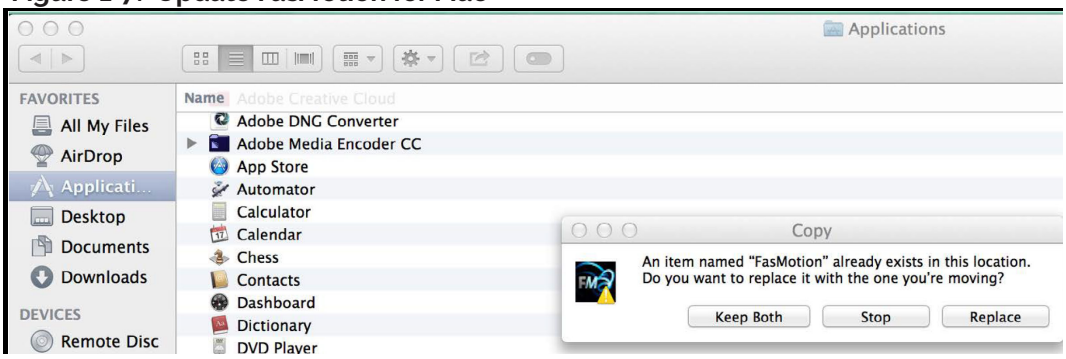
To install Fas*M*otion on a Mac:

Figure 1-6: Install Fas*M*otion for Mac



1. Copy Fas*M*otion.dmg to your Mac.
2. Double-click on Fas*M*otion.dmg to run. A window will open with icons for Fas*M*otion and the Applications folder.
3. Drag the Fas*M*otion icon into the Applications window.
4. If you are updating Fas*M*otion, you will get the message in Figure 1-7. It is recommended that you always use the latest released version. There is generally no reason to keep the old version of Fas*M*otion.

Figure 1-7: Update Fas*M*otion for Mac



1-2 Online Updates

Any computer running Fas*M*otion 3.x.x that has an Internet connection may download updates from the Fastec update server:;

- From the Fas*M*otion menu go to File/User Preferences
- Select Updates.

Here you may enable the system to automatically check Monthly, Weekly, or Daily for Camera, Controller, and Fas*M*otion software updates.

Note: HS Controller updates include Linux and application updates.

You may click on the "Check Now" button at any time to see if any new updates have become available since the system checked automatically.

Current versions IL/TS camera software and HS controller software are always shown.

Figure 1-8: User Preferences...Updates

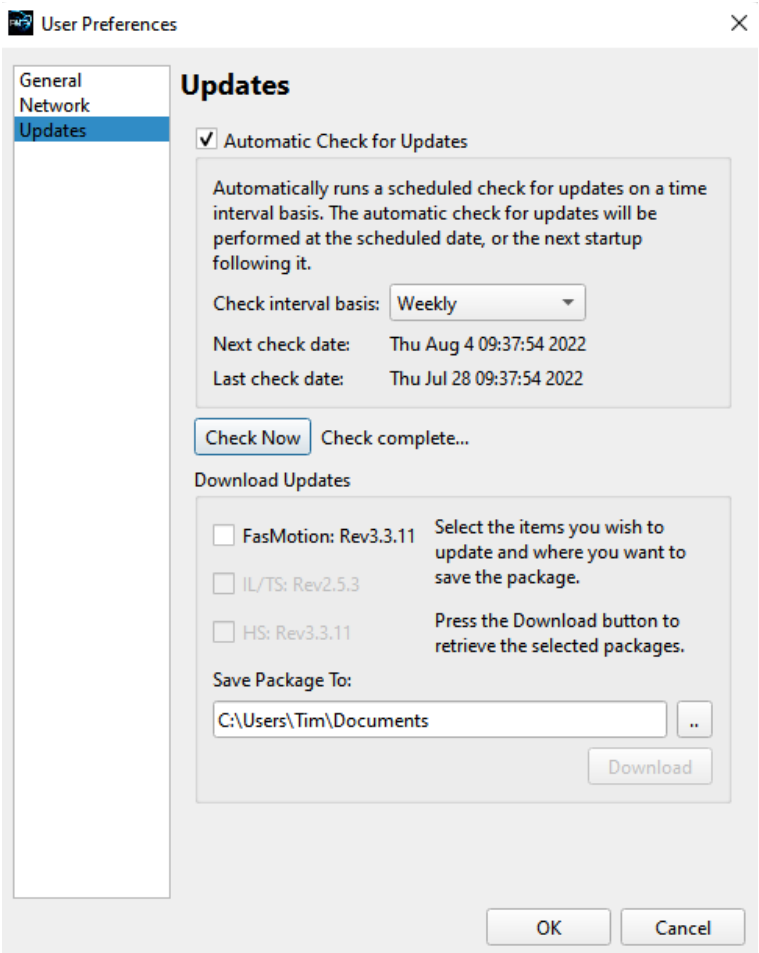
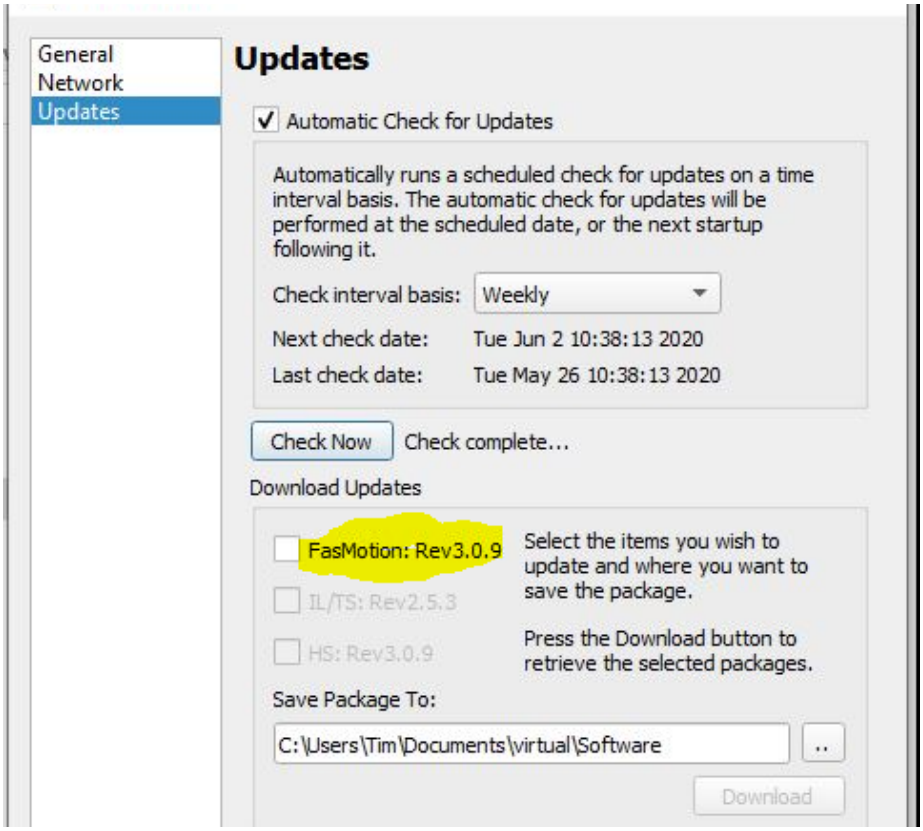


Figure 1-9: Fas*M*otion in Updates dialog



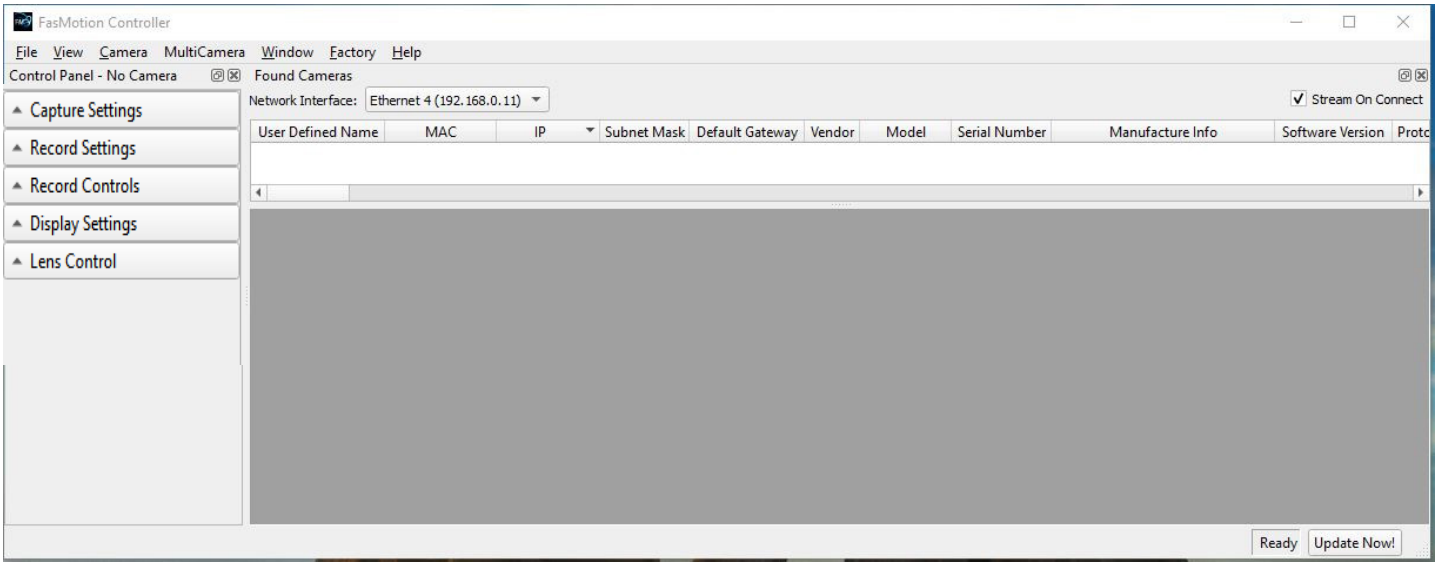
When a IL/TS camera update is downloaded, you will be given the option of creating an SD card for updating the camera.

If a Fas*M*otion update is downloaded, you will be given the option of performing the. update at that time. The install file may also be used to migrate FasMotion to another computer.

HS controller update files saved on a PC may be transferred to a removable device, then installed on the controller. (This is done if the controller does not have Internet access.)

NOTE: Full HS controller updates include updates for Linux and installed applications. These are all done for controllers via internet connection, but are not included in the saved HS controller update file

Figure 1-10: Update Now! button in Fas*M*otion Window



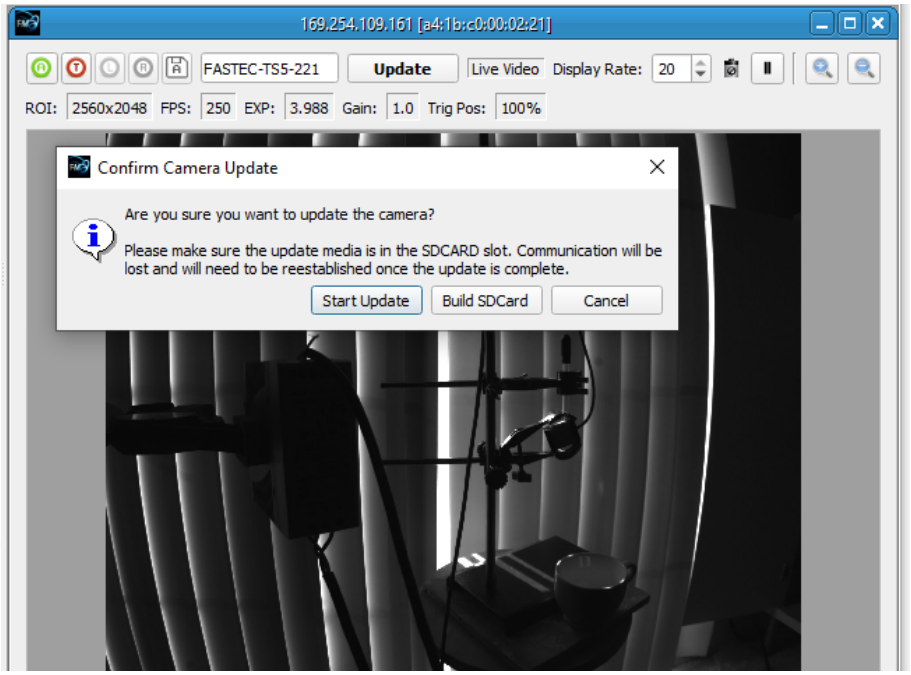
For Fas*M*otion on a PC or Mac

If the system is aware that a new version on Fas*M*otion is available on the server, which could be the case if the Automatic Check for Updates is enabled, or if you have recently checked for an update but have not installed it, then the "Update Now!" button will appear in the lower right corner of the Fas*M*otion window. You may click on this to download the new version and will be given the opportunity to update Fas*M*otion. (All instances of Fas*M*otion will close during the update.)

For HS systems:

Always look for the camera update button ("Figure 1-11: Camera Update Button" on page 14)-- for HS systems, the camera and Fas*M*otion are always updated together using that button.

Figure 1-11: Camera Update Button



If the system is aware of a camera update newer than the version of any camera connected to Fas*M*otion, and Update button will appear next to the camera name in the camera window.

For TS and IL cameras:

You may download the latest camera software for that camera.

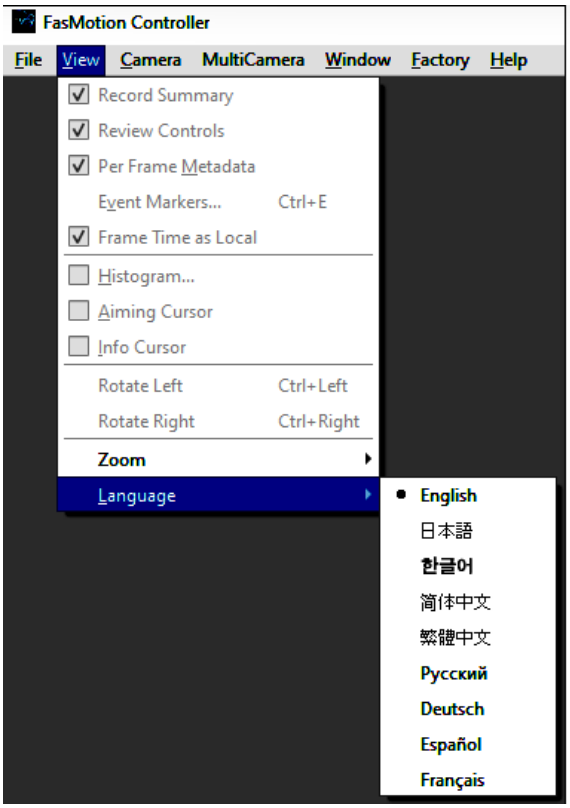
Once the software is on your system, click the Update button again.

If you have already built an SD card and inserted it into the camera, you may Start the update. If not, you may build an SD card, then perform the update.

For HS cameras:

This will allow you to update the camera and controller directly. (No SD card is used.) This will update the camera and all Fastec and application software on the system.

Figure 1-12: Language Selection



1-3 Language Selection

To select a language in Fas*M*otion:

1. Open the Fas*M*otion Application
2. Click on View
3. Select Language from the View Menu
4. Make your language selection

1-4 Connect the Camera to a Wired Network

All Fastec IL and TS cameras require a Gigabit Ethernet connection in order to run Fas*M*otion.

HS cameras have Fas*M*otion natively installed on their controllers and do not require a network connection: you may simply connect a display, keyboard, and pointing device directly to the HS camera controller, which runs the Linux version of Fas*M*otion.

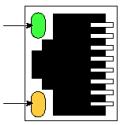
HS cameras that have their controllers attached to a network, however, may be accessed by any computer on the network running a local copy of Fas*M*otion. Fas*M*otion on the controller must not have an active camera window, as this would make it unavailable to other computers. (A camera may only be "attached" to one instance of Fas*M*otion at a time.

To attach the camera to a network:

1. Before powering up the camera or PC, connect the camera to your network via a switch or router, or directly to your PC using CAT 5E or CAT 6 Ethernet cable.
2. For IL and TS systems power up the camera first, then, once the camera has booted up, power up the PC. For HS cameras, power up HS camera first, then the camera controller.
3. For IL and TS cameras, watch the LEDs on the RJ-45 connector. When the camera connects to the PC or local network the green LED will begin to blink in a pattern depending on connection speed. (See "Table 1-1: IL/TS Camera Network LEDs".)
4. Start the Fas*M*otion software application.
5. Select a camera from the "Found Cameras" list in Fas*M*otion. Double-click to open. (If the Found Cameras pane is not present, go to Window/Found Cameras.)

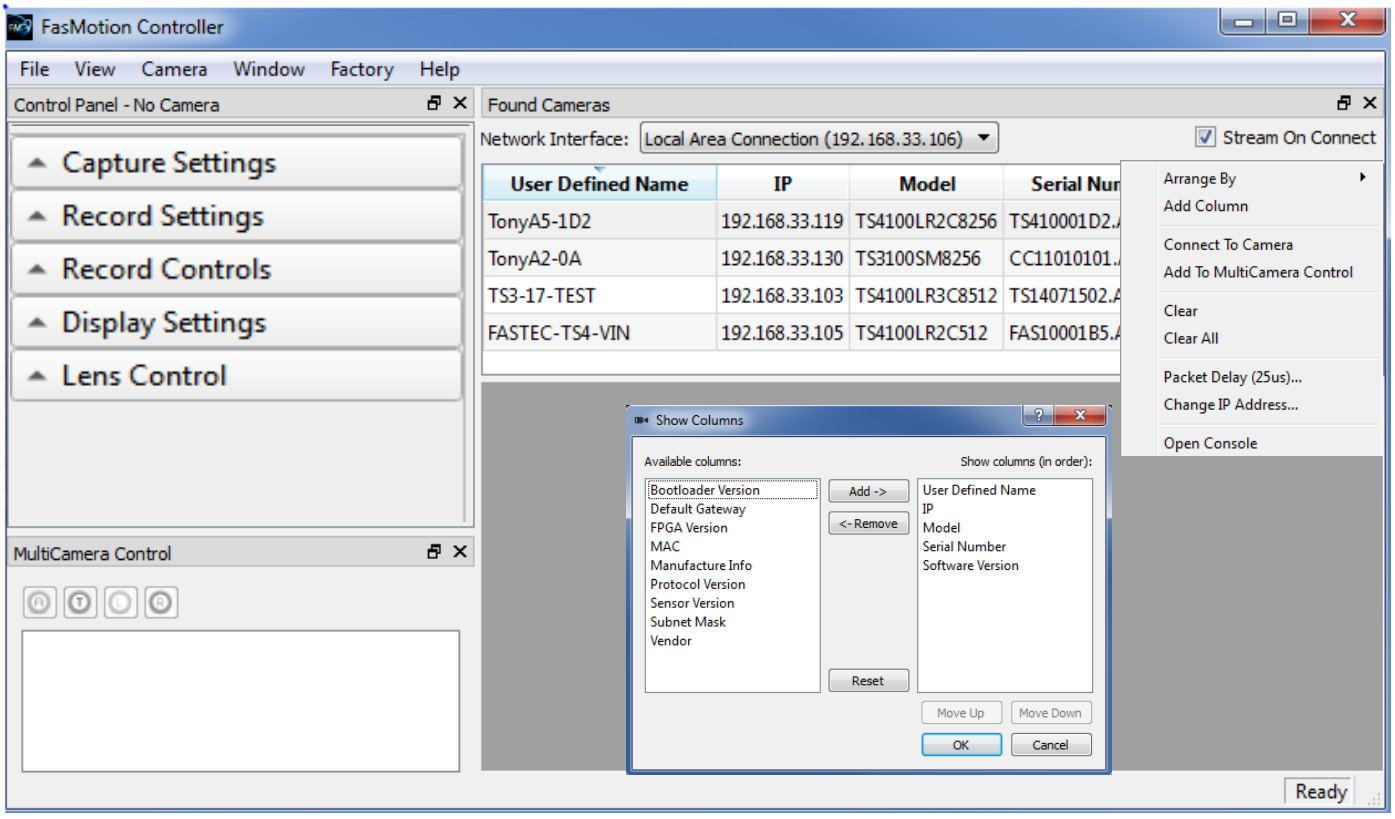
Note: "Figure 1-13: FasMotion "Found Cameras" Pane" shows the context menu for the "Found Cameras" dialog, which opens with a right-click on the list. This menu may be used to arrange or configure the dialog as well as carry out other functions described elsewhere. "Arrange By" sorts the list according to whatever parameter you choose. Also shown here is the "Show Columns" dialog, which opens when you select "Add Column." This is used to add or remove camera parameters from the "Found Cameras" list.

Table 1-1: IL/TS Camera Network LEDs

LEDs on RJ-45 Connector		Camera Networking LED
		
Green (Connection)	Amber (activity)	Amber (activity)
1 Blink = 10Mb	Blinks for all network activity	Blinks for camera network activity only
2 Blinks = 100Mb		
3 Blinks =1Gb		

Note: It is best, especially for initial setup, to disable Network Interface Cards (NICs) that will not be used with Fas*M*otion, especially any adapters sharing the same subnet. Please refer to "Application Note 5: Optimizing IL/TS for Image Transfers" on page 88 for more details.

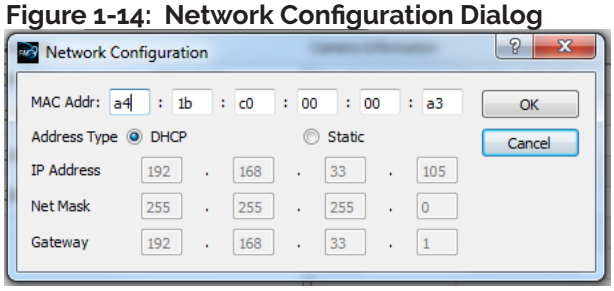
Figure 1-13: Fas*M*otion "Found Cameras" Pane



1-5a Managing IL/TS Camera Network Settings

Camera network settings may be configured using the Network Configuration dialog in Fas*M*otion.

Figure 1-14: Network Configuration Dialog



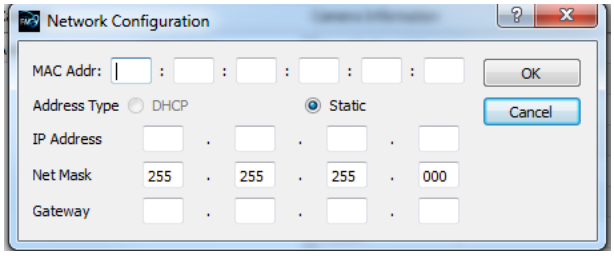
The default network setting is DHCP. Manually configuring the IP is not necessary in most installations. The camera will automatically be assigned an IP address by a DHCP host on your network, or it will assign itself a Local Link Address (169.254.xxx.xxx) like any computer.

1. Follow directions in "1-4 Connect the Camera to a Wired Network" on page 14.
2. Click on the camera you wish to manage (do not double-click) to highlight the selection.
3. Right-click on the "Found Cameras" dialog to bring up the context menu, and then select "Change IP Address." (See "Figure 1-13: FasMotion "Found Cameras" Pane" on page 15.)

From this dialog you may select DHCP if you wish for the camera to receive an IP address dynamically from your DHCP server or if you wish for the camera to establish a Local Link Address. (See "1-4 Connect the Camera to a Wired Network" on page 14.) Or you may select Static and edit the IP Address, Net Mask, and Gateway to work with your established network.

If you wish to configure a camera that is not on your subnet (Fas*M*otion will not list it):

Figure 1-15: Empty Network Configuration



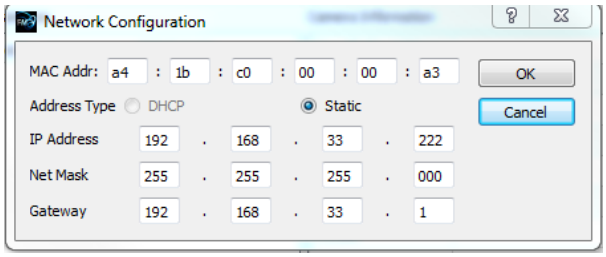
If the camera is physically attached (via Gigabit Ethernet), but is not reachable in Fas*M*otion via the network because it is not on the same subnet, you may still change its settings using the Network Configuration dialog.

1. Open the Network Configuration Dialog with no camera selected.

The Network Configuration dialog will open in an unpopulated state as in Figure 1-15.

2. Enter the MAC address of your camera.
3. Enter a Static IP Address, Net Mask, and Gateway for your camera that conforms to your network settings. (If you wish to use DHCP, you will have to set a compatible static IP address first, and then re-attach to set the camera to DHCP.)

Figure 1-16: New Network Configuration



In the example shown in Figure 1-16, settings compatible with the local network are entered.

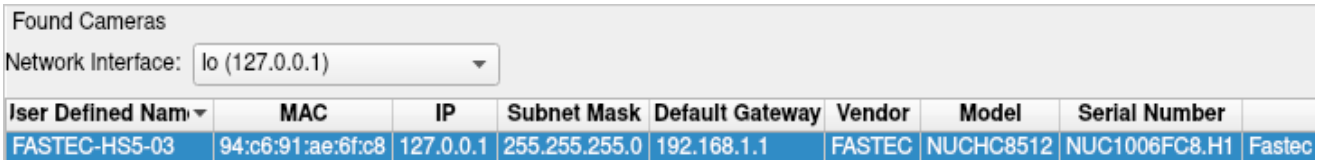
4. Click on OK.
5. Click on Scan. If the IP Address is compatible with the chosen Network Interface, the camera will now appear on the list.

1-5b Managing HS Network Settings

HS camera network settings may only be configured via the HS Controller. While these may be accessed via a remote desktop connection using 3rd party applications such as VNC or TeamViewer, it is recommended that network settings be performed directly on the Controller.

When the HS Controller boots up connected with a Camera, FasMotion opens at startup with a live image. FasMotion "Found Cameras" window displays the Network Interface, lo (127.0.0.1), which is the controller's "localhost" address that is used to "loop back" the camera connection to the Controller to communicate with FasMotion. If no wired or wireless connection has been enabled, this will be the only Network Interface available on the Found Cameras window. **This interface should never be changed, and no local network created on this subnet.**

Figure 1-17: HS Found Cameras Window "localhost"



Once the Controller is connected to wired and/or wireless networks, those interfaces will appear in the Network interface dropdown. Here we have selected the Gig-E interface.

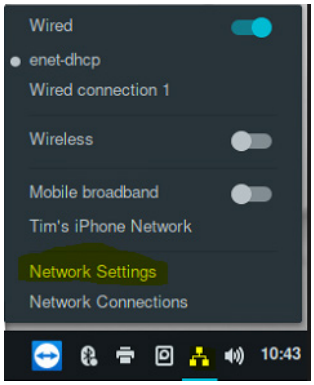
Note that unlike IL and TS cameras that require a Gigabit Ethernet connection, the HS will work on any interface, including WiFi.

Figure 1-18: HS Network Interfaces

The camera may then be accessed by any PC on the same subnet running FasMotion 3.0.x or higher.

Figure 1-19: HS Found Cameras with Wired Interface

Figure 1-20: Select Network Settings

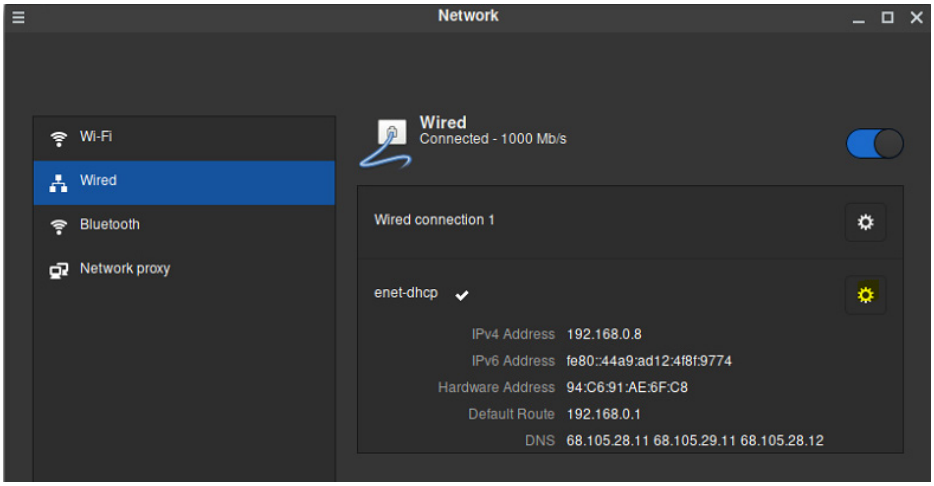


The camera's IP address may be changed via the Network Configuration Dialog (see Figure 1-14 on page 16), or via the Linux Network Settings accessible via the controller's desktop task bar.

The Linux Network Settings gives you access to all network interfaces and allows you to configure them.

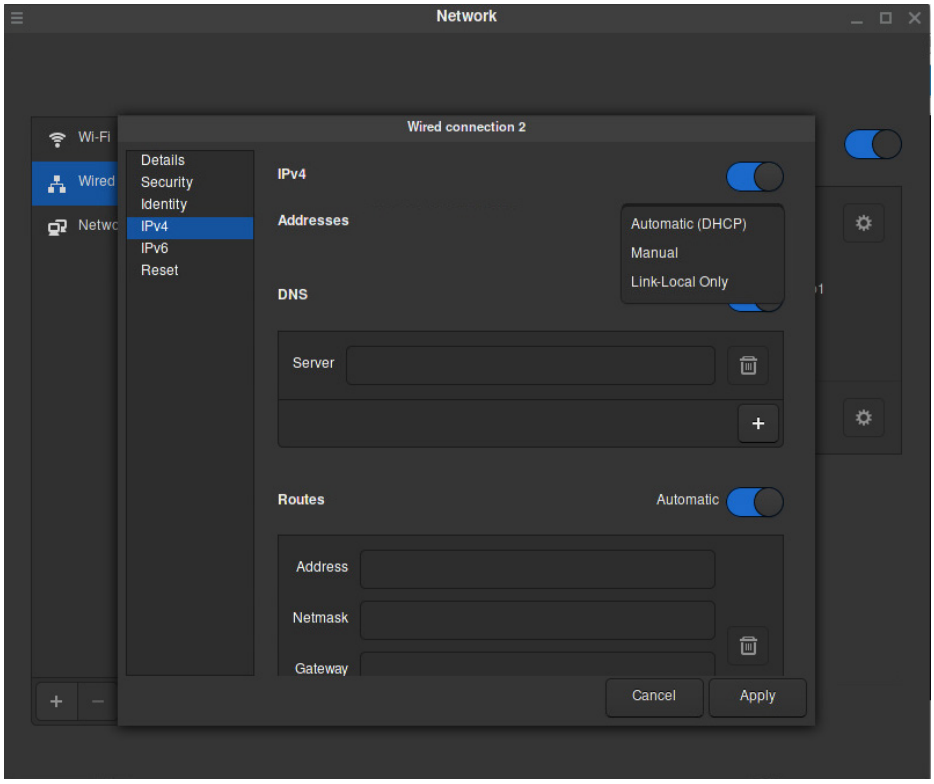
If you have multiple interfaces, the camera will only use one and will always default to a wired interface if available.

Figure 1-21: Wired Network Settings on HS Controller



The network settings dialog on the HS Controller clearly list the name and parameters of each connection.

Figure 1-22: IPv4 Settings on HS Controller



Note that on the HS controller, three types of addresses are selectable:

- Automatic (DHCP)
- Manual (Static)
- Link-Local Only

Use the Link-Local setting for direct Computer to Controller, or Controller to IL/TS camera connections when a DHCP server (LAN or local router) is not present. The controller will assign the interface a 169.254.x.x address.

1-6 WiFi Setup (IL Cameras)

The "WiFi Config..." element in the Fas*M*otion Configuration menu will only appear if the attached camera is in Live mode and has been factory licensed for WiFi and has its WiFi dongle attached via its USB port.

Note: The camera may not be operated via WiFi in Fas*M*otion**.** The WiFi configuration utilities are present in Fas*M*otion to satisfy the setup requirements for IL cameras.

HS controllers have built-in WiFi adapters. See the HS manual for details.

WiFi for TS cameras is set up using the touch display. See the TS manual for details.

WiFi Setup for an Existing Network

1. Select WiFi Config... from the Configuration Menu.
2. Click on the Scan button to see a list of local WiFi networks.
3. Select a network from the "WiFi Scan Results" dialog. You will most likely wish to leave DHCP selected unless you are familiar with the network and wish to supply a valid IP address, net mask, and gateway.
4. Type in the password, if needed and then click on OK. The dialog will close.
5. If you selected DHCP, you can re-open the WiFi configuration dialog after a few minutes and you will see the assigned IP address for the camera.

WiFi Setup for an Ad Hoc Network

1. Select WiFi Config... from the Configuration Menu.
2. Write a name you wish to use for the SSID, in this example we have used "ginny."
3. Check the Ad Hoc check box and then, leaving the DHCP radio button selected, click on OK.
4. The dialog box will close. If you reopen it in a couple of minutes you will be able to read the IP address assigned to the camera (as shown in this example).

Connecting to the IL via WiFi

1. Open the Wireless network settings utility on your computer or mobile device. You will see a list of available wireless networks.
2. From this list, select the wireless network the IL is using as seen in the WiFi line in the camera's System Menu. Note that "ginny" has a unique icon because it has no internet connection.
3. Enter the password, if any.

The IL and your computer or mobile device are now both connected to the same wireless network.

Figure 1-23: Fas*M*otion Configuration Menu with WiFi

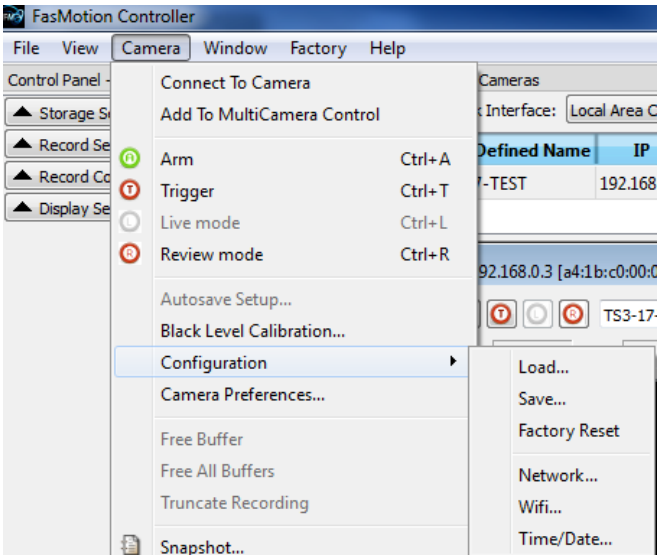


Figure 1-24: WiFi Configuration Dialog

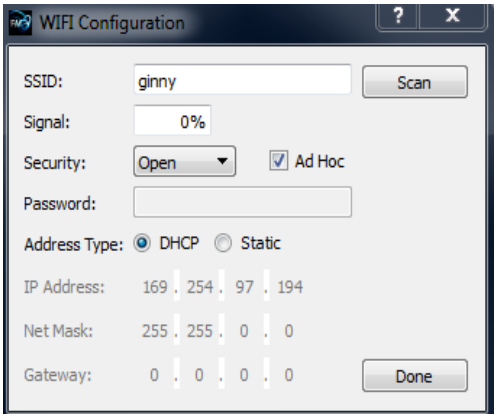
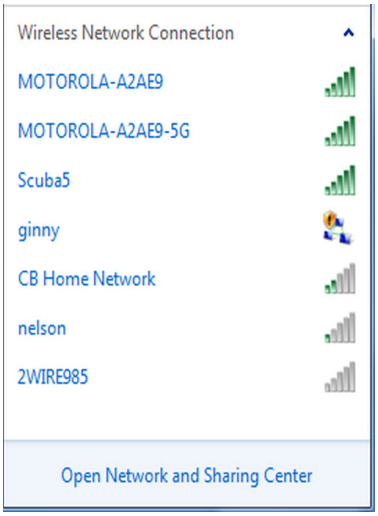


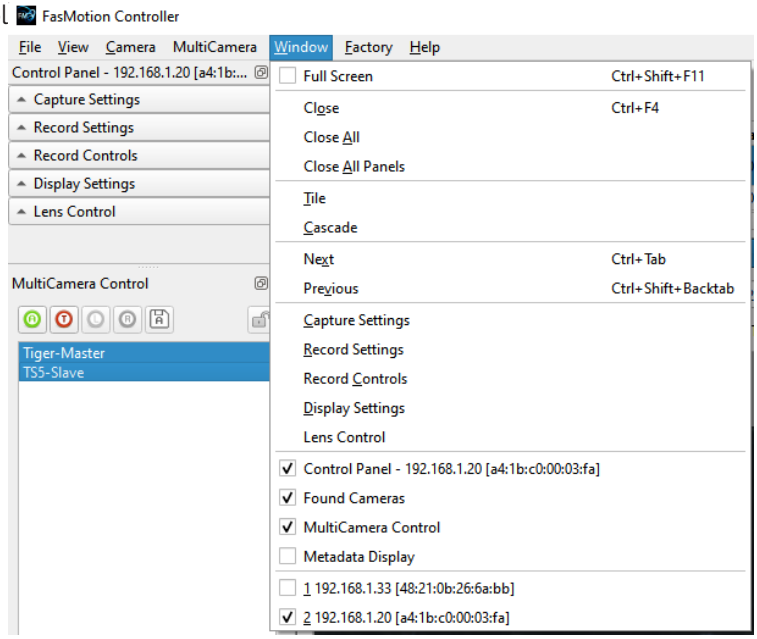
Figure 1-25: WiFi Access Point Scan Dialog



1-7 Fas*M*otion Application Window

Figure 1-27 shows the application window with no cameras connected. To the left, is the Control Panel, which has four sub-panels: Storage Settings, Record Settings, Record Controls, and Display Settings. Sub-panels may be opened or closed using the "▼▲" buttons, or by selecting the panel in the Window Menu, shown in Figure 1-26.

Figure 1-26: Fas*M*otion Window Menu

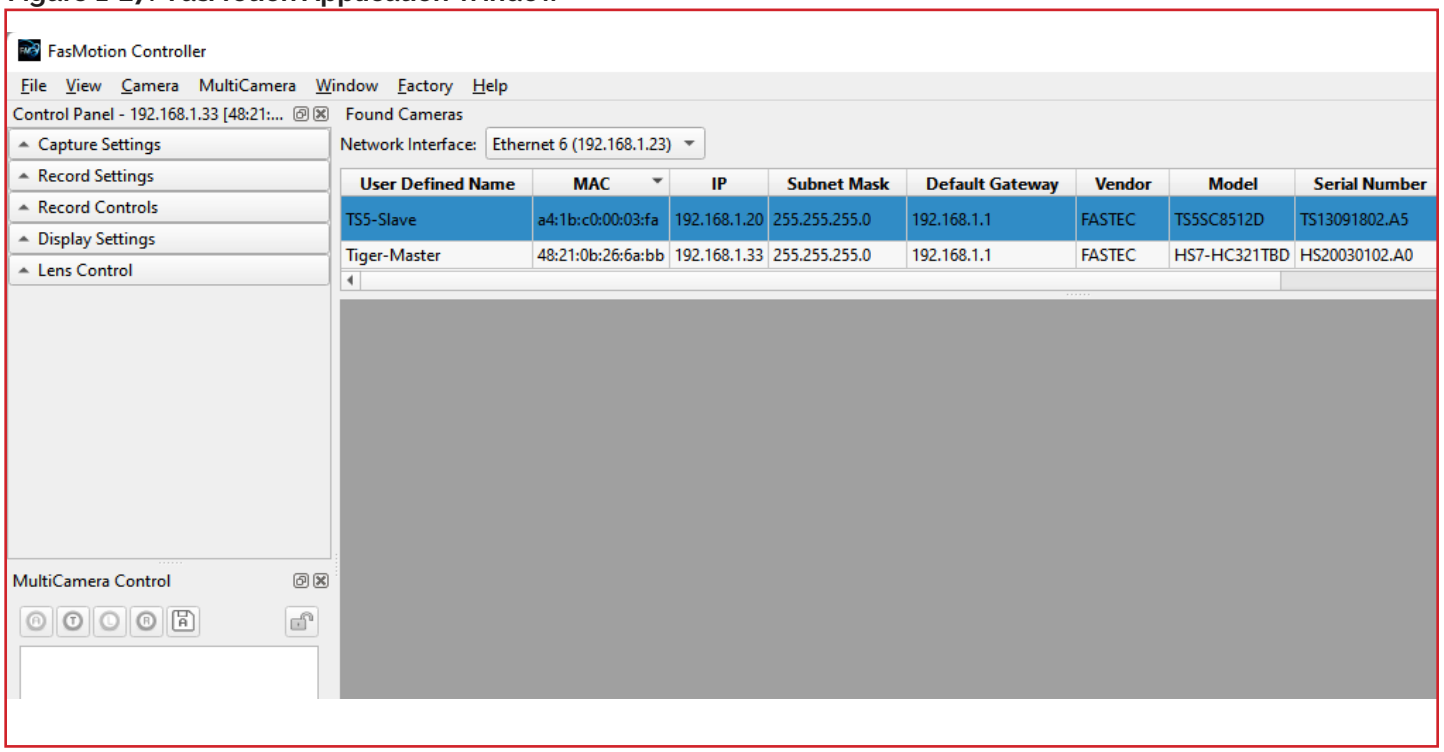


The Multi-Camera Control panel is below the Control Panel, and to the right, is the image window.

The Control Panel and Found Cameras and Multi-Camera Control panes may remain docked within the Fas*M*otion application window or be moved outside of the application window to any location on your desktop. If you use two displays, you may wish to move the one or more of them to your extended desktop in order to give yourself a larger image window. They detach by clicking on the gray border at the top in each pane. To return the a pane back to the application window, just double-click on that same border.

The **Window menu** gives you some flexibility in what is displayed. For example you may uncheck the Found Cameras or Multi-Camera Control panes or the control panel if you wish to hide them temporarily. This may be helpful if you wish to have more space for the camera window or if you wish to simplify the controls once the camera(s) are set up.

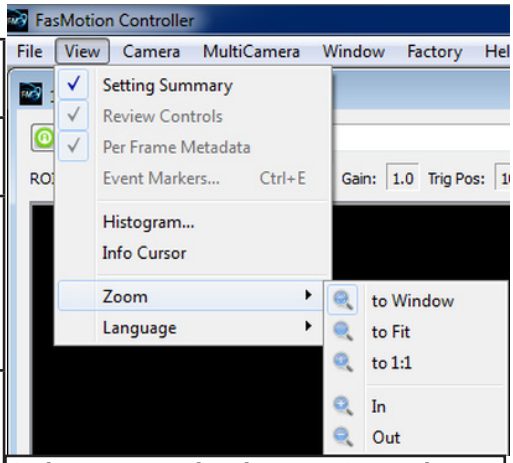
Figure 1-27: Fas*M*otion Application Window



1-8 Controlling the Image Displays

Zoom to Window	*The full image is sized to completely fill the image window. The image may be distorted as the aspect ratio is lost.*
Zoom to Fit	*The image expands proportionally and fills the image window without losing its aspect ratio.*
Zoom 1 to 1	*The image is represented pixel for pixel on the display. Depending on the display resolution, the image may only fill part of the image window, or the image may be cut off, in which case sliders will appear so that you may access the entire image.*
Zoom In	*The image is enlarged greater than 1:1 with the first click, then progressively larger with each additional click. When the image exceeds the size of the window, sliders will appear for access.*
Zoom Out	*If you have Zoomed-In on an image, Zoom-Out allows you to back through the zoom settings down to 1:1.*

Figure 1-28: View Menu



Ctrl + Mouse Wheel Zoom Control:

Place the cursor on a point of interest on the image, hold down the Ctrl button, and then turn the mouse wheel. If the image zoom becomes larger than the window, the mouse cursor becomes a "hand" and can be used to reposition the image within the window.

Setting Default Gamma and JPEG Quality

Camera Preferences is in the Camera menu.

The Default Gamma setting is used to set the default output Gamma for displayed and saved images.

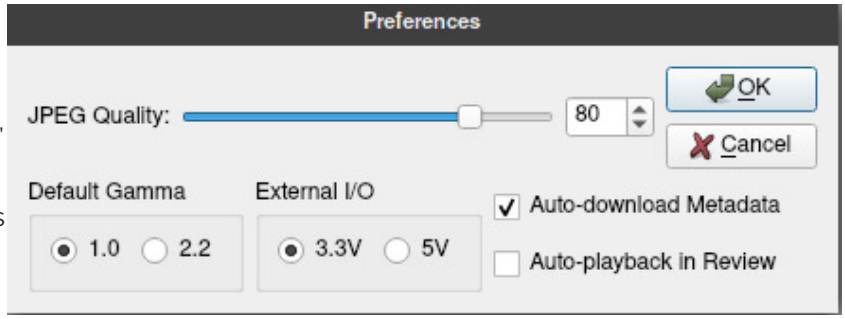
The default Gamma is 1.0 (linear). Many laptop computer displays have a Gamma of 1.0, while larger flat panel LCD monitors often have a Gamma of 2.2.

Note that changing the Default Gamma setting does not change the current Gamma of the camera, it sets it reset value. To set the Gamma of the camera to a new default, navigate to the Display Settings tab and select "Reset Light and Color Settings."

Figure 1-30 on page 22 uses two screen shots of a high-contrast image to demonstrate the difference in appearance between Gamma 1.0 and 2.2. These images were displayed on a monitor with a 2.2 Gamma.

JPEG Quality is set to 80 by default as a good compromise between quality and image size. For higher-quality Stills, JPEGs and AVI files set to 100. For faster live refresh rates (streaming to the display) set this lower.

Figure 1-29: Camera Preferences



Auto-playback

The Auto-playback check box is also found in the Preferences Dialog.

When the Auto-playback box is checked, the camera will playback immediately at whenever a recording is complete in Standard Basic mode. This box becomes unchecked if LR mode is selected on cameras with that option.

External I/O (voltage)

For HS cameras only, there is an external I/O voltage selection.

Display Rate for live images:

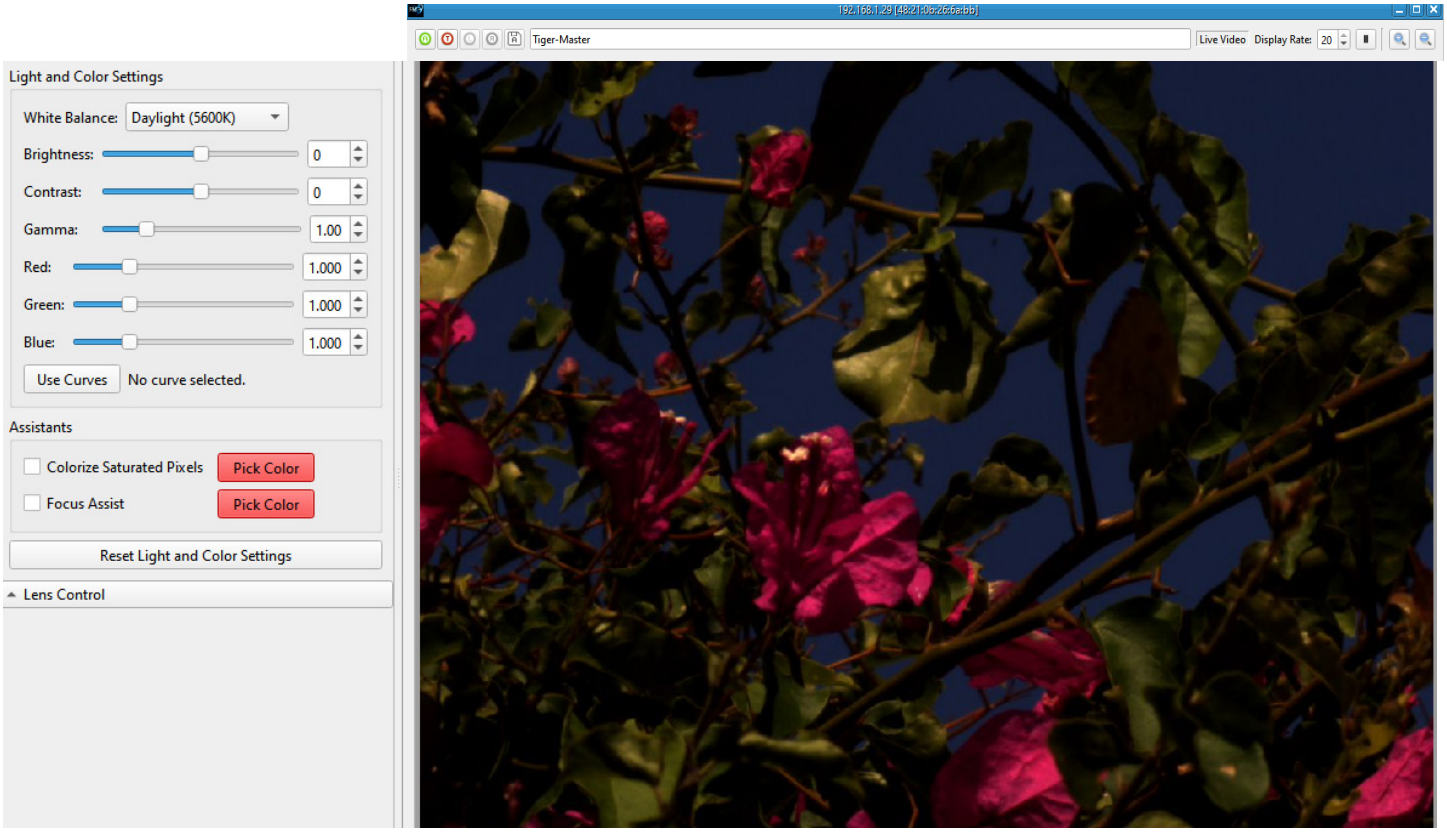
The display rate for live images in Fas*M*otion may be adjusted using the spinner at the top of the Image Window. (See Figure 1-30 on page 22.) This number will automatically change according to the performance of the network and the PC. The JPEG Quality setting will also affect the display rate as it controls the size of the JPEGs sent via Ethernet to Fas*M*otion.

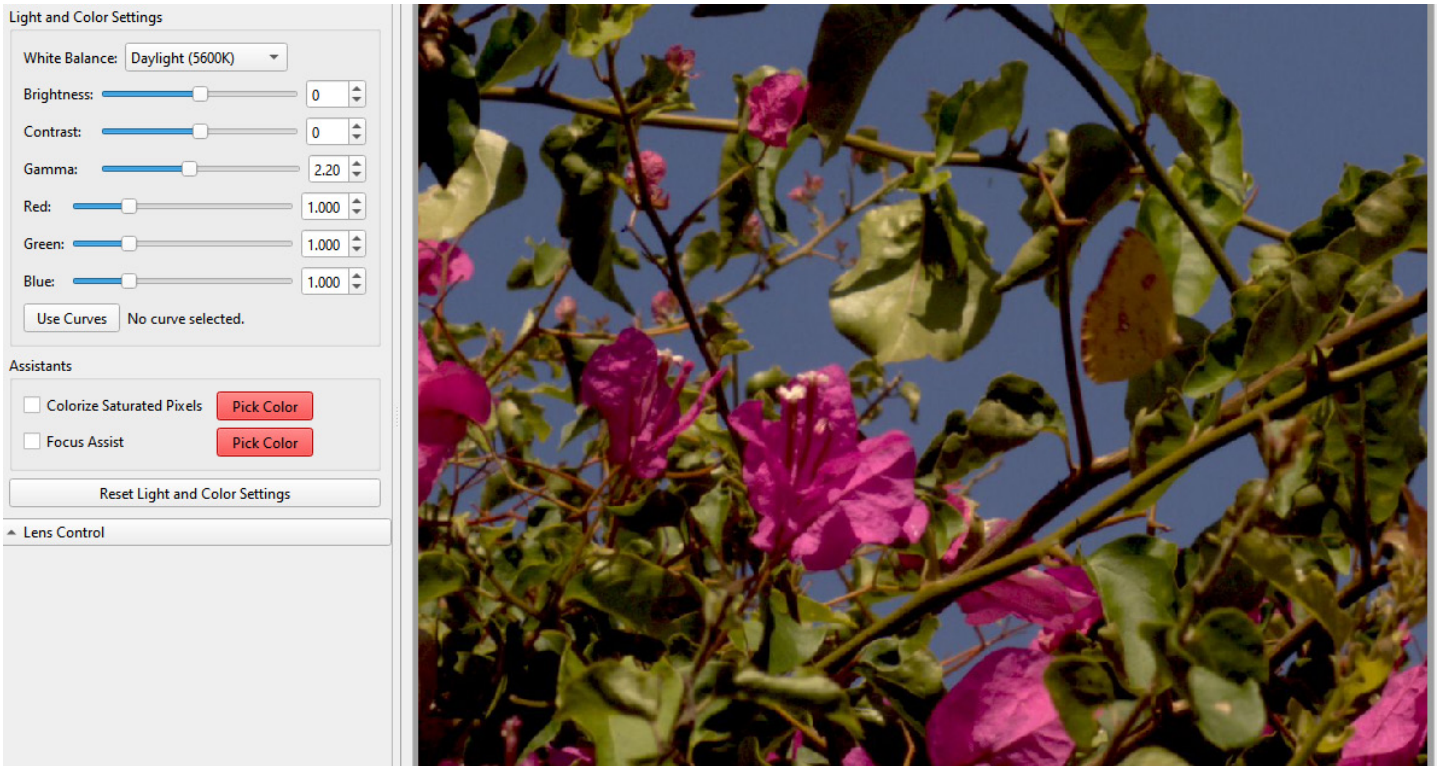
There is also a pause/play button on the top of the Image Window. This may be used to temporarily start and stop the video stream.

The first image, with Gamma set to 1.0, appears very dark on this display. If the lens is opened or the exposure increased, the dark areas will gain detail, but the brighter areas will saturate.

In the second image, with Gamma set to 2.2 to match the display, the detail in the shadows is evident. Now we can see that there is a butterfly in the shot that just looked like another leaf before adding the gamma correction.

Figure 1-30: Gamma Comparison





Setting up the HDMI display on TS and IL Cameras:

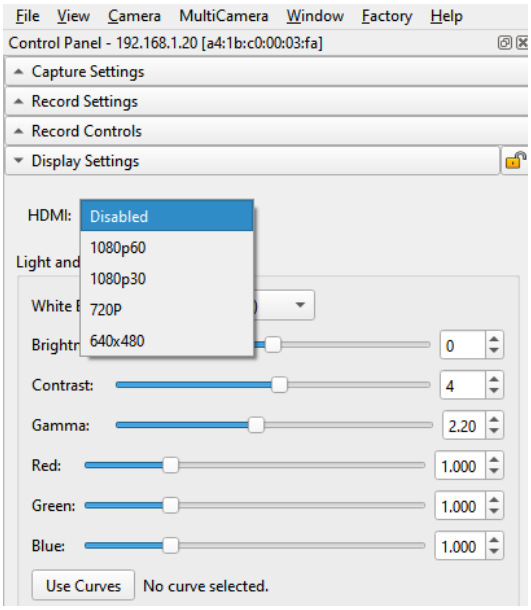
TS and IL cameras have HDMI outputs that can be used for displaying both live and recorded images. The HDMI port is located on the side of the camera between the Power and External I/O connectors.

To enable the HDMI output click on the HDMI button on the Display Settings Tab and select the resolution you wish to use.

Note: The images from the camera will be scaled to fit the HDMI display screen while maintaining aspect ratio. This means that there may be black borders on the sides or top and bottom of images, depending on aspect ratio and best fit.

HDMI output is compatible with image sizes up to 1920 x 1080. If the camera is set to a higher resolution, HDMI will become disabled.

Figure 1-31: HDMI Settings



1-9 Name the Camera

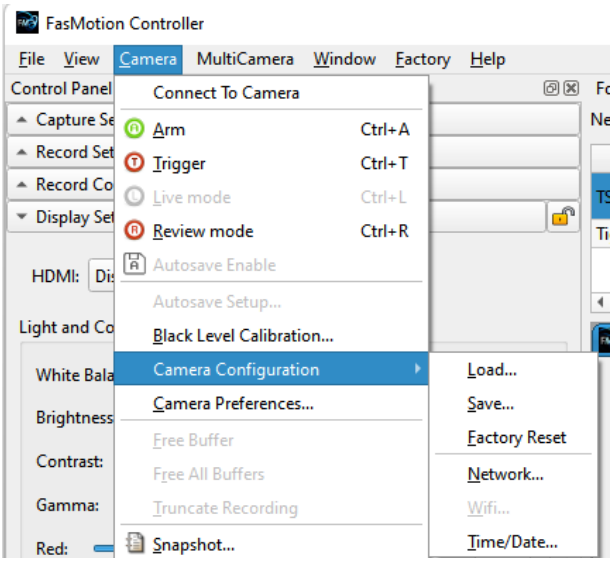
When the Camera leaves the factory its default name is based on model and the last three digits of the Mac address, for example: FASTEC-HS6-5f4. The camera name can be used both for communicating on a network and as part of the filename when saving images.

It may be beneficial to rename the camera according to its function, locality, field of view, etc. depending on how the camera is to be deployed.

To change the camera name simply edit the name as it appears in the box above the image window.

There are limitations in the character set that may be used for the name as it must be "legal" both as a filename and network device name. All numbers and upper- and lower-case letters may be used. The only punctuation that may be used is the "-" (not "_").

Figure 1-32: Camera Configuration Menu



1-10 Camera Time and Date

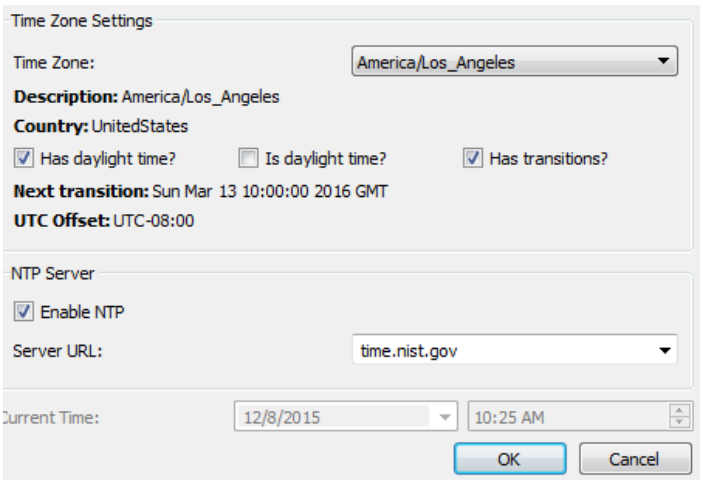
When you receive your camera, the time zone may need to be set to reflect your local time.

Access the Time and Date dialog from the Camera Configuration menu in Fas*M*otion. (The Camera Menu is also available as a context menu, opened with a right-click on the camera window.) The Time Zone pull down menu has an extensive list of cities. If you cannot find a city in the list to reflect your time zone, go to the bottom of the list and select a UTC time offset instead.

If NTP is enabled, the time will be corrected each time the camera boots up when connected to a PC with Internet access.

Note: On IL and TS cameras, a rechargeable battery will maintain time while the camera is disconnected from power. If your camera is not powered up for a few weeks, the time and date may need to be reset.

Figure 1-33: Time and Date Configuration



1-11 Connect to an IL or TS Camera Outside Fas*M*otion

Fas*M*otion software is the primary PC interface for Fastec. It is the most flexible and efficient way to use the camera. There may be times, however when you may wish to access the camera using a computer that does not have Fas*M*otion loaded.

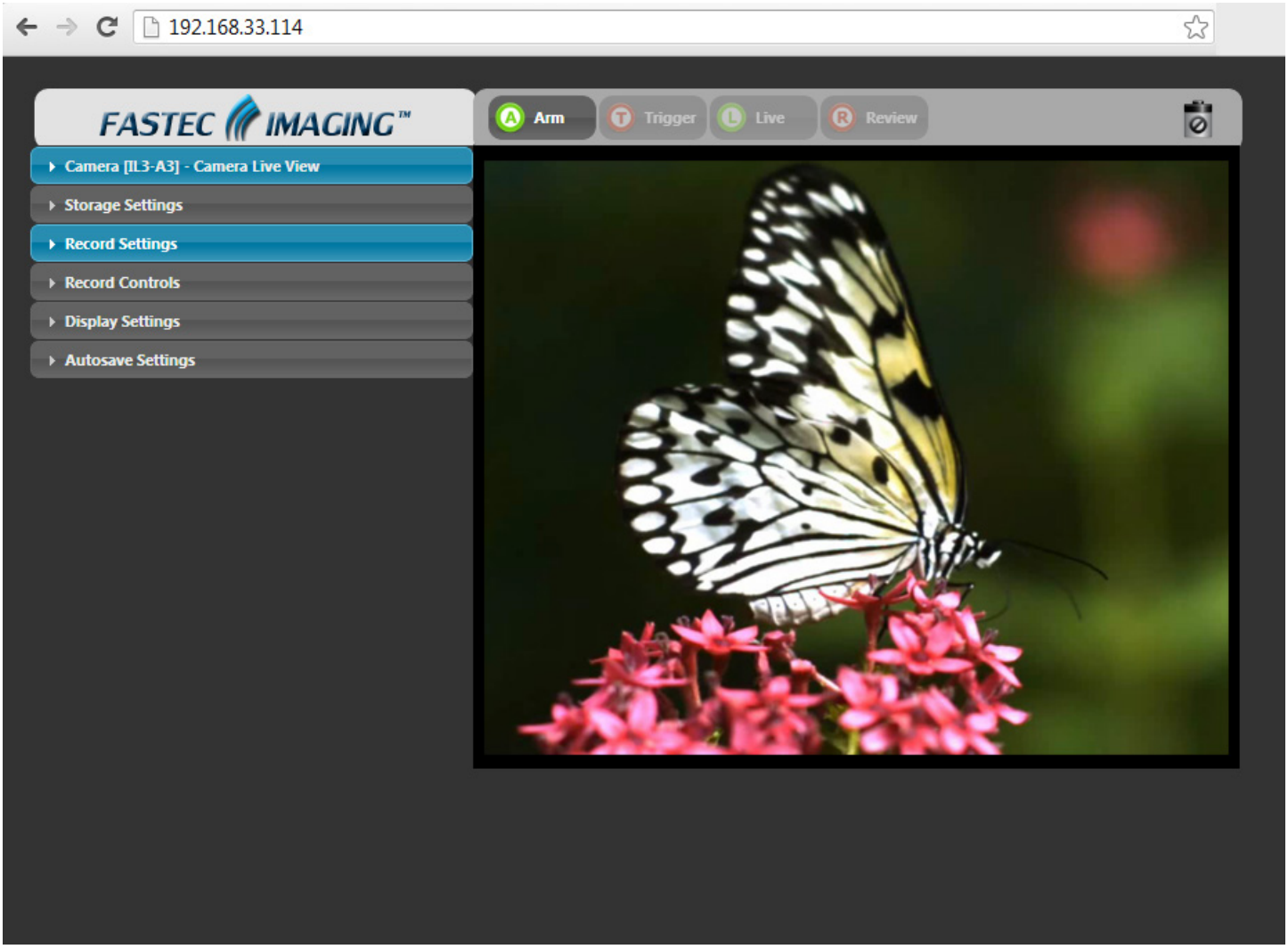
To open the Networked TS or IL camera in a Web browser in the **Web-Application**:

The Web-application works with many web browsers, including Google Chrome, Mozilla Firefox, Safari and Microsoft Internet Explorer. Unlike Fas*M*otion, it does not require a wired Gig-E connection on the host device. It works on most PCs, Smartphones, and tablets:

1. Type the camera's IP address or camera name into the browser's Location bar.
2. A camera control application within the camera does the rest. A control menu will appear in your browser that will give a live camera view and complete control over the camera operation. Details on use of the camera's web browser appear in the Web Application-manual.

Note: The Web-Application is useful for setting up and controlling the camera, but it does not have the display performance (refresh rate) of Fas*M*otion and has no utility for saving video or image files on the host device (PC, Tablet, etc.).

Figure 1-34: Web-Application



1-12 Camera Memory and Image Storage

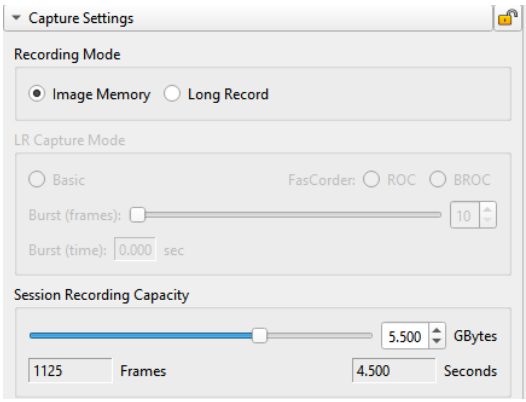
TS and IL cameras have 4GB, or 8GB of internal high-speed memory, referred to as Image Memory, used for capturing high-speed video in **Image Memory Recording** modes. HS cameras may have up to 32GB of Image Memory. All, or a portion (partition) of this memory may be used when recording. Total record time for Image Memory Recording will depend on the amount of memory selected, as well as the resolution, frame rate, and bit depth.

For IL and TS cameras in **LR (Long Record) mode**, raw video is streamed directly to the camera's internal SSD. On these cameras, 8GB Image Memory (required) is utilized as a buffer while streaming.

HS cameras in **FasFire LR mode** capture consecutive 4GB partitions, comprising a Partition Capture Stack automatically saved to a high-speed NVMe and available for review as one contiguous (LR) recording.

See "2-2 Long Recording Modes" on page 35 for more details.

Figure 1-35: Session Recording Capacity

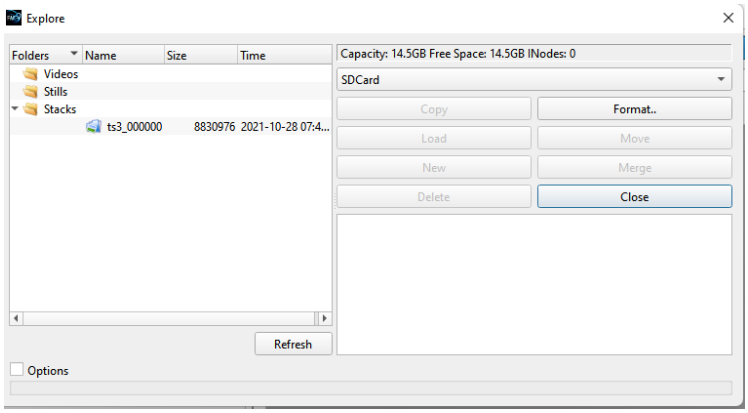


Configure Session (Standard Mode):

The Session Recording Capacity slider selects the amount of memory used to capture video. This slider has a granularity of 250MB.

Use the Format selection in the Storage Device Explorer to format any Camera device. This is accessed via the FasMotion Menu: File >> Open Storage Device... (Previously on the Storage Tab.) For HS cameras, devices may include the (optional) internal camera SSD as well as any mass storage device attached to the camera's controller with the exception of the controller's internal SSD.

Figure 1-36: Storage Device Explorer



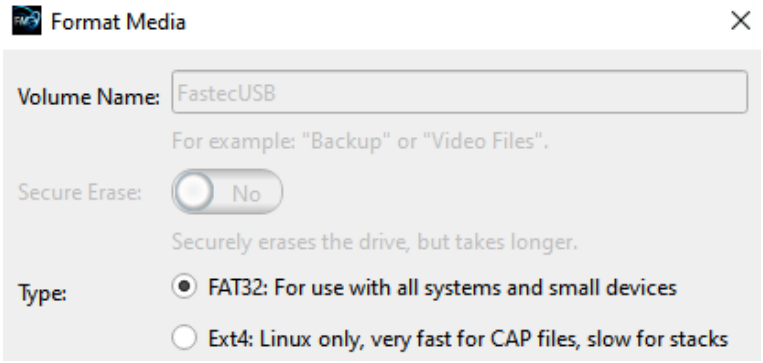
Formatting the Camera's internal SSD:

Format the SSD to delete all recordings and completely clean it off. (Deleting individual recordings is not allowed.) This should be done often to keep performance as high as possible.

NOTE: For IL and TS cameras, formatting the SSD is the only recommended way of deleting any files on it.

When formatting the SSD on most cameras, you may be given an option of Sanitizing the drive. Sanitization is a low-level process that securely erases all data and renews the SSD for optimal performance.

Figure 1-37: IL and TS Format Dialog



Formatting SD Cards and USB drives on IL and TS:

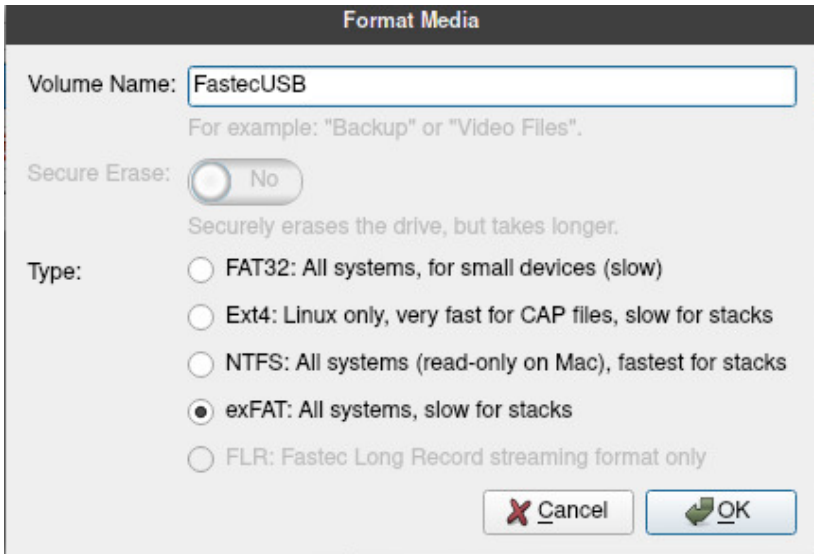
Formatting SD Cards and USB drives is the easiest and most effective way of deleting all recordings. When formatting SD Cards and USB drives, Fas*M*otion will give the option of "FAT32" or "Ext4."

Formatting Storage Media Devices on HS Systems:

Media storage devices on HS systems may include the internal camera SSD as well as any external USB or Thunderbolt drives connected to the controller.

The HS system dialog assigns default volume names for drives, but allows the user to rename them. Ext4 is the only format used on the camera's internal SSD, but for external drives there are several choices. If you are going to performing multiple image captures and saves, it is a good idea to do some experimenting with storage devices and file formats to find what is most efficient for your application.

Figure 1-38: HS Format Media Dialog



FAT32 is a **legacy** file system that may be used on devices that may not support the others. It is not recommended for volume work as it is slow.

Ext4 is a **Linux only** file system that works well with high-performance external NVMe SSDs, especially for CAP file transfers.

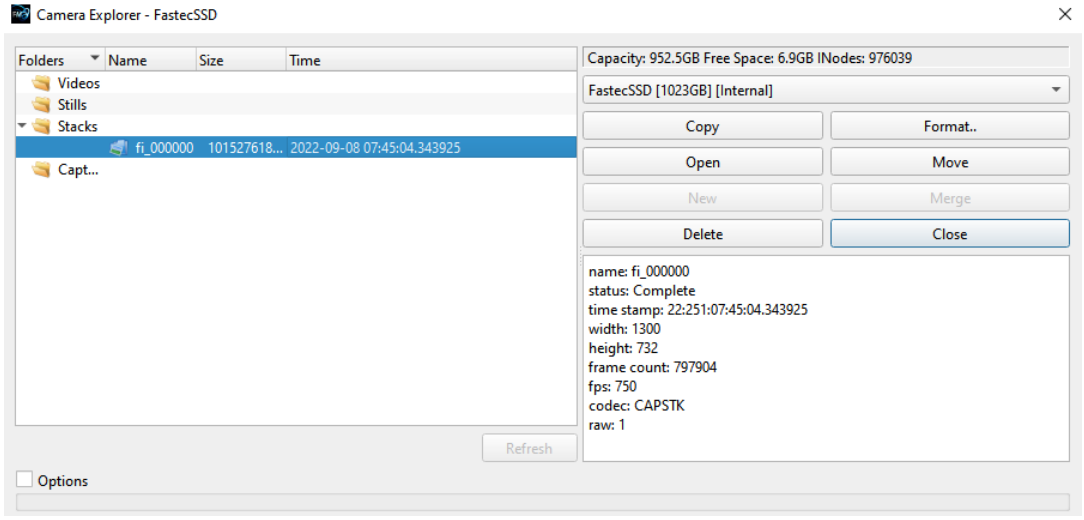
NTFS works very well on Windows systems and is efficient for managing large image stacks. NTFS drives may be read by Mac systems, but not written to.

exFAT works on all file systems, and is almost as fast for CAP files (or CAP file stacks used in FFLR) as Ext4. **This is the default format for external devices.**

Exploring Camera Media:

Open the Fas*M*otion Camera Explore dialog by selecting "Open Storage Device..." from the Fas*M*otion File menu.

Figure 1-39: Storage Explore Dialog



You will notice that the information about the clip or still will be displayed, including the time stamp, resolution, frame count, frame rate, and file format. Any selected still or clip may be copied, moved or deleted.

Deleting Imagery from the Camera

Stills, Image Stacks and AVI videos may be deleted from SD cards or USB devices via the Camera Explorer. Deletion of files on IL and TS SSDs is done only via Format.

Please see "3-9: Transfers, Batch Transfers and Conversions" on page 68 for mor information on the use of the Storage Explore Dialog.

1-13 Connecting Multiple Cameras in Fas*Motion*

One instance of FasMotion is capable of controlling several cameras on a single network.

- Each camera must be connected to the same subnet. (One instance of FasMotion may use only one network interface.)
- Each camera will have its own image window for live view and playback.
- Any IL, TS, or HS camera compatible with 3.0.x FasMotion may be part of the camera network
- As cameras are added in FasMotion, more system memory is required. It is recommended that systems supporting two cameras should have a minimum of 8GB of RAM and that 2GB should be added for each additional camera.

To set up Multi Camera Mode:

1. Enable Multi-Camera Control in User Preferences (Figure 1-40).
2. Open the Multi-Camera control pane the via Window menu (Figure 1-41). As with all FasMotion panes, the Multi-Camera pane location may be adjusted by the user. In Figure 1-42 on page 28 the pane has been nested to the right of the image windows.
3. Open two or more cameras in FasMotion. As each camera opens, a camera window will appear within image window. Camera windows will automatically tile themselves to fill the space. Camera windows may be re sized manually by pulling from any of their corners. Use the Tile or Cascade items in the Window menu to automatically re-arrange the windows.
4. Right-click on the Multi-Camera control pane to open the context menu to add or remove cameras from the pane.
5. Click on a camera window to select it. When selected, the window border will be a darker shade than the other cameras. See the image window on the left, below. The selected window will always have a faster refresh rate than the others, so live images and video playback will always appear smoother.

Figure 1-40: Preferences..Multi-Camera

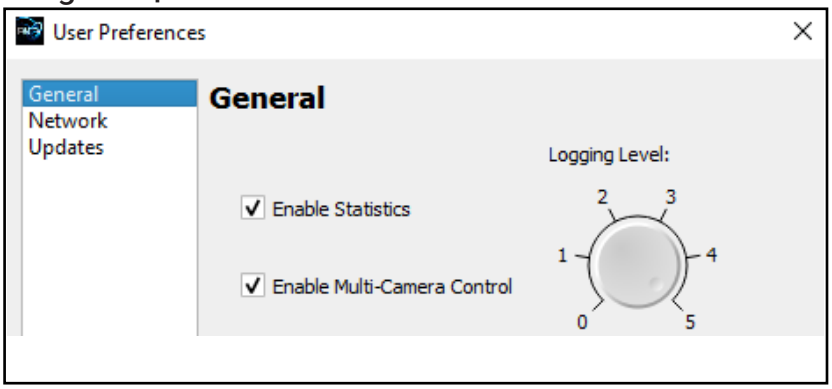
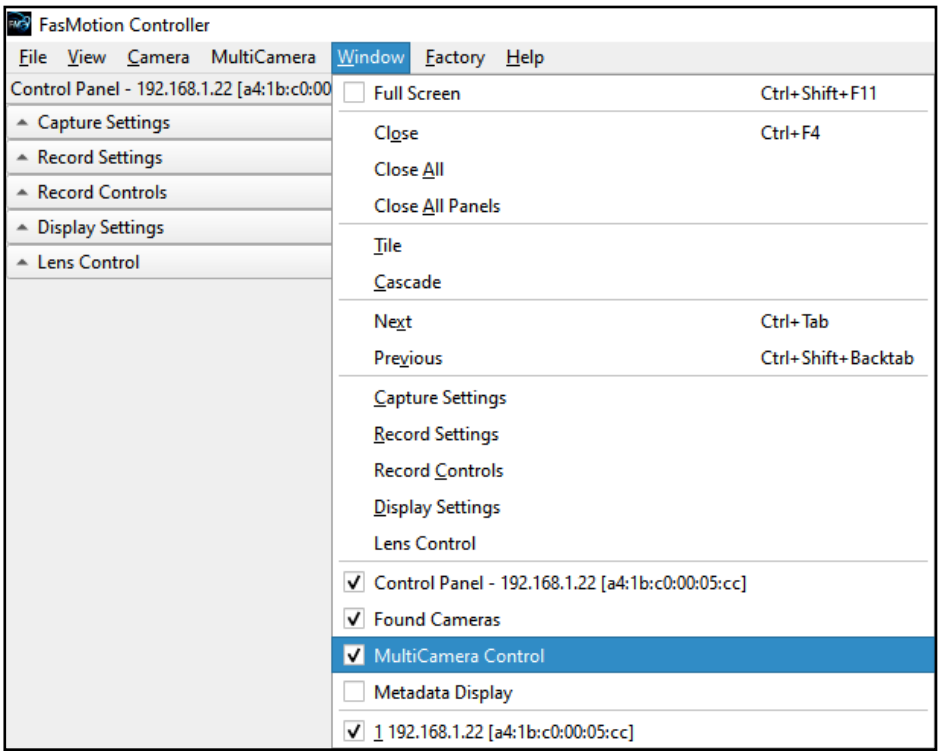


Figure 1-41: Multi-Camera in Window

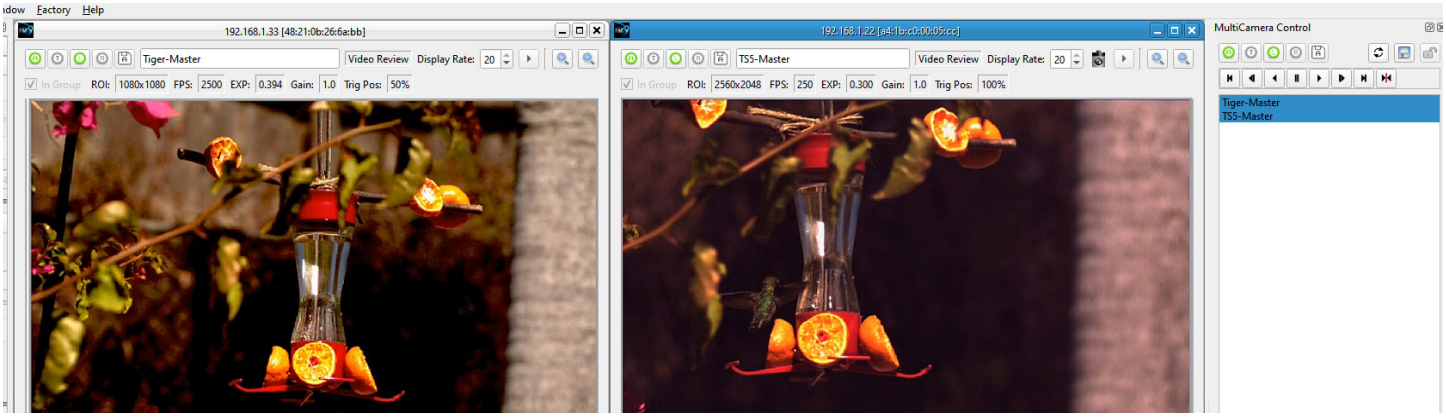


Multi Camera Setup

Cameras highlighted in the Multi-Camera Control pane can be set to Arm, Trigger, display Live images, etc. via the control buttons on the pane. The context menu allows you to add or remove cameras from the list and also to push camera configurations to the selected group. (See "1-14 Configurations" on page 29.)

All models of IL, TS, and HS cameras may be included in multi-camera control, but it is up to the user to sort out disparities in performance between models regarding frame rates, resolutions, etc. The Lock button allows changing parameters of all selected cameras simultaneously, provided

Figure 1-42: Multi-Camera Pane



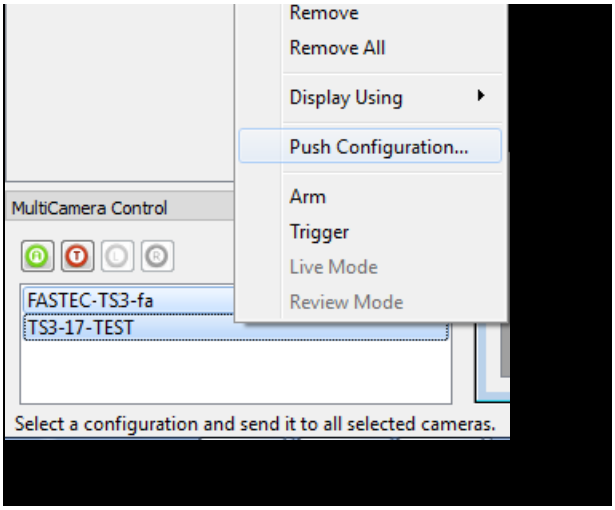
they are all the same model. When locked, all changes made in the control panel are applied to all cameras. (Only new changes apply.)

Sync and Save buttons are used to save clips from multiple cameras. The

Sync button transfers Start Clip and End Clip values to the camera with focus to all others selected.

The Save button opens the save dialog to set the format and destination clips from selected cameras. If this is used, all cameras will necessarily use the same save file type and destination. Imagery from each camera will be saved in turn.

Figure 1-43: Multi-Camera Control Context Menu



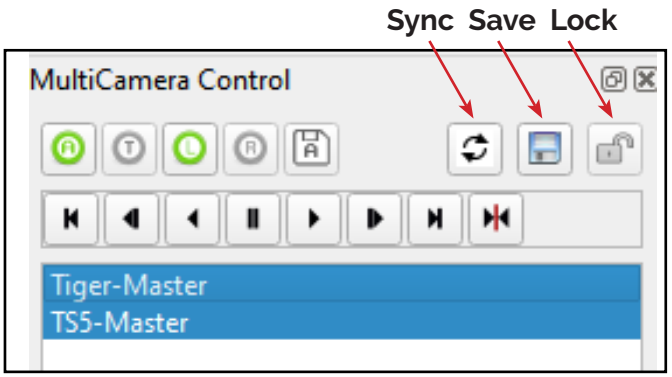
Synchronization and triggering

Multi-camera control must **not** be confused with frame or trigger synchronization.

It must be remembered that Fas*M*otion commands are sent via Gigabit Ethernet to cameras on a network. While these commands are received and executed very quickly by the cameras, the time lag is significant for cameras recording at high speeds.

For details on precision hardware frame and trigger synchronization please refer to "4 Synchronizing Cameras" on page 70.

Figure 1-44: Multi-camera Control Closeup



1-14 Configurations

Camera Configurations, which include all settings (resolution, frame rate, session length, exposure, etc.), may be Saved, Reloaded, or Reset to factory defaults.

Configurations for all cameras may be saved to a .cfg file on a computer or HS controller via Fas*M*otion. These can be loaded to any camera of the same model on any PC where Fas*M*otion is installed.

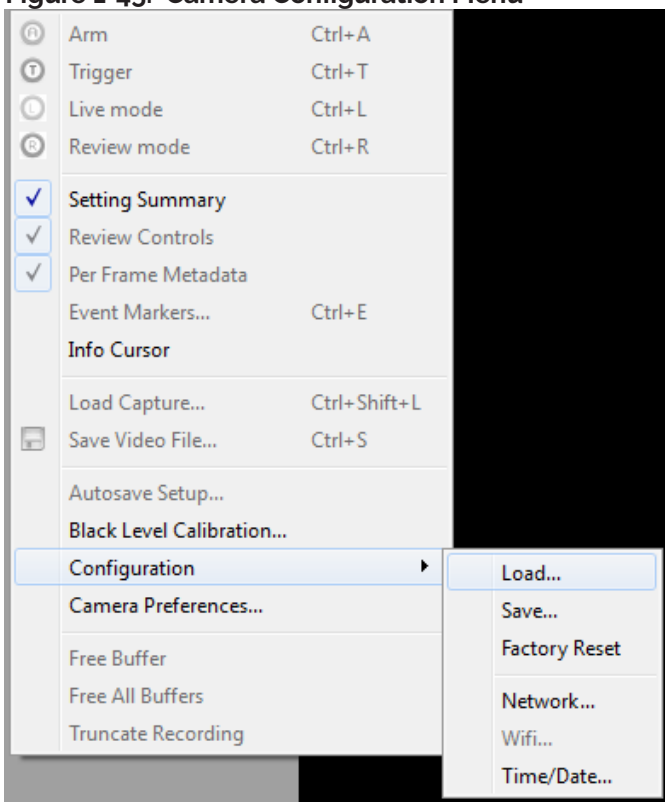
Additionally, two configurations may be saved directly onto TS cameras via the Camera GUI (see the TS User Manual).

To Save the Current Configuration:

Click on Save... in the Camera Configuration Menu. (Camera Configuration may be opened from the Camera Menu (see Figure 1-32 on page 23) or the Camera Context Menu, which opens with a right-click to the camera window.)

This will open an Explore window that allows you to browse to a location where you may save the current configuration.

Figure 1-45: Camera Configuration Menu



To Load a Saved Configuration:

Click on Load... in the Camera Menu. This will open an Explore window, which will allow you to navigate to the folder where you saved .cfg files and select the Configuration you would like to load.

Loading a Common Configuration to Several Cameras:

Note: Only load common configurations to cameras of the same model!

Select the target cameras in the Multi-Camera Control window. Right-click to open the Multi-Camera Context Menu and select Push Configuration. (See "Figure 1-43: Multi-Camera Control Context Menu" on page 28.) This will open an Explore window allowing you to browse and select the Configuration you wish to load onto the selected cameras.

To Load the Factory Configuration:

Click on Factory Reset in the Configuration Menu. This will load the factory default settings for the camera.

Note: This is not a routine operation as it rewrites your camera configuration. Always power cycle the camera after loading Factory Configs.

1-15 Reboot and Power Down

IL, TS, and HS cameras may be Powered Down or Rebooted from the Camera Menu.

If you power the camera down, it will turn off completely. In the case of the HS, Power Down from the Camera menu, powers down both the camera and controller.

To turn an IL or TS back on, press the camera's Power (on/off) button. If you disconnect any camera from power, it will boot when power is re-applied.

For HS cameras, always power up the camera before the controller.

If you Reboot the camera, it will do a "warm boot." That is, it will disconnect from Fas*M*otion, clear its memory, and restart its Operating System. Some of the electronics and logic will not be reset during a warm boot. On the HS, both the camera and controller will reboot.

Note: Both Power Down and Reboot will erase any imagery in the cameras High-Speed internal memory, but will not disturb any image data already saved to SSD, SD Card, and USB drives.

1-16 Camera Information

Camera information is located in the "Found Cameras" window.

The information shown is selectable via the Add Column Dialog box, which is available through the Found Cameras Context Menu. To select and organize the information on the Found Cameras window:

1. Right-click on the Found Cameras window to open the context menu.
2. Select Add Column
3. From the Add Column Dialog, you may Add or Remove information items, including:
   - Camera Name
   - Model
   - Serial Number
   - Software Version
   - IP address
   - Subnet Mask
   - Default Gateway
   - MAC
   - Vendor
   - Manufacture Info
   - Protocol Version
   - Bootloader Version
   - FPGA Version
   - Sensor Version
4. Use the Move Up and Move Down buttons to change the order that the information will appear.

Figure 1-46: Found Cameras Context Menu

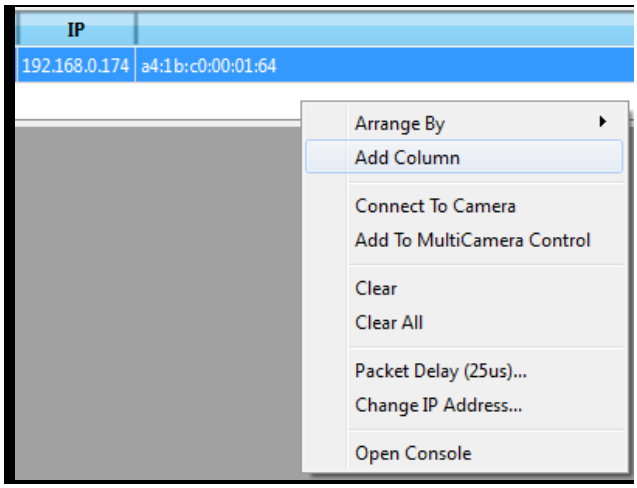
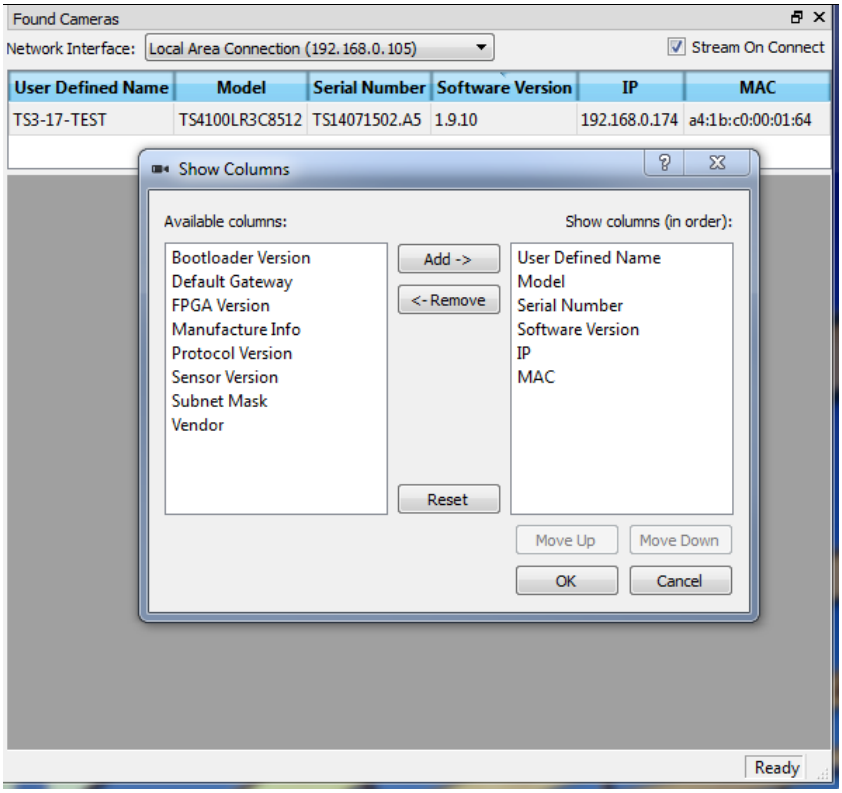


Figure 1-47: Add Column Dialog



1-17 Solving IL and TS Setup Issues

If the camera is not present in the Found Cameras window:

Any camera connected via Gigabit Ethernet should appear on the Fas*M*otion Found Cameras window as long as:

1. The physical connection is sound (good CAT 5E or CAT 6 cable, etc.).
2. The camera's IP address is on the same subnet of the selected network interface.

It is best to check #1, the physical connection, first.

- Make sure that the cable is marked CAT 5E or CAT 6 (or better).
- Connect the computer to another network device with the same cable and confirm that it can connect.
- Connect the camera to the computer via the GigE cable and confirm that the green LED on the camera's Ethernet connector lights in a three-blink pattern. (Three blinks indicate a GigE connection; two indicate 100BaseT.)

The simplest way to ensure #2, above, is to use a direct connection between the camera and computer (no switches or routers between camera and computer).

- If the camera's network configuration is set for DHCP, which is the default setting, Make sure the computer is set to DHCP: the TCP/IPv4 properties of the network adapter are set to obtain an IP address automatically.
- If the camera's network configuration is set to a Static IP address, make sure that the computer is set to a Static IP address on the same subnet.
- If the camera is set to an unknown Static IP address and you cannot view the camera display to retrieve it, refer to "1-5a Managing IL/TS Camera Network Settings" on page 16.

If you can connect to the camera in Fas*M*otion, but do not get a Live image:

In most cases, all of the control and setup features work in Fas*M*otion, but you cannot get a live image or transfer images to the computer. There are two common causes:

1. WiFi is enabled on the computer.
2. The firewall is not allowing Fas*M*otion to use UDP, which is the protocol for both live view and file transfers.
3. The system will not support UDP packets of 1500 bytes or greater.

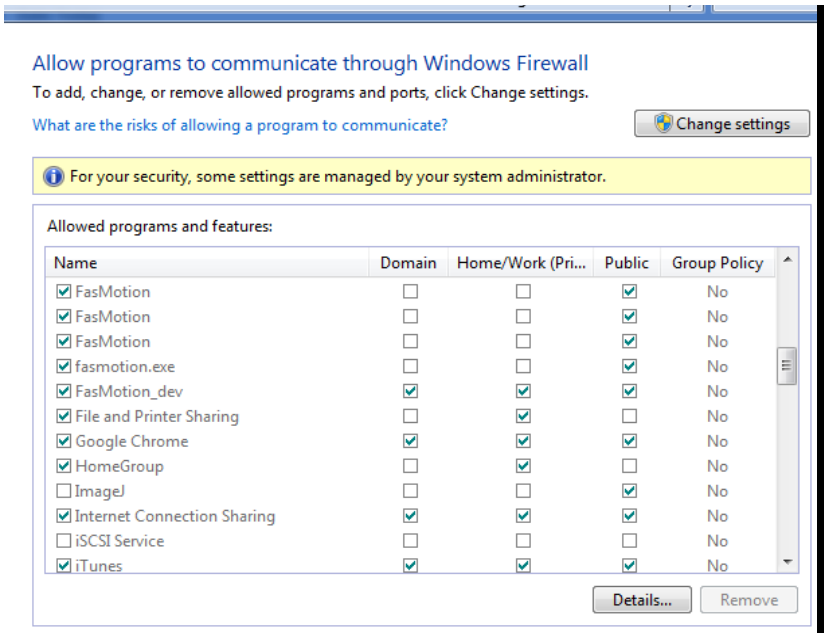
The first thing to do is always to make sure that the GigE interface that the camera is connected to is the only network interfaced active--disable the WiFi adapter and any other NICs present.

Check to see that all instances of Fas*M*otion are allowed through the Windows firewall.

Note that the example shown here is from a Fastec test computer that has had many versions of Fas*M*otion on it. Your computer is not likely to have this many, but there may be more than one.

If image transfers from camera to computer are slow or fail, please refer to "Application Note 5: Optimizing IL/TS for Image Transfers" on page 88 and make sure your system meets the requirements and is set up properly.

Figure 1-48: Allow Programs Through Windows Firewall



2 Recording with FasMotion

2-1a Capture Settings for IL and TS Cameras

The **Capture Settings tab** is used to select the **Recording Mode:**

- Image Memory Mode
  - Session Recording Capacity
- LR Capture Mode:
  - LR-Basic
  - LR-ROC
  - LR-BROC
    - BROC Burst Length

All IL and TS cameras may be operated in **Image Memory Mode**. While running in Image Memory Mode, cameras will record into the installed high-speed memory (4GB or 8GB).

For **Image Memory** recordings:

1. Select the Image Memory radio button. (This will be the only possible selection for cameras without the Long Record option.
2. Set the Session Recording Capacity slider to select the required recording time or number of frames.

The Session Recording Capacity slider is used to select the amount of memory used for recording. The number of frames and the time, in seconds, for the recording, which will depend on the resolution, frame rate, bit depth and the memory selected is shown here.

It is important to be able to limit the recording capacity in order to optimize workflow, especially for automated captures using Autosave and/or FasFire. (See "2-13 Autosave in FasMotion" on page 50 and "2-14 FasFire in FasMotion" on page 51.)

Figure 2-1: Capture Settings: Image Memory Mode

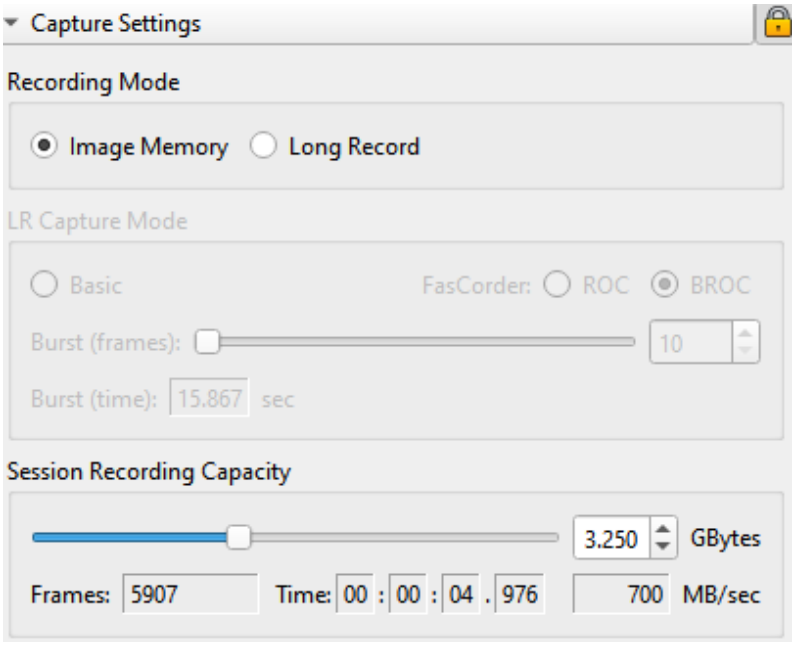
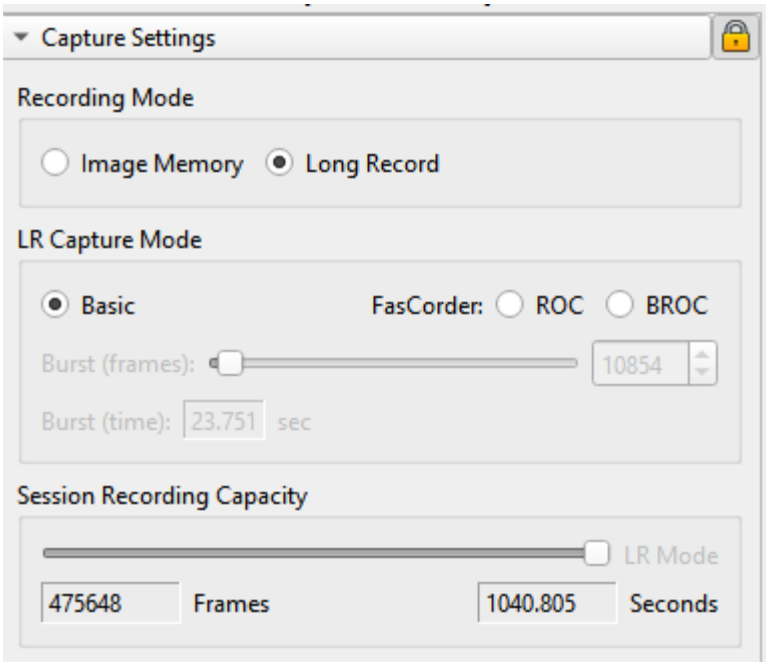


Figure 2-2: Capture Settings: Long Record Basic



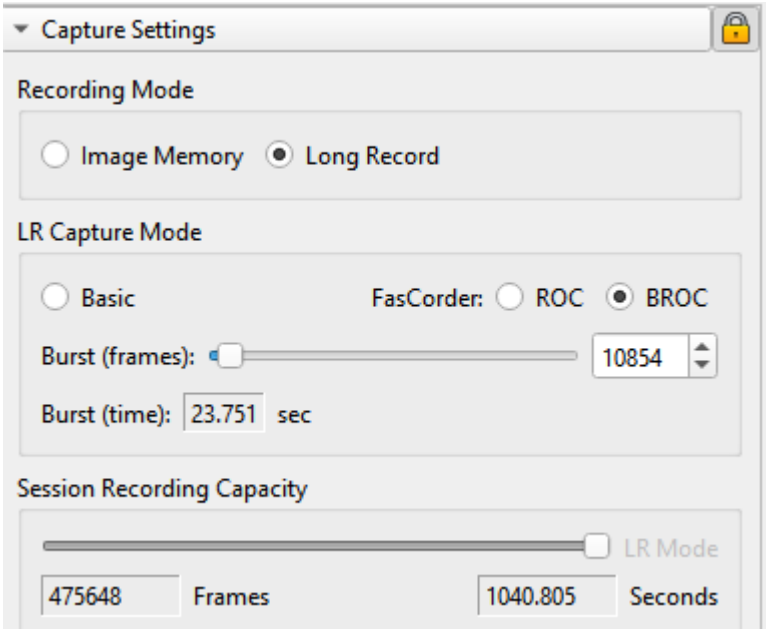
All IL and TS "Dual Mode" cameras, (IL4 / TS4, and IL5 /TS5 cameras with LR option) may be operated in **Long Record** mode.

Note: Frame rates are limited for LR recordings due to SSD bandwidth. Please refer to the User Manual for your camera for details.

For **Long Record** sessions:

1. Select the Long Record radio button.
2. Select an LR Capture Mode. For more information on the LR Capture Modes, refer to "2-2 Long Recording Modes" on page 35.
3. If BROC recording is selected, use the Burst slider to select the number of frames to be recorded for each trigger.

Figure 2-3: Capture Settings: Long Record BROC



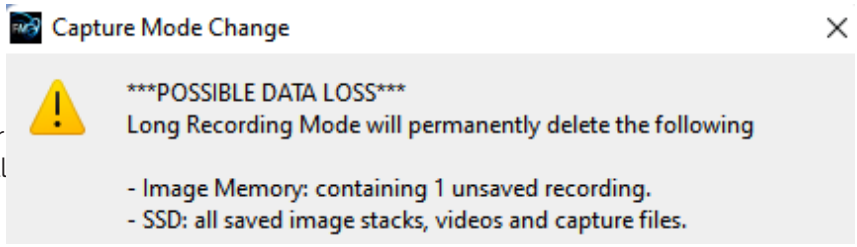
Switching from Image Memory mode to Long Record Mode in Fas*Motion*:

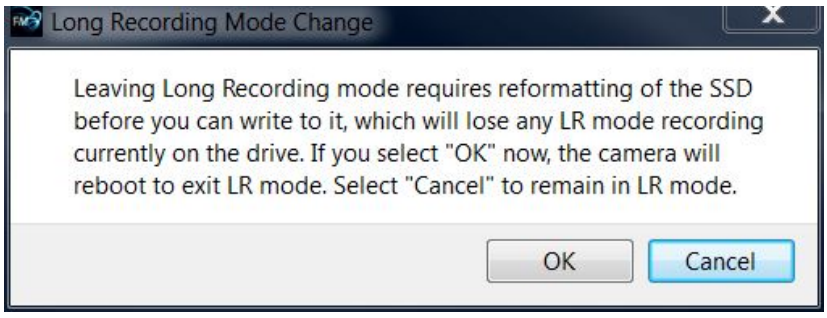
1. With the camera in Live, open the Capture Settings tab.
2. Select the Long Record radio button

A Mode Change message box will appear with the warning that Long Recording mode will overwrite data on the SSD.

3. Click OK to continue. IL and TS cameras will reboot in order to enter Long Record Mode. HS Cameras will enter Long Record mode without rebooting.

Figure 2-4: Mode Change Messages





Note: For IL and TS systems, the file system on the SSD will be overwritten as soon as the camera is Armed and streaming in LR mode begins. At that time any imagery on the SSD taken in Image Memory Mode will be lost.

Switching Back to Standard Mode:

1. With the camera in Live, open the Record Settings tab.
2. Select the Image Memory radio button.

The Mode Change dialog will appear again, but this time the text informs you that you will need to format the SSD before you will be able to save images to it in any format (AVI, MP4, TIFF, etc.) after making an Image Memory recording.

NOTE: You must format the SSD AFTER rebooting into Image Memory Mode on IL and TS cameras.

2-1b Capture Settings for HS Cameras

Beginning with FasMotion version 3.4, Long Record Mode on HS cameras is called **FasFire LR**.

HS cameras with the LR option may be operated either in Image Memory mode or FasFire LR mode.

For **Image Memory recordings** follow the same steps as outlined for IL and TS cameras in "2-1a Capture Settings for IL and TS Cameras" on page 32.

For **FasFire LR recordings:**

1. Select the FasFire LR radio button.
2. Select an LR Capture Mode. For more information on the LR Capture Modes, refer to "2-2 Long Recording Modes" on page 35.
3. Select the LR Save Device. New for Version 3.4, LR recordings may use the internal Fastec SSD, or external SSDs, selectable via the FasFire LR Save Device pulldown.
4. If BROC recording is selected, use the Burst slider to select the number of frames to be recorded for each trigger.

Any of these "Devices" may have a mix of Image Memory and FasFire LR recordings on them at any time.

NOTE: The frame rates for FFLR recordings are not limited by the system for the data rates of the selected Device because any device may be used the performance of which is not known to the system. Refer to "App F Part 3: FFLR Data Rate Benchmarks" on page 112 for guidance on testing devices for FFLR.

5. Use the Session Recording Capacity slider to select the amount of storage space to use for recording. (Multiple recordings may be made.)

If there is insufficient space on any device, it will no longer be listed in the FasFire LR Save Device pulldown. If no device has sufficient space, the FasFire LR radio button will be grayed out.

Figure 2-5: Capture Settings: FasFire LR Enabled

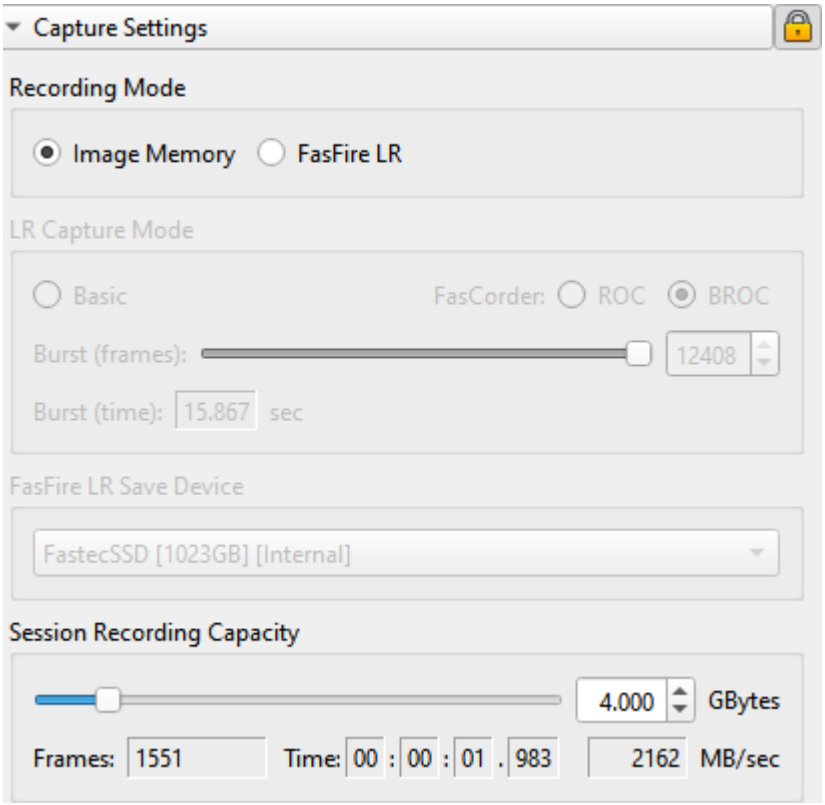
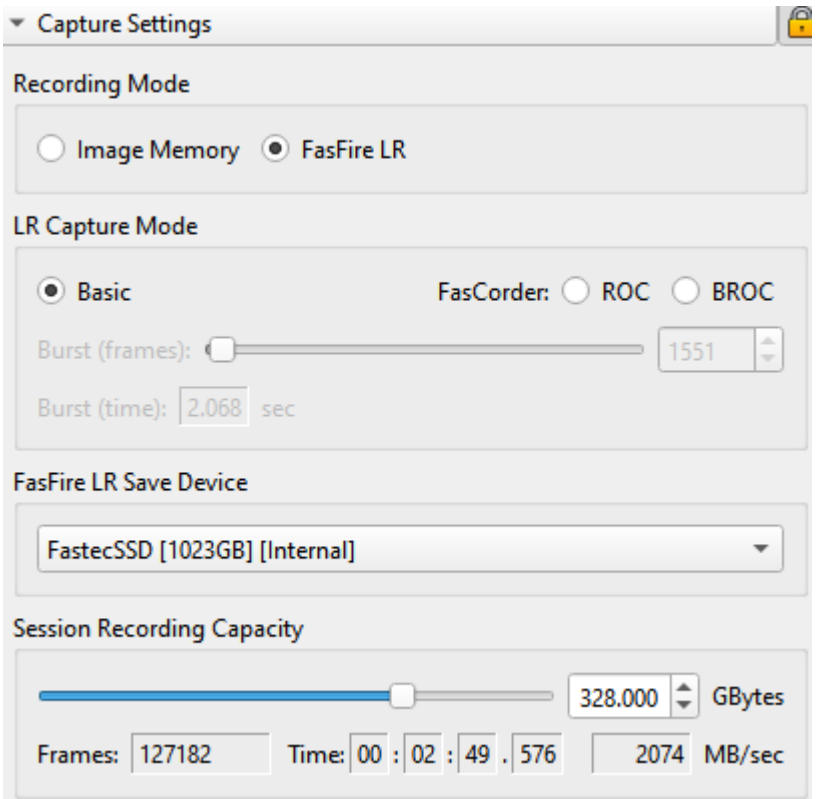


Figure 2-6: Capture Settings Image Memory Enabled (HS)



2-2 Long Recording Modes

Long Record Basic mode works much like Standard Basic mode, described in "Standard Basic Mode Recording" on page 47:"

1. Click on the Arm button to begin streaming pre-trigger frames into a circular buffer on the SSD.
2. Trigger the camera at the appropriate time. The trigger point may be set anywhere on the timeline. See "To Set the Trigger Position:" on page 41.

- When triggered, the camera will record the trigger frame, plus all post-trigger frames on the onboard SSD, then proceed into Playback.
- The progress of the recording is displayed on the time line very much as it is with Standard basic mode. Please refer to "Figure 2-27: Record Progress Bar: Armed" on page 47.

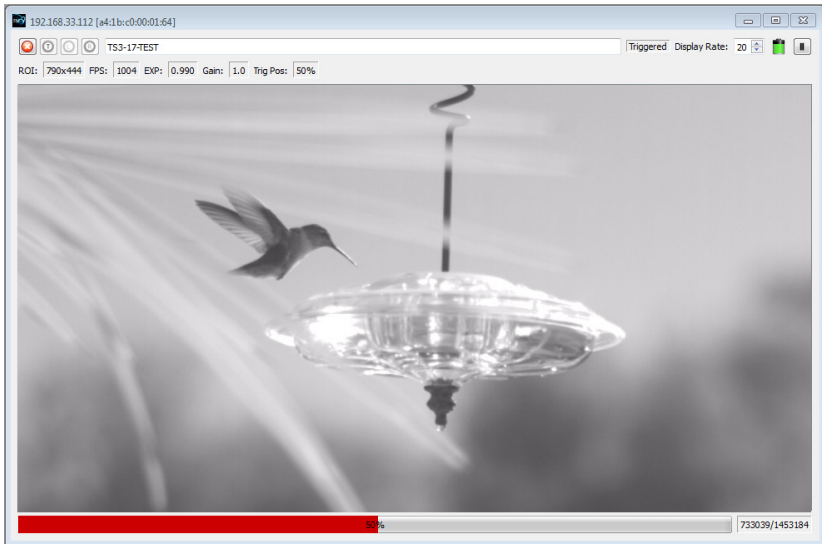
Note: If you wish to stop recording before all post-Trigger frames are recorded, you may cancel the recording by clicking the Arm button, then select "Yes" to retain the current session in the Cancel Record dialog. See "Figure 2-26: Cancel Recording Dialog" on page 47.

- The basic performance specifications vary depending on model, but generally Long Record allows for much longer recordings at somewhat slower frame rates than Standard mode.
- Autosave is available in Standard, but not in Long Record Modes.
- Long Record mode recordings are written to the SSD, which is non-volatile media. The recording is not lost when the camera powers down.

FasCorder ROC mode is convenient if multiple recordings of various durations will be made or if there are pauses in the action that need not be recorded. **FasCorder BROC mode** records a specified number of frames with each trigger. See "2-1a Capture Settings for IL and TS Cameras" on page 32.

1. Once the camera is set to ROC or BROC mode, click on the Arm button. You will now see the recording timeline and a live image in the Camera Window.

Figure 2-7: FasCorder in FasMotion



2. Click on the Trigger button. The TSx is now recording and streaming images directly to the onboard SSD. The position bar goes solid red. The Arm button will become a white "X" on red, while the Trigger button remains red.
3. **ROC mode**: Click on the trigger button again. The recording will now pause. and the position indicator will alternate yellow / orange and the Arm button will turn brown as in Figure 2-36 on page 52. Repeated triggering will cause the camera to alternate between recording and paused states.

BROC mode: A specified number of frames will be recorded with each trigger, then the recording will pause. The buttons and position indicators will be the same as for ROC mode. If the camera is triggered again before the specified number of frames has been recorded, the additional frames are appended.

4. Press the Arm button. A message will appear giving you the options of exiting to Review and Save, or to continue recording.

Note: Appending to ROC and BROC recordings upon returning from Playback or a Power cycle will cause a number of black frames (up to 128) to be inserted in the recording time line.

It is possible to alternate FasCorder ROC and BROC recordings in any combination as they are compatible formats. Long Record basic recordings, however, are not compatible with FasCorder and cannot coexist on the SSD.

2-3a Frame Rate and Resolution for Image Memory Recording

Record Settings are interactive:

- The Resolution you choose will define the maximum Frame Rate and number of frames that can be captured given the Capture Settings.
- The Frame Rate will define maximum Shutter Speed (exposure time in µsec).
- The Frame Rate and number of Frames captured define the duration of the recording (time in seconds).
- If you select Autoset in either Frame Rate or Resolution, that parameter will be selected automatically to its maximum allowable value, dependent on the other current settings.

To set the **Resolution:**

1. Confirm that the camera is in Live mode. See Table 2-3 on page 46.
2. Select the Aspect Ratio you wish to use. The choices are Custom, 1:1, 5:4, 4:3, and 16:9.
3. Adjust the image Width (in pixels) you wish to use. This can be done either by editing the number in the Width edit box, or by moving the slider.

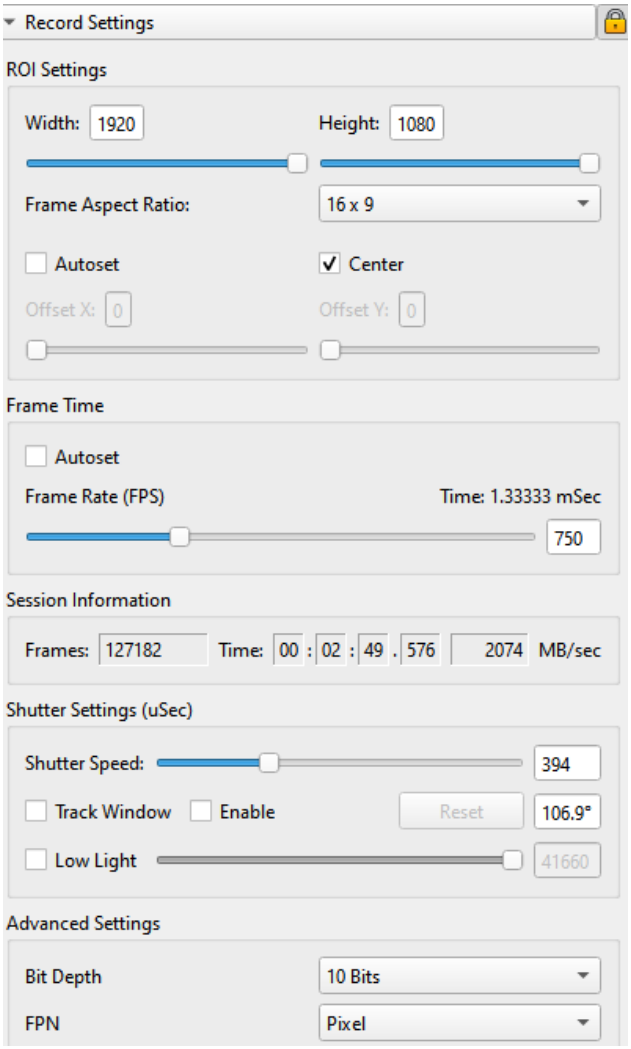
Please refer to your specific camera's manual for sample frame rates and resolutions.

Whenever any slider is blue. It may be controlled by dragging it with the mouse. Often the best way to get a precise value, if needed is by changing the value directly using the edit box.

To set the Frame Rate:

Either edit the number in the Frame Rate edit box or move the Frame Rate slider to the desired position using the mouse.

Figure 2-8: Record Settings Tab



Offset Control:

To make use of the best resolving properties of your lens, you will want to position the image at the optical center, which corresponds to the center of the sensor. In this case you would make sure that the "Center" check box is checked.

It is also possible, that you will wish to shift your ROI (Region of Interest) without moving the camera.

Let's say, for example, that you have captured images at 1024 x 1024, and are now interested at capturing a 512 x 512 portion of the scene, let's say the bottom right hand quarter at a higher frame rate.

In this case, you would wish to add 512 to both the X and Y offset. For example, a 1024 x 1024 centered image the offsets will be 128 and 0 on a TS3 camera. The resultant offsets for a 512 x 512 image (lower right quadrant) would be 640 and 512.

Note: Offset 0:0 is the upper left hand corner of an image of the largest resolution available, depending on the model of the camera and any binning or sub-sampling applied.

2-3b Frame Rate and Resolution for Long Record and FFLR

Setting Frame Rates and Resolutions for Long Record and FFLR is done the same way as for Image Memory recording, as described in"2-3a Frame Rate and Resolution for Image Memory Recording" on page 36.

Maximum Frame Rates for TS and IL cameras in Long Record mode are generally lower than in Image Memory mode and depend on the camera model.

For example, an IL5 or TS5 camera in Image Memory mode may be set to record 1280 x 1024 @ 991fps in 8 bits. (Figure 2-9) When the camera is reset into Long Record Mode, the frame rate will automatically be reduced to 366fps. (Figure 2-10)

IL5xxD and TS5xxD cameras have a Long Record bandwidth of about 480MBs.

Beginning with version 3.4, Maximum Frame Rates for HS5 and HS7 operating in FasFire Long Record mode **have not** been limited in the FasMotion code for the speed of the storage device.

There are a large range of internal and external drives that may be used for this mode. Many have less bandwidth than the high-performance NVMe SSDs used internally to the camera. Others, especially as time goes on, will surely have even higher performance. For these reasons, **setting bandwidth limits needs to be done by the user**, depending on the performance of the storage device to be used.

Note that the Session Information in FasMotion now indicates the bandwidth necessary for a given set of camera settings in MB/sec.

Figure 2-9: Memory Mode Bandwidth

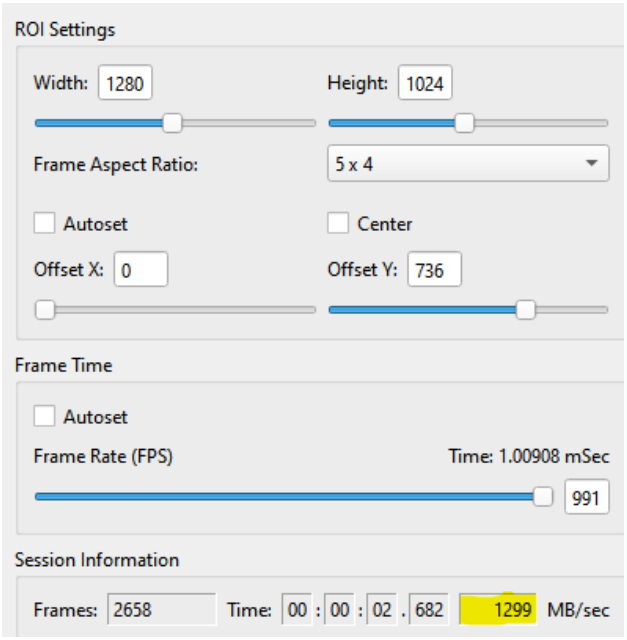
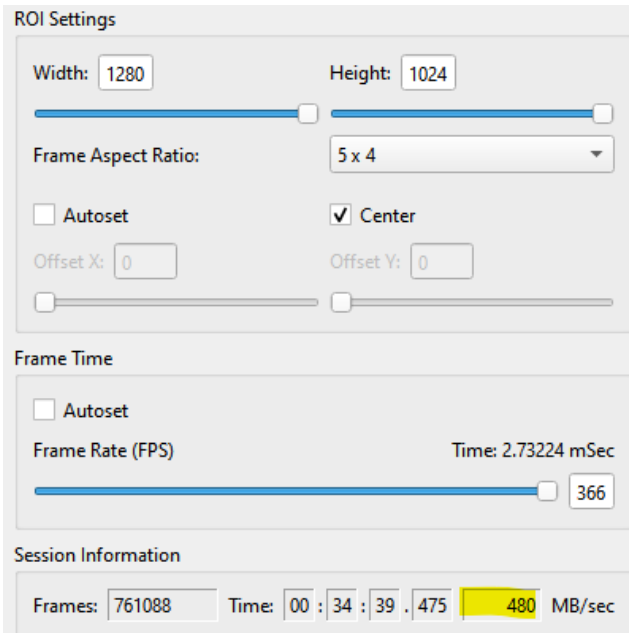


Figure 2-10: IL/TS LR Mode Bandwidth



Testing for FFLR Bandwidth Limits

All HS systems with the Long Record option have high-performance SSDs installed in the camera. These drives are capable of about 2000 MB/s in either local or remote mode as long as the Controller is not running extra applications on it.

The simplest way to test if the system can maintain the bandwidth required for a given ROI and framerate is to do a test run in FFLR mode with the desired parameters set and watch the FasFire gas gauge. If the gas gauge always shows 6 or 7 buffers available, you know you're OK.

If you would like to know what the actual bandwidth is, you can look at the system log to see the speed for each 4GB SSD transfer made during the test:

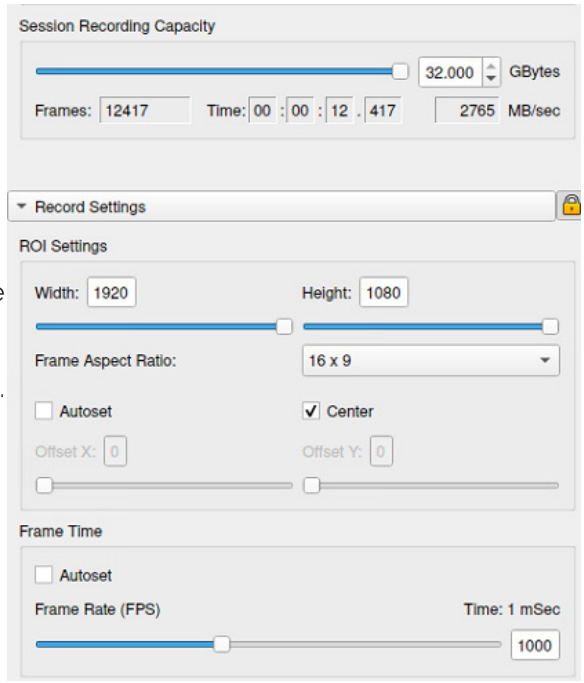
1. Open a Terminal window on the controller: Ctrl-Alt-t
2. Go to the "scratch" directory where the log file is: cd ~/.config/Fastec/scratch
3. Search the log file (cs.log) for the text "sec =" : cat cs.log |grep sec=
4. The system will return results with the timing for each 4GB FFLR buffer (See Figure 2-11 on page 38).
5. Parse the Byte/sec data from the result and compute the average
6. A good rule is to use that number, converted to MB/sec as the upper limit, and 85% x as a "safe" number.

Figure 2-11: Bandwidth Results in Camera Log

```
fascam@Tiger-Master:~/.config/Fastec/scratch
File  Edit  View  Search  Terminal  Help
[fascam@Tiger-Master ~]$ cd ~/.config/Fastec/scratch
[fascam@Tiger-Master scratch]$ cat cs.log |grep sec=
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000006/0000000.cap' part_num=0 status=0x0 frames=1551 bytes=4294967296 sec=1.685579 [2548066448.38 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000006/0000001.cap' part_num=1 status=0x0 frames=1551 bytes=4294967296 sec=1.749003 [2455666054.32 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000007/0000000.cap' part_num=0 status=0x0 frames=1551 bytes=4294967296 sec=1.749841 [2454490034.24 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000007/0000001.cap' part_num=1 status=0x0 frames=1551 bytes=4294967296 sec=1.793790 [2394353461.66 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000007/0000002.cap' part_num=2 status=0x0 frames=1551 bytes=4294967296 sec=1.791353 [2397610798.10 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000007/0000003.cap' part_num=3 status=0x0 frames=1551 bytes=4294967296 sec=1.812956 [2369041110.76 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000007/0000004.cap' part_num=4 status=0x0 frames=1551 bytes=4294967296 sec=1.802389 [2382930264.22 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000007/0000005.cap' part_num=5 status=0x0 frames=1551 bytes=4294967296 sec=1.796484 [2390762899.09 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000007/0000006.cap' part_num=6 status=0x0 frames=1551 bytes=4294967296 sec=1.836898 [2338163194.69 Byte/sec]
saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000007/0000007.cap' part_num=0 status=0x0 frames=1551 bytes=4294967296 sec=1.812388 [2369783565.11 Byte/sec]
```

Refer to "App F Part 3: FFLR Data Rate Benchmarks" on page 112 for guidance on testing devices for FFLR.

Figure 2-12: 1080p @ 1000 Bandwidth



2-3c OverSpeed Burst Recording

You want to record 1920 x 1080 @ 1000fps (10 bits) for 30 seconds. With 32GB of Image Memory, you can record for only 12.417 seconds in Image Memory Mode. (See Figure 2-12.) The bandwidth required for Basic FFLR mode is 2765 MB/sec, but your storage device will only do 2000. What do you do?

FFLR utilizes up to seven 4GB image buffers in FasFire mode to create longer recordings than would be possible with Image Memory Mode recordings. In order to maintain its bandwidth without gaps in the recording, the system must not capture images any faster than it can transfer them to a storage device.

With seven image buffers available, the system may lag behind to some extent from time to time as long as it never runs out of available buffers for the next capture.

Once the user has confidence that the system can maintain a given transfer rate using the test in "Testing for FFLR Bandwidth Limits" on page 37, it is possible to calculate the interval of time it would take to run out of buffers if recording above the maximum sustainable bandwidth. The "OverSpeed Burst Calculator" will do this for you:

Figure 2-13: OverSpeed BROC Calculator

Drives	Safe Data Rates	
Fastec SSD (Internal)	2000	MB/s
Video SSD (External TB)	1400	MB/s
Fastec USB (External USB)	250	MB/s
Select Storage Device:	Fastec SSD (Internal)	
Overspeed Burst Rate	2760	MB/s
OK / Caution / Alert		
BROC/ROC Time		
Max Time	31.58	Sec
Set BROC Time:	30	Sec
Repeat Interval	42	Sec

1. Enter "safe" data rate values for storage devices you may use.
2. Select the storage device for your test.
3. Select your OverSpeed Burst Rate--in this case we selected the record bandwidth required for 1920 x 1080 @ 1000fps.
4. Enter the number of seconds you wish to record in "Set BROC Time"-- we selected 30. (This value is close the limit, so it is displayed in yellow.)

The calculator is telling us that for BROC recordings, we can set the camera at 1920 x 1080 @ 10 bits for 30 seconds at 1000 fps (30,000 frames).

It is also telling us that we can begin such a recording every 42 seconds. In other words, we can make a 30 second recording, the wait 7 seconds, and make another.

2-4 Setting Shutter Speed in Fas*M*otion

The Shutter Speed is expressed in microseconds of exposure time and in shutter angle (degrees).

Minimum Exposure:

Minimum exposure is 2µsec for all TS3 / TS4 models, 3µsec for all TS5 models (regardless of frame rate).

Maximum Exposure:

Table 2-1: Maximum Exposure by Model

IL/TS3, IL/TS4 and HS7	IL/TS5 and HS5
1/(Frame rate) - 6µs Example: At 500 fps the max exposure is: (1/500sec) -6µs = 2000µsec -6µsec = 1994µsec	1/(Frame rate) - 12µs Example: At 500 fps the max exposure is: (1/500sec) -12µs = 2000µsec -12µsec = 1988µsec

For those accustomed to using shutter angle, to convert that to degrees:

$$(\text{Exposure (in } \mu\text{sec)} / \text{Frame Time}) \text{ X } 360^{\circ}$$

For example, at 500fps, an exposure time of 250µsec is:

$$(250\mu\text{sec} / 1/500 \text{ sec}) \text{ X } 360^{\circ} = (250 / 2000) \text{ X } 360^{\circ} = 45^{\circ}$$

Setting the Shutter Speed:

Shutter Speed is set using the slider or edit box in the "Shutter Settings" section of the Record Settings Tab. (See "Figure 2-14: Shutter Settings".)

Low Light Mode:

In some special circumstances, the available light for setting up the camera for a high-speed event is not as bright as what will be used for event itself. You may, for example be using some lights that can only be switched on for a short time and are not available for camera set up.

The exposure for Low Light Mode is much longer than would be possible for a high frame rate. The default shutter speed for Low Light mode is 41.666ms, which is the "1X" shutter speed for 24 FPS. The shutter speed for Low Light may be adjusted via Fas*M*otion by checking the Low Light box and moving the slider or editing the Low Light edit box.

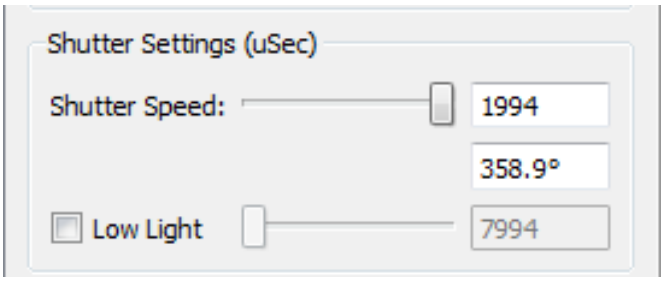
To enter Low Light Mode:

Note: Be careful when using the Low Light feature! **It is very easy to forget that it is on!** Remember to set your exposure for the light that will be present during the image capture.

1. Set the Shutter Speed just as you need it for the high speed event.
2. Click on the Low Light check box. A check mark will appear in the box. The edit box and the slider will become active.
3. Adjust the slider or edit the box for the desired exposure.
4. Press the Arm Button.

The camera will begin recording. You will notice that the image is darker now than in Live Mode (unless you are recording at 24fps).

Figure 2-14: Shutter Settings



5. Press Arm again to quit recording. (Click "OK" on the Warning message to Cancel.)

2-5 Enabling Auto-Exposure Tracking

The auto-exposure tracking feature is designed to adjust the shutter setting of a camera to accommodate changes in available light such as changes in sunlight due to moving clouds.

It is not meant to track immediate changes such as flickering light sources, or explosive events.

1. Set your shutter speed to get the best exposure for the present lighting conditions. It is best if the shutter speed is not too close to either the maximum or minimum for the current frame.
2. Click the Track Window check box to begin using the auto-exposure function. A green track window will appear on the image.
3. Move and/or re size the track window to so that it covers an appropriate area of the image. Choose this area carefully:

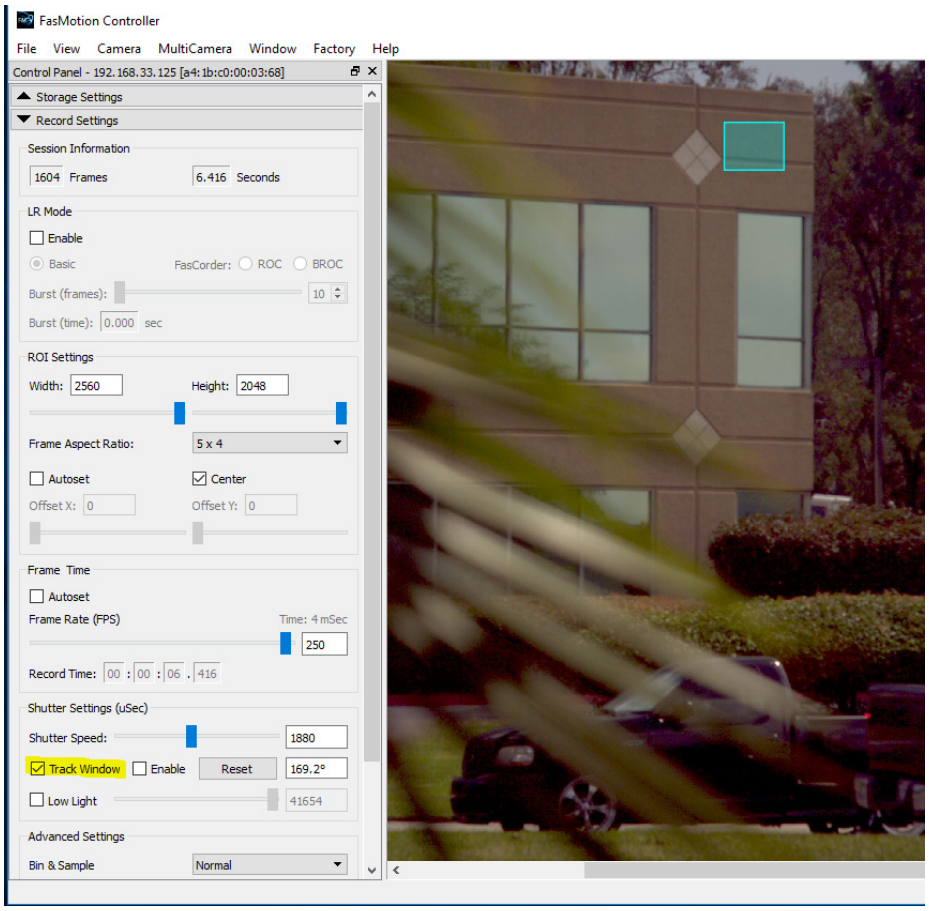
- It should be illuminated similarly to the area of interest
- It should not become obscured by other moving objects

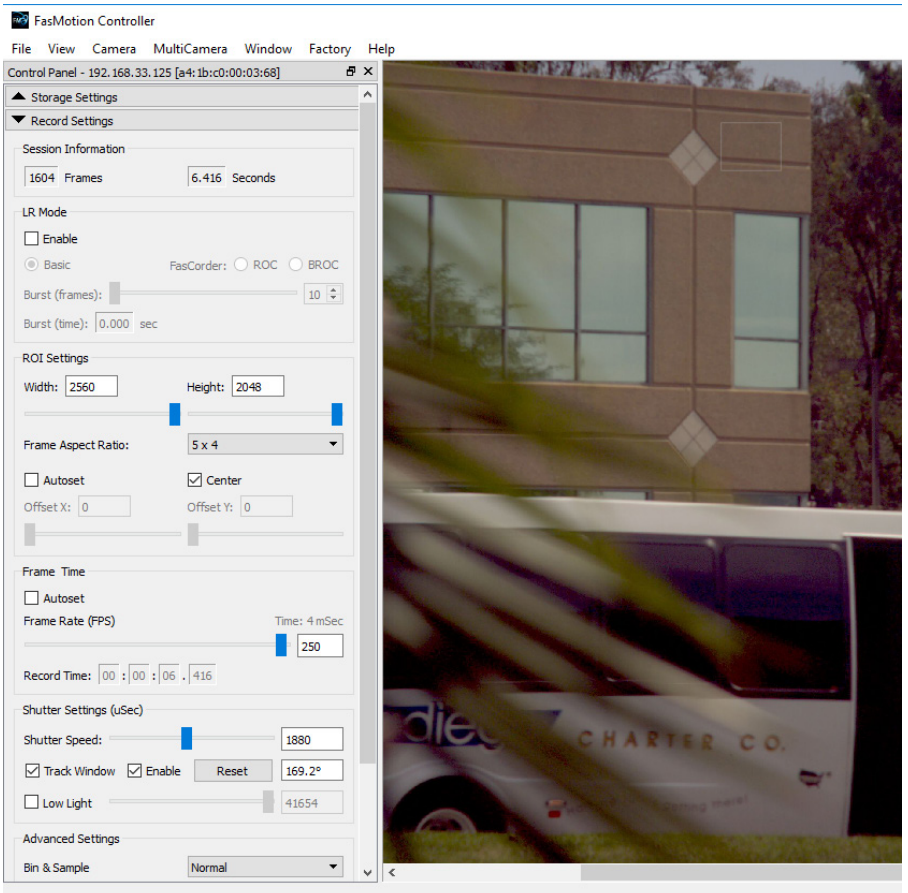
4. Click the Enable check box to begin tracking. The tracking window will now become a thin white border.

Click the Reset button to begin over. This will re-locate and re-size the tracking window and turn it green again, making it easier to locate.

NOTE: Exposure Tracking and Image Trigger cannot be used at the same time. When one is enabled, the other becomes unavailable.

Figure 2-15: Exposure Tracking Window





2-6 Setting Bit Depth in Fas*Motion*

The IL/TS3/4 and HS7 records and saves 8-bit or 10-bit data, while the IL/TS/HS5 records and saves 8- 10- or 12-bit data. The advantage of recording higher bit depths is greater fidelity when enhancing the images. The disadvantage is that it takes more memory to record or save 10- or 12-bit data.

Note: CAP, DNG, and TIFF (raw) are the only saved file types that preserve more than 8 bits, so these file types should be used if you are planning to do post-processing.

When saving 10- or 12-bit data (to a mass storage device) in TIFF (RAW) format, the actual file type is a 16- bit file, so it is substantially larger than an 8-bit mono file. The 10-bit (RAW) color image is not colorized--it is a RAW Bayer image (not "colorized," which would make it about 3x as large), so it is about 2/3 the size of the 24-bit color file (8 bits per each of 3 color channels).

Table 2-2: IL/TS/HS5 Bit Selection

	Bit:	12	11	10	9	8	7	6	5	4	3	2	1
Selection	10 Bits	x	x	x	x	x	x	x	x	x	x		
	Upper 8 Bits	x	x	x	x	x	x	x	x				
	Middle 8 Bits			x	x	x	x	x	x	x	x		
	Lower 8 Bits					x	x	x	x	x	x	x	x
	12 Bits [12:1]	x	x	x	x	x	x	x	x	x	x	x	x
	10 Bits [12:3]	x	x	x	x	x	X	x	x	x	x		
	8 Bits [12:5]	x	x	x	x	x	x	x	x				
	10 Bits [11:2]		x	x	x	x	x	x	x	x	x	x	
	8 Bits [11:4]		x	x	x	x	x	x	x	x			
	10 Bits [10:1]			x	x	x	x	x	x	x	x	x	x
	8 Bits [10:3]			x	x	x	x	x	x	x	x		
	8 Bits [9:2]				x	x	x	x	x	x	x	x	
	8 Bits [8:1}					x	x	x	x	x	x	x	x

To choose the recording bit depth:

1. Navigate to the Record Menu.
2. Select Bit Depth. For IL/TS-3/4 and HS7, the choices are: 10-bit, Upper 8 bits, Middle 8 bits, or Lower 8-bits. For the IL/TS/HS5, there are more choices, listed on Table 2-2.
3. Select the desired bits. Note that selection of high bits (default) always presents the cleanest image, while selection of lower bits presents the brightest images with added noise. (See "Application Note 2: Understanding Bit Depth" on page 81.)

For more information, read the Understanding Bit Depth blog posts on the Fastec Webite.

2-7 Setting the Trigger Position

In standard mode, a camera records into a fixed, selectable circular buffer, the length of which is determined by the user (see "1-12 Camera Memory and Image Storage" on page 25).

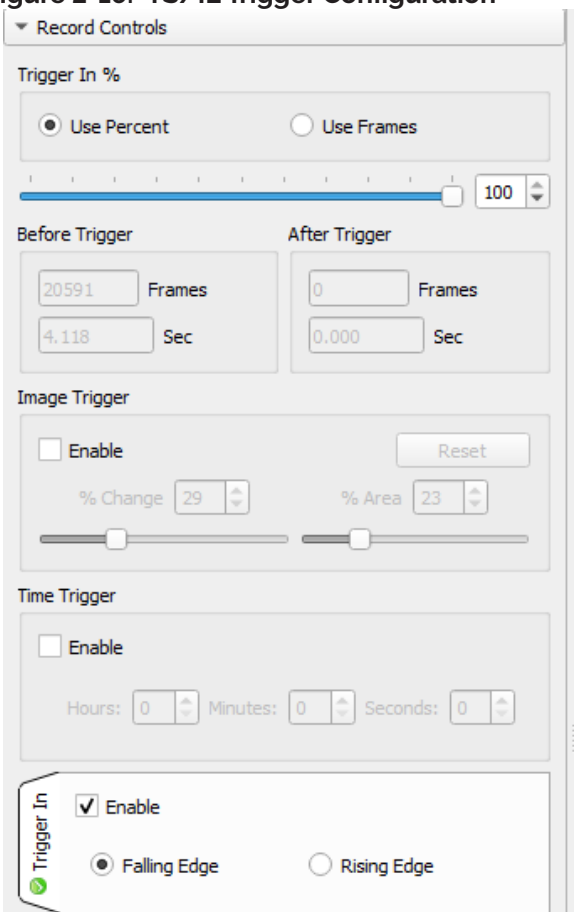
This section explains how to set the trigger position within the buffer, which determines the amount of record time (number of frames captured) preserved for the interval after the trigger. (Frames may be recorded before and/or after the trigger.)

See "Application Note 3: Trigger Position and the Circular Buffer" on page 83 for a detailed description.

To Set the **Trigger Position**:

1. On the Record Controls Tab select either the "Use Percent" or "Use Frames" radio button. The slider and edit box represent the session buffer, which is the camera memory you will be recording into. The trigger position is expressed either in % or frames.
2. Set the position by moving the slider or typing into the edit box or using the spinner buttons.

Figure 2-16: TS/IL Trigger Configuration



2-8 Configuring I/O in Fas*Motion*

The I/O portion of the Record Controls tab includes dialogs for each of the I/O signals.

I/O connections may be used in either of two ways:

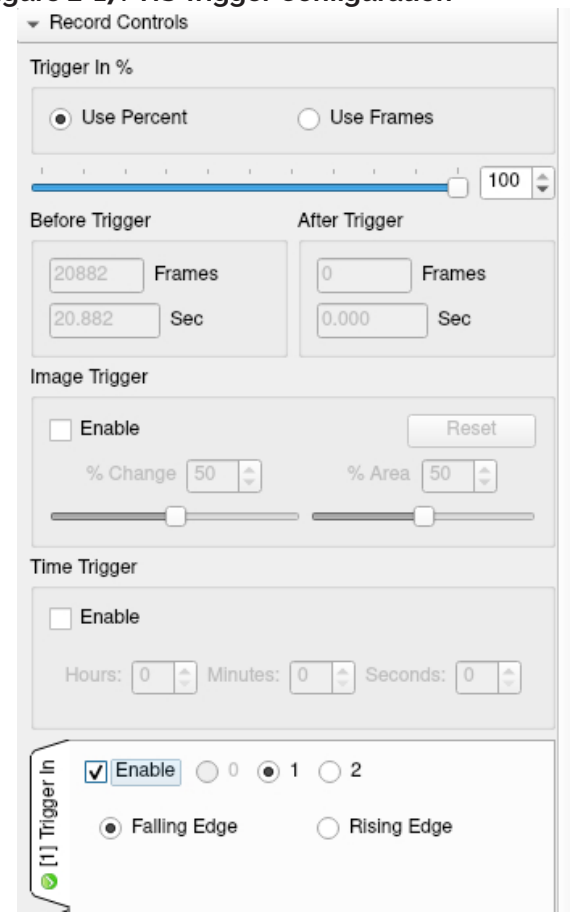
1. As a control I/O signal for the camera, which include Trigger-In, Trigger-Out, Sync-In, Sync-Out, Arm-In, Arm-out.
2. As an input for an external signal for creating Markers. (See "Jumping to Markers" on page 55.)

For HS cameras there are three external I/O ports, which can be configured for any of these purposes via radio buttons, (see "Figure 2-17: HS Trigger Configuration"). simply select any of the I/O tabs in Record Controls and select the I/O port you wish to use for that function.

Note that IL and TS cameras ship with a three-signal cable that supports Trigger In, Sync In, and Sync Out. A six-signal cable (PN:1105-0405) is available that supports the Trigger Out, Arm In, and Arm Out as well.

For IL and TS cameras the I/O cable has BNC connectors that are tabled for each of the I/O functions.

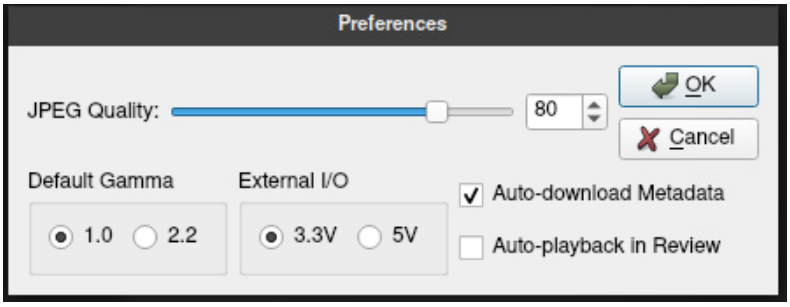
Figure 2-17: HS Trigger Configuration



I/O Voltage

I/O voltage is selectable (3.3v or 5V) on HS cameras in the camera preferences dialog ("Figure 2-18: HS External I/O Voltage"). IL and TS camera I/O operate at 3.3V.

Figure 2-18: HS External I/O Voltage



To enable the external trigger:

For greater precision, you may activate the trigger electrically.

Open the Record Controls Tab (see "Figure 2-19: FasMotion I/O Dialog in Record Controls" on page 43).

1. Click on the Trigger-in Tab.
2. Choose "Rising" for rising signals or a switch opening and "Falling" for a falling signal or switch closure.

Please refer to your camera manual for connection information and warnings.

IRIG Enable

For TSx cameras that have the IRIG option, the IRIG input may be enabled and the option to use the year in the timestamp via the Record Controls tab. (See "4-6 IRIG Timestamps and Sync" on page 77.)

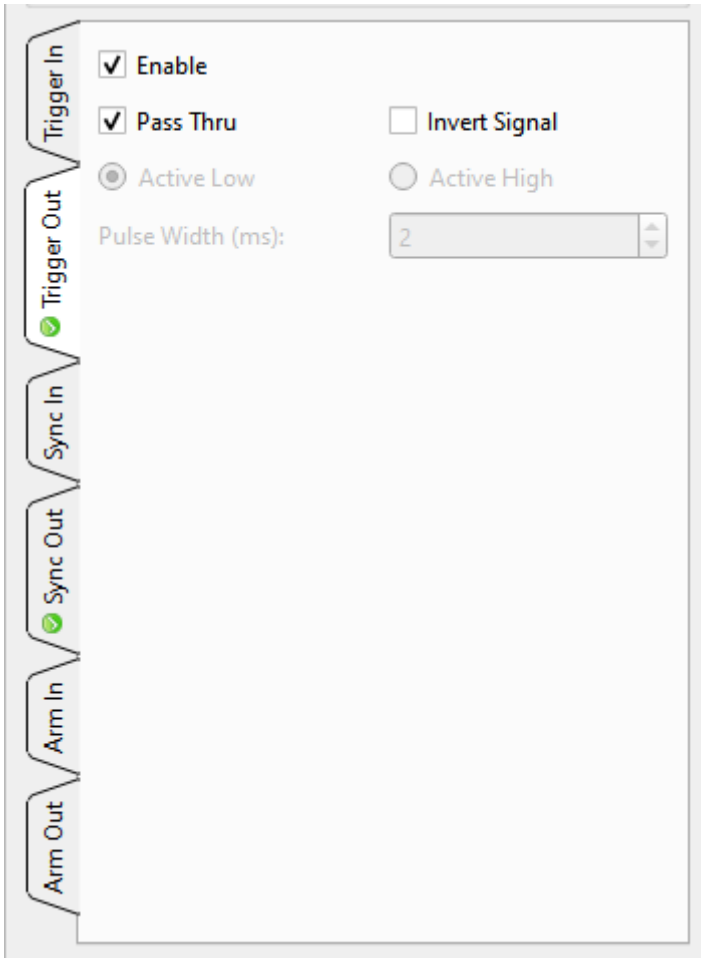
Trigger Out

Pass Thru" and "Invert Signal." If either of these is selected, Trigger Out will follow whatever the Trigger-in signal is, either in its original, or its inverted form. (If there is no signal on Trigger-in, there will be no signal on Trigger-out.)

"Active Low" or "Active High" should be used if the camera or software is originating the signal from the trigger button (HS or TS), Time Trigger, Software Trigger, or Image Trigger.

Pulse Width is only asserted for "Active Low / Active High

Figure 2-19: FasMotion I/O Dialog in Record Controls



Enable Sync-in / Sync-out

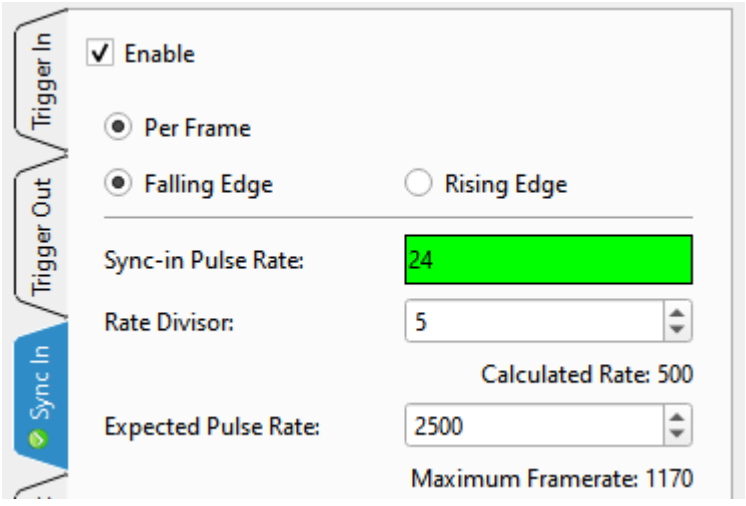
Sync In and Sync Out functions are used to synchronize the frame timing of a camera with another device or clock. These may include other cameras, strobe lighting, machinery, etc.

Sync In and Sync Out controls are somewhat interactive:

- When **Sync In** "Per Frame" is enabled, the Camera Frame Rate and Rate divisor edit boxes are enabled. (See "4-1 Sync In" on page 70 for details.)
- Expected Pulse Rate should be set to the expected frequency of the input signal. (See "4-1 Sync In" on page 70.)
- The calculated rate is the rate anticipated after the Rate Divisor is used. The system will use this to set the limit for Shutter Speed and in the metadata. (This will change the setting in Record Settings as well.)
- When **Sync-out** is enabled, the Shutter and Duty Cycle controls become active.
- Selecting "Shutter" makes the Sync-out pulse follow the shutter timing.
- Selecting "Duty Cycle" allows you to select the % of time the Sync-out pulse is "True." (This may be used in conjunction with polarity choices to establish the phase relationship between devices.)

For timing diagrams and a more detailed description of how these signals may be used for camera synchronization, please refer to "4 Synchronizing Cameras" on page 70.

Figure 2-20: Sync-in Tab Dialog



Enable Arm-in / Arm-out

In the case of **Arm-in**, the signal may be either an "Edge" or a "Level."

If Edge is selected, the camera will Arm and begin recording as soon as it sees an edge. Whether this happens on a High to Low transition (Active Low) or a Low to High transition (Active High) is selectable.

Once Armed, the camera will not change its recording state because of any activity on this input until the present recording ends.

If Level is selected, the camera will only remain in an "Armed" state while Arm In is held low: The camera will begin recording as soon as the Arm In goes Low. If the signal goes away before the camera receives a trigger, the camera will disarm and nothing will have been saved. If the signal goes low again, the camera will Arm and begin recording.

Note the "Discard Unsaved Images" box. If this is checked and the camera has images in its buffer (in review) when the camera receives an Arm In signal, they will be discarded without any additional user intervention. If this box is not checked, the I/O signal would be ignored if the camera has images in the buffer.

The **Arm Out** signal is used to pass the Arm signal to another camera or device or to light an external LED to inform a user that the camera is Armed.

The Arm-out Signal can either follow the armed/ unarmed state of the camera, or be a Pass Thru signal from "Arm-in."

Figure 2-21: Sync-out Tab Dialog

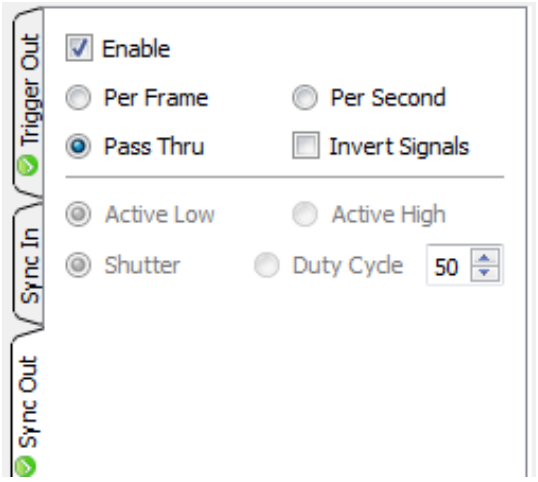


Figure 2-22: Arm-in Tab Dialog

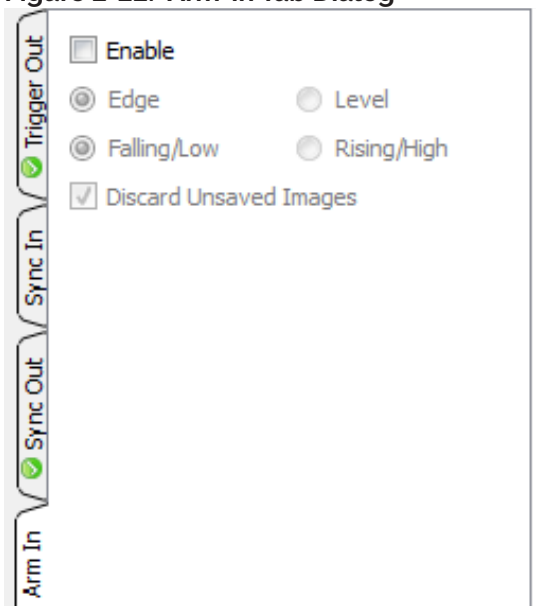
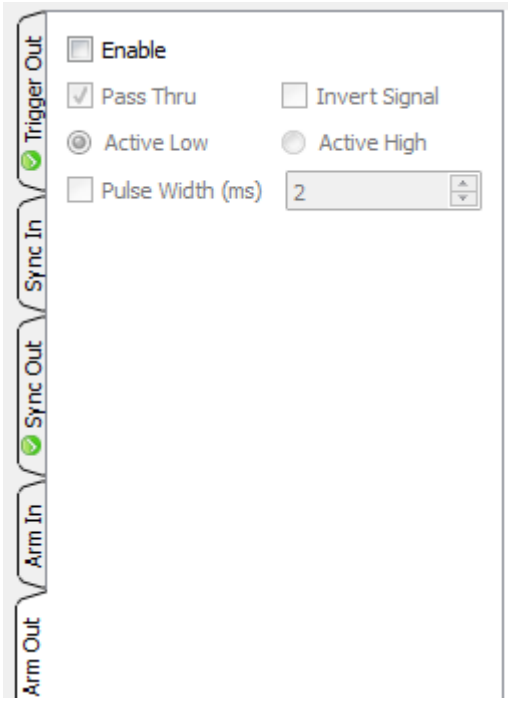


Figure 2-23: Arm-out Tab Dialog



2-9 Black Level Calibration and Analog Gain

Black level calibration does two things:

1. It sets the black level of the camera to ensure that, in the absence of all light, there is no offset or clipping (the "blackest" pixel will have a value of 0).
2. Dark frame data is saved for correcting Fixed Pattern Noise (FPN)..

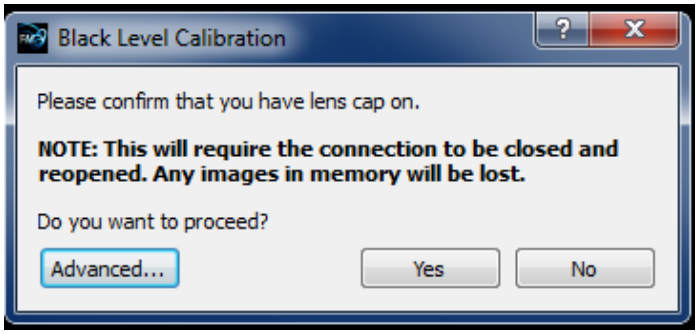
Calibrate Black Level:

To be assured that you are getting the best possible images, perform a calibration:

- When you first boot the camera up.
- If you change Shutter Speed, Bit Depth, Frame Rate, Resolution, or Offset.

In the Advanced Settings section of the Record Settings Tab (see Figure 2-8 on page 36) you will see an FPN selection dropdown menu. The items included vary depending on the sensor.

Figure 2-24: Black Level Calibration Dialog



- Disabled means that no FPN correction is used
- Sensor (on 5-series cameras) means that the on-board sensor correction is being used
- Pixel means that the "black frame' taken during calibration is being used

On TS and IL cameras, the sensor must be blocked from all illumination during black level calibration.

On HS cameras, the built in mechanical shutter covers the sensor during black level calibration.

To Calibrate the Camera:

1. Set the camera to Live.
2. Shut out all light to the sensor. HS cameras do this automatically using the built-in mechanical shutter, but for TS and IL cameras, close the f-stop down all the way and put a lens cap on it or cover it securely.
3. Select Black Level Calibration from the Camera Menu. For information on Advanced Calibration, refer to "Application Note 7: Advanced Calibration IL/TS/3-4" on page 96.

Note: If you make a setting change that makes the stored black frame incompatible, you will notice an asterisk next to Pixel on the FPN Selection button: "Pixel*" ... this is a reminder to do another calibration.

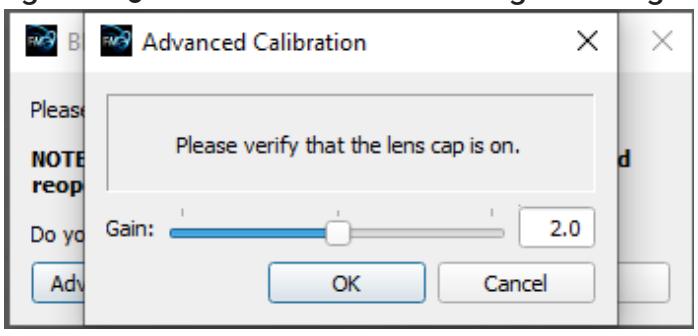
Analog Gain

Analog gain or "sensor gain" is applied via the Advanced Calibration Dialog.

The settings available depend on camera model:

HS5 :	Gain 1.0, 2.0, 4.0
IL5 / TS5	Gain 1.0, 2.0, 4.0
IL3 / TS3	Gain 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0
HS7	No analog gain available

Figure 2-25: Advanced Calibration Dialog for Analog Gain



2-10 Record: Arm and Trigger in Fas*Motion*

Table 2-3: Camera Control Buttons

	Live Mode	**A** (Arm) and **T** (Trigger) buttons active: Camera in Live mode, waiting to Arm
	Recording: Armed	**A** (Arm) and **T** (Trigger) buttons active: Camera is Armed, waiting for the trigger
	Recording: Triggered	No buttons active: Camera has been triggered and is continuing to record
	Review Mode	**L** (Go to Live) button active: Camera has been armed and triggered, in Review
	Live Images in Buffer	**A** (Arm), **T** (Trigger) and **R** (Review) buttons active: Camera in Live mode, has a recording in the buffer

Lights Camera Action!

- The Resolution and Frame rate are set
- The scene is framed and focused
- The Shutter Speed is set
- The Bit Depth is set
- The Trigger Point and Trigger Type is set
- Black Level Calibration has been done

Take a Still JPEG Image

It is optional, but recommended, to take a reference still of the scene:

With the TSx in Live Mode (not Recording or Reviewing a recording) either click on the Trigger Button or click on "Snapshot..." in the Camera menu.

A dialog box will appear asking where to store the image. Select the storage media you wish to use. (The image will be saved in <storage device>/DCIM/100fastc.)

Standard Basic Mode Recording

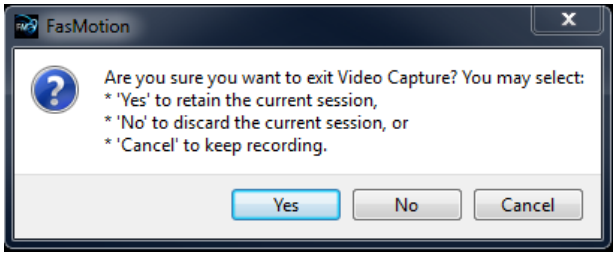
To begin recording, click the Arm button. The Arm Button will turn from green to brown (see "Table 2-3: Camera Control Buttons" on page 46) and the camera begins recording into its circular buffer (see "Application Note 3: Trigger Position and the Circular Buffer" on page 83 for an explanation of the circular buffer). The Camera LED will change from Green (Live) to slowly flashing Amber. It will record for an indefinite period of time until it gets a Trigger. (See "2-7 Setting the Trigger Position" on page 41.)

If the Arm Button is pressed a second time, the Recording will abort. The button and the LED will return to green. The Cancel Recording dialog gives the option to retain the images already recorded, discard them, or to continue recording.

The recording state is indicated by a progress bar at the bottom of the image window. Numbers to the right of the progress bar represent the number of recorded frames / total frames.

When all of the pre-trigger frames have been recorded, the progress bar stops and turns Yellow.

Figure 2-26: Cancel Recording Dialog



Note: If the camera is triggered before the pre-trigger portion of the buffer is full, it will immediately cease taking pre-trigger frames, record frame "0" and progress to the post-trigger portion of the recording. When complete, the recording will have contiguous frames, with the full complement of post -trigger frames, but fewer pre-trigger frames. (See "2-7 Setting the Trigger Position" on page 41.)

Figure 2-27: Record Progress Bar: Armed

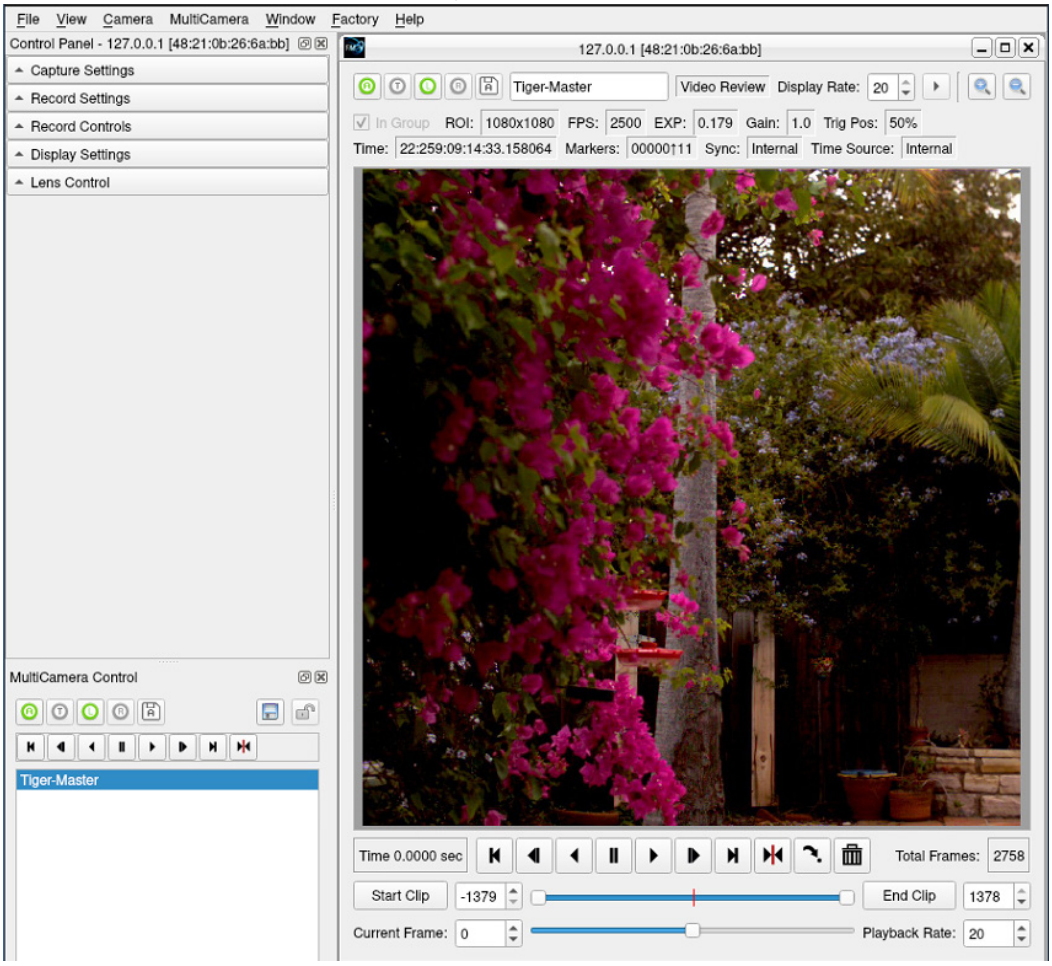
Figure 2-28: Record Progress Bar: Triggered

To end Recording, Click the Trigger Button:

Click on the Trigger button, (see "Table 2-3: Camera Control Buttons" on page 46). There is unavoidable latency when using the trigger in software. If an accurate trigger is required, send an electrical trigger signal.

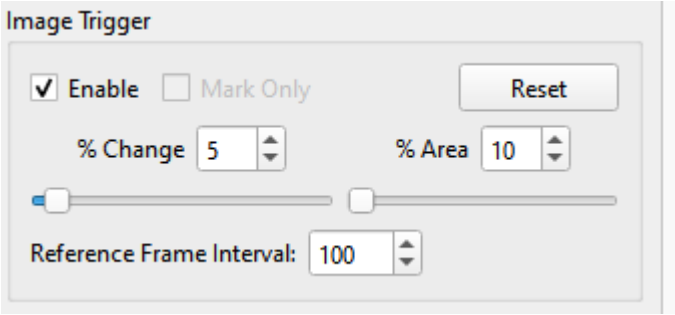
When triggered, the camera will capture frame "0" and the post-trigger frames (if any). When the recording is complete, the progress bar will disappear, and the Playback Controls will appear.

Figure 2-29: Camera Window with Playback Controls



2-11 Image Trigger

Figure 2-30: Image Trigger Dialog



The Image Trigger feature in Fas*M*otion triggers a camera automatically upon sensing changes of image content in a user-defined region compared with baseline values.

NOTE: When the Image Trigger feature is enabled, the camera will continue to accept triggers from any other source, including the I/O trigger input, the trigger button on the camera, and software triggers from FasMotion.

To set up the Image Trigger:

1. Click the Enable check box in the Image Trigger dialog on the Record Controls tab.
2. A rectangular reticle will appear. Re-size and locate this on the location on which you wish to trigger. In Figure 2-31 the reticle has been placed just in front of the bird feeder in order to trigger on any birds flying in front of it.
3. Disable / enable the check box to re-sample the background image in the reticle area. The reticle will turn white while taking sample images and return green when done.

The reticle will turn red whenever the image changes enough to assert a trigger.

For IL and TS cameras FasMotion samples frames coming from the camera at about 20fps. Latencies due to PC and network response are inevitable. It is best to anticipate these and set your trigger point a little earlier (.1 to .2 seconds) than you normally would.

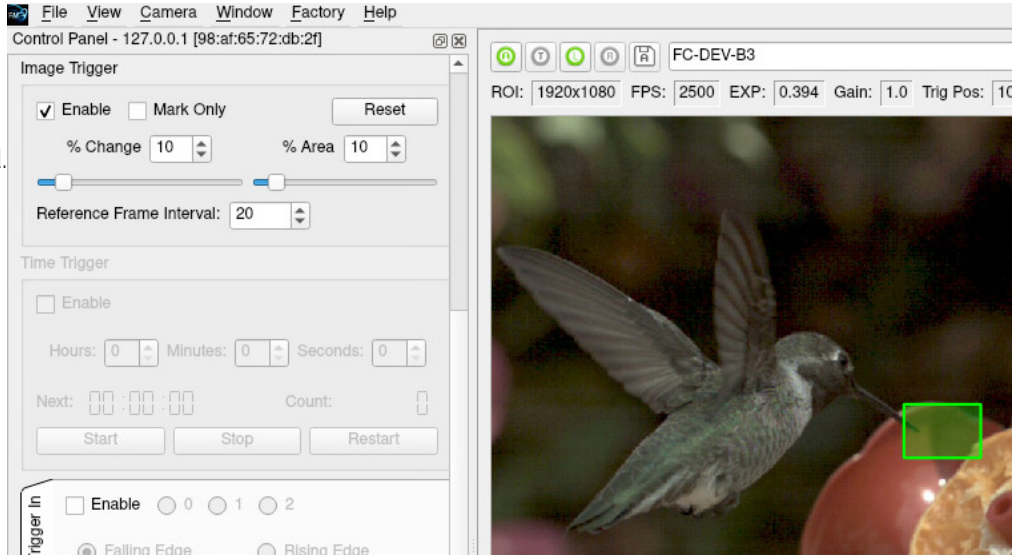
For **HS cameras** The FPGA in the camera samples every frame directly from the sensor regardless of frame rate. For the HS, there is a 1-frame latency between reading the image reticle and asserting the trigger.

Tuning the Trigger

Use the **% Change** and **% Size** parameters to adjust the threshold at which the image trigger may be asserted.

Use the **Reference Frame Interval** parameter to set the frequency at which the reference image for the reticle is refreshed.

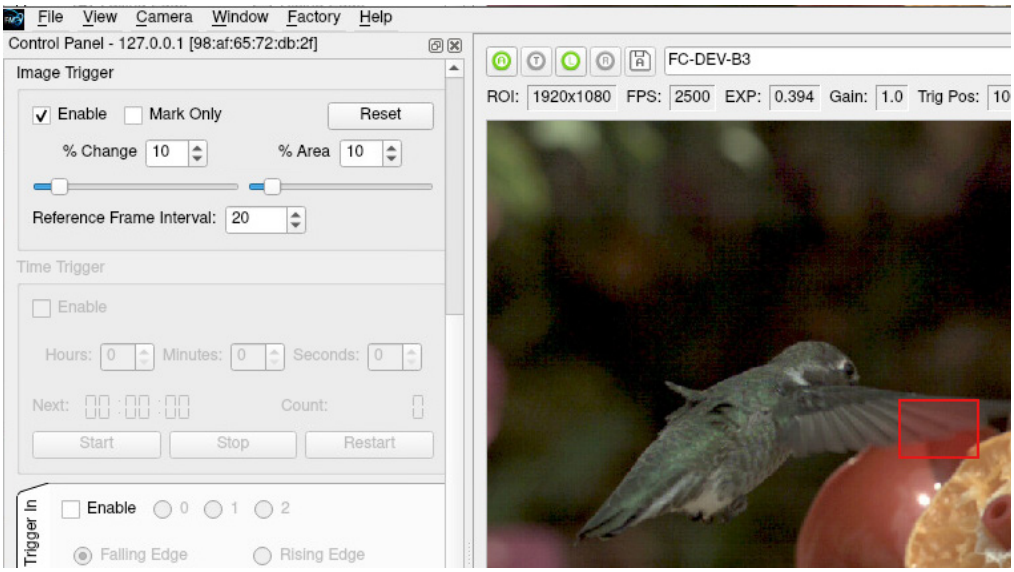
Figure 2-31: Image Trigger Setup



A "0" Baseline Update setting means that the reticle values are never refreshed once the Image trigger is enabled. Use this if you do not expect any changes in the background. Use values from 1 to 9999 to allow assert triggers for progressively slower rates of change. (A value of 1 will tend to tolerate all but the fastest changes before triggering, while larger values will trigger on slower changes.)

The image trigger reticle and all controls remain active in Live, Armed, and Review. (The reticle is seen in Review; it is not included in saved images.)

Figure 2-32: Image Trigger-Triggered



It is often helpful to test and tune the trigger in Review (playback).

On HS systems, when the Image trigger is enabled with the **Mark Only** check box selected the camera will not trigger but will place a marker in the time line for every frame where the trigger threshold is met if Event Markers are enabled. (See "Figure 3-6: IL/TS Event Marker Control" on page 55.)

Whenever the Image Trigger is enabled on HS systems, a couple of lines are written into the per frame metadata indicating the number pixels in the reticle above the target threshold. (See Figure 2-32 and "Appendix C: Contents of <Capture>.xml file" on page 102.):

<time>21:090:15:47:18.893793</time>

<vtrig_area>6082</vtrig_area> (Number of pixels over the threshold)

<vtrig_flags>2</vtrig_flags> ("2" = Trigger)

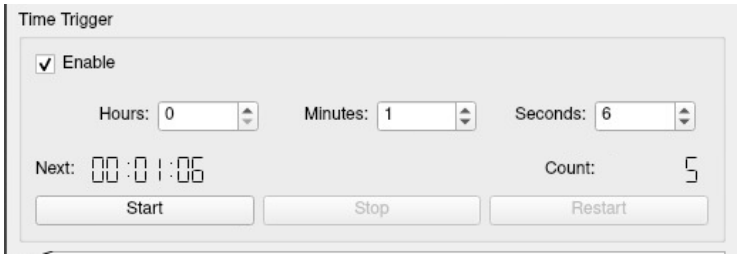
2-12 Time Trigger

The Fas*M*otion Time Trigger sends a software trigger to the camera at user-specified intervals of from 1 second to more than 24 hours.

While the time trigger is enabled, all other triggers, including the Image Trigger are also accepted by the camera.

For example, you may wish the camera to be triggered via external I/O to record fault conditions or another event being monitored. At the same time, you may wish to take a context recording every hour using the Autosave feature.

Figure 2-33: Time Trigger Dialog



If the Trigger-out I/O is enabled, a pulse will be generated on Trigger-out when the camera's trigger is asserted.

To use the Time Trigger

1. Click the Enable check box in the Time Trigger dialog on the record tab.
2. Set the time interval using the edit boxes / spinners provided.
3. Click on Start when you wish the timer to start. You will see the time count down until the trigger. The Count field will increment with each trigger.
4. Click Stop when you wish the timer to stop. This will pause the timer, stopping the countdown until you click on Start to proceed.
5. Click on Restart to begin the count down from the beginning.

The timer is reset whenever the timing parameters are changed:

Note: The time trigger is sent via Ethernet from the PC on IL and TS cameras, thus there is a latency involved that will diminish the accuracy of the timing. Also, the timed trigger will not persist when the camera is disconnected from Fas*M*otion.

2-13 Autosave in Fas*M*otion

The camera may be used to capture many consecutive events. Using Autosave, this can be done unattended, that is, the camera may be left at a location to automatically, Trigger, Save captured imagery, and then re-Arm itself indefinitely-constrained only by the mass storage space available.

Consider that a camera with an optional SSD installed, depending on the resolution and download file format, could record and save hundreds or even thousands of events in a completely unattended mode!

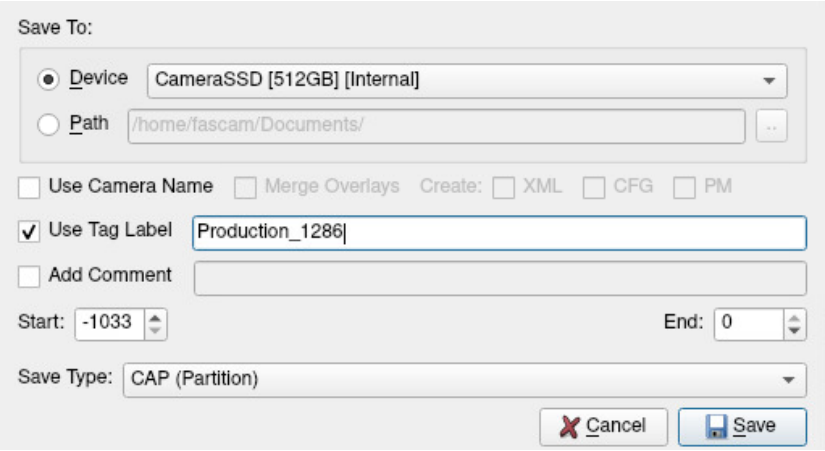
Advantages of using Autosave:

- Autosave is a good choice for **multiple rapid events**. When you are planning to save every capture and review later, the fastest way to get the job done is to use Autosave. .
- Autosave is also useful for **production environments** or in any scenario where it is used for multiple consecutive tests without any setup changes. Here it is preferred because it limits human intervention, thereby limiting both human effort and the possibility of human error.
- In an **unattended event,** especially in a **remote location** or when there is no easy access to the camera, Autosave is recommended because it is the quickest way to secure the image data. Saving the data to nonvolatile memory can be important if there is a possibility of power loss.

To set up **Autosave**:

1. Select Autosave Setup from the Camera Menu or Camera Window context menu.
2. Select a target drive using the "Device / Path" radio buttons.
3. Select a file type from the "Save Type:" pull-down list. File type choices may change depending on the target drive. See "Application Note 6: Choosing an Image File Format" on page 94.
4. Set start and end points for your saved clips (only if you wish to save less than the full session).

Figure 2-34: Autosave Settings Dialog



5. Select any desired options for file naming etc. (See "3-5 Saving Images to Mass Storage in FasMotion" on page 60 for details.)
6. Click on the Save button to enable Autosave.
7. Arm and trigger the camera. Autosave will continue re-arming itself, capturing images and downloading them until the target drive runs out of space. At this time, it will progress to Review mode so the user download manually to a different drive or clear space.

Autosave must be re-enabled after exiting the recording. This may be done using the autosave enable button, which is black when disabled and red when enabled. If recording parameters change such that the Autosave settings are no longer valid.

2-14 Fas*F*ire in Fas*M*otion

The camera is capable of recording images to one memory partition while saving images from another partition to non-volatile "Device" media such as an SSD, SD card, or USB device. Depending on the amount of high-speed DRAM memory on your camera (up to 32GB on HS) and the Session Length (partition size) you set (see "1-12 Camera Memory and Image Storage" on page 25), the Fas*F*ire feature lets you capture up to 16 clips in quick succession without ever waiting for the camera to finish saving the last.

You will usually find that the camera has saved one or more partition before you get to the last one. Depending on the session size, the speed of the media, and the interval between events, you will often find that you will be able to keep recording clips at will until the space in the save media is exhausted. (This will vary on the speed of the storage device and the file type selected.)

For example, if you have 4GB of DRAM in your camera, and you set the Session Length to 0.50GB. You have divided the memory into 8 partitions. The camera will reserve one of these for buffering and open up the remaining 7 for Fas*F*ire.

Entering Fas*F*ire via Fas*M*otion

The camera will operate in Fas*F*ire mode whenever there are at least two Fas*F*ire partitions, the camera is set to AutoSave, and the target drive is on the "Device" list (the camera's internal SSD, SD card, or USB device or Thunderbolt device on HS controllers). (Refer to "2-13 Autosave in FasMotion" on page 50.) With Autosave active, as soon as the camera receives an Arm signal, Fas*F*ire will commence.

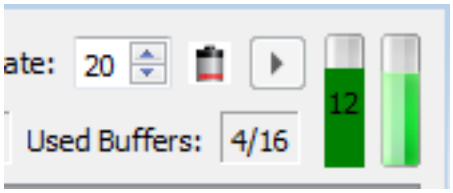
Note: For IL and TS cameras, there is no live streaming video in Fas*M*otion while the camera is saving. If you need to see a Live image, you may connect the camera to an HDMI display.

Using the Gas Gauges in Fas*M*otion

Two gas gauges appear in the upper right corner of the image window during Fas*F*ire operation. The gas gauge on the left in Figure 2-35 indicates the number of available partitions for recording into. The gas gauge on the right shows the progress of the current save.

As DRAM memory is filled the gauge on the left decrements its counter, indicating the number of partitions available. As partitions become available again, after video clips are saved to the target drive, the number will increment and the green level will grow upwards. If all but one of the partitions become full, the last segment of the gas gauge will turn red. And when the very last segment is used, you will see the normal Autosave progress bar until one partition is saved and the gauge begins to be restored again.

Figure 2-35: Fas*F*ire Gas Gauges in Fas*M*otion



Cancelling Fas*F*ire

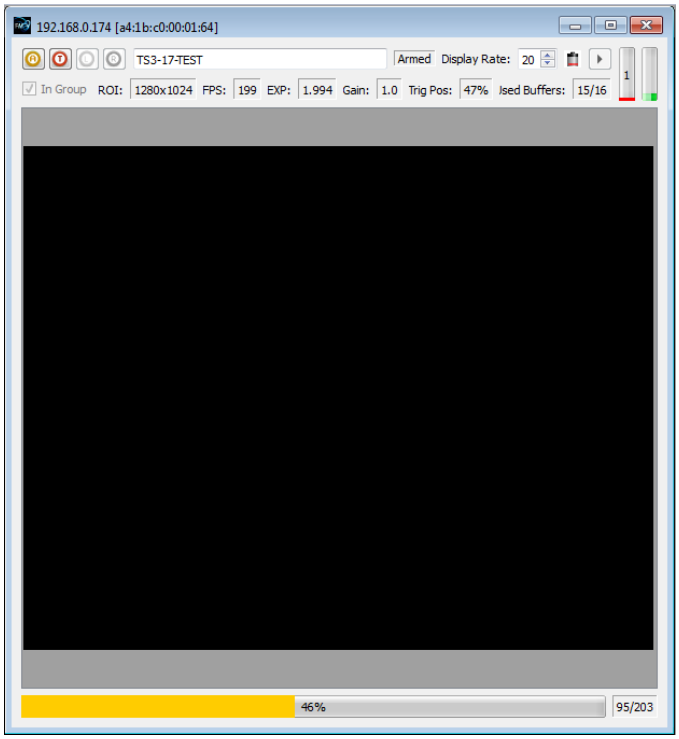
If you press the Arm button while recording, you will get a warning message asking if you wish to cancel. If you click on "OK," the camera will continue to save images.

If you click on Arm and Trigger, the camera will make one more capture and go into Review/ Playback.

The last recording will be available for Review/ Playback and Save, as will any other recordings still in DRAM.

Reminder: once the camera has exited the recording state, Autosave must be re-enabled if you wish to commence recording again in FasFire mode.

Figure 2-36: Fas*F*ire in Fas*M*otion, one Partition Left

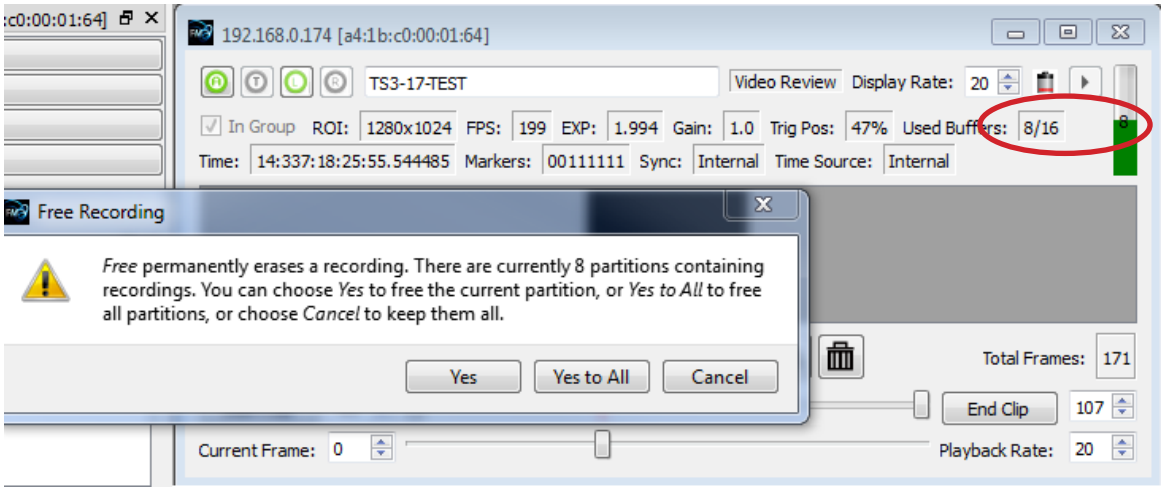


Video Review with Multiple Partitions

If AutoSave is canceled with multiple unsaved clips in DRAM, the Fas*M*otion gas gauge will show the number of available clips. See Figure 2-35.

In this example there are 8 clips available for review. They are always presented with the newest first. You may review the present clip and save it, and then to see the next, you click on "Free," which will delete the present partition allowing you to review and save the next.

Figure 2-37: Video Review, Fas*M*otion with Multiple Partition



3 Review: Playback and Save

3-1 Playback Basics

Images captured by IL, TS, and HS cameras may be viewed in the FasMotion camera window, either from camera memory, or from recordings saved to accessible media. All file types except for MP4 videos, may be played in Fas*M*otion.

Playback controls are very similar to those you will find in popular media players with a couple addition buttons added to easily find frames of interest such as the Trigger frame and frames with Event Markers, discussed in "Jumping to Markers" on page 55.

Figure 3-1: Fas*M*otion Playback Window

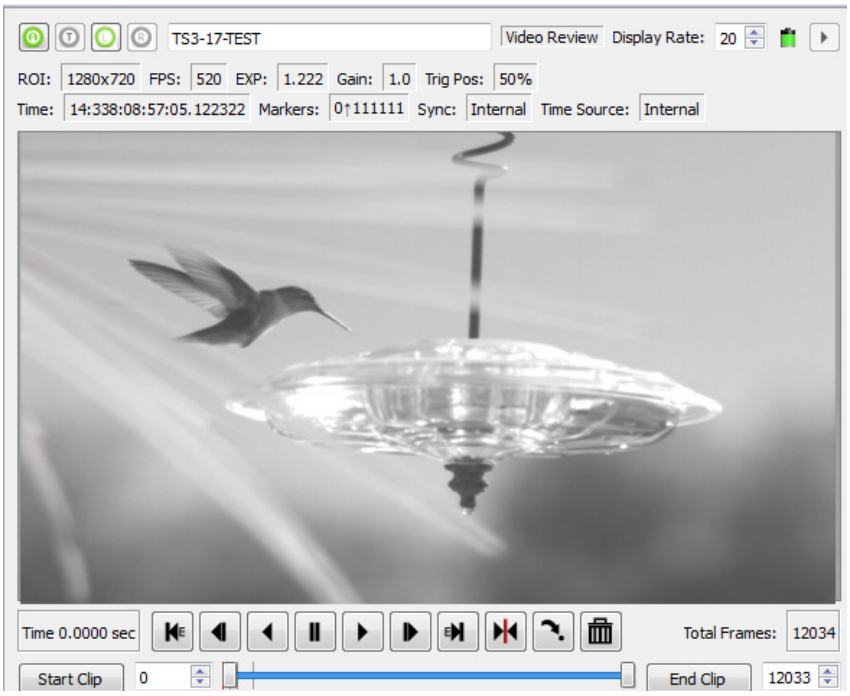


Table 3-1: Playback Buttons

	Jump to previous Marker (only present when Event Markers are enabled).
	Go to beginning of clip--goes to Cut-In point. Click a second time and it goes to the very beginning of the video.
	Move one frame backward. When highlighted, hold OK button on D-Pad to skip backward.
	Play backward. Use up and down buttons on D-Pad to adjust speed.
	Pause play.
	Play forward. Use up and down buttons on D-Pad to adjust speed.
	Move to end of clip--goes to Cut-Out point. Click a second time to go to the end of the video.
	Jump to next Marker (only present when Event Markers are enabled)
	Jump to Trigger frame.
	Jump to Time.
	Truncate / Delete. In LR ROC or BROC mode, use this to delete any amount of image data from some selected point to the end of the recording. In other modes, use to delete the present partition.

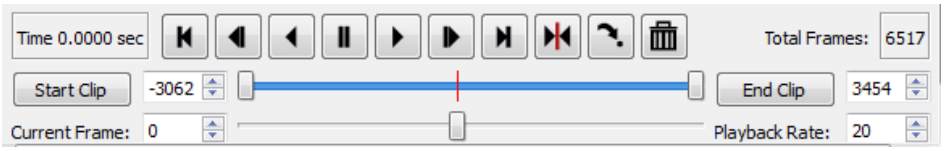
Searching for Interesting Parts

Very often the first thing you will wish to do when reviewing a clip is to "scrub" through it using the playback slider looking for the most interesting moments.

1. Click on the Pause Play button. (Only necessary if you have already clicked on another of the playback buttons.) This will enable all of the playback buttons (they become black). (If any of the buttons become gray (inactive) you will not be able to scrub through the clip.
2. Move the Start Clip bumper all the way to the left (beginning of segment) and the End Clip bumper all the way to the end. (This is the default position when you enter Review.)
3. Click and hold the Playback Bug and move it along the progress bar. This will allow you to move to any point in the video that might be of interest.

Using the Slider

Figure 3-2: Playback Bug Selected



When selected the Playback Bug will turn blue. There are several mouse and keyboard stokes available when the bug is selected:

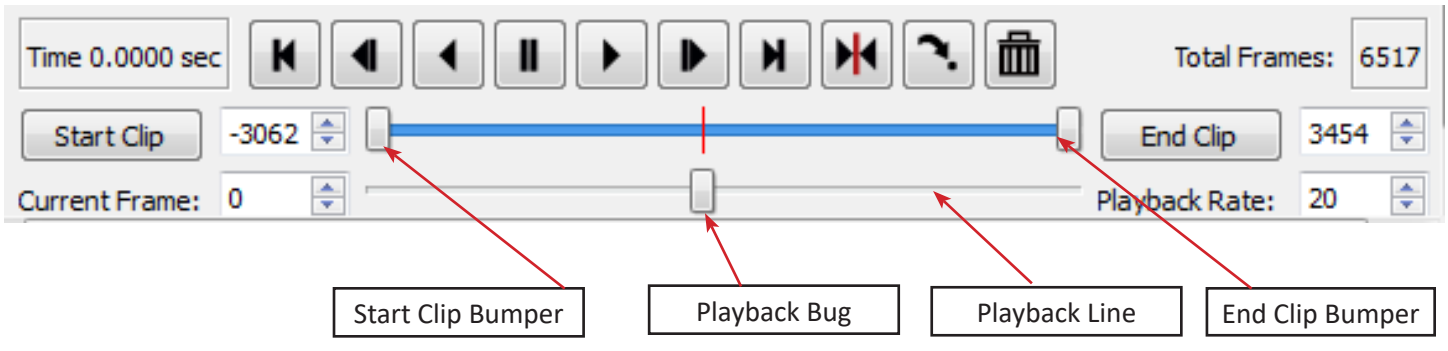
- Click on the slider bar to the left of the Playback bug to move 10 frames backward
- Click on the slider bar to the right of the Playback bug to move 10 frames forward
- Double-click on the clip bar (upper bar) to zoom in
- Click on the left or down arrow on the keyboard to move 1 frame backward
- Click on the right or up arrow on the keyboard to move 1 frame forward
- Click on Page down to move 10 frames backward
- Click on Page up to move 10 frames forward
- Click on End to move to the end
- Click on Home to move to the beginning

3-2 Advanced Playback Features

Setting the Start Clip and End Clip points:

1. Click on the Pause play button. All buttons should now be active (black).
2. Click and drag the Playback Bug to the frame you wish to be the starting point. You can use the Current Frame edit box and/or spinner, or your PC keyboard <- and -> keys to zero-in on the correct frame.
3. Click on the Start Clip button. The Start Clip Bumper will move to that frame.
4. Move the Playback Bug to the frame you wish to be the ending point (as in #2, above).
5. Click on the End Clip button.

Figure 3-3: Video Controls (Playback)



Jumping to a Frame by Time

Click on the "Jump to Time" button in Fas*M*otion to find a frame based on its time. See "Playback Buttons" on page 53.

- Select the "Relative" radio button if you wish to jump to a frame based on the time relative to the trigger time.
- Select the "Absolute" radio button if you wish to jump to a frame based on the "time of day" clock, which is used for timestamps in the metadata.

Note that the Year, Day, Hour, Minute fields only become active according to the length of the captured video. For example, in Absolute mode, if you have a recording that begins at 6:56 am and ends at 7:01 am, the Hour, Minute and second fields will be active. In Relative Mode only the Minute and second fields will be active.

Figure 3-4: Jump to Time Relative

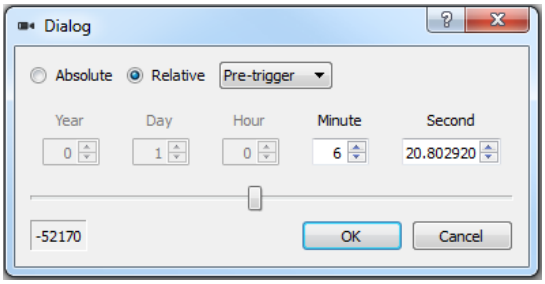
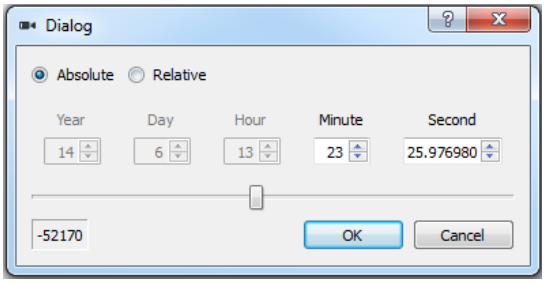


Figure 3-5: Jump to Time Absolute



Jumping to Markers

IL and TS cameras have six LVTTL I/O ports, while HS cameras have three ports that are factory-configured LVTTL (3.3v) or TTL (5v). These may be used for camera control or as event marker inputs, or some combination of the two. Note that the signal level for each I/O port is recorded in the per frame metadata independent of their use.

When used for camera control, these ports are defined as Trigger-in, Trigger-out, Sync-in, Sync-out, Arm-in, and Arm-out.

When used as markers we refer to the same ports as T-I, T-O, S-I, S-O, A-I, and A-O, respectively. Please refer to "2-8 Configuring I/O in FasMotion" on page 42.

Rec Start marks the beginning of an LR ROC or BROC recording. This is an especially useful marker to be used whenever FasCorder mode is used. See "2-2 Long Recording Modes" on page 35.
When playing captured video, event marker locations may be made visible as hatch marks on the time line.

Figure 3-6: IL/TS Event Marker Control

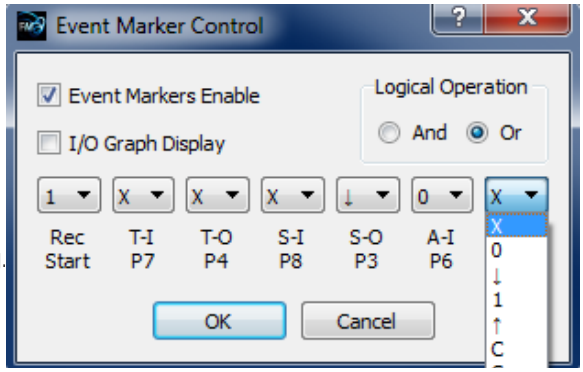
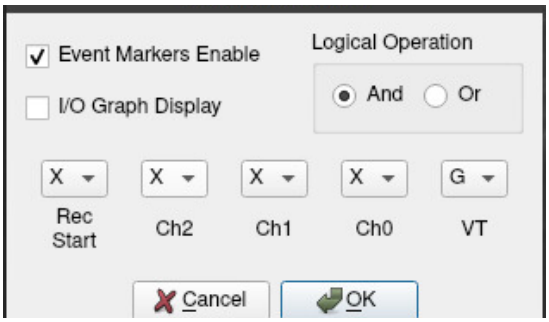


Figure 3-7: HS Event Marker Control



Setting up Event Markers in Fas*M*otion

1. Open the Event Marker Control dialog: (in Review mode) click on the Events... button in the Video Review Tab.
2. To make markers appear on the timeline, select the Enable Markers check box.
3. For each I/O signal you wish to use, click on the associated button, and select the state for which that signal will be defined as "true."
4. Select between the "And" and "Or" radio buttons. If you wish to create a mark whenever ***any*** of the signals are "true" use "And," or only when ***all*** the signals are "true" use "Or."
5. Click on "OK" to accept the Event Marker controls.

Note: The Event Marker setup is not associated with a video file or stack. Fas*M*otion saves the Event Marker setup each time Fas*M*otion is closed and uses the same parameters the next time it is opened.

Table 3-2: Marker Logic

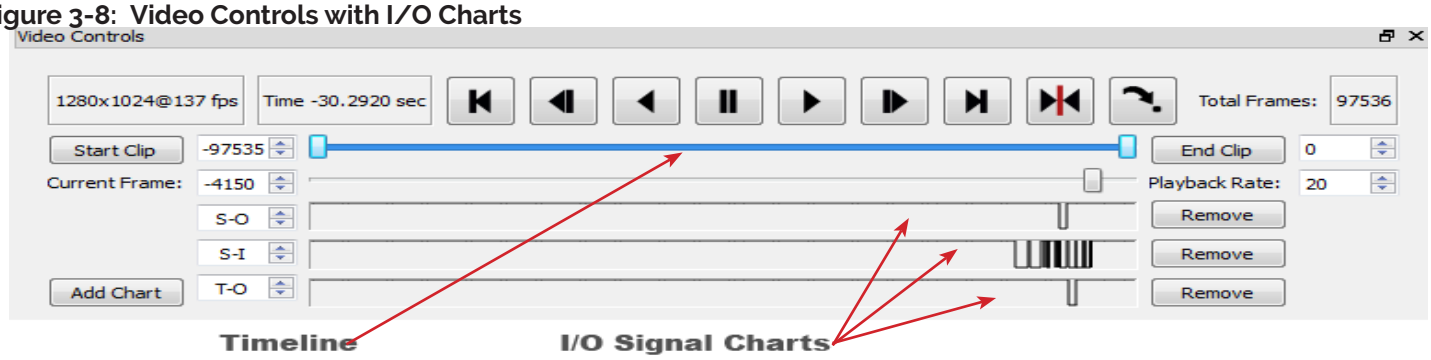
X = Ignore
O = Low
= High to Low transition
1 = High
= Low to High transition
C = Transition
G = Glitch (edges / no transition) or Baseline update for Image Trigger on HS camera

Using I/O Graph Display

I/O channel signal activity may be viewed in graphical form using the I/O Graph Display.

1. Click on the I/O Graph Display check box in the Event Marker Control dialog. An I/O chart will appear beneath the time line in the Video Controls window. See "Figure 3-8: Video Controls with I/O Charts".
2. Use the up/down arrows in the spinner box to the left of the I/O Graph Display to select the I/O channel you wish to view.
3. Additional charts may be added by clicking on the "Add Chart" button to the left of the bottom most I/O chart.

Figure 3-8: Video Controls with I/O Charts



Zooming in on the Time line

The time line in the Video Controls window may span many thousands of images in a "Normal Mode" recording, and hundreds of thousands of images in "Long Recording Mode." The time line Zoom feature allows you to reduce the number of frames viewable across the time line, making the task of finding specific events in the video much easier.

To Zoom In:

Double click on the time line to zoom to 2x.

A highlight mark will appear over the zoomed area of the Time line and a "Zoomed Playback Line" that spans the highlighted area will appear below the Playback Line.

The highlighted portion of the Time line may be moved by clicking and dragging it, so that any portion of the captured video may be accessed.

Zoom In and Zoom Out buttons appear at either end of the Zoomed Playback Line. Clicking on the Zoom-In button increases the Zoom 2x: to 4x, 8x, 16x, etc. to the maximum zoom of 4 frames.

Note that the I/O signal charts also expand when zoomed in. If there is a lot of activity on these channels, as in the examples shown here, zooming in is advantageous for seeing the signals clearly.

Figure 3-9: Video Controls with 2x Zoom

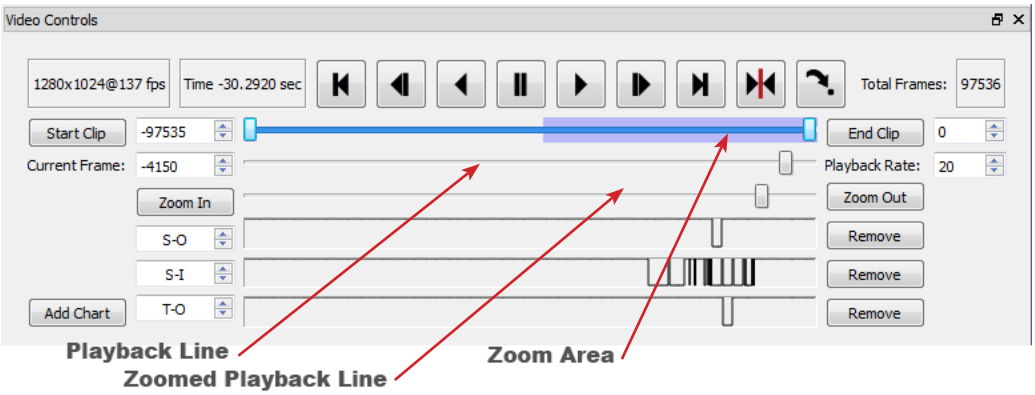
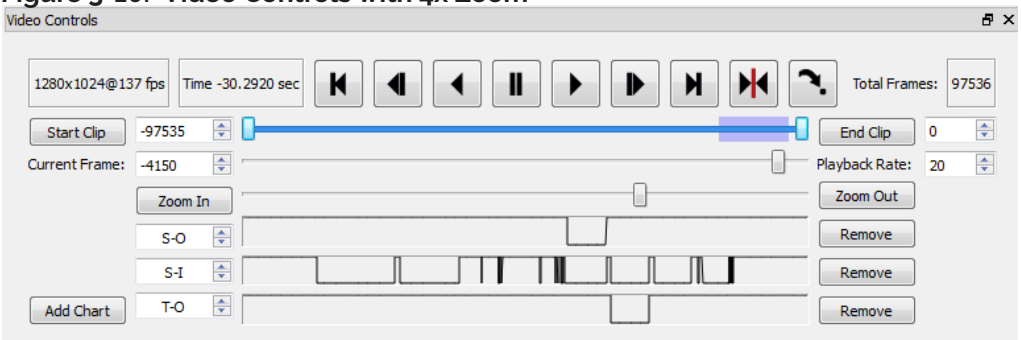


Figure 3-10: Video Controls with 4x Zoom



Viewing Per Frame Metadata in Fas*M*otion

Whenever the camera records imagery, it also records a timestamp and I/O status for each frame as well as camera setup parameters. This metadata may be displayed during playback and may also be saved to an XML file (see "Appendix C: Contents of <Capture>.xml file" on page 102 and "3-5 Saving Images to Mass Storage in FasMotion" on page 60).

Per Frame Metadata may always be viewed while playing unsaved images in camera memory and also may be viewed when playing back saved image Stacks, AVIs, and CAP files in *Fas*Motion.

To View Per Frame Metadata:

Right-click on the Camera window when in Playback and click on Per Frame Metadata.

The Per Frame Metadata includes a Timestamp, Marker information, IRIG status, Sync status, and Time source.

Timestamp Format

The default TimeStamp format is for the camera window and overlays is:

YY:DDD:HH:MM:SS.xxxxxx

For the example shown in Figure 3-12 this is:

YY = Year: 22 = 2022

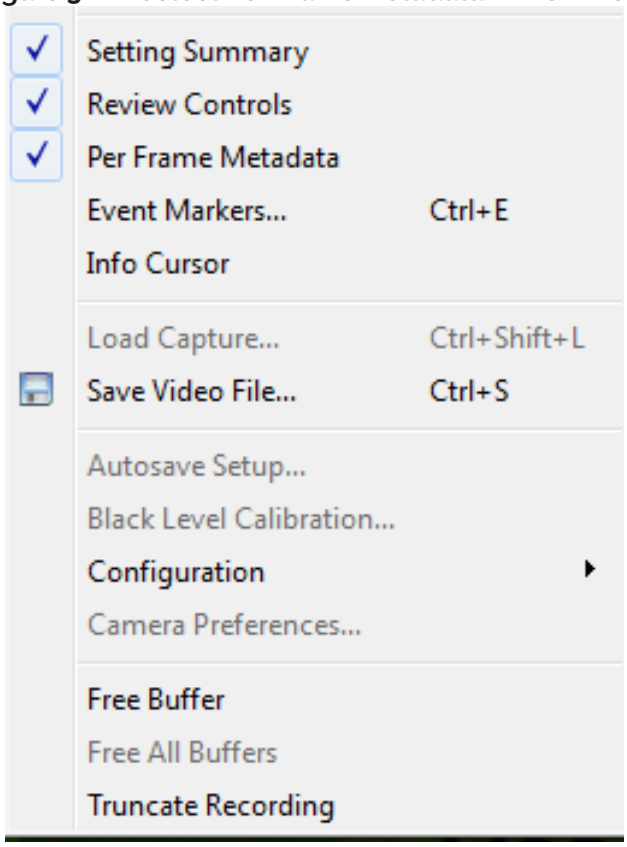
DDD = Day: 090 = March 31 See "Appendix E: Day Number Calendar Conversion" on page 105.)

HH:MM= Hour: Minute: 09:27 = 9:27 am

SS.xxxxxx = Seconds: = 56.574277 (granularity to µsec)

TimeStamps may also be displayed in the format used on the PC by selecting the "Frame Time as Local" check box in the FasMotion View Menu.

Figure 3-11: Select Per Frame Metadata in View Menu



Markers: 00111111

The Timestamp line includes event markers. In the example shown in Figure 3-12, all of the I/O pins were "high" for the duration of the displayed image frame. (See "4-5 Timestamps and Markers" on page 75 for more information.)

Figure 3-12: Per Frame Metadata in Fas*M*otion

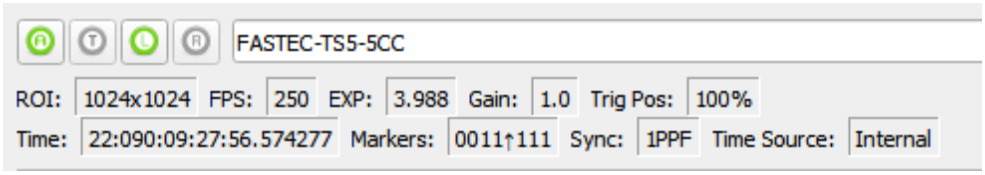
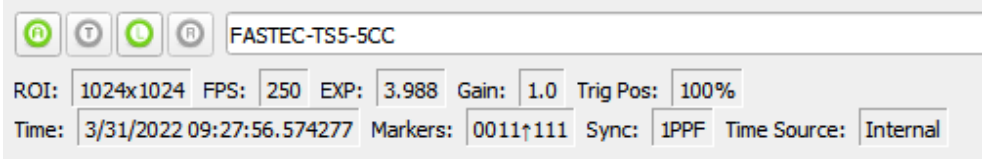


Figure 3-13: Frame Time as Local in Metadata



Sync: Internal

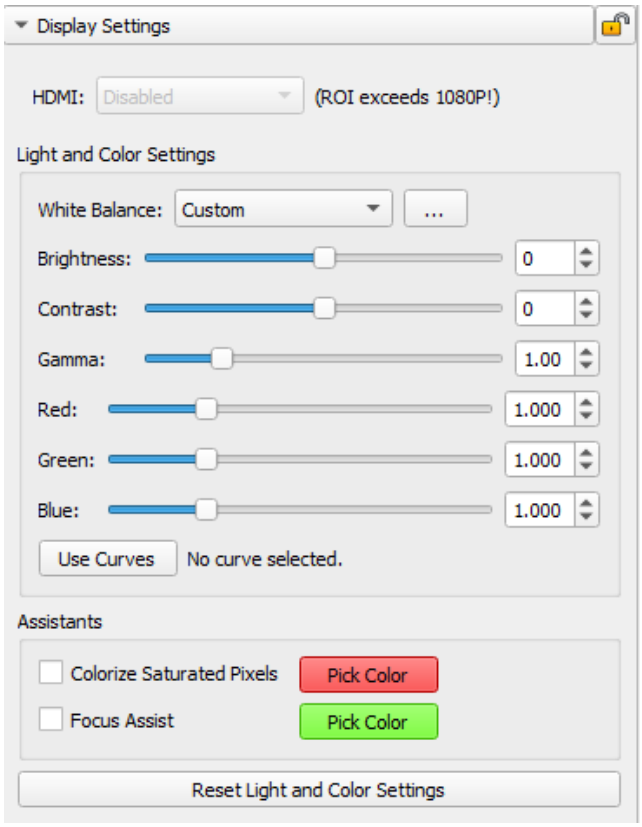
The Sync term can be Internal (internal camera clock used for frame timing), PPF (Sync-In pulse used for per-frame timing), or PPS (1Hz clock input at Sync in or IRIG used to derive the camera frame timing). See "4-1 Sync In".

Time: Internal

The Time is either Internal (using the cameras internal clock), or IRIG (using an IRIG time source.) See"4-6 IRIG Timestamps and Sync" on page 77.

3-3 Image Processing

Figure 3-14: Display Settings for Color Camera



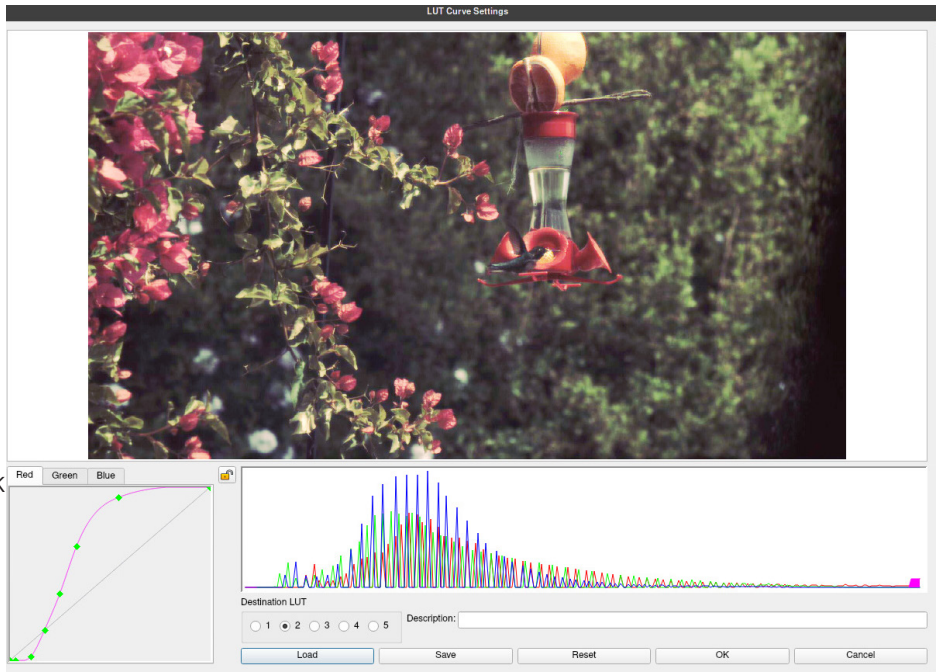
The Display settings tab has settings that affect the appearance of Live and Saved images. Figure 3-14 shows the Color camera version of this. The Mono version (not shown) is the same minus the White Balance and Red, Green, and Blue sliders.

When using these controls, keep in mind:

- These settings will make changes to the image data (pixel values) for saved JPG, AVI, BMP, MP4, and TIF images.
- JPG, AVI, BMP, MP4, and TIF are all 8-bit file types. If 10 or 12 bits were recorded, a 10:8 LUT is used to maintain intermediate pixel values for these images. (For more information, read the Understanding Bit Depth blog posts on the Fastec Webite.)
- These settings will ***not*** change the image data (nor the appearance) of DNG, TIF(raw), and CAP(Partition) files.
- DNG, TIF (raw), and CAP (Partition) files will preserve 10- and 12-bit image data.

If you wish to do post-processing on your image data, and especially if you wish to do your processing on 10- or 12-bit images, it is best to save DNG color cameras or TIF (raw) for mono cameras.

Figure 3-15: Color Curves on HS System



The **Curves feature** gives you more flexibility to adjust the image from within FasMotion than the sliders. These features are mutually exclusive, you may use one or the other but not both.

Curves on the Color HS cameras have separate controls for Red, Green, and Blue channels as well as a lock to adjust all together.

Curves on Mono HS and all IL and TS system hove only one channel.

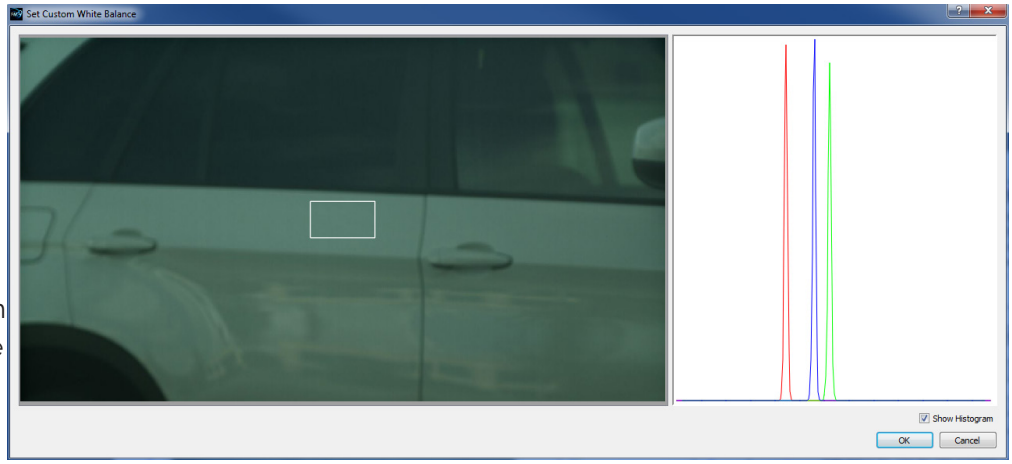
If 10 or more bits are recorded, the Curves function will write a 10 - 8 - bit LUT that is used by the image processor when saving 8-bit file types, JPG, AVI, BMP, MP4, and TIF. If no post-processing is intended, using Curves is the best way to enhance imagery on the camera system. Watch the Curves Tutorial to see how it is used.

3-4 Custom Color Correction in Fas*Motion*

When the preset White Balance options, Daylight, Tungsten, and Fluorescent, do not give you the color reproduction you need, there are a couple of other options available:

The Custom item in the Display/White Balance menu allows you to set the color correction via a gray card or neutral gray object.

Figure 3-16: Custom White Balance



To use Custom White Balance:

1. Click on the "Custom" button in the White Balance menu. A rectangular reticle will appear in the middle of the image window and a special histogram will appear (See "Figure 3-15: Color Curves on HS System" on page 58.)
2. Center the reticle (the white box in the center of the image) on a neutral gray object in the field of view. In this instance we are using an 18% gray card, which is the recommended target. Most often the card will only fill a portion of the field of view--it only needs to fill the reticle. It is important that the card, or other neutral gray object, is located close to the objects of interest and is exposed to the same light as the objects you are going to image.
3. Adjust the lens aperture so that the histogram shows mid-range pixel values with no saturation. (It is important that the high pixel value is less than 255.) Notice on the example here, that the RGB peaks are not well aligned and that the Red peak is farthest to the left. This means that the color is skewed slightly towards the Green, the complement to Red.

Note: The histogram used with Custom White Balance represents only the area of the reticle, not the whole image. For more information regarding TSx Histograms please refer to "Application Note 1: Histograms" on page 79.

4. Click on "OK." You will immediately notice a difference in the color.

Using RGB Gain Controls

Another option for addressing color correction is via RGB Gains. It is recommended that you use the RGB gains sparingly and as a final "tweak" to make subtle changes to the color. The best use of this is to get the color as close as possible using the White Balance presets or Custom options before adjusting the RGB gains.

To use RGB Gain:

1. Open the Display Settings Tab. You will notice sliders with edit boxes and spinners for Red, Green, and Blue.
2. For any color gain you wish to increase, move the slider to the desired position. On the TS5, remember to use the D-Pad for fine adjustment.

Note: Remember that in the Bayer pattern, 1/2 of the pixels are green, 1/4 are blue and 1/4 are red. Whenever you change gain values you will be adding some noise to the image. It is best to avoid using any more gain than you need to, and to take special care with the green channel as it represents half of the pixels in the image.

3-5 Saving Images to Mass Storage in Fas*M*otion

Image sequences may be saved as CAP files (proprietary raw format, see "Appendix D: Partition Capture (CAP) File Format" on page 103), as AVI videos, in which one file contains all the frames of the sequence, or TIFF, JPEG, or BMP stacks, which are collections of files, one file per frame of imagery. The file-save options change depending on whether or 8-bit or 10- or 12-bit image data has been written to internal high-speed memory:

Table 3-3: TS5 Bit Selection

10- or 12-bits recorded	8-bits recorded
TIFF (8-bit M /24-bit C) or RAW TIFF (16-bit)	TIFF (8-bit M / 24-bit C) or RAW TIFF (8-bit)
DNG (16-bit raw format)	DNG (8-bit Raw format)
BMP (8-bit M /24-bit C)	BMP (8-bit M/ 24-bit C)
AVI (8-bit M /24-bit C)	AVI (8-bit M / 24-bit C)
JPEG (8-bit M /24-bit C)	JPEG (8-bit M / 24-bit C)
CAP (10- or 12-bit raw format)	CAP (8-bit Raw format)

Calculating file sizes for TIFF and BMP images is very simple:

Resolution x Bit depth/8 = approximate BMP or TIFF file size in Bytes

(to convert Bytes to KB, divide by 1024)

For example, a 1280 x 1024 Mono BMP or TIFF is:

1280 x 1024 x 8 / 8 = 1,310,720 bytes = 1,280K

A 1280 x 1024 16-bit RAW TIFF/DNG is:

1280 x 1024 x 16 / 8 = 2,621,440 bytes = 2,560K

CAP files are always the size of the current buffer (session size).

The actual file size of a 1280 x 1024 mono BMP or TIFF is about 1281K (the additional 1K for the file header). The actual size of 16-bit RAW TIFF is 2561K (again add an additional 1K for the header).

Note: The RAW 16-bit TIFF saved from the camera has 10 bits of image data. The 16-bit format is used for compatibility reasons.

Calculating file sizes for AVI and JPEG images is much more difficult. The compression is often approximately 10x to 20x, but it can be much greater for images with little content, and it can be much less for complex images.

RAW images are not colorized, so Mono and Color images are the same size. Colorization increases file size 3x because 8 bits are saved for each of red, green, and blue channels.

To **Save** a recording to a connected mass storage device on the TSx or to a drive Path on a computer:

1. Make a recording and establish the Start Clip and End Clip points you wish to use. (See "3-2 Advanced Playback Features" on page 54.)

Note that the frame numbers initially shown in the dialog box will be the actual start and stop frames for the entire capture unless the Start Clip and End Clip bumpers have been moved. If you are not sure what the actual beginning and end frame numbers for the clip are, you can find them on the far left / far right sides of the Clip bar.

2. Select a target drive using the "Save to Camera / Path radio buttons. If you select "Path" the target drive and folder will be a folder on a drive accessible by the computer.
3. Select a file type from the "Save Type:" pull-down list. File type choices may change depending on the target drive. If you wish to save CAP files, you must save to the SSD. If you wish to save AVI files, you must save to a location other than SSD. See "Application Note 6: Choosing an Image File Format" on page 94.

- The default folder name format for the image stacks is 000000. If you would like the name to include the camera name, Select Use Name in the dialog. The resulting folder name format for the example would become TS3-11_000000.
- If you would like to add a tag to the name, select Tag. The Tag may be edited. Using the Tag in the example, the folder name becomes 2011-10-11_000000.
- Both the Name and the Tag may be used, in which case the folder name becomes TS3-11_2011-10-11_000000 in the example.
- Select Create XML if you would like the per-frame metadata for your clip saved in an XML file along with your image stack or video. (See "Appendix C: Contents of <Capture>.xml file" on page 102.) This will allow you to view per-frame metadata when playing your saved files back in Fas*M*otion.
- If AVI files are saved, the default file name is TS3_000000.AVI. The Use Name and Use Tag options are also valid for AVI files, in which case the resulting file names are TS3-11_000000.AVI, or 2011-10-11_000000.AVI, etc. If the file size exceeds the 4GB limit for 32-bit file systems, the TSx will make a second file for the remainder of the imagery. (MiDAS and other players will play the video as one.)
- If CAP files are saved, they will not use either the camera name or the tag. CAP files are saved only to the SSD. They must be loaded back into high-speed memory in the camera to be reviewed, and then converted into a downloadable file format.

Figure 3-17: Fas*M*otion Save Dialog

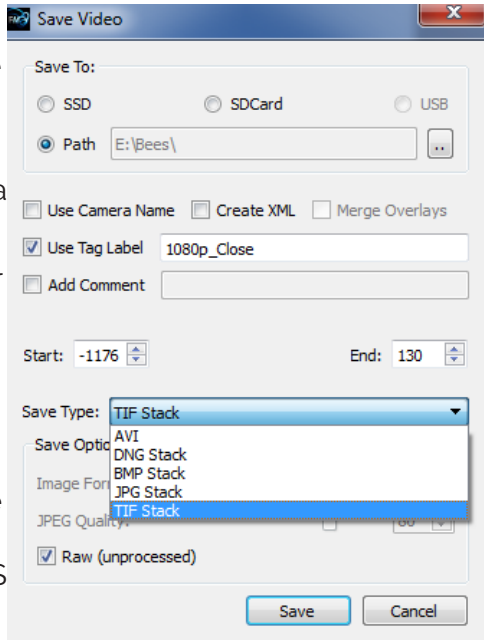
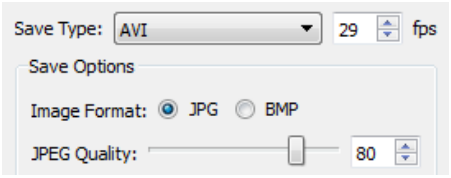


Figure 3-18: AVI Selected



Note: If AVI to Path is selected, there is a choice between using the MJPEG codec (select JPG) and saving without compression (BMP). Whenever JPG is chosen, the JPEG Quality slider is active.

Note: CAP files load back into memory much faster than they are saved, taking 20 to 45 seconds for a full 8GB load, depending on SSD version, and proportionately shorter times for smaller ones.

When the TSx saves imagery to mass storage it creates the following:

- DCIM is an industry standard directory name for Digital Camera Images.
- 100fastc is a sub-directory under DCIM.
- ts3_000000 is the first sub-directory under DCIM/100fastc, used for storing image stacks.
- hs-video. This is the directory that all AVI files are written to.
- <filename>.txt. For each download, the camera creates this text file. In it are the setup values, including resolution, frame rate, camera name, time stamp for the capture, image processing values, color processing values, etc. (See "Appendix B: Contents of <Capture>.txt file".)
- <filename>.cfg is a binary file used for MiDAS player so that it can properly play them.

Note: Image files may be saved multiple times using different formats, different start and stop points, and different image processing options (brightness, contrast, gamma, color, etc.). If 10 or 12-bit images have been captured, imagery may be saved multiple times using different bit-depths.

3-6 Adding Overlay Metadata

Overlay metadata, images and custom text may be added to image stacks and video files in FasMotion, either as text boxes within the image frame or pinned above or below the image frame or positioned on either side.

The overlays may be added as images are Saved or may be added when videos or stacks on the computer are opened by FasMotion, then re-saved (transcoded) back to the computer.)

As Seen in the Example 1, multiple overlays may be used. Each may have its own shape, font, and color scheme.

Figure 3-19: Metadata Overlay Example 1

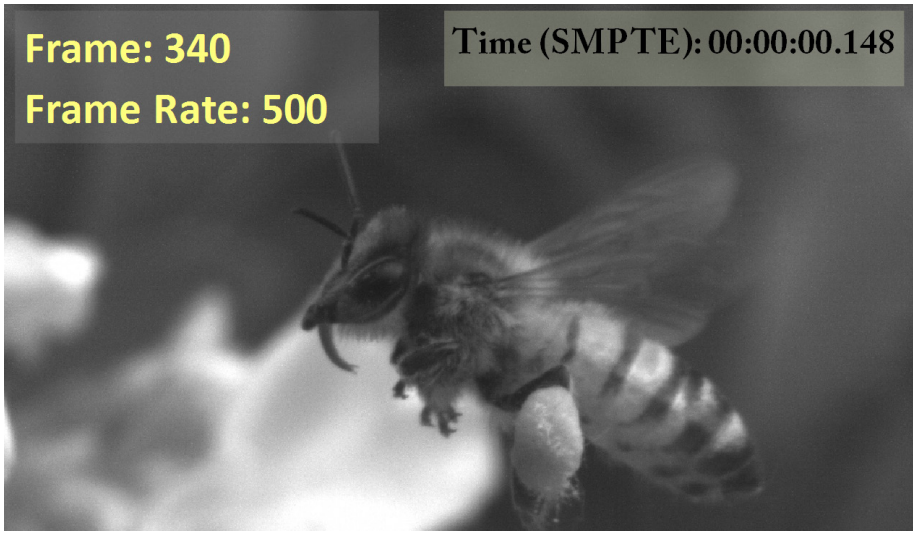
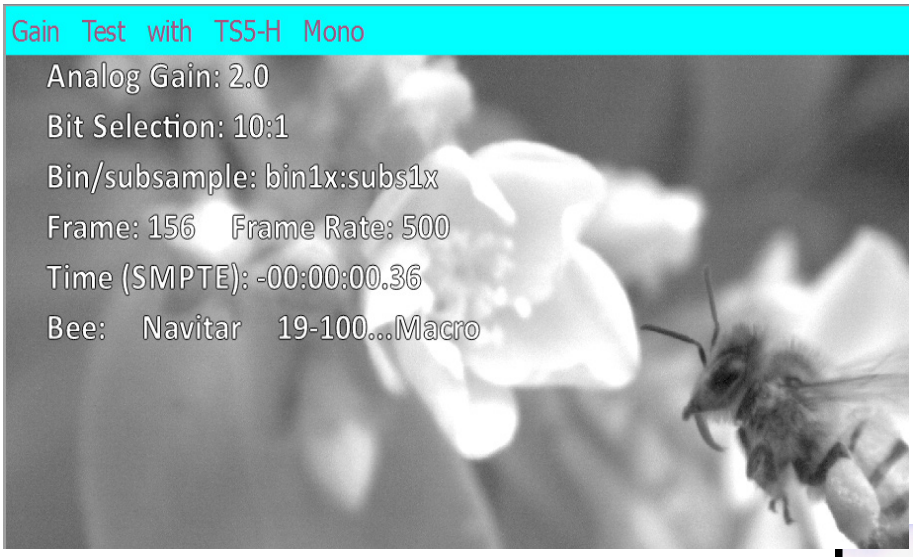


Figure 3-20: Metadata Overlay Example 2



Example 2 uses white text with black outline and a transparent background allowing the characters to be easily readable regardless of the changing image beneath. It illustrates the use of two overlays on the same video. The overlay at the top of the image, magenta text over a turquoise background, which demonstrates that you may use color overlays even if the image is mono. Note that this text box adds to the vertical size of the saved image.

If very narrow resolutions are used, there may not be a room for text without forcing it to wrap in undesired ways, so if the chosen overlay shape is wider than the original image, the saved images will have added black horizontal space.

For example 3, a transparent background was used with white text so that it shows up nicely against both the dark roof and the added black space.

Figure 3-21: Metadata Overlay Example 3

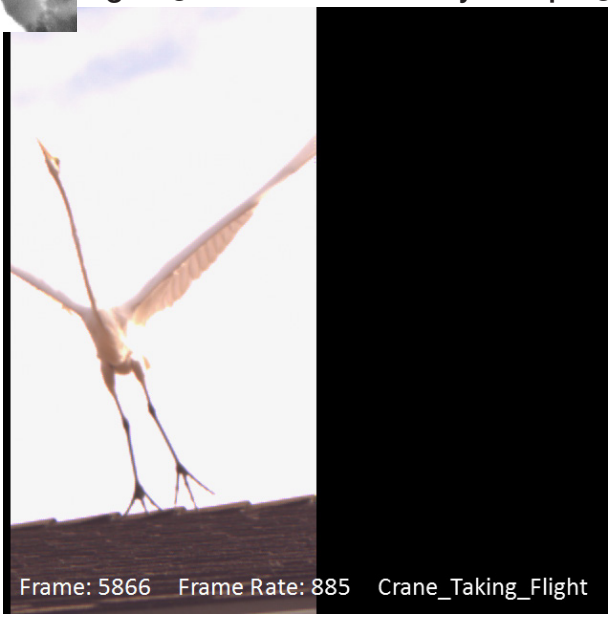
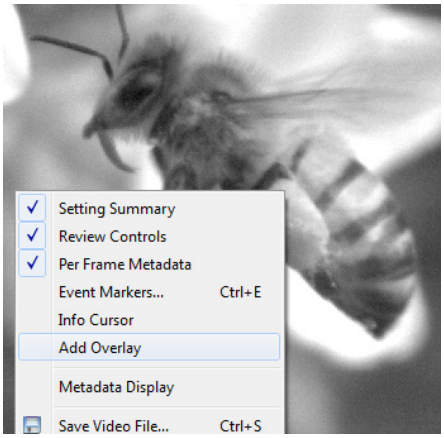


Figure 3-22: Playback Context Menu



Setting up the Text Overlay:

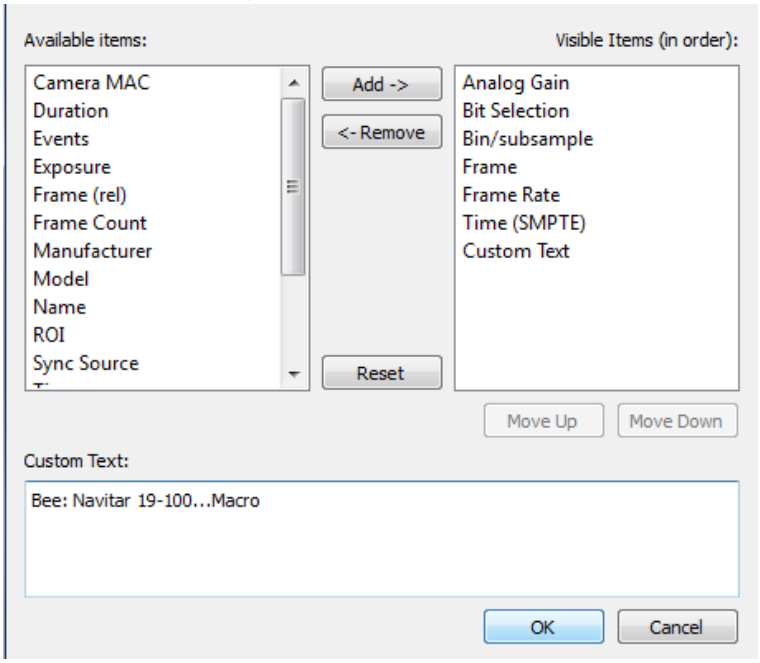
1. Right-click on the image in Playback to open the context menu.
2. Select "Add Overlay" to bring up the Overlay Item Selection Dialog.

Note that overlays persist in FasMotion and that the "Merge Overlay" check box in the Save Menu is always checked by default if an overlay is present.

3. Select the metadata items you wish to use in your overly from the Overlay Item Selection Dialog.
4. Add any custom text you wish to use.

Note: Remember that you can have multiple overlays!

Figure 3-23: Overlay Item Selection Dialog



5. Adjust the position of the overlay by placing the mouse cursor inside the overlay left click and drag with your mouse.
6. To shape the overlay, place the mouse cursor on a corner until you see the red dot on it, then left-click and drag.
7. Right-click on the Overlay to open the Overlay Context Menu.
8. Select Change Item Font and select your font and Size. You may also select "Outline Text" from the context menu. (The outline is black)
9. Select "Item Text Color..." from the context menu to select the color for the text. (This dialog is identical to the Background Color Dialog.)

Figure 3-24: Overlay Context Menu

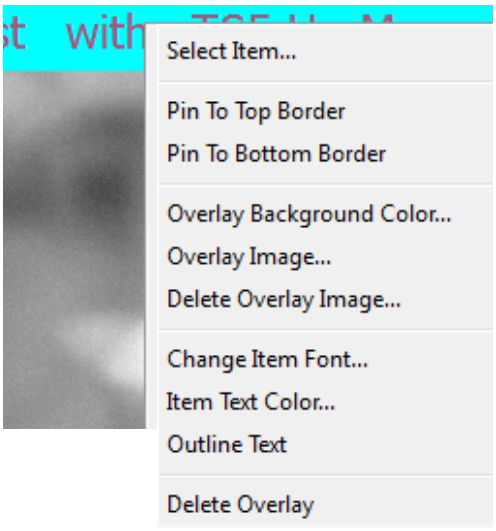


Figure 3-25: Overlay Font Dialog (Windows)

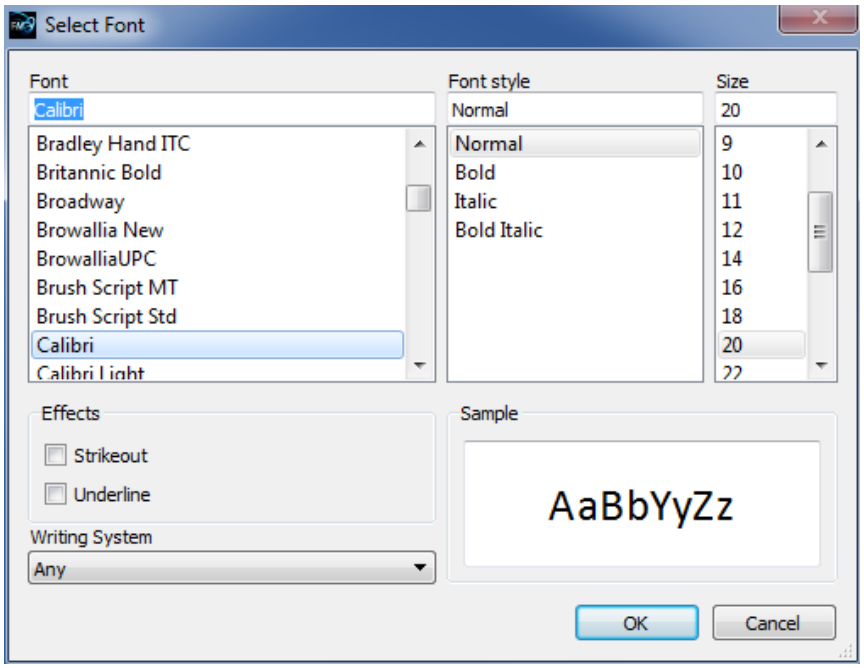


Figure 3-26: Font Selection on Mac

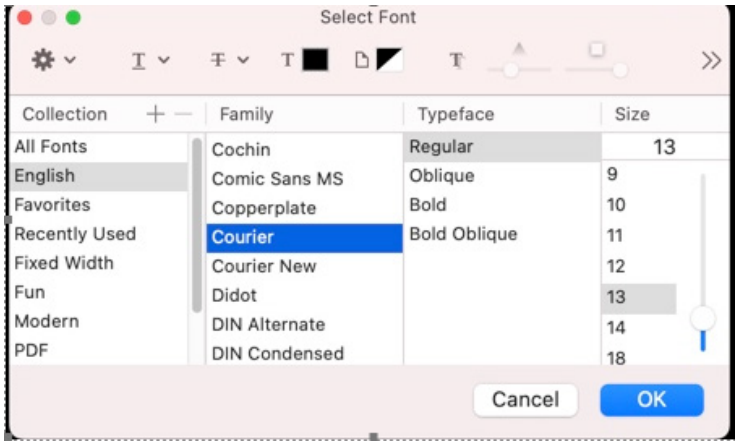
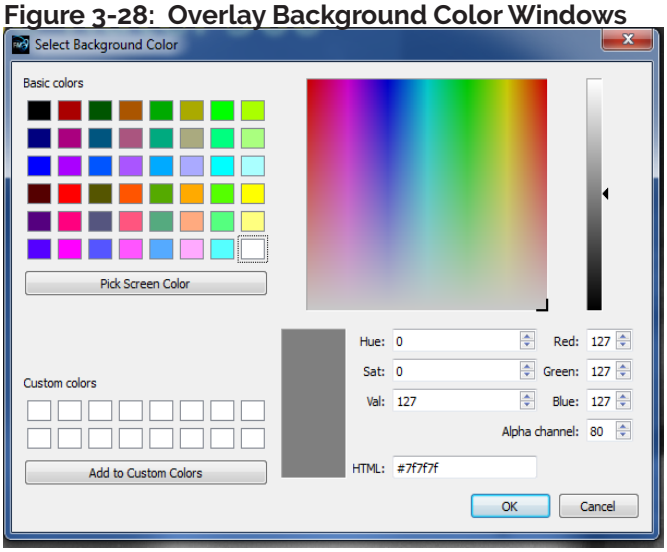


Figure 3-28: Overlay Background Color Windows



10. Select "Overlay Background Color..." to change the color of the overlay background. The Alpha channel is used for transparency on Windows: 0 = totally transparent, 255=totally opaque.
11. Save the image data with the overlay as an AVI or Stack (any type except DNG) to a Path. Remember that the Merge Overlay check box must be checked.

Note that the Color and Font Selection dialogs are different depending on the Operating System.

Figure 3-29: Overlay Colors Mac

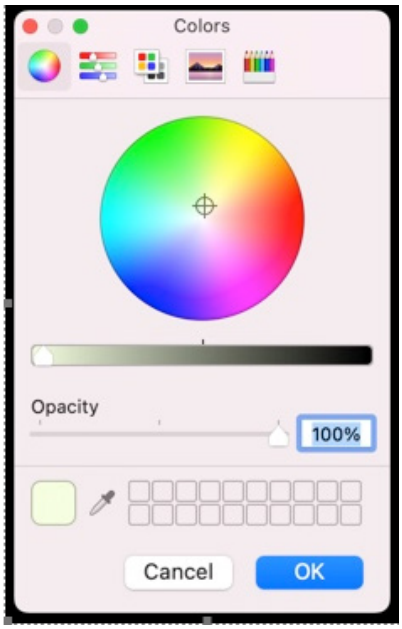


Figure 3-27: Font Selection in Linux

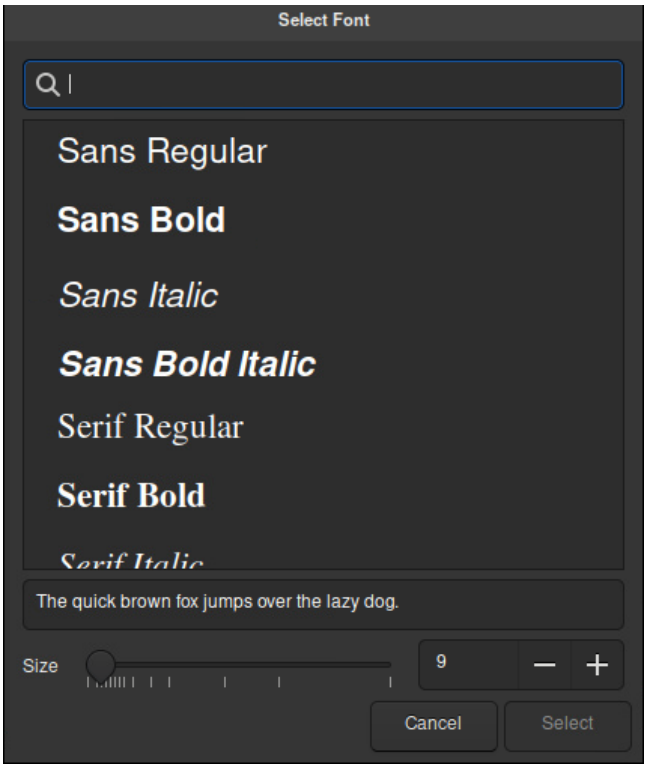
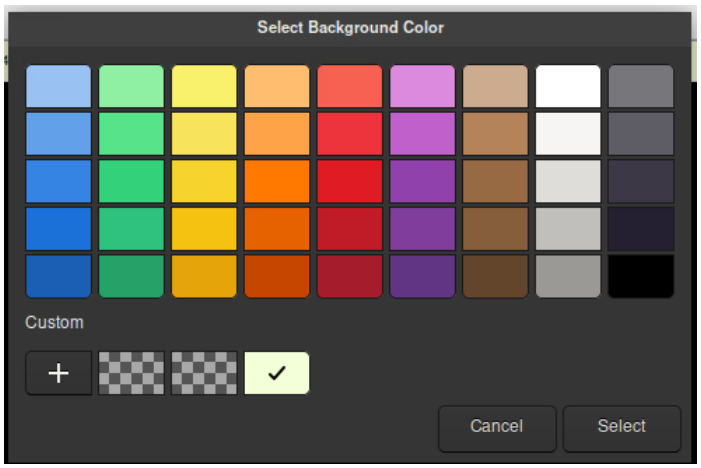


Figure 3-30: Overlay Color in Linux



"Time" Overlay Items

Overlay Item	Description
Time	Beginning of integration (exposure) for the current frame
Frel	Time relative to a user-selected frame
SEMPTE	Time offset from trigger frame- format: HH:MM:SS:frames
Trel	Time relative to the Trigger Frame
Time Source	Internal (camera) or IRIG (military-related option for TS cameras)
Time 0 Offset	Time offset between the time of the trigger input and the frame 0 TimeStamp

See video: Time Overlay Review

Figure 3-31: Image Overlay Example

Setting up an Image Overlay:

Image overlays may be added to any recording in much the same way as text overlays:

1. Right-click on the image window in Playback to bring up the context menu (see Figure 3-22).
2. Select "Add Overlay."
3. The Overlay Item Selection Dialog will open. Click on "Cancel."
4. You will now have an overlay at the top of the image with the text "<add items>"
5. Right-click on the overlay box to bring up the Overlay Context Menu and select "Overlay Image..."
6. A browser will open which will allow you to select a .jpg, .png, .bmp, or .tif image.
7. Size the overlay by grabbing it by a corner and stretching or shrinking it to fit.

Note: If you wish to use an image with a transparency (alpha) channel, use a png image.

3-7: Playback from File (Review) and Transcoding

FasMotion is capable of playing back and transcoding AVI videos and image stacks.

To open a video or stack, select "Open Video File..." from the File Menu in FasMotion.

This will open a Windows Explore window that will allow you to browse the media connected to your computer. In the lower right corner of the window you will see the list of Image file types FasMotion can open: jpg, jpeg, bmp, tif, tiff, dng and avi.

You may also click on the down arrow to select cap files.

You may open multiple files for playback, although only one file may be either played or saved at a time.

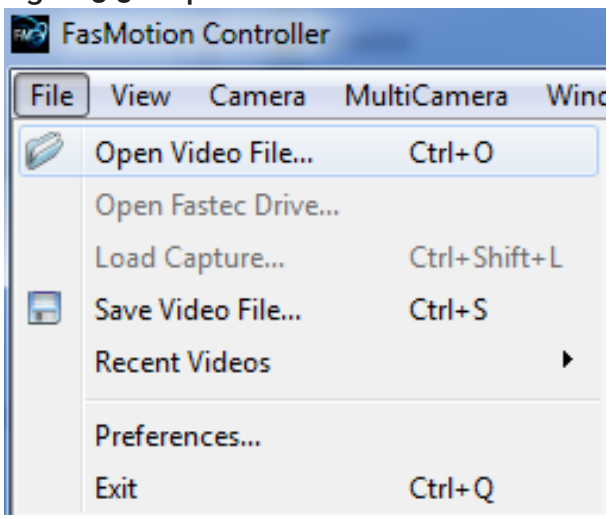
To Transcode a video, that is, to re-save it, right-click on the image window (or Ctrl+S) and select "Save Video File..."

This will open the familiar Save Video dialog box. This is a slightly different version of the dialog than you would see if saving video from the camera. It allows only saves to a Path (not to any camera media).

This dialog supports:

- Transcoding from any saved stack or CAP file (not AVI).
- Adjusting Start and End points.
- Adjust JPEG Quality. (When transcoding from JPEG to JPEG or JPEG to AVI, there will always some loss of fidelity even if JPEG Quality is set to 100. If the original JPEG was saved with JPEG Quality set to 80, setting it to 100 for the second generation will not make the second generation better than the first.)
- Adding overlays (cannot remove original overlays).
- Save to AVI, BMP, JPG, or TIF. Save to DNG only from CAP file.

Figure 3-32: Open Video File



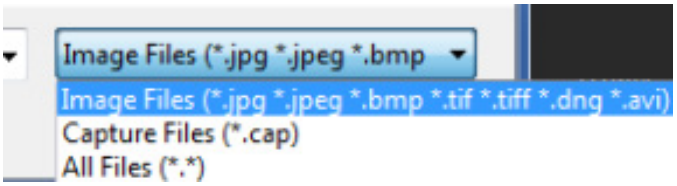
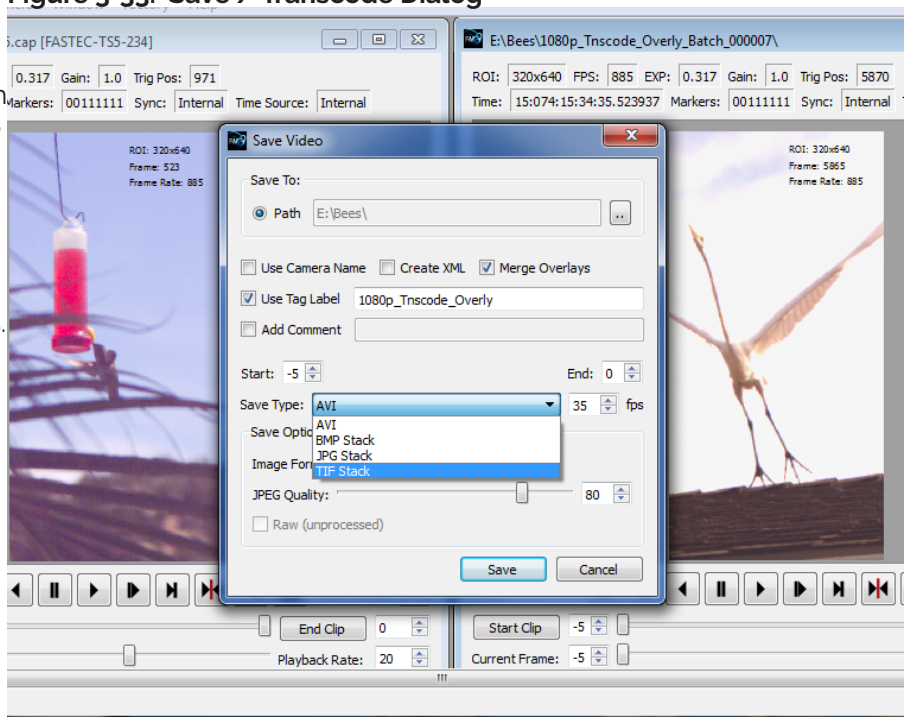


Figure 3-33: Save / Transcode Dialog



3-8: Review While Record

FasMotion is capable of Reviewing saved video while capturing new recordings.

For IL and TS cameras, this is limited to recordings that have been transferred to a PC, Mac, or HS Controller

While recording in Image Memory mode:

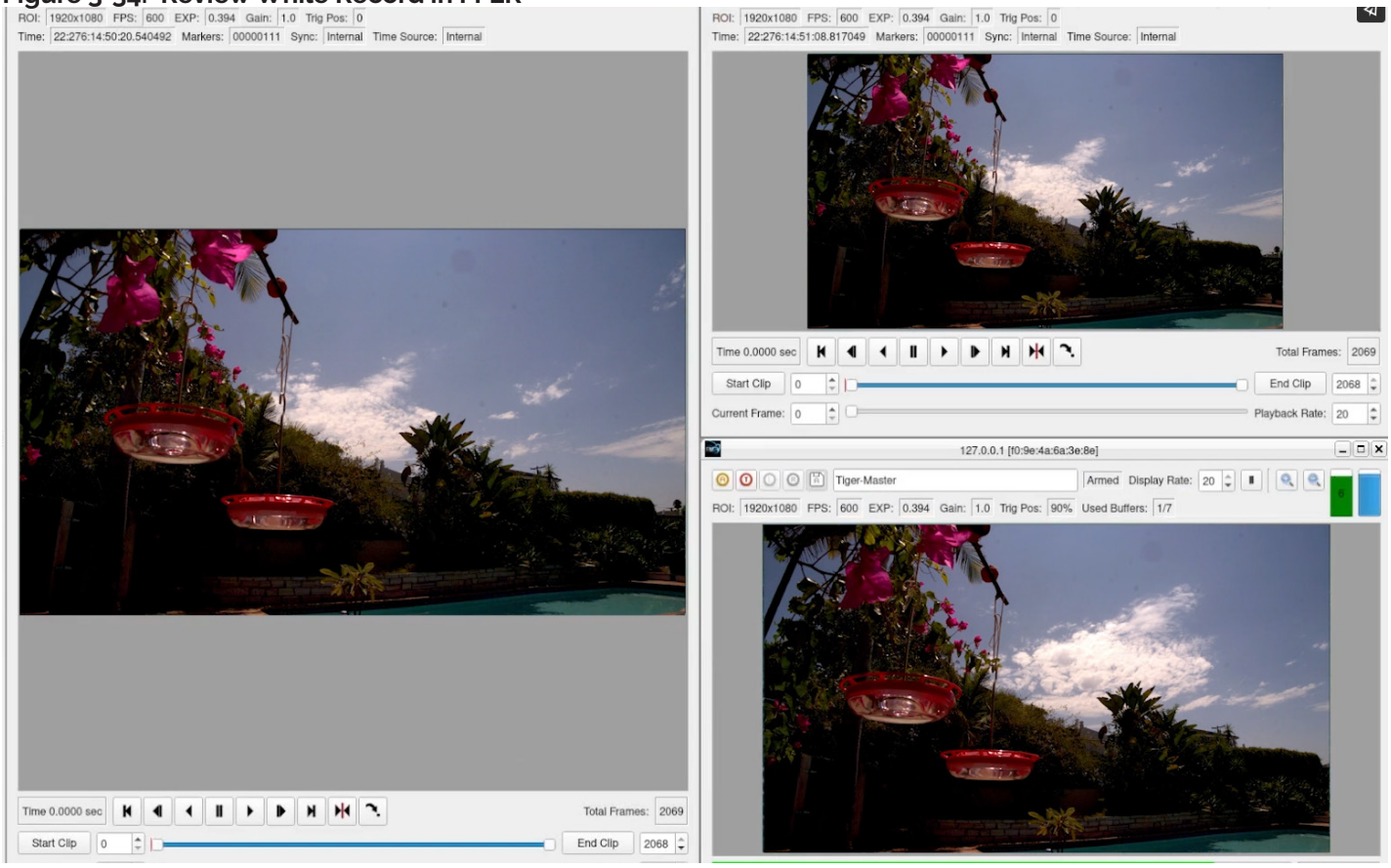
1. Go to the File menu and select "Open Video File..."
2. Navigate to the location of the recording you wish to open:
   - For IL and TS cameras, this must be a location via a Path on the PC. Devices connected to the camera (internal SSD, USB drive, or SD card) cannot be used.
   - For HS cameras operating Locally (FasMotion running on the Controller, this location may be the Fastec SSD (internal to the camera) Video SSD (connected to the Controller via Thunderbolt), or Fastec USB (connected to the Controller via USB).
3. Double-click on video file or any image in a stack to open the recording in a new FasMotion image window.

While recording in FasFire or FasFire LR mode on an HS camera, you may open very recently recorded CAP files that may be incorporated in a final contiguous video along with the present recording. See 3.3 Update Video (02:15); and 3.4 Update Video (03:58)

Limitations:

- It is possible to open HS camera files over a networked HS system on a remote PC. This is not recommended for Review While Record because it can be a burden on resources. If it is required for a given application, it may require some computer and network optimization.
- If Review While Record is used during the pre-trigger portion of an LR Basic mode recording, the file in Review may not be part of the final capture as it will be written over.
- Bandwidth for FasFire LR may be affected by whatever is running on the Controller. If the FasFire LR recording requires a bandwidth that is close to the system's limit, care should be taken regarding opening any new video windows or other applications while recording.

Figure 3-34: Review While Record in FFLR



3-9: Transfers, Batch Transfers and Conversions

Stills, stacks, videos, and capture files (CAP), saved on camera media may be managed via File > OpenStorage_Device...

Copy / Batch Copy

Stills, videos, and stacks may be copied from any camera media (SD card, SSD, or USB device) to any other camera media or to a Path accessible via your computer (any media attached to your computer or networked drive, etc.).

1. Select the camera media you wish to copy from using the radio buttons in External Storage box on the Storage Settings tab.
2. Click on the Explore button. The media on the camera will be accessed and read at this point, which may take a minute or two, depending on the number of files and folders present.
3. Select the type of image data you wish to copy, (Stills, Stacks, Video or Capture).
4. You will be presented with a list of available files or folders to pick from. Pick one or more from this list. You may click on one, or Ctrl/click on multiple files, or Shift/click on the first and last of a sequence for a **Batch Copy**.
5. Once you have made your selection, click on Copy. A little dialog box will open that allows you to choose a destination.
6. Select from the list of available camera media to copy to another drive on the camera, or Path to copy to media attached to your computer.

Move

Move works exactly like Copy, except that the source files are deleted after they are copied.

Note: Move is not enabled for the SSD on most IL and TS cameras.

Figure 3-35: Open Storage Device

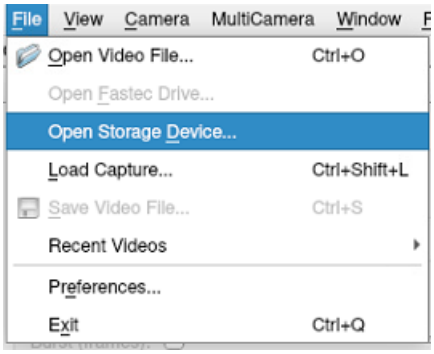


Figure 3-36: Fas*M*otion Explore Menu

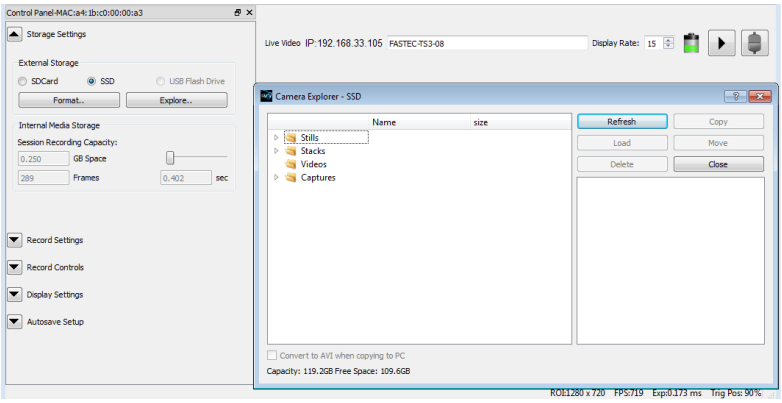


Figure 3-37: Copy: Choose Destination

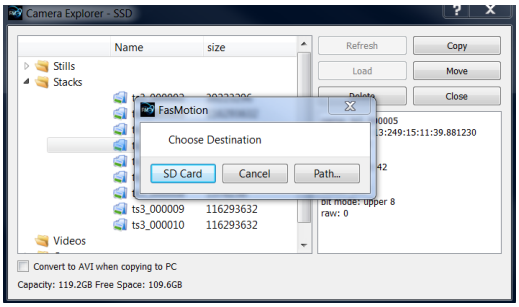
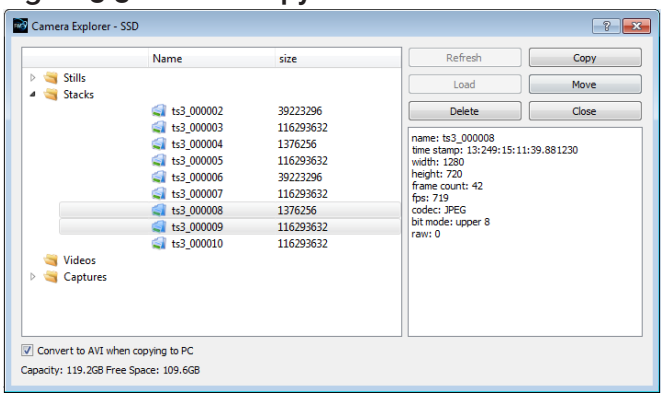


Figure 3-38: Batch Copy Convert: JPEG or BMP to AVI



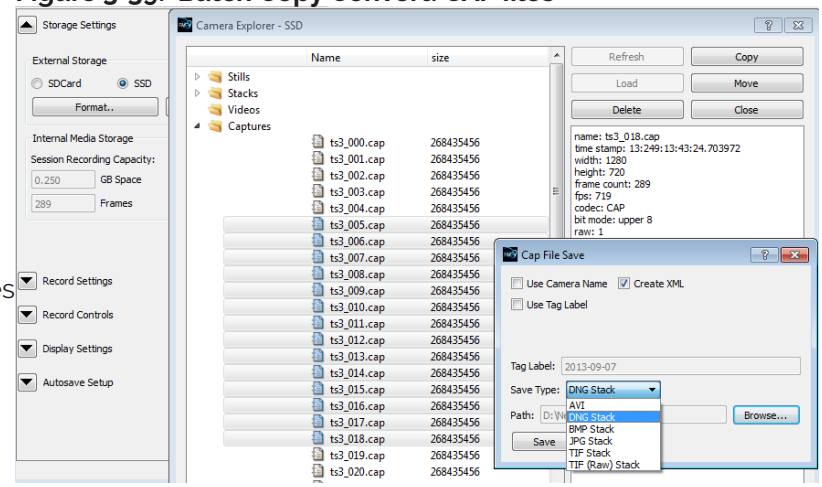
Convert JPEG or BMP Stacks to AVIs

JPEG and BMP stacks will be converted to AVI videos during transfers (copy or move) if the "Convert to AVI" box in the lower left corner of the explore window is checked. Refer to "Batch Copy Convert: JPEG or BMP to AVI" on page 68.

There is no additional compression used when converting JPEGs or BMPs to AVIs. Compression for JPEG/AVI files will be the same as the original JPEG, which was selected via JPEG Quality camera Preferences when the JPEG was saved.

BMP/AVI files are uncompressed and may very large. Be aware that very large AVI files may take extra time to load and play on your computer.

Figure 3-39: Batch Copy Convert: CAP files



Batch Copy and Convert CAP Files

Note: CAP files may be located on any HS camera Device and on TS or IL cameras with SSDs that have serial numbers above A0. If you have an older TS3 or a TS3 without an SSD and would like to add this functionality, please contact your Fastec distributor and inquire about an upgrade.

When one or more CAP (Partition Capture) files are selected for Copy or Move, an additional dialog box will appear that will give you all the available options for naming the saved images, inclusion of the per frame metadata XML file, file type and Path.

Note: the display properties, including color balance, gamma, etc. of the saved imagery will be those set in the camera when the CAP files were captured. If you would like to make any changes, you will want to load the CAP files individually and save them via the Review/Save Tab after making any changes.

4 Synchronizing Cameras

Please refer to the User Manual for your camera for electrical specifications. Do not experiment with these connections if you are unsure of compatibility with your source as they are sensitive to over voltage and can be easily damaged. If in doubt, contact support@fastecimaging.com

Camera sync features are determined by I/O connections and not via multi-camera control. Triggering via multi-camera (software) control does not imply synchronous triggering, which must be accomplished via I/O connections.

4-1 Sync In

Fastec cameras are easily synchronized to an external device such as other cameras, or precision timing generators. The "Per Frame" option is used when you wish the camera to capture at a rate of one sync-pulse per frame or fewer.

To set up Sync-In:

1. Open the Record Controls tab in Fas*M*otion.
2. Click on the "Enable Sync In" check box to enable Sync In. For HS cameras, you will select a port via the radio buttons.

Note: As soon as Sync In is enabled, the camera needs a sync pulse in order to continue taking Live frames. You may not notice this immediately because Fas*M*otion will continue to display the last frame it captured.

3. Select Rising Edge or falling edge depending on the source.
4. Set the **Expected Pulse Rate**. This is the expected speed in Hertz of the input signal you expect during the recording. (The **Sync-in Pulse Rate** will reflect the current frequency of the signal seen at the Sync-in I/O.) It is important that the input signal does not exceed this, but if it does, you will see the red messages shown in Figure 4-2.

NOTE: In this example, the Sync-in Pulse rate shows 24Hz. It could be that the camera used as the sync source is in Low Light Mode--set to 24fps, but it is expected to shift up to 2500fps when Armed. (See "Low Light Mode:" on page 39.)

Figure 4-1: Sync In Settings Dialog

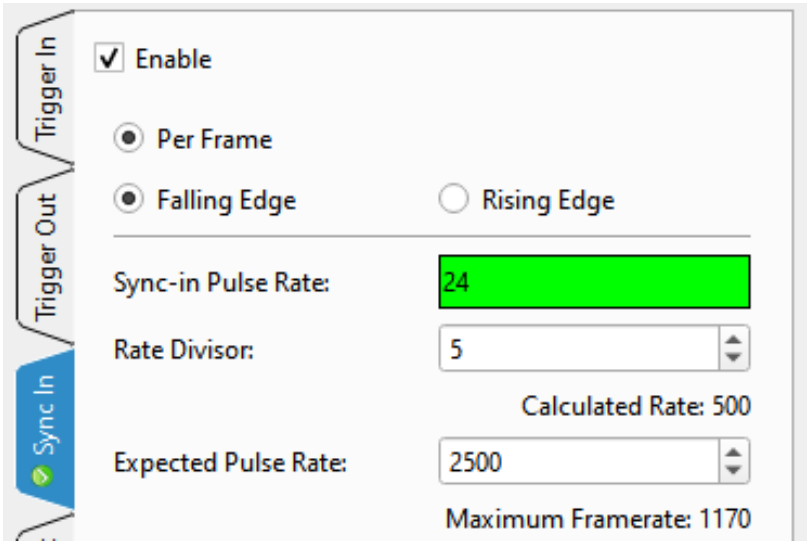
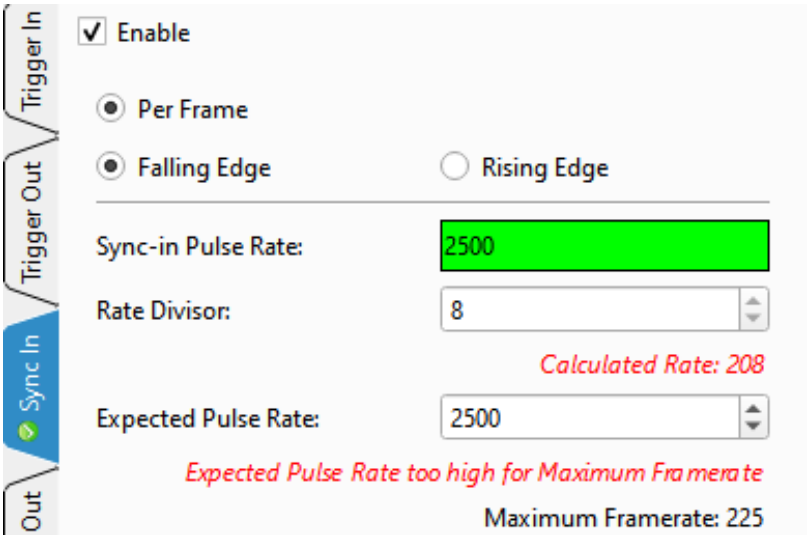
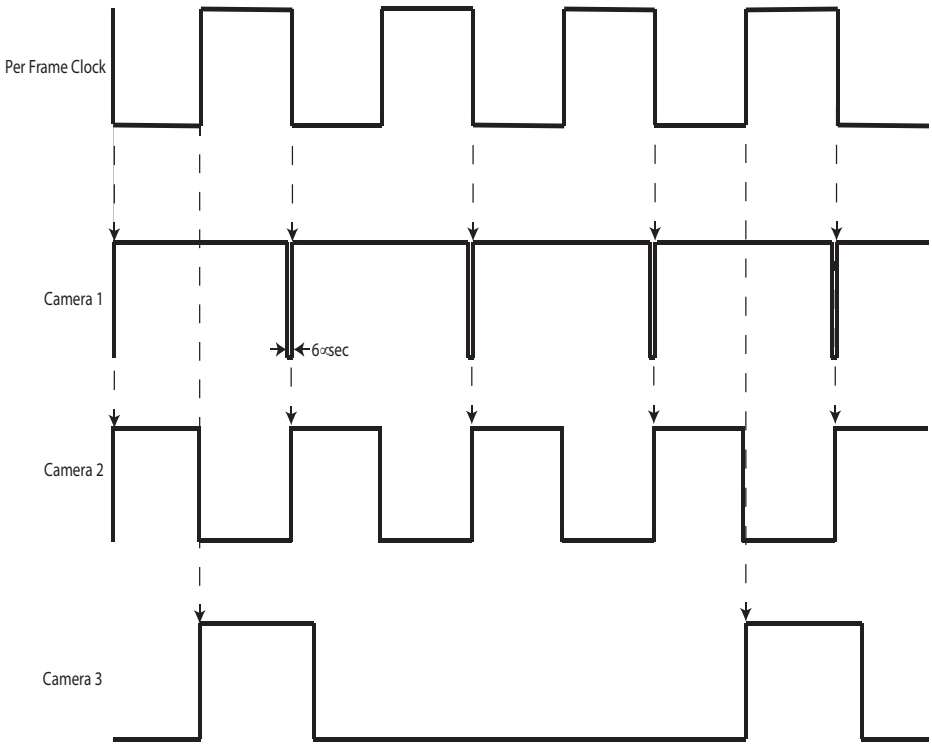


Figure 4-2: Sync-in: Expected Rate too high!



5. Set the rate divisor. In the example shown in Figure 4-1, the desired frame rate is 500, while the Expected Pulse Rate is 2500, so a divisor of 5 is used.
6. The frame rate used for the recording metadata will now be 500fps.

Figure 4-3: Sync: Per Frame Timing



Sync-frame timing examples:

The Sync-in signal may be from another Camera (See "4-3 Master/Slave Setup" on page 72) or some other external clock.

Note: for each camera in Figure 4-3, the signal shown represents the exposure (high = shutter "open")

Camera 1 is set for Falling Edge, @ 1x shutter (longest shutter for that frame rate). This is not typical, but it requires very accurate timing as there is only a 6µsec inter-frame time as shown in the diagram. (Interframe timing will vary depending on the sensor type.)

Camera 2 is set for Falling Edge, @ 2x shutter. Note that exposures for Camera 1 and Camera 2 begin at the same time.

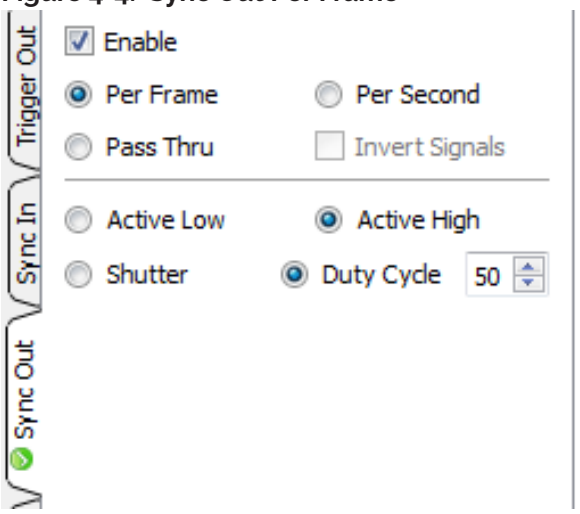
Camera 3 is set for Rising Edge, @ 4x shutter and has a rate divisor of 3.

4-2 Sync Out

Per Frame

External devices such as additional cameras, strobe lights, and test instruments may be synchronized via Sync Out pulses from the. The "Per Frame" option output is one pulse per frame--the sync pulse rate is equal to the recording frame rate.

Figure 4-4: Sync Out Per Frame



T**o set up Sync Out:**

1. Open the Record Controls tab and locate the Sync Out controls.
2. Click on the check box to enable Sync Out. Select port if using an HS system.
3. The signal can either be **Active High**, meaning the signal goes high when the shutter opens, or **Active Low**, meaning the signal goes low with when the shutter opens. Select Active High or Low from the dialog box.
4. The signal can either follow the Shutter (integration time) or you can select Duty Cycle and control the % of frame time (1/frame rate) for the active portion of the signal using the number box provided.

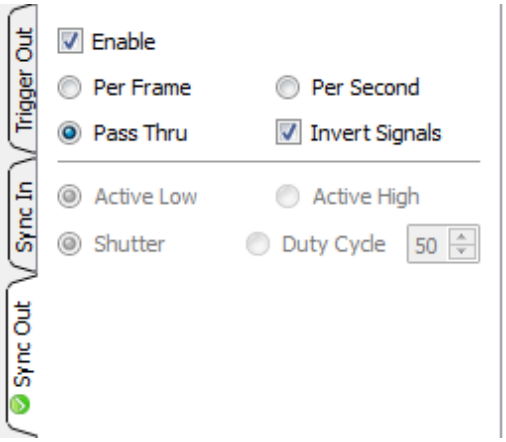
Per Second

If you choose the "Per Second," the camera will output a 1Hz signal. The only active options in this mode are Active High and Active Low.

Pass Thru

When you select Sync Out Pass Thru, the signal received on Sync In is sent to Sync Out. The only setting that affects this signal is the Invert Sync In option, which simply inverts the signal.

Figure 4-5: Sync Pass Thru



4-3 Master/Slave Setup

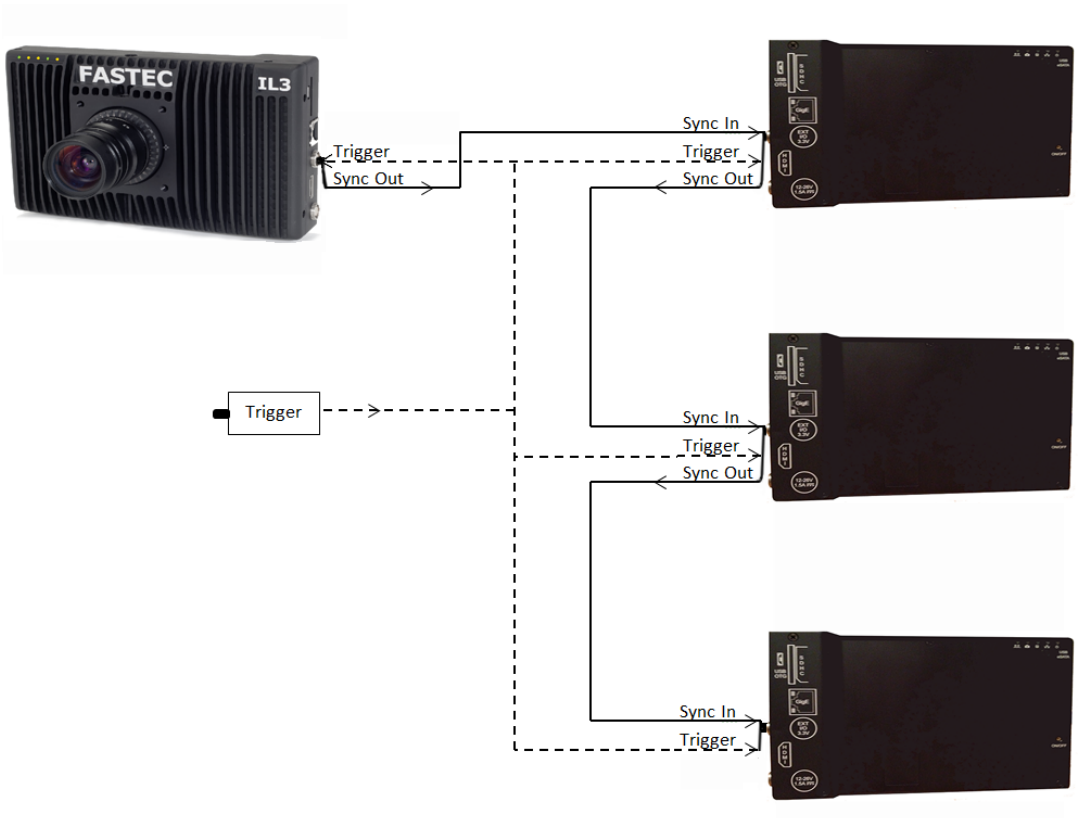
There are many possible configurations used to synchronize groups of cameras. The Master/Slave configuration is often used when a group of cameras is used to capture multiple synchronous views of an event that is not driven by a clock or PLC. For example, when studying animal or human kinetics, the subject (animal or human) is not supplying a sync signal for the camera system, so the camera system uses its own: Sync Out from a Master camera.

In this configuration, any camera may be used as the Master.

Commonly, all cameras are set to the same Frame Rate and Resolution, are triggered together, and integrate frames together (synchronize frame start times). For this setup:

- Enable External Trigger for all cameras and use the same polarity for all.
- Sync Out from the Master camera is set to "Per Frame"
- Sync Out for the Slave cameras is set to "Pass Thru." Invert Sync In is **not** selected.
- Sync In for the Slave cameras Master Frame rate is set the same as the Frame rate of the Master camera.

Figure 4-6: Master and Slave Cameras



- Choice of Shutter or Duty Cycle does not matter for most applications.
- If the Master Sync Out is Active High, then the Slave Sync In must be set for Rising Edge. If Master Sync Out is Active Low, then the Slave Sync In must be set for Falling Edge.

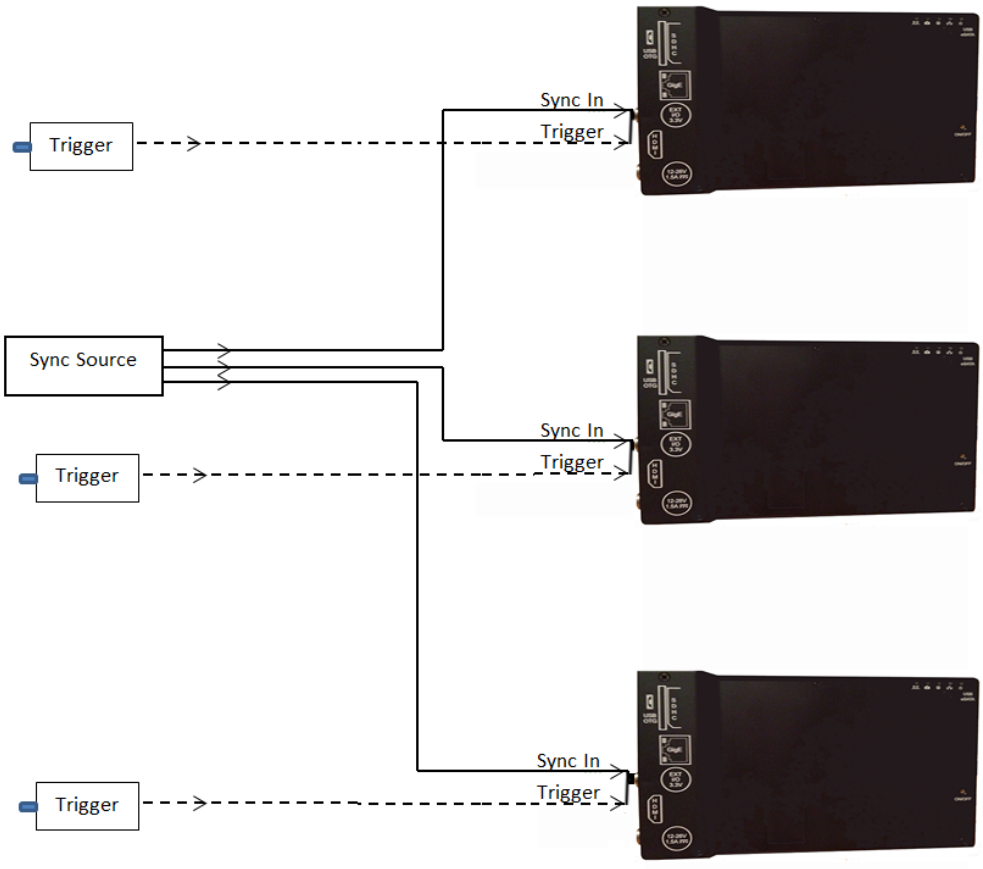
NOTE: For the "common" setup as well as for variations listed below, always make sure that the Post Trigger portion of the recording time for the Master camera is equal to or greater than each of the Slave cameras. This is important because Sync Out pulses cease with the completion of the capture, so the Master camera must continue recording until all Slave cameras complete their recordings.

Parameters that affect post trigger recording time include: Trigger position, Resolution, Bit depth, base internal Memory (camera model), Frame rate.

Variations on Master/Slave:

- Use a slower frame rate for one or more of the slave cameras by using a Rate Divisor in the Sync-In setup. (Make sure to make allowance for the extended time per the note above.)
- Extend the overall record time by adjusting the trigger position for all cameras. For example, set the Master to a Start trigger, the first Slave to 10%, the second Slave to 50%, etc. This would also be used if the subject is progressing through the different cameras' fields of view, as a runner running by each camera in sequence.
- Run cameras out of phase with each other. Higher effective frame rates can be simulated by running cameras out of phase with each other. This is usually done by using Duty Cycle in Sync Out, for example: if you set the Duty Cycle for 50% and invert the signal, the next camera in line will run 180 degrees out of sync.

Figure 4-7: External Sync: Local Grouping



4-4 External Source Sync

Synchronizing to an external source is most common in applications where a preferred sync pulse is available such as one from a PLC, IRIG, or GPS.

NOTE: Please refer to the User Manual for your camera for electrical specifications.

This sync pulse may be used for a localized group of cameras, in which the cameras are connected as in "Figure 4-7: External Sync: Local Grouping" on page 73 is commonly used. The cameras may also be placed far apart, in which case they are connected to a distributed sync signal as in "Figure 4-8: External Sync: Distributed Grouping" on page 74.

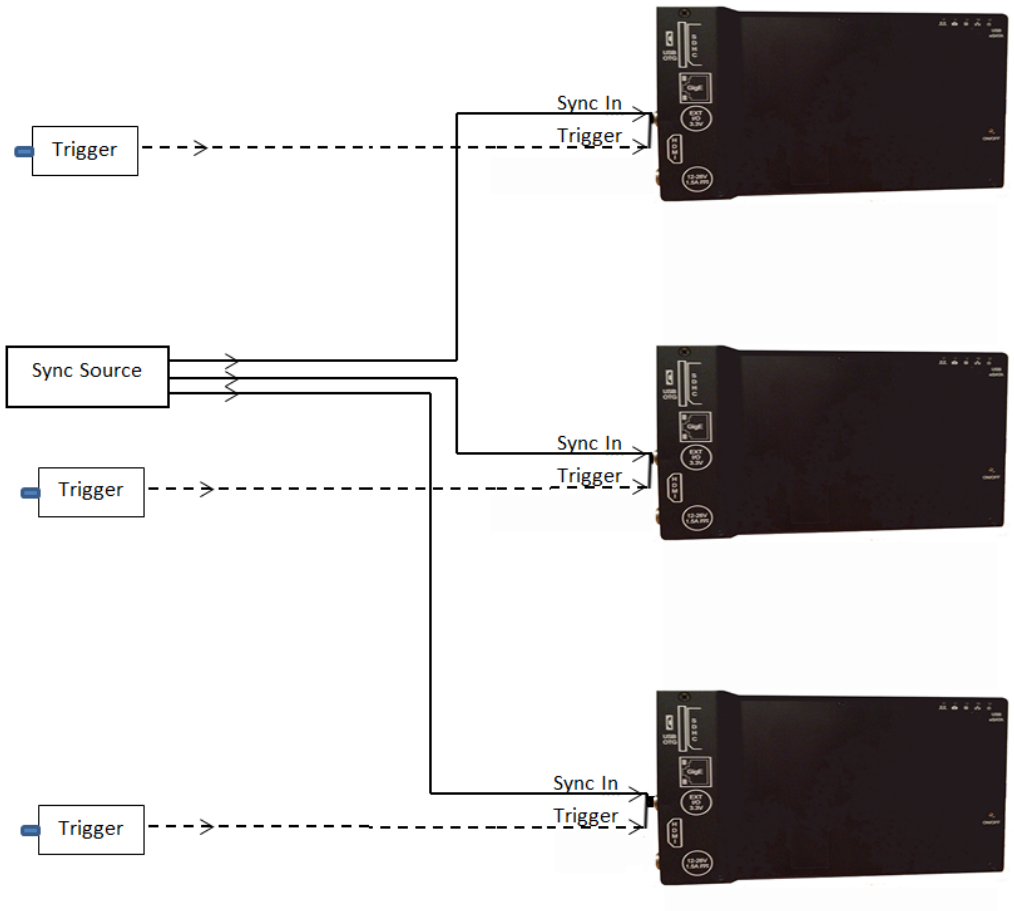
In the case of using a PLC or other local clock, you will need to know the polarity and frequency of the signal to set the cameras up. Optimum frame rates can often be derived using the Rate Devisor function.

When using IRIG or GPS as an input, you will first need to derive a 1Hz signal from the source, and then use the Per Second option. This gives you complete flexibility with respect to frame rate: you can select any frame rate you wish to use.

Note: full IRIG and GPS implementation is planned for a future release.

Triggering in a distributed grouping may either be implemented locally via switch, camera button, or software, or it may be available along with the sync as a distributed signal.

Figure 4-8: External Sync: Distributed Grouping

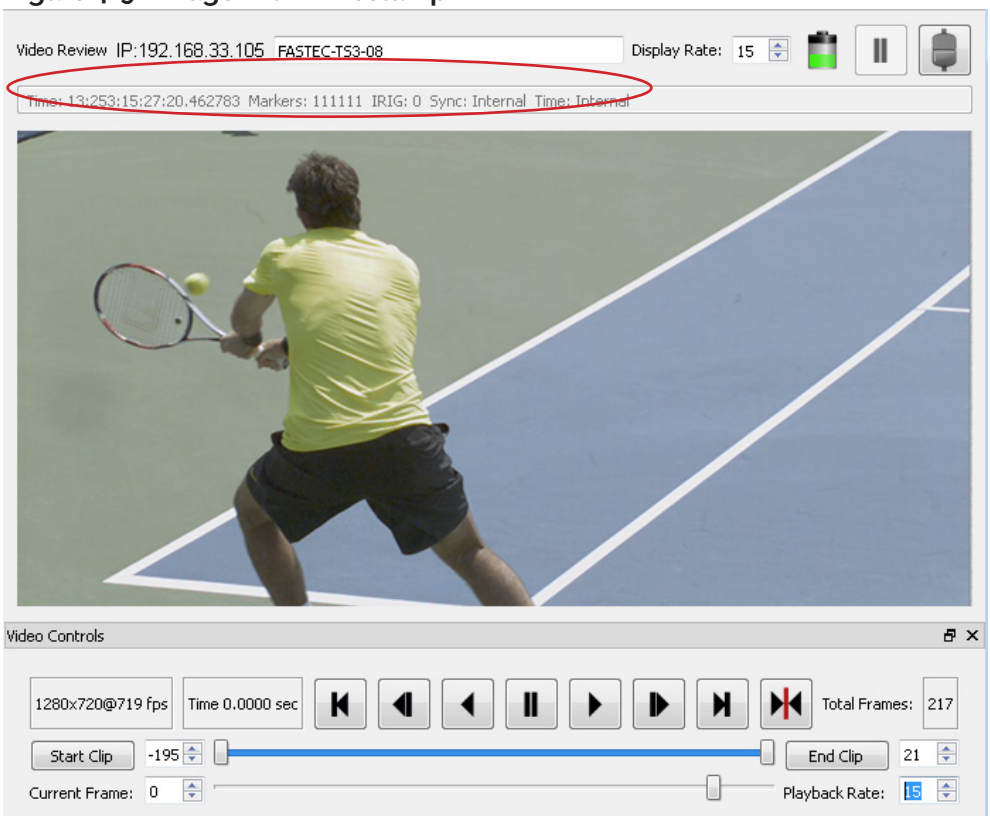


4-5 Timestamps and Markers

Whenever the camera records images, it also records timestamps for each frame. Each timestamp may be displayed during playback and may also be saved to an XML file (see "Appendix C: Contents of <Capture>.xml file" on page 102 and "3-5 Saving Images to Mass Storage in FasMotion" on page 60).

Figure 4-9: Image with Timestamp

To view the Timestamp and Markers, select "Per Frame Metadata" in the View Menu while in Playback mode.



Timestamp Format

Time:
YY:DDD:HH:MM:SS.xxxxxx

For the example shown in Figure 4-9 this is:

YY = Year: 13 = 2013

DDD =Day: 253 = September 10 (See "Appendix E: Day Number Calendar Conversion" on page 105.)

HH:MMM = Hour:Minute: 15:27 = 3:27pm

SS.xxxxxx = Seconds: 20.462783 (granularity to µsec)

Note: the Timestamp line is always available during playback from camera memory or from CAP files loaded into camera memory from an SSD. It is also seen in saved files played back via FasMotion.

Markers: 111111

The Timestamp line includes event markers. In the example shown in Figure 4-9 all of the I/O pins were "high" for the duration of the displayed image frame.

For each I/O pin there is a default signal, such as Trigger-In, Sync-In, Arm-Out, etc. that can be enabled via the Control menu. These same I/O pins may be utilized for marking events in the captured video clip. The electrical interface is the same for all pins.

NOTE: These pins are sensitive to over voltage and can easily be damaged. Please refer to the User Manual for your camera for details.

IRIG: 0

In the example IRIG is not enabled (0). (IRIG is not currently an option for the IL or HS.)

Sync: Internal

The Sync term can be Internal (internal camera clock used for frame timing) or PPF (Sync-In pulse used for per-frame timing). See "4-1 Sync In" on page 70.

Time: Internal (The Time is always set to Internal for the IL HS as the IRIG option is not available.)

The pin out and default signal list for the markers is seen in. Any pin that has not been enabled for Trigger, Arm, or Sync, including those that default as outputs, may be used as a marker input.

On a camera that has none of its I/O options enabled, all of the I/O pins will be high and the Markers in the Timestamp line and in the per-frame metadata will always be 1's as in Table 4-1.

Table 4-1: I/O Pins to Markers (TS/IL)

(0x3f) = Marker:		0	0	1	1	1	1	1	1
I/O Pin	Default Signal								
x	Section Start	0							
x	Record Start		0						
7	Trigger-In			1					
4	Trigger-Out				1				
8	Sync-In					1			
3	Sync-Out						1		
6	Arm-In							1	
5	Arm-Out								1

The markers are represented in the XML data in hexadecimal format: "<markers>0x3f"

If the user chooses to pull one or more of those pins down during a capture, all frames captured while those pins were held low will now show a "0" for the appropriate digit.

Section (not yet used) and Record Start are not tied to I/O pins. Record Start marks the beginning of FasCorder ROC and BROC recordings on Dual Mode cameras in Long Record.

Figure 4-10: Per Frame Metadata from XML File

```
- <frame>
    <number>87</number>
    <irig>0</irig>
    <sync_mode>0</sync_mode>
    <time_state>0</time_state>
    <markers>0x3f</markers>
    <time>13:213:15:39:31.879023</time>
```

See "Appendix C: Contents of <Capture>.xml file"

Example: If pins 4 and 5 are held down during some part of a recording, then, when viewing those frames the Timestamp line in playback would show Markers: 00101110.

Using this same example, the XML file would show <markers>0x2e.

Using Event Markers:

1. Select an unused (not enabled) I/O pin to use as an input. For this example. we will use Sync-Out, but any of the six I/O pins may be used. (We will first confirm that Sync-Out is not enabled by going to the Control menu on the camera GUI--we should see "Disabled" on the Sync Out line.)
2. Connect a switch or LVTTL source to the selected I/O pin. (For our example, we will connect a simple switch to the Sync-Out BNC of the I/O cable.)
3. Make a recording (Arm and Trigger), closing the switch for some portion of the recording.
4. Review the recording in Playback with the Timestamp line turned on. (Select Per Frame Metadata in the View menu of Fas*M*otion.) Scrub the playback bug back and forth along the time line while watching for changes in the "Markers: xxxxxxxx" section of the time line. Refer to "3-2 Advanced Playback Features" on page 54 for details on using markers and viewing I/O data in Review.

You will see the Arm-Out marker go to 0: "Markers: 00111110" for the portion of the clip taken while the switch was closed.

If you save the clip with the XML file to a PC, you will be able to play the file back in FasMotion (any format except DNG) and see the Timestamp line. The XML file will contain the per-frame metadata for the clip, which includes the marker information. For this example, you would see "0x3e" in the marker line for any frame for which the switch was closed.

4-6 IRIG Timestamps and Sync

TSx cameras with the IRIG option installed have a BNC connector located on the top of the housing, between the Power and Network LEDs. (See Figure 4-11.)

This IRIG input BNC is compatible with IRIG-B signals, both modulated and un-modulated.

When connected to an IRIG time code source, the IRIG-enabled TSx is capable of providing accurate per-frame timestamps for all captured imagery. The IRIG signal may also be used as a synchronization source for one or more cameras.

Enabling IRIG

Only TSx cameras with IRIG installed will have the IRIG item in the Control menu. When enabling, you may choose to use the Year in the timestamp or not.

As soon as IRIG is enabled from this menu, the camera will look for a signal the text in the menu will become "Waiting for IRIG lock" and will remain in this state until the signal is locked and decoded.

Upon IRIG lock, this same menu item will display the present IRIG time.

IRIG Timestamps

When IRIG is enabled, Timestamps displayed on the camera GUI in Review mode are the same format as described in "4-5 Timestamps and Markers" on page 75. You will notice in Figure 4-16 that IRIG is set to "1" (locked) and that Time is also set to IRIG.

Figure 4-11: IRIG BNC

Figure 4-12: Enabling IRIG

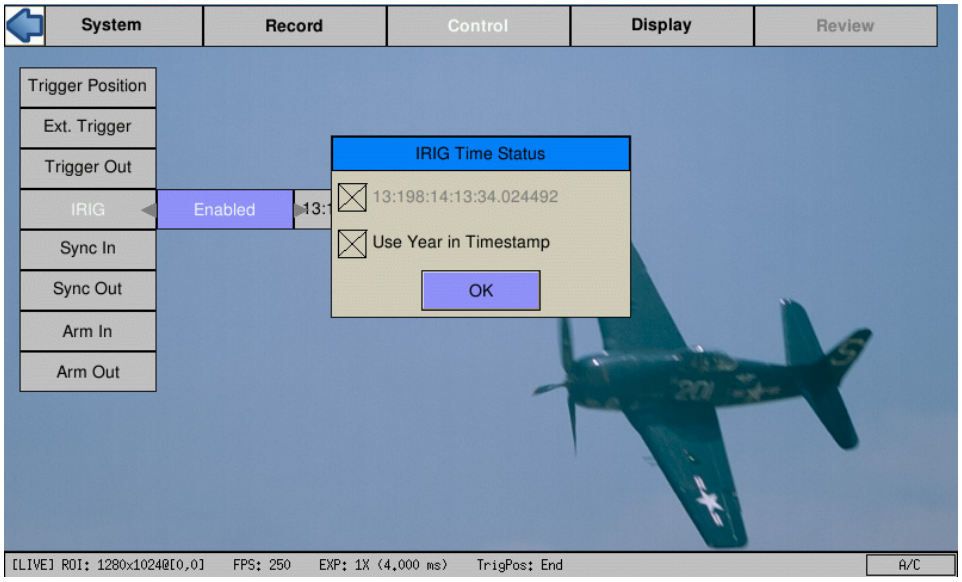


Figure 4-13: IRIG Waiting for Lock

Figure 4-14: IRIG Timestamp in IRIG Menu

IRIG Sync

Cameras may be synchronized using the IRIG 1Hz signal. When IRIG is Enabled, the "Per Second" selection in the Sync-In Dialog is changed to IRIG.

IRIG enabled Cameras may also be synchronized using the same Per Frame modes and Master/Slave configurations as cameras without IRIG. Please refer to the first two sections of this chapter for setup and timing considerations.

Sync LED

The Sync LED is there to let you know at a glance whether or not all necessary signals are present. The basic rule is that if the LED is blinking, one or more signals are missing or not yet locked.

Figure 4-15: Sync-In Dialog with IRIG Enabled

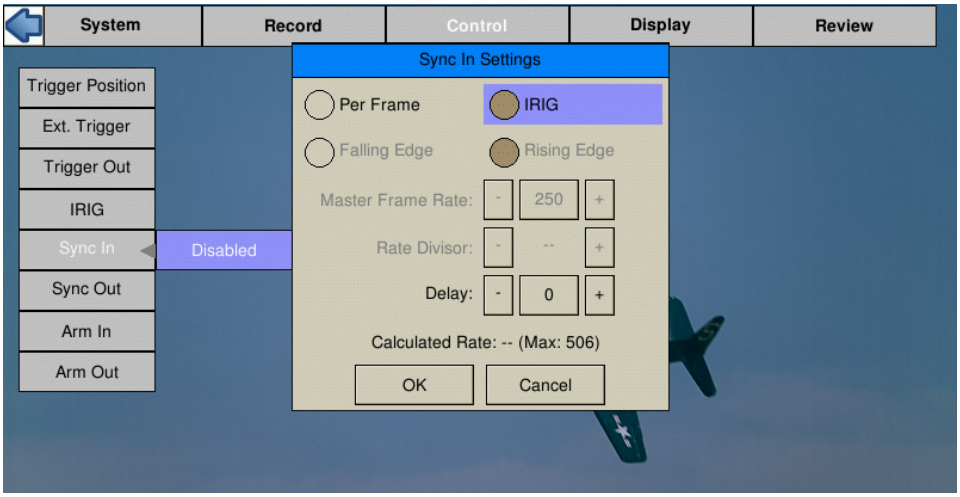


Figure 4-16: IRIG Timestamp in Review

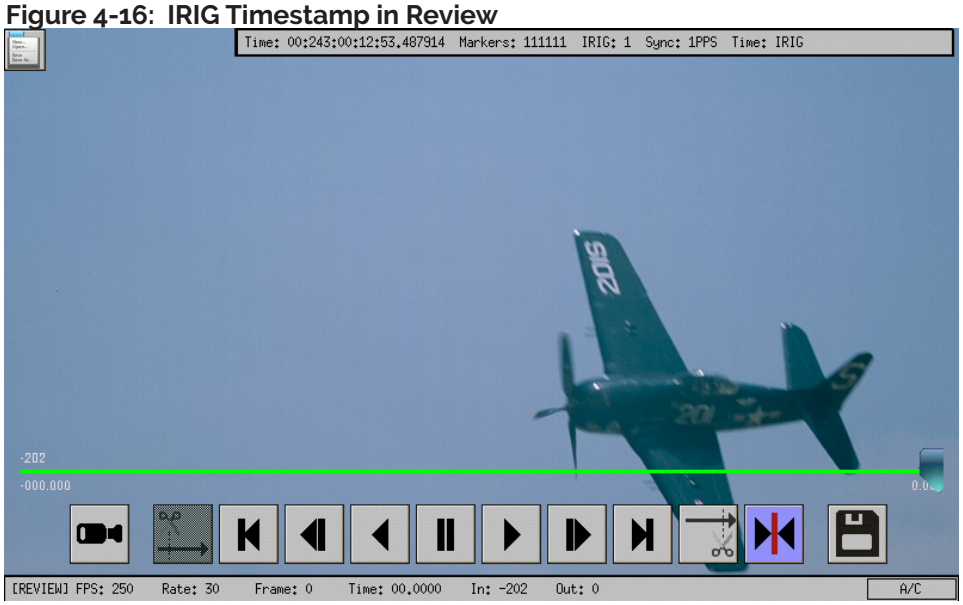


Table 4-2: Sync LED Behavior for TS Cameras

Sync LED Behavior		Sync In	IRIG Enable	IRIG-In
	Solid Black	Disabled	No	X
	Slow Blink Amber	PPF/PPS + No Signal	No	X
	Solid Amber	PPF/PPS + Signal	No	X
	Slow Blink Magenta	Disabled	Yes	No Signal
	Fast Blink Magenta	Disabled	Yes	Locking
	Solid Magenta	Disabled	Yes	Locked
	Slow Blink Red	PPF + No Signal	Yes	No Signal
	Fast Blink Red	PPF + No Signal	Yes	Locking
	Solid Red	PPF + No Signal	Yes	Locked
	Slow Blink Green	PPF + Signal	Yes	No Signal
	Fast Blink Green	PPF + Signal	Yes	Locking
	Solid Green	PPF + Signal	Yes	Locked
	Slow Blink Blue	IRIG	Yes	No Signal
	Fast Blink Blue	IRIG	Yes	Locking
	Solid Blue	IRIG	Yes	Locked

Application Notes

Application Note 1: Histograms

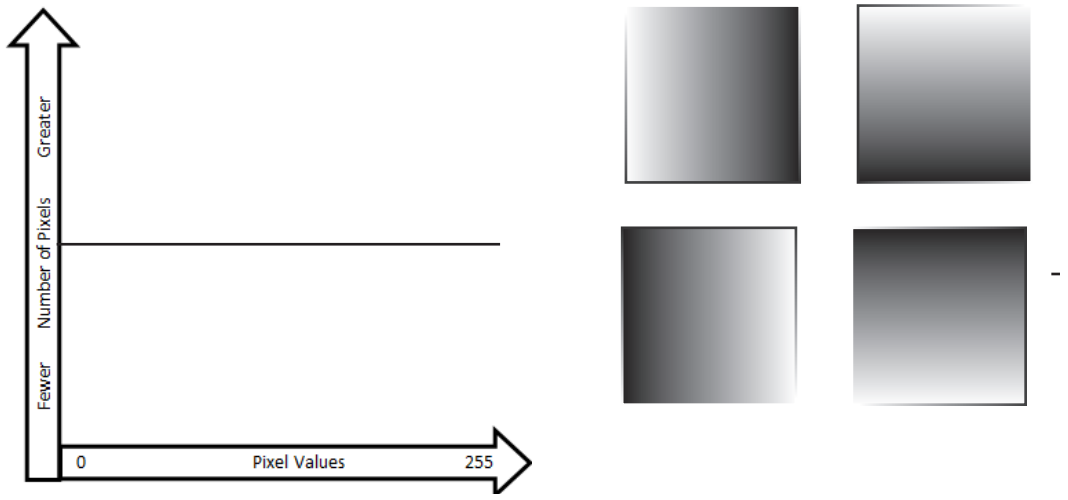
Histograms are available to help the user assess the lighting and color balance of the scene framed by the camera. This App Note is a guide for interpreting histograms of camera images. For more general definition of histograms please view our tutorial video on histograms.

Histograms are available on cameras with Mono and Color sensors. Histograms for Color cameras use Red, Green, and Blue lines to represent the RGB pixel values, while histograms for Mono cameras use a single black line to represent all pixel values.

Note: Histograms on the TSx always shows pixel values 0-255. When the camera is recording in 10-bit mode, the histogram uses high, med, or low 8-bits, depending on the Display setting.

Mono Histograms:

Figure 5-1: Histogram: Linear Gradient



The Mono histogram is a simple single-line graph. The Y-axis (vertical) represents the number of pixels. The X-axis (horizontal) represents pixel values. The first thing to understand is that the histogram offers quantitative information only; it includes no spatial information. Looking at a histogram gives you no idea of the location of bright or dark pixels in the image.

A histogram of a perfect linear gradient, regardless of its orientation would be a straight horizontal line because there would be the same number of pixels of each value.

The histogram of a perfect mono-tonal image is a straight vertical line because all pixels have the same value. In practice, because it is unlikely that we will be able to image a perfectly flat field, the histogram of a mono-tonal image will be a bell curve. The histogram shown to the right in Figure 5-2 is in the format used on the TSx. It shows minimum, maximum, and peak values for the

Figure 5-2: Histogram: Mono-tonal

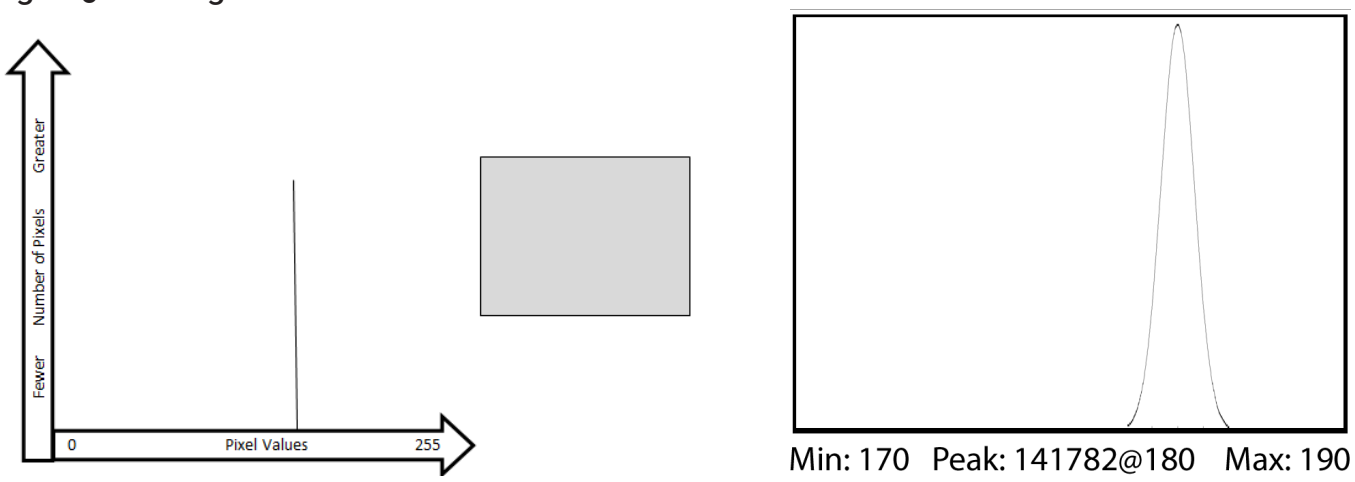
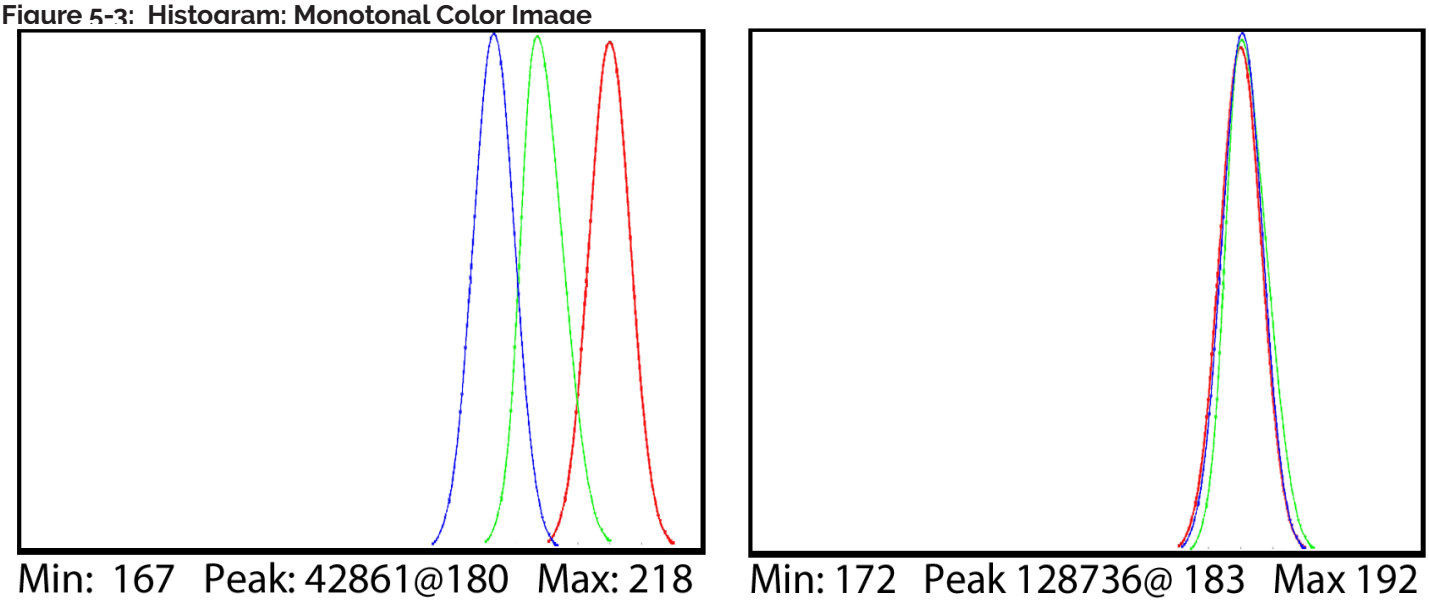


image. The peak value also includes the number of pixels exactly at the peak value: Peak: <# of pixels>@<pixel value>.

Figure 5-3: Histogram: Monotonal Color Image



If we view the same mono-tonal content used in Figure 5-2 on a color camera, we get the more complex histograms seen in Figure 5-3.

Assuming that the mono-tonal image is a neutral gray target, the histogram on the left shows what you would expect if the camera's color balance is shifted a bit toward the red, as it might be under tungsten illumination. In this case the color channels are easily visible as they are separated. The histogram on the right shows what you would expect if the camera's color balance is a good match.

Histograms and Exposure Settings

Professional Digital photographers are very sophisticated in their use of histograms. While the use of histograms as a tool for fine-tuning light and color content for artistic purposes is beyond the scope of this App Note, there are a couple of simple rules to follow that will be helpful.

1. The best images contain a balance of highlights and lowlights. To this end it is good to strive for a distributed grouping of peaks across the histogram.
2. Try to identify the peaks for any objects of interest in the scene. Make sure that those objects are not in danger of exceeding the camera's dynamic range--that they are not close in value to either 0 or 255.
3. Avoid Min: 0. If the minimum pixel level is 0, you know that some pixels are registering no light at all. If there are some very dark areas in the scene, you might expect this and accept it. But if the scene is more uniform and you need to be able to bring out details in the dark areas, avoid Min: 0, as no amount of gamma or brightness adjustment will help. If you are recording in 10-bit mode and viewing the upper 8-bits, you may wish to view mid and low 8-bit settings just to see if you are truly at Min: 0
4. Avoid Max: 255. Once an area reaches saturation (255), it is game-over in terms of image processing. In color images this may even result in some color shifting as one color may easily saturate before the others.

Application Note 2: Understanding Bit Depth

Each pixel in a digital image has a numeric value. Low numbers represent dark pixels; higher numbers represent brighter ones.

Mono images that we see displayed on computer screens use 256 shades of gray. The pixel values range from 0 to 255. Color images use 256 shades each of red, green, and blue. With 256 (red) x 256 (green) x 256 (blue), color images may use more than 16 million colors!

IL/TS3, IL/TS4 and HS7 sensors output 10-bit image data. This represents 1024 shades of gray for mono and 1024 shades each for Red, Green, and Blue for color-- that would be 1024^3... more than a billion colors! IL/TS/HS5 sensors output 12-bit image data, which represents 4096 shades of gray for mono and 4096^3 colors.

Consider 10-bit images:

Decimal numbers 0 to 1023 are expressed 0000000000 to 1111111111 in binary. Each binary digit is a "bit." So a 3 bit number, 000 to 111, is the equivalent to decimal 0 to 7. An 8-bit number, 00000000 to 11111111, is the equivalent to decimal 0 to 255. A 10-bit number is equivalent to decimal 0 to 1023.

Because we will be accessing the imagery on devices such as computers and LCD screens like the one on the TSx, that can only display 256 shades of gray (or 256^3 colors) one valid option is to save only 8 of the 10 bits produced for each pixel of the sensor. If we choose this option, we will need to decide which 8 of the 10 bits to save. There are three choices:

1. **High 8-bit** (dropping the two least significant bits and saving the high-order bits):

11111111~~11~~

In this case we have a mapping that looks like this:

10-bit (1024) values (in decimal): 0 1 2 3 4 5 6 7 8 9 10 11 .....511.....1023

8-bit (256) values (in decimal): 0 0 0 0 1 1 1 1 2 2 2 2 .....127.....255

Note that for the 10-bit image 0 is black 511 is midway to saturation (white) and 1023 is at saturation. For the 8-bit image 0 is black, 127 is midrange and 255 is white--the two images would appear the same to us.

2. **Bit Shifting for Mid 8-bit images** (dropping the least significant bit and the most significant bit):

~~1~~11111111~~1~~

In this case the mapping looks like this:

10-bit (1024) values: 0 1 2 3 4 5 6 7 8 9 10 11.....255.....511.....1023

8-bit (255) values: 0 0 1 1 2 2 3 3 4 4 5 5.....127.....255

Note that while we have the same starting point (black = 0), saturation now comes at the midrange of the original 10-bit data. Compared with the High 8-bit mapping, this image has twice as steep a response slope--it is much brighter. This brightness will come at the cost of seeing more noise, however.

3. **Bit Shifting for Low 8-bit** order bits (dropping the two most significant bits):

~~11~~11111111

10-bit (1024) values: 0 1 2 3 4 5 6 7 8 9 10 11.....255.....512.....1023

8-bit (255) values: 0 1 2 3 4 5 6 7 8 9 10 11..... 255

As with the other mappings, black is black = 0, but with the Low 8-bit mapping, saturation comes twice as fast as with the Mid 8-bit and 4x as fast as with the High 8-bit.

Note: On the IL/TS/HS5, 8-bit images may be bit shifted to any of five positions so instead of having just high-8, mid-8, and low-8, there are two more intermediate choices, each shift changing the slope by a factor of two.

Please see the Fastec Blog Page for more in-depth descriptions and video examples.

Figure 5-4: Results of Bit Shifting in Images

This image represents the high 8-bits of the image. This is the normal setting for high-quality 8-bit images. The dynamic range of this image may be improved by increasing the Gamma.

Note: a better-quality image may be created by setting bit depth to 10 and adjusting the gamma for the display being used.

The second image of the set represents the image with the using the middle 8-bits of a TS3 image (bits 11:4 of the TS5). Here you can see that there is more definition in the darker areas. There is increased noise, but it is not noticeable in this small image.

Using the middle 8-bits is basically equivalent to 2x digital gain.

The third image represents the low 8-bits of TS3 image (bits 10:3 of the TS5). There is increased visibility into the dark shadows at the expense of more noise. This setting might be helpful when image quality is less important than visibility in low-light applications.

Using the low 8-bits is basically equivalent to 4x digital gain.

Application Note 3: Trigger Position and the Circular Buffer

Capturing a high-speed event can be a tricky proposition. Often high-speed events that we are interested in will happen without warning. Other times high speed events are tightly controlled. The TSx is designed to handle myriad scenarios. Here are several examples:

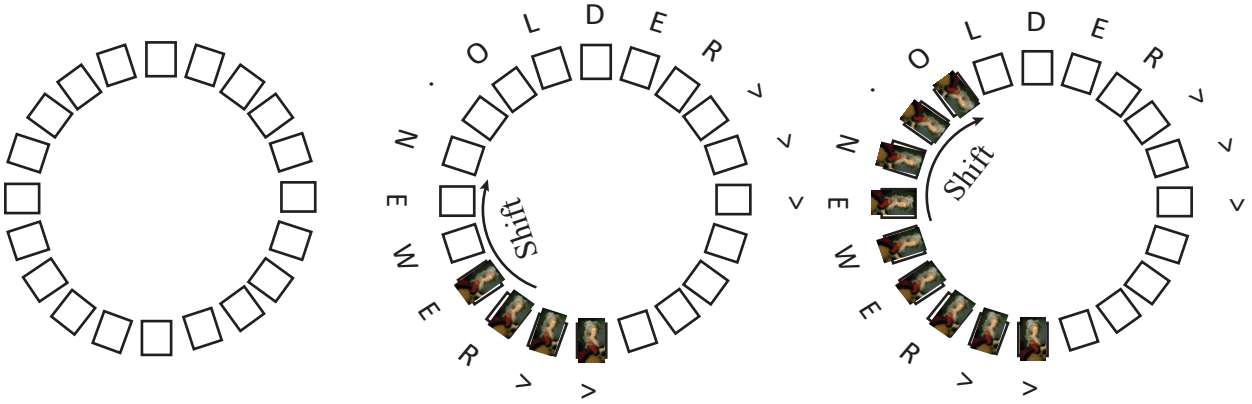
Example 1: Someone is blowing up a balloon until it pops. You want to capture the balloon pop. You have a partition of memory with one second of record time. It is difficult to estimate within a second when that balloon is going to pop!

Example 2: Jams happen once or twice a day on an automated production line. When they occur, they may set off a chain of events that you would like to capture. The jam is detected by sensors on the machinery that is propagated to various parts of the line. You need to image the time just before the jam occurred to help understand the cause. You are equally as interested to capture the time just after the event to understand how the equipment reacted to the jam.

Example 3: You would like to image the launch of a missile. You have ample warning when ignition is to happen. There is a long count down. There may even be a signal available at launch time.

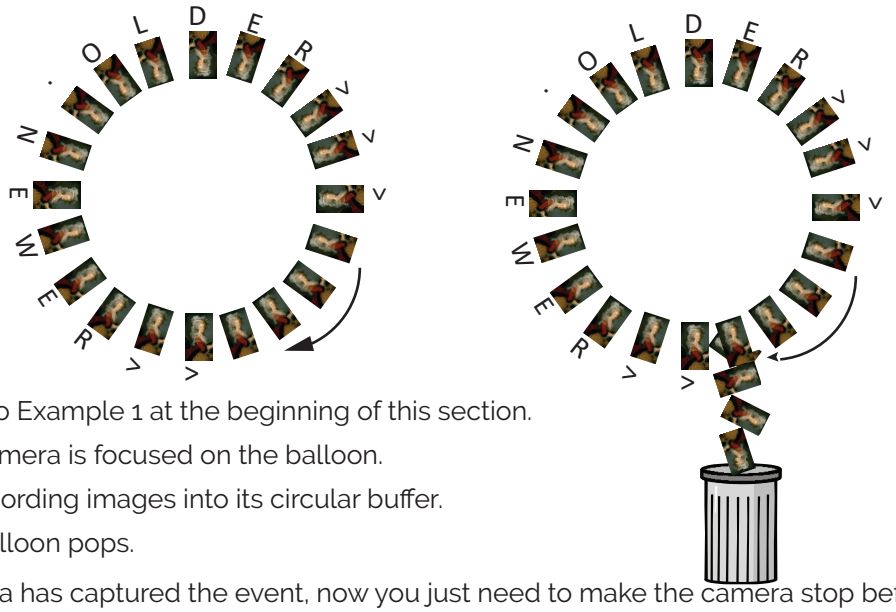
In order to capture events like the ones in the examples above, the TSx uses a circular image buffer that is able to capture high speed imagery indefinitely, though it may only be able to retain a few seconds at a time. The figure below is a representation of a circular buffer. First the empty buffer is seen with 20 empty slots for images. The second graphic shows the first four frames. With each frame added, the older images are shifted up, the newest ones added at the bottom.

Figure 5-5: Circular Buffer Fills and Images Shift Position



Eventually, the circular buffer will fill up and overflow, but when it does, it continues to keep the newest images as it discards the oldest.

Figure 5-6: Circular Buffer Fills and Images Shift Position



Referring to Example 1 at the beginning of this section.

- The camera is focused on the balloon.
- It is recording images into its circular buffer.
- The balloon pops.

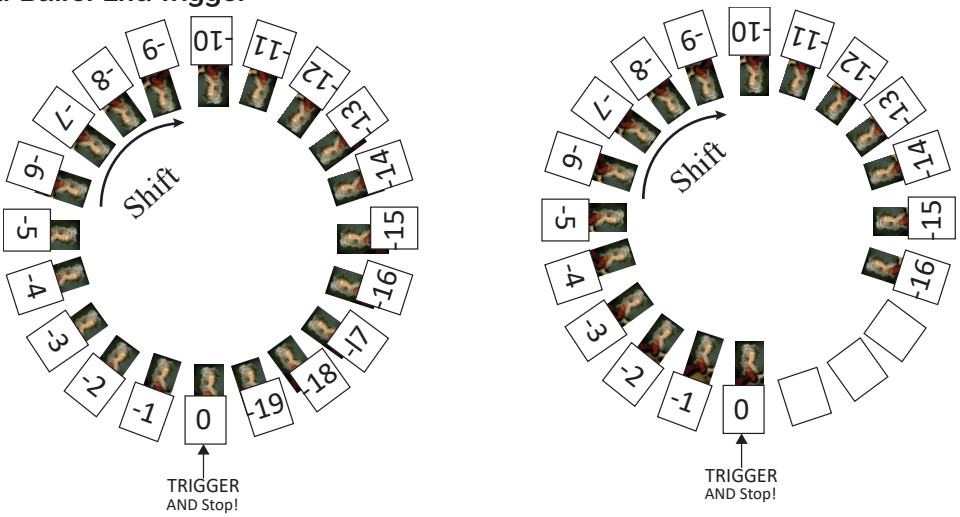
The camera has captured the event, now you just need to make the camera stop before the images are discarded. For this we use an **End Trigger**.

Note: In still photography, cameras are triggered to take one image. In high-speed video capture, we trigger on events, recording many images.

With the camera configured for an End Trigger the camera will fill its 20-frame circular buffer until it gets a Trigger from the Trigger Button on the top of the TSx, from a Trigger signal received on the Sync I/O connector, or from a software application and Stop recording. The last frame recorded will be given the number "0." All previous Frames will be given sequential negative numbers.

Played back, the resulting video begins on frame -19, progresses to frame 0, then stops. If the camera did not run long enough to fill its buffer, it would still stop when it received the trigger and the resulting video would be shorter, starting with a less negative number (#-16 in the graphic below).

Figure 5-7: Circular Buffer End Trigger



Referring to Example 2 in the beginning of this section:

- The TSx is Recording the machinery running normally. It may be running for hours before anything interesting happens.
- The machinery has a problem.
- A signal is sent in reaction to the problem.

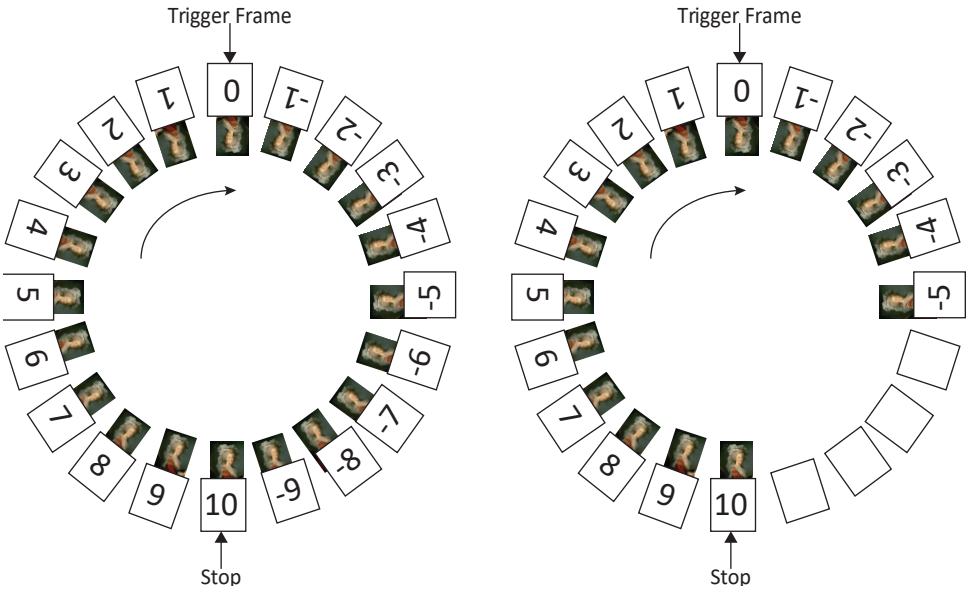
In this case, the camera needs to record the seconds before and after the problem is detected. The TSx has the perfect trigger setting for this. The 50% Trigger divides the image capture into two halves, the images just before the trigger is received (**pre-trigger frames**), and the images immediately after the trigger is received (**post-trigger frames**).

Using the **50% Trigger** the TSx fills the circular buffer until it gets the trigger. For the example here, there is a good chance it will be getting the trigger signal directly from the machinery to its Sync I/O connector, but it would work as well, triggered manually by a patient human.

When the TSx is triggered, it keeps recording until it has captured the 1/2 the buffer's worth of post-trigger frames. The buffer now contains pre-trigger frames with negative frame numbers, frame "0" and post-trigger frames with positive numbers. When played, the video on the below left begins with frame #-9 and ends with frame #10.

If the camera is triggered before it has captured its full allotment of pre-trigger frames, it will still record 1/2 the buffer in post-trigger frames and stop. The video on the right begins with frame #-5 and ends with frame #10.

Figure 5-8: Circular Buffer 50% Trigger



Referring back to the 3rd example at the beginning of the section:

- The TSx is framed and focused on a missile about to launch.
- It begins recording well before launch time. But it is only required to capture the launch.
- There is a countdown. The TSx receives its trigger electronically from launch control or manually.

In this case no video is required before time 0 of the launch. The Trigger acts like a "start button" for the camera to begin saving captured video.

For this type of recording, the TSx has a **Start Trigger**. Using the Start Trigger, when the TSx gets a trigger, it will record Frame 0, and then fill the buffer with post-trigger frames. The video played back will begin with Frame 0, then proceed with all positive frame numbers.

Selecting Other Trigger Values

More likely than using the Start Trigger for example 3, however, is to use a 5% or 10% Trigger. This affords you a cushion of safety in case there is a problem with the launch signal--giving you time to trigger manually. Also, in the case that there is a problem in the launch sequence just before ignition, that would be captured as well.

The 10% trigger works just like the 50% trigger explained above, except that only 10% of the imagery is captured pre-trigger, and 90% is captured post-trigger.

Using Fas*M*otion or the Web-App, the trigger position can be placed anywhere by percentage or frame number. The TSx on-display interface has Start, 10%, 50%, 90% and End options.

Application Note 4: Frame Rate, Resolution, and Exposure

Scale and Resolution/Frame Rate

Selecting the proper resolution and frame rate for a given high-speed event is important. It is based on the Field of View (FOV) required to get a good image of your object of interest and the speed at which the object will move through that FOV.

For example, if you wish to image an automobile traveling at 50 mph across an intersection, full resolution and a relatively slow frame rate will work because your field of view (FOV) will be large and the car will not be moving through it very quickly.

Imaging a bird traveling at the same speed will require a much smaller FOV as the bird is 1/20th the size of the car. If you wish to use the same scale (object size/FOV), the FOV becomes 1/20th the size, and the bird moves through it 20 times as fast.

If you got acceptable imaging of an auto at 60FPS, it may take 1250FPS to get similarly acceptable imaging of a bird at moving the same speed.

Aliasing and Frame Rate

If you are imaging a motion that is cyclical in nature like a wheel spinning or a lever moving up and down, it is important to use a high enough frame rate to avoid motion aliasing. If you know the speed of the object, use a frame rate at least a few times as fast as the repetition rate to get a valid characterization of the motion. If you do not know the speed, use as high a frame rate as possible to start with and adjust from there. (Be sure to analyze the movement one frame at a time as the playback speed may cause aliasing as well.)

Generally, you will choose to use the largest resolution possible for the frame rate required. This will give you the best definition of your object of interest. Smaller resolutions may be desired to increase the record time. Choosing the right shutter speed is dependent not only on the speed at which an object is traveling through the FOV, it is also dependent on how the imagery is going to be used.

For motion analysis it is best to get as short an exposure as possible to limit motion blur. (Motion blur can be defined as the number of pixels traversed by an edge of an object during an exposure.)

For smooth video, on the other hand, long exposures are best. These make for more attractive movies, but blurry stills.

Application Note 5: Optimizing IL/TS for Image Transfers

Transferring large volumes of image data from the camera to a computer over the Gigabit Ethernet connection can be very fast on an optimized system. For example, a full 8GB camera buffer will produce about 25GB of color TIFF files. An optimized high-performance system may transfer 25GB of full-resolution images from camera in less than five minutes, while on a non-optimized system, the transfer could easily take more than an hour.

Several parameters contribute to file transfer performance:

- Network and PC hardware
- Computer activity
- Fas*M*otion setup
- Image file format and resolution

Network and PC Hardware

- Processor/Chipset type and speed: use fast multi-core processors, 64-bit system.
- Memory capacity and speed: 4GB minimum. 8GB recommended.
- Graphics card type speed and on-board memory: Graphics performance can throttle live and playback views, graphics cards without on-board memory will take system memory and may slow things down.
- NIC type and speed: NIC performance varies widely. Pick a Gigabit NIC that supports Jumbo Frames. We have found that some systems only perform well with Jumbo frames set to 9K, while others work well at 1500. This is a parameter that you may need to experiment with to get optimum results.
- Multiple Network interfaces may be available. For optimum transfers, disable or disconnect all interfaces other than the one to be used with the camera during transfers. Two or more interfaces are on the same subnet should never be allowed. (Having both wired and wireless interfaces active is a common problem.)
- Hard Disk type: sustained transfer speed is most important drive attribute. Having a second drive on the system for image transfers is helpful--avoid using the drive that the OS and any program files are on. SATA II or III SSD or high-speed spinning media drives may be added internally or externally to your PC. If the PC has an eSATA port, consider connecting an SSD to it for image transfers.
- Disk state: fragmented disks and disks that are running out of space will slow transfers.

PC OS/Software

- Close all other applications, services, updaters, etc., including performance monitors such as Task Manager, Wireshark, HD Tune Pro, etc. while running Fas*M*otion.
- File System format: On a Windows PC, use NTFS for the data drive, for Mac us HFS+
- Do not index the target drive.
- Set UDP receive buffers to 3MB on Mac computers: edit or create /etc/sysctl.conf to contain the line: net.inet.udp.recvspace=3145728

Note: this requires some low-level changes to your Mac that you may not be accustomed to making. There is a lot of online help available, but if you need assistance, please contact Fastec.

- PC Power Management: disable all, including sleep modes.
- Disable all Firewalls and Anti-virus software! (You will not want the PC attached to the any outside network including the Internet while connected to the camera.)
- 3rd party filter drivers: (disable using NIC's properties page)

NIC Parameters

- Set Transmit/Receive buffers to maximum (these may also be referred to as descriptors)
- Jumbo Frames/Packets set to maximum size (usually 9K). Experiment with these settings as results to vary from system to system. On a Mac, the setting is MTU 9000.
- Enable full-duplex mode
- Set speed to 1000baseT (Gigabit)
- Enable interrupt moderation / throttling (set to adaptive if available)
- Enable Checksum offloads

Camera Connection

- Point to point connection without any routers or switches between the camera and the computer is best. If you do need to use a Router or Switch, confirm that it supports and is configured for Gigabit Ethernet, UDP, and Jumbo Packets. Many Switches Some Routers have built-in firewalls-these will need to be disabled.
- Use Cat 5e or Cat 6 cables only. (Cat 5 cables do not support Gigabit Ethernet and may cause the system to run at 100Mb.)

Fas*M*otion Parameters

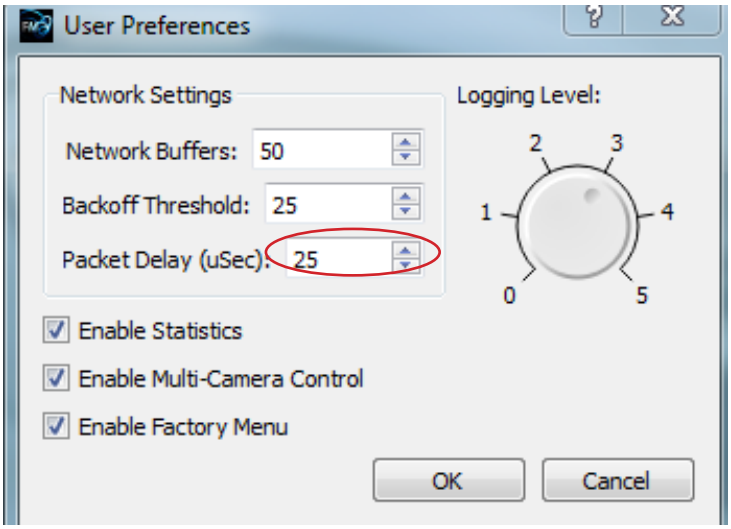
There are several parameters to be set to optimize performance. Fas*M*otion Default Parameters are set conservatively so the application will run on an average non-optimized system. If your system is excessively slow or busy, you may need to change to more conservative settings. If you have optimized your system for image transfer performance, you will wish to change to more aggressive settings in order to get faster transfers.

UDP Transfers

The camera system, while controlled by Fas*M*otion, uses UDP protocol for all video streaming (Live and Playback) and for all file transfers.

If the camera is allowed to send image data and metadata as fast as it is able, it will easily swamp most systems and will cause the UDP connection to fail. The system introduces an inter-packet delay to slow the camera down to a level where the PC can keep up.

Figure 5-9: Fas*M*otion User Preferences: Packet Delay



Setting Packet Delay

The camera is The Packet Delay setting is found in the FasMotion User Preferences dialog. This is an edit box/spinner that sets the inter-packet delay in µsec.

The default setting is 200. Very fast systems with direct connections will be able to keep up with a delay of 10 to 20, while slow systems or systems on shared networks may need a setting of 200 or higher. For transfers of very large numbers of very small frames (tens of thousands of JPGs, for example, or possibly large numbers of low-resolution stacks of uncompressed images) the delay will also need to be increased in order to accommodate file-system overheads.

Transfer performance can be monitored by simply watching the progress bar during a Save or Copy. If you notice the progress stopping often or if the system needs to retrieve missing frames at the end of a transfer, that is a good indication that the PC is not keeping up and that the Packet delay needs to be increased.

A better way to assess transfer performance is by enabling and reviewing the stats.csv file after a transfer (see the next section).

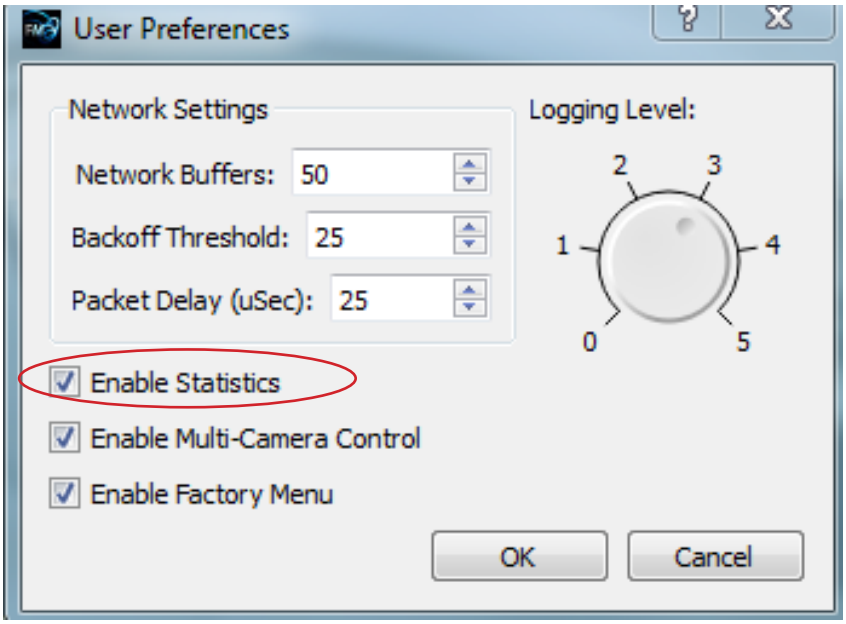
Enabling Statistics in Fas*M*otion

One important consideration in optimizing your system is how to compile results.

For information on all Save operations from camera to PC, enable Statistics. This creates a line of comma delimited text for every Save or transfer done to PC media (such as Save or Copy to Path) by Fas*M*otion.

This information is collected each time a Save operation is performed and is appended to the file "Stats.csv" found in the Documents folder.

Figure 5-10: Fas*M*otion User Preferences: Enable Statistics



Tab headers for this text file include:

- **Duration -**total time of the transfer (hh:mm:ss:decimal)
- **Bytes -** the number bytes transferred
- **Speed** - transfer speed in MB/s
- **Missed Frames** - frames missed in the first pass (these are retrieved at the end of the transfer)
- **Good Frames** - total number of frames transferred--this should match the number of frames in the clip
- **PktSize** -Packet Size (default is usually 1500, Jumbo frames may be up to 9000)
- **PktDlyBegin/End**--Packet Delay (the delay time in µsec set in the Camera Find window)
- **Buffer** - number of buffers reserved in PC memory.
- **Backoff** - Fas*M*otion keeps track of how much memory it is using for buffering images. If it uses more than the specified "Backoff," it will tell the camera to stop sending image data until it catches up.
- **Min-**--Minimum Buffers (the minimum number of buffers Fas*M*otion had in reserve during the transfer. If this number gets down to 0, you will see a number in the "Missed Frames" column and you will notice in the Save dialog that the system had to go back and retrieve missed frames after the first pass.)
- **Drv** -Drive (the target drive letter such as E: or C:)
- **Ext** -Extension (the file type saved)

Table 5-1 on page 91 is from an actual benchmark test of an optimized system. The performance, which included saves of full (8GB) camera buffers of all file types in 1280 x 1024, 1280 x 720, and 512 x 512 resolutions, is representative of a very fast purpose-built system. A raid array used for storage is capable of unusually high sustained transfer rates. Table 5-2 on page 91 is from a benchmark test of a moderate-performance system.

Table 5-1: Image Transfer Performance

Duration: h:m:s:dec	Bytes	Speed MB/s	Miss-Frames	ROI	Good-Frames	Pkt-Size	MissPkts	PktDly	Buffer	Backoff	Min	Drv	Ext
0:1:52:856	913889066	7.78172	0	1280x1024	6517	9000	0	20	250	125	244	E:	avi
0:2:24:731	8545872440	56.5971	0	1280x1024	6517	9000	0	20	250	125	227	E:	dng
0:4:44:3	25626251672	86.0532	0	1280x1024	6517	9000	0	20	250	125	124	E:	bmp
0:1:52:838	913889066	7.78172	0	1280x1024	6517	9000	0	20	250	125	245	E:	jpg
0:4:45:15	25627789684	85.7564	0	1280x1024	6517	9000	0	20	250	125	122	E:	tif
0:2:24:712	8543813068	56.5834	0	1280x1024	6517	9000	0	20	250	125	229	E:	tif
0:1:53:653	996320922	8.40855	0	1280x720	9269	9000	0	10	250	125	213	E:	avi
0:2:21:445	8547871800	57.8148	0	1280x720	9269	9000	0	10	250	125	226	E:	dng
0:5:6:405	25627450264	79.8701	0	1280x720	9269	9000	0	10	250	125	88	E:	bmp
0:1:53:630	996320922	8.40855	0	1280x720	9269	9000	0	10	250	125	231	E:	jpg
0:5:7:622	25629637748	79.6167	0	1280x720	9269	9000	0	10	250	125	89	E:	tif
0:2:21:446	8544942796	57.795	0	1280x720	9269	9000	0	10	250	125	221	E:	tif
0:5:8:805	25627450264	79.3514	0	1280x720	9269	9000	0	20	250	125	93	E:	bmp
0:1:55:323	1078091543	8.94042	0	512x512	32584	9000	0	20	250	125	196	E:	avi
0:2:27:543	8561250496	55.5418	0	512x512	32584	9000	0	20	250	125	72	E:	dng
0:7:13:126	25626924992	56.4428	0	512x512	32584	9000	0	20	250	125	84	E:	bmp
0:1:55:896	1078091543	8.94042	0	512x512	32584	9000	0	20	250	125	18	E:	jpg
0:7:13:978	25634614816	56.4598	0	512x512	32584	9000	0	20	250	125	63	E:	tif
0:2:26:260	8550953952	55.855	0	512x512	32584	9000	0	20	250	125	156	E:	tif

System: Intel i7-3770 CPU @ 3.40GHz
8.00GB RAM
ARECA (X86-64-STORPORT) SAS RAID (RAID6-ENGINE) (4 SSD drives)

- In the chart above, there are 3 sets of saves. Each line represents one save.
- The largest, uncompressed file types had the fastest transfer rates, but the longest transfer times
- Note that the Min (minimum buffers) get progressively smaller as the frame sizes got smaller and the number of frames increased. For 512 x 512 jpeg, the min value went down to 18. If the min value had gone to 0, the system would have begun missing frames and doing retries, greatly slowing things down. (For smaller resolutions a higher packet delay may be recommended)

Table 5-2: Table Stats.txt Moderate Performance System

Duration h:m:s:dec	Bytes	Speed MB/s	Miss-Frames	ROI	Good-Frames	Pkt-Size	MissPkts	PktDly	Buffer	Backoff	Min	Drv	Ext
0:1:51:796	251596130	2.16163	0	1280x1024	6517	9000	0	110	300	150	295	C:	avi
0:3:52:273	8545872440	35.1292	0	1280x1024	6517	9000	0	110	300	150	237	C:	dng
0:8:38:916	25626251672	47.1797	0	1280x1024	6517	9000	0	110	300	150	146	C:	bmp
0:1:51:717	251596130	2.16163	0	1280x1024	6517	9000	0	110	300	150	289	C:	jpg
0:8:38:554	25627789684	47.1826	0	1280x1024	6517	9000	0	110	300	150	51	C:	tif
0:3:52:391	8543813068	35.1208	0	1280x1024	6517	9000	0	110	300	150	212	C:	tif

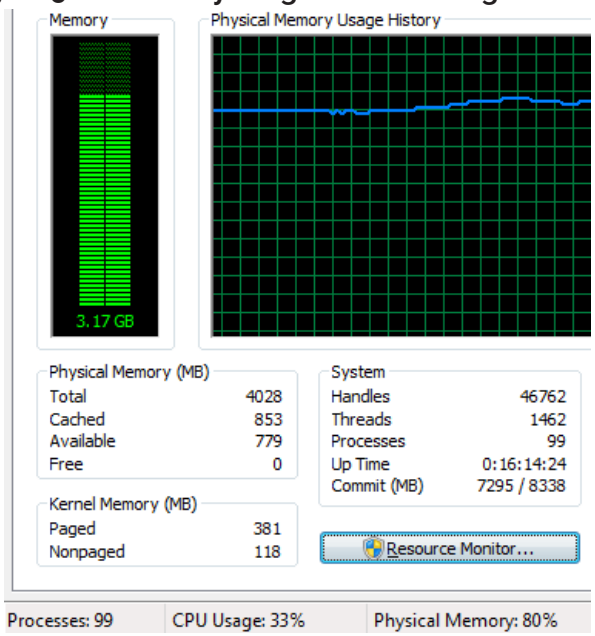
System: Intel i5-2400S CPU @ 2.50GHz
6.00GB RAM
ST31000524AS Drive: 7200 RPM spinning media SATA/SAS

Note: Installation of an additional drive, capable of high sustained transfer speeds can boost performance substantially. This same system was used for the downloads in "Table 5-5: Finding the Correct Packet Delay Value" on page 93, but those used an external target drive.

When the PC is Too Busy:

Referring to Table 5-3, you will notice that for several of the transfers there are missing frames and packets. These were downloads of only 188 frames, which should be very easy considering that Fas*M*otion reserved 250 buffers--more than enough to buffer the entire transfer. The Min (minimum buffers) never got close to the Backoff number, so the Fas*M*otion never got a chance to slow the camera down before it started missing frames.

Figure 5-11: Memory Usage in Task Manager



To understand what happened here, it is helpful to look at the performance tab in Task Manager. Notice in Figure 5-11 that the "Free" memory has gone to 0. This means that, having no more physical memory, the system is going to slow down. It will not be able to service the application properly.

What is happening here is that the system is very busy. To create this example, the computer used had about a dozen applications opened.

It is common to have a lot of applications and services running "in the background" on a computer. In order to get consistent high-speed file transfers from Fas*M*otion it is very important to have as little else running on the PC as possible.

Note: In each instance on the table, all of the frames were successfully saved as the system automatically retrieves any "missed frames" at the end of the download.

Use Jumbo Packets!:

Table 5-3: Missing Frames on a Busy System

Duration h:m:s:dec	Bytes	Speed MB/s	Miss-Frames	ROI	Good-Frames	Pkt-Size	MissPkts	PktDly	Buffer	Backoff	Min	Drv	Ext
0:0:6:650	26573616	4.22376	0	1280x1024	188	1500	0	180	250	125	236	C:	AVI
0:0:33:468	246528160	7.12447	0	1280x1024	188	1500	0	180	250	125	247	C:	DNG
0:1:40:407	739256608	7.0501	5	1280x1024	188	1500	9708	180	250	125	248	C:	BMP
0:0:7:611	26563368	3.61897	3	1280x1024	188	1500	280	180	250	125	216	C:	JPG
0:1:41:698	739300976	6.98072	5	1280x1024	188	1500	5354	180	250	125	247	C:	TIF
0:0:33:951	246468752	7.12276	1	1280x1024	188	1500	578	180	250	125	247	C:	TIF

Referring to Table 5-4, using Jumbo Packets (sometimes called Jumbo Frames) can make a big difference. You may find that a larger packet delay is required with Jumbo Frames, but because the packets are bigger, there are fewer of them, and fewer delays as well.

In this example there was about a 3x improvement in transfer rate simply by using Jumbo Packets.

Table 5-4: Benefit from Jumbo Packets

Duration h:m:s:dec	Bytes	Speed MB/s	Miss-Frames	ROI	Good-Frames	Pkt-Size	MissPkts	PktDly	Buffer	Backoff	Min	Drv	Ext
0:0:28:484	484259096	16.4938	0	1280x960	394	1500	0	40	200	100	196	F:	tif
0:0:28:156	484259096	16.4938	0	1280x960	394	1500	0	40	200	100	195	F:	tif
0:0:9:438	484259096	51.3139	0	1280x960	394	9000	0	40	200	100	182	F:	tif
0:0:26:734	1317578048	48.3285	0	1280x960	1072	9000	0	40	200	100	105	F:	tif
0:0:47:203	2443418992	49.5793	0	1280x960	1988	9000	0	40	200	100	190	F:	tif

Finding the Correct Packet Delay Value:

The correct packet delay value is one where the PC can keep up with the flow of incoming packets. The use of the buffer will sometimes mask the fact that the drive is not quite keeping up.

Referring to Table 5-5, compare the Min column (that is the minimum number of buffers available during the save) with the "Good Frames" column (the number of frames saved). You can see that as the number of frames increases, the Min number decreases, which means that the hard drive is not quite keeping up with the flow.

Note: In each instance on the table, all of the frames were successfully saved as the system automatically retrieves any "missed frames" at the end of the download.

Table 5-5: Finding the Correct Packet Delay Value

Duration h:m:s:dec	Bytes	Speed MB/s	Miss-Frames	ROI	Good-Frames	Pkt-Size	MissPkts	PktDly	Buffer	Backoff	Min	Drv	Ext
0:0:14:663	1179664800	80.3583	0	1280x1024	300	9000	0	40	200	100	178	K:	bmp
0:0:19:266	1572886400	78.9485	0	1280x1024	400	9000	0	40	200	100	174	K:	bmp
0:0:23:562	1966108000	81.5229	0	1280x1024	500	9000	0	40	200	100	168	K:	bmp
0:0:28:242	2359329600	80.3583	0	1280x1024	600	9000	0	40	200	100	161	K:	bmp
0:0:41:923	3538994400	82.3182	0	1280x1024	900	9000	0	40	200	100	152	K:	bmp
0:0:56:45	4718659200	80.3583	0	1280x1024	1200	9000	0	40	200	100	130	K:	bmp
0:1:10:535	5898324000	80.3583	0	1280x1024	1500	9000	0	40	200	100	105	K:	bmp
0:1:33:768	7864432000	80.6463	0	1280x1024	2000	9000	0	40	200	100	99	K:	bmp
0:2:19:27	11796648000	80.9364	0	1280x1024	3000	9000	0	40	200	100	99	K:	bmp
0:5:13:731	25626251672	78.0802	1	1280x1024	6517	9000	40	40	200	100	99	K:	bmp
0:5:15:858	25626251672	77.5844	0	1280x1024	6517	9000	0	**50**	200	100	**188**	K:	bmp
0:5:16:5	25626251672	77.3389	0	1280x1024	6517	9000	0	35	200	100	99	K:	bmp
0:5:16:338	25626251672	77.3389	0	1280x1024	6517	9000	0	25	200	100	96	K:	bmp

The last three downloads shown on the table demonstrate that a higher Packet Delay is a little better for this system. In these last three saves, delays of 50, 35, and 25 were used. You can see that the speed of the transfer was not really affected by the increased delay times, but that the Min buffer value was very high. For this system a Packet Delay of 40 will probably be OK, but 50 is a better number because the system can maintain the same transfer rate without exhausting its buffers.

Table 5-6: Sample Mac Stat.csv Entries

Duration	Bytes	Speed (MB/sec)	Miss-Frames	Good-Frames	PktSize	MissPkts	PktDly-Begin	PktDly-End	Buffer	Back-off	Min	Drv	Ext
0:1:53:53	855392409	7.21917	0	9269	9000	0	20	20	200	100	174	/U	avi
0:1:52:853	855392409	7.28362	0	9269	9000	0	20	20	200	100	194	/U	jpg
0:2:24:884	8552320920	56.6398	0	9269	9000	0	20	20	200	100	197	/U	bmp
0:4:34:914	25626251672	89.1938	0	6517	9000	0	15	15	200	100	198	/U	bmp
0:4:36:409	25626251672	88.5475	0	6517	4500	0	10	10	200	100	198	/U	bmp
0:2:34:456	12804839864	79.2964	0	6946	9000	0	20	20	200	100	196	/U	tif
0:2:34:982	12804839864	79.2964	0	6946	4500	0	10	10	200	100	196	/U	tif
0:3:12:49	12804839864	63.6023	0	6946	1500	0	10	10	200	100	195	/U	tif
0:1:24:165	600384525	6.81632	0	6946	9000	0	20	20	200	100	176	/U	avi
0:1:27:766	600384525	6.58128	0	6946	4500	0	20	20	200	100	176	/U	avi

The examples on this table were test results using a MacBook Pro with a built-in SSD. The first three entries were from a mono camera, the rest are color. The TIFF files were 10-bit raw TIFFs. Note that the fastest speeds were from the largest files (color BMP). The MacBook Pro in this configuration is the fastest computer we have tested.

Application Note 6: Choosing an Image File Format

Fastec cameras are capable of outputting images in 8 different file formats that use various levels of processing. These formats serve different purposes depending on imaging, storage, and work flow requirements.

Image Processing

FPN correction (black frame calibration) may be applied to any format and is controlled by software **before** image acquisition. See "2-9 Black Level Calibration and Analog Gain" on page 45.

Display Settings (see "Figure 1-30: Gamma Comparison" on page 22) are primarily used to adjust the image brightness, contrast, gamma, etc. for viewing live images, but the parameters are also applied in many of the saved formats as well.

Color Interpolation (for color cameras only) is processed before images are saved in some formats, and may be a post-process for other formats.

Intra-frame compression, applied to JPEG images is a compression of the image data for each frame individually. The quality is selectable by the user

Inter-frame compression, applied to MP4 images is a video compression whereby image data is compressed frame-to-frame.

Table 5-7: File Format Features

Format	Description	Processing	Pro	Con
JPG Stack		Intra-frame compression. Level of compression is selectable and is dependent on complexity	• Small • Popular still format • Easy analysis	
AVI		JPEG Compression Color Interpolation Brightness, Contrast, Gamma, Gain, FPN*	• Small • Popular video format • Nice 1-file archive format	• Degrades with re-processing
DNG		FPN*, ("As-shot" parameters** saved-not processed)	• Maintains highest image fidelity • All bits saved in 10-bit mode • Compatible with high-quality image and video production tools • Compact vs BMP/TIF	• Huge folders full of files
BMP		Color Interpolation Brightness, Contrast, Gamma, Gains, FPN*	• Good image fidelity • Compatible with popular imaging tools	• Huge folders full of files
TIF		Color Interpolation Brightness, Contrast, Gamma, Gains, FPN*	• Good image fidelity • Compatible with popular imaging tools	• Huge folders full of files
TIF(r)		FPN* only	• Maintains highest image fidelity • All bits saved in 10-bit mode • Compact vs BMP/TIF	• Huge folders full of files
CAP		None (black frame and "As-shot" parameters** saved)	• Maintains highest image fidelity • Only format that can be played back by the camera • 1-file format • Fastest Saves to SSD • Convert to any other format via the camera	• Proprietary format

*FPN: FPN correction is user selectable. If FPN is set to Column, the correction is at the sensor-level and is asserted for all file types. If it is set to Off/Disabled, there will be no correction in any format. If it is set to Pixel, the black frame will be subtracted in all formats except for CAP. For CAP files, the black frame is copied into the CAP file and the correction is asserted when creating image data display and conversion.

** "As-shot" parameters: all image processing parameters, including color corrections, gains, brightness, contrast, and gamma are saved, but not asserted (pixel values are not manipulated). This allows for post-processing of the original pixel data.

Table 5-8: Save to SSD Benchmarks

	1280x1024 10-bit		1280 x 1024 8-bit		1280x720 10-bit		1280x720 8-bit		512x512		256x256	
Save to SSD	Rate MB/s	Images /s	Rate MB/s	Images /s	Rate MB/s	Images /s	Rate MB/s	Images /s	Rate MB/s	Images /s	Rate MB/s	Images /s
CAP	104.46	84.64	104.37	62.56	125.34	142.58	118.01	100.60	115.65	458.86	103.35	1652.59
DNG	52.47	41.96	100.14	40.05	44.22	50.28	83.53	47.50	15.16	60.05	3.21	50.92
BMP	127.32	33.95	127.57	34.02	109.17	41.40	109.35	41.47	45.80	60.58	9.77	52.09
JPG	4.34	27.64	2.40	27.25	1.65	27.90	1.06	28.05	1.42	37.96	0.45	35.58
TIFF	127.25	33.93	126.91	33.84	109.22	41.42	108.48	41.14	45.27	59.87	9.77	52.01
TiFF(r)	52.37	41.89	100.43	40.17	43.90	49.93	83.29	47.37	15.13	59.97	3.24	51.63

See "Appendix F: Device Benchmarks" on page 107

Application Note 7: Advanced Calibration IL/TS/3-4

Calibration accomplishes two functions:

1. Sets the black level of the camera.
2. Saves a dark frame used to correct FPN. (If Pixel FPN is selected.)

See "2-9 Black Level Calibration and Analog Gain" on page 45 for more details.

Advanced Calibration allows you to set analog gain for all cameras and also allows you to manually set the black level for TS3 and TS4 cameras.

Figure 5-12: Black Level Calibration Dialog

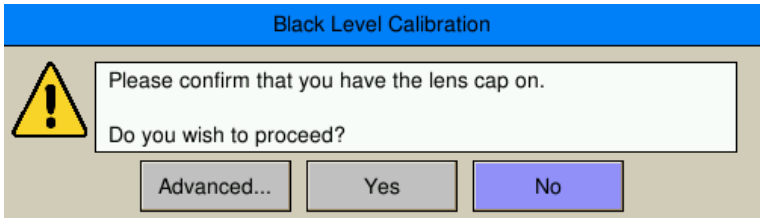
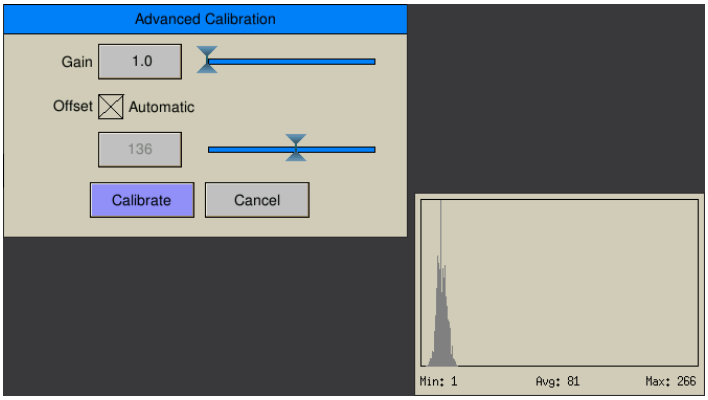


Figure 5-13: TS3 / TS4 Advanced Calibration Dialog



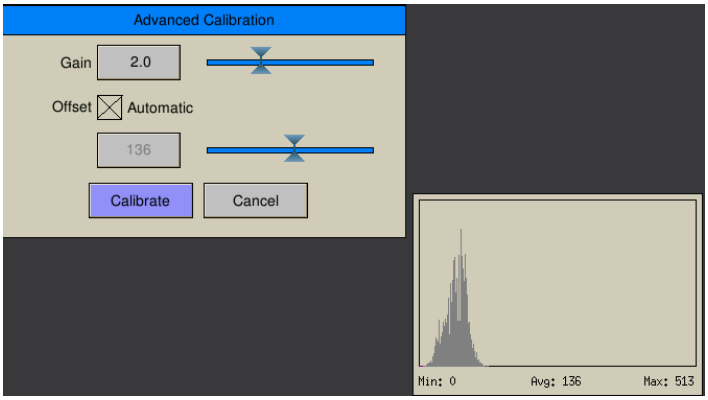
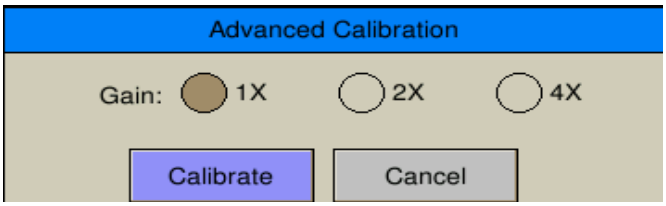


Figure 5-14: TS5 Advanced Calibration Dialog



Advanced Calibration:

1. Cover the lens.
2. On the camera display, select Black Level from the Record Menu, then click on "Calibrate." From Fas*M*otion, select "Black Level Calibration" from the Camera Menu.
3. Click on "Advanced" to open the Advanced Calibration dialog.
4. Set the Gain and Offset (Black level) values you wish to use and click on "Calibrate."

Note: the raw histogram for TS3 /TS4 shows raw 10-bit values (not RGB). The scale goes from 0 to 1023.

Applying Gain:

Gain values from 1 to 4 may be applied.

Doubling the gain (from 1 to 2, or from 2 to 4) will double the responsivity. This is equivalent to doubling the exposure or opening the lens 1 f-stop.

Doubling the gain will also double the amount of noise in the image, including the FPN. This is easily seen from Figure 5-13. The signals shown in the histograms are what the sensor "sees" with the lens cap on (in the absence of light). This is the noise signal that is subtracted from the image with Pixel FPN on. (If Column FPN is used, this same noise signal will be suppressed on a per-column basis within the sensor.)

Figure 5-15: Example of Analog Gain

The image quality is best at a gain of 1.0, but it remains very good through a gain of 2.0, especially for scenes that do not have a large dynamic range. Using higher gain values works well for applications where image quality may be balanced with the need to eliminate motion blur or where higher frame rates are needed.

Adjusting Black Level Offset TS3 /TS4:

Adjusting the black level Offset may accomplish several things:

- Set the image slightly darker (reduce offset) or brighter (increase offset) to fine-tune the features in the image that appear black. This is the classic photographic use of black level adjustment. The key here is to make small changes. Just a couple of counts change in the offset will make a discernible difference in the image.
- Reduce near-saturation noise in a high-contrast image with FPN set to Pixel by reducing the offset. This has the effect of reducing the amplitude of the noise signal near saturation caused by subtraction of the dark frame. It has the side-effect of slightly increasing the noise near black. It can be done at any gain level, but it becomes increasingly valuable as the gain increases, causing increased noise.
- Reduce the near-black noise by increasing the offset. This is the opposite of the bullet, above.

Figure 5-16: Example of Manual Black Level Adjustment

As the offset decreases, the darkest portion of the signal becomes clipped. This clipped portion is not captured in the Black Frame, so it is not calibrated out, causing increased noise near black. To eliminate near-black noise, increase the offset.

Both images in Figure 5-16 were taken after calibrations with the gain set to 2.0. The top image was calibrated with the Black Level set to Automatic while the bottom image was calibrated with the Black Level set manually. The histograms shown with these images are the raw histograms taken during calibration (with the lens covered).

The top image has a noisy near-saturation section, circled in red. The bottom image, calibrated with the offset reduced, does not suffer from the same issue.

Note: When using the offset adjustment to eliminate near-saturation noise, be careful using Gamma adjustment as well. Near-saturation noise may be eliminated by adjusting the Gamma, then reducing the exposure or aperture to move the image away from saturation. If the offset is decreased as in the example here, some dark pixels will be clipped as evidenced in the magenta "bumper" in the histogram. Increasing Gamma when dark pixels are clipped will expose noise in the dark areas of the image.

Appendices

Appendix A: Definition of terms

Table 6-1: Definitions

Arm	When armed, the camera will capture and write images into a partition of camera memory, or stream images to an SSD.
AVI	Audio Video Interleave (AVI) is a popular multimedia container. (One file = many images.) Fastec AVI files may comprise JPEG or BMP images.
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 boosts all pixel values without disturbing the slope of the response curve.
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 Configurations 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.
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.
FasFire	A recording mode developed by Fastec in which newly captured image data is written to one partition of Memory concurrently with saving images from other partitions to a camera storage device.
FasFire LR	FasFire Long Record (FFLR) utilizes the FasFire engine, saving 4GB CAP files sequentially to construct gapless recordings of any length, saved to any HS device storage.

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 displayed on a given monitor 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 or DVR. 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 shut down.
JPEG Stack	Joint Photographic Expert Group (JPEG) file 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 is excellent, although there may be some discernible noise in the displayed image, often referred to as JPEG artifacts.
MP4 Video	MP4 is a multimedia container, popular for streaming characteristics. It may be highly compressed without loosing image quality.
Network	Cameras may be connected to a PC or LAN via Gigabit Ethernet networks.
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.
Record Bar	When the camera is Armed and it commences capturing images, the Record Bar presents a graphic indication of the progress of filling the buffer.
Refresh Rate	Rate at which image data is re-painted on the display or monitor.
Review	Review is a camera state for viewing and/or saving 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, etc., and saving image data in various forms to mass storage devices.
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.
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 (16 bits) without any contrast, gamma, brightness or color interpolation applied.
Trigger	Triggers are used to control image capture in the camera. They may be programmed to define the beginning, middle, or end of a capture buffer. Triggers may be applied in hardware via trigger button or I/O signal, or in software
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: Contents of <Capture>.txt file

[Image]

roi_x=240
roi_y=212
width=800
height=600
bit_mode=upper 8
sensor_options=bin2x:subs1x
frame_count=15
trigger_frame=278
start_frame=270
end_frame=284
time_stamp=2013:03:21 13:44:56
comment=Test 3_21a

x = image offset from corner of sensor

y = image offset from corner of sensor

(These will vary with resolution.

If centered:

x = (<resolution> - 1280)/2

y = (<resolution> - 1024)/2

(If not centered, then user values)

[Camera]

make=FASTEC
model=TS3100LC4
fpga_rev=0x0001009b
software_version=1.5.38
mac_address=a4:1b:c0:00:00:be
camera_name=FASTEC-TS3-BE
sensor_type=C31L

Sensor = C31L (Color)

Sensor = M31L (Mono)

[Record]

fps=24
shutter_speed=41666
multi_slope=0:0
trigger_settings=22
sync_in=0x0
sync_out=0x0

Multi-slope = option not implemented

Trigger, Sync_in, Sync_out superseded by per-frame metadata in XML file.

[Normalization]

red_balance=276
blue_balance=348
green_balance=256
brightness=100
contrast=100
gamma=100
sensor_gain=100
red_gain=0
green_gain=0
blue_gain=0
red_matrix=[236,20,3]
blue_matrix=[10,-205,451]
green_matrix=[-36,248,44]

<xxx_balance> = color balance presets or custom setting

brightness, contrast, gamma: user settings

<xxx_gain> user color gain settings

<xxx_matrix> 3x3 color correction matrix

Appendix C: Contents of <Capture>.xml file

```
<FastecMetadata>
  <capture version="1.0">
    <image>
      <frame_count>192</frame_count>
      <start_frame>356</start_frame>
      <end_frame>547</end_frame>
      <bit_mode>unknown</bit_mode>
      <sensor_options>bin2x:subs1x</sensor_options>
      <roi>
        <x>0</x>
        <y>32</y>
        <width>1280</width>
        <height>960</height>
      </roi>
      <trigger>
        <frame>680</frame>
        <time>15:077:11:01:03.198634</time>
      </trigger>
      <comment></comment>
    </image>
    <camera>
      <make>FASTEC</make>
      <model>TS5HC8256</model>
      <fpga_rev>0x20008</fpga_rev>
      <software_version>2.0.9</software_version>
      <mac_address>a4:1b:c0:00:02:34</mac_address>
      <camera_name>FASTEC-TS5-234</camera_name>
      <sensor_type>C5LA</sensor_type>
    </camera>
    <record>
      <fps>594</fps>
      <shutter_speed>420</shutter_speed>
      <multi_slope>0:0</multi_slope>
      <sync_in>0x0</sync_in>
      <sync_out>0x0</sync_out>
    </record>
    <normalization>
      <red_balance>6255</red_balance>
      <green_balance>4096</green_balance>
      <blue_balance>5198</blue_balance>
      <brightness>100</brightness>
      <contrast>100</contrast>
      <gamma>100</gamma>
      <sensor_gain>200</sensor_gain>
      <red_gain>1.0</red_gain>
      <green_gain>1.0</green_gain>
      <blue_gain>1.0</blue_gain>
      <red_matrix>[4978,-509,-371]</red_matrix>
      <green_matrix>[-542,5354,-715]</green_matrix>
      <blue_matrix>[318,-2289,6068]</blue_matrix>
    </normalization>
  </capture>
  <frames>
    <frame>
      <number>356</number>
      <hw_number>14048</hw_number>
      <irig>0</irig>
      <sync_mode>0</sync_mode>
      <time_state>0</time_state>
      <markers>0x003f</markers>
      <time>15:077:11:01:02.653150</time>
        <vtrig_area>6082</vtrig_area>
        <vtrig_flags>2</vtrig_flags>
    <frame>
```

Frame count = number of saved frames

Start frame = First frame saved (from 0)

sensor_options: 2x binning 1x subsample (TS5)

x = image offset from corner of sensor

y = image offset from corner of sensor

(These will vary with resolution.

If centered:

x = (<resolution> - 1280)/2

y = (<resolution> - 1024)/2

(If not centered, then user values)

Sensor = C31L (Color)

Sensor = M31L (Mono)

Multi-slope = option not implemented

<xxx_balance> = color balance presets or custom setting

brightness, contrast, gamma: user settings

<xxx_gain> user color gain settings

<xxx_matrix> 3x3 color correction matrix

IRIG = 0 (disabled) = 1 (enabled)

Time State = 0 (Master)

Time State = 1-3 (Sync In: Per Sec Slave)

Time State = 4-6 (Sync In: Per Sec IRIG)

sync_mode = 0 (disabled)

sync_mode = 1 (Per Frame)

sync_mode = 2 (Per Second)

Vtrig_area = pixel count above threshold

vtrig_flags - = 0 = no trigger; 1 = trigger

Appendix D: Partition Capture (CAP) File Format

Partition Capture file format is a Fastec Imaging proprietary raw data format used to store image data gathered by the TSx in one "Session" into the camera's built-in SSD drive. The session length is set by the user (see "1-12 Camera Memory and Image Storage" on page 25) to any multiple of 256MB up to the memory capacity of the camera, either 4GB or 8GB. The actual length of a recorded session may vary, however, depending on whether the full allotment of pre-trigger frames were captured before the trigger was asserted (see "Application Note 3: Trigger Position and the Circular Buffer" on page 83).

There are three major distinguishing benefits of CAP files:

1. CAP file transfer time from DRAM to SSD is the shortest of all of the non-compressed file types.
2. CAP files are the only files that may be copied back into DRAM from the SSD and played back from the camera or on a PC via the camera.
3. CAP files are the only non-compressed single file format available from the camera.

Note: CAP files are only available on cameras with SSDs, SN A0 and higher.

Figure 6-1: CAP File Diagram

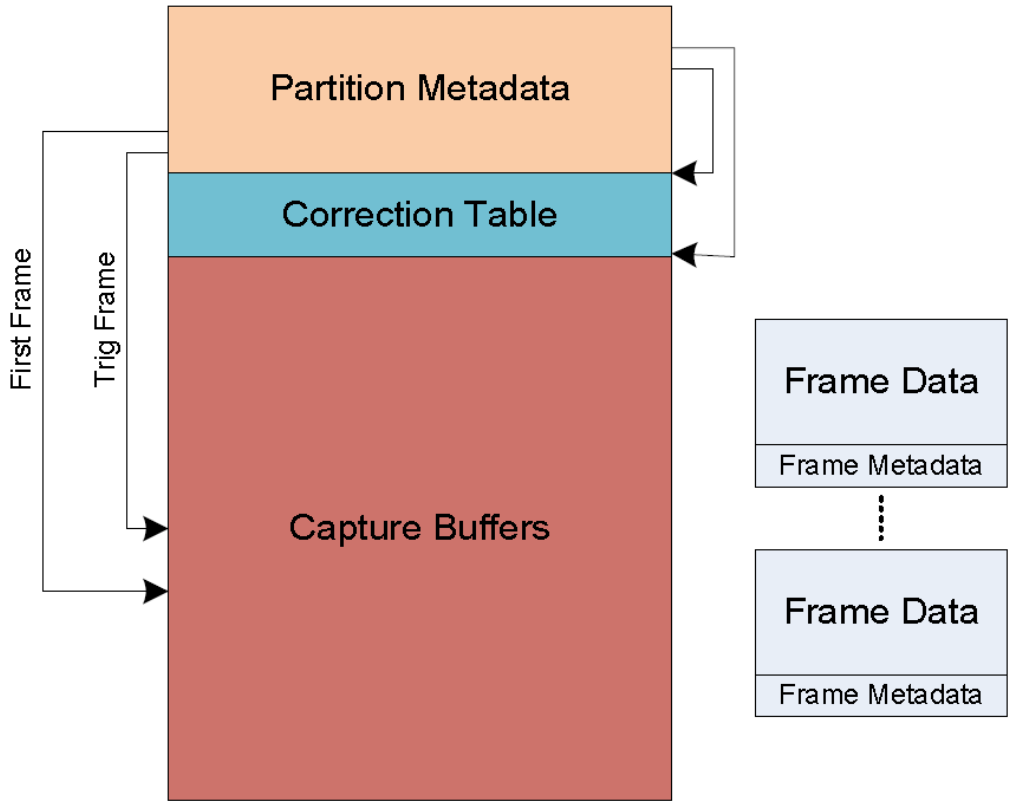


Table 6-2: CAP File Format

Field	Size	Description
Manufacturer's name	32	"FASTEC".
Model name	32	"TS3100SC8064" for example.
Serial number	16	"0.0.122.A3" for example.
Application version	32	"1.5.8" for example.
Camera name	16	"FastecA4-7A" for example.
Ethernet MAC address	6	The MAC address of the camera.
Bit selection	1	0:Low8, 1:Mid8, 2:High8, 3:10Bits
Sensor gain	1	The gain used by the sensor (analog gain).
FPGA version	4	FPGA version information.
ROI x-offset	2	Left side of the ROI window.
ROI y-offset	2	Top side of the ROI window.
ROI width	2	Width of the ROI window.
ROI height	2	Height of the ROI window.
Frames per second	4	Number of frames per second.
Shutter speed	4	Exposure time in microseconds.
Sensor type	4	Type of sensor used, "L13C" for example.
GPS location	64	GPS location information.
Frame count	4	Total number of frames captured.
Frame size	4	Size of the frames in quadwords.
First frame	4	Frame number of the first frame in the capture buffer.
Trigger frame	4	Frame number of the trigger frame in the capture buffer.
Trigger time seconds	4	Linux time of the trigger event.
Trigger time nanoseconds	4	Nanoseconds of trigger event from last second.
Start of video	4	Start of capture buffer, in quadwords.
As-shot neutral	12	The AsShotNeutral value.
Matrix coefficients	36	IPM matrix coefficients.
White balance gains	12	IPM white balance gain settings.
Multislope settings	2	LUPA 1300-2 multislope settings.
Trigger settings	1	Trigger position setting in percent, or 127 if position was specified by frame count instead of percent
SyncIn settings	1	
SyncOut settings	1	
Brightness	1	0-255 centered around 128.
Contrast	1	0-255 centered around 128.
Gamma	1	0-250 centered around 100.
RGB gain settings	3	Red, green, blue gain settings.
FPN settings	1	Off, sensor or pixel correction.
Correction table offset	4	Offset to the correction table.
Correction table length	4	Size of the correction table, in quadwords.
Reserved	16	Reserved for future use
Trigger frame setting	4	Post-trigger frame count setting, if setting is not by percent
Comment	64	User comment

Appendix E: Day Number Calendar Conversion

Time stamps are written to camera metadata in the following format:

YY:DDD:HH:MM:SS.xxxxxx

For example, 13:206:15:36:13.987304 = 2013, 206th day, 15th hour, 36th minute, 13.987304 seconds, which is July 25, 2013 at 3:36 in the afternoon + 13.987304 seconds

Table 6-3 and Table 6-4 convert calendar dates to day numbers.

Table 6-3: Dates and Day Numbers (non leap years)

JAN		FEB		MAR		APR		MAY		JUNE		JUL		AUG		SEPT		OCT		NOV		DEC	
1/1	1	2/1	32	3/1	60	4/1	91	5/1	121	6/1	152	7/1	182	8/1	213	9/1	244	10/1	274	11/1	305	12/1	335
1/2	2	2/2	33	3/2	61	4/2	92	5/2	122	6/2	153	7/2	183	8/2	214	9/2	245	10/2	275	11/2	306	12/2	336
1/3	3	2/3	34	3/3	62	4/3	93	5/3	123	6/3	154	7/3	184	8/3	215	9/3	246	10/3	276	11/3	307	12/3	337
1/4	4	2/4	35	3/4	63	4/4	94	5/4	124	6/4	155	7/4	185	8/4	216	9/4	247	10/4	277	11/4	308	12/4	338
1/5	5	2/5	36	3/5	64	4/5	95	5/5	125	6/5	156	7/5	186	8/5	217	9/5	248	10/5	278	11/5	309	12/5	339
1/6	6	2/6	37	3/6	65	4/6	96	5/6	126	6/6	157	7/6	187	8/6	218	9/6	249	10/6	279	11/6	310	12/6	340
1/7	7	2/7	38	3/7	66	4/7	97	5/7	127	6/7	158	7/7	188	8/7	219	9/7	250	10/7	280	11/7	311	12/7	341
1/8	8	2/8	39	3/8	67	4/8	98	5/8	128	6/8	159	7/8	189	8/8	220	9/8	251	10/8	281	11/8	312	12/8	342
1/9	9	2/9	40	3/9	68	4/9	99	5/9	129	6/9	160	7/9	190	8/9	221	9/9	252	10/9	282	11/9	313	12/9	343
1/10	10	2/10	41	3/10	69	4/10	100	5/10	130	6/10	161	7/10	191	8/10	222	9/10	253	10/10	283	11/10	314	12/10	344
1/11	11	2/11	42	3/11	70	4/11	101	5/11	131	6/11	162	7/11	192	8/11	223	9/11	254	10/11	284	11/11	315	12/11	345
1/12	12	2/12	43	3/12	71	4/12	102	5/12	132	6/12	163	7/12	193	8/12	224	9/12	255	10/12	285	11/12	316	12/12	346
1/13	13	2/13	44	3/13	72	4/13	103	5/13	133	6/13	164	7/13	194	8/13	225	9/13	256	10/13	286	11/13	317	12/13	347
1/14	14	2/14	45	3/14	73	4/14	104	5/14	134	6/14	165	7/14	195	8/14	226	9/14	257	10/14	287	11/14	318	12/14	348
1/15	15	2/15	46	3/15	74	4/15	105	5/15	135	6/15	166	7/15	196	8/15	227	9/15	258	10/15	288	11/15	319	12/15	349
1/16	16	2/16	47	3/16	75	4/16	106	5/16	136	6/16	167	7/16	197	8/16	228	9/16	259	10/16	289	11/16	320	12/16	350
1/17	17	2/17	48	3/17	76	4/17	107	5/17	137	6/17	168	7/17	198	8/17	229	9/17	260	10/17	290	11/17	321	12/17	351
1/18	18	2/18	49	3/18	77	4/18	108	5/18	138	6/18	169	7/18	199	8/18	230	9/18	261	10/18	291	11/18	322	12/18	352
1/19	19	2/19	50	3/19	78	4/19	109	5/19	139	6/19	170	7/19	200	8/19	231	9/19	262	10/19	292	11/19	323	12/19	353
1/20	20	2/20	51	3/20	79	4/20	110	5/20	140	6/20	171	7/20	201	8/20	232	9/20	263	10/20	293	11/20	324	12/20	354
1/21	21	2/21	52	3/21	80	4/21	111	5/21	141	6/21	172	7/21	202	8/21	233	9/21	264	10/21	294	11/21	325	12/21	355
1/22	22	2/22	53	3/22	81	4/22	112	5/22	142	6/22	173	7/22	203	8/22	234	9/22	265	10/22	295	11/22	326	12/22	356
1/23	23	2/23	54	3/23	82	4/23	113	5/23	143	6/23	174	7/23	204	8/23	235	9/23	266	10/23	296	11/23	327	12/23	357
1/24	24	2/24	55	3/24	83	4/24	114	5/24	144	6/24	175	7/24	205	8/24	236	9/24	267	10/24	297	11/24	328	12/24	358
1/25	25	2/25	56	3/25	84	4/25	115	5/25	145	6/25	176	7/25	206	8/25	237	9/25	268	10/25	298	11/25	329	12/25	359
1/26	26	2/26	57	3/26	85	4/26	116	5/26	146	6/26	177	7/26	207	8/26	238	9/26	269	10/26	299	11/26	330	12/26	360
1/27	27	2/27	58	3/27	86	4/27	117	5/27	147	6/27	178	7/27	208	8/27	239	9/27	270	10/27	300	11/27	331	12/27	361
1/28	28	2/28	59	3/28	87	4/28	118	5/28	148	6/28	179	7/28	209	8/28	240	9/28	271	10/28	301	11/28	332	12/28	362
1/29	29			3/29	88	4/29	119	5/29	149	6/29	180	7/29	210	8/29	241	9/29	272	10/29	302	11/29	333	12/29	363
1/30	30			3/30	89	4/30	120	5/30	150	6/30	181	7/30	211	8/30	242	9/30	273	10/30	303	11/30	334	12/30	364
1/31	31			3/31	90			5/31	151			7/31	212	8/31	243			10/31	304			12/31	365

Table 6-4: Dates and Day Numbers (leap years)

JAN		FEB		MAR		APR		MAY		JUNE		JUL		AUG		SEPT		OCT		NOV		DEC	
1/1	1	2/1	32	3/1	61	4/1	92	5/1	122	6/1	153	7/1	183	8/1	214	9/1	245	10/1	275	11/1	306	12/1	336
1/2	2	2/2	33	3/2	62	4/2	93	5/2	123	6/2	154	7/2	184	8/2	215	9/2	246	10/2	276	11/2	307	12/2	337
1/3	3	2/3	34	3/3	63	4/3	94	5/3	124	6/3	155	7/3	185	8/3	216	9/3	247	10/3	277	11/3	308	12/3	338
1/4	4	2/4	35	3/4	64	4/4	95	5/4	125	6/4	156	7/4	186	8/4	217	9/4	248	10/4	278	11/4	309	12/4	339
1/5	5	2/5	36	3/5	65	4/5	96	5/5	126	6/5	157	7/5	187	8/5	218	9/5	249	10/5	279	11/5	310	12/5	340
1/6	6	2/6	37	3/6	66	4/6	97	5/6	127	6/6	158	7/6	188	8/6	219	9/6	250	10/6	280	11/6	311	12/6	341
1/7	7	2/7	38	3/7	67	4/7	98	5/7	128	6/7	159	7/7	189	8/7	220	9/7	251	10/7	281	11/7	312	12/7	342
1/8	8	2/8	39	3/8	68	4/8	99	5/8	129	6/8	160	7/8	190	8/8	221	9/8	252	10/8	282	11/8	313	12/8	343
1/9	9	2/9	40	3/9	69	4/9	100	5/9	130	6/9	161	7/9	191	8/9	222	9/9	253	10/9	283	11/9	314	12/9	344
1/10	10	2/10	41	3/10	70	4/10	101	5/10	131	6/10	162	7/10	192	8/10	223	9/10	254	10/10	284	11/10	315	12/10	345
1/11	11	2/11	42	3/11	71	4/11	102	5/11	132	6/11	163	7/11	193	8/11	224	9/11	255	10/11	285	11/11	316	12/11	346
1/12	12	2/12	43	3/12	72	4/12	103	5/12	133	6/12	164	7/12	194	8/12	225	9/12	256	10/12	286	11/12	317	12/12	347
1/13	13	2/13	44	3/13	73	4/13	104	5/13	134	6/13	165	7/13	195	8/13	226	9/13	257	10/13	287	11/13	318	12/13	348
1/14	14	2/14	45	3/14	74	4/14	105	5/14	135	6/14	166	7/14	196	8/14	227	9/14	258	10/14	288	11/14	319	12/14	349
1/15	15	2/15	46	3/15	75	4/15	106	5/15	136	6/15	167	7/15	197	8/15	228	9/15	259	10/15	289	11/15	320	12/15	350
1/16	16	2/16	47	3/16	76	4/16	107	5/16	137	6/16	168	7/16	198	8/16	229	9/16	260	10/16	290	11/16	321	12/16	351
1/17	17	2/17	48	3/17	77	4/17	108	5/17	138	6/17	169	7/17	199	8/17	230	9/17	261	10/17	291	11/17	322	12/17	352
1/18	18	2/18	49	3/18	78	4/18	109	5/18	139	6/18	170	7/18	200	8/18	231	9/18	262	10/18	292	11/18	323	12/18	353
1/19	19	2/19	50	3/19	79	4/19	110	5/19	140	6/19	171	7/19	201	8/19	232	9/19	263	10/19	293	11/19	324	12/19	354
1/20	20	2/20	51	3/20	80	4/20	111	5/20	141	6/20	172	7/20	202	8/20	233	9/20	264	10/20	294	11/20	325	12/20	355
1/21	21	2/21	52	3/21	81	4/21	112	5/21	142	6/21	173	7/21	203	8/21	234	9/21	265	10/21	295	11/21	326	12/21	356
1/22	22	2/22	53	3/22	82	4/22	113	5/22	143	6/22	174	7/22	204	8/22	235	9/22	266	10/22	296	11/22	327	12/22	357
1/23	23	2/23	54	3/23	83	4/23	114	5/23	144	6/23	175	7/23	205	8/23	236	9/23	267	10/23	297	11/23	328	12/23	358
1/24	24	2/24	55	3/24	84	4/24	115	5/24	145	6/24	176	7/24	206	8/24	237	9/24	268	10/24	298	11/24	329	12/24	359
1/25	25	2/25	56	3/25	85	4/25	116	5/25	146	6/25	177	7/25	207	8/25	238	9/25	269	10/25	299	11/25	330	12/25	360
1/26	26	2/26	57	3/26	86	4/26	117	5/26	147	6/26	178	7/26	208	8/26	239	9/26	270	10/26	300	11/26	331	12/26	361
1/27	27	2/27	58	3/27	87	4/27	118	5/27	148	6/27	179	7/27	209	8/27	240	9/27	271	10/27	301	11/27	332	12/27	362
1/28	28	2/28	59	3/28	88	4/28	119	5/28	149	6/28	180	7/28	210	8/28	241	9/28	272	10/28	302	11/28	333	12/28	363
1/29	29	2/29	60	3/29	89	4/29	120	5/29	150	6/29	181	7/29	211	8/29	242	9/29	273	10/29	303	11/29	334	12/29	364
1/30	30			3/30	90	4/30	121	5/30	151	6/30	182	7/30	212	8/30	243	9/30	274	10/30	304	11/30	335	12/30	365
1/31	31			3/31	91			5/31	152			7/31	213	8/31	244			10/31	305			12/31	366

Appendix F: Device Benchmarks

App F: Part1: IL / TS Device Benchmarks

IL and TS cameras may transfer various image data types to an internal camera SSD (if installed), SD card, or media connected via the camera's USB type A port.

CAP file transfers are limited to the camera SSD and are, by far, the fastest. From the table below, it is clear that 2GB CAP files are saved to the SSD in about 5.5sec regardless of image size.

Transfer performance of all other image file formats tend to depend more on per-image processing overheads than transfer speeds. For this reason save times for 2GB partitions of small-resolution image stacks take many times longer than for CAP file transfers.

The per-image overhead while saving stacks is most pronounced when saving to the camera's SSD. For example, JPG stacks of 256 x 256 images may be saved much more quickly to either the SD card or USB than to the internal SSD.

Table 6-5: TS/IL internal SSD 2GB Partition Save Performance

TYPE	Resolution	Frames	Bytes	Time (sec)	MB/s	Images/s	CAP/TYPE*
CAP	1920 x 1080	645	2147483648	5.34	383.6	120.8	1.0
DNG	1920 x 1080	645	2675325840	26.56	96.1	24.3	5.0
BMP	1920 x 1080	645	4012452120	30.99	123.5	20.8	5.8
JPG	1920 x 1080	645	85014194	35.69	2.3	18.1	6.7
TIFF	1920 x 1080	645	4012601760	30.99	123.5	20.8	5.8
TIFF(raw)	1920 x 1080	645	2675124600	26.65	95.7	24.2	5.0
CAP	1024 x 1024	1275	2147483648	5.34	383.8	238.9	1.0
DNG	1024 x 1024	1275	2674623600	30.65	83.2	41.6	5.7
BMP	1024 x 1024	1275	4010874600	34.16	112.0	37.3	6.4
JPG	1024 x 1024	1275	90755789	50.45	1.7	25.3	9.4
TIFF	1024 x 1024	1275	4011170400	34.33	111.4	37.1	6.4
TIFF(raw)	1024 x 1024	1275	2674225800	31.01	82.2	41.1	5.8
CAP	512 x 512	5077	2147483648	5.44	376.4	933.2	1.0
DNG	512 x 512	5077	2664815760	110.89	22.9	45.8	20.8
BMP	512 x 512	5077	3992999576	111.93	34.0	45.4	21.0
JPG	512 x 512	5077	107109673	154.04	0.7	33.0	28.8
TIFF	512 x 512	5077	3994177440	112.74	33.8	45.0	21.1
TIFF(raw)	512 x 512	5077	2663231736	112.26	22.6	45.2	21.0
CAP	256 x 256	20109	2147483648	5.57	367.4	3607.0	1.0
DNG	256 x 256	20109	2647631376	455.96	5.5	44.1	85.4
BMP	256 x 256	20109	3954716376	453.06	8.3	44.4	84.9
JPG	256 x 256	20109	120810861	633.19	0.2	31.8	118.6
TIFF	256 x 256	20109	3959381664	455.97	8.3	44.1	85.4
TIFF(raw)	256 x 256	20109	2641357368	452.70	5.6	44.4	84.8

* CAP files are saved at rates from 5x to more than 100x faster than other file types.

Raw data transfer rates of SD cards and USB-2 drives may be several times slower than that of the camera's SSD, but there are several advantages:

- Image file formats are directly importable into other systems for playback and analysis
- AVI format, which offers the best transfer performance, is not available for SSD saves on IL and TS
- Saving large stacks of very small images is faster when saving to USB drive or SD card than to SSD

Table 6-6: TS/IL SD card and USB Drive 2GB Partition Save Performance

TYPE	Resolution	Frames	Bytes	Time (sec)	MB/s	Images/s
SD card						
AVI (JPG)	1920 x 1080	645	66660934	31.34	2.03	20.6
BMP	1920 x 1080	645	1338168600	386.66	3.30	1.7
JPG	1920 x 1080	645	66660934	44.92	1.42	14.4
TIF	1920 x 1080	645	1337652600	430.66	2.96	1.5
TIF(RAW)	1920 x 1080	645	2675124600	795.40	3.21	0.8
USB Drive						
AVI (JPG)	1920 x 1080	645	66660934	27.50	2.75	23.5
BMP	1920 x 1080	645	1338168600	179.22	7.12	3.6
JPG	1920 x 1080	645	66660934	32.26	2.34	20.0
TIF	1920 x 1080	645	1337652600	151.28	8.43	4.3
TIF(RAW)	1920 x 1080	645	2675124600	289.72	8.81	2.2
SD card						
AVI (JPG)	256 x 256	20109	109117159	141.56	0.74	142.1
BMP	256 x 256	20109	1339581144	718.16	1.78	28.0
JPG	256 x 256	20109	110263907	372.40	0.28	54.0
TIF	256 x 256	20109	1323493944	787.25	1.60	25.5
TIF(RAW)	256 x 256	20109	2641357368	1200.49	2.10	16.8
USB Drive						
AVI (JPG)	256 x 256	20109	109117159	134.84	0.77	149.1
BMP	256 x 256	20109	1339581144	369.13	3.46	54.5
JPG	256 x 256	20109	110263907	235.88	0.30	85.3
TIF	256 x 256	20109	1323493944	376.91	3.35	53.4
TIF(RAW)	256 x 256	20109	2641357368	510.09	4.94	39.4

App F: Part2: HS-Series Camera Device Benchmarks

HS-5 and HS-7 cameras may have an SSD installed in the camera body or may have external SSDs attached to the Controller via Thunderbolt or USB ports.
The following tables show results of testing the same Samsung 970Pro SSD in various scenarios:

- "Fastec SSD" is the name given drives installed within the camera. These always are formatted EXT4, a "Linux only" file system. This gives the device the best performance for CAP file saves, but relatively poor performance for other file types
- "Video SSD" is the name given drives connected to the controller via Thunderbolt. These typically use either exFAT or NTFS file systems. (exFAT is better for CAP saves, while NTFS is better for large stacks.
- "USB SSD" is the name given drives connected to the controller via USB. These will not have the raw top-end speed of the other interfaces, but can be quite acceptable for large stacks when formatted NTFS

Table 6-7: HS7 Fastec SSD 2GB Partition Save Performance

TYPE	Resolution	Frames	Bytes	Time (sec)	MB/s	Images/s	CAP/TYPE*
CAP	1920 x 1080	755	2147483648	0.79	2578.31	950.5	1.0
DNG	1920 x 1080	755	3214554300	18.59	164.93	40.6	23.4
BMP	1920 x 1080	755	4821161850	19.10	240.70	39.5	24.0
JPG	1920 x 1080	755	223398836	12.71	16.76	59.4	16.0
TIFF	1920 x 1080	755	4821355600	19.06	241.29	39.6	24.0
TIFF(raw)	1920 x 1080	755	3214309400	18.56	165.18	40.7	23.4
CAP	1024 x 1024	1529	2147483648	0.82	2511.19	1874.8	1.0
DNG	1024 x 1024	1529	3207481156	19.16	159.62	79.8	23.5
BMP	1024 x 1024	1529	4809900678	19.64	233.53	77.8	24.1
JPG	1024 x 1024	1529	148252815	12.80	11.05	119.4	15.7
TIFF	1024 x 1024	1529	4810282928	19.63	233.67	77.9	24.1
TIFF(raw)	1024 x 1024	1529	3206997992	19.20	159.27	79.6	23.5
CAP	512 x 512	6119	2147483648	0.79	2599.22	7765.9	1.0
DNG	512 x 512	6119	3211863100	52.97	57.82	115.5	67.2
BMP	512 x 512	6119	4812507834	54.10	84.83	113.1	68.7
JPG	512 x 512	6119	294363147	42.57	6.60	143.8	54.0
TIFF	512 x 512	6119	4814037584	54.06	84.92	113.2	68.6
TIFF(raw)	512 x 512	6119	3209929496	53.00	57.76	115.4	67.3
CAP	256 x 256	24320	2147483648	0.83	2467.95	29307.0	1.0
DNG	256 x 256	24320	3202554880	176.71	17.28	137.6	212.9
BMP	256 x 256	24320	4782819840	186.99	24.39	130.1	225.3
JPG	256 x 256	24320	364134814	157.82	2.20	154.1	190.2
TIFF	256 x 256	24320	4788899840	187.11	24.41	130.0	225.5
TIFF(raw)	256 x 256	24320	3194869760	177.16	17.20	137.3	213.5

* CAP files are saved at rates from 15x to more than 200x faster than other file types.

Table 6-8: HS7 Video SSD (TB4) 2GB Partition Save Performance (exFAT)

TYPE	Resolution	Frames	Bytes	Time (sec)	MB/s	Images/s	CAP/TYPE*
CAP	1920 x 1080	775	2147483648	1.08	1893.69	716.6	1.0
AVI BMP	1920 x 1080	775	4821349400	19.17	239.87	40.4	17.7
AVI JPG	1920 x 1080	775	1242655847	12.71	93.23	61.0	11.8
MP4	1920 x 1080	775	2410789400	13.22	173.85	58.6	12.2
DNG	1920 x 1080	775	3214554300	18.58	164.99	41.7	17.2
BMP	1920 x 1080	775	4821161850	19.09	240.89	40.6	17.6
JPG	1920 x 1080	775	1242426447	12.71	93.23	61.0	11.8
TIFF	1920 x 1080	775	4821355600	19.03	241.56	40.7	17.6
TIFF(raw)	1920 x 1080	775	3214309400	18.82	162.91	41.2	17.4
CAP	256 x 256	24320	2147483648	1.13	1812.46	21522.9	1.0
AVI BMP	256 x 256	24320	4788705280	24.34	187.62	999.1	21.5
AVI JPG	256 x 256	24320	395416409	47.90	7.87	507.7	42.4
MP4	256 x 256	24320	2397952000	18.58	123.11	1309.3	16.4
DNG	256 x 256	24320	3202554880	65.78	46.43	369.7	58.2
BMP	256 x 256	24320	4782819840	67.96	67.12	357.9	60.1
JPG	256 x 256	24320	388217689	78.83	4.70	308.5	69.8
TIFF	256 x 256	24320	4788899840	68.33	66.84	355.9	60.5
TIFF(raw)	256 x 256	24320	3194869760	66.54	45.79	365.5	58.9

Table 6-9: HS7 Video SSD (TB4) 2GB Partition Save Performance (NTFS)

TYPE	Resolution	Frames	Bytes	Time (sec)	MB/s	Images/s	CAP/TYPE*
CAP	1920 x 1080	775	2147483648	5.13	398.89	150.9	1.0
AVI BMP	1920 x 1080	775	4821120000	18.56	247.79	41.8	3.6
AVI JPG	1920 x 1080	775	234307330	12.59	17.76	61.6	2.5
MP4	1920 x 1080	775	2410560000	13.17	174.53	58.8	2.6
DNG	1920 x 1080	775	3214554300	18.01	170.18	43.0	3.5
BMP	1920 x 1080	775	4821161850	20.51	224.22	37.8	4.0
JPG	1920 x 1080	775	234307330	12.54	17.82	61.8	2.4
TIFF	1920 x 1080	775	4821355600	19.97	230.27	38.8	3.9
TIFF(raw)	1920 x 1080	775	3214309400	18.05	169.84	42.9	3.5
CAP	256 x 256	24320	2147483648	5.40	379.21	4503.1	1.0
AVI BMP	256 x 256	24320	4788705280	23.76	192.17	1023.4	4.4
AVI JPG	256 x 256	24320	311758780	53.94	5.51	450.9	10.0
MP4	256 x 256	24320	2397952000	18.99	120.43	1280.8	3.5
DNG	256 x 256	24320	3202554880	27.81	109.82	874.4	5.1
BMP	256 x 256	24320	4782819840	28.14	162.10	864.3	5.2
JPG	256 x 256	24320	304560060	54.43	5.34	446.8	10.1
TIFF	256 x 256	24320	4788899840	28.13	162.33	864.4	5.2
TIFF(raw)	256 x 256	24320	3194869760	23.61	129.05	1030.0	4.4

Table 6-10: HS7 USB SSD (USB 3.2) 2GB Partition Save Performance (exFAT)

TYPE	Resolution	Frames	Bytes	Time (sec)	MB/s	Images/s	CAP/TYPE*
CAP	1920 x 1080	775	2147483648	2.12	967.20	366.0	1.0
AVI BMP	1920 x 1080	775	4821349400	18.94	242.72	40.9	8.9
AVI JPG	1920 x 1080	775	1242655847	12.98	91.30	59.7	6.1
MP4	1920 x 1080	775	2410789400	13.22	173.97	58.6	6.2
DNG	1920 x 1080	775	3214554300	18.34	167.13	42.3	8.7
BMP	1920 x 1080	775	4821161850	18.77	244.94	41.3	8.9
JPG	1920 x 1080	775	1242426447	12.68	93.42	61.1	6.0
TIFF	1920 x 1080	775	4821355600	18.82	244.35	41.2	8.9
TIFF(raw)	1920 x 1080	775	3214309400	18.30	167.52	42.4	8.6
CAP	256 x 256	24320	2147483648	2.60	788.28	9360.8	1.0
AVI BMP	256 x 256	24320	4788705280	24.16	189.04	1006.7	9.3
AVI JPG	256 x 256	24320	395416409	47.75	7.90	509.3	18.4
MP4	256 x 256	24320	2397952000	18.95	120.69	1283.5	7.3
DNG	256 x 256	24320	3202554880	91.48	33.39	265.9	35.2
BMP	256 x 256	24320	4782819840	94.16	48.43	258.2	36.2
JPG	256 x 256	24320	304560060	99.99	15.80	243.2	38.5
TIFF	256 x 256	24320	4788899840	94.77	48.19	256.6	36.5
TIFF(raw)	256 x 256	24320	3194869760	92.37	32.98	263.3	35.6

Table 6-11: HS7 USB SSD (USB 3.2) 2GB Partition Save Performance (NTFS)

TYPE	Resolution	Frames	Bytes	Time (sec)	MB/s	Images/s	CAP/TYPE*
CAP	1920 x 1080	775	2147483648	5.394981	379.61	143.7	1.0
AVI BMP	1920 x 1080	775	4821349400	18.536033	248.06	41.8	3.4
AVI JPG	1920 x 1080	775	234536730	12.50686	17.88	62.0	2.3
MP4	1920 x 1080	775	2410789400	13.169342	174.58	58.8	2.4
DNG	1920 x 1080	775	3214554300	18.088559	169.48	42.8	3.4
BMP	1920 x 1080	775	4821161850	23.133161	198.75	33.5	4.3
JPG	1920 x 1080	775	234307330	12.745972	17.53	60.8	2.4
TIFF	1920 x 1080	775	4821355600	22.648028	203.02	34.2	4.2
TIFF(raw)	1920 x 1080	775	3214309400	18.049332	169.83	42.9	3.3
CAP	256 x 256	24320	2147483648	5.353934	382.52	4542.5	1.0
AVI BMP	256 x 256	24320	4788705280	23.762052	192.19	1023.5	4.4
AVI JPG	256 x 256	24320	311758780	53.810506	5.53	452.0	10.1
MP4	256 x 256	24320	2397952000	19.228285	118.93	1264.8	3.6
DNG	256 x 256	24320	3202554880	27.8119	109.82	874.4	5.2
BMP	256 x 256	24320	4782819840	37.901119	120.35	641.7	7.1
JPG	256 x 256	24320	304560060	54.666062	5.31	444.9	10.2
TIFF	256 x 256	24320	4788899840	37.372542	122.20	650.7	7.0
TIFF(raw)	256 x 256	24320	3194869760	28.211424	108.00	862.1	5.3

App F Part 3: FFLR Data Rate Benchmarks

FasFire LR recordings utilize the CAP Partition save utility to create long record sequences on any device connected to an HS system controller.

Performance depends in large part on the target drive, which may be an SSD supplied by Fastec, or any user-supplied drive.

Performance is also dependent on the SSD file system (format), temperature throttling, host configuration (local/remote), and applications running on the Controller, as seen on the tables shown here.

This section offers benchmarks for SSD FFLR performance for two common devices:

- "Fastec SSD," the high-performance Samsung 970 Pro that comes pre-installed in HS series cameras with the "D" (long record) option.
- "Video SSD," a high-performance Samsung 970 Pro that may be purchased as an external drive. In this case it is installed into a Fledging fan-cooled enclosure and is connected to the Controller via the Thunderbolt 4 interface. For this test the drive was formatted exFAT.

It is important to note that these devices (Samsung 970 Pro) have been subjected to many hours of testing and have proven never to slow down unless they are purposely forced to overheat. Similar drives with equal or better published specifications may have equal or superior performance in short tests, but may slow down intermittently, making them less suitable for this application.

Table 6-12 and Table 6-13 comprise data from 32GB tests performed with the camera set up as shown in Figure 6-2.

You can the "MB/sec" value in Session Recording Capacity, that in order to maintain this speed for long recordings, the system must be able to save at 2162MB/sec.

Compilation of the data is achieved by opening a Terminal (command) window on the controller (Ctl-Alt-t) and typing the following commands:

> fascam@Tiger-Master ~]$ cd ~/.config/Fastec/scratch

> fascam@Tiger-Master scratch]$ cat cs.log |grep sec=

This will return the following for each 4GB buffer used in the capture:

saveVideo: file='/media/FastecSSD/DCIM/100fastc/fi_000006/0000000.cap' part_num=0 status=0x0 frames=1551 bytes=4294967296 sec=1.685579 [2548066448.38 Byte/sec]

The Byte/sec data may be parsed out from this and averaged to produce a benchmark you may use to establish FFLR data rates.

Figure 6-2: FFLR Benchmark Setup Example

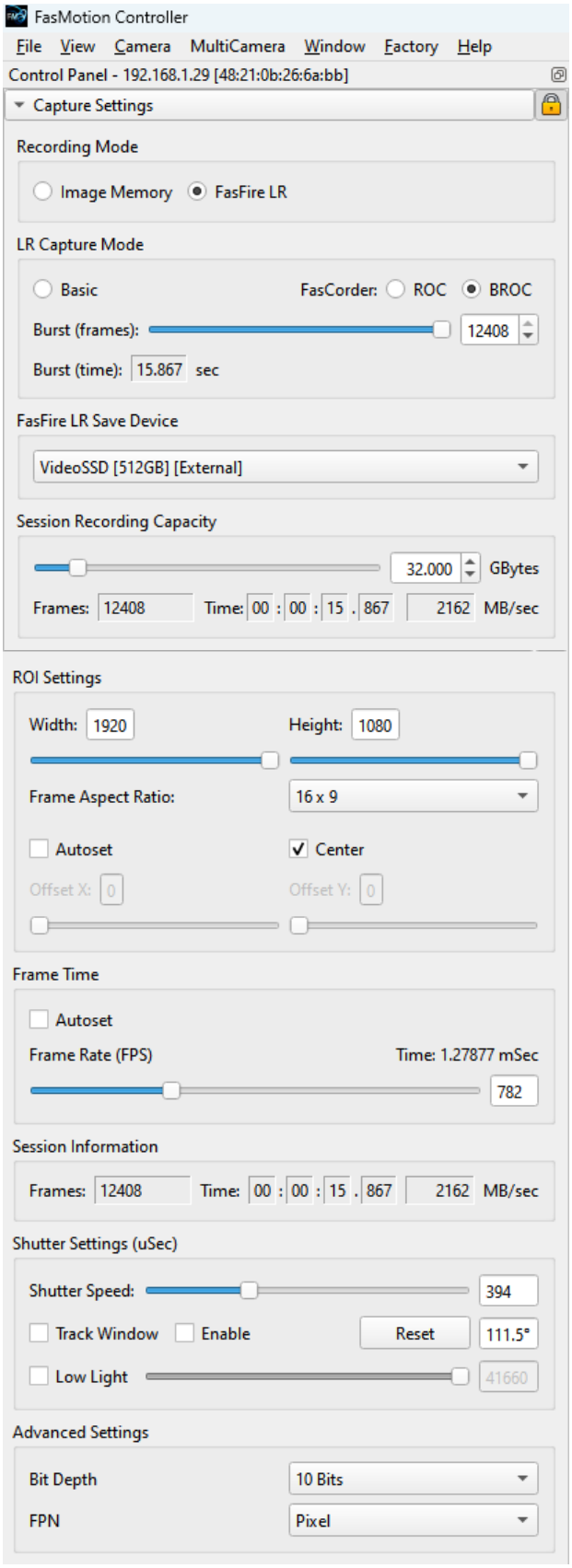


Table 6-12: HS7 Fastec SSD FFLR 4GB CAP

	Capture (4GB each)	Time	MB/s
Remote Connection (Networked)	1:8	1.75	2341
	2:8	1.79	2283
	3:8	1.79	2287
	4:8	1.81	2259
	5:8	1.80	2273
	6:8	1.80	2280
	7:8	1.84	2230
	8:8	1.81	2260
	Average for 32GB	**1.80**	**2277**
Local Connection	1:8	1.90	2153
	2:8	1.87	2185
	3:8	1.95	2105
	4:8	1.88	2183
	5:8	1.90	2161
	6:8	1.86	2202
	7:8	1.90	2160
	8:8	1.90	2160
	Average for 32GB	**1.89**	**2164**
Remote via TeamViewer	1:8	2.12	1930
	2:8	2.23	1840
	3:8	2.21	1857
	4:8	2.16	1898
	5:8	2.21	1854
	6:8	2.24	1832
	7:8	2.39	1712
	8:8	2.32	1769
	Average for 32GB	**2.23**	**1836**
TeamViewer with OBS running	1:8	2.81	1459
	2:8	2.85	1436
	3:8	2.75	1488
	4:8	2.85	1438
	5:8	2.73	1499
	6:8	3.02	1356
	7:8	2.98	1375
	8:8	2.93	1399
	Average for 32GB	**2.87**	**1431**

Table 6-13: HS7 Video SSD FFLR 4GB CAP

	Capture (4GB each)	Time	MB/s
Remote Connection (Networked)	1:8	2.51	1630
	2:8	2.53	1618
	3:8	2.51	1629
	4:8	2.50	1639
	5:8	2.51	1634
	6:8	2.50	1636
	7:8	2.63	1560
	8:8	2.51	1632
	Average for 32GB	**2.53**	**1622**
Local Connection	1:8	2.60	1577
	2:8	2.71	1512
	3:8	2.60	1575
	4:8	2.61	1569
	5:8	2.56	1599
	6:8	2.70	1519
	7:8	2.63	1555
	8:8	2.85	1440
	Average for 32GB	**2.66**	**1543**
Remote via TeamViewer	1:8	2.97	1380
	2:8	3.05	1345
	3:8	2.94	1393
	4:8	3.05	1342
	5:8	3.11	1315
	6:8	3.19	1286
	7:8	3.22	1271
	8:8	3.29	1246
	Average for 32GB	**3.10**	**1322**
TeamViewer with OBS running	1:8	3.78	1084
	2:8	3.77	1086
	3:8	3.80	1077
	4:8	4.06	1009
	5:8	4.12	995
	6:8	3.85	1063
	7:8	4.07	1006
	8:8	4.07	1007
	Average for 32GB	**3.94**	**1041**

App F Part 4: FFLR Endurance Benchmarks

Storage devices and enclosures must be endurance tested before they can be reliably used for FasFire Long Record in extended use.

Table 6-1 and the associated graph show the results of an endurance test.

The camera was set to record at 1500fps at a resolution of 1000 x 1000 in 8 bits (~1500MB/sec). We used a 400GB session length recording BROC mode with the Burst (frames) set to use the whole session capacity. The camera was operated remotely from a PC with FasMotion controlling the camera over a network..

The SSDs used for all three tests were Samsung 970 Pros, but they were in different enclosures:

- Ext / Flg: Fleging TB3 cooled Thunderbolt enclosure (advertised speeds to 2000MB/s
- Internal: SSD integrated into the HS camera
- Ext / Sab: Saberent USB 3 (10Gb/sec) enclosure (using USB-C) (Saberent has newer, faster enclosures as well, but we used the older model for this test)

The results are clear:

The Fleging version was able to maintain its speed throughout the test.

The Internal SSD version was faster and maintained its speed.

The USB 3 Sabrent kept up for the first 10 4GB buffers, then failed.

The important idea here is to make sure the drive you use will be able to maintain its speed for whatever interval is needed. If you just need a 30-second burst then have plenty of time between tests for the drive to recover, a USB device like the Saberent may work.

Be careful to fully test any drive you plan to use for extended periods as some drives and/or enclosures may take much longer to fail than this example.

NOTE: For longer tests use FFLR Basic mode with End Trigger. This will force the camera to record and continually write over the oldest CAP files on the destination drive until a trigger is received.

Table 6-14: Performance of SSD by Enclosure

Save Data Rates MB/sec		
Ext / Flg Enc	Ext / Sab Enc	Internal
1663	2261	2267
1614	2210	2356
1659	2217	2401
1665	2243	2308
1647	2148	2383
1658	2212	2336
1655	2243	2402
1661	2208	2407
1563	1550	2339
1572	1635	2360
1642	1668	2385
1633	743	2381
1650	992	2376
1645	874	2394
1531	708	2385
1648	225	2412
1660	394	2386
1651	142	2363
1649	125	2350
1584	129	2357
1644	118	2397
1642	1646	2343
1650	1680	2371
1632	1692	2371
1610	1689	2410
1650	1696	2369
1655	1682	2301
1643	1689	2367
1648	422	2366
1639	361	2355
1659	234	2343
1654	152	2413
1633	131	2344
1648	123	2269
1663	122	2389
1633	0	2400
1644	0	2367
1661	0	2341
1655	0	2365
1598	0	2385
1643	0	2360